Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C

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Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1

Integrated Biodiversity and Ecology

(Terrestrial and Aquatic Ecosystems, and Species Assessment Report)

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

BIODIVERSITY AND ECOLOGY
TERRESTRIAL AND AQUATIC ECOSYSTEMS, AND SPECIES

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Kate McEwan[7, 8]	Bats	Draft V1 – February 2018 Draft V2 – July 2018 Draft V3 – April 2019 Final Report – October 2019
Lizande Kellerman[2] & Simon Todd[3]	Desert, Nama Karoo & Succulent Karoo	Draft V1 – January 2019 Draft V2 – January 2019 Draft V3 – April 2019 Final Report – October 2019
Dr. Lara van Niekerk[1], Carla-Louise Ramjukadh[1] Steven Weerts[1] & Dr. Susan Taljaard[1]	Estuaries	Draft V1 – April 2018 Draft V2 – October 2018 Draft V3 – April 2019 Final Report – October 2019
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8 South African Bat Assessment Association Panel

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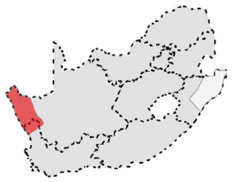
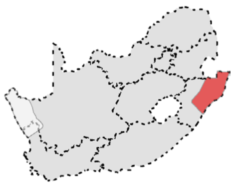
ABBREVIATIONS AND ACRONYMS

AoO	Area of Occupancy
BFD	Bird Flight Diverters
BLSA	Bird Life South Africa
CARA	Conservation of Agricultural Resources Act (43/1983)
CBA	Critical Biodiversity Area
CR	Critically Endangered
DEA	Department of Environmental Affairs
ECO	Environmental Control Officer
EFZ	Estuary Functional Zone
EGI	Electricity Grid Infrastructure
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
EN	Endangered
EoO	Extent of Occurrence
ESA	Ecological Support Area
EWT	Endangered Wildlife Trust
GIS	Geographic Information Systems
IAP	Invasive Alien Plant
IBA	Important Bird Area
IDP	Integrated Development Plan
IUCN	International Union for Conservation of Nature
KZN	Kwa-Zulu Natal
LED	Light Emitting Diode
LT	Least Threatened
MAP	Mean Annual Precipitation
NEM:BA	National Environmental Management: Biodiversity Act (10/2004)
NEM:ICMA	National Environmental Management: Integrated Coastal Management Act (24/2008)
NEM:PAA	National Environmental Management: Protected Areas Act (57/2003)
NEMA	National Environmental Management Act (107/1998)
NFA	National Forest Act (84/1998)
NFEPA	National Freshwater Ecosystem Priority Areas
NGO	Non-Government Organisation
NP	National Park
NPAES	National Protected Area Expansion Strategy
NT	Near Threatened
NWA	National Water Act (36/998)
PA	Protected Area
PES	Present Ecological State
QDGC	Quarter Degree Grid Cell
RQO	Resource Quality Objectives
SABAP	Southern African Bird Atlas Project
SACAD	South African Conservation Areas Database
SACNASP	South African Council for Natural Scientific Professions
SANParks	South African National Parks
SAPAD	South African Protected Areas Database
SCC	Species of Conservation Concern
SDF	Spatial Development Frameworks
SEA	Strategic Environmental Assessment
SPLUMA	Spatial Planning and Land Use Management Act (16/2013)
SWSA	Strategic Water Source Areas
ToPS	hreatened or Protected Species Regulations (2013)
VU	Vulnerable
WCBSP	Western Cape Biodiversity Spatial Plan
WHS	World Heritage Site
WUL	Water Use License

1 SUMMARY

This chapter consolidates the potential impacts from the development of Electricity Grid Infrastructure (EGI) on terrestrial and aquatic ecology and biodiversity in two proposed expanded EGI corridors in South Africa (Table i). The ecological and biodiversity environmental aspects of the proposed expanded EGI corridors 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 expanded EGI corridors. Section references for the environmental description and sensitivity mapping for each corridor is indicated in the last column.

Site	Brief description	§
Expanded Western EGI corridor 	• This proposed corridor is situated within Fynbos, Succulent Karoo, Nama Karoo, and 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, with extensive areas earmarked as potential National Protected Areas Expansion Strategy (NPAES) focus areas. • Relatively untransformed when compared to the proposed expanded Eastern EGI corridor.	6.1 7.2.1
Expanded Eastern EGI corridor 	• This proposed corridor is situated within Savanna, Grassland and Indian Ocean Coastal Belt vegetation types in the KwaZulu-Natal Province. • Transformed by urban settlement and agriculture, especially in the vicinity of Richards Bay. • The dense human population has resulted in large-scale transformation of the natural habitat, resulting in large sections of the corridor rated as low sensitivity for birds. However, the remaining natural areas support a wide variety of power line sensitive Red Data bird species. • Many protected areas associated with large wetlands are present.	6.2 7.2.2

Highly sensitive ecological features exist in both 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). Areas that have already been transformed by anthropogenic activities such as urbanisation and agriculture are mainly of low sensitivity (Figure i). Aligning the proposed EGI routings to follow existing disturbance corridors presents an (environmental) opportunity.

Overall low human population, with most of the natural habitat relatively untransformed, results in the proposed expanded Western EGI corridor to be more sensitive for birds (Figure i). This, coupled with the occurrence of several high-risk species, has resulted in the majority of the habitat receiving a High Sensitivity rating. Conversely the dense human population in the proposed expanded Eastern EGI corridor has resulted in large-scale transformation of the natural habitat, resulting in large sections of the corridor rated as low sensitivity for birds (Figure ii). However, the remaining natural areas support a wide variety of power line sensitive Red Data bird species.

A number of Red Data Bat species occur in the proposed expanded Eastern EGI corridor - fruit bats and large insectivorous bats in particular could be affected by EGI development.

The proposed Expanded Western EGI corridor is situated in more arid areas and are less sensitive from an aquatic ecology perspective due to the relatively limited presence of aquatic features (Figure i). 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 (e.g. increased power line spanning distance across watercourses) and best practice to reduce potential impact.

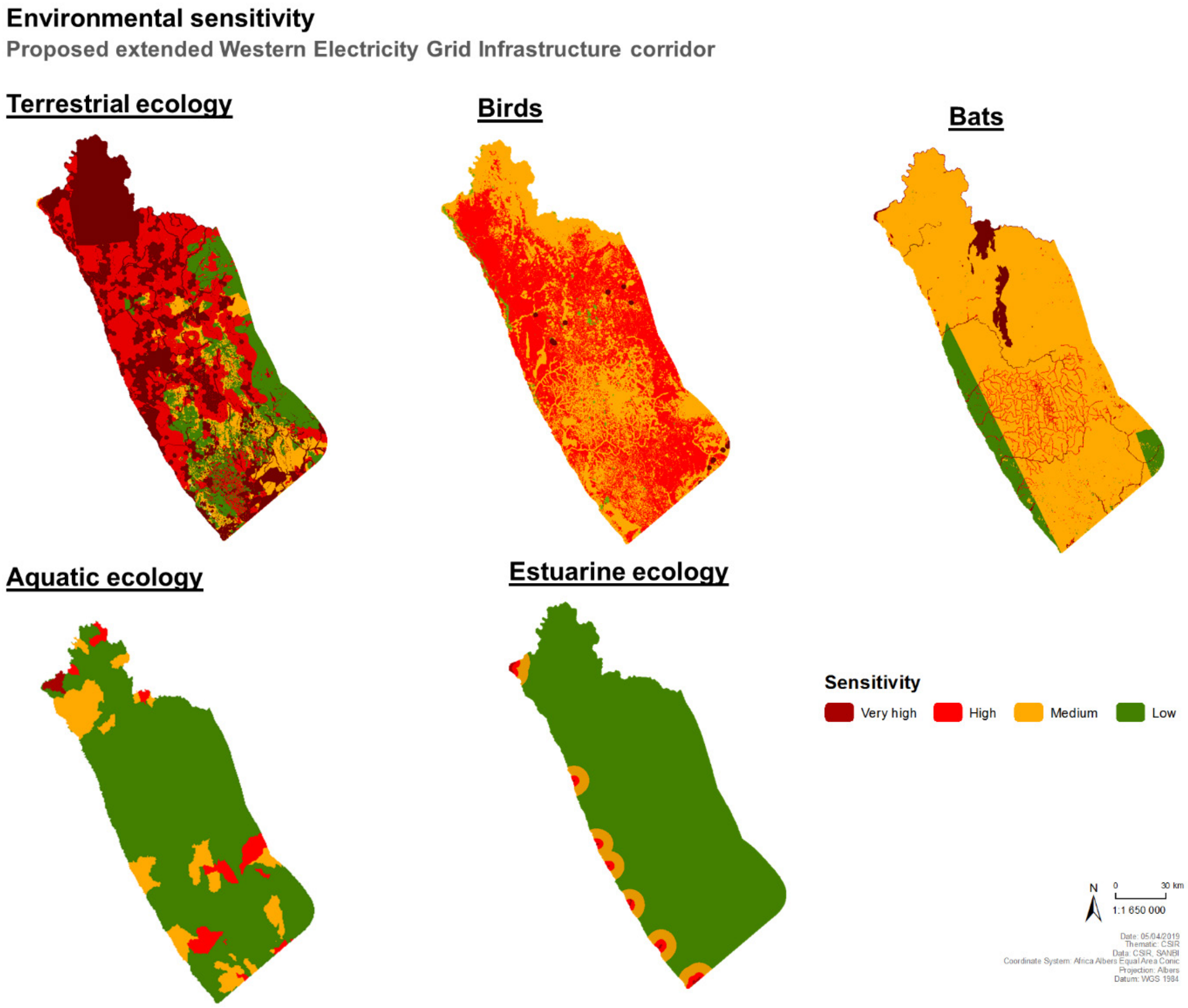


Figure i: Environmental sensitivity of terrestrial and aquatic ecosystems and species in the proposed expanded Western EGI corridor.

Figure ii: Environmental sensitivity of terrestrial and aquatic ecosystems and species in the proposed expanded Eastern EGI corridor.

Key potential impacts of proposed EGI development to terrestrial and aquatic ecosystems and biodiversity are mainly related to vegetation clearance during construction, which may have consequences for terrestrial fauna directly (e.g. habitat loss). Potential impacts to birds include collision and electrocution, whilst bats may also be impacted mainly via habitat alteration and loss and, to a lesser degree, potential electrocution and electromagnetic interference (Figure iii) (Section 5).

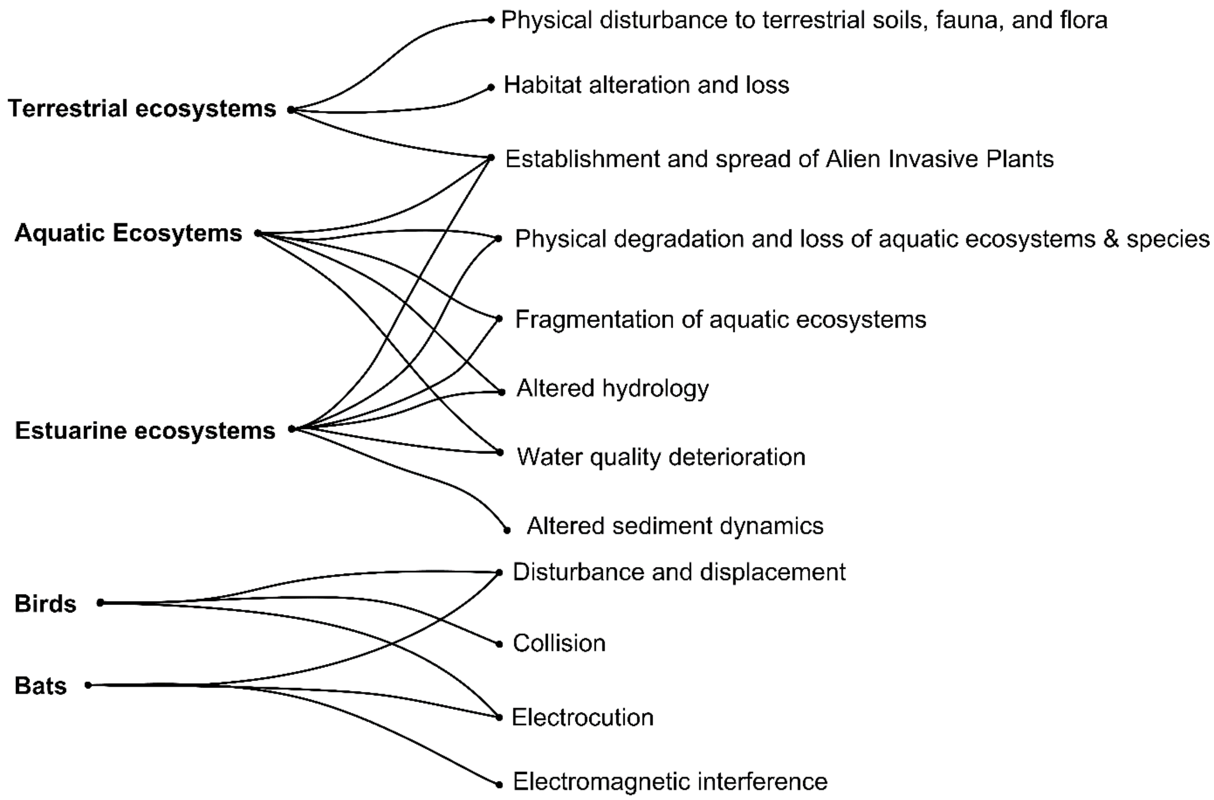


Figure iii: Key potential impacts of proposed EGI development to terrestrial and aquatic ecosystems and species.

The mitigation hierarchy must be applied during all development phases of the proposed EGI. Key mitigation measures include (Section 8):

- Avoid, as far as possible, the most sensitive areas identified in this assessment and areas identified by specialists in the field during subsequent project level assessments (as required);
- Minimise footprint and construction duration;
- Minimise new development footprints through utilising existing infrastructure and disturbance corridors as far as possible;
- Manage and continuously control Invasive Alien Plants;
- Manage and continuously control soil erosion;
- Manage construction and operational personnel 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.

2 INTRODUCTION

This chapter consolidates and summarises the key findings from several independent specialist investigations (Annexures to this chapter) as part of a Strategic Environmental Assessment (SEA) of the potential impacts from the development of Electricity Grid Infrastructure (EGI) in two proposed corridors (study areas) (Figure 1) on terrestrial and aquatic biodiversity and ecology (Figure 2). The proposed corridors aim to expand the EGI corridors promulgated under the National Environmental Management Act (104 of 1998, as amended) (NEMA) in February 2018 in Government Gazette 41445, Government Notice 113 (South Africa, 2018). This assessment also 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 the ecosystems.

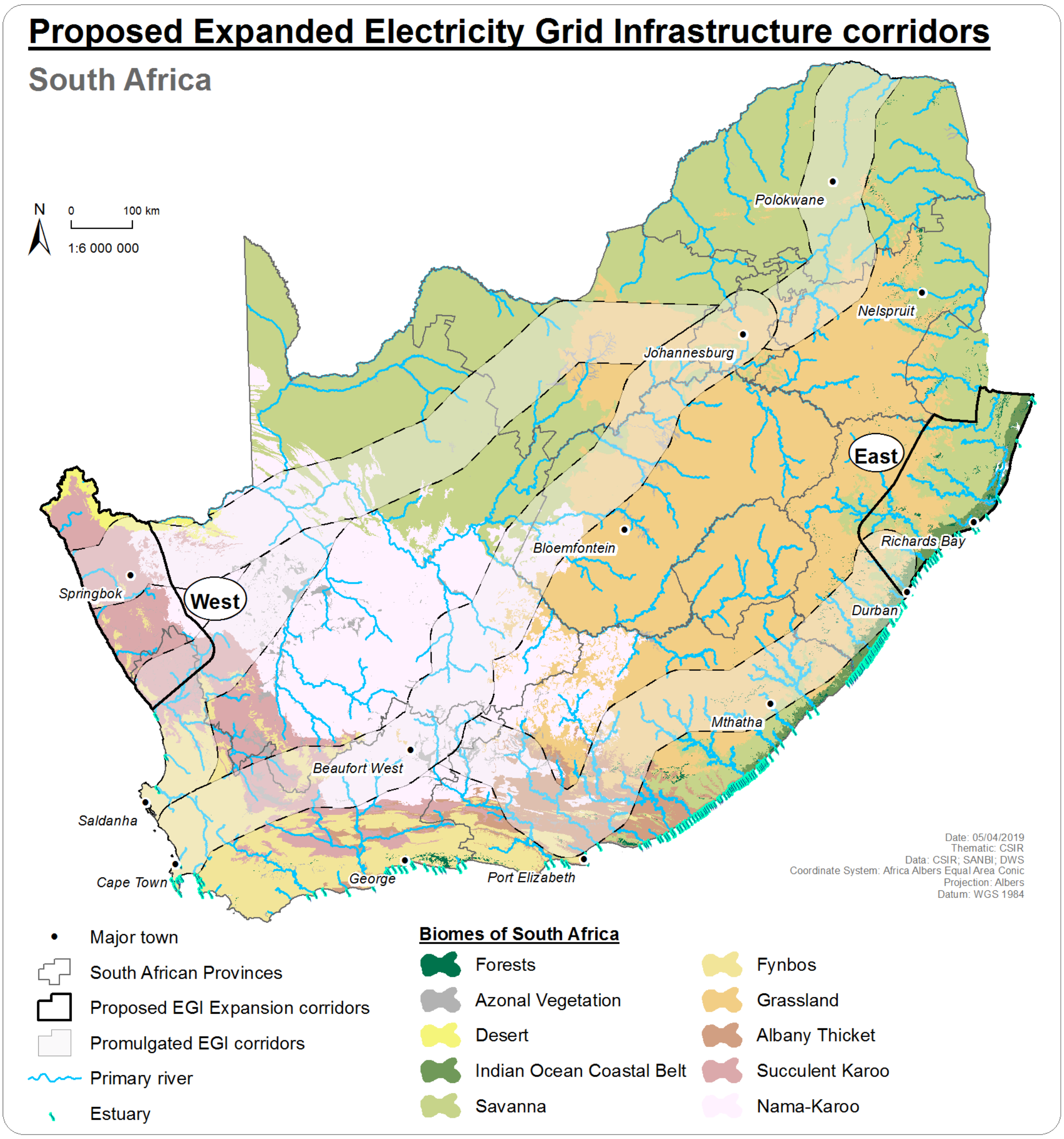


Figure 1: Location of the proposed Expanded Electricity Grid Infrastructure corridors, in relation to the promulgated corridors (South Africa, 2018), with the main terrestrial and aquatic ecosystem components considered in this assessment.

3 SCOPE OF BIODIVERSITY AND ECOLOGY FOR THIS ASSESSMENT

The ecological and biodiversity environmental aspects for the proposed expanded EGI corridors have been grouped according to the biomes that are found within the EGI corridors (Figure 2). These act as the point of departure for terrestrial ecosystems and the fauna that inhabit them. 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 4.3 for all assumptions and limitations underpinning this assessment). The Albany Thicket biome is not situated within either of the proposed expanded EGI corridors, and thus not included in this assessment.

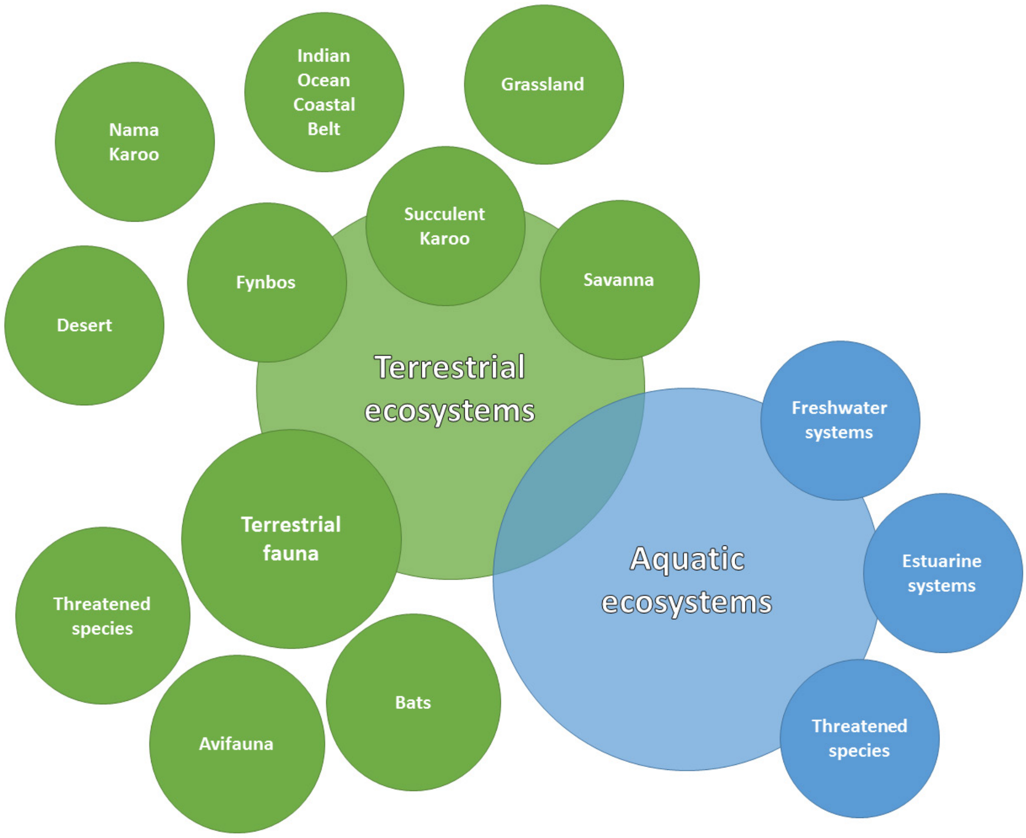


Figure 2: Overview of the terrestrial and aquatic ecosystem topics forming part of this strategic assessment, focusing on biomes, sensitive ecosystems, the ecological processes that underpin their functioning, and the plant and animal species inhabiting those ecosystems.

4 APPROACH AND METHODOLOGY

4.1 Study Methodology

The assessment used existing information to describe the ecosystems and species in the proposed expanded EGI corridors (Section 6), as well as the key potential impacts (Section 5) to these ecosystems that may be caused by EGI development. Existing spatial data, representing terrestrial and aquatic ecosystems (including species) (Section 4.2), were assigned sensitivity classes (Section 7). Recommendations are made in terms of avoiding, minimising and mitigating potential impacts (Sections 8 and 9).

4.2 Spatial Data Sources

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

4.2.1 Terrestrial ecology

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

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
Provincial conservation planning	<u>Northern Cape</u> 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.
	<u>Western Cape</u> 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, 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.
	<u>KwaZulu-Natal</u> 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 the protection of biodiversity, and in turn the protection of ecological infrastructure and associated ecosystem services.
**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). <u>Protected areas:</u> • Special nature reserves; • National parks;

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
		• 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 84 of 1998); • Mountain catchment areas declared in terms of the Mountain Catchment Areas Act, 1970 (Act 63 of 1970). Conservation Areas: • 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

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
		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.*		
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	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.	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 expanded western EGI corridor study. But areas that

Feature	Source	Summary
TERRESTRIAL ECOSYSTEMS		
	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	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.

4.2.2 Aquatic ecosystems

4.2.2.1 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. 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 12 Level 1 and 29 Level 2 River Ecoregions occur within the proposed expanded EGI corridors.
River Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES)	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. https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx.	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.
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,	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,

Feature	Source	Summary
FRESHWATER		
	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.	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. 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.
**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.*		

4.2.2.2 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 nearly 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 status.
	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.

<table>
<tr><th>Feature</th><th>Source</th><th>Summary</th></tr>
<tr><td colspan="3">ESTUARINE</td></tr>
<tr><td>Important nurseries</td><td rowspan="3">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.</td><td>Estuaries that are critically important nursery areas for fish and invertebrates and make an important contribution towards estuarine and coastal fisheries.</td></tr>
<tr><td>Important estuarine habitats</td><td>Estuaries that support important rare or sensitive habitats (saltmarsh, mangroves, swamp forest) that provide important ecosystem services.</td></tr>
<tr><td>Natural or near natural condition estuaries</td><td>Estuaries in good condition (designated by an A or B health category are more sensitive to development (likely to degrade in overall condition).</td></tr>
<tr><td colspan="3">*Estuaries were also considered in the spatial sensitivity analysis for avifauna</td></tr>
</table>

4.2.3 Species

4.2.3.1 Terrestrial and aquatic fauna

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

<table>
<tr><th>Feature</th><th>Source</th><th>Summary</th></tr>
<tr><td colspan="3">TERRESTRIAL AND AQUATIC FAUNA</td></tr>
<tr><td rowspan="2">Red Data species</td><td><u>Mammals</u>
Child et al. (Eds). 2016. The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. SANBI & EWT: South Africa</td><td>Known spatial locations for recorded Red Listed mammals in South Africa.</td></tr>
<tr><td><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).</td><td>Known spatial locations for recorded Red Listed reptiles in South Africa.</td></tr>
</table>

Feature	Source	Summary
TERRESTRIAL AND AQUATIC FAUNA		
	Amphibians 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.
	Plants 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 aquatic plants in South Africa.
	Fish distributions 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 three of the selected fish species.
	Freshwater fish 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.
	Aquatic macro-invertebrates 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 359 monitoring sites on South African rivers.
	Butterflies 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. Saftronics, Johannesburg and Animal	Known spatial locations for recorded Red Listed butterflies in South Africa.

Feature	Source	Summary
TERRESTRIAL AND AQUATIC FAUNA		
	Demography Unit, Cape Town.	
	<u>Dragonflies and damselflies (Odonata)</u> 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 164 records for these selected species within South Africa. This data includes records of the conservation important Odonata selected for this assessment.

4.2.3.2 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 km². 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 Atlas 2 (SABAP2)	UCT. 2007 - present. The Southern African Bird Atlas 2 (SABAP2). Animal Demography Unit,	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). This first bird atlas project took place from 1987-

Feature	Source	Summary
AVIFAUNA		
	UCT.	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

Feature	Source	Summary
AVIFAUNA		
		IBA. No verification of current status of nests was conducted.
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 KwaZulu-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 SEA 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 proposed expanded EGI corridors.
Southern Bald Ibis breeding colonies.	BLSA. 2015. 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.
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.
Red Data nest localities in the KwaZulu-Natal	Ezemvelo KZN Wildlife. 2018. Red data Bird nest localities.	Nests localities of Bateleur, Black Stork, African Crowned Eagle, Lappet-faced Vulture, Marabou Stork, Martial Eagle, Secretarybird, Tawny Eagle, White-backed Vulture and White-headed Vulture.

4.2.3.3 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 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	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 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.

Feature	Source	Summary
BATS		
	Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.	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.

4.3 Assumptions and Limitations

The following assumptions and limitations form the basis for this assessment:

General

- This is a strategic-level 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 and siting of EGI, real-world conditions must be verified on the ground.
- 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.
- 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.

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.
- Faunal records are limited to primarily areas which are easy to access and where monitoring is safe to undertake e.g. in Protected Areas (PAs).
- The Forest biome has not been included in this assessment as it represents a constraint to the EGI as mature trees will impact on the servicing and maintenance of power lines. Therefore, the forest biome will be avoided for the routing of the EGI. However, where the forest biome cannot be avoided by the power line route, due to the rare and sensitive environments that are associated with the biome, developers would be required to fulfil the requirements of the 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 'Moderate' 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.

Avifauna

- Due to the relatively coarse resolution of a Quarter Degree Grid Cell (QDGC) (25 x 27.4km), sometimes species were recorded within a QDGC which contains more than one biome, some of which it is unlikely to occur in. In such an instance professional judgment was used to assess the potential for a species to occur in a given habitat and it was taken into account in the risk rating process.
- Field verification will still need to take place on a site by site basis linked to development proposals.
- The recommendations put forward should be seen as generic and not replacing the project-specific recommendations for an individual project.

- The potential impact of EGI development, specifically power lines, on avifauna in South Africa is relatively well studied, but important information is still lacking:
    - It is unclear how some Red Data species will react to the disturbance associated with the construction of power lines - more scientifically verifiable knowledge of the disturbance thresholds of these species would improve predictive capabilities.
    - The actual mortality of power line sensitive Red Data species will always remain unknown. The impact of mortality on these populations is therefore difficult to assess, and needs to be deduced from the available, incomplete data currently available.
    - Published, scientifically verified results from the experiments performed by the Endangered Wildlife Trust (EWT) to test the efficacy of Bird Flappers to prevent collision mortality is eagerly awaited.

Bats

- 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 Occupancy (AoO) vs Extent of Occurrence (EoO) for species of conservation importance, but this level of detail was beyond the scope of this high level SEA. Commissioning such a detailed mapping exercise of the AoO for all species of conservation importance, both plants and animals, would be a worthwhile exercise for the DEA to consider for future conservation planning.
- Currently there is a lack of data on the impacts of power lines on bats in South Africa.

Other 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.

Freshwater ecosystems

- 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.
- Fine-scale GIS layers have been thinned out to make processing more efficient - allowing a suitable fine scale resolution for strategic planning, whilst ensuring efficient processing. It is assumed that Site specific studies will utilise all information available (SEA threat and sensitivity layers) as well as the detailed fine-scale GIS layers. Such fine-scale detail is potentially excessive at the strategic planning phase.
- Only point data for species of conservation concern was used based on current availability and sources.

Estuaries

- 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 during the construction and operational phases.
- 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.

4.4 Relevant Regulatory 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 EGI 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.
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

Instrument	Key objective
	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 2003) (NEM:PAA)	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 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.

Instrument	Key objective
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 NEMBA 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) (NEM:WA)	Minimising the consumption of natural resources; avoiding and minimising the generation of waste; reducing, re-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

Instrument	Key objective
	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 Basic Assessment or EIA process to make sure that the mitigation hierarchy is exhausted. Should it be determined in the Basic Assessment or 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 Basic Assessment or 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 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.

Instrument	Key objective
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
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

Instrument	Key objective
Northern Cape	
Northern Cape Nature Conservation Act, 2009 (Act 10 of 2009).	To provide for the sustainable utilization of wild animals, aquatic biota and plants: to provide for the implementation 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 phases.

Instrument	Key objective
OTHER	
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).

5 IMPACT CHARACTERISATION

The potential impacts of EGI development are summarised as three key impacts to each terrestrial ecosystems (Section 5.1), birds (Sections 5.2.1 - 5.2.3,) bats (Sections 5.2.4 - 5.2.6), and five potential impacts to aquatic ecosystems (Section 5.3) (Table 8).

Table 8: Summary of the key impacts from EGI 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
BIRDS				
Electrocution			x	
Collision			x	
Displacement		x	x	x
BATS				
Disturbance and displacement		x	x	x
Electrocution			x	
Electromagnetic interference			x	
AQUATIC ECOSYSTEMS				
Degradation, fragmentation and loss		x	x	
Hydrological alteration		x	x	x
Water quality deterioration		x	x	x
Altered sediment dynamics		x	x	x
Establishment and spread of IAPs		x	x	

5.1 Terrestrial ecosystems

5.1.1 Physical disturbance to soils, fauna and flora

EGI, specifically power lines, require a wide servitude that is regularly maintained and kept clear of significant woody or larger plant species to better facilitate the management and maintenance of the infrastructure. This entails that natural vegetation within the servitudes are kept at an early seral stage, preventing secondary and more advanced seral processes (Figure 3). Under some situations, such vegetation clearance may serve to bisect habitats and changes in vegetation form and structure may extend beyond the servitude boundary.

Box 1: Vegetation management under power lines

Vegetation management under powerlines generally entails the removal of tree species where they occur in a pylon corridor; and the cutting back of taller plant species to 500 mm high. In the more arid Desert, Karoo and Fynbos biomes trees are only likely to occur along water courses or in the Kamiesberg area. Otherwise they are expected to be scattered individuals or small clumps. Where these cannot be avoided, the impact of the removal of a few trees is unlikely to be significant. Since the shrubs in the Desert, Karoo and Fynbos biomes vegetation in the corridor rarely ever exceed 1.5 m tall it would seem that cutting is not necessary. However, this would be required in the proposed expanded Eastern EGI corridor where the IOCB and Savanna biomes are associated with taller woody vegetation.

Eskom generally practices clearing under its powerlines to avoid the electrical shorts that can happen when soot accumulates on the isolators or reaches sufficient concentrations to cause flash overs. Should Eskom deem it necessary to maintain cleared 80 m wide belts under the powerlines this is likely to have significant impacts on ecosystem structure, biodiversity and function, at least at the local level and where remnants become further fragmented into smaller remnants (Pool-Stanvliet et al., 2017; Rouget et al., 2014, 2006, 2003). This outcome should be avoided if at all possible given the potentially significant loss of habitat this would entail, the potential loss of species unable to survive the clearing, and the formation of a linear barrier that may affect faunal migration and movements. Since the EGI corridor is generally routed across the altitudinal and climatic gradients between the coast and the inland highlands in this area, the clearing also could affect the viability of climate adaptation corridors that have been planned in the area.

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

- Loss of biodiversity;
- Establishment and invasion by IAPs (also see Section 5.1.2);
- Loss of faunal habitat and consequently Species of Conservation Concern (SCC);
- Nuisance, especially during construction, which may cause changes to fauna behaviour and movement:
    - Noise;
    - Dust; and
    - Vibration.
- Increased human activities may cause animals to migrate away from their natural habitat;
- Poaching, collection of plants and animals that are collectable or have indigenous/medicinal uses;
- Entrapment of animals open excavations (which could then have fatal consequences as a result of drowning in pools of collected water, dehydration, or starvation);
- Road mortalities;
- Reduced movement and mortalities of sub-surface fauna (e.g. moles) due to soil compaction;
- Electrocution on ground as tortoises and other small fauna that become trapped underneath or against electrical fences, should such electrified fencing be installed;
- Electrocution of fauna that climb or perch on pylons;
- Altered hydrological patterns, drainage and runoff movements;
- Loss of topsoil and changes in terrain morphology;
- Habitat fragmentation;
- Disrupted ecosystem services; and
- Declined ecosystem resilience.

With a loss of habitat and/or its transformation within both the servitude and areas immediately adjacent to them, such change is likely to affect faunal populations within particular areas, or alternatively give rise to change in species' behaviour. Thus the clearance of large swathes of land is likely to affect faunal populations both directly and indirectly and in the medium to long term lead to the ousting of specific faunal populations or alternatively promote the establishment of others. A case in point, may be the clearance of forest and establishment of a scrub or graminoid veld form within a servitude that will favour grazers but may lead to the ousting of frugivorous species that were reliant upon fruiting species. In addition, such transformation may also alter transitory niche or migratory routes of certain species or act as physical barriers to others.

Box 2: Fire-dependant ecosystems and EGI.

Fires under powerlines can be a hazard but management of fuel loads by carrying out fires at ecologically acceptable times of the year and in weather that will minimise the hazard should allow ecologically acceptable fire regimes to be maintained. The Environmental Management Programme should include measures to reduce fire hazards in accordance with the relevant specifications.

The area of the servitude within 5 m from the outside conductors is critical for clearing any dense bushes (e.g. due to bush encroachment in the Savanna biome) or any other plants that pose a fire risk. The areas closer to the power line pylons carry a lower fire risk than the mid-span area (Eskom, 2009).

Vegetation management in power line servitudes are dependent on the vegetation type and atmospheric conditions. Not all plants in the pose equal fire risk. Excessive removal of plants may increase the risk of soil erosion in certain soils and generates large quantities of unwanted plant material, but will also have an impact on the plant species composition in the modified habitat in the servitude. Larger trees, bushes, and shrubs, as well as high-growing grasses will typically be removed to reduce fuel availability for veld fires that may cause damage to electricity power lines (Eskom, 2009).

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). Fynbos requires fires at intervals of 10-30 years to maintain biodiversity and ecosystem functioning (Kraaij and Wilgen, 2014; Le Maitre et al., 2014) but fires in arid Fynbos are rare and may not be essential for regeneration. Many species' seeds may 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 occur in and do regenerate 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), 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.

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 areas, 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). Power lines, can on occasion, also be a direct cause of fire due to sparking and can therefore create unwanted fires. Consideration will need to be given as to how vegetation under the powerlines can be maintained given that fire exclusion under powerlines is a common management practice (O'Connor and Bredenkamp 1997, Scholes, 1997).

5.1.2 Establishment and spread of invasive alien plants

Power line servitudes are areas of high physical disturbance, subject to regular vehicular traffic and periodic clearance. This sustained level of disturbance presents suitable conditions for the establishment and spread of Invasive Alien Plants (IAPs). Servitudes often act as repositories and vector corridors of exotic plant propagules and thereby promote and facilitate the spread of IAPs. This is also relevant to aquatic ecosystems (see Section 5.3).

5.1.3 Ecosystem alteration and loss

Physical disturbance to soils, fauna and flora, and IAP establishment and spread can ultimately manifest as ecosystem alteration and loss. It is also associated with the introduction of non-local genetic stock, 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).

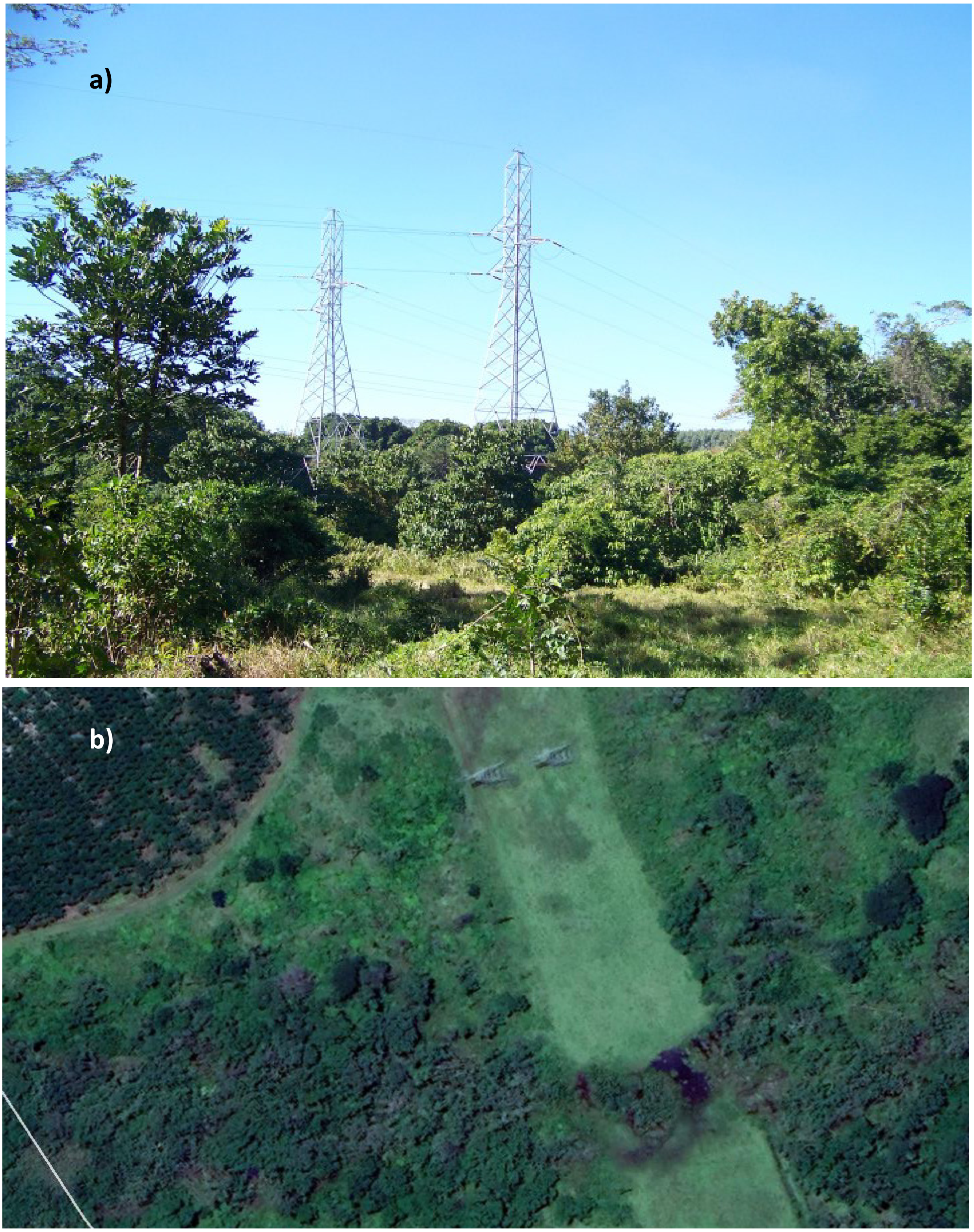


Figure 3: An example of vegetation clearance - a 132 kV line passing through a section of swamp forest vegetation in the Indian Ocean Coastal Belt biome near Port Durnford, south of Richards Bay (Photo: SDP); and B) An aerial image of the same corridor pictured in (a), indicating extent of the cleared vegetation (Google Earth, 2018).

5.2 Birds and bats

5.2.1 Bird electrocution

When a large bird makes contact with two live components simultaneously, or a live and earthed component, a short circuit is created, which electrocutes the bird. Electrocution risk is a function of the pole configuration and the size of the bird. In South Africa, large raptors and vultures are most vulnerable to electrocutions, on voltages of 11 kV up to 132 kV (Van Rooyen, 1998).

5.2.2 Bird collision

Bird injury or death can be caused by the bird colliding at high speed with the power line infrastructure, usually the earthwire of transmission and sub-transmission lines (> 66kV), or the conductors themselves in the case of reticulation lines (11 – 33 kV). In South Africa, most heavily impacted upon are bustards, storks, cranes and various species of waterbirds (Jenkins et al*.,* 2010).

5.2.3 Bird displacement due to habitat destruction and disturbance

During the construction and maintenance of power lines and substations, some habitat destruction and transformation inevitably takes place. This happens with the construction of access roads, the clearing of servitudes and the levelling of substation yards. These activities have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through transformation of habitat, which could result in temporary or permanent displacement.

Apart from direct habitat destruction, the above-mentioned construction and maintenance activities also impact on birds through disturbance, particularly during breeding activities. Disturbance of breeding individuals could lead to breeding failure through abandonment of the nest or through exposing the eggs and nestlings to predation when the adult birds temporarily leave the nest area.

5.2.4 Displacement of and disturbance to bats

During the construction phase, particularly the erection of pylons, the clearance of vegetation, digging and drilling of foundations, noise and vibrations from construction activities may cause disturbance to bats and displace them from their original habitat.

Southern Africa has eleven genera of fruit bats, comprising 21 species (Simmons, 2005). Three of these species commonly occur in South Africa. These species may potentially be affected by the development; however, no record of bat fatalities due to power line infrastructure exists to date in South Africa.

Whether or not electromagnetic radiation will affect flying bats or interfere with the echolocation of insectivorous bats during foraging is unknown. Options for mitigating the effects of electromagnetic radiation is limited, but will be best achieved by avoiding the areas where bats may congregate for prolonged periods such at roost sites or around surface water and irrigated croplands.

Construction activities, such as digging and blasting for pylon foundations and vehicle movement could cause noise, dust and vibrational disturbances to roosting colonies, especially during the breeding season from approximately October to March. 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 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.

5.2.5 Electrocution of bats

No record of bat fatalities due to power line electrocution or collisions with infrastructure exists to date in South Africa. Collision related impacts may be compounded if the power line is erected along established migratory pathways. Certain fruit bat species (Pteropodidae) in Asian and Australasian countries have fallen victim to electrocution due to power lines (Martin 2011; Rajeshkumar et al., 2013). This effect was exemplified in a study by Krystufek (2009) on Indian flying foxes (*Pteropus giganteus*) in the Sri Lankan Paradeniya Botanic Garden. The study revealed that dead bats were regularly found hanging on the power lines and that on one particular day as many as 74 carcasses were found over a 3 km stretch of power line.

5.2.6 Electromagnetic inteference to bat echolocation

There is limited evidence to suggest that electromagnetic radiation emitted by the power lines will affect flying bats or interfere with the echolocation of insectivorous bats during foraging. An Irish study found that electromagnetic fields from high voltage power lines do not deter bats (Eirgrid, 2015).

5.3 Aquatic ecosystems

The impacts associated with EGI range from those that are direct (e.g. pylon construction and clearing areas for servitudes) to those that are more subtle (indirect) and which occur over longer timeframes (e.g. vegetation compositional changes from continued disturbance/clearing, habitat fragmentation, hydrological alteration, and alien plant infestation). The main impacts to aquatic (i.e. freshwater and estuarine) ecosystems associated with EGI were identified and discussed in detail in the freshwater specialist component of the 2016 EGI SEA (Todd et al., 2016b). The majority of the impacts identified in this assessment are relevant to the scope of the present study, and have been contextualised here in relation to the following activities and their associated impacts to aquatic ecosystems and biota.

The activities from EGI development driving impacts to aquatic ecosystems include:

- Access roads – development of new access roads to enable construction, as well as ongoing maintenance during the operational phase;
- Construction of substations, pylons and power line servitudes – direct clearing and/or removal of vegetation to allow for the construction of substations and pylons, as well as to establish servitudes to access the pylons and power lines for on-going maintenance.

Box 3: EGI development and groundwater

The majority of EGI is constructed above ground, with the exception of foundations that are required for the pylons and substations, which generally extend to about 3.5 m. The small scale depth of the EGI and associated construction activities are unlikely to significantly impact on ground water and deep aquifers. The Biodiversity Specialists suggest that the consideration of groundwater is not a major concern as aquatic systems are not driven significantly by ground water resources, and the impacts from EGI will be non-existent when considering deep ground water flows.

It is important to note that site specific assessments will be undertaken subsequent to the SEA, and if warranted, Geohydrological and/or Geotechnical Assessments will be commissioned by the EGI Developer once a specific route has been determined.

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 EGI development.

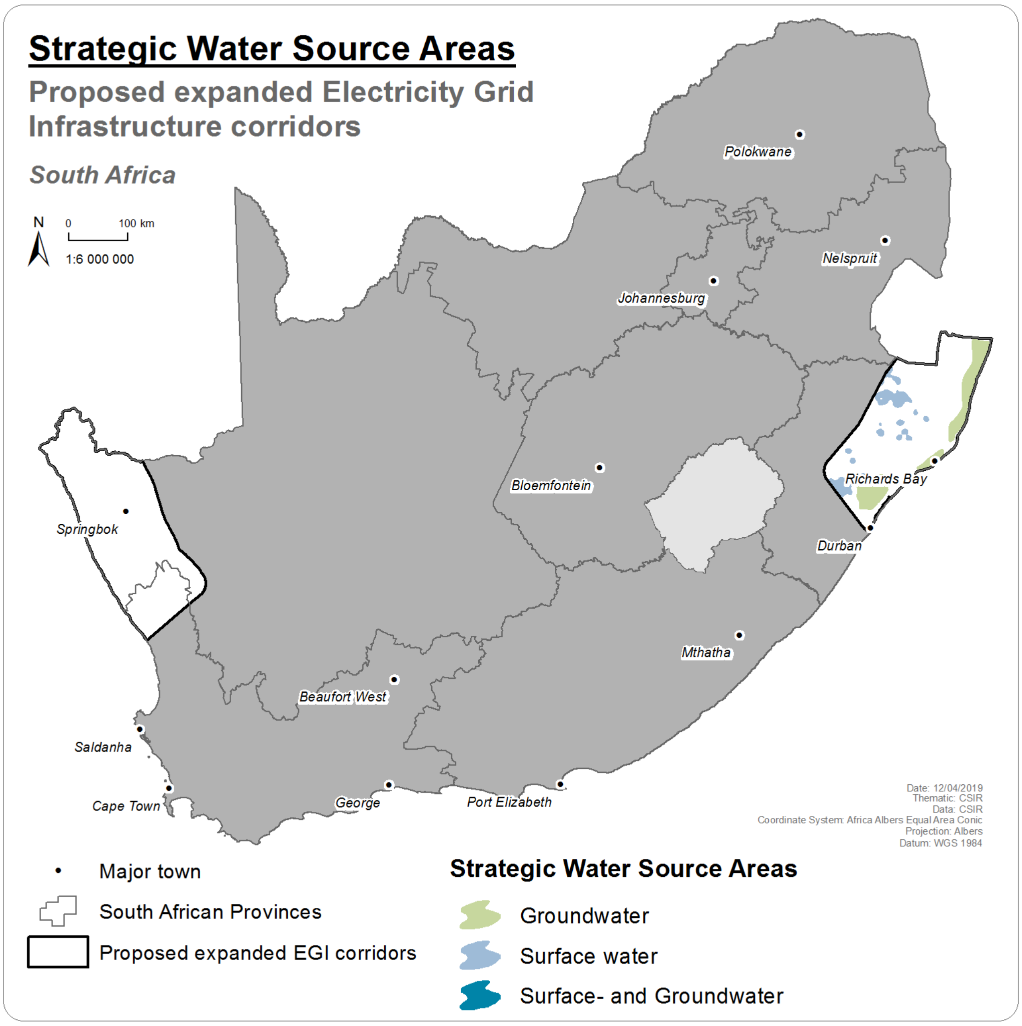


Figure 4 illustrates the proposed expanded EGI corridors, as well as National Surface Water and Ground Water SWSAs. The proposed expanded Eastern EGI Corridor includes the KwaDukuza, Richards Bay Ground Water Fed Estuary and Zululand Coastal Plain Ground Water SWSAs. No SWSAs are located within the proposed expanded Western EGI Corridor.

Figure 4: Strategic Water Source Areas of South Africa.

5.3.1 Degradation and loss of aquatic ecosystems and species

Earthworks and excavations would mainly affect fossorial fauna (i.e. animal adapted to living underground), as well as small, less-mobile fauna (e.g. amphibians, as well as freshwater obligate reptiles and shrews/rodents). Mortality of fauna from accidental collisions due to the movement of vehicles/machinery across the site can also be an issue for smaller, less mobile species of fauna. Illegal hunting/poaching could also present a significant impact during the construction phase whereby certain personnel/contractors engage in such activities.

Certain fauna are more susceptible to impacts from increased noise and/or artificial lighting. Artificial lighting in and around substations may for example have a significant impact on normal life cycles of adult forms of aquatic macro-invertebrates, as well as increased mortality rate. Noise impacts will affect noise-sensitive mammals, particularly larger mammals such as Otter species and Servals. Noise and light impacts ultimately result in the displacement of fauna away from the noise impact area, but is expected to be temporary, and restricted to the construction phase.

IAPs that already occur in the area are likely to invade newly disturbed areas, by gradual (or even rapid) encroachment into disturbed areas (e.g. temporary construction camps, borrow pits, vehicle parking, stock pile areas, etc.), transitional habitats, as well as around pylons/substations and along access roads. The spread of existing, and the introduction of new problem, plant species may be facilitated by movement of people and construction vehicles. IAP infestation within freshwater ecosystems will further degrade habitats and habitat availability for associated biota. Secondary impacts (or caused by IAPs) include, but are not limited to:

- Competition with native plant species, especially when considering the severity of allelopathic influences caused by certain IAP (e.g. *Acacia mearnsii*);
- Shading of banks and instream habitats, which in turn impacts on water temperatures and freshwater fauna and flora that are intolerant;
- Shift in allochthonous and autochthonous organic compounds within wetland and river ecosystems;
- Bank instability, erosion and collapse, with exacerbated deposition of sediments and debris; and
- In more severe cases, reduced water availability due to excessive water consumption from most IAPs (in particular, deep-rooted tree species such as *Eucalyptus* species).

5.3.2 Fragmentation of aquatic ecosystems

Fragmentation of freshwater ecosystems, estuary mouth dynamics and flow patterns may result in an indirect loss of ecological patterns and processes such as species movement and dispersal, habitat connectivity, increased edge effects and disturbance, establishment of IAPs.

Linear developments, such as transmission lines, cause fragmentation of aquatic ecosystems, especially where areas are permanently impacted. This presents a serious issue particularly to fauna, and leads to populations becoming more isolated, resulting in a reduction of inter-population connectivity and compromised genetic viability. For example, inappropriately designed and constructed river crossings could prevent fish from moving/migrating freely within a river system. Habitat fragmentation also has the potential to exacerbate impacts to freshwater ecosystems, such as through altering micro-climatic conditions (e.g. fire, wind, desiccation, etc.). These alterations in turn affect the perimeter of wetland and riparian habitats resulting in edge effects and development of transitional habitats. This presents a favourable situation for IAPs to establish, with knock-on effects for freshwater ecosystem and associated fauna and flora (as discussed in the following point).

5.3.3 Hydrological alteration

Compaction of soils, creation of preferential flow paths and stormwater runoff may result in increased flows (hydrological alteration) within receiving aquatic environments, particularly in relation to runoff discharge points, which in turn has a number of indirect issues such as bank erosion and collapse, scouring and channel incision, headcut erosion, desiccation of wetland/riparian soils and vegetation, increased turbidity, sedimentation and smothering of benthos. Stormwater runoff resulting in increased flows into estuaries may lead to bank erosion and collapse, scouring, channel incision, desiccation of estuarine/wetland/riparian soils and vegetation, increased turbidity, sedimentation and smothering of benthos. The combined effects will negatively affect the ecological integrity and ability of the estuarine and freshwater ecosystems to function properly.

5.3.4 Water quality deterioration

Waste pollution and contamination of aquatic environments from foreign materials (e.g. fuels/hydrocarbons, cement, and building materials) being dumped and/or carried into aquatic environments results in deteriorated water quality.

Water quality may deteriorate as a result of sediment disturbance and/or the removal of estuarine and riparian vegetation, or pollution events, resulting in:

- decrease pH as a result of disturbance of the anoxic sediment profiles characteristic of estuaries;
- increase the Total Dissolved Solids (TDS);
- increase the Total Suspended Solids (TSS);
- increase the organic matter content; and/or
- Increase the nutrient content.

This can have knock-on effects on aquatic biota. It can result in algal blooms/eutrophication, can cause anoxia or hypoxia and fish and invertebrate mortalities. Increased turbidity in clear water systems can lead to smothering of primary producers and disrupted predator-prey relationships.

6 CORRIDORS DESCRIPTION

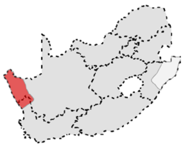
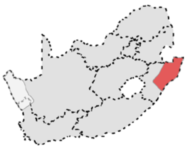
All of the biomes of South Africa, except for Albany Thicket, are within either the proposed expanded Eastern or Western EGI corridor (Table 9).

Table 9: Extent of the biome within each of the proposed expanded EGI corridors.

Biome	Extent (% of each proposed expanded EGI corridor)	
	Expanded Western EGI corridor	Expanded Eastern EGI corridor
Succulent Karoo	75	
Nama-Karoo	11	
Fynbos	3	
Azonal Vegetation	2	2
Albany Thicket		
Grassland		25
Indian Ocean Coastal Belt		14
Savanna		55
Desert	8	
*Forests**		*3*

**The forest biome has not been included in this assessment as it represents a constraint to the EGI as mature trees will impact on the servicing and maintenance of power lines. Therefore, the forest biome will be avoided for the routing of the EGI. However, where the forest biome cannot be avoided by the power line route, due to the rare and sensitive environments that are associated with the biome, developers would be required to fulfil the requirements of the EIA Regulations at the time.*

Table 10: Summary of the key environmental features in each of the proposed expanded EGI corridors.

Site	Brief description
Expanded Western EGI corridor 	• This proposed corridor is situated within 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, with extensive areas earmarked as potential NPAES focus areas. • Relatively untransformed when compared to the proposed expanded Eastern EGI corridor.
Expanded Eastern EGI corridor 	• This proposed corridor is situated within Savanna, Grassland and Indian Ocean Coastal Belt vegetation types in the KwaZulu-Natal Province. • Transformed by urban settlement and agriculture, especially in the vicinity of Richards Bay. • Many protected areas associated with large wetlands are present.

6.1 Western Expansion Corridor

6.1.1 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 (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).

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, namely the Gariep Desert (located mostly within the borders of South Africa) and the Southern Namib Desert (Jürgens, 2006), which further consists of fifteen vegetation types – all of which are wholly or partially present in the proposed expanded western EGI corridor.

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 (Jürgens, 2006).

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 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 and increase further desertification.

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 4: 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).

6.1.2 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/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).

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). 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).

Box 5: 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).

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, Nababeep 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, also 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).

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);
- 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);
- Horticulture (e.g. succulents);
- Medicinal bioprospecting (e.g. cancer bush and kougoed);
- Mining (e.g. diamonds, copper, zinc); 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).

6.1.3 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. 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.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 km^2, 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., *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.

Box 6: 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 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., 2016a; 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).

6.1.4 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.

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). 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 Fynbos Biome in the proposed expanded Eastern EGI corridor comprises four vegetation types: Namaqualand Granite Renosterveld, Kamiesberg Granite Fynbos, Namaqualand Sand Fynbos, Stinkfonteinberge Quartzite Fynbos and Bokkeveld Sandstone Fynbos (Rebelo et al., 2006). 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. 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., 2013d; 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., 2013b; 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. Fynbos is subject to invasion by introduced alien tree species which must be removed in terms of the NEM:BA. Invasive trees known to be present in fynbos in the corridor include *Acacia cyclops* and *Prosopis* species. Invading alien grasses are an issue of increasing concern in the drier parts of South Africa and there is concern that they can alter and transform ecosystems, including making them fire-prone (Rahlao et al., 2009; Todd, 2008; Visser et al., 2017). In the corridor area the current and potential invaders include *Bromus* species and potentially *Pennisetum setaceum* which are invaders in the Succulent Karoo but are spreading into Fynbos. Both are dispersed by wind and along roads by the movement of vehicles and special care will have to be taken to avoid dispersing them in the construction and operational phases of the powerlines and to control them if they become established. Grass invasion may be facilitated by 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) and may severely affect heuweltjie[1] communities (D.C. Le Maitre personal observation).

[1] Heuweltjies are circular features with distinctive plant communities and enhanced levels of faunal diversity and activity associated with their characteristically relative fertile soils.

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 (such as within the expanded Western EGI Corridor) to guide rehabilitation. These areas 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. 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, compared with the adjacent Succulent Karoo vegetation, are strong rationales for making every effort to avoid Fynbos in arid areas when selecting the final power line routes and placement. Disturbance also facilitates invasion, so regular monitoring and control operations will be required as part of the Environmental Management Programmes (EMPrs) for the construction and operational phases.

Box 7: 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). Some of the taller Fynbos shrub species may exceed height requirements for the powerline although this is unlikely in the case of the arid fynbos occurring in this area. Should this be the case then the powerline 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.

6.1.5 Birds

The following Red Data species, that are sensitive to power lines, are associated with the biomes and vegetation types found in the proposed Western Expansion EGI corridor (Table 11).

Table 11: Red Data bird species that occur in the proposed Western Expansion EGI corridor which are sensitive to power lines.

Species	Status	Fynbos	Succulent Karoo	Nama Karoo	Desert	Azonal
African Marsh-Harrier	EN	x				x
Black Harrier	EN	x	x	x	x	
Black Stork	VU	x	x	x	x	x
Blue Crane	NT	x	x			x
Caspian Tern	VU					x
Greater Flamingo	NT	x	x	x	x	x
Karoo Korhaan	NT	x	x	x	x	
Lanner Falcon	VU	x	x	x	x	x
Lesser Flamingo	NT	x	x	x	x	x
Ludwig's Bustard	EN	x	x	x	x	
Maccoa Duck	NT					x
Martial Eagle	EN	x	x	x	x	
Secretarybird	NT	x	x	x		
Southern Black Korhaan	VU	x	x			
Verreaux's Eagle	VU	x	x	x	x	
Great White Pelican	VU					x
Kori Bustard	NT		x			
EN = Endangered; VU = Vulnerable; NT = Near Threatened						

6.1.6 Bats

The following bats of conservation importance are found in the proposed Western Expansion EGI corridor (Table 12).

Table 12: Red Data bat species that occur in the proposed Western Expansion EGI corridor which are sensitive to power lines.

Species Name	Common Name	Conservation Status (Child et al., 2016)
Cistugo seabrae	Angolan Hairy Bat	NT (Jacobs et al., 2016a)
Laephotis namibensis	Namib Long-eared Bat	VU (Jacobs et al., 2016b)
VU = Vulnerable; NT = Near Threatened		

6.1.7 Freshwater ecosystems

Rivers are predominantly non-perennial/ephemeral in character. A small proportion (~10%) of the rivers are classified as perennial/permanently - flowing rivers, largely the Orange River and other smaller rivers (e.g. Doring, Olifants and Sout Rivers). Non-perennial systems that dominate the corridor include the Holgat, Kamma, Buffels Swartlintjies, Groen and Goergap. Most of the river habitats fall within the Namaqua Highland Ecoregion (48%), followed by the Western Coastal Belt (26%), and the Orange River Gorge (16%). Only 4% of the river habitat is considered to be Threatened (i.e. Endangered and Vulnerable). The Doring River and the lower Olifants River are the only flagship/free-flowing rivers in the corridor. The Present Ecological State (PES) of rivers is generally good, with less than 25% of the rivers assessed to be in either a fair, poor or very poor state.

Wetland habitats occupy a low proportion of the corridor (~1%) owing to the xeric climatic conditions of the Succulent Karoo. Nevertheless, the area supports up to 57 wetland types dominated by floodplain wetland habitat along the lower Gariep River and channelled-valley bottom wetlands within the Namaqualand Hardeveld region, as well as a number of endorheic pans that are more unique to the region. One Ramsar wetland occurs within the corridor, and is located at the mouth of the Gariep River. A small proportion of the wetlands in the corridor are characterised as NFEPA wetlands, which predominantly include floodplain wetlands along the Gariep River and seeps within the Namaqualand Hardeveld region.

Approximately 95% of the Western Corridor comprises land that is largely natural, thus only a 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. Key impacts include:

- Pollution from application of fertilizers, herbicides and pesticides, as well as point-source discharges from urban centres (e.g. Bitterfontein, 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.

Box 8: Red Data aquatic biota likely to be encountered in the proposed Expanded Western EGI corridor.

One Endangered fish, *Pseudobarbus phlegethon* occurs in the Olifants River, which flows through the extreme south-western corner of the Western EGI Corridor. There are also two Near Threatened fish (i.e. *Labeobarbus seeberi* and *Pseudobarbus serra*) that occur in the corridor. Two notable amphibians occur in the north western parts of the corridor, namely *Breviceps macrops* (Near Threatened), which inhabits sandy habitats along Namaqualand coast, 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. The Spotted-necked Otter *Hydrictis maculicollis* (Vulnerable) has been recorded near the mouth of the Gariep River. Two Vulnerable plants, *Isoetes eludens* and *Oxalis dines*, and four Near Threatened plants occur as a few isolated populations in the corridor.

6.1.8 Estuarine ecosystems

In total seven estuaries fall within the Expanded Western EGI corridor. These have a combined estuarine habitat area of 5 300 ha. They include the Orange, Spoeg, Groen, Sout, Buffels, Swartlintjies and Olifants Estuaries. The Spoeg, Groen, Buffels and Swartlintjies are all small systems that extend less than 5 km into the proposed EGI corridor (Fielding, 2017). The remaining systems are longer and extend significant distances into the proposed EGI corridor (Olifants <20 km, Orange <10 km and Sout <10 km).

Three estuaries in this corridor (Swartlintjies, Spoeg and Groen) are in excellent or good condition (i.e. Categories A to B according to health status on the DWS scale, whereby "A" is near natural and "F" being extremely degraded) (Van Niekerk et al., 2018). These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily (Fielding et al., 2017).

Of the seven estuaries in this corridor, the Orange and Olifants estuaries are of Very High biodiversity importance, ranking in the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). Four estuaries in the corridor are identified as national conservation priorities by the National Estuaries Biodiversity Plan (Turpie et al., 2012). These are the Orange, Spoeg, Groen and Olifants estuaries.

In addition, two estuaries, the Olifants and Orange, 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 Orange, Spoeg, Groen, Sout and Olifants estuaries are also considered important as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh. The Buffels, Swartlintjies Groen, Spoeg and Sout are relatively small but recent studies on the ecological water requirements have highlighted their regional importance as a very limited wetland type habitat for estuarine and coastal birds along arid west coast (DWS, 2017).

Box 9: 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.**

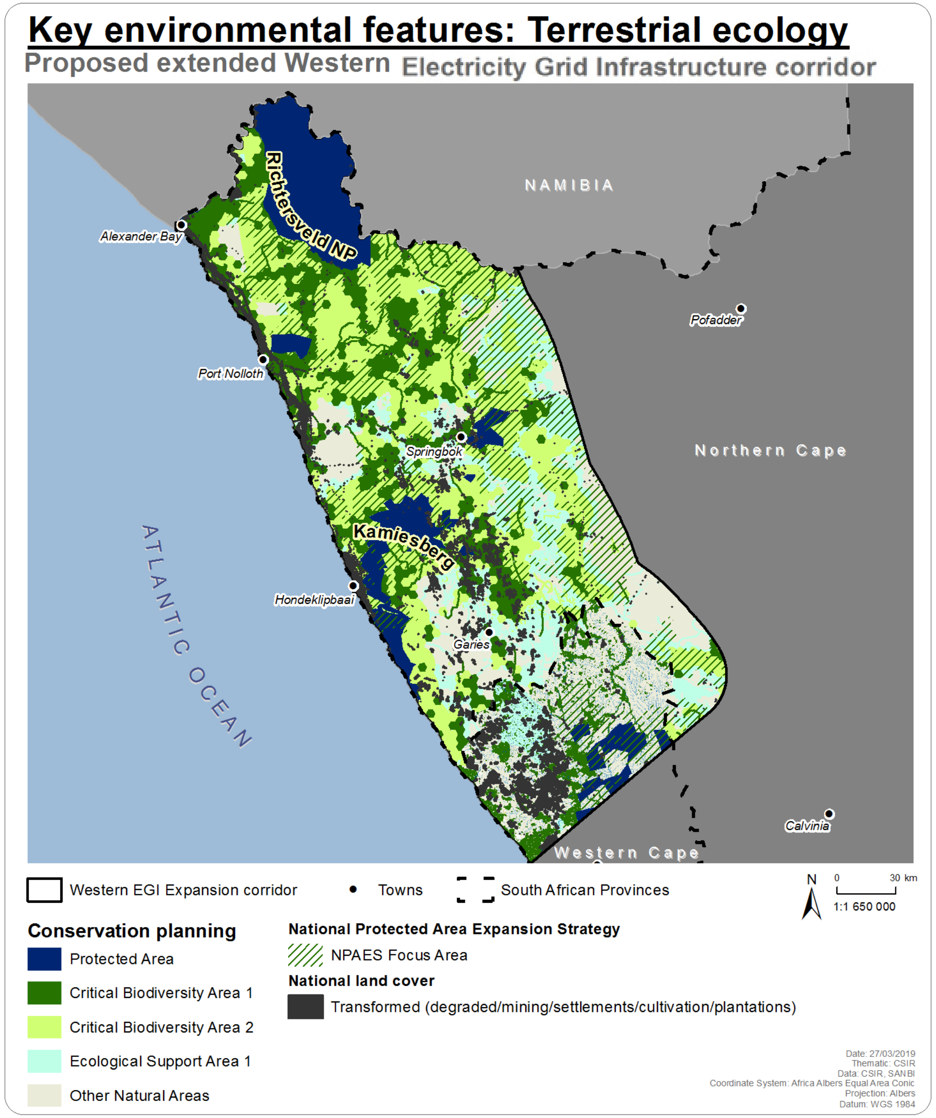


Figure 5: Key environmental features of the proposed Western EGI Expansion corridor.

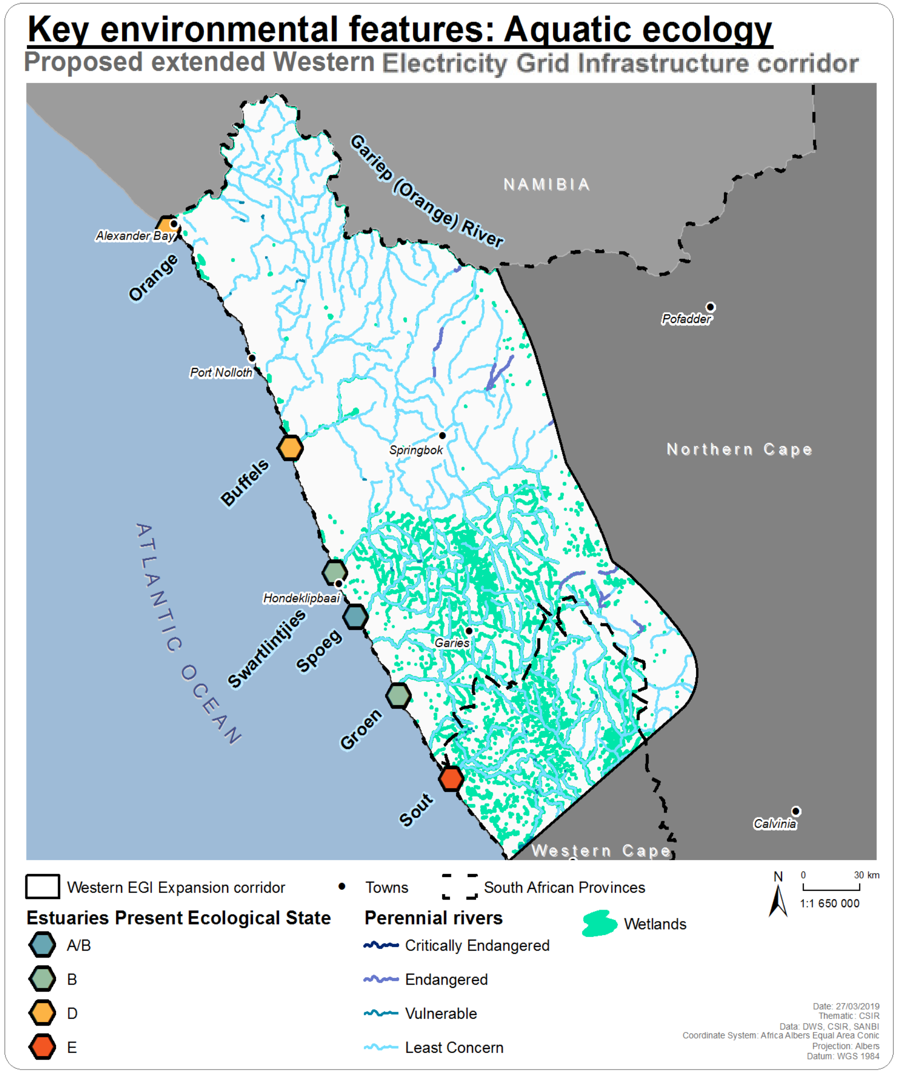


Figure 6: Key aquatic ecosystem features of the proposed Western EGI Expansion corridor.

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

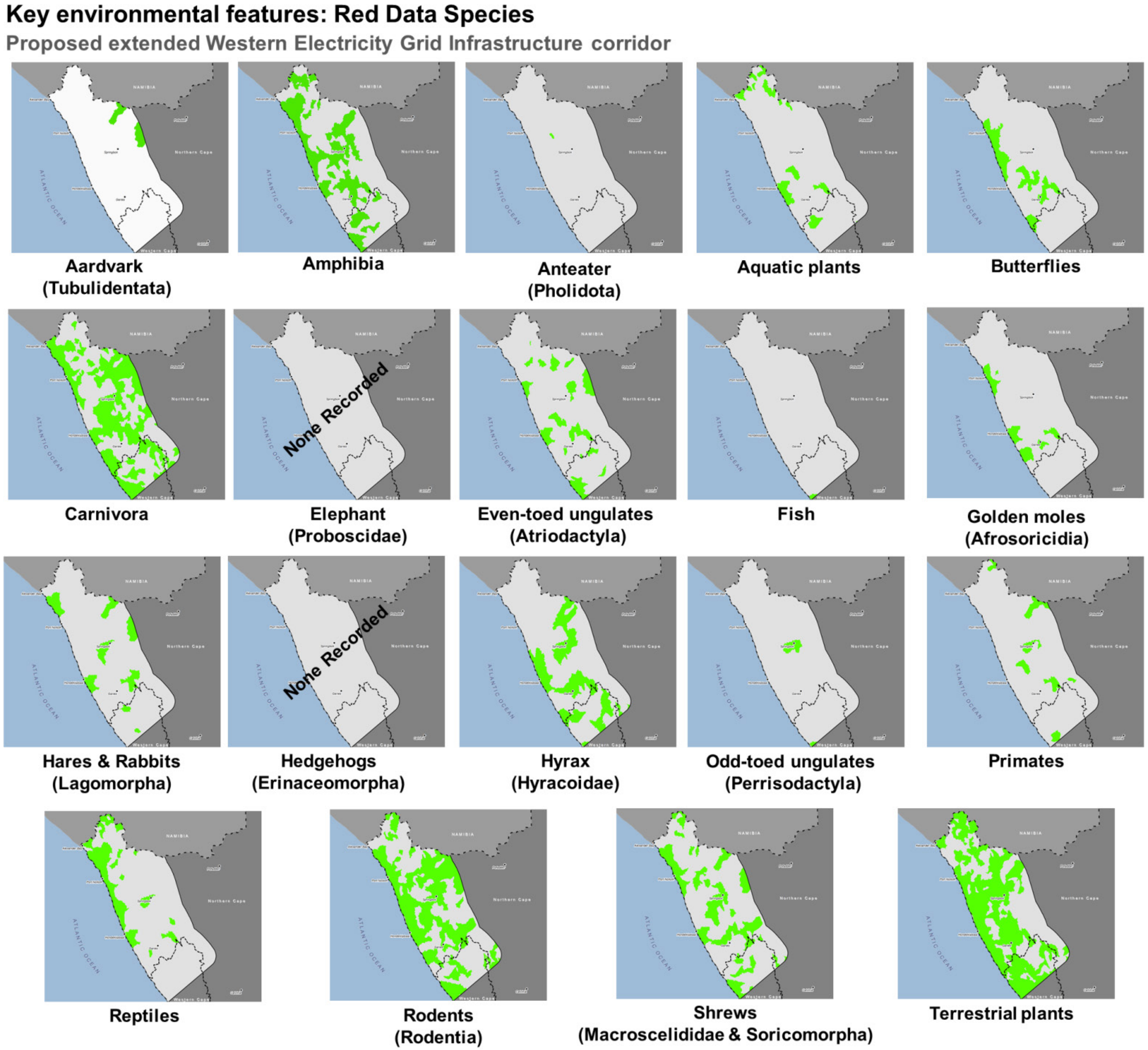


Figure 7: Distribution of recorded Red Data species in the proposed expanded Western EGI corridor (at quinary catchment scale).

6.2 Eastern Expansion Corridor

6.2.1 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).

The expanded Eastern EGI corridor extends from Durban to the Mozambique border. The IOCB within this corridor comprises of Maputaland Coastal Belt (CB 1), Maputaland Wooded Grassland (CB 2) and KwaZulu-Natal Coastal Belt. Subtropical Freshwater Wetlands, Swamp Forest and Lowveld Riverine Forest are three significant azonal vegetation types found within this section of the IOCB. A prominent protected area and land use feature is the Isimangaliso Wetland Park, a Ramsar Site of significance and World Heritage Site. Isimangaliso Wetland Park extends from Maphelane, just north of Richards Bay to Kosi Bay and extends inland to the Mkuze Nature Reserve. iSimangaliso includes significant areas of swamp forest and riverine habitat as well as CB1 and CB2.

To the south, the IOCB, between Durban and Richards Bay the IOCB is largely transformed, with the exception of a few outliers of undisturbed and protected habitat, such as the Amatikulu Nature Reserve (Dokodweni/Nyoni area) and the Ongoye Forest, near Mtunzini. Apart from the abovementioned outliers of natural habitat, urban sprawl, the N2 freeway, extensive sugar cane farming and silviculture, as well as dune mining near Mtunzini are major disturbance factors within this section of the IOCB.

Box 10: 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 EGI 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.

The Futululu and Dukuduku Forest areas as well as the Umfolozi floodplain between St Lucia and Mtubatuba indicate 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 found 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.

6.2.2 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 (Reyers, 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. Large amounts of the grassland in the Expanded Eastern EGI corridor has been transformed into subsistence agriculture, forestry plantations and sugarcane fields (Fairbanks et al 2000). This places a high conservation importance on all remaining Grassland.

6.2.3 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 Stinkwood, require a permit in terms of the NFA to be cut.

Savanna as a biome, is well conserved; however, many of the specific Savanna vegetation types found within the corridor, are very poorly conserved, this is especially true for the Zululand area (Mucina and Rutherford, 2006).

Box 11: 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 EGI 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, including disturbances to nesting sites, 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 within the corridor. 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 Expanded EGI 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.

The proposed expanded Eastern EGI corridor covers the Zululand area stretching from the Mozambique border to just north of Durban. It includes much of what is referred to as the Maputoland Centre of Plant Endemism. Excluding the northern edge of this corridor which is grassland, and the coastal edge which is IOCB vegetation, the balance is Savanna. Much of this Savanna vegetation is from threatened Savanna vegetation types. This region also has a large number of important conservation areas that are critical components of the conservation strategy for the region. In addition many of these reserves are key eco-tourism destinations. Though outside of the Savanna and grasslands, the iSimangaliso Wetland Park complex is a Ramsar site and important wetland area. Much of this area is under communal land management forming part of the previous Zululand homeland. As such it tends to have a high human settlement density. Plantation forestry and sugarcane fields are two of the most important agricultural activities, and both of these have fragmented the natural biodiversity.

6.2.4 Birds

The following Red Data species, that are sensitivity to power lines, are associated with the biomes and vegetation types found in the proposed Eastern Expansion EGI corridor (Table 13).

Table 13: Red Data bird species that occur in the proposed Eastern Expansion EGI corridor which are sensitive to power lines (Taylor et al., 2015).

Species	Status	Savanna	Grassland	Forest	Indian Ocean Coastal Belt	Azonal
African Marsh-Harrier	EN	x	x		x	x
Abdim's Stork	NT		x			x
Black Harrier	EN		x			
Black Stork	VU	x	x		x	x
Cape Parrot	EN			x		
Caspian Tern	VU					x
Greater Flamingo	NT				x	x
Lanner Falcon	VU	x	x	x	x	x
Lesser Flamingo	NT				x	x
Maccoa Duck	NT					x
Martial Eagle	EN	x	x		x	
Secretarybird	NT	x	x			
Lappet-faced Vulture	EN	x				
Verreaux's Eagle	VU	x	x			
Marabou Stork	NT	x			x	x
Denham's Bustard	VU		x		x	
Pink-backed Pelican	VU					x
Saddle-billed Stork	EN					x
Southern Bald Ibis	VU		x			
Burchell's Courser	VU		x			
Cape Vulture	EN	x				
Southern Ground-Hornbill	EN	x			x	
Tawny Eagle	EN	x				
Wattled Crane	CR		x			x
African Grass-Owl	VU		x			x
Grey Crowned Crane	EN		x		x	x
White-bellied Korhaan	VU	x	x		x	
White-backed Vulture	CR	x				
Yellow-billed Stork	EN					x
African Crowned Eagle	VU			x		
African Finfoot	VU					x
African Pygmy-Goose	VU					x
Bateleur	EN	x				
Great White Pelican	VU					x
Hooded Vulture	CR	x				
Pel's Fishing-Owl	EN					x
Southern Banded Snake-Eagle	CR				x	
White-headed Vulture	CR	x				
White-backed Night-Heron	VU					x
Black-rumped Buttonquail	EN		x			
Orange Ground-thrush	NT					
Spotted Ground-thrush	EN			x		
CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened						

6.2.5 Bats

The following bats of conservation importance are found in the proposed Eastern Expansion EGI corridor (Table 14).

Table 14: Red Data bat species that occur in the proposed Eastern Expansion EGI corridor which are sensitive to power lines (Child et al., 2016).

Species Name	Common Name	Conservation Status (Child et al., 2016)
Cloeotis percivali	Short-eared Trident Bat	EN (Balona et al., 2016)
Epomophorus wahlbergi	Wahlberg's Epauletted Fruit Bat	LC (Schoeman et al., 2016)
Kerivoula argentata	Damara Woolly Bat	NT (Monadjem et al., 2016a)
Miniopterus inflatus	Greater long-fingered bat	NT (Richards et al. 2016a)
Neoromicia rendalli	Rendall's serotine	LC (Monadjem et al., 2016b) Rare in SA
Otomops martiensseni	Large-eared free-tailed Bat	NT (Richards et al., 2016b)
Rhinolophus blasii	Peak-saddle Horseshoe Bat	NT (Jacobs et al., 2016c)
Rhinolophus swinnyi	Swinny's Horseshoe Bat	VU (Jacobs et al., 2016d)
Rousettus aegyptiacus	Egyptian Rousette Bat	LC (Markotter et al., 2016)
Scotoecus albofuscus	Thomas' House Bat	NT (Richards et al., 2016c)
Scotophilus nigrita	Giant Yellow House Bat	NT (Fernsby et al., 2016)
Taphozous perforatus	Egyptian Tomb Bat	NT (Richards et al., 2016d)
EN = Endangered; VU = Vulnerable; NT = Near Threatened; LC = Least Concern		

6.2.6 Freshwater ecosystems

Rivers within the Eastern EGI Corridor are predominantly perennial/permanently-flowing (87%), majority of which occur in the North Eastern Uplands, Lowveld and North Eastern Coastal Belt ecoregions. Major river systems include the Mkuze, Phongolo, Mfolozi, Thukela, Mhlatuze and Mvoti Rivers that drain across the width of the corridor into the Indian Ocean. Up to 16% of the river habitat is considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). This corridor contains the following remaining flagship/free-flowing rivers in the country, namely: the Mfolozi and Thukela River systems, and the Mkuze River and one of its tributaries, the Msunduzi. The PES of rivers is fairly good, with 50% of the rivers assessed to be in a natural/good condition, while 35% are in a fair condition and 15% are in a poor/very poor condition.

Wetland habitats within the Eastern EGI Corridor occupy a notable proportion of the corridor (~10%) comprising up to 83 different wetland types dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the IOCB 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 large proportion (~65%) of the wetlands in the corridor are characterised as NFEPA wetlands, a third of which is made up of channelled-valley bottoms, floodplains, seeps and valley-head seeps within the IOCB region.

Approximately 65% of the Eastern Corridor comprises land that is largely natural, with a significant proportion of the area protected by existing conservation areas (e.g. Isimangaliso Wetland Park, Hluhluwe-Imfolozi Game Reserve, Tembe Elephant Park, Ndumo Game Reserve, Ithala Game Reserve). The remaining area has been transformed largely by cultivation, plantations, urbanisation and rural settlements. Impacts on freshwater ecosystems caused by land use activities associated within these transformed areas vary across the landscape, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity. Key impacts 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, etc.) 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. Inanda, Hazelmere and Goedertrouw and Pongolapoort Dams), inter-basin transfers, WWTW 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 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 has 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).

Box 12: Red Data aquatic biota likely to be encountered in the proposed Expanded Eastern EGI corridor.

The only Critically Endangered Odonata for South Africa occurs along the Phongolo River in the north-western corner of the Eastern EGI Corridor, namely *Chlorocypha consueta*. The Endangered *Diplacodes pumila* also occurs in the corridor along with seven species listed as Vulnerable and four species listed as Near Threatened. Two Endangered fish, *Marcusenius caudisquamatus* and *Silhouettea sibayi*, occur predominantly within coastal rivers within the corridor, as well as two species listed as Vulnerable, including the widespread *Oreochromis mossambicus*. The corridor also supports three Near Threatened and two Data Deficient fish species. Two Endangered amphibians, *Hyperolius pickersgilli* and *Natalobatrachus bonebergi*, also occur along the coastal areas, while the Endangered *Leptopelis xenodactylus* occurs more inland at isolated localities. Threatened reptiles include *Bradypodion melanocephalum*, which often occurs in vegetation along rivers and adjacent to wetlands, and *Pelusios rhodesianus*, which is known from a few water bodies along the coastal region – both are listed as Vulnerable. Up to eight Red Listed mammals occur within the Eastern Corridor, including five rodents/shrews, as well as Spotted-necked Otter *Hydrictis maculicollis* and Cape Otter *Aonyx capensis*. One Critically Endangered plant, *Kniphofia leucocephala*, occurs in isolation in the Richards Bay area. There are also five Endangered, 16 Vulnerable, 12 Near Threatened freshwater plants occurring within the corridor.

6.2.7 Estuarine ecosystems

In total, 21 estuaries fall within the Expanded Eastern EGI Corridor, with a combined estuarine habitat area of 55 700 ha. 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 St Lucia (<30 km), Thukela (<25 km), Mhlathuze (<15 km), Mfolozi (<15 km) and Kosi (<10 km).

Only five estuaries in this corridor are in an excellent or good condition (Categories A to B). These are Mdlotane, Matigulu/Nyoni, Mlalazi, Mgobezeleni and Kosi estuaries. These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily.

Durban Bay, Mlalazi, Mhlathuze, Mfolozi, St Lucia and Kosi estuaries are of Very High biodiversity importance, ranking amongst the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). In addition, Mgeni, Mhlanga, Mdloti, Tongati, Mhlali, Mdlotane, Zinkwasi, Thukela, Matigulu/Nyoni, Richards Bay and Nhlabane estuaries are rated as Important from a biodiversity perspective.

Seventeen estuaries in the corridor are identified as conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012) and the KwaZulu-Natal Conservation Plan. These include Durban Bay, Mgeni, Mhlanga, Mhlali, Mvoti, Mdlotane, Zinkwasi, Thukela, Matigulu/Nyoni, Siyaya, Mlalazi, Mhlathuze, Richards Bay, Mfolozi, St Lucia, Mgobezeleni and Kosi estuaries.

Twelve estuaries 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). These include Durban Bay, Mgeni, Zinkwasi, Thukela, Matigulu/Nyoni, Mlalazi, Mhlathuze, Richards Bay, Nhlabane, Mfolozi, St Lucia and Kosi.

From a habitat diversity and abundance perspective, all the estuaries, with the exception of Mvoti, are considered important as they support sensitive estuarine habitats such as mangroves, swamp forest and saltmarsh (intertidal and/or supratidal).

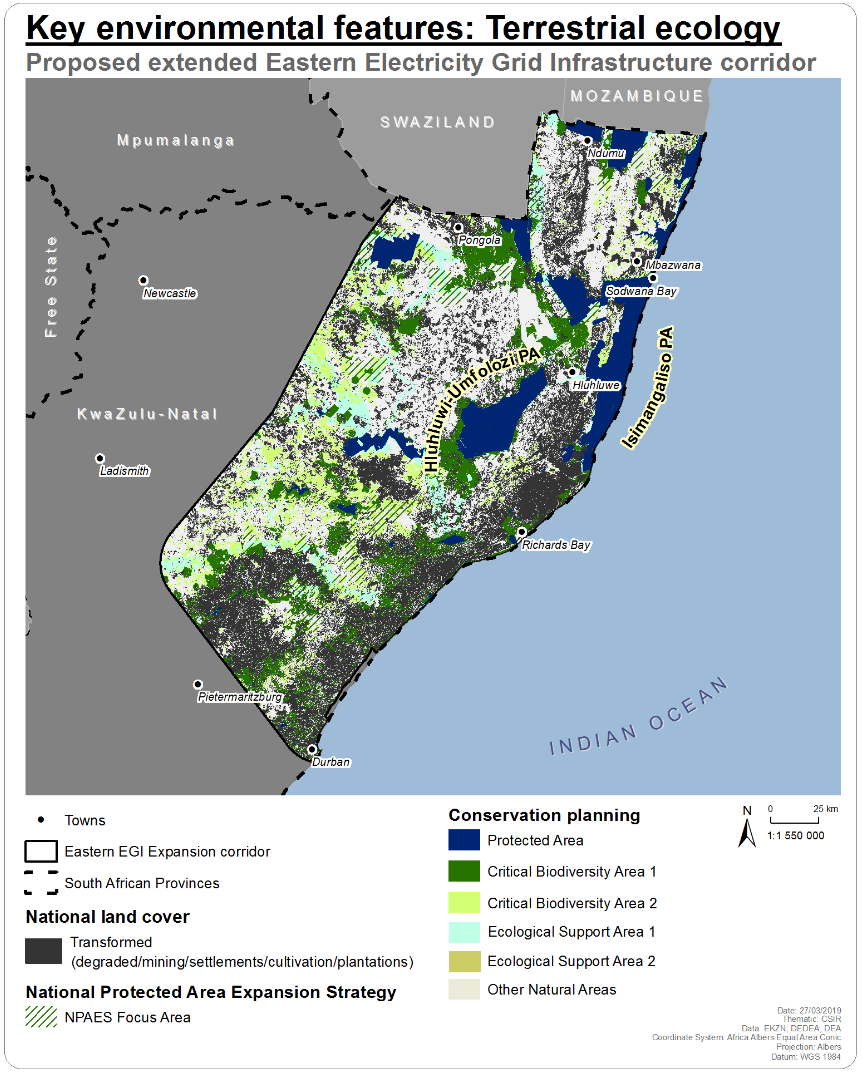


Figure 8: Key environmental features of the proposed Eastern EGI Expansion corridor.

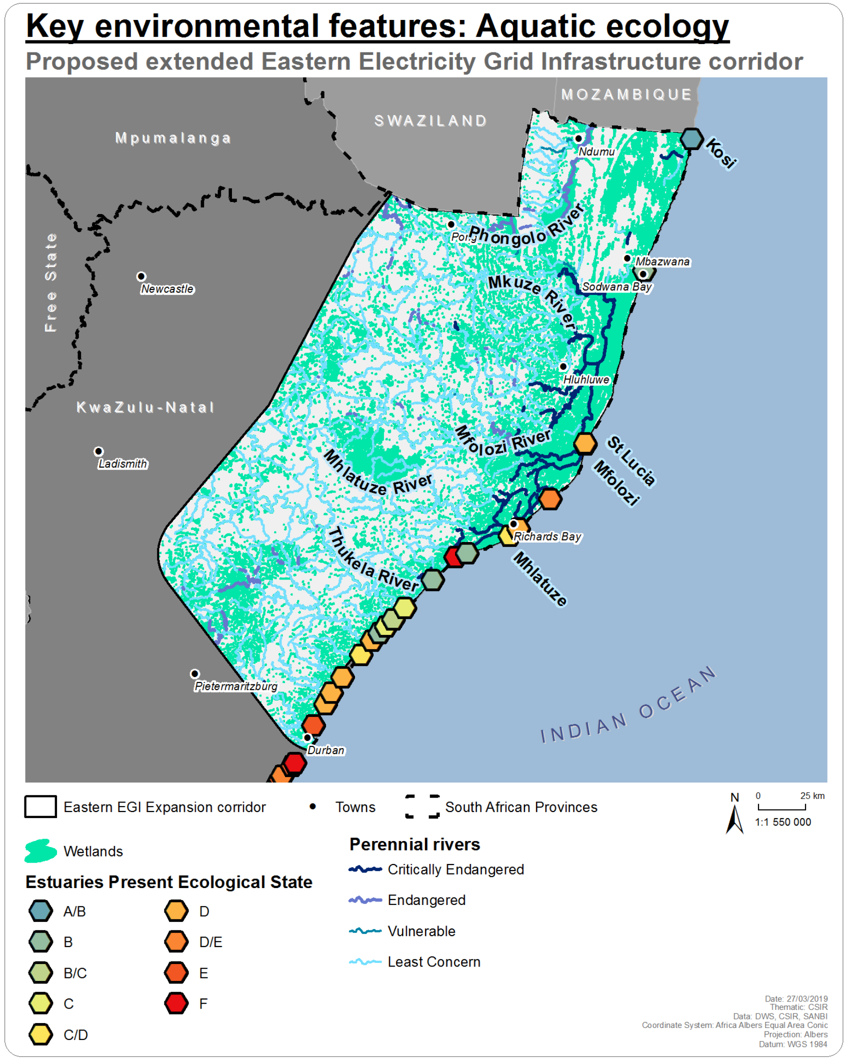
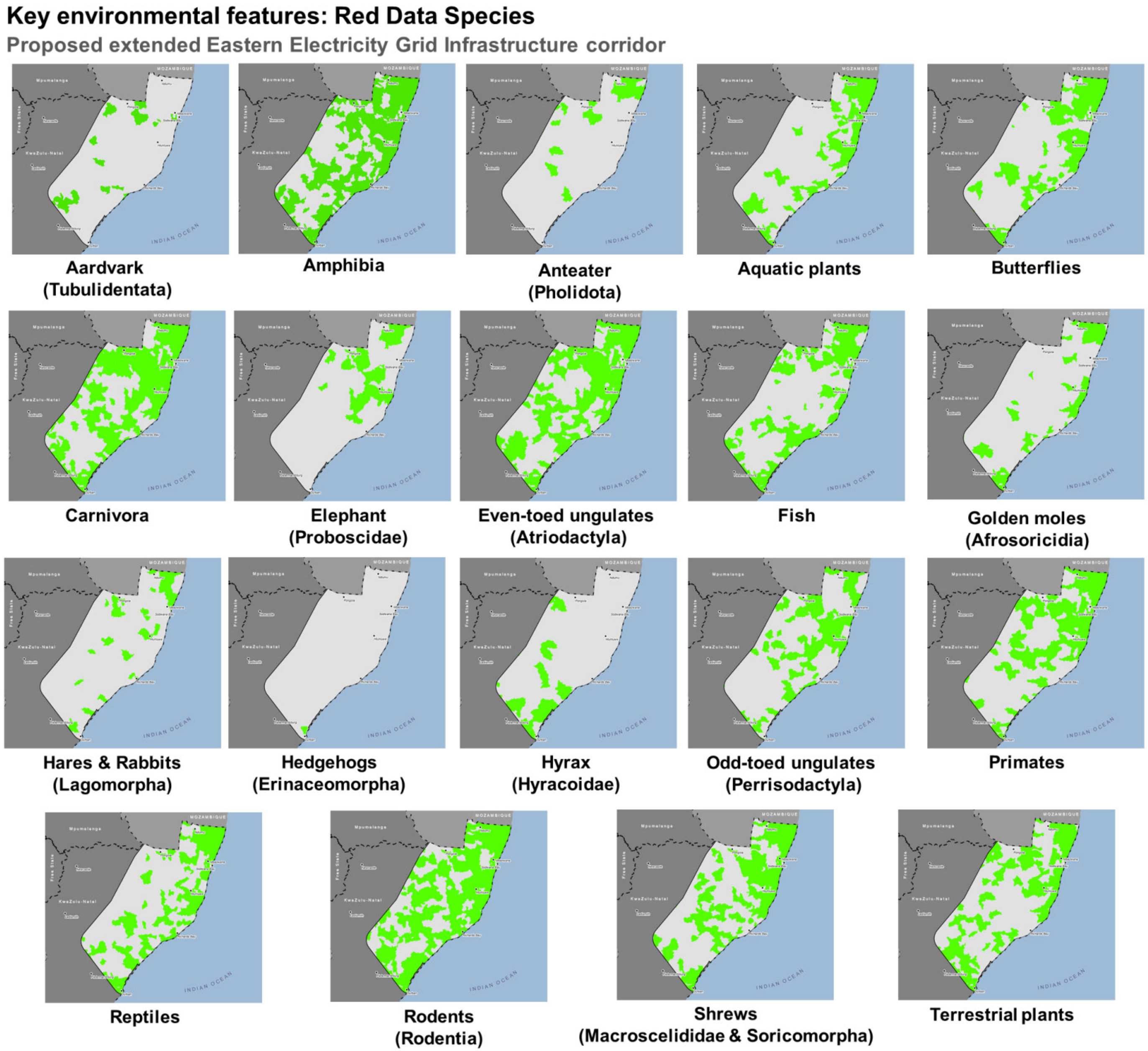


Figure 9: Key aquatic ecosystem features and associated Red Data species of the proposed expanded Eastern EGI corridor.

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



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

Figure 10: Distribution of recorded Red Data species in the proposed expanded Eastern EGI corridor (at quinary catchment scale).

7 ENVIRONMENTAL SENSITIVITY

7.1 Identification of feature sensitivity criteria

The data presented in Table 1 - Table 6 (Section 4.2) 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.

7.1.1 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 15).

Table 15: Sensitivity ratings assigned to important environmental features of the Desert, Succulent Karoo and Nama Karoo biomes in the proposed Expanded Western EGI corridor.

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 fields	Low
Old agricultural fields + CBA	Medium
Field crop boundaries	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
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	

7.1.2 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 16).

Table 16: Sensitivity ratings assigned to important environmental features of the Fynbos biome in the proposed Expanded Western EGI corridor.

Feature Class	Sensitivity Rating
Protected Areas Western Cape	
- NPs, Nature Reserves, World Heritage Sites	Very High 10 km Buffer[a]: 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
- World Heritage Sites	Very High
- NPAES	Medium
Conservation planning	
- CBA1	Very High
- CBA2	High
- ESA, ESA1, ESA2	Medium
- Land Cover : Natural Area	Medium
- Land Cover: Transformed	Low
- Other Natural Areas	Medium
Species of Conservation Concern	
Quinary catchments where fauna and flora SCC are present	High
[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; SCC = Species of Conservation Consern	

7.1.3 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 17).

Table 17: Sensitivity ratings assigned to important environmental features of the Indian Ocean Coastal Belt biome in the proposed Expanded Eastern EGI corridor.

Feature Class		Sensitivity Rating
- Coastline		1 km buffer: Very High
- PA		5 km buffer: Very High
- WHS		Very High
- Ramsar Sites		High
- Forest Nature Reserve		Very High
- NPAES		Medium
- National Forests		Very High
- Conservation categories	CBA Irreplaceable	High

Feature Class		Sensitivity Rating
from KZN CBA Plan	CBA Optimal	Medium
	ESA	Low
- Ezemvelo KZN Wildlife Stewardship areas		Very High
- Landcover	Modified	Low
	Field Crop Boundaries	Low
- Vegetation	LT	Low
	VU	Medium
	EN	High
	CR	Very High
- Ecoregion		Medium
- Private Nature Reserves and Game farms	Game Farms Title Deeds	5 km buffer: Medium
	Nature Reserves/Protected Areas	Very High
PA = Protected Area; WHS = World Heritage Site; CA = Conservation Area; CBA = Critical Biodiversity Area; ESA = Ecological Support Area; KZN = KwaZulu-Natal; LT = Least Threatened; VU = Vulnerable; EN = Endangered; CR = Critically Endangered.		

7.1.4 Grassland & Savanna

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

Table 18: Sensitivity ratings assigned to important environmental features of the Grassland and Savanna biomes in the proposed Expanded Eastern EGI corridor.

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 1		Very High
CBA 2		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
Species of Conservation Concern		
Quinary catchments where fauna and flora SCC are present		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		

7.1.5 Birds

An aggregated bird habitat sensitivity score for each habitat class within each biome, within each corridor was calculated by summing the species-specific probability scores for that particular habitat class (Table 19 and Table 20).

Table 19: Sensitivity ratings for avifauna habitat and species in the Expanded Western EGI corridor.

Biome	Feature Class	Sensitivity rating
Azonal Vegetation	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated vines	Medium
	Drainage lines	Medium
	Grassland	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Shrubland fynbos	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: Medium
	Woodland/Open bush	Medium
Desert	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated commercial pivots	Medium
	Cultivated orchards	Medium
	Cultivated vines	Medium
	Drainage lines	Medium
	Grassland	High
	Industrial	Low
	Low shrubland	High
	Shrubland fynbos	High
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: Medium
	Woodland/Open bush	Medium
Fynbos	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated subsistence	Medium
	Drainage lines	Medium
	Grassland	Medium
	Industrial	Low
	Low shrubland	Medium
	Shrubland fynbos	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: Medium

Biome	Feature Class	Sensitivity rating
	Woodland/Open bush	Medium
Nama Karoo	Bare	Medium
	Cliffs	1 km buffer: Medium
	Drainage lines	Medium
	Grassland	High
	Industrial	Low
	Low shrubland	High
	Shrubland fynbos	High
	Thicket /Dense bush	Medium
	Wetlands and waterbodies	500 m buffer: Medium
	Woodland/Open bush	Medium
Succulent Karoo	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated commercial pivots	Medium
	Cultivated subsistence	Medium
	Cultivated vines	Medium
	Drainage lines	Medium
	Grassland	High
	Industrial	Low
	Low shrubland	High
	Plantations	Medium
	Shrubland fynbos	High
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: Medium
	Woodland/Open bush	Medium
Key avifauna features	Nest sites of Red Data species	2.5 km buffer: Very high
	Cape Vulture colonies and vulture restaurants	5 km buffer: Very high

Table 20: Sensitivity rating for avifauna in the Expanded Eastern EGI corridor

Biome	Feature Class	Sensitivity rating
Azonal Vegetation	Bare	Medium
	Cliffs	1km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated commercial pivots	Medium
	Cultivated orchards	Medium
	Cultivated subsistence	Medium
	Cultivated sugar cane	Medium
	Drainage lines	High
	Grassland	Medium
	Indigenous Forest	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low

Biome	Feature Class	Sensitivity rating
	Wetlands and waterbodies	500 m buffer: Very high
	Woodland/Open bush	High
Forests	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated orchards	Medium
	Cultivated subsistence	Medium
	Cultivated sugar cane	Medium
	Drainage lines	Medium
	Grassland	Medium
	Indigenous Forest	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: Medium
	Woodland/Open bush	Medium
Grassland	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated commercial pivots	Medium
	Cultivated orchards	Medium
	Cultivated subsistence	Medium
	Cultivated sugar cane	Medium
	Drainage lines	Medium
	Grassland	High
	Indigenous Forest	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: High
	Woodland/Open bush	High
Indian Ocean Coastal Belt	Bare	Medium
	Cliffs	Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated orchards	Medium
	Cultivated subsistence	Medium
	Cultivated sugar cane	Medium
	Drainage lines	Medium
	Grassland	Medium
	Indigenous Forest	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Thicket /Dense bush	Medium
	Urban	500m buffer: Low

Biome	Feature Class	Sensitivity rating
	Wetlands and waterbodies	500 m buffer: High
	Woodland/Open bush	High
Savanna	Bare	Medium
	Cliffs	1 km buffer: Medium
	Cultivated commercial fields rainfed	Medium
	Cultivated commercial pivots	Medium
	Cultivated orchards	Medium
	Cultivated subsistence	Medium
	Cultivated sugar cane	Medium
	Drainage lines	High
	Grassland	High
	Indigenous Forest	Medium
	Industrial	Low
	Low shrubland	Medium
	Plantations	Medium
	Thicket /Dense bush	Medium
	Urban	500 m buffer: Low
	Wetlands and waterbodies	500 m buffer: High
	Woodland/Open bush	Very high
Key avifauna features	Nest sites of Red Data species	2.5 km buffer: Very high
	Cape Vulture colonies and vulture restaurants	5 km buffer: Very high

7.1.6 Bats

Habitat features and types were assigned varying sensitivities according to their bat importance. Where appropriate, buffers with a specific sensitivity have been assigned. The exact bat roost points have remained confidential in order to protect the roosts.

Table 21: Sensitivity rating for bats in the proposed Expanded Eastern and Western EGI corridors.

Feature Class		Sensitivity rating
Ecoregions	KwaZulu-Cape Coastal Forest Mosaic	High
	Maputuland Coastal Forest Mosaic	High
	Maputuland-Pondoland Bushlands and Thickets	High
	Nama Karoo	Low
	Drakensberg Montane Grasslands, Woodlands and Forest	Medium
	Southern African Mangroves	Low
	Zambesian and Mopane Woodlands	Medium
	Montane Fynbos and Renosterveld	Low
	Succulent Karoo	Low
Geology	Limestone	200 m buffer: Very High
	Dolomite	200 m buffer: Very High
	Arenite	200 m buffer: Medium
	Sedimentary and Extrusive Rock	200 m buffer: Medium
Bat Roosts	Bat Roost Points	500 m buffer: Very High

Feature Class			Sensitivity rating
Landcover	Plantations / Woodlands: Young and Mature		200 m buffer: Medium
	Thicket/ Dense Bush		200 m buffer: Medium
	Indigenous Forest: Very High		200 m buffer: Very High
	Urban Areas		Medium
	Disturbed and eroded land		Low
	Irrigated fields		Medium
Wetlands	All Wetlands		200 m buffer: Very High
Rivers	Major Perennial Rivers		200 m buffer: Very High
Dams	Farm Dams and Natural Dams		200 m buffer: Very High
EOO	*Cistugo seabrae*	Expanded Western EGI corridor	Medium
	Laephotis namibensis		
	Cloeotis percivali	Expanded Eastern EGI corridor	
	Epomophorus wahlbergi		
	Kerivoula argentata		
	Miniopterus inflatus		
	Neoromicia rendalli		
	Otomops martiensseni		
	Rhinolophus blasii		
	Rhinolophus swinnyi		
	Rousettus aegyptiacus		
	Scotoecus albofuscus		
	Scotophilus nigrita		
	Taphozous perforates		
EoO = Extent of Occurrence			

7.1.7 Freshwater ecosystems

The sensitivity rating for freshwater ecosystems is a combined rating for rivers, wetlands and freshwater biota (Table 22). 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 EGI in order to reduce impacts on freshwater ecosystems and associated biodiversity.

Table 22: Sensitivity ratings assigned to important freshwater features in the proposed Expanded Eastern and Western EGI corridors.

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

Feature Class		Sensitivity Rating
		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; ONA = Other Natural Area		

7.1.8 Estuarine ecosystems

Sensitivity was assigned to a suite of environmental indicators for estuaries (Table 23).

Table 23: Sensitivity ratings assigned to important estuarine features in the proposed Expanded Eastern and Western EGI corridors.

Sensitivity Indicator	Sensitivity Class
Estuaries in Formally /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
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	

7.2 Four-Tier Sensitivity Mapping

7.2.1 Expanded Western Corridor

7.2.1.1 Terrestrial ecosystems

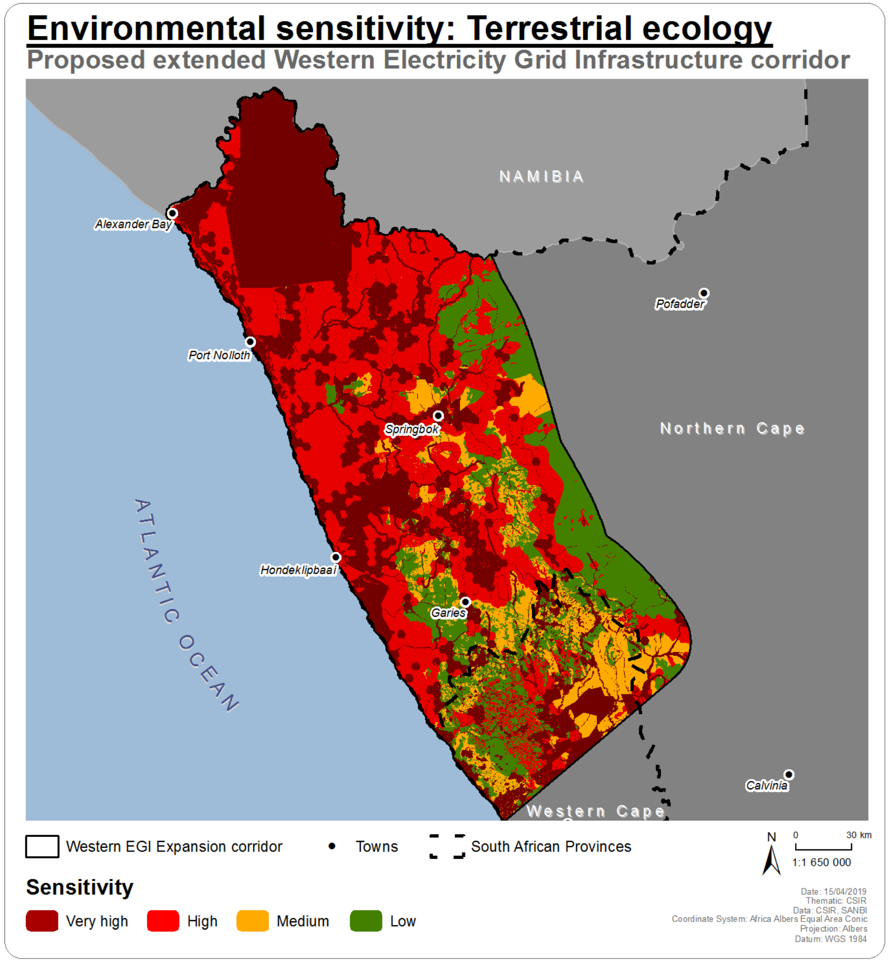


Figure 11: Environmental sensitivity of terrestrial ecosystems to proposed EGI development in the expanded Western EGI corridor.

7.2.1.2 Birds

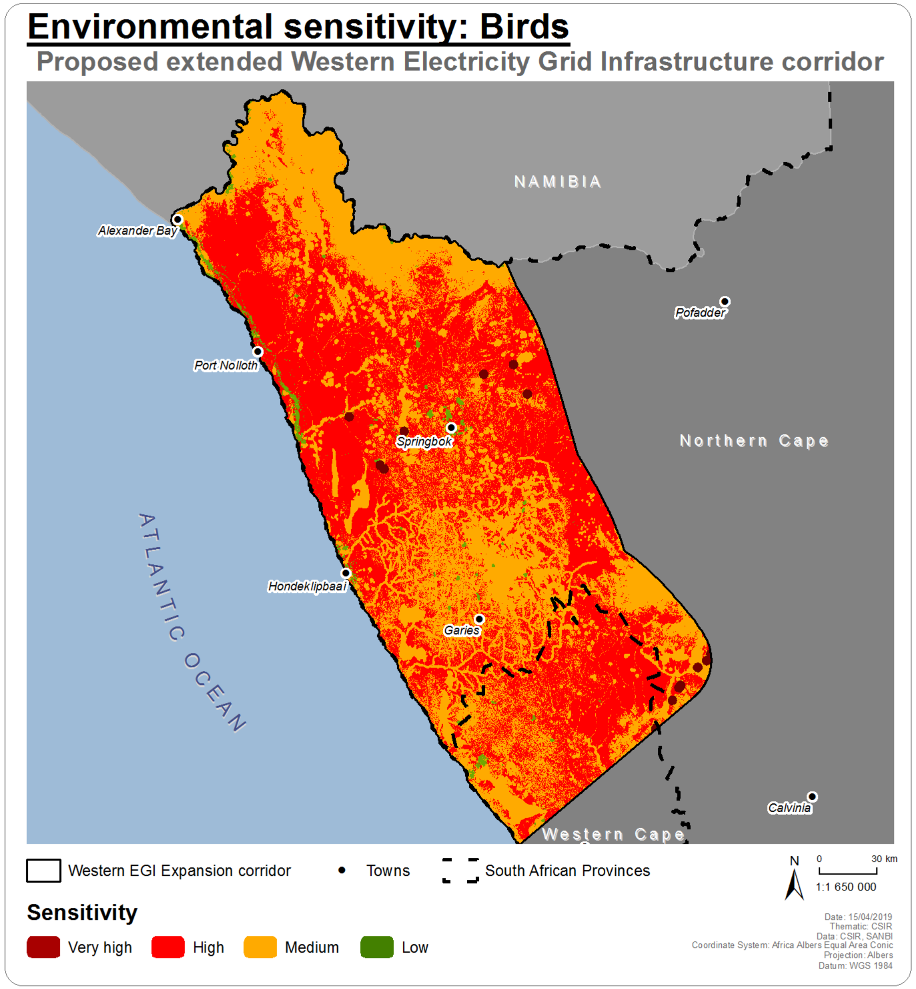


Figure 12: Sensitivity of birds to proposed EGI development in the expanded Western EGI corridor.

7.2.1.3 Bats

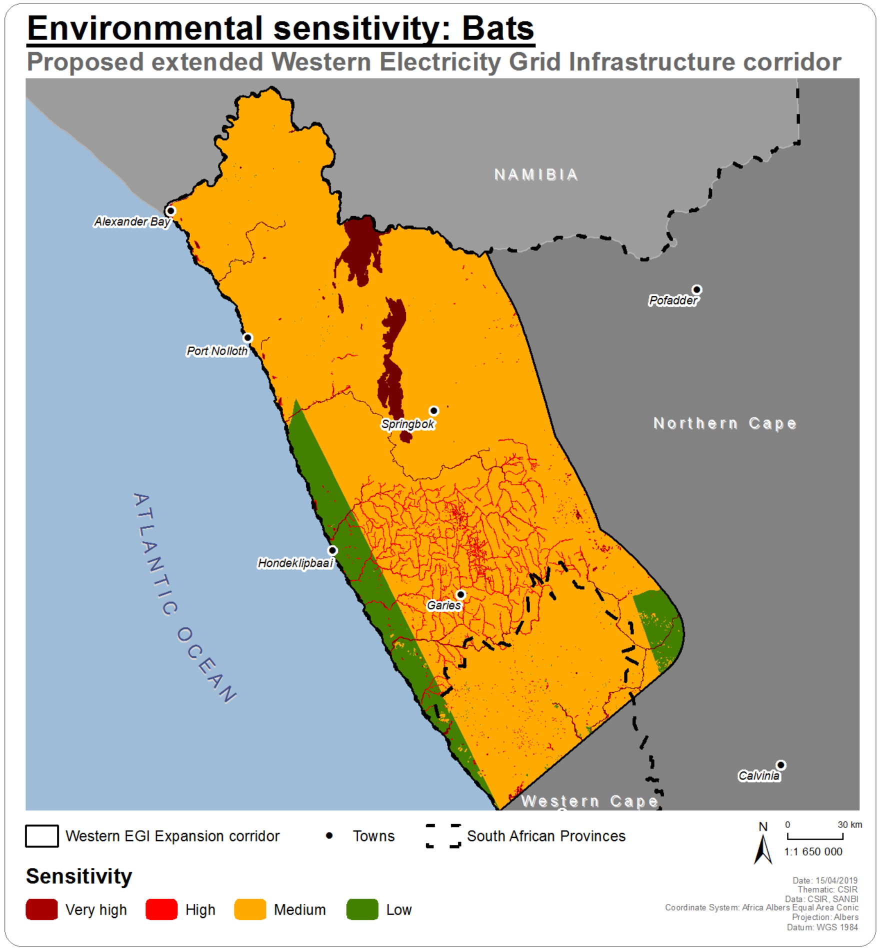


Figure 13: Sensitivity of bats to proposed EGI development in the expanded Western EGI corridor.

7.2.1.4 Aquatic ecosystems

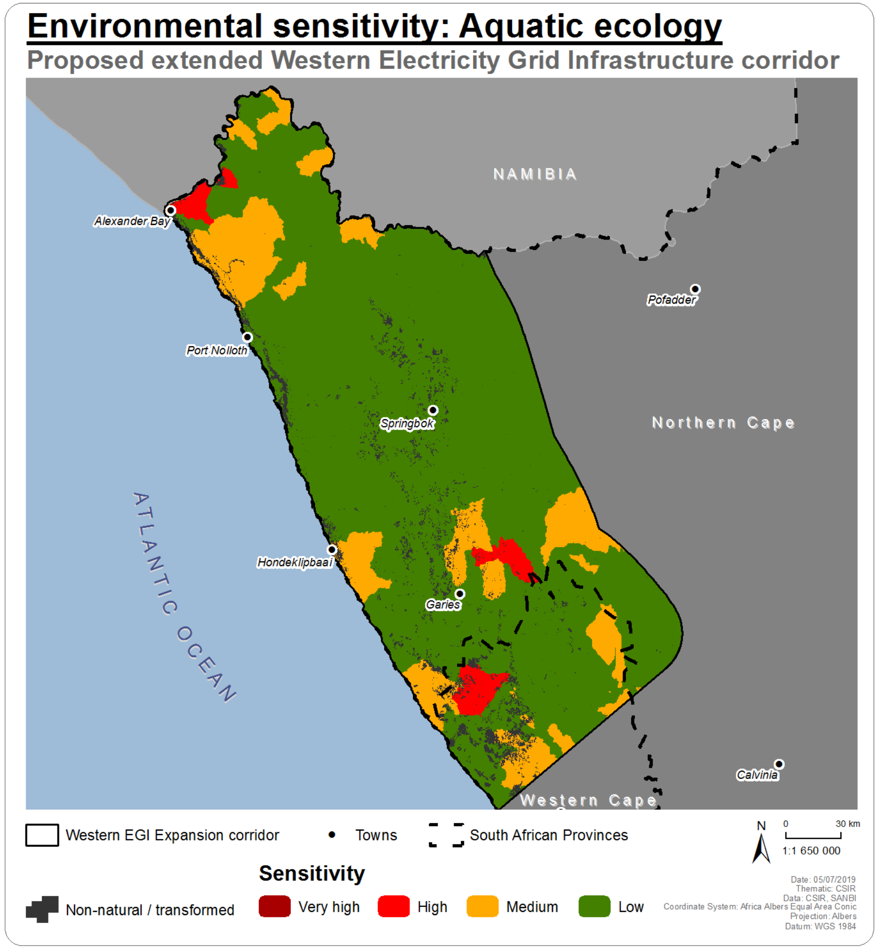


Figure 14: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed EGI development in the expanded Western EGI corridor.

7.2.1.5 Estuarine ecosystems

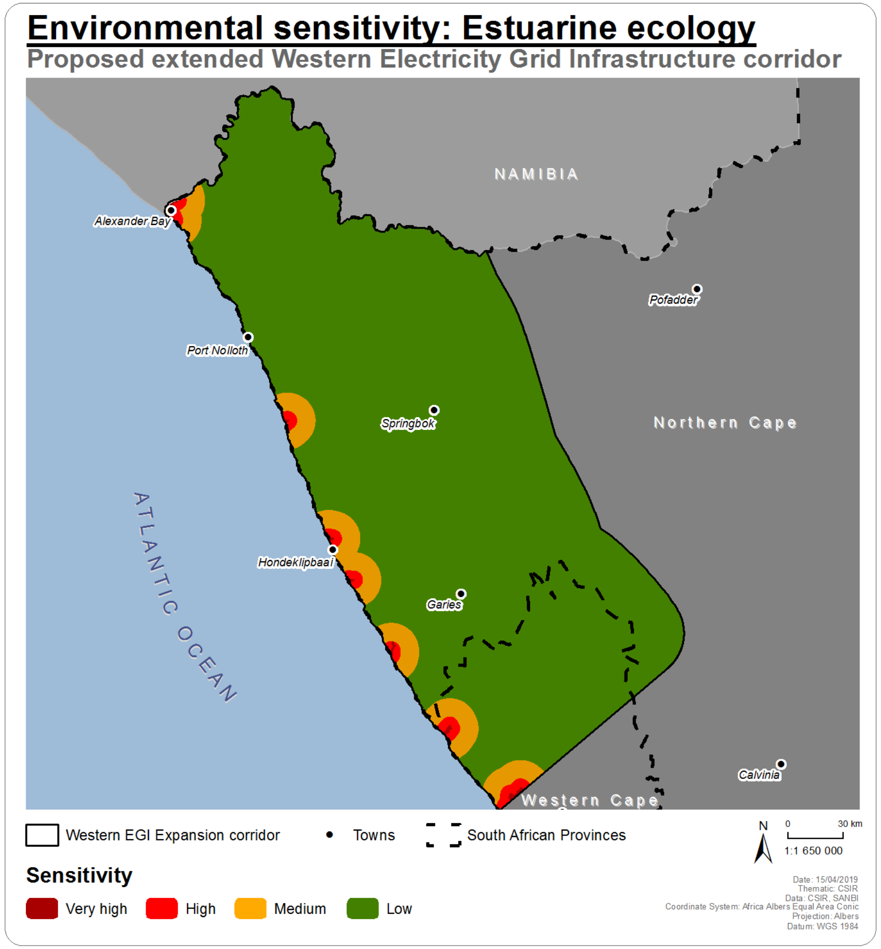


Figure 15: Environmental sensitivity of estuarine ecosystems to proposed EGI development in the expanded Western EGI corridor.

7.2.2 Expanded Eastern Corridor

7.2.2.1 Terrestrial ecosystems

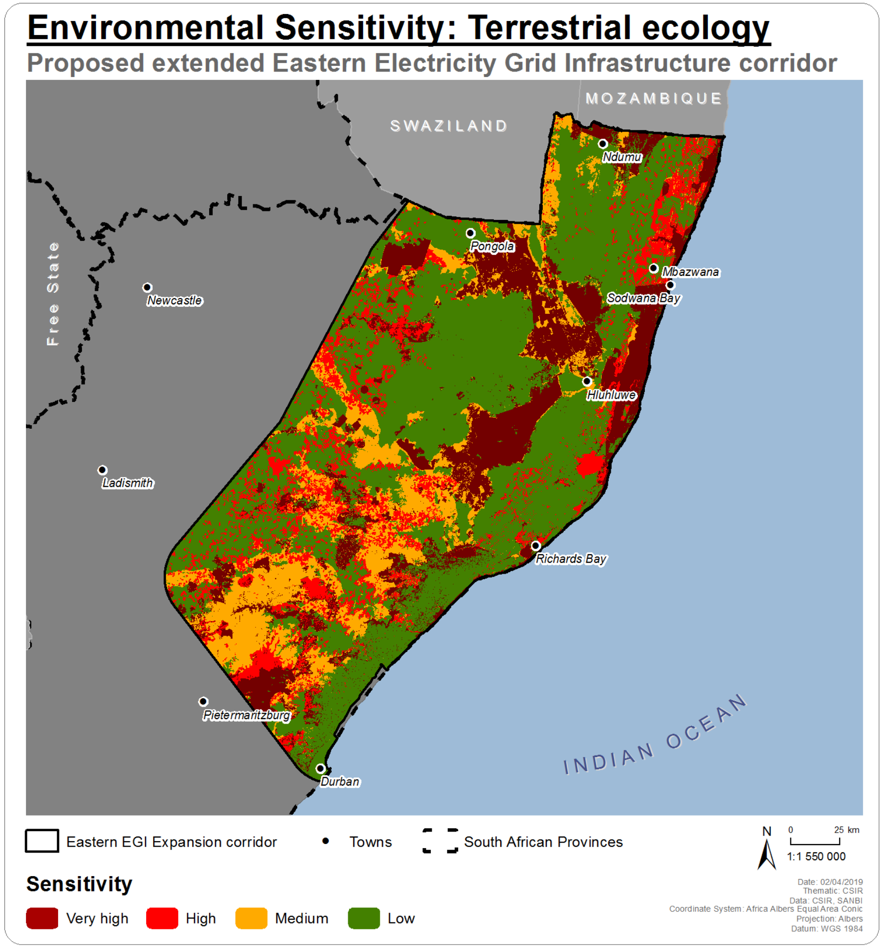


Figure 16: Environmental sensitivity of terrestrial ecosystems to proposed EGI development in the expanded Eastern EGI corridor.

7.2.2.2 Birds

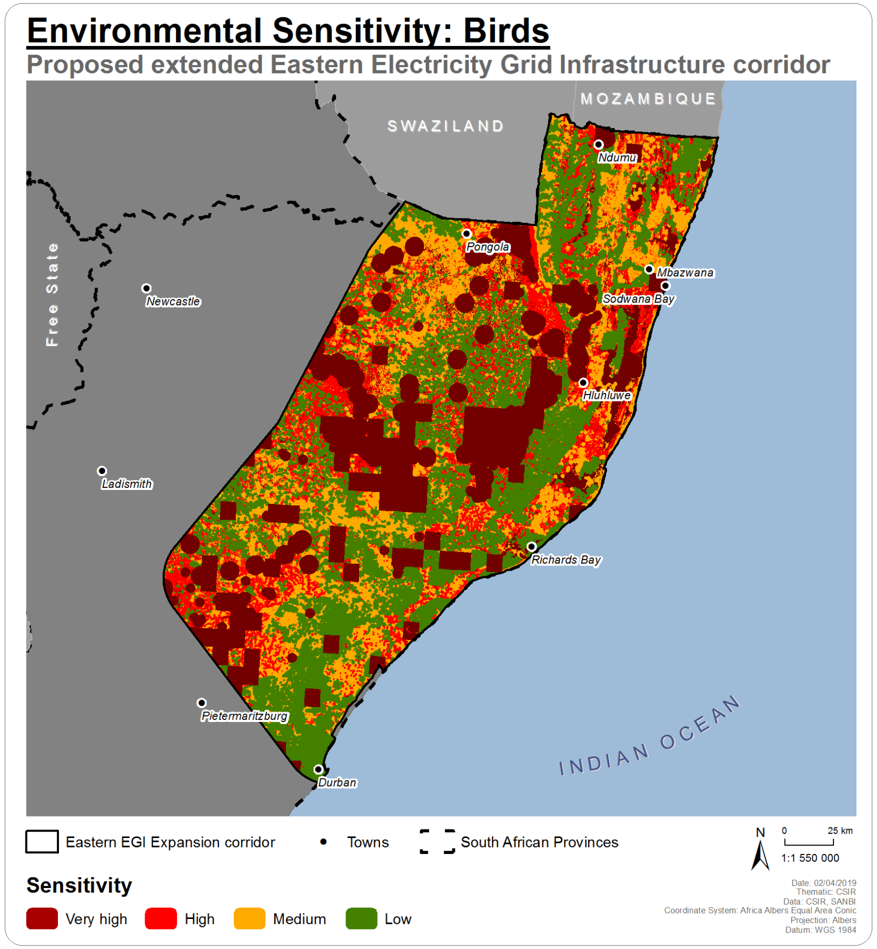


Figure 17: Sensitivity of birds to proposed EGI development in the expanded Eastern EGI corridor.

7.2.2.3 Bats

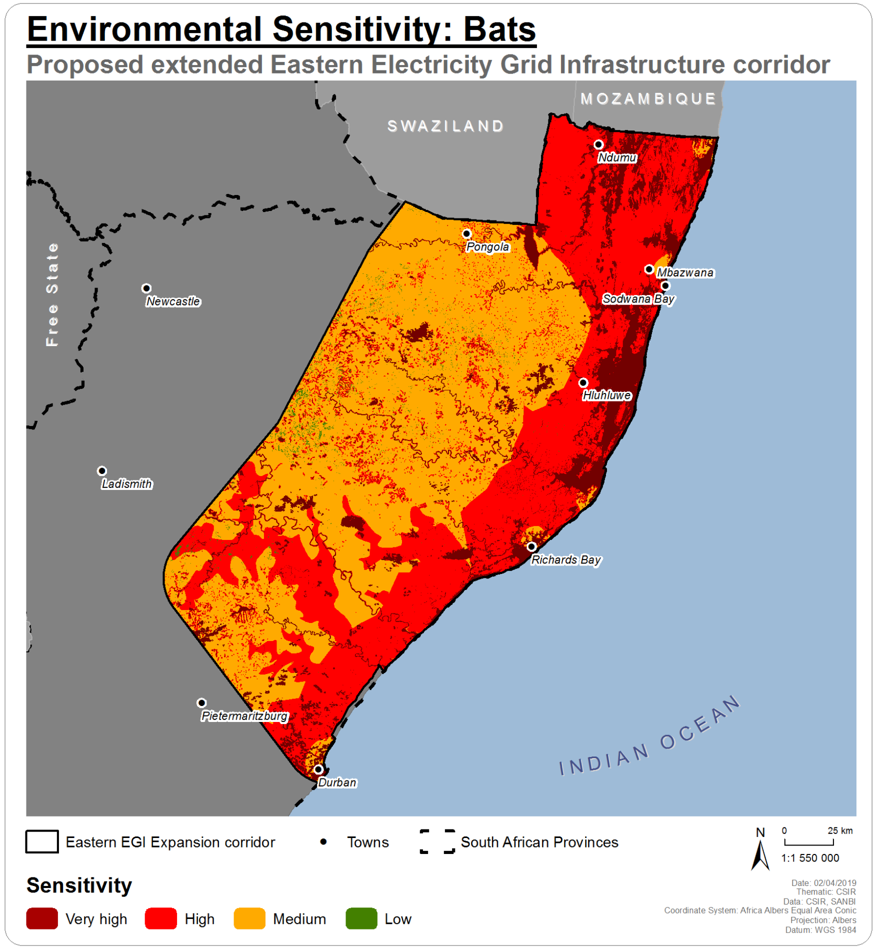


Figure 18: Sensitivity of bats to proposed EGI development in the expanded Eastern EGI corridor.

7.2.2.4 Aquatic ecosystems

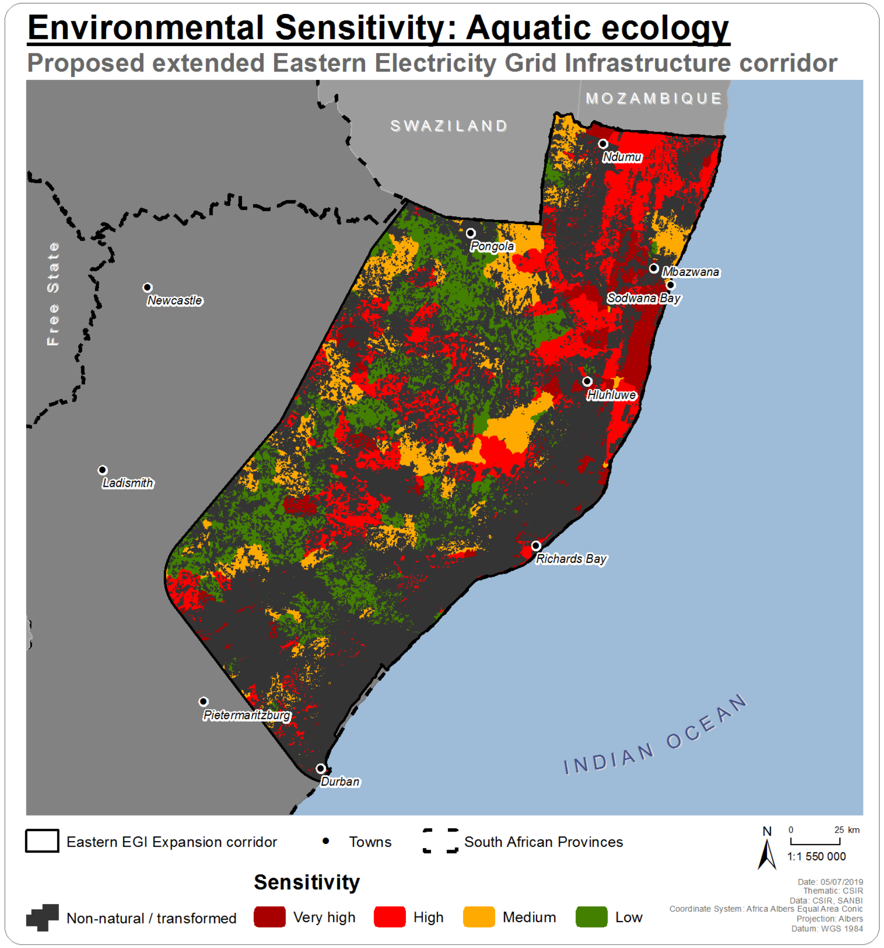


Figure 19: Environmental sensitivity per quinary catchment (overlaid with non-natural/transformed landcover) of aquatic ecosystems to proposed EGI development in the expanded Eastern EGI corridor.

7.2.2.5 Estuarine ecosystems

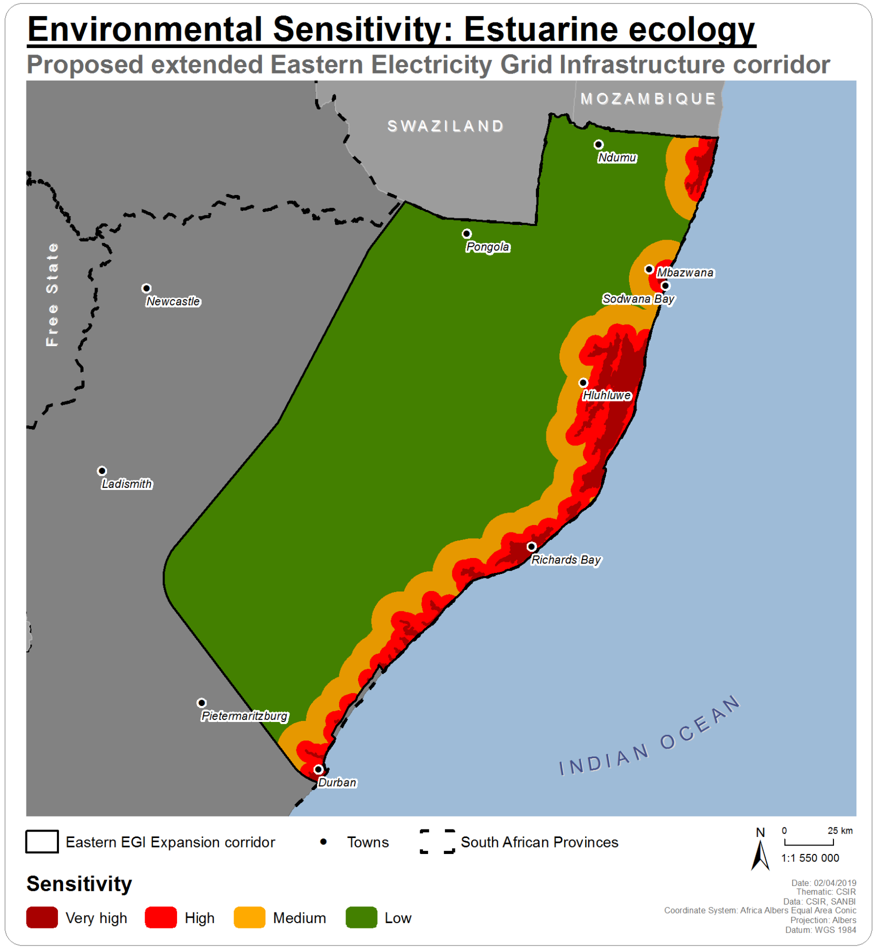


Figure 20: Environmental sensitivity of estuarine ecosystems to proposed EGI development in the expanded Eastern EGI corridor.

8 KEY POTENTIAL IMPACTS AND MITIGATION

The NEMA calls for the widely recognised mitigation hierarchy (avoid, mitigate/manage, rehabilitate, offset) (Figure 21) to be implemented to minimise or negate negative impacts, and maximise positive impacts of infrastructure development. Section 8 presents recommended mitigation measures for potential environmental impacts from EGI development.

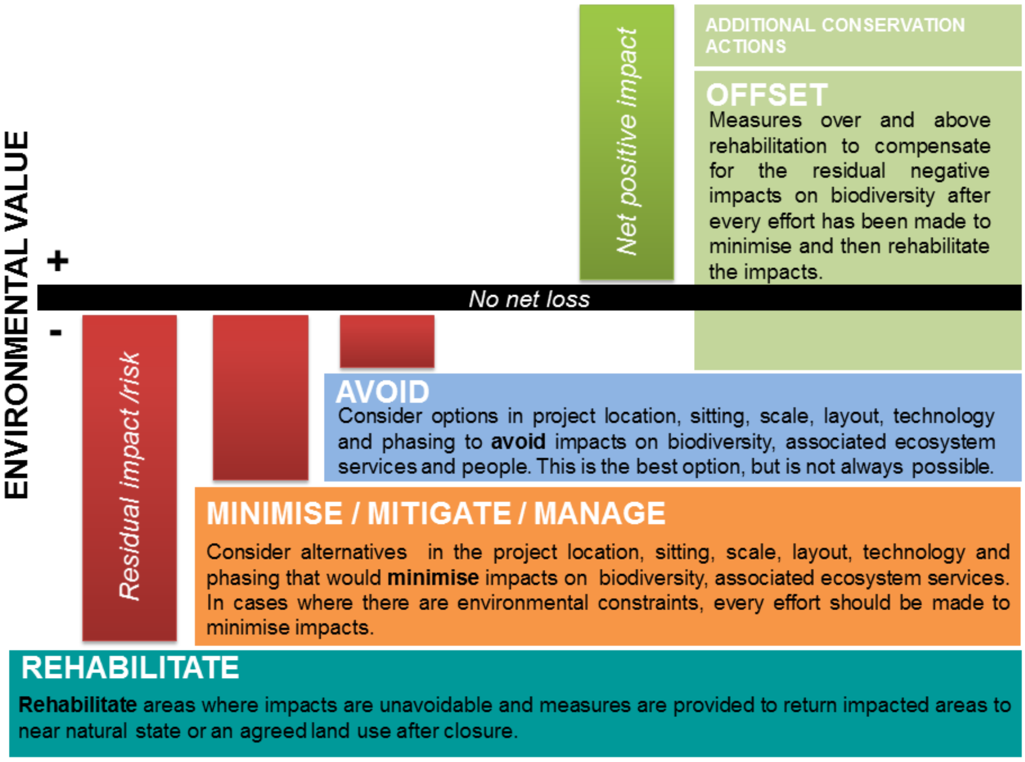


Figure 21: Implementation of the mitigation hierarchy is encouraged to ensure more sustainable and responsible development (after Rio Tinto, 2013).

8.1 Physical disturbance to soils, fauna and flora (Terrestrial Ecology and Species)

Planning and pre-construction

AVOID

- Use of **environmental sensitivity maps** in routing design;
- **Avoid**, as far as possible, **High and Very High sensitive areas (including areas of natural forest), which may also contain valuable species,** during the route planning;
- Areas with a high abundance of threatened ecosystems and species (High to Very High Sensitivity) should be avoided if possible.
- **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);
- **Avoid areas of high erosion vulnerability** as far as possible; and
- **Route roads so they do not run directly up steep slopes, provide good drainage and erosion control, and re-vegetate bare soil.**

MINIMISE / MITIGATE / MANAGE

- Design to **use common/shared infrastructure** as far as possible with development in nodes, rather than sprawling development;
- All **access tracks must be built and maintained to appropriate environmental standards**;
- If areas with high abundance of threatened ecosystems cannot be avoided, then relocation of threatened species or some form of offset may provide some mitigation;
- **Design and install mammal and snake barriers or deterrents on pylons** in areas with high mammal and/or snake activity or High sensitivity; and
- **Undertake specialist assessments:**
  - Where avoidance is not possible, in areas of Medium 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, burrows, and movement corridors of 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; and
- **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**;
- **Plant rescue of small tree specimens may be undertaken** (with necessary approvals in place as required) and transferred to outside of the servitude;
- **Specialist inspection (walk through) of proposed micro-sited route and pylon foundation to be conducted prior to clearing of vegetation and breaking of ground** to **ensure no animal burrows, nests, and roosts are harmed**. Rescue and release less mobile species such as snakes, frogs, reptiles, invertebrates and certain burrowing mammals that are found prior to construction. No animals should be intentionally harmed or killed for any purpose;
- **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 the norms and standards of the Nature Conservation Authorities;
- **Equip deep open trenches at pylon foundation sites with suitable ramps, ladders or steps** 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 leading to rivers and wetlands** through appropriate drainage and erosion control structures to minimise impacts on rivers and wetlands (e.g. barriers, geotextiles, active rehabilitation);
- **Where the EGI cuts through unstable soils** (e.g. sodic soils) ensure that adequate interventions are taken to prevent erosion and piping;
- **Take care where the EGI crosses dynamic swelling and contracting soils** (e.g. vertic soils) ensure that soil movement does not cause damage to the EGI 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**; and
- **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; and
- **Surveillance and monitoring of potential poaching and illegal species collection** (e.g. snares, debarking, hunting);

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[2];
- **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 trenches dug for infrastructure foundations, 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.

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

8.2 Establishment and spread of Invasive Alien Plants

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 EGI;
- **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; and
- **Carry out initial control measures prior to the construction.**

Construction

AVOID

- **Avoid unnecessary disturbance** of plant cover and topsoil;
- **Do not use soil sources contaminated with IAP seeds** for construction work.

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 onto the pylon site both when initially brought into the area and when moved between vegetation types, as well as before moving it from a section of the route where invading species were controlled to a section that is free of invading species. Keep vehicle and machinery movement to a single route to reduce the extent of the impact;
- **Any materials that may include alien species propagules must be obtained from sources known to be free of listed alien species** (e.g. only source sand from a quarry certified to be alien species free);
- **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**;**
- **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 inspections (particularly at the pylon sites and access roads), 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 EGI 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.**

8.3 Ecosystem alteration and loss

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;
- **Ensure proper design and planning for demolition activities**, with an emphasis on using delayed explosion methods, if and where blasting is required;
- **Minimise blasting operations to mid-day**, if and where blasting is required;
- **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; and
- **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 13: 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 EGI, the latter option may be the most practical offset strategy, if the offset approach is adopted.

8.4 Impacts to birds

The key potential impacts to avifauna are: 1) Mortality of power line sensitive Red Data species through collisions; 2) Mortality of power line sensitive Red Data species through electrocutions; and 3) Displacement of Red Data species due to habitat destruction and disturbance. These impacts pose specific risks to various sensitivity Red Data avifauna species, the effects of which can manifest as multiple casualties that destabilise populations and result in negative population growth (Shaw, 2013). The species-specific risks and recommended mitigation actions are presented in Table 24 (proposed Expanded Western EGI corridor) and Table 25 (proposed Expanded Eastern EGI corridor).

Table 24: Mortality and displacement of specific Red Data bird species in the proposed Expanded Western EGI corridor, and recommended mitigation measures.

Species-specific Risk	Mitigation
Greater Flamingo collisions at waterbodies.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal light emitting diode (LED) mitigation devices.
Kori Bustard collisions in the Nama and Succulent Karoo.	Mark power lines with Bird Flight Diverters (BFDs).
Black Stork collisions and displacement at waterbodies, drainage lines and cliffs.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies and across drainage lines with BFDs. Search suitable cliffs for nest sites and buffer nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the Environmental Control Officer (ECO). An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain, if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Blue Crane collisions at cultivated commercial fields and waterbodies.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Great White Pelican collisions at waterbodies and along the coast	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with BFD.
Lesser Flamingo collisions at waterbodies and along the coast.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices.

Species-specific Risk	Mitigation
Ludwig's Bustard collisions in the Nama and Succulent Karoo.	Mark power lines with BFDs.
Martial Eagle electrocutions and displacement of breeding birds on transmission lines in the Nama and Succulent Karoo.	Use only bird-friendly power line designs. Investigate all suitable transmission and sub-transmission lines (≤66kV) for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Secretary Bird collisions in the Nama and Succulent Karoo.	Mark power lines with BFDs
Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites throughout the corridor.	Use only bird-friendly power line designs. Investigate all suitable cliff sites for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Caspian Tern collision at large waterbodies throughout the corridor.	Mark power lines with BFDs.

Table 25: Mortality and displacement of specific Red Data bird species in the proposed Expanded Eastern EGI corridor, and recommended mitigation measures.

Species-specific Risks	Mitigation
African Marsh-harrier collisions throughout the corridor.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines with Bird Flight Diverters (BFDs).
Southern Ground Hornbill collisions, electrocutions and displacement throughout the corridor.	Use only bird-friendly power line designs. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Black Stork collisions and displacement at waterbodies, cliffs and drainage lines throughout the corridor.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies and across drainage lines with BFDs. Search cliff areas for nest sites and buffer these by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Blue Crane collisions and disturbance of breeding birds in grassland and wetland areas in Grassland.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer nest sites by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Cape Vulture electrocutions, disturbance at breeding colonies and roosts throughout the corridor. Collisions and electrocutions at vulture restaurants.	Use only bird-friendly designs. Buffer breeding colonies and vulture restaurants by 5 km. Should the full extent of the buffering at vulture restaurants and breeding colonies not be practically possible, the areas must be thoroughly investigated by an avifaunal specialist and those power lines that could pose a collision threat to vultures must be identified and marked with BFDs. In addition, it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.

Species-specific Risks	Mitigation
Denham's Bustard collisions in grassland areas throughout the corridor.	Mark power lines with BFDs
Great White Pelican and **Pink-backed Pelican** collisions and displacement at waterbodies in Indian Ocean Coastal Belt.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies BFDs.
Greater and Lesser Flamingo collisions at waterbodies throughout the corridor.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices.
Grey Crowned Crane collisions at wetlands and cultivated commercial fields in Grassland and Indian Ocean Coastal Belt. Displacement of breeding birds in wetlands in Grassland and Indian Ocean Coastal Belt.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Secretary Bird collisions throughout the corridor except Indian Ocean Coastal Belt.	Mark power lines with BFDs
Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites.	Use only bird-friendly power line designs. Investigate all suitable cliff sites for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Wattled Crane collisions and displacement at wetlands in Grassland.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Southern Bald Ibis collision and displacement at cliffs in Grassland.	Investigate all suitable cliff sites for nests and buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule

Species-specific Risks	Mitigation
	which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Blue Swallow displacement due to habitat destruction in the KwaZulu – Natal mistbelt in the Grassland biome.	Buffer all known Blue Swallow breeding habitat by 2.5 km. Should the full extent of the buffering not be practically possible, a thorough investigation must be conducted by a suitably experienced avifaunal specialist with experience of Blue Swallows to identify any potential nesting holes, which must then be appropriately buffered, in consultation with EKZN Wildlife and BLSA to prevent destruction of the nest holes.
Displacement due to disturbance and habitat destruction at nest localities of **Bateleur, Lappet-faced Vulture, Marabou Stork, Martial Eagle, Secretarybird, Tawny Eagle, Southern, White-backed Vulture, Hooded Vulture** and **White-headed Vulture** in Savannah, **African Crowned Eagle** and **Banded Snake-Eagle** in Forest, and **Pel's Fishing Owl** at rivers and waterbodies in the northern part of the corridor.	Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
Saddle-billed Stork and **Yellow-billed Stork** collisions at waterbodies in Savanna.	Avoid routing power lines within 500 m from the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with BFDs

8.5 Potential impacts to bats

Table 26 presents mitigation measures for potential impacts from EGI development to bats.

Table 26: Potential impacts from EGI development to bats, and recommended mitigation actions.

Key Impact	Mitigation
Displacement and disturbance	Avoidance of verified high and very high bat sensitivity areas. Particular attention in the bat assessments (where required) should be given to species of conservation importance as per Sections 6.1.6 and 6.2.5. If development does take place in areas of verified High or Very High sensitivity, where required, based on the Decision-Making Tools (e.g. based on the recommendation of the general faunal ecologist), a bat specialist must be appointed to undertake site visits to recommend micro-siting measures, and advise on the least harmful time in terms of the breeding season of the relevant bats in the area.
Electrocution	Avoidance of verified high and very high bat sensitivity areas. Particular attention in the bat assessments (where required) should be given to fruit bats and large insectivorous bats.
Electromagnetic interference	Avoidance of verified high and very high bat sensitivity areas. The bat assessments (where required) should conduct a desktop review on any possible new developments in this area of research.

8.6 Degradation, fragmentation and loss of aquatic ecosystems and species

Planning and pre-construction

AVOID

- Power line routing and siting of other EGI 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** including **estuarine vegetation and associated coastal freshwater riparian vegetation,** as far as possible.
- **Avoid EFZs** (very high sensitivity), and, if possible, other areas of high sensitivity.
- **Avoid road crossings and servitude clearance through wetlands, rivers and estuaries by using existing road networks and crossings,** and avoid and/or minimise these activities in associated coastal wetlands and rivers within 5 km of EFZ.
- **Excavations and construction of borrow pits for road construction should be located outside of the recommended buffer areas around wetlands and watercourses** and should be rehabilitated following construction. Pits or excavations should be checked regularly by the on-site ECO and plans put in place for species rescue and relocation.
- **As far as possible heavy machinery should not be operated in wetlands / water course and their associated buffers.** If this is unavoidable then all operations should be managed by an on-site ECO, with further screening/groundtruthing assessments conducted on an ad-hoc basis. Relocation of sensitive flora and fauna may be required prior to operation.
- **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).

MINIMISE / MITIGATE / MANAGE

- Where highly sensitivity catchments area unavoidable, placement of pylons and EGI within these catchments (as well as catchments with a low sensitivity) should as far as possible **avoid freshwater ecosystems,** or areas of these systems that are deemed to be sensitive or of concern **and associated buffers**, which should be determined during route screening, validation and walk-throughs.
- Minimise the number of watercourse crossings for access roads.
- **Where road crossings through wetlands, rivers, and rivers flowing into estuaries, cannot be avoided or minimised**:

  - **Ensure that appropriate crossings are designed and constructed 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. The concentration of flow (particularly during high flow conditions) should be minimised as far as possible.
- **Bank stabilisation measures** (gabions, eco logs, geofabric, sediment fences) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction.
- **Minimise disturbance to surrounding vegetation** 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.
- **A mitigation option for potential vegetation clearing/trimming impacts includes constructing taller pylons in certain areas** that are high enough to allow for the growth of relatively tall vegetation.

Construction

AVOID

- **All wetlands, watercourses and estuaries (as well as their associated inflowing coastal wetlands and rivers) should generally be** avoided (as far as possible) and appropriately demarcated as no-go areas.
  - 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);
- **Prohibit fishing or hunting** by personnel in the proximity of aquatic habitats.

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 necessary infrastructure have been installed**;
- **Open, deep trenches/excavations for infrastructure foundations 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 areas where dug trenches are required**, 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), associated with wetlands and rivers should ideally **take place during the dry season** to reduce potential impacts to coastal freshwater ecosystems, downstream estuaries, and freshwater ecosystems that are linked to rainfall-runoff;
- **Workers should be made aware** of the importance of not destroying or damaging the vegetation along and in watercourses, wetlands and estuaries of not undertaking activities that could result in the pollution aquatic systems, 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; and
- **Fixed point photography to monitor vegetation changes and potential site impacts** occurring during construction phase

Operations and maintenance

MINIMISE / MITIGATE / MANAGE

- **Roads/crossings not needed after the construction process should be decommissioned and rehabilitated** in accordance with detailed rehabilitation plans.
- **Minimise the amount of lighting at substations and switching stations by installing low intensity lights** that are directed exclusively to the areas where night-time lighting is required.

Post-construction and rehabilitation

REHABILITATE

- **Plan appropriate rehabilitation procedures/measures**;
- **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; and
- **Implement continuous erosion control.**

8.7 Altered hydrology

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**;
- **Avoid EFZs** (very high sensitivity), and, if possible, other areas of high sensitivity;
- **Avoid road crossings and servitude clearance through estuaries** and avoid and/or minimise these activities in associated coastal wetlands and rivers within 5 km of EFZ; and
- **Avoid clearing of estuarine vegetation and riparian vegetation.**

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;
- **Employ river/wetland bank stabilisation measures** (gabions, eco logs, geofabric, sediment fences or similar adequate measures) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction. Appropriate rehabilitation procedures/measures should be planned; and
- **Suppress dust** (e.g. spraying surfaces with water obtained from a suitable, licenced/approved source) to minimise the transport of wind-blown dust into aquatic systems.

Box 14: Rehabilitation of estuarine ecosystems.

While extent and duration of disturbances from the construction of the EGI may not be very substantial, 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.

8.8 Water quality deterioration

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**; and
- **Avoid construction activities within estuaries** (i.e. EFZ).
- **Stockpiling and washing areas should be clearly demarcated and sign posted.** These areas should be **set back outside of the buffer zone of freshwater ecosystems** - 30 m of the edge of any wetlands or drainage lines/rivers.
- **No vehicles, machinery, personnel, construction material, cement, fuel, soap/detergents, oil or waste should be allowed outside of the demarcated stockpiling/washing areas.**

MINIMISE / MITIGATE / MANGE

- **Minimise the number of watercourse crossings** for access roads; and
- **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; and
- **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, wetland, or estuary areas;
- **No spoil material, including stripped topsoil, should be temporarily stockpiled within 30 m of the edge of any wetland, watercourse, drainage line or estuary**:
  - 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, watercourses and estuaries (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; and
- **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, rivers or EFZs, and within 10 km of EFZ of inflowing coastal wetlands/ rivers.

9 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

In addition to the mitigation and management actions recommended in Section 8, the following key best practice guidelines and monitoring requirement recommendations, again following the mitigation hierarchy (refer to Figure 21), need to be taken into account.

9.1 Terrestrial ecosystems

9.1.1 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;
  - Areas with protected tree species and other threatened species.
- Biodiversity Offsets:
  - Consider biodiversity offsets where very high and 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 power line routes to follow, as far as possible, existing disturbance corridors.
- Develop robust pre-construction environmental baseline, including identified indicator species as reference for monitoring;
- 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 EoO / distribution range of Species of Conservation Concern (SCC) are not well known and as such, the planning phase should make provision for flexibility in determining the final EGI alignment to avoid locally sensitive features and populations of SCC.
  - Should sections of the planned EGI 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 project level 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 South African Council for Natural Scientific Professions (SACNASP) accredited botanist and zoologist must conduct the impact assessment in accordance with the NEMA regulations.
- The final power line routing and placement of substations and other ancillary infrastructure 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).
- Plan the route to avoid threatened species occurrences and populations where these are found. Where this is not possible, obtain appropriate permits for special and threatened species where they will be disturbed or displaced. Plan for re-location where necessary.
- Little is known about the seasonality of animal movements but minimise disturbances in the spring which is likely to be the breeding season; movements are most likely in spring and autumn.
- Consider seasonal timing – winter will likely be best to avoid breeding seasons when appropriate. Spring and autumn are typically most likely for seasonal migrations and if migrations are an issue should be avoided.
- Convene an expert workshop to discuss and debate the best options and propose methods for rehabilitation, including experiments that should be carried out and monitored, and obtain their recommendations on monitoring and evaluating the effectiveness of the rehabilitation in terms of ecosystem biodiversity, structure and function for areas with different sensitivities. The outputs of this workshop should be incorporated into the EMPr.
- Plan access track (service road) routes and pylon locations to minimise risks of erosion through routing and effective drainage measures.
- Pre-construction walk-through and on-site assessment by a SACNASP accredited botanist and zoologist of the final EGI 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.

9.1.2 Construction

- Limit disturbance footprint, and the associated duration of the disturbance.
- The construction operating corridor should be clearly delimited and demarcated with construction tape or similar markers to limit construction activity and disturbance to the EGI construction corridor.
- Helicopters should be used to string lines, especially where lines traverse high or very High sensitivity environments or rugged areas.
- When introducing material for rehabilitation, try to obtain it from local sources or at least from the same vegetation type.
- Carry out regular inspections to ensure that no alien species are becoming established, and eradicate those species populations that are detected.
- 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.

- Revegetate under pylons with species indigenous to the area. A mix of local grass species is best to rapidly establish ground cover and initiate ecological process.
- 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.
- Ensure proper drainage so that roads do not initiate erosion.
- 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 EGI 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.
- Appoint and involve an ECO to provide oversight and guidance to all construction activities, as well as ensure full consideration and implementation of the EMPr.
- Power line pylon footprints should be cordoned off during the construction phase and vegetation control and management around pylon footings should be undertaken during and immediately after the construction of pylons to prevent exotic weed invasion at these points.

9.1.3 Operations and maintenance

- Follow general vegetation- and access management measures.
- If the substations 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 power lines, substations, ancillary infrastructure, or any work area in the vicinity of EGI 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 EGI 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 EGI;
- Monitor vegetation recovery using photographic methods.
- The monitoring of “sensitive habitats” where power line pylons have been established either within or adjacent to such vegetation units, should be undertaken. Monitoring should include evaluation of change in adjacent habitat form and structure, as well as other more evident factors such as erosion and collapse related to the structures.
- 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.
- Monitor the success of the rehabilitation measures and carry out remedial measures where necessary.
- The issue of maintaining fire regimes is problematic because fires appear to be very rare in these arid fynbos environments and little is known about the desired intervals between such fires. They are most likely to occur in summer. The best option is to ensure that records are kept of all fires and their causes so that information on the fire regimes in this arid fynbos can be accumulated, assessed and use to guide fire management decisions and actions.
- Ensure necessary precautions to prevent electric shock hazards by installing (i) barriers to prevent unauthorised climbing on transmission towers/pylons, and (ii) appropriate colour coding and warning signs on EGI facilities and structures.

9.1.4 Post-construction and rehabilitation

- Clear rehabilitation targets should be set for each area based on the background perennial vegetation cover.
- Follow best rehabilitation practices as recommended by the expert workshop and incorporated into the EMPr (this includes minimising the duration and extent of the disturbance).
- 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.

Box 15: Environmental rehabilitation in arid areas.

Arid areas, as found in the proposed Expanded Western EGI Corridor, 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.

9.1.5 Monitoring requirements

- Populations of key fauna and flora SCC, of which the known EoO 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 planned power line routes, 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 EGI:
    - 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.
- Monitoring of poaching/livestock theft/illegal plant collection along the line of the powerline, especially where it passes through private or public protected areas, especially during construction, but also during operation.
- Use of Geographic Information Systems, spatial data and aerial photography / satellite imagery is recommended as a key tool for long-term monitoring and management.

9.2 Birds

9.2.1 Planning and pre-construction

Identification of technically feasible assessment corridor alternatives for assessment during the project specific assessment process.

A suitably qualified avifaunal specialist should be appointed to conduct an avifaunal study. The specialist should proceed as follows:

- The centre line of each assessment corridor must be determined.
- A 2 km buffer zone must be drawn around the centre line of each assessment corridor.
- The sum total area of each habitat sensitivity class in the assessment corridor must be calculated, based on the four-tier avifaunal sensitivity map.
- The procedure to follow for the avifaunal assessment of each assessment corridor alternative must be determined, based on the majority sensitivity class in the corridor.
- The specialist must make a recommendation on whether the power line may proceed or not, based on the anticipated impacts on Red Data avifauna, and must identify a preferred corridor which will have the least impact on Red Data avifauna, i.e. one which avoids Very High and High sensitive areas as much as possible.
- If the power line project may proceed, the specialist must describe suitable mitigation measures to be implemented, based on the type of impacts.

9.2.2 Construction

Power line pylon pegging and servitude clearing

If a feasible corridor alternative is identified and authorisation or similar is obtained to proceed with the project, the procedure is as follows:

- Once the pylon positions have been pegged, a walk-through should be conducted by a suitably qualified avifaunal specialist to identify all active Red Data nests in the servitude and immediately adjacent areas prior to the commencement of the servitude clearing. Due to the length of time between the authorisation (or similar) of the project and the commencement of construction activities, the nest surveys (if any) conducted during the planning phase will have to be repeated.

This is usually only applicable in Very High and High sensitivity areas but depending on the circumstances of each project and the professional opinion of the specialist, this may have to be extended to Medium and Low sensitivity areas as well. The width of the corridor to be surveyed will be determined by the species which are likely to breed there.

- Should such a nest be discovered, the avifaunal specialist should 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.
- During the walk-through, the specialist must also identify sections of line to be marked with Bird Flight Diverters (BFDs).

Pylon foundation construction and power line stringing

- If it has been established during the walk-through that a breeding pair of Red Data species could be displaced, appropriate management measures would need to be implemented, the nature of which will depend on the Red Data 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:
  - The eggs and/or chicks must be removed to a rehabilitation facility if the nest will be destroyed.
  - Construction activities must be timed to avoid the disturbance of the breeding birds during critical phases of the breeding cycle.
  - Activities must be restricted to the servitude width.
  - No access must be allowed to property/habitat beyond the servitude.
  - Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads.
  - BFDs must be fitted to those sections of the line which were identified during the walk-through.

Rehabilitation

- Activities must be restricted to the servitude width.
- No access must be allowed to property/habitat beyond the servitude.
- Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads.
- People and equipment must be restricted to a minimum to execute the on-site work.
- A suitably qualified rehabilitation expert must be appointed to manage the process in order to recreate the natural environment as best as possible.

9.2.3 Operations and maintenance

Aerial/ground patrol of the power lines

- If possible, patrols should be scheduled to occur outside of breeding window of Red Data species, especially large raptors breeding on transmission lines.
- Once-off pass through should be planned vs. “in and out’ to limit potential disturbance to birds.

Repairs and maintenance

- If feasible, repairs should be scheduled outside the breeding window of Red Data species, especially large raptors breeding on the power line.
- Temporary removal of a nestlings and/or eggs by a qualified expert for the duration of the repair activities might be necessary.
- Problem nests to be relocated to a different location to prevent pollution of insulators and eliminate the risk of streamer faulting, through the use of nesting platforms.

9.2.4 Rehabilitation and post-closure

Dismantling and recycling

- A walk-through should be conducted by a suitably qualified avifaunal specialist to identify all active Red Data nests in the servitude, including those on the pylons, and immediately adjacent areas prior to the commencement of the dismantling operations.
- Should such a nest be discovered, the avifaunal specialist should 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 dismantling operations.
- If it has been established during the walk-through that a breeding pair of Red Data species will be displaced, appropriate management measures would need to be implemented, the nature of which will depend on the Red Data 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:
    - The eggs and/or chicks must be removed to a rehabilitation facility if the nest will be destroyed.
    - Dismantling activities must be timed to avoid the disturbance of the breeding birds during critical phases of the breeding cycle.
- Activities must be restricted to the servitude width.
- No access must be allowed to property/habitat beyond the servitude.
- Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads.

9.2.5 Monitoring requirements

Depending on the sensitivity of the power line, post-construction monitoring may be required for a specific period to assess the effectiveness of BFDs, and to identify additional sections of line to be fitted with BFDs.

9.3 Bats

9.3.1 Planning and pre-construction

- Ensure site specific Bat Assessments are conducted to inform planning and placement, where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist).

9.3.2 Construction, Operational, Rehabilitation and Post-Closure

- Site specific Bat Assessments to conduct impact assessments and provide mitigation and monitoring requirements for each phase of development, where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist). The principles of avoidance, minimization, mitigation and only if unavoidable offset/ compensation should apply.

9.3.3 Monitoring requirements

- The EMPr should be audited bi-annually to ensure that any mitigation measures listed were and continue to be adhered to.

9.4 Aquatic ecosystems

9.4.1 Planning and pre-construction

The planning phase for EGI development through firstly establishing preferred power line alignments, then determining sites for substations, placement of pylons, and needs for ancillary infrastructure (e.g. access roads, water abstraction points, etc.) has the potential to greatly reduce impacts on freshwater ecosystems and associated fauna and flora through simply avoiding areas of very high sensitivity, and as far as possible avoiding areas of high sensitivity. In order to significantly reduce potential impacts on freshwater biodiversity, sub-quaternary catchments classified with a very high or high sensitivity should be avoided. Where these areas cannot be avoided, a detailed desktop investigation should be followed to determine whether the EGI alignment and development footprint can avoid the actual freshwater ecosystems (i.e. wetland and river habitats) and associated buffers. This process should also be followed for all other quinary catchments (including medium and low sensitivities).

Where it is impossible to avoid freshwater ecosystems (i.e. wetland and river habitats) and associated buffers altogether, it will be necessary to undertake more detailed project level specialist studies, and if necessary investigate needs and opportunities for offsets (refer to Section 9.1.1 for recommendations of biodiversity offsets). Preference should be given to position the EGI within already disturbed/degraded areas (e.g. freshwater ecosystems and buffers that are already invaded by IAPs). Mitigation specific to impact significance should be considered that is cognisant of the mitigation hierarchy, where very high significance impacts are avoided, while high and medium significance impacts are mitigated as far as possible. Offsets should only be considered once alternatives and mitigation measures have been exhausted, and in instances where it is provided that there are significant residual impacts due to the proposed development. Any freshwater ecosystems that will be affected by EGI development must be subject to project level assessments.

9.4.2 Construction

This phase may include the construction of pylons and substations, and stringing of transmission lines, and will thus include a number of impacts typical of construction activities, such as disturbance to wildlife through noise/light pollution, creation of dust, erosion and degradation/disturbance of habitats and vegetation (including areas for access via roads and servitudes and movement of heavy machinery), and bulldozing and vegetation/habitat clearing. Specific measures and actions required during the construction phase are presented in Sections 8.6 - 8.8, but key aspects to consider are:

- Timing of construction activities to occur in the dry season as much as possible;
- Appointment and involvement of an ECO to provide oversight and guidance to all construction activities, as well as ensure full consideration and implementation of the EMPr; and
- Environmental monitoring (or biomonitoring) required for pre-construction, during construction and post construction at strategically selected monitoring sites based on additional detail specified in Section 9.4.5.

9.4.3 Operations and maintenance

This phase will predominantly include activities typical of routine maintenance, such as clearing/trimming of natural wetland or riparian vegetation (to maintain required height clearance of transmission lines over vegetation), IAP control and application of herbicides, and operation of high-voltage transmission lines. Specific measures to be considered are provided in in Sections 8.6 - 8.8.

9.4.4 Rehabilitation and post-closure

Rehabilitation and post-closure measures would most likely be required for areas in and around pylons 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.

Additional points to be considered regarding rehabilitation of degraded areas within and adjacent to freshwater ecosystems include:

- IAP clearing and control – an IAP control programme should be developed and implemented based on site-specific details, including, but not limited to, types of IAPs, growth forms, densities and levels of infestation, potential dispersal mechanisms, knock-on impacts to freshwater ecosystems caused during implementation (e.g. herbicide drift and contamination), etc.;
- Erosion control and re-vegetation – the objective should be to establish indigenous vegetation cover as soon as possible, as well as to control and limit secondary impacts caused by rainfall-runoff. Where necessary geotextile fabrics, brush mattresses/bundles, geocells, and hydroseeding with a suitable grass seed mix should be considered, while more severe cases of erosion/bank collapse will require more advanced stabilisation methods (e.g. reshaping, planting, concrete blocks, riprap, gabions/reno mattresses, etc.).

9.4.5 Monitoring requirements

Sites/areas where freshwater ecosystems are likely to be affected by EGI 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 (biannual monitoring during the operational phase is not necessary for transmission lines or pylons);
- A single sample can be collected at closure, with additional sampling events 3 and 6 months post closure; and
- Fixed point photography to monitor changes and long term impacts.

9.5 Estuarine ecosystems

In addition to the best practice guidelines and monitoring requirements recommended for aquatic ecosystems (Section 9.4), the following requirements apply specifically to estuarine ecosystems.

9.5.1 Planning and pre-construction

The careful and informed planning of EGI development through firstly establishing preferred power line routes, determining suitable sites for substations, placement of pylons, and needs for ancillary infrastructure (e.g. access roads) has the potential to greatly reduce impacts on estuarine and associated freshwater aquatic ecosystems through simply avoiding areas of very high sensitivity, and as far as possible avoiding areas of high sensitivity. Where estuarine areas cannot be avoided, then a detailed investigation should be followed to determine whether the EGI alignment and development footprint can avoid the actual estuarine ecosystems (i.e. estuary) and associated aquatic and riparian buffers.

Where it is impossible to avoid estuaries and associated aquatic ecosystems and buffers altogether, then it will be necessary to undertake more detailed project level specialist studies, and if necessary investigate needs and opportunities for offsets. Preference should be given to position the EGI within already disturbed/degraded areas. Mitigation specific to impact significance should be considered that is cognisant of the mitigation hierarchy, where very high significance impacts are avoided, while high and medium significance impacts are mitigated as far as possible. Offsets should only be considered once alternatives and mitigation measures have been exhausted. Indeed, in the case of estuaries there is very little if any potential for offsets. Any estuarine ecosystem that will be affected by EGI development within the proposed Expanded EGI Corridors must be subject to an appropriate site-specific estuarine specialist investigation.

9.5.2 Construction

Given the high sensitivity and ecological importance of estuaries it is recommended that clearing of estuarine vegetation and disturbance of estuarine processes be avoided.

Some key mitigation measures specific to estuaries, and additional to those proposed for aquatic ecosystems in general (Section 9.4), include

- Detailed site-specific assessment required if construction is planned for within the EFZ.
- An onsite ECO is required to provide oversight and guidance to all construction activities.
- Environmental monitoring or biomonitoring is required pre-, during- and post-construction at pre-selected monitoring sites. This should include fixed point photography or remote sensing should be implemented to monitor changes and long term impacts.
- Construction activities to occur, if possible, while the estuary mouth is open to minimise impacts to biodiversity.
- Dust suppression is required to prevent smothering of estuarine vegetation.

9.5.3 Operations and maintenance

Assuming that EGI development does not occur in the EFZ as a result of very high sensitivity and ecological importance of estuaries, operations and maintenance predominantly include activities typical of routine maintenance, such as clearing/trimming of coastal riparian or wetland vegetation within 5 km of the estuaries, as well as IAP control and application of herbicides. In addition to the mitigation measures presented in Sections 8.6 - 8.8, specific measures for protecting estuarine processes are:

- Fixed point photography could be used to monitor long-term vegetation changes and potential site impacts.
- Avoid the use of herbicides in close proximity (closer than 50 m) to wetlands or rivers and do not disturb riparian/or wetland buffer areas.
- At all times care should be taken not to destabilise riparian areas and increase the sediment load down-stream to the estuary.

9.5.4 Monitoring requirements

Given the high sensitivity and ecological importance of estuaries it is recommended that EGI development should not occur within the EFZs. However, EGI development may involve construction and operation activity within or in proximity to coastal freshwater ecosystems such as rivers, wetlands and seeps that flow into estuaries. Where impacts to estuaries and/or coastal freshwater ecosystems within 5 km of estuaries cannot be avoided, monitoring measures should be implemented at a minimum; with additional supporting input from in-depth specialist studies where required.

For all construction activities within 5 km of an estuary, monitoring of a potential impact is recommended at sites to be determined in-field by qualified and experienced estuarine and/or freshwater ecosystems specialists. Sampling is required prior to construction taking place to allow for the establishment of the systems baseline condition (i.e. its state prior to development activities). Monthly monitoring is recommended for the duration of construction to evaluate trends, with summer and winter monitoring at three year intervals recommended thereafter during the operation phase.

Depending on the impact site, monitoring/sampling is to be conducted by estuarine/freshwater specialists with relevant qualifications and experience pertaining to estuarine sediment dynamics, physical processes, water quality and ecology (or freshwater aquatic ecology if in coastal freshwater ecosystem). Resource Quality Objectives (RQO) as set under the NWA provides the benchmark conditions to maintain in estuaries or rivers.

Monitoring effort should be appropriate to the nature and intensity of potential impacts, and information from monitoring should be used to inform and influence EGI development activities to prevent environmental damage, or ensure that remediation measures after the fact are successful in rehabilitating impacted habitats. This will require the development of case-specific monitoring plans, but some guidelines are presented here which are based on those developed for use in RQO studies. These requirements are specifically important in the event of construction within an estuary and its EFZ is impossible to avoid.

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.

In cases where freshwater ecosystems within 5 km upstream of estuaries are likely to be affected by EGI development appropriate measures of monitoring should be considered as recommended in Section 9.4.5.

10 REFERENCES

Allsopp, N. 1999. Effects of grazing and cultivation on soil patterns and processes in Namaqualand. *Plant Ecology*, 142:179–187.

Anderson, B., Allsopp, N., Ellis, A.G., Johnson, S.D., Midgley, J.J., Pauw, A., Rodger, J.G. 2014. Biotic interactions. In: Allsopp, N., Colville, J.F., Verboom, G.A. (*Eds*.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 224–247.

Atkinson, D. 2007. People-centred environmental management and municipal commonage in the Nama Karoo. *Development of Southern Africa* Vol: 24, Issue 5: pp 707–724.

Avenant NL, Balona J, Cohen L, Jacobs D, MacEwan K, Monadjem A, Richards LR, Schoeman C, Sethusa T, Taylor PJ. 2016. A conservation assessment of Laephotis wintoni. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa

Balona J, Cohen L, White W, Jacobs D, MacEwan K, Monadjem A, Richards LR, Schoeman C, Sethusa T, Taylor P. 2016. A conservation assessment of Cloeotis percivali. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. and De Villiers, M.S. (Eds.). 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata Series No. 1. South African National Biodiversity Institute, Pretoria.

Bergh, N.G., Verboom, G.A., Rouget, M., Cowling, R.M., 2014. Vegetation types of the Greater Cape Floristic Region. In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, pp. 1–25.

Blignaut, J., de Wit, M., Milton, S., Esler, K., Le Maitre, D., Mitchell, S., Crookes, D., 2013. Determining the economic risk/return parameters for developing a market for ecosystem goods and services following the restoration of natural capital: A system dynamics approach. Volume 1. Main Report. Report No. 1803/2/13, Water Research Commission, Pretoria

Bond, W.J., Slingsby, P., 1990. Collapse of an ant-plant mutualism: the Argentine ant, Iridomyrmex humilis, and myrmecochorous Proteaceae. *Ecology,* 65:1031–1037.

Bradshaw, P.L., Cowling, R.M. 2014. Landscapes, rock types, and climate of the Greater Cape Floristic Region. In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, pp. 26–46.

Carrick, P.J., Erickson, T.E., Becker, C.H., Mayence, C.E., Bourne, A.R. 2015. Comparing ecological restoration in South Africa and Western Australia: the benefits of a 'travelling workshop. *Ecological Management & Restoration*, 16:86–94.

Carrick, P.J., Krüger, R. 2007. Restoring degraded landscapes in lowland Namaqualand: Lessons from the mining experience and from regional ecological dynamics. *Journal of. Arid Environments*, 70:767–781.

Child M.F., Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert H.T. (*Eds*.). 2016. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Cohen L, Taylor P, Jacobs D, Kearney T, MacEwan K, Monadjem A, Richards LR, Schoeman C, Sethusa T. 2016. A conservation assessment of Rhinolophus cohenae. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Colville, J.F., Potts, A.J., Bradshaw, P.L., Measey, G.J., Snijman, D., Picker, M.D., Procheş, Ş., Bowie, R.C.K., Manning, J.C. 2014. Floristic and faunal Cape biochoria: do they exist? In: Allsopp, N., Colville, J.F., Verboom, G.A. (*Eds*.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 73–92.

CSIR (Council for Scientific and Industrial Research). 2017. Protecting South Africa's strategic water 42 source areas. https://www.csir.co.za/protecting-south-africa%E2%80%99s-strategic-water-43 source-areas. Date accessed: Feb. 2019.

Cowling, R.M. and Roux, P.W. 1987. The Karoo Biome: a preliminary synthesis. Part 2 – Vegetation and history. FRD, Pretoria.

Cowling, R.M., Esler, K.J. and Rundel, P.W. 1999. Namaqualand, South Africa – an overview of a unique winter-rainfall desert ecosystem. *Plant Ecology,* 142: 3–21.

Cramer, S. 2016. Uranium Mining Threatens the Karoo. Available at http://karoospace.co.za/uranium-mining-threatens-the-karoo/

DEA (Department of Environmental Affairs). 2019. Renewable Energy Data Release Schedule 2019 – 2020. Directorate: Enterprise Geospatial Information Management (EGIM), Department of Environmental Affairs (DEA), Pretoria. Available at https://egis.environment.gov.za/.

Dean, W.R.J. and Milton, S.J. 2019. The dispersal and spread of invasive alien *Myrtillocactus geometrizans* in the southern Karoo, South Africa. *South African Journal of Botany,* 121:210–215.

Dean, W.R.J., Seymour, C.L. and Joseph, G.S. 2018. Linear structures in the Karoo, South Africa, and their impacts on biota. *African Journal of Range and Forage Science* 35(3-4): 223-232.

Desmet, P.G. and Cowling, R.M. 1999. The climate of the Karoo, a functional approach. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Driver, A., Sink, K.J., Nel, J.L., Holness, S.H., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. and Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis report. South African National Biodiversity Institute & Department of Environmental Affairs, Pretoria.

DWS (Department of Water and Sanitation) 2017. Determination of Ecological Water Requirements for Surface water (River, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA. Buffels, Swartlintjies, Spoeg, Groen and Sout Estuaries Ecological Water Requirement. Authored by CSIR: L van Niekerk, J Adams, SJ Lamberth, S Taljaard for Rivers for Africa. DWS Report No: RDM/WMA06/00/ CON/COMP/0316.

Eirgrid. 2015. Eirgrid Evidence Based Environmental Sudies, Study 3: Bats – Literature review and evidence based field study on the effects of high voltage transmission lines on bats in Ireland. Available at http://www.eirgridgroup.com/site-files/library/EirGrid/EirGrid-Evidence-Based-Environmental-Study-3-Bats.pdf.

Eskom. 2009. Transmission vegetation management. Revised. Eskom Transmission, Guideline Ref. EGL41-334. http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/Documents/Tx_vegetation_management.pdf.

Esler, K.J., Milton, S.J. 2006. Towards best practice in management of road, powerline and rail reserves. Stellenbosch.

Esler, K.J., Milton, S.J., Dean, W.R.J. 2010. Karoo Veld - Ecology and Management. Briza Press, Pretoria.

Esler, K.J., Pierce, S.M., de Villiers, C. 2014. Fynbos: Ecology and Management. Briza Publications, Pretoria.

Fairbanks, D.H.K., Thompson, M W M., Vink, D. E., Newby, T. S., van den Berg H.M. and Everard, D. A. 2000. The South African land-cover characteristics database: a synopsis of the landscape. *South African Journal of Science,* 96:69-82.

Fernsby N, Cohen L, Richards LR, Taylor PJ, Child MF. 2016. A conservation assessment of Scotophilus nigrita. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Fielding, P. 2017. Draft Management Plan for the Buffels Estuary. Report prepared for the Kamiesberg Local Municipality.

Fielding, P., Massey, V., Clark, B. 2017. Draft Management Plan for the Swartlintjies Estuary. Report prepared for the Kamiesberg Local Municipality.

Gaertner, M., Fisher, J., Sharma, G., Esler, K. 2012a. Insights into invasion and restoration ecology: Time to collaborate towards a holistic approach to tackle biological invasions. NeoBiota 12, 57.

Geldenhuys, C.J. 1994. Bergwind fires and the location pattern of forest patches in the southern Cape landscape, South Africa. J. Biogeogr. 21, 49–62.

Griffiths, M.H., 1997. Management of South African dusky kob Argyrosomus japonicus (Sciaenidae) based on per-recruit models. *South African Journal of Marine Science*, 18: 213-228.

Hall, S.A., Newton, R.J., Holmes, P.M., Gaertner, M., Esler, K.J. 2017. Heat and smoke pre-treatment of seeds to improve restoration of an endangered Mediterranean climate vegetation type. *Austral Ecology*, 42:354–366.

Hayes, A.Y. and Crane, W. 2008. Succulent Karoo Ecosystem Programme, Phase 2 (2009 – 2014). Consolidation and Securing Programme Sustainability. A Strategic Plan of Action for South Africa. Supported by the Critical Ecosystem Partnership Fund and South African National Biodiversity Institute. pp 1-41.

Heelemann, S., Procheş, Ş., Porembski, S., Cowling, R.M. 2010. Impact of graminoid cover on postfire growth of nonsprouting Protea seedlings in the eastern Fynbos Biome of South Africa. *African Journal of Ecology*, 49:51–55.

Heelemann, S., Proches, S., Rebelo, A.G., Van Wilgen, B.W., Porembski, S., Cowling, R.M. 2008. Fire season effects on the recruitment of non-sprouting serotinous Proteaceae in the eastern (bimodal rainfall) fynbos biome, South Africa. *Austral Ecoogy,* 33:119–127.

Hoffmann, M. T., Skowno, A., Bell, W., and Mashele, S. 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

Hoffmann, M. T., Todd, S., Ntshona, Z. and Turner, S. 2014. Land degradation in South Africa. Collection. University of Cape Town.

Hoffmann, M.T. and Ashwell, A. 2001. Nature divided: land degradation in South Africa. University of Cape Town Press, Cape Town.

Hoffmann, M.T., Carrick, P.J., Gillson, L and West, A.G. 2009. Drought, climate change and vegetation response in the succulent Karoo, South Africa. *South African Journal of Science,* 105: 54–60.

Hoffmann, M.T., Carrick, P.J., Gillson, L and West, A.G. 2009. Drought, climate change and vegetation response in the succulent Karoo, South Africa. *South African Journal of Science,* 105: 54–60.

Hoffmann, M.T., Cousins, B., Meyer, T., Petersen, A. and Hendricks, H. 1999. Historical and contemporary land use and the desertification of the Karoo. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Holmes, P.M. 2005. Results of a lucerne old-field restoration experiment at the Fynbos-Karoo interface. *South African Journal of Botany*, 71:326–338.

Holmes, P.M. 2008. Optimal ground preparation treatments for restoring lowland Sand Fynbos vegetation on old fields. *South African Journal of Botany,* 74:33–40.

Holmes, P.M., Cowling, R.M. 1997. Diversity, composition and guild structure relationships between soil-stored seed banks and mature vegetation in alien plant-invaded South African fynbos shrublands. *Plant Ecology*, 133:107–122.

Holmes, P.M., Richardson, D.M., Van Wilgen, B.W., Gelderblom, C. 2000. Recovery of South African fynbos vegetation following alien woody plant clearing and fire: implications for restoration. *Austral Ecology*, 25:631–639.

Holness, S. and Oosthuysen, E. 2016. Critical Biodiversity Areas of the Northern Cape: Technical Report. Northern Cape Department of Environment and Nature Conservation, Kimberley.

Holness, S., Driver, A., Todd, S., Snaddon, K., Hamer, M., Raimondo, D., Daniels, F., Alexander, G., Bazelet, C., Bills, R., Bragg, C., Branch, B., Bruyns, P., Chakona, A., Child, M., Clarke, R.V., Coetzer, A., Coetzer, W., Colville, J., Conradie, W., Dean, R., Eardley, C., Ebrahim, I., Edge, D., Gaynor, D., Gear, S., Herbert, D., Kgatla, M., Lamula, K., Leballo, G., Lyle, R., Malatji, N., Mansell, M., Mecenero, S., Midgley, J., Mlambo, M., Mtshali, H., Simaika, J., Skowno, A., Staude, H., Tolley, K., Underhill, L., van der Colff, D., van Noort, S. and von Staden, L. 2016. Biodiversity and Ecological Impacts: Landscape Processes, Ecosystems and Species. In Scholes, R., Lochner, P., Schreiner, G., Snyman-Van der Walt, L. and de Jager, M. (Eds.). 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/

IUCN (International Union for Conservation of Nature). 2012. 2001 IUCN Red List Categories and Criteria version 3.1. Second edition. International Union for Conservation of Nature, Gland, Switzerland. 32 pp.

Jacobs D, MacEwan K, Cohen L, Monadjem A, Richards LR, Schoeman C, Sethusa T, Taylor PJ. 2016a. A conservation assessment of Cistugo seabrae. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs D, Cohen L, MacEwan K, Monadjem A, Richards LR, Schoeman C, Sethusa T, Taylor PJ. 2016b. A conservation assessment of Laephotis namibensis. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs D, Cohen L, Richards LR, Monadjem A, Schoeman C, MacEwan K, Sethusa T, Taylor P. 2016c. A conservation assessment of Rhinolophus blasii. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs, D.S., Schoeman M.C., Cohen, L., MacEwan, K., Monadjem, A., Richards, L.R., Sethusa, T. and Taylor, P. 2016d. A conservation assessment of Rhinolophus swinnyi. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs, K. and Jangle, R. 2008. Karoo Ecosystem Management Plan: Western Cape. Unpublished, The Nature Conservation Corporation, Cape Town.

James, C.S. & King, J.M. 2010. Ecohydraulics for South African Rivers: A Review and Guide. Water Research Commission, WRC Report No. TT 453/10. The publication of this report emanates from a project entitled: South African Handbook on Environmental River Hydraulics. WRC Project No. K5/1767.

James, J.J. & Carrick, P.J. 2016. Toward quantitative dryland restoration models. *Restoration Ecology*, 24:S85–S90.

Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International,* 20: 263-278.

Jonas, Z. 2004. Land use and its impacts on the Succulent Karoo. Master's Thesis. Department of Botany, Leslie Hill Institute for Plant Conservation, University of Cape Town, Rondebosch.

Jürgens, N. 2006. Desert Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 301–323.

Khavhagali, V.P. 2010. Importance, threats, status and conservation challenges of biodiversity in Northern Cape. *The Grassland Society of Southern Africa*, 10(4): 14–17.

Kottek, M., Grieser, J., Beck, C., Rudolf, B. & Rubel, F. 2006. World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*, 15(3):259-263.

Kraaij, T. 2010. Changing the fire management regime in the renosterveld and lowland fynbos of the Bontebok National Park. *South African Journal of Botany,* 76:550–557

Kraaij, T., Cowling, R.M., van Wilgen, B.W. 2013b. Lightning and fire weather in eastern coastal fynbos shrublands: seasonality and long-term trends. *International Journal of Wildland Fire,* 22:288–295.

Kraaij, T., Cowling, R.M., van Wilgen, B.W., Schutte-Vlok, A. 2013d. Proteaceae juvenile periods and post-fire recruitment as indicators of minimum fire return interval in eastern coastal fynbos. *Applied Vegetation Science*, 16:84–94.

Kraaij, T., Wilgen, B.W. Van, 2014. Drivers, ecology, and management of fire in fynbos. In: Allsopp, N., Colville, J.F., Verboom, G.A. (*Eds*.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 47–72.

Krug, C.B. 2004. Practical guidelines for the restoration of renosterveld. Conservation Ecology Department, University of Stellenbosch.

Kruger, F.J., Bigalke, R.C. 1984. Fire in fynbos. In: Booysen, P.D., Tainton, N.M. (Eds.), Ecological Effects of Fire in South African Ecosystems. Springer-Verlag, Berlin, pp. 67–114.

Krupek, A., Gaertner, M., Holmes, P.M., & Esler, K.J. 2016. Assessment of post-burn removal methods for Acacia saligna in Cape Flats Sand Fynbos, with consideration of indigenous plant recovery. *South African Journal of Botany*, 105:211–217

Krystufek, B. 2009. Indian flying fox Pteropus giganteus colony in Peradeniya Botanical Gardens, Sri Lanka. *Hystrix, the Italian Journal of Mammalogy*, 20(1):29-35.

Le Maitre, D., O'Farrell, P., Milton, S., Atkinson, D., De Lange, W., Egoh, B., Reyers, B., Colvin, C., Maherry, A., and Blignaut, J. 2009. Assessment and Evaluation of Ecosystem Services in the Succulent Karoo Biome. Report prepared by CSIR for the Succulent Karoo Ecosystem Programme (SKEP) Coordination Unit, SANBI.

Le Maitre, D.C., Forsyth, G.G., Dzikiti, S and Gush, M.B. 2016. Estimates of the impacts of invasive alien plants on water flows in South Africa. *Water SA*, 42(2): 659–672.

Le Maitre, D.C., Kruger, F.J., Forsyth, G.G. 2014. Interfacing ecology and policy: Developing an ecological framework and evidence base to support wildfire management in South Africa. *Austral Ecology*, 39:424–436.

Le Maitre, D.C., Seyler, H., Holland, M., Smith-Adao, L., Nel, J.L., Maherry, A. and Witthüser, K. (2018) Identification, Delineation and Importance of the Strategic Water Source Areas of South Africa, Lesotho and Swaziland for Surface Water and Groundwater. Report No. TT 743/1/18, Water Research Commission, Pretoria.

Lisóon, F. and Calvo, J.F. 2014. Bat activity over small ponds in dry Mediterranean forests: Implications for conservation. *Acta Chropterologica* 16(1): 95-101.

Lloyd, J.W. 1999. Nama Karoo. In: J. Knobel (Ed). The magnificent natural heritage of South Africa. Sunbird Publishing, Cape Town, South Africa. pp 84–93.

Lovegrove, B. 1993. The living deserts of southern Africa. Fernwood Press, Cape Town.

Markotter, W., MacEwan, K., White, W., Cohen, L., Jacobs, D., Monadjem, A., Richards, L.R., Schoeman, C., Sethusa, T., Taylor, P.J. 2016. A conservation assessment of Rousettus aegyptiacus. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Martin, L. 2011. Is the fruit you eat flying-fox friendly? The effects of orchard electrocution grids on Australian flying-foxes (Pteropus spp., Megachiroptera). In: B. Law, P. Eby, D. Lunney and L. Lumsden, The Biology and Conservation of Australasian Bats. Joint Symposium on the Biology and Conservation of Australasian Bats, Sydney, NSW, Australia, (380-390). 12-14 April, 2007. doi:10.7882/FS.2011.039

McAuliffe, J.R., Hoffmann, M.T., McFadden, L.D., Bell, W., Jack, S., King, M.P. and Nixon, V. 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.

McAuliffe, J.R., Hoffmann, M.T., McFadden, L.D., Jack, S. Bell, W. and King, M.P. 2019. Whether or not heuweltjies: Context-dependent ecosystem engineering by the southern harvester termite, *Microhodotermes viator*. *Journal of Arid Environments* (in press).

McCracken, D. 2008. Saving the Zululand Wilderness: An Early Struggle for Nature Conservation. Jacana.

Milton, S. 2009. The basis for sustainable business in the Karoo: Bringing ecological and economic issues together. Paper presentation. Karoo Development Conference and Expo, Graaff-Reinet, Eastern Cape.

Milton, S. J., Zimmermann, H. G. and Hoffmann, J. H. 1999. Alien plant invaders of the Karoo: attributes, impacts and control. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Milton, S.J. and Dean, W.R.J. 2012. Mining in the Karoo – Environmental Risks and Impacts. Paper presentation at the Karoo Development Conference, Beaufort West.

Minter, L.R. 2004. Atlas and red data book of the frogs of South Africa, Lesotho, and Swaziland. Animal Demography Unit, University of Cape Town.

Mirimin, L., Macey, B., Kerwath, S., Lamberth, S., Bester-van der Merwe, A., Cowley, P., Bloomer, P. and Roodt-Wilding, R., 2016. Genetic analyses reveal declining trends and low effective population size in an overfished South African sciaenid species, the dusky kob (Argyrosomus japonicus). *Marine and Freshwater Research*, 67: 266-276.

Monadjem, A., Cohen, L., Jacobs, D.S., MacEwan, K., Richards, L.R., Schoeman, C., Sethusa, T. & Taylor, P.J. 2016a. A conservation assessment of Kerivoula argentata. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. & Schoeman M.C. 2010. Bats of southern and central Africa – A biogeographic and taxonomic synthesis. Wits University Press, Johannesburg.

Monadjem, A., Taylor, P.J., Richards, L.R., White, W., Cohen, L., Jacobs, D., MacEwan, K., Schoeman, M.C. and Child, M.F. 2016b. A conservation assessment of Neoromicia rendalli. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Mucina, L., Geldenhuys, C.J., Rutherford, M.C., Powrie, L.W., Lotter, M.C., Von Maltitz, G.P., Euston-Brown, D.I.W., Matthews, W.S., Dobson, L., McKenzie, B. 2006c. Afrotemperate, Subtropical and Azonal Forests. In: Mucina, L., Rutherford, M.C. (Eds.), The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 585–615.

Mucina, L., Jürgens, N., Le Roux, A., Rutherford, M.C., Schmiedel, U., Esler, K., Powrie, L.W., Desmet, P.G. and Milton, S.J. 2006b. Succulent Karoo Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 221–299.

Mucina, L., Rutherford, M.C., Palmer, A.R., Milton, S.J., Scott, L., Lloyd, J.W., Van der Merwe, B., Vlok, J.H.J., Euston-Brown, D.I.W., Powrie, L.W. and Dold, A.P. 2006a. Nama Karoo Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 221–299.

Musil, C.F., Milton, S.J., Davis, G.W. 2005. The threat of alien invasive grasses to lowland Cape floral diversity: an empirical appraisal of the effectiveness of practical control strategies. *South African Journal of Science*, 101: 337–344.

Ndhlovu, T., Milton, S. and Esler, K.J. 2015. Effect of *Prosopis* (mesquite) invasion and clearing on vegetation cover in semi-arid Nama-Karoo rangeland, South Africa. *African Journal of Range and Forage Science, 33*(1): 11-19

Ndhlovu, T., Milton-Dean, S.J. and Esler, K.J. 2011. Impact of *Prosopis* (mesquite) invasion and clearing on the grazing capacity of semiarid Nama Karoo rangeland, South Africa. *African Journal of Range and Forage Science,* 28(3): 129–137.

Noroozi, J., Talebi, A., Doostmohammadi, M., Rumpf, S.B., Linder, H.P. and Schneeweiss, G.M. 2018. Hotspots within a global biodiversity hotspot - areas of endemism are associated with high mountain ranges. Scientific Report. *Nature*, 8(10345): 1–10.

O'Connor, T.G. and Bredenkamp G.J. 1996. Grasslands. In Cowling, R. M., Richardson, D., & Pierce, S. M. (*Eds*) Vegetation of Southern Africa. Cambridge, UK: Cambridge University Press.

Palmer, A.R. and Hoffmann, M.T. 1997. Nama-Karoo. In: Cowling, R.M., Richardson, D.M. and Pierce, S.M. (Eds.). Vegetation of southern Africa. Pp 167-188. Cambridge University Press, Cambridge.

Pauw, M.J. 2011. Monitoring Ecological Rehabilitation on a Coastal Mineral Sands Mine in Namaqualand, South Africa. Conservation Ecology and Entomology, University of Stellenbosch, Stellenbosch.

Rahlao, S.J., Milton, S.J., Esler, K.J., Van Wilgen, B.W. and Barnard, P. 2009. Effects of invasion of fire-free arid shrublands by a fire-promoting invasive alien grass (*Pennisetum setaceum*) in South Africa. *Austral Ecology* 34: pp920–928.

Rajeshkumar, S., Raghunathan, C. & Krishnamoorthy, V. 2013. Observation on Electrocution of Flying Fox (Pteropus giganteus) In Andaman Islands and their conservation strategies. Journal of the Andaman Science Association 18(2): 213-215. *Journal of the Andaman Science Association*, 18: 213-215.

Rebelo, A.G., Boucher, C., Helme, N., Mucina, L., Rutherford, M.C., Smit, W.J., Powrie, L.W., Ellis, F., Jan, J.N., Scott, L., Radloff, F.G.T., Steven, D., Richardson, D.M., Ward, R.A., Procheş, Ş.M., Oliver, E.G.H., Manning, J.C., Mcdonald, D.J., Janssen, J.A.M., Walton, A., Roux, A., Skowno, A.L., Simon, W., Hoare, D.B. 2006. Fynbos Biome. In: Mucina, L., Rutherford, M.C. (Eds.), The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria, pp. 52–219.

Reyers B, Fairbanks DHK, van Jaarsveld AS & Thompson MW. 2001. Priority areas for the Conservation of South African Vegetation: a coarse filter approach. *Diversity and Distributions,* 17:79-95.

Richards, L.R., Cohen, L., Jacobs, D., MacEwan, K., Monadjem, A., Schoeman, C., Sethusa, T. & Taylor, P.J. 2016d. A conservation assessment of Taphozous perforatus. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., MacEwan, K., White, W., Cohen, L., Jacobs, D.S., Monadjem, A., Schoeman, C. & Taylor, P.J. 2016a. A conservation assessment of Miniopterus inflatus. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., Schoeman, C., Taylor, P.J., White, W., Cohen, L., Jacobs, D.S., MacEwan, K., Sethusa, T. & Monadjem, A. 2016b. A conservation assessment of Otomops martiensseni. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., White, W., Cohen, L., Jacobs, D., MacEwan, K., Monadjem, M., Schoeman, C. & Taylor, P.J. 2016c. A conservation assessment of Scotoecus albofuscus. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Rio Tinto. 2013. Suistainable Development. http://www.riotinto.com/documents/ RT_SD_report_2013.pdf.

Rundel, P.W. and Cowling, R.M. 2013. Biodiversity of the Succulent Karoo. In: Levin, S.A. (Eds.) Encyclopedia of Biodiversity, Second Edition. Volume 1, pp. 485-490. Waltham, MA: Academic Press.

Rutherford, M.C., Powrie, L.M. and Schultze, R.E. 1999. Climate change in conservation areas of South Africa and its potential impact on floristic composition: a first assessment. *Diversity and Distributions* 5: 253–262

Schoeman, C., Jacobs, D.S., Cohen, L., MacEwan, K., Monadjem, A., Richards, L.R., Sethusa, T. & Taylor, P.J. 2016. A conservation assessment of Epomophorus wahlbergi. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Scholes, R. J. 1997. Savanna. In Cowling, R. M., Richardson, D., & Pierce, S. M. (*Eds*) Vegetation of Southern Africa. Cambridge, UK: Cambridge University Press.

Shaw, J.M. 2013. Power line collisions in the Karoo: Conserving Ludwig's Bustard. Unpublished PhD thesis. Percy FitzPatrick Institute of African Ornithology, Department of Biological Sciences, Faculty of Science University of Cape Town May 2013.

Simmons, N. B. 2005. Order Chiroptera. In: Mammal Species of the World: A Taxonomic and Geographic Reference, D. E. Wilson and D. M. Reeder, eds., Smithsonian Institution Press, Washington, DC. Fossil Evidence and the Origin of Bats. Available from: https://www.researchgate.net/publication/30845735_Fossil_Evidence_and_the_Origin_of_Bats [accessed Jul 09 2018].

Sirami, C., Jacobs, D.S. and Cumming, G.S. 2013. Artificial wetlands and surrounding habitats provide important foraging habitat for bats in agricultural landscapes in the Western Cape, South Africa. *Biological Cons*ervation, 164: 30–38.

Smith, A.B. 1999. Hunters and herders in the Karoo landscape. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

South Africa. 2011. National Environmental Management: Biodiversity Act: National list of ecosystems that are threatened and in need of protection. Government Gazette, 558(34809): 1 – 544, December 9.

South Africa. 2018. Notice of identification in terms of Section 24(5)(a) and (b) of the National Environmental Management Act, 1998, of the procedure to be followed in applying for Environmental Authorisation for large scale electricity transmission and distribution development activities identified in terms of Section 24(2)(a) of the National Environmental Management Act, 1998, when occurring in geographical areas of strategic importance. *Government Gazette*, 41445:113, 16 February 2018.

Taylor M. R. and Peacock, F. 2018. State of South Africa's Bird Report 2018. Johannesburg: BirdLife South Africa.

Taylor, M.R., Peacock, F. & Wanless, R.M. (*Eds*). 2015. The 2015 Eskom red data book of birds of South Africa, Lesotho and Swaziland. BirdLife South Africa.

Taylor, P., Jacobs, D., Cohen, L., Kearney, T., McEwan, K., Richards, L., Schoeman, C., Sethusa, T. & Monadjem, A. 2016a. A conservation assessment of Rhinolophus smithersi. *In:* Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert H.T. (*Eds*). The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Taylor, P.J., Richards, L., Bayliss, J., Cotterill, F.P.D. & Child, M.F. 2016b. A conservation assessment of Tadarida ventralis. In Child MF, Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert HT, editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Tinley, K.L. 1985. Coastal dunes of South Africa. National Scientific Programmes Unit: CSIR.

Todd, S. 2008. Options for Invasive Grass Management in the Nieuwoudtville Wildflower Reserve. Prepared for Indigo Development and Change, Nieuwoudtville.

Todd, S.W., Hoffmann, M.T., Henschel, J.R., Cardoso, A.W., Brooks, M. and Underhill, L.G. 2016a. The Potential Impacts of Fracking on Biodiversity of the Karoo Basin, South Africa. In: Glazwewski, J. and Esterhuyse, S. (Eds.). Hydraulic Fracturing in the Karoo: Critical Legal and Environmental Perspectives. First edition. Juta Press. pp 278–301.

Todd, S., Kirkwood, D., Snaddon, K. and Ewart-Smith, J. 2016b. Terrestrial and Aquatic Biodiversity Scoping Assessment Specialist Report. In: Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. Report prepared by the CSIR, DEA, Eskom and SANBI, Appendix C.3, pp. 1-169.

Turner, A.A. (*Ed*). 2017. Western Cape Province State of Biodiversity 2017. CapeNature Scientific Services, Jonkershoek, Stellenbosch

Turpie, J.K and Clark B 2009. Development of a Conservation Plan for temperate South African estuaries on the basis of biodiversity importance, ecosystem health and economic costs and benefits. CAPE programme.

Turpie, J.K., Forsythe, K.J., Knowles, A., Blignaut, J., Letley, G. 2017. Mapping and valuation of South Africa's ecosystem services: A local perspective. *Ecosystem Services*, 1–14.

Turpie, J.K., Heydenrych, B.J., Lamberth, S.J. 2003. Economic value of terrestrial and marine biodiversity in the Cape Floristic Region: implications for defining effective and socially optimal conservation strategies. *Biological Conervation*, 112:233–251.

University of Cape Town (UCT). 2018a. MammalMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT). 2018d. FrogMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT).2018b. ReptileMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT).2018c. ScorpionMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

Van Jaarsveld, E. 1987. The succulent riches of South Africa and Namibia. *Aloe* 24:45-92.

Van Niekerk, L, Adams, JB Lamberth, SJ, MacKay, F, Taljaard, S, Turpie, JK, Ramhukad, C-L, South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Environment. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol4/A. Draft Report.

Van Rooyen, C.S. 1998. Raptor mortality on power lines in South Africa. *Proceedings of the 5th World Conference on Birds of Prey and Owls*. Midrand (South Africa). Aug.4 – 8, 1998.

Van Wilgen, B.W., Forsyth, G.G., de Klerk, H., Das, S., Khuluse, S., Schmitz, P. 2010. Fire management in Mediterranean-climate shrublands: a case study from the Cape fynbos, South Africa. *Journal of Applied Ecology*, 47:631–638.

Van Wilgen, B.W., Reyers, B., Le Maitre, D.C., Richardson, D.M. and Schonegevel, L. 2008. A biome-scale assessment of the impact of invasive alien plants on ecosystem services in South Africa. *Journal of Environmental Management* 89: 336 –349.

Van Wyk, A.E. and Smith, G.F. 2001. Regions of floristic endemism in southern Africa. A review with emphasis on succulents. Umdaus Press, Hatfield

Vernon, C.J. 1999. Biogeography, endemism and diversity of animals in the Karoo. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Visser, V., Wilson, J.R.U., Canavan, K., Canavan, S., Fish, L., Le Maitre, D., Nänni, I., Mashau, C., O'Connor, T., Ivey, P., Kumschick, S., Richardson, D.M. 2017. Grasses as invasive plants in South Africa revisited: Patterns, pathways and management. *Bothalia* 47, 29 pages.

Walker, C., Milton, S.J., O'Connor, T.G., Maguire, J.M. and Dean, W.R.J. 2018. Drivers and trajectories of social and ecological change in the Karoo, South Africa. *African Journal of Range and Forage Science* 35:3-4, pp157-177.

Watkeys, M.K. 1999. Soils of the arid south-western zone of Africa. Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Williamson, G. 2010. Richtersveld – The Enchanted Wilderness. 2nd Ed. Umdaus Press, Hatfield. ISBN 978-919766-47-8, pp1–260.

Wilson, J.R., Gaertner, M., Griffiths, C.L., Kotzé, I., Le Maitre, D.C., Marr, S.M., Picker, M.D., Spear, D., Stafford, L., David, M., Wilgen, B.W. Van, Wannenburgh, A. 2014. Biological invasions in the Cape Floristic Region: history, current patterns, impacts, and management challenges. In: Allsopp, N., Colville, J., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press: Cape Town, pp. 273–298.

Woodhall, S. 2005. Field guide to the butterflies of South Africa. Struik.

Yamamoto, S. 1996. Gap regeneration of major tree species in different forest types of Japan. *Vegetatio*, 127(2):203-213.

11 SPATIAL DATA SOURCES

Animalia fieldwork database. Obtained from Werner Marais in July 2013.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander G.J., et al. (*Eds*). Atlas and red data list of the reptiles of South Africa, Lesotho and Swaziland, p. 423, SANBI: Pretoria (Suricata series; no. 1).

Bats KZN fieldwork database. Obtained from Leigh Richards and Kate Richardson in July 2017.

BLSA. 2014. White-winged Flufftail confirmed sightings 2000 – 2014. https://www.birdlife.org.za/.

BLSA (BirdLife South Africa). 2015. Nest localities of Southern Bald Ibis. https://www.birdlife.org.za/.

BLSA. 2018a. A list of potential Bush Blackcap, Spotted Ground-Thrush and Orange Ground-Thrush breeding habitat. https://www.birdlife.org.za/.

BLSA. 2018b. Yellow-breasted Pipit core distribution mapping. https://www.birdlife.org.za/.

BLSA. 2018c. Rudd's Lark core distribution mapping. https://www.birdlife.org.za/.

BLSA. 2018d. Botha's Lark core distribution mapping. https://www.birdlife.org.za/.

Burgess et al. 2004. Terrestrial ecoregions of Africa and Madagascar: A conservation Assessment. Island Press: Washington DC.

Burgess, N., Hales, J.D., Underwood, E., Dinerstein, E., Olson, D., Itousa, I., Schipper, J., Ricketts, T. & Newman, K. 2004. Terrestrial ecoregions of Africa and Madagascar: A conservation Assessment. Island Press: Washington DC.

CapeNature. 2017. Western Cape Biodiversity Spatial Plan 2017. http://bgis.sanbi.org/.

CGS (Council for Geoscience). 1990. 1: 1M geological data.

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.

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

Collins, N., (2017). National Biodiversity Assessment (NBA) 2018. Wetland Probability Map. https://csir.maps.arcgis.com/apps/MapJournal/index.html?appid=8832bd2cbc0d4a5486a52c843daebcba#

CSIR (Council for Scientific and Industrial Research). 2015. Information on various Red Data species nests obtained from the Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa.

DAFF (Department of Agriculture, Forestry, and Fisheries). 2016. National Forest Inventory. https://www.daff.gov.za/daffweb3/Branches/Forestry-Natural-Resources-Management/Forestry-Regulation-Oversight/Forests/Urban-Forests/Forestry-Maps.

DAFF. 2014. Field Crop Boundaries. Available at: http://bea.dirisa.org/resources/metadata-sheets/WP03_00_META_FIELDCROP.pdf

David Jacobs fieldwork database. Obtained from David Jacobs in May 2018.

DEA. 2016. National Protected Areas Expansion Strategy for South Africa. Pretoria: DEA.

DEA (Department of Environmental Affairs). 2018a. South African Protected Areas Database (SAPAD) Data. Q2, 2018.

DEA. 2018b. South African Conservation Areas Database (SACAD) Data. Q2, 2018.

DWS (Department of Water and Sanitation). 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/.

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. https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx.

DWS. 2015. Invertebrate Distribution Records. Department of Water and Sanitation RQIS-RDM, Pretoria. http://www.dwa.gov.za/iwqs/biomon /inverts/invertmaps.htm/ and http://www.dwa.gov.za/iwqs/biomon/inverts/ invertmaps_other.htm/

EWT (Endangered Wildlife Trust). 2006a (as supplemented by more recent unpublished data). Nest database for cranes, raptors and vultures. Endangered Wildlife Trust.

EWT. 2006b (as supplemented by more recent unpublished data). List of eagle nests on Eskom transmission lines in the Karoo.

Ezemvelo KZN Wildlife. 2016 KwaZulu-Natal Biodiversity Sector Plans. http://bgis.sanbi.org/.

Ezemvelo KZN Wildlife. 2018. Blue Swallow breeding areas.

Ezemvelo KZN Wildlife. 2018. Red data Bird nest localities.

Geoterraimage. 2015. 2013-2014 South African Natioanl Land-Cover. Department of Environmental Affairs. https://egis.environment.gov.za/.

Henning, G.A., Terblanche, R.F. and Ball, J.B., 2009. South African red data book: butterflies.

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.

IUCN (International Union for the Conservation of Nature). 2017. The IUCN Red List of Threatened Species, 2017. http://www.iucnredlist.org/

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.

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. Saftronics, Johannesburg and Animal Demography Unit, Cape Town.

MGHP (Mabula Ground Hornbill Project). 2018. Potential nesting areas of Southern Ground Hornbills. http://ground-hornbill.org.za/

Minter, L.R. 2004. Atlas and red data book of the frogs of South Africa, Lesotho, and Swaziland. Avian Demography Unit: UCT.

NC DENC (Northern Cape Department of Environment and Nature Conservation). 2016. Critical Biodiversity Areas of the Northern Cape. http://bgis.sanbi.org/.

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.

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.

Raimondo, D., Staden, L.V., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. and Manyama, P.A., 2009 (as updated in 2018). Red list of South African plants 2009, 2018 update. South African National Biodiversity Institute.

Ramsar Convention. 1971. Convention on Wetlands of International Importance especially as Waterfowl Habitat. https://www.ramsar.org/

Rautenbach, I.L. 1982. Mammals of the Transvaal. No. 1, Ecoplan Monograph. Pretoria, South Africa.

Samways, M.J. & Simaika, J.P. 2016. Manual of Freshwater Assessment for South Africa: Dragonfly Biotic Index. SANBI: Pretoria: Suricata 2, p. 224.

SANBI (South African Biodiversity Institute). 2012 Vegetation Map of South Africa, Lesotho and Swaziland. http://bgis.sanbi.org/.

SANBI. 2018. Interim findings of the National Biodiversity Assessment (work in progress). As available.

SANBI. 2018. Updated vegetation Map of South Africa, Lesotho and Swaziland. http://bgis.sanbi.org/.

Skowno et al. 2015. Terrestrial and Aquatic Biodiversity Scoping Assessment. In: Van der Westhuizen, et al. (*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

TNC (The Nature Conservancy). 2009. Terrestrial ecoregions. http://maps.tnc.org/gis_data.html

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.

Turpie, J.K., Wilson, G. & 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.

UCT (University of Cape Town). 1997. The Southern African Bird Atlas 1 (SABAP1). Animal Demography Unit, UCT.

UCT. 2007 - present. The Southern African Bird Atlas 2 (SABAP2). Animal Demography Unit, UCT.

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.

Van Niekerk, L., Adams, J.B., Bate, G.C., Forbes, N., Forbes, A. Huizinga, P., Lamberth, S.J., MacKay, F., Petersen, C., Taljaard, S., Weerts, S., Whitfield, A.K. & Wooldridge, T.H. 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.

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. & Wooldridge, T. H. 2015. Desktop Provisional Ecoclassification of the Temperate Estuaries of South Africa. Water Research Commission Report No K5/2187.

Van Niekerk, L., Taljaard, S., Ramjukadh, C.-L. Adams, J.B., Lamberth, S.J., Weerts, S.P., 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.

VulPro & Endangered Wildlife Trust. 2018. The national register of Cape Vulture colonies.

VulPro. 2017. National vulture restaurant database. http://www.vulpro.com/.

Wingate, L. 1983. The population status of five species of Microchiroptera in Natal. M.Sc. Thesis, University of Natal.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.1

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

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

FYNBOS BIOME

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ABBREVIATIONS AND ACRONYMS

CBA	Critical Biodiversity Area, numerals 1 and 2 indicate differing conservation importance
CR	Critically Endangered
EGI	Electricity Grid Infrastructure
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
EN	Endangered
ESA	Ecological Support Area, numerals 1 and 2 indicate differing conservation importance
IAP	Invasive alien plants
IAS	Invasive alien species
LM	Local Municipality
NBA	National Biodiversity Assessment
NPAES	National Protected Area Expansion Strategy
ONA	Other Natural Area
PA	Protected Area
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
VU	Vulnerable
WCBSP	Western Cape Biodiversity Spatial Plan

SUMMARY

A few patches of Fynbos Biome can be found in the proposed Expanded Western Electricity Grid Infrastructure (EGI) corridor.

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 threatened species occur in the lowlands which are the logical route for the proposed powerline corridors. On the inland side and in the drier valleys in the western part of the biome the Fynbos adjoins the Succulent Karoo. The western part of the biome experiences winter rainfall. 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. 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 may only germinate after fires and many species require fires to flower, produce seed and reproduce. Fires occur in and do regenerate 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. Fires under powerlines can be a hazard but management of fuel loads by carrying out fires at ecologically acceptable times of the year and in weather that will minimise the hazard should allow ecologically acceptable fire regimes to be maintained. The Environmental Management Programme should include measures to reduce fire hazards in accordance with the relevant specifications.

All forms of Fynbos are highly susceptible to invasion by alien (introduced) tree species, the arid fynbos in this corridor being invaded mainly by *Acacia cyclops* and *Prosopis* species. Sand-plain Fynbos and Renosterveld are very prone to invasion by alien herbaceous species, particularly grasses but invasions in Strandveld are poorly documented. Invasive species control will be an important part of the construction and operational phases, especially in the restored areas of pylon foundations at substations.

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). There are areas with populations of various species within the corridor that need to be excluded, as far as possible, during the routing phase of the EGI development.

Some of the taller Fynbos shrub species may exceed height requirements for the powerline although this is unlikely in the case of the arid fynbos occurring in this area. Should this be the case then the powerline 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 cleared strips under the powerline may become a barrier to the movement of some terrestrial fauna, notably reptile and invertebrate species. Fire could be used in the vegetation managed and, if it is, the intervals between fires and the seasonal timing need to be ecologically acceptable as noted above.

There is a growing body of research on the restoration of Fynbos, but it is still a developing science. There are a few guidelines and handbooks for restoration which have been noted in the text. 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 the Expanded Western EGI Corridor, 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, compared with the adjacent Succulent

Karoo vegetation, are strong rationales for making every effort to avoid Fynbos in arid areas when selecting the final EGI routes and placement. Disturbance also facilitates invasion, so regular monitoring and control operations will be required as part of the Environmental Management Programmes 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 powerline construction and operation makes it very difficult to assess the sensitivity with much confidence, especially the impacts of an extensive linear disturbance and potential habitat alteration. The effectiveness of the proposed mitigation also is difficult to assess for many species, especially those with limited mobility and have narrow distributions and/or specific habitat requirements which confine them 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.

Corridor	Overall Suitability	Comment
Expanded Western EGI Corridor	Moderate suitability for power line infrastructure development.	Fynbos occupies very little of the proposed Expanded Western EGI Corridor but the Fynbos that there is, is also characterised by a significant density of High and Very High sensitivity features. These areas typically harbour endemic and threatened plants and fauna. Much of the fynbos is located on the upper slopes and crests of mountain ranges which makes these areas unlikely to be selected for the final routes. However, there are areas of sand fynbos in the coastal areas which are more suitable for powerline routing but these should be avoided if at all possible. The risk of failure of the rehabilitation is high because Fynbos, especially the sand fynbos, is at the climatic limit so plant recruitment is likely to fail, especially for perennial species, unless there is good rainfall.

1 INTRODUCTION

The Department of Environment Affairs (DEA) appointed the Council for Scientific and Industrial Research (CSIR) to undertake a Strategic Environmental Assessment (SEA) for the expansion of Electricity Grid Infrastructure (EGI) within two 100 – 125 km corridors. The CSIR, in turn, appointed Dr David Le Maitre to carry out an assessment of the potential impacts of EGI on the Fynbos biome with the boundaries of the proposed Expanded Western EGI Corridor which extends northwards from about Nuwerus to the Orange River. This is an extension of the original EGI SEA (which was carried out in 2016 by the CSIR on behalf of DEA and Eskom) to include a section linking South Africa and Namibia. The Expanded Eastern EGI Corridor is not included within this assessment, as it does not intersect with 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. Aquatic ecosystems, including wetlands, were excluded from this assessment because these are covered separately by other specialist studies (Appendix C.1.7 of the EGI Expansion SEA Report).

2 SCOPE OF THIS STRATEGIC ISSUE

This study assesses the potential impacts of EGI in the proposed Expanded Western EGI Corridor on the vegetation types and the associated fauna (excluding avifauna) of the Fynbos Biome within the boundary of this corridor. Two boundaries were provided by the South African National Biodiversity Institute (SANBI), the one being the corridor itself and the other the same corridor but with the inland boundary buffered by 25 km.

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 APPROACH AND METHODOLOGY

3.1 Study Methodology

A desktop approach was used to assess terrestrial biodiversity sensitivity for the sections of the Fynbos Biome that are situated within the corridor section. The southern section of the corridor is located in the Western Cape but most of it is located within the Northern Cape Province. The two provinces do not have the same level of detail in their conservation planning although the 2016 plan for the Northern Cape (Holness and Oosthuysen, 2016) has far more detail than previous plans for this Province. The Western Cape has recently completed its own detailed assessment which supersedes and replaces all the previous studies including the national datasets (Pool-Stanvliet et al., 2017). The plan is detailed in a handbook which sets out, among others, the land-uses that can be permitted in areas that fall in the different categories of conservation protection. These differences were reconciled as far as possible.

The datasets provided for this study by SANBI and by the CSIR (as shown in Table 1) were consulted to determine if there were any conservation priorities such as threatened fynbos vegetation types or Critical Biodiversity Areas (CBAs) within the corridor boundaries. These datasets included the most recent conservation planning outputs for the corridor as well as information on the location of specific taxa. However, the data did not distinguish between the different categories of CBAs or Ecological Support Areas (ESAs) and so the original conservation plan datasets for the Northern Cape and for the Matzikama Local Municipality (LM) subset of the Western Cape Biodiversity Spatial Plan (WCBSP) were downloaded from the SANBI Biodiversity GIS (BGIS). The National Protected Areas Expansion Strategy (DEAT, 2008) is currently being updated, with a dataset for 2010 from the BGIS website being the most recent that is available. The 2016 Northern Cape Biodiversity Plan has updated the areas planned for protected area expansion but the WCBSP did not include the expansion of protected areas in the Matzikama dataset so the 2010 data were used for this part of the corridor.

3.2 Data Sources

A list and description of all data sources on which this assessment is based, and from which sensitive features/criteria were extracted is given in Table 1. Forest patches are often embedded in the Fynbos but there are no such patches in this corridor so forest was not included. 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 of the DEA (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[1], birds, butterflies, 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.

The Northern Cape Biodiversity Plan included locations of populations of threatened species of plant, butterfly, and reptiles based on data from SANBI, and the province, as CBA1 minimum (Holness and Oosthuysen, 2016) (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 Plan, areas supporting high climate change resilience (i.e. climate change adaptation corridors) were included as ESA polygons based on data from the National Biodiversity Assessment (NBA) 2011 (Driver et al., 2011) and sourced from SANBI (Table 1) (Holness and Oosthuysen, 2016). The Table Mountain Fund Climate Adaptation Corridors (Pence, 2009) were included in the ESAs and CBAs in the WCBSP after being edited to exclude all portions falling within the urban edge (Pool-Stanvliet et al., 2017).

The full set of threatened species locations for all the taxa within the corridor was supplied by SANBI to address potential gaps due to the optimisation processes noted above. 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 (see Section 6). 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.

The threatened species that would be most at risk typically occur within remnants of natural vegetation in the Sandveld and on the Kamiesberg. Whether or not the powerline 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 that 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

[1] Some amphibian species are independent of water and thus terrestrial but those species are not included in this assessment

of the taxa with smaller ranges. Although the larger mammals will be disturbed during the construction phase, they are highly unlikely to be permanently affected by the powerline and so are not shown in the maps 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 (PAs)	SANBI (2018) supplied for the SEA from the South African Protected and Conservation Areas Database with permission from DEA	PAs 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, and some forms of Stewardship Sites). This includes Protected Environments, Biosphere unprotected areas which are part of the outer zone of a Biosphere Reserve.
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
Listed Threatened Ecosystems of South Africa	Department of Environmental Affairs (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	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
Western Cape Biodiversity Spatial Plan datasets (Matzikama Local Municipality)	Pool-Stanvliet et al. 2017. The Western Cape Biodiversity Spatial Plan Handbook. Stellenbosch: 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.
2016 Northern Cape Critical Biodiversity Areas	2016 Northern Cape CBAs (Holness and Oosthuysen, 2016) Datasets downloaded from the BGIS.	The most recent biodiversity conservation plan available for the Province; includes Critical Biodiversity Areas and Ecological Support Areas. The Northern Cape CBA Map updates, revises and replaces all older systematic biodiversity plans and associated products for the province.
Critically Endangered, Endangered and Vulnerable taxa	Mammals (Child et al., 2016) Reptiles (Bates et al., 2014) Plants (Raimondo et al., 2009) updated to 2018; butterflies (Henning et al., 2009; Mecenero et al., 2013)	As prepared by SANBI and supplied to the CSIR
Other natural areas	Geoterraimage. 2015. 2013-2014 South African National Land-Cover. Department of Environmental Affairs. Geospatial Data. https://egis.environment.gov.za/	Natural land cover classes were used to identify remnants. Based on the natural land cover classes in the DEA Land Cover 2013/14 for the Northern Cape. A customised land cover classification was developed for the Western Cape for 2017 (Pool-Stanvliet et al., 2017)

3.3 Assumptions and Limitations

This desktop assessment of biodiversity sensitivity is based primarily on the most recent datasets available as supplied by SANBI in January 2018. None of these datasets were refined and/or modified. However, original data from the 2016 WCBSP for Matzikama LM and the 2016 Northern CBAs was added to better understand the features being considered in this study and the reasons for corridor being dominated by CBA1 and CBA2 features. This is a sufficient level of detail for this study, but route selection will require more detailed field work by specialists to ground-truth and verify these assessments as well as consultation with local experts (Table 2).

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 (Table 2). This heterogeneity is inappropriate for fine-scale analysis and interpretation, such as proposing provisional routes, except in a very general sense. Data at this range of spatial resolutions and accuracies cannot simply be mixed and used to assess routes with a high degree of confidence without field verification. The extent of the corridor that needs to be assessed means that fine-scale features cannot be assessed in detail. This is just 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.

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 – an area may be classified as CBA1 because it contains a threatened ecosystem, or threatened flora or fauna, or is irreplaceable or provides 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 powerline through that area on those different features could be very different, even depending on the species involved. This means that their sensitivities would differ and cannot be reduced to one single sensitivity rating.

This assessment also only focuses on terrestrial ecosystems and their fauna and flora (Table 2), 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 powerline (Mouquet et al., 2013; Nakano and Murakami, 2001; Samways and Stewart, 1997). There is a separate assessment of aquatic systems but, ideally, the terrestrial and aquatic experts should collaborate to develop an integrated assessment. Only such an integrated assessment can provide the knowledge required to properly assess ecosystem sensitivity and the impacts that powerline 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.

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 powerlines 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 powerlines.

Table 2: Summary of limitations and assumptions in this study

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Resource availability	Only existing, published datasets used	Field verification of datasets and outcomes, and extensive local expert consultation	Reasonable accuracy of data layers used. Field verification will take place on a site by site basis linked to development proposals.
Scale of analysis	This assessment is limited to a strategic overview of important conservation concerns, not detailed route planning	As above.	As above.
The information is not sufficiently accurate or complete to be sure the species may not occur if suitable habitat is available	Datasets used as supplied by SANBI for the SEA	Field verification of datasets and outcomes, and extensive local expert consultation	The locations in the data layers are reasonably accurate and complete. Field verification will take place on a site by site basis (e.g. suitable habitat remnants) linked to development proposals.
Scope	Limited to terrestrial biodiversity.	Embedded ecosystems with different functions (e.g. wetlands, river floodplains) and the functional interactions between these ecosystems.	Wetlands, birds and bats biodiversity concerns are adequately covered in separate specialist reports (Appendix C.1.6, Appendix C.1.7 and Appendix C.1.8 of the EGI Expansion SEA Report, respectively).

3.4 Relevant Regulatory Instruments

A wide range of regulatory instruments are applicable for the construction and operation of powerlines and across the different spheres of government (Table 3).

Table 3: Summary of the relevant regulatory instruments for the different spheres of government.

Instrument	Key objective	Feature
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.	Only where this includes terrestrial features due to boundary choices. Unlikely to be an issue unless the final routing crosses the Orange River near the mouth.
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: 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).	All natural and heritage features in protected areas including species and ecosystems
National Environmental Management Act (Act 107 of 1998) as amended.	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."	Overall promotion of the protection and conservation of all natural features
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	Overall promotion of the protection and conservation of all threatened species and ecosystems; regulation and control

Instrument	Key objective	Feature
	protected ecosystems, in one of four categories: critically endangered (CR), endangered (EN), vulnerable (VU) or protected. Listing Notice 3 (Government Notice R324 of 2017) Activity 12 relates to clearing of 300 m^2 or more of vegetation, within Critical Biodiversity Areas. The Act and Regulation 598 of 1 August 2014 require the control of listed invasive alien species, including plants on all land.	of invasive listed alien species
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.
Spatial Planning and Land Use Management Act (SPLUMA) (No. 16 of 2013)	This is a national framework Act that regulates spatial planning as well as land use management, across all spheres of government.	Protection of natural features through zonation and other planning measures that prohibit or limit development and human activities.
NEMA EIA 2014 Regulations (Government Gazette 40772 (as amended, 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. 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.	Prohibition and limitation of activities and developments affecting natural areas by requiring of Strategic and site or Project level Environmental Impact Assessments
NEM: Biodiversity Act (No 10 of 2004): Alien and Invasive Species Regulations, 2014	Listings of alien species by category, restricting activities involving alien species and other matters	Requirement for land owners to control invasive alien species on their land in accordance with the restrictions and measures provided for in the act and regulations.
NEMA Biodiversity Act 10 of 2004: Threatened and protected species regulations (2015) (seemingly not yet in force)	The purpose of these Regulations is to regulate the activities involving specimens of listed threatened or protected species	Protection of threatened and protected species.

Instrument	Key objective	Feature
Provincial Instrument		
Nature Conservation Laws Amendment Act of 2000 (an amendment of the Cape nature Conservation Ordinance of 1994)	This Act is applicable in the Western Cape. It provides measures to protect the natural flora and fauna, lists nature reserves and endangered flora and fauna	Protection of natural flora and fauna
Northern Cape Nature Conservation Act No. 9 of 2009 (came into force in January 2012 but according to some legal authorities the 1994 Ordinance still applies)	To provide for the sustainable utilisation of wild animals, aquatic biota and plants; to provide for the issuing of permits and other authorisations; and to provide for matters connected therewith.	Protection of natural flora and fauna

4 IMPACT CHARACTERISATION

The development of EGI involves the construction of powerlines, substations and other infrastructure together with permanent access routes for the servicing the infrastructure including the powerlines. The access roads have to be built to a level which enables vehicular access during construction as well as for maintenance operations, including poor weather conditions. They are generally constructed for all-wheel drive vehicles which are able to transport the equipment and materials required for construction and subsequently for maintenance work.

This assessment assumes that the proposed EGI infrastructure will be developed for a typical 765 kV power line which requires a servitude of 40 m on either side of the power line and an additional 50 m on either side for the "development envelope", making a total width of 180 m (Figure 1) (DEA, 2016). Building width restrictions are 22-40 m from the centre line and vegetation clearance is required from the centre to the outer conductor plus an additional 10 m either side. The minimum vertical clearance would be 8.5 m. During construction each pylon footprint would be about 1 ha or 166 ha per 100 km. There will be substations which could be as large as 70 ha and could have significant impacts. However, the only planned substation (powerline anchor point) indicated in this corridor will be located near Springbok (DEA, 2016). This is located is well outside the fynbos biome and has been excluded from this assessment. Access (service) roads for construction are generally ±4 m wide during construction but can be allowed to revert to a typical two-track for those required for maintenance operations. The width of the road impact will depend on the habitat, slope or terrain because traversing slopes requires cut and fill, and routing tracks directly up steep slopes is not desirable because of the risk of erosion, even with suitable drainage. Special provision will have to be made in areas with deep, loose sand to ensure that the tracks do not grow wider or become multiple tracks as drivers seek to find easier routes. There will also be temporary areas for construction camps or storage of materials and for borrow pits (permanent excavations). Any areas and roads that will not be used for maintenance during the operational phase must be restored.

Figure 1: Diagram of the typical footprint of a 765 kV powerline corridor (DEA, 2016).

The fynbos vegetation is typically a low shrubland (<1.2 m) and so does not need special maintenance under the powerline which means that its habitat suitability for fauna should not be affected. Normally fynbos would require fires to maintain biodiversity and ecosystem function (Kraaij and Wilgen, 2014), but fires are very infrequent in these arid fynbos areas. 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 biggest fire being in the Kamiesberg (unpublished data, Advanced Fire Information System, Meraka Institute, CSIR). Eskom does practice clearing under its powerlines to avoid the electrical shorts that can happen when soot accumulates on the isolators or reaches sufficient concentrations to cause flash overs. Should Eskom deem it necessary to maintain cleared 80 m wide belts under the powerlines this is likely to have significant impacts on ecosystem structure, biodiversity and function, at least at the local level and where remnants become further fragmented into smaller remnants (Pool-Stanvliet et al., 2017; Rouget et al., 2014, 2006, 2003). This outcome should be avoided if at all possible given the potentially significant loss of habitat this would entail, the potential loss of species unable to survive the clearing, and the formation of a linear barrier that may affect faunal migration and movements. Since the EGI corridor is generally routed across the altitudinal and climatic gradients between the coast and the inland highlands in this area, the clearing also could affect the viability of climate adaptation corridors that have been planned in the area.

The diversity and endemism of the terrestrial fauna in Fynbos is relatively low 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). 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). Little is known about its importance in arid fynbos although it is known to be widespread in the fynbos and to occur in Springbok in the corridor (Picker and Griffiths, 2011). Ant seed dispersal is disrupted by the Argentine 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, 1988; Wilson et al., 2014).

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 persist. Nevertheless, the planning of the powerline and its operation should make provision for periodic fires and the environmental management programme should make provision for prescribed fires at ecologically acceptable intervals and times of the years while minimising the hazard that fires under powerlines can pose. The optimal seasons for burning are summer or autumn but the desired intervals between fires are not known at present. Expert advice should be obtained before conducting any planned fires.

All the fynbos vegetation in the corridor 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 (Blignaut et al., 2013) which is in an area with higher and more reliable rainfall. There has been research on restoration in Namaqualand but in the Strandveld or Succulent Karoo and not in the fynbos (Carrick et al., 2015; Carrick and Krüger, 2007; James and Carrick, 2016). 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; Krug, 2004). 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 the areas of fynbos when selecting the final EGI routes.

Fynbos is subject to invasion by introduced alien tree species which must be removed in terms of the National Environmental Management: Biodiversity Act and regulations (see section 3.4). Invasive trees known to be present in fynbos in the corridor include *Acacia cyclops* and *Prosopis* species. Invading alien grasses are an issue of increasing concern in the drier parts of South Africa and there is concern that they can alter and transform ecosystems, including making them fire-prone (Rahlao et al., 2009; Todd, 2008; V. Visser et al., 2017). In the corridor area the current and potential invaders include *Bromus* species and potentially *Pennisetum setaceum* which are invaders in the Succulent Karoo but are spreading into Fynbos. Both are dispersed by wind and along roads by the movement of vehicles and special care will have to be taken to avoid dispersing them in the construction and operational phases of the powerlines and to control them if they become established. Grass invasion may be facilitated by 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; Vernon Visser et al., 2017) and may severely affect heuweltjie[2] communities (D.C. Le Maitre personal observations).

Field surveys to assess the occurrence of threatened and other species of interest must be commissioned about a year in advance of the date by which decisions about the final routing are made. This is because

[2] Heuweltjies are circular features with distinctive plant communities and enhanced levels of faunal diversity and activity associated with their characteristically relative fertile soils.

many plant species, in particular, are only flower and can be positively identified in the spring or early summer. Some may only flower after fire but the low frequency of fire will generally rule out detection of these species.

In summary, the construction of powerlines and associated infrastructure has a number of key ecosystem impacts during the construction and operational phases, the main ones being:

- Changes in ecosystem structure, function and biodiversity with potential impacts on threatened ecosystems and species including loss of habitat and displacement;
- Alien plant invasions which can also alter fire regimes.

5 EXPANDED WESTERN EGI CORRIDOR DESCRIPTION

The corridor is situated on the West Coast of South Africa and in the winter rainfall area 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 summers are hot and dry but the temperatures are moderated by onshore winds.

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). The 25 km buffer includes some areas of Bokkeveld Sandstone Fynbos but they do not extend into the corridor itself. The only Azonal vegetation types within the corridor are found in the estuary and areas of salt marsh of the Olifants River which just enters the 25 km buffer in the extreme south. They are described in a separate specialist report (Appendix C.1.6 of the EGI Expansion SEA Report).

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 mountains in the Richtersveld. All of these montane fynbos vegetation types grade into Succulent Karoo rather than having abrupt transitions. Namaqualand Sand Fynbos is found on the leached, deep sands on the coastal plain where it is embedded in the Strandveld vegetation types which are part of the Succulent Karoo. The Namaqualand Sand Fynbos is generally within 20 km of the coast, but a narrow strip does extend about 30 km inland in the northernmost section of the vegetation type. Namaqualand Sand Fynbos may require the additional moisture from the frequent fogs that occur on the West Coast, particular in the summer and early autumn, and can supply reasonable amounts of water (Olivier, 2002). However, their ecological role is not well understood. Cutting or mowing of the vegetation under the powerline could reduce its ability to capture moisture and could make it more prone to mortality during summer, especially during droughts.

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 Northern Cape, the Kamiesberg Granite Fynbos is considered a CBA1 because of its extreme rarity and endemism – it covered less than 5000 ha originally and is confined to the province (Holness and Oosthuysen, 2016). Most of the Namaqualand Granite Renosterveld and Namaqualand Sand Fynbos fall into areas which are CBA1 or CBA2. All of the areas which were considered CBAs were classified as such because of conservation importance and not just because they are earmarked for protected area expansion.

Only the Namaqualand Sand Fynbos extends into the Western Cape in the Matzikama LM. Portions of this vegetation type are regarded as CBA1 and portions as Other Natural Areas (ONAs). The southern end of the most southerly portion of Namaqualand Sand Fynbos is part of a climate adaptation corridor. A portion of the Bokkeveld Sandstone Fynbos falls into the 2016 National Protected Area Expansion Strategy but all of it is within the 25 km buffer around the corridor.

The northern section of the Stinkfonteinberge Quartzite Fynbos falls within the Richtersveld National Park and the southern portion within the Richtersveld World Heritage Site. There are no PAs in the Namaqualand Granite Renosterveld and Kamiesberg Granite Fynbos; two small portions of the Namaqualand Sand Fynbos fall into the Namaqua National Park. The Namaqualand National Park forms a link between the coast and the Namaqua Highlands. Linking this park to the Kamiesberg is seen as a very high conservation priority so routing a powerline through this area would be seen as much more than just a significant aesthetic and visual impact.

The terrestrial fauna of these fynbos vegetation types has not been well studied and is poorly known. Threatened species of plant, mammal, and reptile locations, based on data supplied by SANBI and the provincial records, were included this assessment (see Table 1 for details). In the Northern Cape all threatened species were in included in the areas designated as CBA1. For the Matzikama LM (which falls in the Western Cape), threatened species occurrences were included in the CBAs but some records may have been excluded through the optimisation process. To compensate for this all the threatened species locations within the corridor and 25 km buffer, as supplied by SANBI, were included in the maps for this assessment. The only Important Bird Area in the corridor is the Ramsar site on the Orange River estuary which is the subject of a separate specialist assessment. No species names were supplied with the data so it is not possible to provide information on the species that are likely to be found in the corridor based on their historical occurrences.

It is very clear from the maps that areas falling in the classes CBA1 and CBA2 extend over the entire northern portion of the corridor and are narrowest near the north-eastern corner of the corridor where the N7 approaches the Orange River.

6 FEATURE SENSITIVITY MAPPING

6.1 Identification of feature sensitivity criteria

This study has used 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, National Protected Area Expansion Strategies (NPAES) and climate adaptation corridors in their CBAs and ESAs and the latest information on the PAs (Table 4). This has been supplemented with information on the treated species locations as supplied by SANBI (see Section 3.2).

Table 4: Summary of the data sources and their preparation and processing as applicable to the Expanded Western EGI Corridor

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
Protected Areas	As included in the 2016 Northern Cape CBA and WCBSP for Matzikama	These datasets were found to be more complete than those in the last version of National PAs available from the BGIS. 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) 2014 EIA Regulations, as amended. Environmental Authorisation is required and a Basic Assessment needs to be conducted for specified activities within these buffers.
World Heritage Site	Richtersveld World Heritage Site in the Northern Cape	The World Heritage Site was treated the same as a Protected Area (see above)
Ramsar site	Estuary including the salt marshes	Excluded from this assessment as it is covered in a separate specialist study
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.
CBA1	Western Cape Biodiversity Spatial Plan: Matzikama & 2016 Northern Cape Critical Biodiversity Areas	In the WCBSP every individual CBA is provided with a "reason" which takes one or more features into account. The "reasons" given often include both terrestrial and aquatic systems in the same CBA which makes it difficult to differentiate. The Northern Cape CBAs took four features into account: ecosystem threat status, rarity, endemism and ecosystem process importance
CBA2	Western Cape Biodiversity Spatial Plan: Matzikama & 2016 Northern Cape Critical Biodiversity Areas	See above for WCBSP. 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)
ESA1	Western Cape Biodiversity Spatial Plan: Matzikama	See above for WCBSP. These areas include ecosystems that range from natural to moderately degraded
ESA2	Western Cape Biodiversity Spatial Plan: Matzikama	See above for WCBSP. These areas require restoration because they are severely degraded or have no natural cover
ESA	2016 Northern Cape Critical Biodiversity Areas	Does not distinguish between ESA categories or give reasons for specific ESAs
Other Natural Areas (ONA)	Western Cape Biodiversity Spatial Plan: Matzikama & 2016 Northern Cape Critical Biodiversity Areas	ONAs are not a priority at present; they retain a natural level of biodiversity and ecosystem functions and should be avoided where possible

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. 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 CBA1 is for ecosystems in natural or near-natural condition and a CBA2 comprises ecosystems that are degraded and can and should be restored. The category ESA is used for areas which are important for buffering and 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, and 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. 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 tightly restricted by guidelines in the protected area plan, as prescribed in the NEM: Protected Areas Act. In essence this amounts to treating PAs as having very high sensitivity and equivalent to a CBA1.

In the 2016 Northern Cape CBA plan the CBAs took four features into account: ecosystem threat status, rarity, endemism and ecosystem process importance (Holness and Oosthuysen, 2016). Threatened species of plant, butterfly, and reptile locations based on data from SANBI and the province were included in the Northern Cape as CBA1 minimum. The PA expansion areas were also categorised as CBA2. 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. 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. The sensitivity ratings given to each feature class and the buffers (where appropriate) are summarized below (Table 5).

Table 5: Summary of the features and the sensitivity ratings applied in the assessment of the proposed Expanded Western EGI Corridor.

Feature Class	Feature Class Sensitivity	Buffer Distance, Sensitivity
World Heritage Site	Very High	High: Northern Cape Biodiversity Plan included proclaimed buffer as CBA2, WCBSP – no such areas in this part of the province
Protected Areas Matzikama (all types)	Very High	No buffer used in Matzikama Local Municipality (WCBSP)
Protected Areas Northern Cape (all types)	Very High	High: in this assessment; Moderate for PA buffers of 5 km and National Parks by 10 km as CBA2
CBA from Western Cape Biodiversity Spatial Plan	CBA1: Very High	None
	CBA2: High	None
	ESA1 and ESA2: Medium	None
CBA from 2016 Northern Cape CBA Plan	CBA1: Very High	None
	CBA2: High	None
	ESA: Medium	None
Threatened taxa - Mammals: Perissodactyla (Zebras, Rhinos) and the larger Carnivora (African Wild Dogs, Cheetahs, Leopards)	High	50 km

Feature Class	Feature Class Sensitivity	Buffer Distance, Sensitivity
Threatened taxa - Mammals: Rodentia, Soricomorpha (Shrews) and Afrosoricida (Golden moles);	High	2.5 km
Threatened taxa - Mammals: larger Artiodactyla (Antelope) – Tsessebe, Bontebok, Roan Antelope, Sable Antelope, Mountain Reedbuck.	High	10 km
Other mammals: (Hyracoideae (Hyraxes), Lagomorpha (Rabbits, Hares), Macroscelidae (Elephant shrews), Pholidota (Pangolins), Primates, Tubulidentata (Aardvarks)).	High	5 km
Threatened taxa - Reptiles: Crocodiles	High	25 km
Threatened taxa - Other reptiles, amphibians and butterflies	High	2.5 km
Land Cover: Natural Area (includes Other Natural Areas) Land Cover: Transformed	Medium Low	None

6.2 Feature maps

The feature maps highlight the Fynbos Biome (outlined by a 5 km external buffer) with the features in the other biomes being shown but translucently masked. This enables the context for each feature within the Fynbos to be seen in relation to the surrounding biomes. This means that important features in the adjacent biome and the connectivity across biome boundaries are at least visually evident to the decision makers.

6.2.1 Expanded Western Corridor

This section highlights the different features that have been combined to develop the overall sensitivity map. Most of the corridor is located in the Northern Cape with a portion of the Matzikama Local Municipality in the Western Cape Province in southern part of the corridor (Figure 2). The Fynbos in this corridor is essentially a set of islands located either on the mountain tops (Kamiesberg, Richtersveld, Bokkeveld in the 25km corridor buffer in the SE corner) or on the coastal plain. Since the Richtersveld portion is located on rugged mountain tops, and either in a national park or world heritage site, it is very unlikely to be considered for the powerline route and so need not be covered in detail. Excluding the Richtersveld portion allows for more detail to be shown of the southern section (Figure 3), illustrating how the Fynbos is embedded in the Succulent Karoo and how conservation features extend across the biome boundaries. The same rationale was applied to the maps of the occurrences of threatened species where only those in the southern section of the corridor and within 5km of the boundary between the Fynbos and the Succulent Karoo biomes are shown. It is evident that the threatened species in the Fynbos are located mainly in the Kamiesberg (Figure 4 and Figure 5). This is not surprising because the Kamiesberg is a relatively well studied and documented part of Namaqualand because of its unusual and unique ecosystems.

The Namaqualand National Park only includes small portions of Fynbos, including part of the central area of Namaqua Sand Fynbos (Figure 2), and extends inland to near the Kamiesberg. The aim is to connect it to the Kamiesberg Fynbos to provide a climate change adaptation corridor and this is included in the protected area expansion strategy. Although the powerline could be routed through this area it should be avoided if possible.

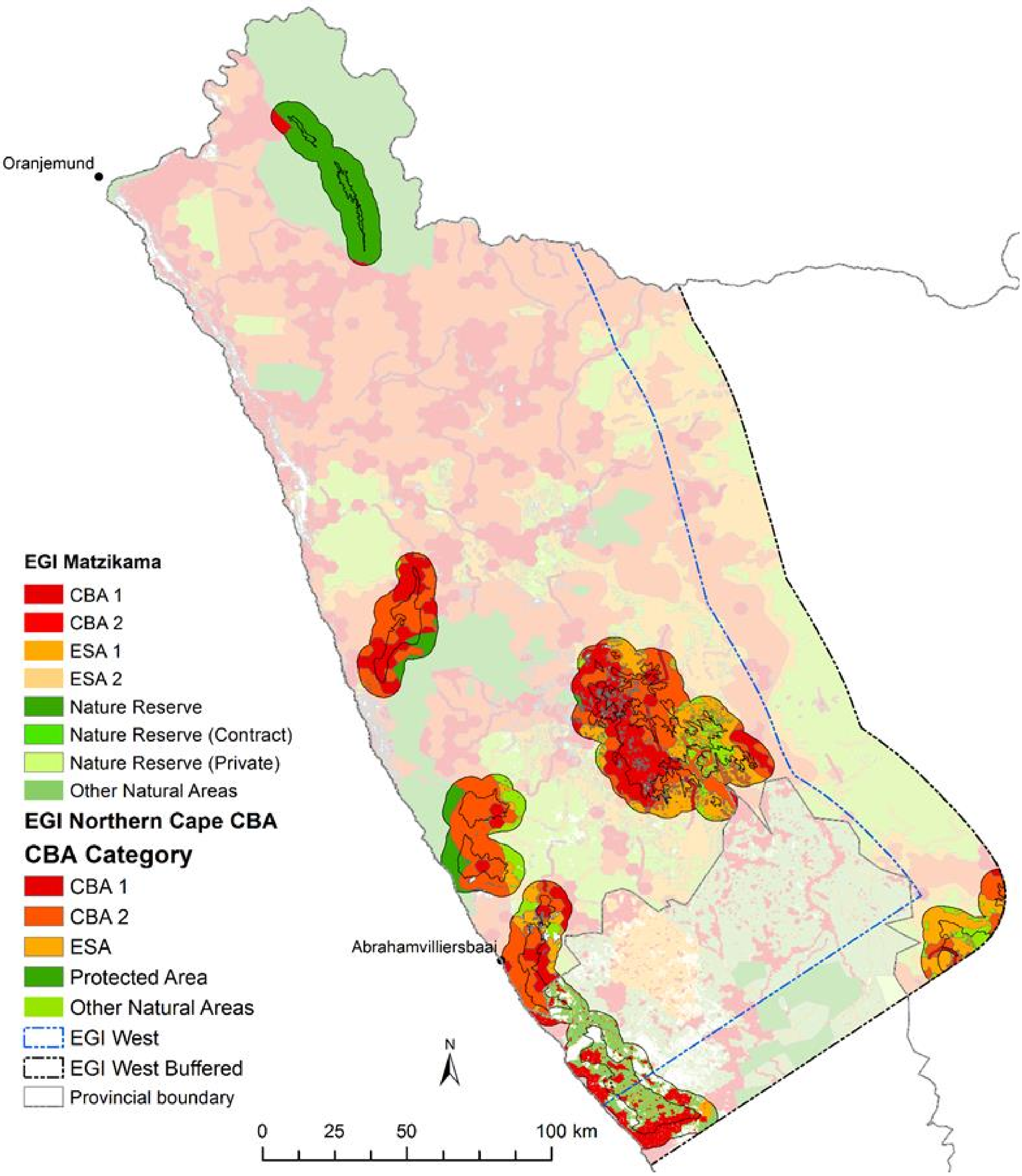

Figure 2: The EGI Expansion Western Corridor showing the outlines of the areas of Fynbos vegetation, outlined by a 5 km external buffer, and overlaid on the conservation plan data for the Northern Cape and the Western Cape. White areas are transformed with no natural vegetation remaining or areas not included in this assessment (e.g. the Olifants River estuary).

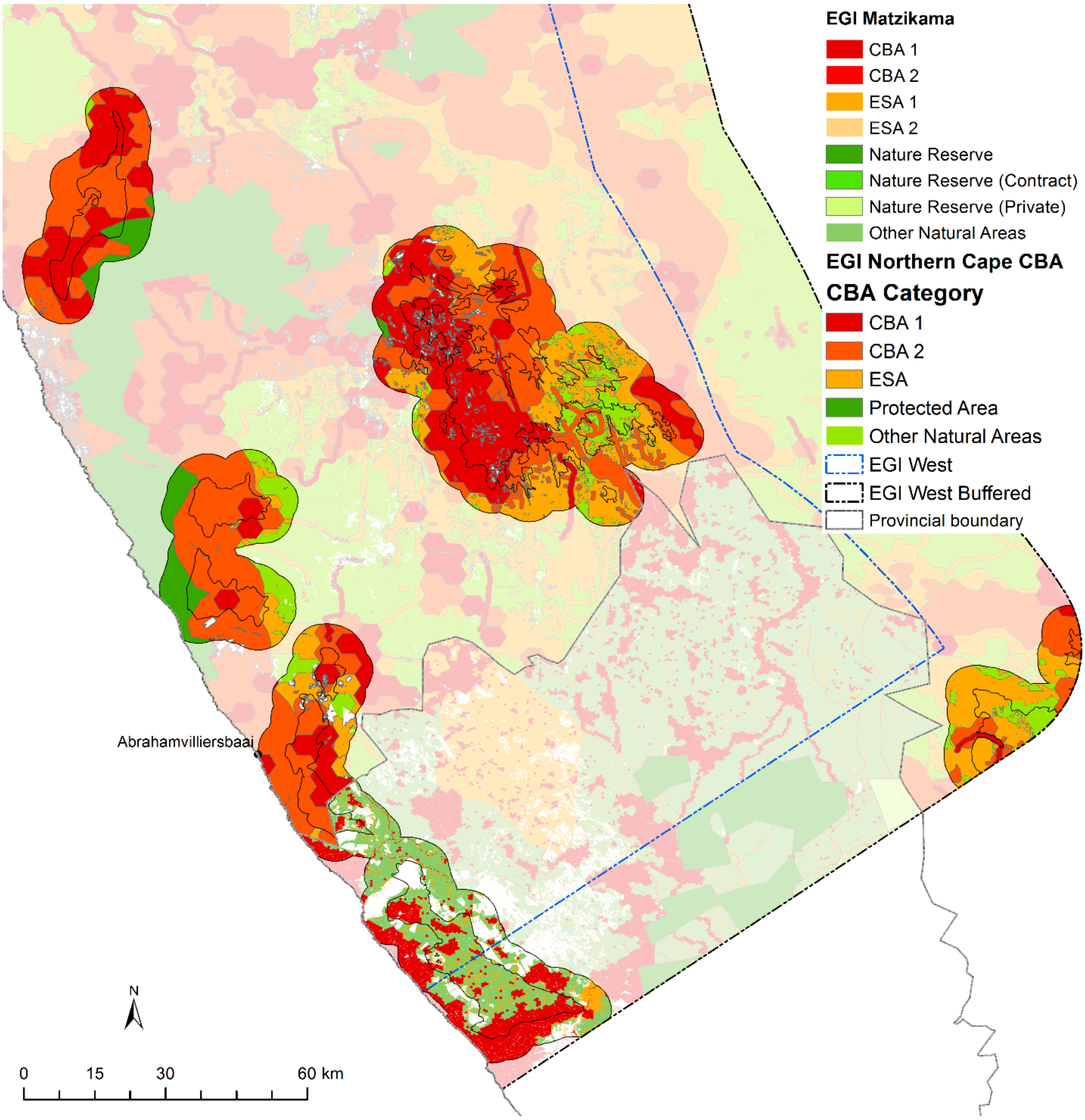

Figure 3: Detail of the southern portion of the Expanded Western EGI Corridor showing the outlines of the areas of Fynbos vegetation (black line), outlined by a 5 km external buffer, and overlaid on the conservation plan data for the Northern Cape and the Western Cape. White areas are transformed with no natural vegetation remaining or were excluded from this assessment).

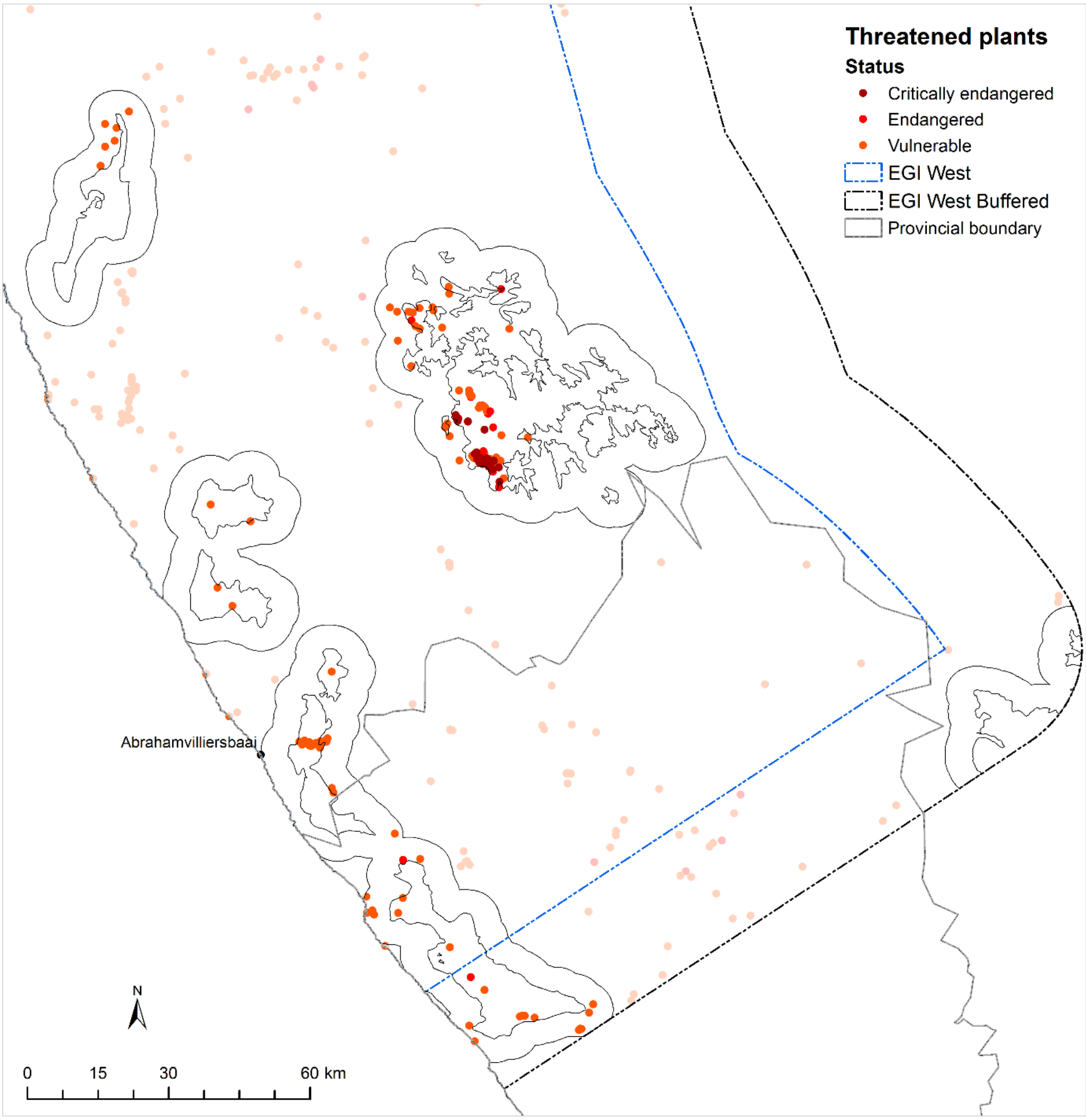

Figure 4: The occurrences of plant species classified as critically endangered, endangered, and vulnerable.

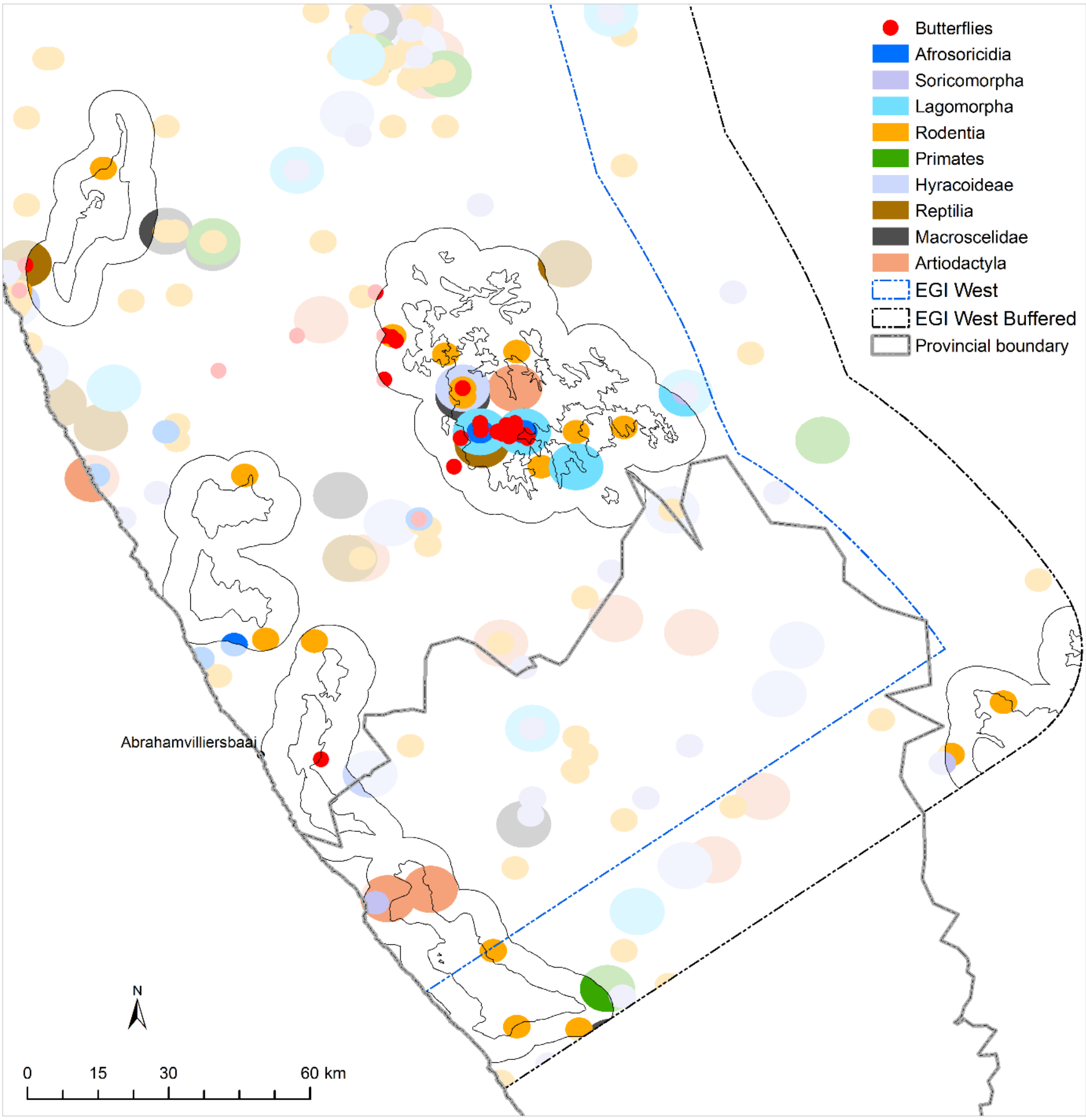

Figure 5: The occurrences of faunal species classified as critically endangered, endangered, and vulnerable.

7 FOUR- TIER SENSITIVITY MAPPING

The relative sensitivity mapping is based on a four-tier sensitivity classification using the following classes:

- Dark Red: Very High Sensitivity
- Red: High Sensitivity,
- Orange: Moderate Sensitivity
- Green: Low Sensitivity

The lowest sensitivity forms the base layer and the higher sensitivity features are overlaid on this so that the final decision making can be based on the highest sensitivity in a given area.

7.1 Four Tier sensitivity maps

The biodiversity planning classes have been converted to the four levels (Table 6):

Table 6: Four-tier sensitivity classes assigned to the biodiversity planning features

Biodiversity planning class	Sensitivity
CBA1	Very high
CBA2	High
ESA1 or ESA2	Moderate
Protected Area	Very High
Other Natural Area	Moderate
Transformed (no natural vegetation remaining)	Low

7.1.1 Expanded Western Corridor

Only the southern portion of the corridor is shown here as the fynbos in the Richtersveld area in the north is all in the Very High sensitivity class because it is all situated within a formally protected area (Figure 6). It is clear that the Fynbos vegetation within this corridor includes extensive areas which are classified as Highly or Very Highly sensitive and should be avoided if at all possible. When taken together with the Succulent Karoo sensitivity classes, the portion between the Namaqualand National Park and the Kamiesberg is an area which is all Highly or Very Highly sensitive, suggesting that a route to the east of the Kamiesberg is the best option. Given that this corridor is dominated by Succulent Karroo, the optimal route will be determined by the spatial distribution and characteristics of the features in this biome rather than the Fynbos.

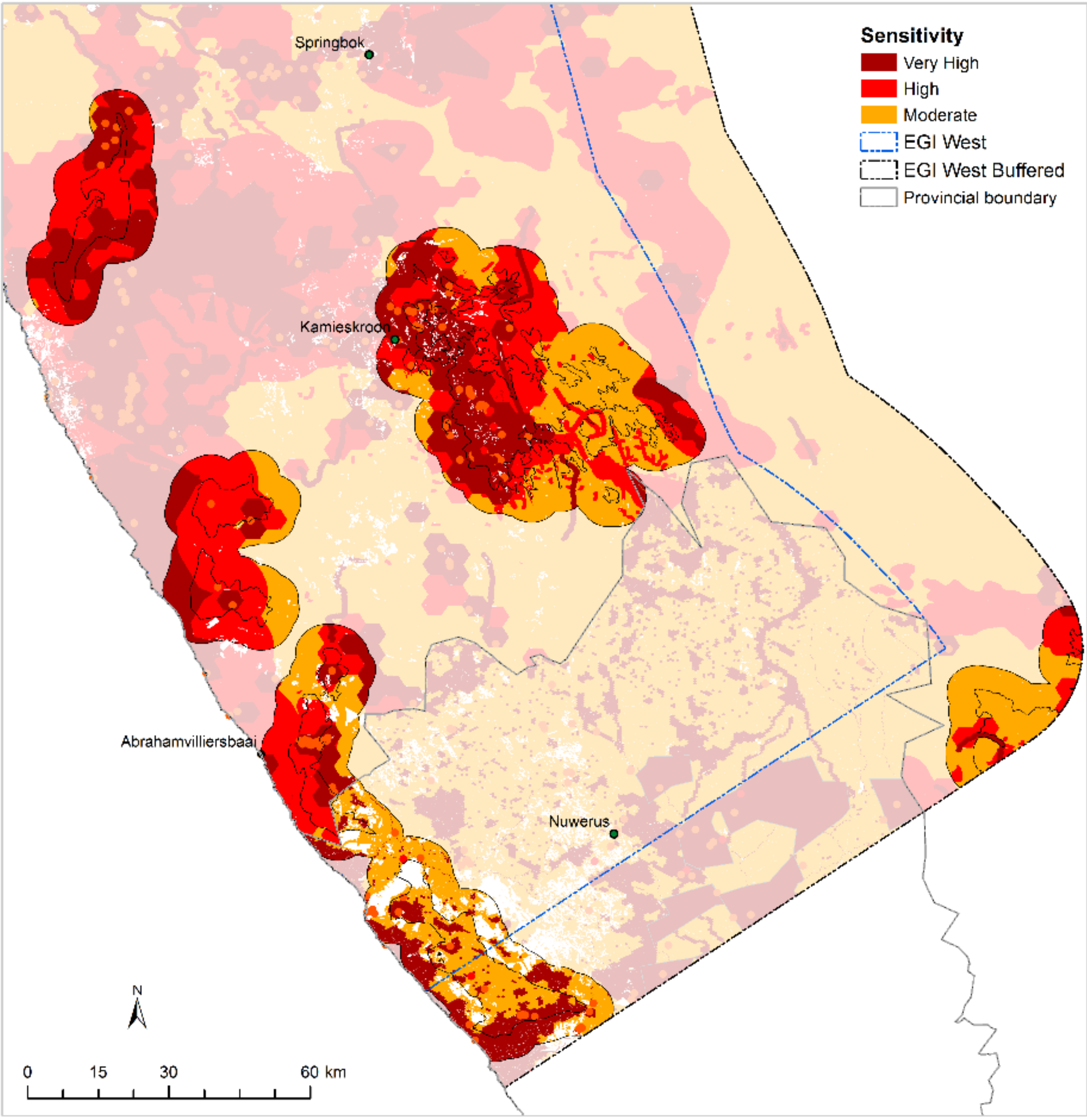

Figure 6: Sensitivity map for the Expanded Western Corridor for EGI. The white areas in the south-western corner are either transformed or are azonal types associated with the Olifants River estuary (extreme south-west in the 25 km buffer) and the subject of a separate specialist study.

8 KEY POTENTIAL IMPACTS AND MITIGATION

The sensitivity map is intended to provide strategic-level guidance by illustrating the areas where biodiversity related features and sensitivities will constrain development options. Specific environmental constraints are linked to all of the High and Very High sensitivity areas, with national legislation governing any development proposed within a national park. The provincial reserves will be governed by their own legislation on development within or areas identified as CBAs as discussed in the Western Cape Biodiversity Spatial Plan Handbook (Pool-Stanvliet et al., 2017).

Additional actions are required for all areas shown as Very High, High or Moderate sensitivity as appropriate for that sensitivity class and the specific requirements of the features associated with the sensitivity class (which will be detailed in the Decision-Making Tools that are being compiled as part of this SEA).

The construction of powerlines and associated infrastructure has a number of key biodiversity impacts during the construction and operational phases (Table 7).

The direct clearing of vegetation and disturbances to the area during pylon construction is one of the single biggest disturbances to biodiversity. The second most extensive potential disturbance is the service (and access) road network created in support of the construction which is assumed to be primarily 4x4 vehicle tracks rather than graded gravel roads. The importation of equipment, construction personnel and materials for pylon foundations could also result in the importation of invasive alien species. The disturbance and clearing of areas for pylon foundations, access roads and line-spanning equipment can initiate soil erosion and invasions by invasive alien species.

As described above, the vegetation is a low to medium height shrubland and should not need to be mowed or cleared under the conductors. If such clearing or mowing is deemed necessary, this will significantly increase the extent and frequency of the impacts during the operation of the powerline and may require special management measures. The disturbance and habitat modification that will be caused by such clearing is likely to alter habitats and hinder movements of some fauna and dispersal of plant species across the powerline corridor. This is important as the powerline will cross corridors specifically designed to allow species to respond to climate change by shifting their distributions along the corridor (Midgley and Thuiller, 2007; Yates et al., 2010). The access tracks will also require maintenance to avoid wind and water erosion, especially on the deep, loose and easily mobilised sands found in the coastal areas. It is understood that no substations are planned within the Fynbos Biome within this corridor.

Although fire is a natural and normal feature in Fynbos, fires appear to be very rare in Fynbos in these areas (see Section 5) and may not be needed to maintain ecosystem biodiversity, structure or function. However, there may have been fires but they covered areas that were too small to be detected by the satellite sensors that have been used, so the incidence of fires may simply be under-reported. In addition, there do not appear to have been any studies of the role and effects of fire in these fynbos ecosystems so more research is needed to address the fire issue.

Although the summary table below required site-specific descriptions, this would require describing all the sites and possible impacts, and as such a generic approach has been adopted here to distinguish between levels of sensitivity and to specify additional mitigatory measures for Very High and High sensitivity sites. Detailed site descriptions are appropriate when the routes are being selected and not before then.

Table 7: Key potential impacts of EGI development in the Fynbos biome and mitigation options.

Key Impact Driver	Site specific descriptions	Possible Impact / Effects	Mitigation options
Vegetation clearing for pylon construction and roads involving removal, replacement or severe disturbance of the vegetation and soils. The affected areas will require rehabilitation. It is understood that no substations will be located within the Fynbos Biome in this corridor.	Generic (for all sensitivity classes)	Permanent changes in ecosystem structure, function and biodiversity and severe disturbance of the vegetation with potential impacts on threatened ecosystems and species, including loss of habitat and loss or displacement of fauna. For more mobile and resilient fauna the impact is likely to be short-term but longer term or permanent for less mobile and resilient species. The footprint is small but the short-term impact is potentially of high significance and could extend beyond the site or road servitude. Impact will also include harm to animals or loss of breeding habitat. Impact may also include electrocution of snakes and other climbing animals during the operational phase.	All access tracks must be built and maintained to appropriate environmental standards during the construction and operational phases. Vehicles speeds to be kept low to minimise collisions with animals. Control dust to minimise settlement on surrounding ecosystems. Control sedimentation runoff into rivers and water bodies. For fauna, avoid roosts, nests, burrows and movement corridors, and provide for buffers where possible; avoid construction activities in the breeding season of threatened taxa. A walk through of each pylon foundation area to be conducted prior to clearing of vegetation and breaking of ground to ensure no animals or nests/ burrows/ roosts are harmed. Rescue and release less mobile species such as snakes, frogs, reptiles, invertebrates and certain burrowing mammals to occur prior to construction. No animals should be intentionally harmed or killed for any purpose. Areas with a high abundance of threatened ecosystems and species (High to Very High Sensitivity) should be avoided if possible. If this is not possible, then relocation of threatened species or some form of offset may provide some mitigation. During the operational phase, install mammal and snake barriers or deterrents on pylons in areas with high mammal and/or snake activity or High sensitivity.
	Very High sensitivity		Specialist field surveys to identify threatened plant or animal species before finalising pylon locations (micro-siting). Relocation of threatened species should be attempted it there is no other option. Use barriers or other measures to minimise the footprint required for the construction of the foundation and other infrastructure.
	High sensitivity		Detailed field surveys to identify threatened species before

Key Impact Driver	Site specific descriptions	Possible Impact / Effects	Mitigation options
			finalising pylon locations. Every effort must be made to minimise the footprint required for the construction of the foundation and other infrastructure.
Introduction of vehicles and machinery, construction teams and importation of materials for construction of the pylons and their foundations could result in the introduction of invasive alien species.	Generic	Alien plant invasions which can result in a loss of biodiversity and change in ecosystem function. Species that increase fuel loads (e.g. grasses) could result in more frequent fires. Alien fauna may displace indigenous species and disrupt ecosystem function	Minimise import of materials that could contain propagules of invasive species, particularly plants and/or screen such materials to ensure they are propagule free
	Very High and High sensitivity		Cleaning of machinery before moving onto the pylon site both when initially brought into the area and when moved between vegetation types. Any materials that may include alien species propagules must be obtained from sources known to be free of listed alien species (e.g. only source sand from a quarry certified to be alien species free). Keep vehicle and machinery movement to a single route to reduce the extent of the impact.
Vegetation clearing for pylon construction and roads. The disturbed areas can provide sites for alien plant invasion and potentially also for other alien species.	Generic	Alien plant invasions can result in a loss of biodiversity and change in ecosystem function. Species that increase fuel loads (e.g. grasses) could result in more frequent fires.	Include a systematic alien species control programme in the Environmental Management Programme (EMPr) as required by the National Environmental Management: Biodiversity Act and Regulations. This should provide for regular inspections of the pylon sites and access tracks for new invasions that must then be controlled.
	Very High and High sensitivity		The Environmental Manager or an alien species expert must carry our regular inspections of the machinery and materials during the construction; all the pylon sites and access tracks should be thoroughly surveyed in the late spring for at least 5-years after construction to ensure that no alien species have become established; any alien species that are detected should be controlled immediately. Further surveys can be aligned with the provisions of the EMPr.
Vegetation rehabilitation after construction and along roads is not successful as is often found with current methods.	Generic	Permanent changes in ecosystem structure, function and biodiversity with potential impacts on threatened ecosystems and species displacement. Potential for successful vegetation rehabilitation is low, resulting in a loss of biodiversity and changes in ecosystem structure and function, including habitat loss	Provide for ongoing measures to prevent or stop soil erosion, especially along access tracks; prevent sedimentation of rivers and water bodies. Aim to achieve at least a functional cover of perennial plant species together with a diversity of annual plants. In all cases rehabilitation must be aimed at preventing wind and water erosion. As far as possible use local plant material to minimise genetic impacts (e.g. use material such as topsoil from the areas cleared for that pylon). Provide for ongoing rehabilitation of the vegetation and support scientific studies of vegetation rehabilitation approaches and methods. The duration of these studies should be sufficiently long to confirm success or failure.

Key Impact Driver	Site specific descriptions	Possible Impact / Effects	Mitigation options
	Very High and High sensitivity		Intensive and active rehabilitation to rehabilitate to acceptable levels of ecosystem biodiversity, structure and function. Funding of studies to improve rehabilitation techniques, especially for perennial plants as keystone species, is strongly recommended. The duration of these studies should be sufficiently long to confirm success or failure.
Vegetation modification during operations to reduce fire risks such as cutting or mowing of the vegetation to reduce fuel accumulation and the potential for fires	Generic	Permanent changes in ecosystem structure, function and biodiversity with potential impacts on threatened ecosystems and species including loss of habitat and the potential loss of species unable to survive the clearing	Avoid such measures if at all possible as the effects of this on biodiversity, ecosystem structure and function in arid Fynbos are not known and could be severe. Use prescribed burning where fire risks need to be reduced, preferably with fires in the summer and at ecologically acceptable intervals.
	Very High and High sensitivity		No modification of this kind should be permitted. See recommendation of fires above.

9 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

This section provides best practice guidelines and management actions (including relevant standards and protocols) for the different stages of the powerline development from planning to operation and rehabilitation. There are several guides that provide advice on the planning of and construction of access tracks and rehabilitation measures which should be consulted and have been included in the references for this assessment (Coetzee, 2005; Esler et al., 2014, 2010).

9.1 Planning phase

- Avoid high sensitivity biodiversity areas (CBA1 and CBA2) and other High and Very High sensitivity areas.
- Avoid routes that go through such features, rather route along the edge.
- Undertake field surveys of the final routes, pylon locations and access tracks (services roads) at a suitable time of the year (e.g. spring when species are most likely to be detectable and identifiable, focusing on the High and Very High sensitivity areas).
- Plan the route to avoid threatened species occurrences and populations where these are found[3]. Where this is not possible, obtain appropriate permits for special and threatened species where they will be disturbed or displaced. Plan for re-location where necessary.
- Little is known about the seasonality of animal movements but minimise disturbances in the spring which is likely to be the breeding season; movements are most likely in spring and autumn.
- Convene an expert workshop to discuss and debate the best options and propose methods for rehabilitation, including experiments that should be carried out and monitored, and obtain their recommendations on monitoring and evaluating the effectiveness of the rehabilitation in terms of ecosystem biodiversity, structure and function for areas with different sensitivities. The outputs of this workshop should be incorporated into the EMPr.
- Plan access track (service road) routes and pylon locations to minimise risks of erosion through routing and effective drainage measures.

9.2 Construction phase

- Plan the flow of construction activities on site to minimise the duration and extent of the disturbance.
- Minimise the construction footprint (area to be disturbed) using fixed barriers (e.g. rope or cable strung between poles) to confine activities and limit the impact in areas with a high or very high sensitivity.
- Carry out the planned threatened species protection measures (e.g. remove and replace after construction) and the re-locations where necessary.
- Carry out the inspections of the machinery and materials for alien species propagules before they are brought onto site.
- Ensure that staff follow procedures that will minimise soil, vegetation and animal disturbance; use rewards for appropriate behaviour and penalties with severe sanctions for prohibited activities such as poaching fauna or illegal plant collection.
- Helicopters should be used to string lines, especially where lines traverse high or very high sensitivity environments or rugged areas.
- Remove and stockpile topsoil from the places where it will be disturbed and replace as soon as possible in the disturbed areas to get the best vegetation recovery.
- When introducing material for rehabilitation, try to obtain it from local sources or at least from the same vegetation type.
- Carry out regular inspections to ensure that no alien species are becoming established, and eradicate those species populations that are detected.

[3] The SANBI threatened species data did not include the taxon names so they could not be summarized for inclusion in an Appendix.

9.3 Operations phase

- Follow general vegetation and access track management procedures.
- Minimise vehicle access to minimise disturbance.
- Monitor for and control soil erosion and invasive alien plants (IAP).
- Monitor the success of the rehabilitation measures and carry out remedial measures where necessary.
- The issue of maintaining fire regimes is problematic because fires appear to be very rare in these arid fynbos environments and little is known about the desired intervals between such fires. They are most likely to occur in summer. The best option is to ensure that records are kept of all fires and their causes so that information on the fire regimes in this arid fynbos can be accumulated, assessed and use to guide fire management decisions and actions.

9.4 Rehabilitation

- Ensure that where special endangered species occurred within the construction sites that they are returned or re-located appropriately.
- Follow best rehabilitation practices as recommended by the expert workshop and incorporated into the EMPr.
- This includes minimising the duration and extent of the disturbance.
- Minimise disturbances to vegetation and animals when removing temporary infrastructure.
- Monitor for IAP and remove if found during the rehabilitation; pay particular attention to the High and Very High sensitivity areas.

9.5 Monitoring requirements

- Monitoring of vegetation recovery should be conducted twice yearly in winter for the first 2 years to assess recruitment, then yearly in late summer to assess plant survival patterns until the natural vegetation is fully re-established, no erosion is being observed.
- Monitor the effectiveness of the rehabilitation using the procedures and methods recommended by the expert workshop and incorporated into the EMPr; pay special attention to the High and Very High sensitivity areas; attempt to achieve a functional vegetation cover as soon as possible in all areas, including perennial plant species.
- Monitor for IAPs and remove if found; pay particular attention to the High and Very High sensitivity areas where there should be annual surveys in spring for at least 5 years and two- or three-yearly surveys after that period as is done in less sensitive areas.
- Monitor for erosion at both the pylon locations and along the access tracks and take appropriate corrective measures (e.g. repairing drainage systems prior to the rainy season).

10 REFERENCES

Anderson, B., Allsopp, N., Ellis, A.G., Johnson, S.D., Midgley, J.J., Pauw, A., Rodger, J.G., 2014. Biotic interactions. In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 224–247.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alesander, G.J., de Villiers, M.S., 2014. Atlas and red list of the reptiles of South Africa, Lesotho and Swaziland. Suricata 1, South African National Biodiversity Institute, Pretoria.

Blignaut, J., de Wit, M., Milton, S., Esler, K., Le Maitre, D., Mitchell, S., Crookes, D., 2013. Determining the economic risk/return parameters for developing a market for ecosystem goods and services following the restoration of natural capital: A system dynamics approach. Volume 1. Main Report. Report No. 1803/2/13, Water Research Commission, Pretoria.

Bond, W.J., Slingsby, P., 1988. Seed dispersal by ants in shrublands of the Cape Province and its evolutionary implications. S. Afr. J. Sci. 79, 213–233.

Carrick, P.J., Erickson, T.E., Becker, C.H., Mayence, C.E., Bourne, A.R., 2015. Comparing ecological restoration in South Africa and Western Australia: the benefits of a 'travelling workshop.' Ecol. Manag. Restor. 16, 86–94.

Carrick, P.J., Krüger, R., 2007. Restoring degraded landscapes in lowland Namaqualand: Lessons from the mining experience and from regional ecological dynamics. J. Arid Environ. 70, 767–781.

Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D., Davies-Mostert, H.T., 2016. The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Coetzee, K., 2005. Caring for Natural Rangelands. Kwazulu Natal University Press, Durban.

Colville, J.F., Potts, A.J., Bradshaw, P.L., Measey, G.J., Snijman, D., Picker, M.D., Procheş, Ş., Bowie, R.C.K., Manning, J.C., 2014. Floristic and faunal Cape biochoria: do they exist? In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 73–92.

DEA, 2009. Guideline regarding the Determination of Bioregions and the Preparation and Publication of Bioregional Plans. Government Gazette No. 32006, 16 March 2009.

DEA, 2016. Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. Report No: CSIR/02100/EMS/ER/2016/0006/B, CSIR, Stellenbosch. Prepared for the Department of Environmental Affairs, Pretoria.

DEAT, 2008. National Protected Area Expansion Strategy for South Africa 2008 Priorities for expanding the protected area network for ecological sustainability and climate change adaptation, Government of South Africa. Department of Environmental Affairs and Tourism, Pretoria.

Driver, A., Sink, K.J., Nel, J.N., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L., Maze, K., 2011. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

Esler, K.J., Milton, S.J., Dean, W.R.J., 2010. Karoo Veld - Ecology and Management. Briza Press, Pretoria.

Esler, K.J., Pierce, S.M., de Villiers, C., 2014. Fynbos: Ecology and Management. Briza Publications, Pretoria.

GTI, 2015. 2013 - 2014 South African National Land-Cover Dataset. Data User Report and MetaData. Version 05 (DEA Open Access), Geoterraimage, Pretoria.

Heelemann, S., Procheş, Ş., Porembski, S., Cowling, R.M., 2010. Impact of graminoid cover on postfire growth of nonsprouting Protea seedlings in the eastern Fynbos Biome of South Africa. Afr. J. Ecol. 49, 51–55.

Henning, G.A., Terblanche, R.F., Ball, J.B., 2009. South African Red Data Book: butterflies. SANBI Biodiversity Series 13, South African National Biodiversity Institute. Pretoria.

Holness, S., Oosthuysen, E., 2016. Critical Biodiversity Areas of the Northern Cape : Technical Report. Northern Cape Department of Environment and Nature Conservation, Kimberley.

James, J.J., Carrick, P.J., 2016. Toward quantitative dryland restoration models. Restor. Ecol. 24, S85–S90.

Kraaij, T., Wilgen, B.W. Van, 2014. Drivers, ecology, and management of fire in fynbos. In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Oxford, UK, pp. 47–72.

Krug, C.B., 2004. Practical guidelines for the restoration of renosterveld. Conservation Ecology Department, University of Stellenbosch.

Krupek, A., Gaertner, M., Holmes, P.M., Esler, K.J., 2016. Assessment of post-burn removal methods for Acacia saligna in Cape Flats Sand Fynbos, with consideration of indigenous plant recovery. South African J. Bot. 105, 211–217.

Le Maitre, D.C., Gaertner, M., Marchante, E., Ens, E.-J., Holmes, P.M., Pauchard, A., O'Farrell, P.J., Rogers, A.M., Blanchard, R., Blignaut, J., Richardson, D.M., 2011. Impacts of invasive Australian acacias: implications for management and restoration. Divers. Distrib. 17, 1015–1029.

Mecenero, S., Ball, J.B., Edge, D.A., Hamer, M.L., Henning, G.A., Krüger, M.A., Pringle, E.L., Terblanche, R.F., Williams, M.C., 2013. Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas. Saftronics (Pty) Ltd., Johannesburg & Animal Demography Unit, Cape Town.

Midgley, G.F., Thuiller, W., 2007. Potential vulnerability of Namaqualand plant diversity to anthropogenic climate change. J. Arid Environ. 70, 615–628.

Mouquet, N., Gravel, D., Massol, F., Calcagno, V., 2013. Extending the concept of keystone species to communities and ecosystems. Ecol. Lett. 16, 1–8.

Musil, C.F., Milton, S.J., Davis, G.W., 2005. The threat of alien invasive grasses to lowland Cape floral diversity: an empirical appraisal of the effectiveness of practical control strategies. S. Afr. J. Sci. 101, 337–344.

Nakano, S., Murakami, M., 2001. Reciprocal subsidies: Dynamic interdependence between terrestrial and aquatic food webs. Proc. Natl. Acad. Sci. U. S. A. 98, 166–170.

Olivier, J., 2002. Fog-water harvesting along the West Coast of South Africa: A feasibility study. Water SA 28, 349–360.

Pence, G.Q.K., 2009. Climate Adaptation Scenarios for the Cape Floristic Region: Technical Report. Unpublished Report, Table Mountain Fund, World Wildlife Fund-South Africa, Cape Town.

Picker, M.D., Griffiths, C.L., 2011. Alien and invasive animals: a South African perspective. Struik Nature, Cape Town.

Pool-Stanvliet, R., Duffell-Canham, A., Pence, G., Smart, R., 2017. Western Cape Biodiversity Spatial Plan Handbook 2017. CapeNature and Department of Environmental Affairs and Development Planning, Western Cape Government, Cape Town.

Rahlao, S.J., Milton, S.J., Esler, K.J., van Wilgen, B.W., Barnard, P., 2009. Effects of invasion of fire-free arid shrublands by a fire-promoting invasive alien grass (Pennisetum setaceum) in South Africa. Austral Ecol. 34, 920–928.

Raimondo, D., von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A., Manyana, P.A., 2009. Red List of South African Plants. Strelitzia 25, South African National Biodiversity Institute, South Africa.

Rebelo, A.G., Boucher, C., Helme, N., Mucina, L., Rutherford, M.C., Smit, W.J., Powrie, L.W., Ellis, F., Jan, J.N., Scott, L., Radloff, F.G.T., Steven, D., Richardson, D.M., Ward, R.A., Procheş, Ş.M., Oliver, E.G.H., Manning, J.C., Mcdonald, D.J., Janssen, J.A.M., Walton, A., Roux, A., Skowno, A.L., Simon, W., Hoare, D.B., 2006. Fynbos Biome. In: Mucina, L., Rutherford, M.C. (Eds.), The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria, pp. 52–219.

Rouget, M., Barnett, M., Cowling, R.M., Cumming, T., Daniels, F., Hoffman, M.T., Knight, A., Manuel, J., Nel, J., Parker, A., Raimondo, D., Rebelo, T., 2014. Conserving the Cape Floristic Region. In: Allsopp, N., Colville, J.F., Verboom, G.A. (Eds.), Fynbos. Oxford University Press, pp. 321–336.

Rouget, M., Cowling, R.M., Lombard, A.T., Knight, A.T., Kerley, G.I.H., 2006. Designing Large-Scale Conservation Corridors for Pattern and Process. Conserv. Biol. 20, 549–561.

Rouget, M., Richardson, D.M., Cowling, R.M., Lloyd, J.W., Lombard, A.T., 2003. Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. Biol. Conserv. 112, 63–85.

Samways, M.J., Stewart, D.A.B., 1997. An aquatic ecotone and its significance in conservation. Biodivers. Conserv. 6, 1429–1444.

Todd, S., 2008. Options for Invasive Grass Management in the Nieuwoudtville Wildflower Reserve. Prepared for Indigo Development and Change, Nieuwoudtville.

Turner, A.A. (ed), 2017. Western Cape Province State of Biodiversity 2017. CapeNature Scientific Services, Jonkershoek, Stellenbosch.

Visser, V., Wilson, J.R.U., Canavan, K., Canavan, S., Fish, L., Le Maitre, D., Nänni, I., Mashau, C., O'Connor, T., Ivey, P., Kumschick, S., Richardson, D.M., 2017. Grasses as invasive plants in South Africa revisited: Patterns, pathways and management. Bothalia 47, 29 pages.

Visser, V., Wilson, J.R.U., Canavan, K., Canavan, S., Fish, L., Le Maitre, D., Nånni, I., Mashau, C., O'Connor, T.G., Ivey, P., Kumschick, S., Richardson, D.M., 2017. Grasses as invasive plants in South Africa revisited: Patterns, pathways and management. Bothalia 47.

Wilson, J.R., Gaertner, M., Griffiths, C.L., Kotzé, I., Le Maitre, D.C., Marr, S.M., Picker, M.D., Spear, D., Stafford, L., David, M., Wilgen, B.W. Van, Wannenburgh, A., 2014. Biological invasions in the Cape Floristic Region: history, current patterns, impacts, and management challenges. In: Allsopp, N., Colville, J., Verboom, G.A. (Eds.), Fynbos: Ecology, Evolution, and Conservation of a Megadiverse Region. Oxford University Press, Cape Town, pp. 273–298.

Yates, C.J., McNeill, A., Elith, J., Midgley, G.F., 2010. Assessing the impacts of climate change and land transformation on Banksia in the South West Australian Floristic Region. Divers. Distrib. 16, 187–201.

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 - EGI Expansion					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 the Specialist**
Brian van Wilgen	2	2 to 13		List of acronyms - it would be useful to add CBA1, CBA 2 etc. with definitions	Added as requested
Brian van Wilgen	3	1		Comments with questions for Eskom to answer indicate some uncertainty - this will have to be cleared up?	These were the comments posed to Eskom: 1. Will access be required just to sets of pylons or will a continuous road system stretching the full length of the route be required? 2. Draft plans for the EGI indicate that the only substation planned for this Expanded Eastern EGI Corridor would be near Springbok which is in the Succulent Karoo. Eskom to please confirm if this is correct or if additional substations are proposed within this corridor? 3. Eskom to confirm vegetation trimming requirements as this will have an implication in terms of the impacts. Response to Point 1 - Eskom provided the following feedback: Access will be a continuous road system stretching the full length of the power line route. Response from CSIR: The specialist assessment has covered road construction and did not specifically mention assuming access to pylons only. The report does not need to be amended. Specialist Response: I agree that the report can stand but it is clear that this could increase the impacts, especially on small highly sensitive areas. Response to Point 2: Eskom feedback is pending. Response from Specialist: Any future sub-station is almost certainly going to be placed to be placed near an existing town given that mining in this area is declining and all the towns are in the Succulent Karoo except for some tiny settlements (e.g. Kamieskroon). There is a range of sensitivities of the fynbos in the corridor. There is a very small probability that a substation will be placed in one of the tiny - all sensitive - pieces of fynbos in this corridor as the fynbos occupies less than 5% or so of the entire area of the corridor. Response to Point 3: Eskom provided various vegetation management documents. It seems like mowing and trimming of vegetation below the powerline does occur. Response from Specialist: The current vegetation types

EXPERT REVIEW AND SPECIALIST RESPONSES: Fynbos Biome - EGI Expansion					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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					do not seem to be specifically mentioned by name, but there are vegetation types which are clearly of a similar type based on their names and descriptions. From the descriptions and the recommended treatments, I can infer the following general principles: (a) Remove tree species where they occur in the pylon corridor; and (b) where shrub species can grow 2m or more tall, they must be cut back to 500 mm high. Trees are only likely to occur along water courses, which are covered in a separate specialist study, or in the Kamiesberg area. In the latter case the trees would occur as scattered individuals or small clumps and the impact of the removal of a few trees is unlikely to have a significant impact. Since the shrubs in the fynbos vegetation in the corridor rarely if ever exceed 1.5 m tall it would seem that cutting is not necessary.
Brian van Wilgen	3	41		"populations of various species within the corridor that need to be excluded" - do you mean "areas with populations of various species within the corridor that need to be excluded"?	Yes, I meant the latter
Brian van Wilgen	4	2		"a couple of guidelines" - do you mean two? Or "a few"?	Few
Brian van Wilgen	4	4		Replace "simulate" with "stimulate"	Corrected
Brian van Wilgen	4	11 to 12		It is suggested that a poor understanding of the potential for restoration provides a "strong rationale" for siting the infrastructure elsewhere. But will the potential for restoration in these alternative areas also be poorly understood - in which case you are simply transferring the problem elsewhere? Or do you mean choose alternative areas that are already degraded?	I was considering two things: (a) to my knowledge there is more understanding of, and more experience in the restoration, of karoo vegetation than these arid fynbos types, so the potential for restoration is greater so it is not simply transferring the problem elsewhere; (b) the proportional impact on the areas of the Succulent Karoo vegetation types will be less as the reasonably intact extent of these vegetation types is much greater. Obviously, if there are already degraded areas which are otherwise suitable then they should be the 1st choice for the route. I see no need to modify the existing text.
Brian van Wilgen	5	24		Associated fauna - does this exclude birds?	(excluding avifauna) has been added
Brian van Wilgen	5	46		Replace "conservation planning priorities" with "conservation priorities"	"planning" deleted
Brian van Wilgen	5	51		Define "LM" Local municipality? Add to list of acronyms on page 2	Spelt out on 1st occurrence, added to acronyms
Brian van Wilgen	6	28 - 29		Not clear what "areas supporting high climate change resilience" are. Do you mean areas where most species would have a better chance of surviving predicted	Added an explanation "(i.e. climate change adaptation corridors)"

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				changes in climate?	
Brian van Wilgen	8	45-46		Replace "experts should sit together and come up with" with "experts should collaborate to develop"	Wording changed as suggested
Brian van Wilgen	9	14 - 17		"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 powerlines." The reality is that "those who will use this information" are unlikely to understand and appreciate these issues. Therefore, the chances of offsetting these impacts is small, and this reality needs to recognised here and spelt out when plausible mitigation is discussed?	While I accept that it is likely that those making the decision about the routing may not have the necessary expertise, in specifying "those who make the decision" I was taking into account that there will be a second level of study which tests and selects routes. This study will be much more detailed and will include inputs from specialists who will appreciate the issues I am raising and factor them into the decision making at that stage. This, I believe, will increase the chances of offsetting these impacts.
Brian van Wilgen	10		Table 3	Are there any parts of the fynbos biome within the corridor that are Ramsar sites, or World Heritage Sites? If not, these rows are redundant?	There are no Ramsar sites within the corridor but the World Heritage sites include the fynbos in the Richetersveld. I kept the Ramsar in for completeness sake.
Brian van Wilgen	13	28		The term "borrow pits" suggests that material will be borrowed and later replaced. However, "permanent excavations" is probably a more appropriate term?	Technically you are correct; I was using the accepted term in the construction industry. I have added permanent excavations in the text.
Brian van Wilgen	13		Figure 1	It is not clear what the "development envelope" is.	I was using the term used in the cited reference, it is also clearly labelled in Figure 1
Brian van Wilgen	13	44 - 45		Query to Eskom needs to be clarified	Response to Point 3: Eskom provided various vegetation management documents. It seems like mowing and trimming of vegetation below the powerline does occur. Response from Specialist: The current vegetation types do not seem to be specifically mentioned by name, but there are vegetation types which are clearly of a similar type based on their names and descriptions. From the descriptions and the recommended treatments, I can infer the following general principles: (a) Remove tree species where they occur in the pylon corridor; and (b) where shrub species can grow 2m or more tall, they must be cut back to 500 mm high. Trees are only likely to occur along water courses, which are covered in a separate specialist study, or in the Kamiesberg area. In the latter case the trees would occur as scattered individuals or small clumps and the impact of the removal of a few trees is unlikely to have a significant impact. Since the shrubs in the fynbos vegetation in the corridor rarely if ever exceed 1.5 m tall it would seem that cutting is not necessary.

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Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Response from the Specialist**
Brian van Wilgen	14	2		Clearing will not only result in loss of habitat, but could also eliminate species not able to survive repeated cutting?	Yes, thank for the comment, added into text
Brian van Wilgen	14	16 - 18		Ensuring that construction material does not contain colonies of a certain ant species will require capacity and expertise that is highly unlikely to be available. It is therefore likely that construction may result in introductions. Is the distribution of the Argentine ant known? And is construction material likely to be sources from known infested areas? It is probably also better to only list the impact in section 4 and the potential for mitigation in section 8.1 (for this and all other impacts)?	I do not think this is an unreasonable request, the screening was done successfully for the Kogelberg Pump Storage Scheme and has been done since. The Argentine ant's distribution is not well known but it is unlikely to occur in such arid areas except in close proximity to water sources and/or human habitation (it is known to occur in Springbok and the surrounds. Because I consider it a minor impact I did not include it among the those addressed in section 8.1
Brian van Wilgen	14	25		Replace "maintain themselves" with "persist".	Change made
Brian van Wilgen	14	28		What are the acceptable intervals and times of the year for fires?	The following sentences have been added: The optimal seasons for burning are summer or autumn but the desired intervals between fires are not known at present. Expert advice should be obtained before conducting any planned fires".
Brian van Wilgen	14	39 - 42		See comment on page 4, lines 11 to 12.	Covered in my response to that comment
Brian van Wilgen	14	46 - 47		The alien species listed here differ from those listed in the summary - for example they include Prosopis and do not include pines, hakea and leptospermum. This needs to be rationalised. Suggest you consult SAPIA to see which alien plants occur in the grid corridors.	The list in the summary has been harmonised
Brian van Wilgen	15	5 to 9		These are proposed mitigation actions and should be moved to section 8.1?	This is a general recommendation and not a mitigatory action so it has been retained where it is.
Brian van Wilgen	15	12		Why "but"? Why not "and"?	Rephrased
Brian van Wilgen	15	15		How likely is it that alien plant invasions will alter fire regimes? And which elements of fire regimes may be altered? Introduction of alien grasses to the karoo may introduce fire to previously fire-free ecosystems, but is this true for fynbos? Invasion by large trees such as pines could increase fire intensity (but not season or frequency) but it is not clear whether the drier fynbos areas are under threat from invasion by pines?	I believe grass invasions can have undesirable effects on the fire regimes - similar to those in semi-arid environment in the USA. Invasion and eventual dominance by annual grasses can create continuous fuel beds that can carry fires well before arid fynbos reaches the stage where all the reseeding species have replenished their seedbanks. So, fires would not be a novel event, but frequent fires would be, and This could result in the loss of many reseeding species. Invasions by pines have not been recorded in these arid fynbos areas but have been noticed elsewhere in arid fynbos.
Brian van Wilgen	16	29		Insert "by" between "supplied" and "SANBI"	Corrected

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Brian van Wilgen	18		Table 4	Are there any parts of the fynbos biome within the corridor that are Ramsar sites, or World Heritage Sites? If not, these rows are redundant? Please spell out CBA1, CBA2 etc.	See my response to the comment on pg 10. The mnemonics are defined in the glossary
Brian van Wilgen	20		Table 5	There are no zebras, rhinos, wild dogs or cheetahs in the fynbos? Nor any of the antelopes mentioned (bontebok are limited to the southeastern parts of the fynbos biome)? Nor crocodiles.	The full list of buffer widths was retained for completeness sake.
Brian van Wilgen	22		Figure 2	It appears that the EGI is buffered in only one direction (to the east and south). Is this correct? Same comment applies to the other figures in this series.	That is correct because the northern border is the South African border and the west is the coastline
Brian van Wilgen	28		Section 8.1	It would be useful here to differentiate between destruction (where vegetation is permanently replaced by infrastructure), disturbance (e.g. mowing or burning, or activities during construction), and fragmentation (where the suitability of remaining, undisturbed habitat is compromised due to a reduction in its extent). This differentiation should be carried forward into Table 7.	While I understand the value of this differentiation it would result in a lot of additional detail and would not add significant value to the assessment. I believe that this is something that can be done during the route selection phase for high sensitivity areas.
Brian van Wilgen	28	32 - 38		The real question here is whether or not the vegetation has to be managed at all. The risk is that the vegetation may burn, and cause power outages, and this risk can be reduced if the vegetation is regularly burnt, or mowed. If the risk of a fire occurring is low, none of this management would be necessary. However, if the risk is high, then the choice should be between prescribed burning under milder conditions, or mowing. Prescribed burning would be preferable as it would almost certainly do less harm to the vegetation.	I believe the vegetation does need to be managed for two main reasons. (1) Monitoring it to make sure that the rehabilitation has been successful and intervening if it has not been; (2) Ongoing management of invading species at least in areas where they occurred or were introduced. Management using fire may not be necessary but, if there are species whose seeds require fire, then excluding fire will result in the loss of these species; burning definitely is the preferred option but needs to be carefully managed to minimise the risk of interfering with the power transmission.
Brian van Wilgen	29		Table 7	"Impact will also include electrocution of snakes". Should this not rather be "may also include"? Do snakes climb power pylons?	I was specifically asked to include this in an earlier draft. I have changed the wording to "may also include"

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Expert Reviewer Name	Page Range	Line/s	Table/ Figure	Expert Reviewer Comments	Response from the Specialist
Brian van Wilgen	29		Table 7	Relocation of vertebrates and even invertebrates is proposed as a mitigation action, but is this realistic? If this is to be done, suitable alternative habitat will have to be found, and this will require specialist expertise. Secondly, such alternative habitat may already be fully occupied, and the relocation will fail. Given the uncertainties, should the likelihood of success of the proposed mitigation not be spelt out?	I agree that the mitigation may or may not succeed with the likelihood depending strongly on the characteristics of the species involved. Each case would have to be assessed on its own merits but at least in the case of rare or threatened species, the option of such mitigation should always be considered.
Brian van Wilgen	31		Table 7	The statement is made that rehabilitation is "typically" not successful, but elsewhere in this report the point is made that there is very little understanding about rehabilitation. Should this not then read that the probability of successful rehabilitation is unknown?	The reviewer has misinterpreted the statement, this section (row) of the table gives some advice on what options there are should the initial intervention not succeed. Typically changed to often.
Brian van Wilgen	31		Table 7	I fully agree that rehabilitation studies should be funded, but the point needs to be made that they should be of sufficient duration to be able to gauge success, and that there should be regular monitoring.	I agree and have added the following sentence: The duration of these studies should be sufficiently long to confirm success or failure.
Brian van Wilgen	31		Table 7	Is avoiding cutting or mowing a mitigation action? If mowing or cutting are necessary, could they be mitigated in some way? What about prescribed burning as an alternative? See comment on page 28, lines 32 - 38.	I agree and have added this sentence: Use prescribed burning where fire risks need to be reduced, preferably with fires in the summer and at ecologically acceptable intervals.
Brian van Wilgen	32		Table 8	In the column headed "Permits", it may be useful to say what the permits are for, and to list the legislation of regulations under which they are required.	The relevant legislation was listed in section 3 and is necessary before undertaking any actions that would disturb threatened species. I do not think further explanation is needed.
Brian van Wilgen	33	39		Could you explain what kind of fixed barriers are envisaged?	I have added an example
Brian van Wilgen	33	46		Not clear how or why you should reward prohibited activities?	I have made it clear that rewards are for good behaviour
Brian van Wilgen	34	15 - 17		It is not very useful to say, under a heading of "best practice", that not much is known. Rather say that best practice would be to establish a picture of prevailing fire regimes to improve understanding, for example by keeping detailed records of all fires?	I agree, added a sentence on recording fires
Brian van Wilgen	34	33		Not sure why it is necessary to monitor twice yearly in winter. Is once not enough? And why the switch to summer for later surveys?	I have added explanations setting out the rationale

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Brian van Wilgen	34	40		Define the acronym IAPs and add to list on page 2.	Done
Brian van Wilgen	34	37		Add EMPr to list of acronyms on page 2.	Done

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.2

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Savanna and Grassland Biomes

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE IN SOUTH AFRICA

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)

CONTENTS

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

CBA	Critical Biodiversity Area
CR	Critically Endangered
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
EIA	Environmental Impact Assessment
EN	Endangered
ESA	Ecological Support Area
IAP	Invasive Alien Plants
NFI	National Forest Inventory
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
VU	Vulnerable

1 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 Critically Biodiversity Areas and, if possible, should be avoided by Electricity Grid Infrastructure (EGI) development. Most of the grasslands falling within this expansion corridor are poorly conserved and considered as threatened vegetation types.

Savannas, although 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 KwaZulu-Natal's 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. Powerline infrastructure is likely to limit large tree re-establishment in a narrow belt directly below the powerline (i.e. within the powerline 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; however, the maintenance of a fire regime is often in conflict with powerline management guidelines (Scholes 1997, O'Connor and Bredenkamp 1997).

Summary of overall environmental suitability of the expanded Eastern Electricity Grid Infrastructure Corridor in the Grassland and Savanna biomes:

Corridor	Overall Suitability	Comment
Expanded Eastern EGI Corridor	Moderate suitability for power line infrastructure development.	The Zululand area is an important biodiversity area, and a network of provincial and private conservation land create a number of pinch points for routing. This expanded corridor falls largely within the Savanna biome and Indian Ocean Coastal Belt Biome.

2 INTRODUCTION

This report deals only with the savanna and grassland areas within the expanded electricity grid infrastructure corridors, and since these biomes are only found with the eastern corridor, it is the only corridor discussed.

The key feature of powerlines is that they are linear in nature. They create extensive destruction of vegetation (approximately 1 ha) per pylon. In addition, vegetation between pylons is typically kept short to prevent interference and fire hazards. The distance between pylons has not been specified and is influenced by typography; however it typically cannot exceed 400m. This can result in this vegetation being retained at an unnaturally low structure. Access roads linked to gridlines also represent a potential disturbance to vegetation and a source of erosion.

One of the key terrestrial biodiversity impacts from pylons is on birds and bats. This is however not covered in this section as it is covered in separate dedicated chapters (Appendix C.1.7 and Appendix C.1.8 of the EGI Expansion SEA Respectively). Without sound management it is also likely that the corridor can be a source of soil erosion. The powerlines will often, out of necessity, route directly up or down slopes, typically with construction and maintenance roads following the same path. The un-vegetated 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 impacted and how the development may impact on these functional attributes. Tree height and density in savannas is a key functional attribute that may be changed. Fire frequency and intensity may also be altered as it is standard practice to limit fire impacts below power line infrastructure (Eskom, 2007).

A large component of the Expanded Eastern Electricity Grid Infrastructure (EGI) Corridor is either savanna or grassland vegetation (Figure 1). The balance is mostly Indian Ocean Coastal Belt Vegetation.

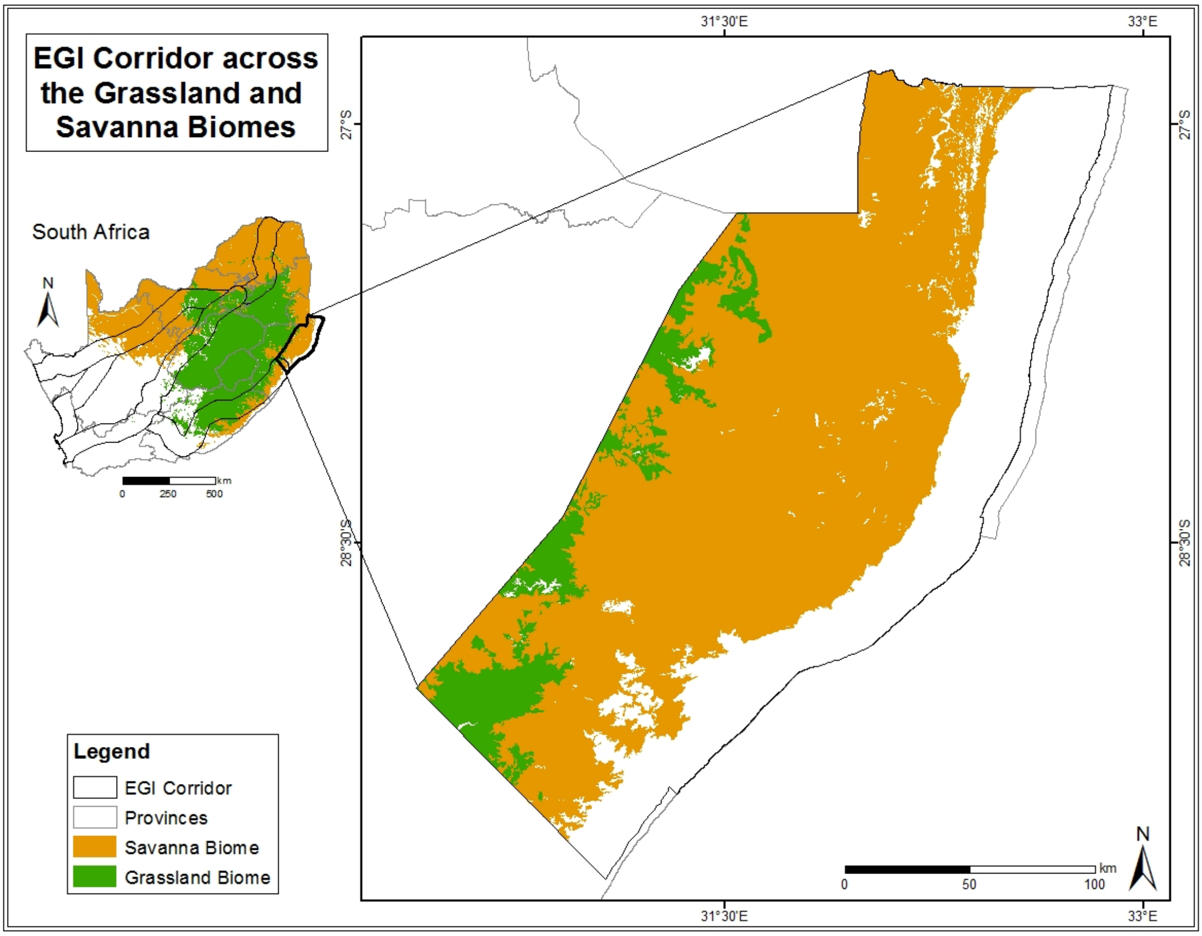

Figure 1: Location of savanna and grassland vegetation in the Expanded Eastern EGI corridor based on (Mucina and Rutherford, 2006)

The unique feature of savanna (Figure 3) 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 and a small disturbance is unlikely to have catastrophic loss to any particular species. However, there are specific locations with threatened 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 (Figure 2), 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 (Mucina and Rutherford, 2006). It is also these forbs that are typically the rare or threatened species within the grasslands. 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.

Savanna, as a biome, is well conserved; however, many of the specific savanna vegetation types found within the corridor, are very poorly conserved, this is especially true for the Zululand area (Mucina and Rutherford, 2006) (Figure 3). Grasslands are arguably one of the most threatened biomes in the country, with many grassland types very poorly conserved (Figure 2) (SANBI no date; Mucina and Rutherford, 2006). In addition grasslands are one 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 grassland biome. Large amounts of the grassland in the Expanded Eastern EGI corridor has been transformed into subsistence agriculture, forestry plantations and sugarcane fields (Fairbanks et al 2000). This places a high conservation importance on all remaining grassland.

Savanna and grassland are the home to a large number of mammals, and these animals move over considerable distances to locate grazing. During the powerline 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, including disturbances to nesting sites, may be impacted 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 savannas and grasslands of the corridor (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, construction activities may be a disturbance to these species, although post construction impacts will be minimal. A few large mammals such as leopard (*Panthera pardus*), mountain reedbuck (*Redunca fulvorufula*) and Oribi (*Ourebia ourebi*) may occur in suitable habitats outside of protected areas and will need specialists to identify potential suitable habitat (Child et al. 2016).

Small mammals, reptiles and insects distributions are far harder to ascertain, although a large number of Critically Endangered, Endangered and Vulnerable species occur within the powerline corridors (see Appendices A-D). 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. 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 threatened species goes beyond the scope of this study, although locations of know occurrences are included and buffered (as described in Table 1).

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.1.7 and C.1.8 of the EGI Expansion SEA Report, respectively). Similarly river and wetland systems and species are also dealt with on their own specialist report (Appendix C.1.6 of the EGI Expansion SEA Report), however, 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 EGI Expansion 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 areas, but reducing in dry areas. Maintaining a fire frequency on the restored land is important for maintaining biological integrity of the vegetation type. Power lines, can on occasion, also be a direct cause of fire due to sparking and can therefore create unwanted fires. Consideration will need to be given as to how vegetation under the powerlines can be maintained given that fire exclusion under powerlines is a common management practice (Mucina and Rutherford 2006, O'Connor and Bredenkamp 1997, Scholes, 1997).

Although both grassland and savanna habitats are relatively well adapted to disturbances, complete clearance of the vegetation for pylons and partial clearing for roads and drag-lines during the construction phase will need direct intervention to ensure rapid and successful rehabilitation. Personal experience has shown that abandoned old fields in savannas can take 20 or more years before the re-establishment of trees, 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.

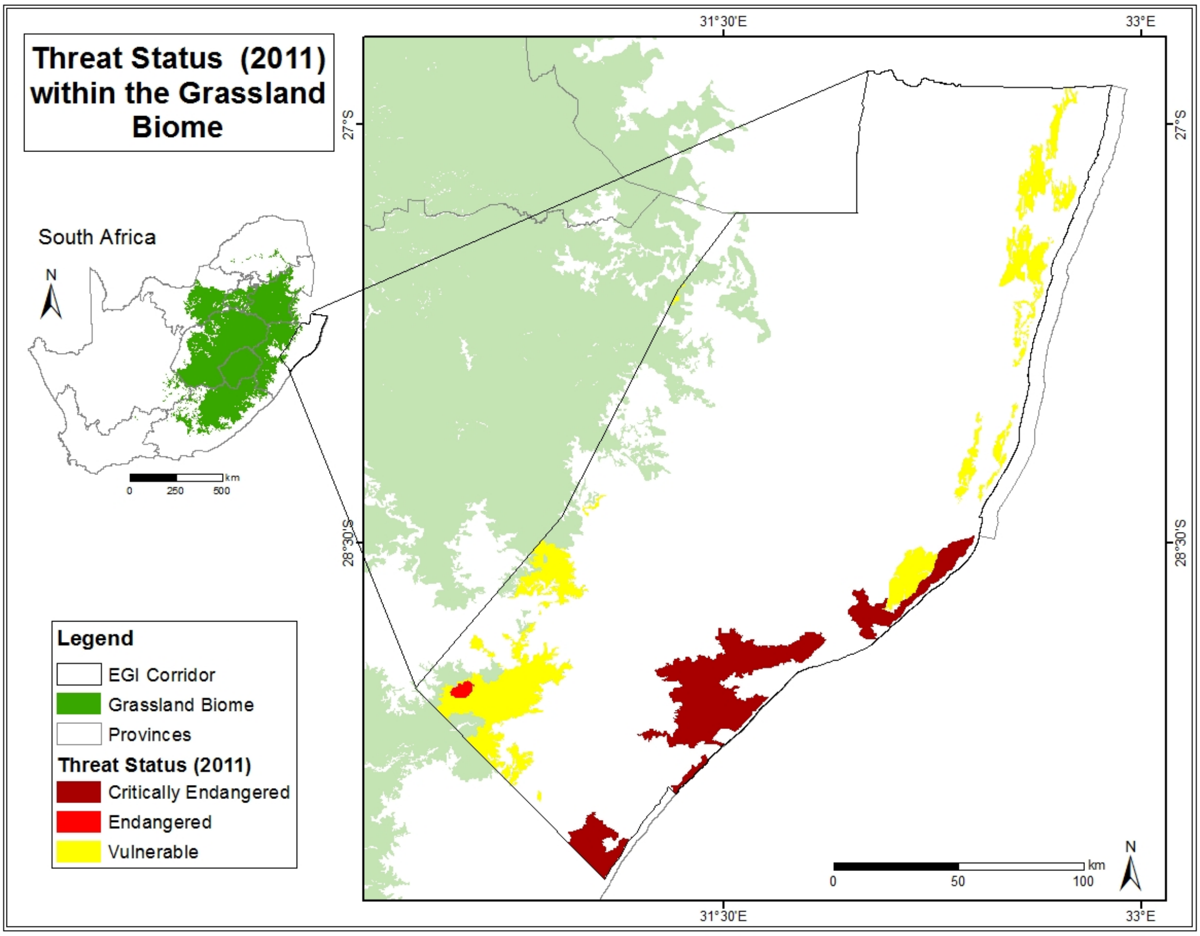

Figure 2: Conservation status of grassland ecosystems (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011). Note, coastal grasslands depicted here fall outside of the grassland biome and are covered in the Indian Ocean Coastal Belt Biome Specialist Assessment.

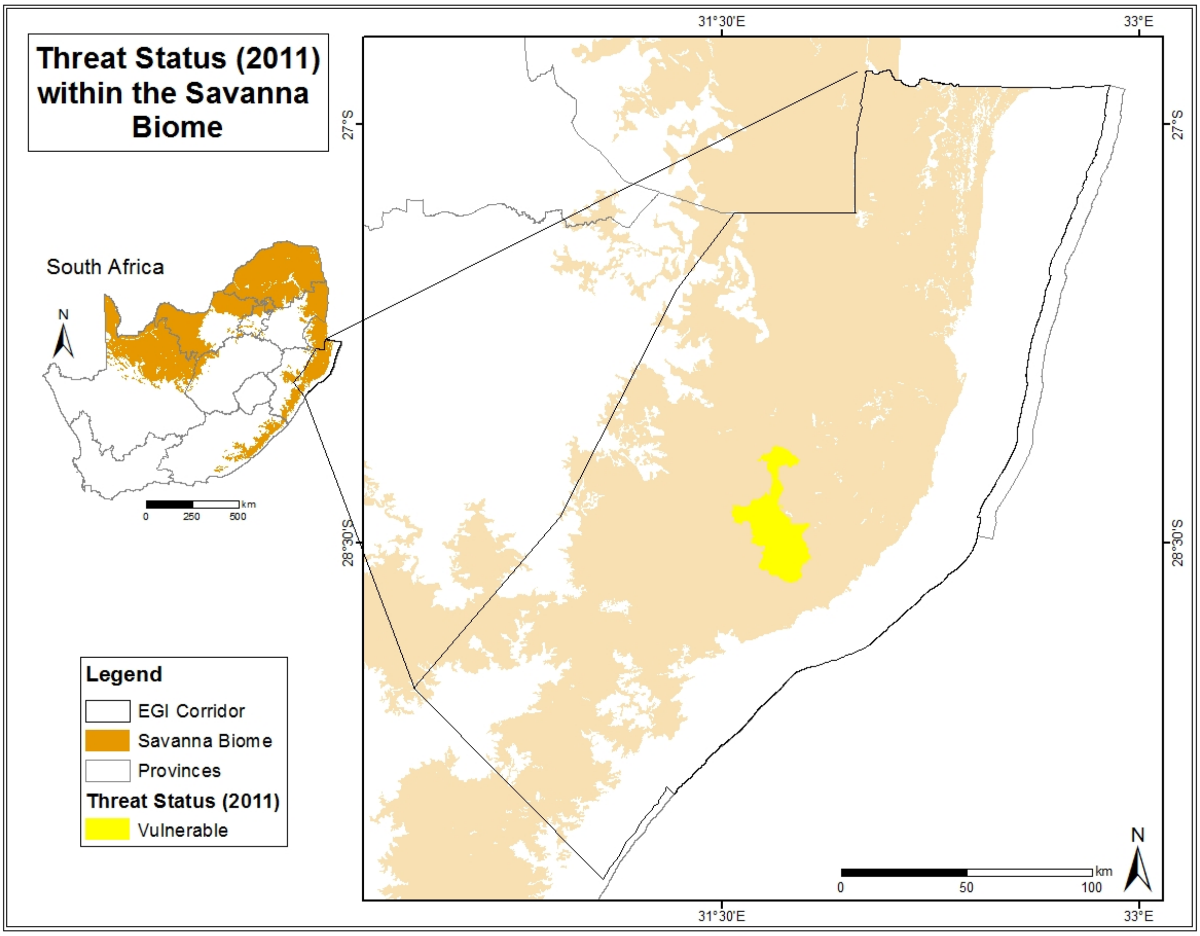

Figure 3: Conservation status of savanna ecosystems (functionally vegetation types from Mucina and Rutherford (2006)) as gazetted (Gazette No 34809 of 2011).

An important issue pertaining especially to grasslands, but to a lesser extent to savanna: disturbances during the construction phase are likely to result in alien invasive plant species colonising the post installation ground. Active alien plant removal interventions will be required until the natural vegetation 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 powerlines, 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.

3 SCOPE OF THE BIODIVERSITY AND ECOLOGY 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.1.6 of the EGI Expansion SEA Report). The same is true for birds and bats (Appendices C.1.7 and C.1.8 of the EGI Expansion SEA Report, respectively). The study considers both the construction phase of the powerline (i.e. the construction of pylons and fixing of powerlines) as well as the operational phase. Decommissioning would be assumed to have similar disturbances to 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 KwaZulu-Natal and form the backbone of this assessment. The Geographic Information System (GIS) data used, based on the national and provincial assessments 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 areas for conservation. There are a large number of provincial nature reserves within the corridors including the Hluhluwe–Imfolozi Reserve, Mkuzi, Tembe and Ndumo as well as the Ramsar iSimangaliso Wetland Park complex, although this is mostly Indian Ocean Coastal Belt vegetation.

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. The Critically Endangered Sand Forest is highlighted as a highly threatened forest type found in this area.

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.

4 APPROACH AND METHODOLOGY

4.1 Study Methodology

SANBI provided a data layer package of available GIS data. This was scanned to identify coverages that would be applicable to this study. In addition the background reports to the datasets were consulted. For this assessment the data described below were considered relevant. For each relevant data field an assessment was made as to whether the field has very high, high, medium or low biodiversity sensitivity for the savanna and grassland biome vegetation. This based on legislative and regulatory consideration, the priorities as defined by CBA categories and guided by expert judgement. The KwaZulu-Natal Biodiversity Sector Plan forms an important data source on the location of important biodiversity and areas critical for conservation.

4.2 Data Sources

Data sources used were collected and pre-processed by SANBI. The data used is summarised in Table 1.

Table 1: Data sources used for this assessment.

Data title	Source and date of publication	Data Description
Protected Areas	National Department of Environmental Affairs (DEA) South African Protected Areas Database, 2017. SANBI Protected Areas Database, 2011.	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 Expanded Eastern EGI Corridor, otherwise both layers were consistent. Note: The Corridor area of the Hluhluwe–Umfolozi complex has a missing section on the National Protected Areas Database. This has been corrected in this report, but not in the base GIS maps.

Data title	Source and date of publication	Data Description
CBA	Provincial datasets (KZN - 2016)	As prepared by SANBI based on the KwaZulu-Natal CBA assessments of 2016.
Threatened ecosystems	DEA and the SANBI 2011	Data as downloaded from the SANBI website
Natural Forest Areas	National Forest Inventory (NFI), sourced 2016, Department of Agriculture, Forestry and Fisheries (DAFF)	As prepared by SANBI
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).

4.3 Assumptions and Limitations

This assessment relies exclusively on secondary data sources and is therefore dependant on any assumptions and limitations of the data sources. Overall key assumptions and limitations are given in Table 2.

Table 2: Assumptions and limitations.

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Resource availability	Only existing, published datasets used	Field verification of datasets and outcomes, and extensive local expert consultation	Reasonable accuracy of data layers used. Field verification will take place on a site by site basis linked to development proposals.
Scale of analysis	This assessment provides a strategic overview or important conservation concerns	As above	As above
Scope	Limited to terrestrial biodiversity.	Excluding wetlands, birds and bats.	Wetlands, birds and bats biodiversity concerns are covered in separate specialist reports as part of this SEA (Appendix C.1.6, Appendix C.1.7, and Appendix C.1.8 of the EGI Expansion SEA Report).
Limitations imbedded in provided data	Datasets used, such as CBA, are used as provided	-	These data sources have multiple assumptions underpinning their development and these have not been considered

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 (Appendices C.1.7 and C.1.8 of the EGI Expansion SEA Report, respectively). 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.

4.4 Relevant Regulatory Instruments

Table 3 below provides a description of the applicable legislation and regulations.

Table 3: Regulatory instruments relevant to EGI development and environmental aspects in the Grassland and Savanna biomes.

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.
National Environmental Management: Protected Areas Act, 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: 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. Activity 12 in Listing Notice 3 (Government Notice R324 of 7 April 2017) of the 2014 Environmental Impact Assessment (EIA) Regulations (as amended) relates to clearance of 300 m^2 or more of vegetation within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004.
National Environmental Management Act (Act 107 of 1998), as amended	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.
NEMA EIA 2014 Regulations, as amended (Government Gazette 40772)	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.
List of protected trees species Gazette 37941 of 2014	Specifies which trees are protected under the National Forests Act (Act 84 of 1998).
KwaZulu-Natal Nature Conservation Act, 1992 (Act 29 of 1992)	According to the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu-Natal Nature Conservation Act, 1992 (Act 29 of 1992), 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).

5 CORRIDORS DESCRIPTION

An overview of the expanded Eastern EGI Corridor is given in Table 4.

Table 4: Environmental overview of the expanded Eastern EGI Corridor.

Site	Brief description
Expansion of Eastern EGI Corridor	This corridor covers the Zululand area stretching from the Mozambique border to just north of Durban. It includes much of what is referred to as the Maputoland Centre of Plant Endemism. Excluding the northern edge of this corridor which is grassland, and the coastal edge which is Indian Ocean Coastal Belt vegetation, the balance is savanna. Much of this savanna vegetation is from threatened savanna vegetation types. This region also has a large number of important conservation areas that are critical components of the conservation strategy for the region. In addition many of these reserves are key eco-tourism destinations. Though outside of the savanna and grasslands, the iSimangaliso Wetland Park complex is a Ramsar site and important wetland area. Much of this area is under communal land management forming part of the previous Zululand homeland. As such it tends to have a high human settlement density. Plantation forestry and sugarcane fields are two of the most important agricultural activities, and both of these have fragmented the natural biodiversity. List of Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) species likely to be encountered in this region are provided in the Appendices B – D.

6 FEATURE SENSITIVITY MAPPING

6.1 Identification of feature sensitivity criteria

Feature sensitivity mapping is based on available national and provincial data (Table 1). The sensitivity of classes is based largely on sensitivities as used in National and KwaZulu-Natal Provincial biodiversity plans (see Table 5). All National and KwaZulu-Natal conservation area are considered of national biodiversity importance. The KwaZulu-Natal critical biodiversity plan was seen as the baseline for biodiversity conservation with CBA1 areas given very high status.

Occurrence of Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) species within the powerline corridor 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. We have therefore used buffers around recorded locations as a caution that these species may be found in the area and that precautions should be taken.

The ranking of sensitivity classes per feature is given in Table 5.

Table 5: Sensitivity ratings and buffers assigned to each feature class.

Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
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
CBA1	Very High	None
CBA2	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 1 above
ESA	Medium	None

7 FEATURE MAPS

7.1 Expanded Eastern EGI Corridor

This section highlights the different features that have been combined to develop the overall sensitivity map (Figure 4 and Figure 5). 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 draw on top of lower features if they overlap. The feature maps are to aid in understanding of the sensitivity maps (section 8), but in no way attempt to designate sensitivity either in the order of features or the colours used.

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.

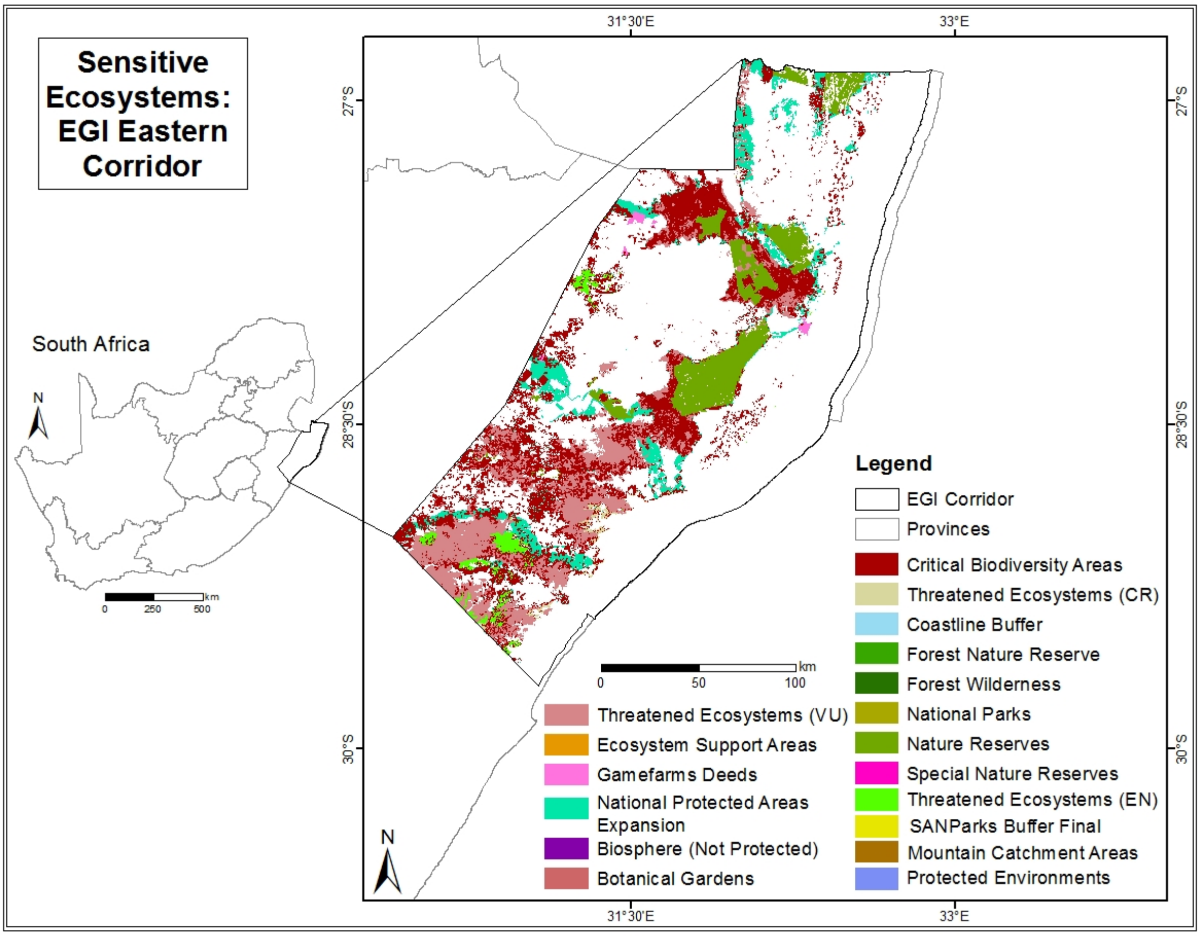

Figure 4: Summary map of feature classes used in the assessment of the expanded Eastern EGI Corridor.

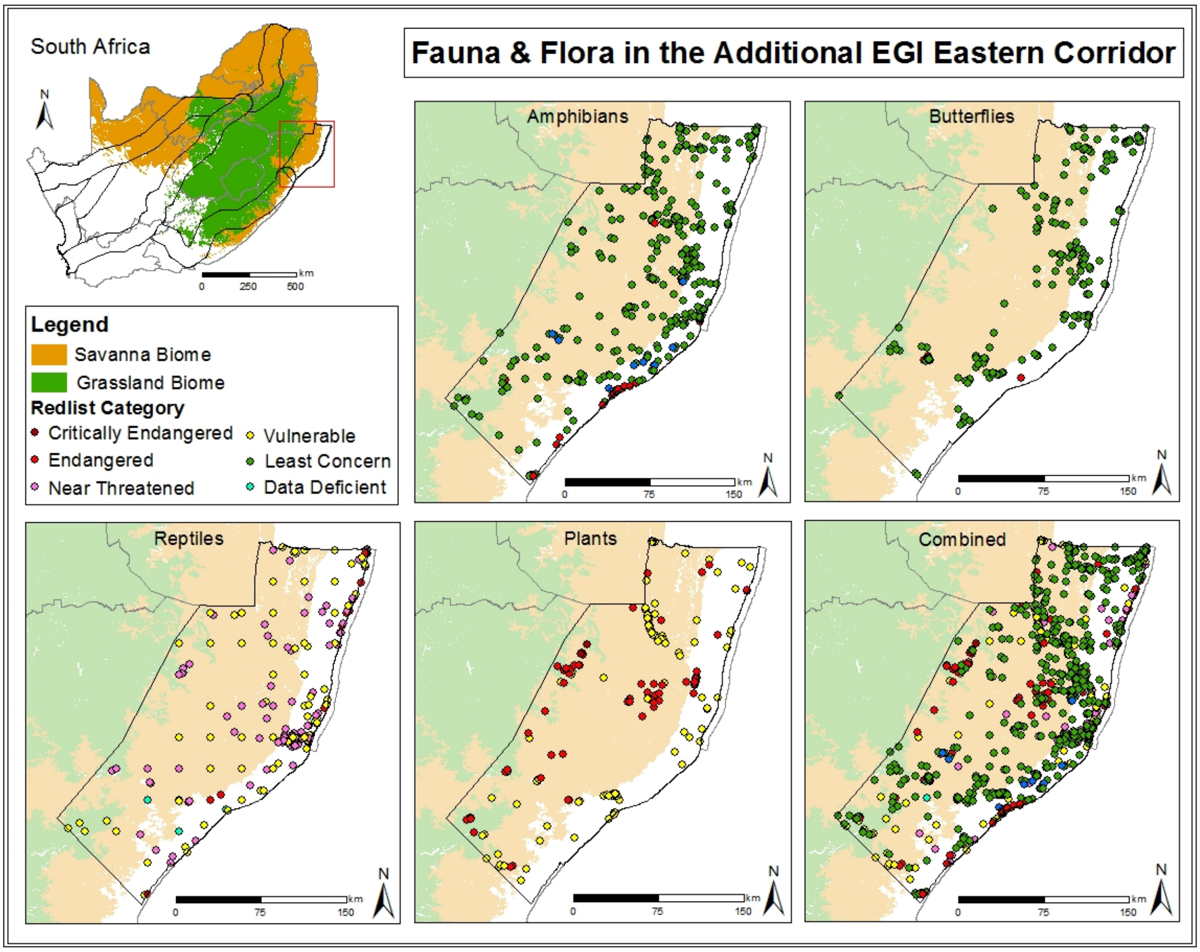

Figure 5: Summary maps of locations of critically endangered, endangered, vulnerable, near threatened and least concern amphibians, plants, butterflies and reptiles of the expanded Eastern EGI Corridor (see the appendixes for species lists). The map on the bottom row (extreme right) is a composite map of amphibians, plants, butterflies and reptiles.

8 FOUR-TIER SENSITIVITY MAPPING

The relative sensitivity mapping is based on a four-tier sensitivity classes approach with the following allocations:

- Dark Red : Very High Sensitivity
- Red : High Sensitivity,
- Orange : Medium Sensitivity
- Green : Low Sensitivity

Sensitivity maps have been drawn in the GIS system with low sensitivities forming the base, and then progressively higher sensitivities being overlayed. As such the highest sensitivity for any given area will be displayed and should be used in decision making.

8.1 Four Tier sensitivity maps

8.1.1 Expanded Eastern EGI Corridor

The expanded eastern corridor has a number of likely pinch points from a biodiversity perspective. The primary one being an area of irreplaceable conservation value linked to the complex of reserves including Mkuzi, Ubombo Mountain Reserve, Somkhanda Game Reserve, Zululand Rhino Reserve, Mduma, and the Thanda Private Reserve (Figure 6). Attempting to route coastward (to the east) would be inhibited by the iSimangaliso Wetland Park (Ramsar site) which are not shown on the maps as they are outside the grassland and savanna biomes.

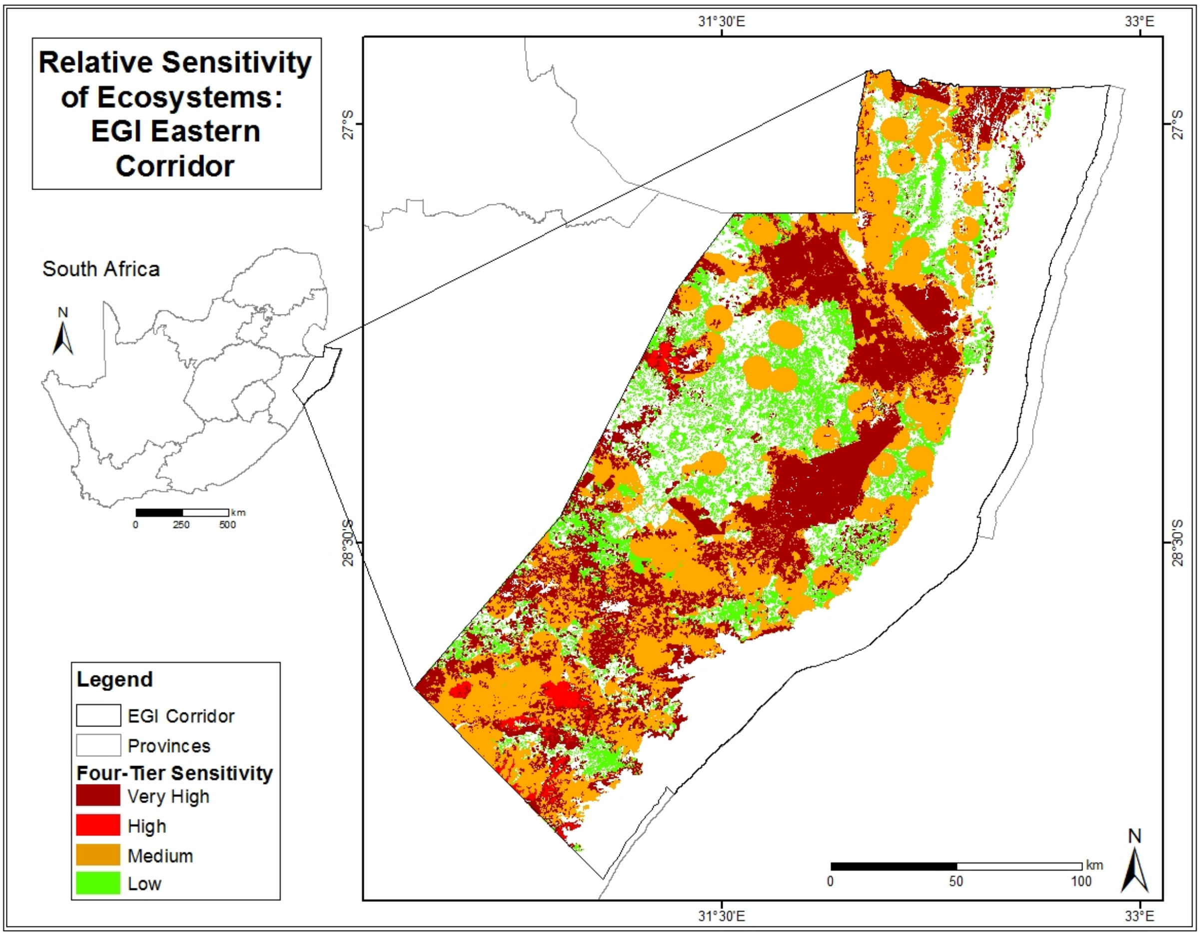

Figure 6: Four tier sensitivity map for the Expanded Eastern EGI Assessment

The southern section of the corridor, although not totally blocked as in the northern section, has multiple pinch points due to scattered areas of high biodiversity importance and a high likelihood of encountering threatened ecosystems and plant and animal species of conservation concern.

9 KEY POTENTIAL IMPACTS AND MITIGATION

The sensitivity map provides a strategic level guidance on areas where additional biodiversity related constraints to development are likely to be found. In most cases there are specific environmental constraints linked to all of the high sensitivity areas. For instance national legislation will govern any development proposed in national parks. Provincial legislation will govern development in provincial nature reserves or areas identified as CBAs. The project specific requirements in the various sensitivity areas will be captured in the Decision-Making tools that will prepared as part of this SEA.

The construction of powerlines and associated infrastructure has a number of key biodiversity impacts during the construction and operational phases.

The direct clearing of vegetation and disturbances to the area during pylon construction is one of the single biggest disturbances to biodiversity. The second potential disturbance is the road network created in support of the construction. It is assumed this will be mostly 4x4 tracks and not the full creation of graded dust roads. Some smaller additional impacts relate to activities such as mixing of cement for the pylon bases. Clearing of areas for pylon construction, access roads and drag lines can all act as points to imitate both erosion and the invasion of invasive alien plant (IAP) species and/or bush encroachment of less desirable indigenous species.

The most significant post-construction impact is that the vegetation under pylons is often kept at a low height to prevent fire and interference with the powerlines. It is normal that a permanent access road is also maintained.

Fire is a natural component of savanna and grassland systems, and suppressing fire will result in compositional and structural changes to the vegetation. In savannas the exclusion of trees from under the powerlines can change the vegetation structure, and hence the ability of the vegetation to support the migration of some species across the area. Some species such as snakes may attempt to climb pylons with potentially devastating impacts to the individual. The powerlines also are a hazard to birds, but this is covered in detail in the bird report (Appendix C.1.7 of the EGI Expansion SEA Report) and will not be covered here.

Table 6: Key potential impacts of EGI development to the Grassland and Savanna biomes and mitigation options.

Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
Vegetation clearing	There are many ecologically sensitive spots in the proposed corridor, and although the pylon footprint is relatively small it and access roads will impact on these areas.	Loss of ecologically significant habitats associated with these species.	Areas with a high abundance of endangered vegetation should be avoided if possible. Relocations of impacted species is a less optimum alternate.
Habitat structural changes	Cutting down of trees and changing fire regimes	Changes in species composition. Creation of barrier which some species may struggle to cross	Maintaining a tree layer (where appropriate). Maintaining fire regimes.
Habitat disturbance	Pylon sites, road networks and other forms of disturbance open the natural vegetation and allow for plant invasions. It can also destroy more sedentary or nesting animals.	Infestation of alien invasive species. Nick points that start soil erosion.	Clearing of Alien invasive species. Appropriate soil and water management.
Erosion	Pylons and access tracks/roads can lead to accelerated soil erosion	Erosion gullies	Route roads so they do not run directly up steep slopes, provide good drainage and erosion control, and re-vegetate bare soil.
Invasive alien plants	Introduced from land disturbances	Impact on indigenous vegetation, change fire profiles, change soil properties	Institute IAP prevention and clearing program.
Electrocution	Monkeys, snakes and other reptiles may climb the pylons and be electrocuted	Loss of individual animals	Barriers to prevent climbing.

10 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, and rehabilitation.

Recommendations are based on Richardson et al. (2017).

10.1 Planning phase

- Consider where high biodiversity areas can be avoided
- Avoid routes that go over protected tree species (see Appendix A)
- Consider where threatened species can be avoided (see Appendices B - D and Figure 5)
- Consider seasonal timing – winter will likely be best to avoid breeding seasons when appropriate. Spring and autumn are typically most likely for seasonal migrations and if migrations are an issue should be avoided.
- Consider the workflow so that any area is only disrupted for a short period of time
- Plan road routes to minimise disruption to critical areas and to reduce risks of erosion

10.2 Construction phase

- Scan the proposed corridor for rare or threatened species. Obtain the appropriate permits if species are to be disrupted. If they cannot be avoided then either re-locate them (animals or plants) or remove them for replanting (for plants and where possible)
- Minimise the construction period at any site
- Minimise the construction footprint (area to be disturbed)
- Ensure proper drainage so that roads do not initiate erosion.
- Revegetate under pylons with species indigenous to the area. A mix of local grass species is best to rapidly establish ground cover and initiate ecological process.
- Train construction staff in procedures to minimise soil, vegetation and animal disturbance, and introduce and incentive/punishment scheme that rewards best practice and provides effective individual sanction for forbidden activities such as poaching or illicit plant collection.

10.3 Operations phase

- Minimise road usage
- Monitor for and control IAPs
- Monitor for and control soil erosion
- Minimise disturbance
- Maintain fire regimes
- Minimise clearing / cutting of high trees. Allow low trees to grow.
- Train and monitor operations staff in their duties with respect to biodiversity protection on the servitudes.
- Monitoring the fire regime on and around the servitude as well as vegetation height and fuel load.

10.4 Rehabilitation and post closure

- Ensure that if rare and endangered species have established within the construction sites that they are treated appropriately.
- Minimise disturbances to vegetation and animals when removing infrastructure
- Rehabilitate vegetation
- Monitor for IAPs and remove if found (for at least 5 years)

10.5 Monitoring requirements

Monitoring should be conducted twice yearly in summer 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 of the natural vegetation cover. Achieving good ground cover of indigenous vegetation as soon as possible should be the short term objective.
- 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 powerline, especially where it passes through private or public protected areas, especially during construction, but also during operation.

11 REFERENCES

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander G.J. et al. (*Eds*.), Atlas and red data list of the reptiles of South Africa, Lesotho and Swaziland, p. 423, South African National Biodiversity Institute, Pretoria (Suricata series; no. 1)

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.

Eskom 2007. Procedure for vegetation clearance and maintenance within overhead powerlines servitudes and on Eskom owned land. Environmental Procedure 32-247. Eskom. Accessed on line:

http://www.eskom.co.za/OurCompany/SustainableDevelopment/EnvironmentalImpactAssessments/Documents/Appendix_16_-_Eskom_Procedure_32-2471.pdf

Fairbanks, D.H.K., Thompson, M W M., Vink, D. E., Newby, T. S., van den Berg H.M. and Everard, D. A. 2000. The South African land-cover characteristics database: a synopsis of the landscape. South African Journal of Science 96:69-82

Gazette 34809 of 2011. Threatened terrestrial ecosystems in South Africa. Schedule to the national environmental management: biodiversity act, 2004. Act 10 of 2004.

Mucina, L. & Rutherford, M.C. (*Eds*). 2006). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. Pretoria: South African National Biodiversity Institute

Neke, K.S. and Du Plessis, M.A. 2004. The Threat of Transformation: Quantifying the Vulnerability of Grasslands in South Africa. Conservation Biology. 18. 466-477

O'Connor, T.G. and Bredenkamp G.J. 1997. Grasslands. In Cowling, R. M., Richardson, D., & Pierce, S. M. (Eds) Vegetation of Southern Africa. Cambridge, UK: Cambridge University Press.

Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A., and Manyama, P.A. (*eds*). 2009. Red List of South African Plants. Strelitzia 25:41-52. South African National Biodiversity Institute, Pretoria.

Reyers B, Fairbanks DHK, van Jaarsveld AS & Thompson MW. 2001. Priority areas for the Conservation of South African Vegetation: a coarse filter approach. Diversity and Distributions. 17:79-95

Richardson, M. L., Wilson, B. A., Aiuto, D. A. S., Crosby, J. E., Alonso, A., Dallmeier, F. & Golinski, G. K. 2017. A review of the impact of pipelines and power lines on biodiversity and strategies for mitigation, Biodiversity and Conservation. Springer Netherlands, 26(8), pp. 1801–1815. doi: 10.1007/s10531-017-1341-9.

SANBI (no date). Implementing the grassland programme. South African National Biodiversity Institute. http://biodiversityadvisor.sanbi.org/wp-content/uploads/2014/07/Grasslands-Programme-fact-sheets.pdf

Scholes, R. J. 1997. Savanna. *In* Cowling, R. M., Richardson, D. et al. (*Eds*). Vegetation of Southern Africa. Cambridge: Cambridge University Press.

APPENDIX A: Trees protected through the National Forestry Act (Act 84 of 1998) and if 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). Tree species not marked with a "YES" in the final column are unlikely to be naturally growing in the corridor.

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	LIKELY TO OCCUR IN THE EXPANDED EASTERN EGI CORRIDOR
Acacia erioloba	Camel thorn	Kameeldoring	168	
Acacia haematoxylon	Grey camel thorn	Vaalkameeldoring, Mokholo	169	
Adansonia digitata	Baobab	Kremetart, Seboi, Mowana	467	
Afzelia quanzensis	Pod mahogany	Peulmahonie, Inkehli	207	YES
Balanites subsp. maughamii	Torchwood	Groendoring, Ugobandlovu	251	YES
Barringtonia racemosa	Powder-puff tree	Poeierkwasboom, Iboqo	524	
Boscia albitrunca	Shepherd's tree	Witgat, Umvithi	122	YES
Brachystegia spiciformis	Msasa	Msasa	198.1	
Breonadia salicina	Matumi	Mingerhout, Umfomfo	684	
Bruguiera gymnorrhize	Black mangrove	Swartwortelboom, IsiHlobane	527	
Cassipourea swaziensis	Swazi onionwood	Swazi uiehout	531.1	
Catha edulis	Bushman's tea	Boesmanstee, Umhlwazi	404	YES
Ceriops tagal	Indian mangrove	Indiese wortelboom, Isinkahe	525	
Cleistanthus schlechteri	False tamboti	Bastertamboti, Umzithi	320	YES
Colubrine nicholsonii	Pondo weeping thorn	Pondo-treurdoring	453.8	
Combretum imberbe	Leadwood	Hardekiil, Impondondlovu	539	
Curtisia dentata	Assegai	Assegaai, Umagunda	570	
Elaeodendron transvaalensis	Bushveld saffron	Bosveld-saffraan, Ingwavuma	416	YES
Erythrophysa transvaalensis	Bushveld red balloon	Bosveld-rooiklapperbos	436.2	
Euclea pseudebenus	Ebony guarri	Ebbeboom-ghwarrie	598	
Ficus trichopoda	Swamp fig	Moerasvy, Umvubu	54	YES

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	LIKELY TO OCCUR IN THE EXPANDED EASTERN EGI CORRIDOR
Leucadendron argenteum	Silver tree,	Silwerboom	77	
Lumnitzera racemosa	Tonga mangrove	Tonga-wortelboom, isiKhahaesibomvu	552	
Lydenburgia abbottii	Pondo bushman's tea	Pondo-boesmanstee	407	
Lydenburgia cassinoides	Sekhukhuni bushman's tea	Sekhukhuni-boesmanstee	406	
Mimusops caffra	Coastal red milkwood	Kusrooimelkhout, Umkhakhayi	583	YES
Newtonia hildebrandtii	Lebombo wattle	Lebombo-wattel, Umfomothi	191	YES
Ocotea bullata	Stinkwood	Stinkhout, Umnukane	118	YES
Ozoroa namaquensis	Gariep resin tree	Gariep-harpuisboom	373.2	
Philenoptera violacea	Apple-leaf	Appelblaar, isiHomohomo	238	
Pittosporum viridiflorum	Cheesewood	Kasuur, Umfusamvu	139	YES
Podocarpus elongatus	Breede river yellowwood	Breeriviergeelhout	15	
Podocarpus falcatus (Afrocarpus falcatus)	Outeniqua yellowwood	Outeniquageelhout, Umsonti	16	YES
Podocarpus henkelii	Henkel's yellowwood	Henkel se geelhout, Umsonti	17	
Podocarpus latifolius	Real yellowwood	Regte-geelhout, Umkhoba	18	YES
Prota comptonii	Saddleback sugarbush	Barberton-suikerbos	88	
Protea curvata	Serpentine sugarbush	Serpentynsuikerbos	88.1	
Prunus africana	Red stinkwood	Rooistinkhout, Umdumezuz	147	YES
Pterocarpus angolensis	Wild teak	Kiaat, Umvangazi	236	
Rhizophora mucronata	Red mangrove	Rooiwortelboom	526	
Sclerocarya birrea subsp. caffra	Marula	Maroela, Umganu	360	YES
Securidaca longepedunculata	Violet tree	Krinkhout, Mmaba	303	

BOTANICAL NAMES	ENGLISH COMMON NAMES	OTHER COMMON NAMES	NATIONAL TREE NUMBER	LIKELY TO OCCUR IN THE EXPANDED EASTERN EGI CORRIDOR
Sideroxylon inerme subsp. inerme	White milkwood	Witmelkhout, Umakhwelafingqane	579	YES
Tephrosia pondoensis	Pondo poison pea	Pondo-gifertjie	226.1	
Warburgia salutaris	Pepper-bark tree	Peperbasboom, isiBaha	488	YES
Widdringtonia cedarbergensis	Clanwilliam cedar	Clanwilliamseder	19	
Widdringtonia schwarzii	Willowmore cedar	Baviaanskloofseder	21	

APPENDIX B: Savanna and Grassland Endangered and Vulnerable mammals that are likely to be encountered in the Expanded Eastern EGI Corridor.

ORDER	FAMILY	BOTANICAL NAME	ENGLISH COMMON NAMES	BIOME WHERE THE SPECIES IS LIKELY TO OCCUR
Endangered				
Afrosoricida	Chrysochloridae	*Amblysomus marleyi*	Marley's Golden Mole	Grassland
Artiodactyla	Bovidae	*Nesotragus moschatus zuluensis*	Suni	Savanna
Artiodactyla	Bovidae	*Redunca fulvorufula fulvorufula*	Mountain Reedbuck	Grassland
Carnivora	Canidae	*Lycaon pictus*	African Wild Dog	Savanna
Perissodactyla	Rhinocerotidae	*Diceros bicornis minor*	Southern-central Black Rhinoceros	Savanna
Artiodactyla	Bovidae	*Ourebia ourebi ourebi*	Oribi	Grassland
Vulnerable				
Artiodactyla	Bovidae	*Damaliscus lunatus lunatus*	Tsessebe	Savanna
Artiodactyla	Bovidae	*Philantomba monticola*	Blue Duiker	Savanna
Carnivora	Felidae	*Panthera pardus*	Leopard	Grassland Savanna
Pholidota	Manidae	*Smutsia temminckii*	Temminck's Ground Pangolin	Savanna
Primates	Cercopithecidae	*Cercopithecus albogularis labiatus*	Samango Monkey	Savanna
Carnivora	Felidae	*Acinonyx jubatus*	Cheetah	Savanna

APPENDIX C: Grassland Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found in the grassland and forest habitats. 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.

BOTANICAL NAME AND STATUS OF GRASSLAND SPECIES
Acalypha entumenica Prain EN
Alepidea cordifolia B.-E.van Wyk EN
Aloe saundersiae (Reynolds) Reynolds CR
Argyrolobium longifolium (Meisn.) Walp. VU
Asclepias gordon-grayae Nicholas EN
Aspalathus gerrardii Bolus VU
Brachystelma gerrardii Harv. EN
Brachystelma ngomense R.A.Dyer EN
Brachystelma sandersonii (Oliv.) N.E.Br. VU
Brachystelma vahrmeijeri R.A.Dyer EN
Cyathocoma bachmannii (Kük.) C.Archer VU
Dierama dubium N.E.Br. VU
Gerbera aurantiaca Sch.Bip. EN
Gymnosporia woodii Szyszyl. EN
Haworthiopsis limifolia (Marloth) G.D.Rowley VU
Helichrysum ingomense Hilliard EN
Kniphofia leucocephala Baijnath CR
Oxygonum dregeanum Meisn. subsp. *streyi* Germish. EN
Pachycarpus concolor E.Mey. subsp. *arenicola* Goyder VU
Restio zuluensis H.P.Linder VU
Riocreuxia woodii N.E.Br. CR PE
Schizoglossum ingomense N.E.Br. EN
Selago zuluensis Hilliard EN
Senecio dregeanus DC. VU
Senecio ngoyanus Hilliard VU
Senecio villifructus Hilliard EN
Syncolostemon latidens (N.E.Br.) Codd VU
Tephrosia inandensis H.M.L.Forbes EN
Thesium polygaloides A.W.Hill VU

APPENDIX D: Savanna Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) plant species likely to be found. 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.

BOTANICAL NAME AND STATUS OF SAVANNA SPECIES
Encephalartos lebomboensis I.Verd. EN
Raphionacme elsana Venter & R.L.Verh. EN
Warneckea parvifolia R.D.Stone & Ntetha CR
Euphorbia gerstneriana Bruyns VU
Dioscorea sylvatica Eckl. VU
Ceropegia cimiciodora Oberm. VU

APPENDIX E: Savanna and Grassland Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) and Near Threatened (NT) Reptile species likely to be found.

ORDER	REPTILES SCIENTIFIC NAME	REPTILES COMMON NAME	IUCN STATUS
Squamata	*Bitis gabonica*	Gaboon Adder	NT
Squamata	*Bradypodion caeruleogula*	uMlalazi Dwarf Chameleon	EN
Squamata	*Chamaesaura macrolepis*	Large-scaled Grass Lizard	NT
Crocodylia	*Crocodylus niloticus*	Nile Crocodile	VU
Squamata	*Cryptoblepharus boutonii*	African Coral Rag Skink	EN
Squamata	*Dendroaspis angusticeps*	Green Mamba	VU
Squamata	*Homoroselaps dorsalis*	Striped Harlequin Snake	NT
Squamata	*Leptotyphlops telloi*	Tello's Thread Snake	NT
Squamata	*Lycophidion pygmaeum*	Pygmy Wolf Snake	NT
Squamata	*Macrelaps microlepidotus*	Natal Black Snake	NT
Squamata	*Natriciteres olivacea*	Olive Marsh Snake	NA
Testudines	*Pelusios rhodesianus*	Variable Hinged Terrapin	VU
Squamata	*Scelotes bourquini*	Bourquin's Dwarf Burrowing Skink	VU
Squamata	*Scelotes inornatus*	Durban Dwarf Burrowing Skink	CR
Squamata	*Tetradactylus breyeri*	Breyer's Long-tailed Seps	VU

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 – EGI Expansion					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		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.	Changed as suggested
RJ Scholes	4	3		In general, this paragraph is correct but a little unclear. Point out that it is other, prior activities which have already transformed the grasslands; thus the remaining pockets may represent critical habitat. The spatial scale of endemism in grasslands is seldom such that a single pipeline would eliminate the entire population of a species; if it were so, a simple re-alignment would suffice to avoid the problem. The paragraph raises and issue, but does not suggest a consequence or solution.	Reworded as suggested
RJ Scholes	4	23		This paragraph needs to be expanded; pointing out that the maintenance of a fire regime is often in conflict with powerline management guidelines.	Added as suggested
RJ Scholes	6	7		I infer that there is a separate specialist study on visual impacts and impact on sense of place, but you need to mention their importance here. In addition to cropping and forestry, the other big (and growing) economic activity in the grasslands and savannas of this corridor is biodiversity-based tourism, which is particularly sensitive to visual and sense of place impacts, regardless of whether they endanger the biodiversity populations directly or not. In the same way you emphasise birds and bats, although they are not treated here, you need to emphasise how unacceptable a large powerline would be in a major protected area or scenic landscape, with respect to the key economic activity in that landscape. Otherwise protected or conserved areas are seen as the cheap option for power corridors - often they are state owned land, so there are no servitude costs and pesky owners to deal with, and there is a mistaken perception that 'nothing is going on there'.	Added as suggested

EXPERT REVIEW AND SPECIALIST RESPONSES: Savanna and Grassland Biomes – EGI Expansion					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	6	7		In a similar vein, I assume there is a specialist report on rivers and wetlands. But you need to mention the connections in this report, for two reasons: wetland and river features are sub-map scale at this strategic level so tend to get overlooked, although they are typically crucial. Secondly, you cannot separate the rivers and wetlands functionally from the matrix in which they are embedded. The actions in the savanna or grassland will impact the rivers and marshes within them, and vice versa.	Added as suggested
RJ Scholes	6	47		You do not raise the issue of the powerline being a potential source of ignition. Sparks caused by line failure are a fire hazard; minimum clearances from the ground, especially when the air temperature is high, have this in mind.	Added as suggested
RJ Scholes	8	15		The paragraph ends without suggesting any mitigative or restorative actions: cleaning of vehicles and clothing to reduce the inadvertent introduction of propagules; follow up operations to control aliens before they come to dominate.	Added as suggested
RJ Scholes	15		5	There is no reason not to label the bottom right panel 'Composite'. You need to change the legend order so that the really important dots are not overlain and obscured by the less important ones.	Panel labelled. Dots are drawn with highest priority on top.
RJ Scholes	15	6		I think figure 5 needs some interpretive text. For instance, noting that there are two corridors which mostly avoid endangered species: one on the coastal plain, but not near the coast itself, and another inland but not on the scarp.	I would prefer not to give specific advice on just this one variable as it is the composite of all biodiversity concerns given later that is important.

EXPERT REVIEW AND SPECIALIST RESPONSES: Savanna and Grassland Biomes – EGI Expansion					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	16		6	I have some real conceptual issues when this kind of ranking scheme is applied across studies without some robust underlying calibration system. How does your very high sensitivity correspond to someone else's?	This is an issue from the overall study, not just this one section. Response from CSIR Project Team Integrating Author: In the integrated chapter the sensitivities are checked for major discrepancies between topics. The sensitivity classes at a strategic level, act as "management and assessment units" to guide the environmental assessments needed in field and the corresponding construction, management and mitigation actions, and is based on expert opinion. Although it is recognised that a consistent underlying framework (such as a risk assessment with calibrated consequence terms) is a more robust approach, this EGI Expansion SEA is an extension of the existing EGI SEA completed in 2016 which was used to gazette Electricity Corridors in South Africa in February 2018, and as such had to follow the same methodology.
RJ Scholes	19	26		...train construction staff in procedures to minimise soil, vegetation and animal disturbance, and introduce and incentive/punishment scheme that rewards best practice and provides effective individual sanction for forbidden activities such as poaching or illicit plant collection.	Added as suggested
RJ Scholes	19	38		Train and monitor operations staff in their duties with respect to biodiversity protection on the servitudes	Added as suggested
RJ Scholes	19	38		Monitoring the fire regime on and around the servitude is an easy and necessary thing to do, given that you have highlighted it as an issue; they should also monitor vegetation height and fuel load.	Added as suggested

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.3

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Indian Ocean Coastal Belt Biome

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

INDIAN OCEAN COASTAL BELT BIOME

Contributing Authors	Simon Bundy[1], Alex Whitehead[1]

[1] SDP Ecological and Environmental Services

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TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

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
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
EGI	Electricity Grid Infrastructure
EKZNW	Ezemvelo KZN Wildlife
ESA	Ecological Support Area
GIS	Geographic Information System
ha	Hectares
IOCB	Indian Ocean Coastal Belt
kV	Kilovolt
KZN	KwaZulu-Natal Province
NPAES	The National Protected Areas Expansion Strategy
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
Spp	Species

1 SUMMARY

This assessment aims to identify the potential impacts of constructing and maintaining Electricity Grid Infrastructure (EGI) (i.e. the transmission (and distribution) power lines and associated infrastructure, such as, but not limited to, substations, service roads, 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, chiefly located along the east coast of Southern Africa, consists of five dominant and six associated azonal and intrazonal vegetation units. Of the 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". 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 powerline infrastructure servitude. The IOCB covers only a small portion of the Expanded Eastern EGI corridor, but is diverse in terms of habitat and land use. The study area included the IOCB that stretched from the Mozambique border to the greater Durban area.

The activities associated with EGI construction and maintenance may pose a risk of disturbance and transformation of natural vegetation (including habitat loss and spread of alien invasive vegetation); and disturbance of fauna.

The IOCB has been extensively transformed by agriculture, forestry plantations and urban development over a relatively short timeframe and as such, much of the EGI corridor may be aligned outside or distal from ecologically important habitats within the IOCB. Any proposed infrastructure routes within the corridors should be planned and placed to align with existing transformed areas as close as possible.

This assessment serves to evaluate the nature of habitat within the proposed corridor and makes recommendations and suggestions in respect of these routes, including features and areas to be avoided and management actions that may impact on habitat form and structure.

2 INTRODUCTION

The proposed establishment of Electricity Grid Infrastructure (EGI) 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 ecologically important and are of conservation importance. This report forms one of a number of environmental investigations that have been undertaken to evaluate and provide recommendations on the alignment of the expanded EGI corridors on the Eastern and Western coast of South Africa. The report therefore 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 coinciding with the proposed expanded Eastern EGI corridor.

3 SCOPE OF THIS STRATEGIC ISSUE

The IOCB is a habitat form or biome that is driven primarily by its proximity to the coast and 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 proposed expanded Eastern EGI corridor only (Figure 1).

This Strategic Environmental Assessment (SEA) of the proposed expanded Eastern EGI corridor through the IOCB has been compiled to provide a high-level approach to evaluation of the proposed corridor and the potential influence and effect that routing and placement of EGI within the corridor may have on the various vegetation units within the biome, as well as the various faunal affiliates. This study gives consideration to powerlines, servitudes, substations, service roads, access roads as described in the Project Description Chapter of this SEA Report (Part 2 of the EGI Expansion SEA Report).

This assessment provides guidance from a broad, eco-morphological perspective that can be utilised for decision-making on and planning for the establishment and routing of EGI corridors within the extent of the IOCB, while offering an overview of opportunities to avoid and/or moderate impacts. It also offers opportunities to ameliorate technical issues that may arise in the establishment of infrastructure.

This study 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 power line and associated infrastructure within the corridor. Relevant data includes readily available GIS data sets provided by the South African National Biodiversity Institute (SANBI), the Council for Scientific and Industrial Research (CSIR), Provincial 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, although this study does touch on these aspects where pertinent to the IOCB (Appendices C.1.5, C.1.6, C.1.7 and C.1.8 of the EGI Expansion SEA Report).

As noted above, the region of emphasis in this study is the expanded Eastern EGI corridor between the Mozambique border and Durban, extending from the coastline to approximately 100 km inland. The IOCB only comprises a narrow portion of this corridor, along the coastline (Figure 1). Although defined as a clear finite area for the purposes of this study, practically, the IOCB can be variable and merge with neighbouring biomes and vegetation types, sharing common characteristics, climatic features and biota.

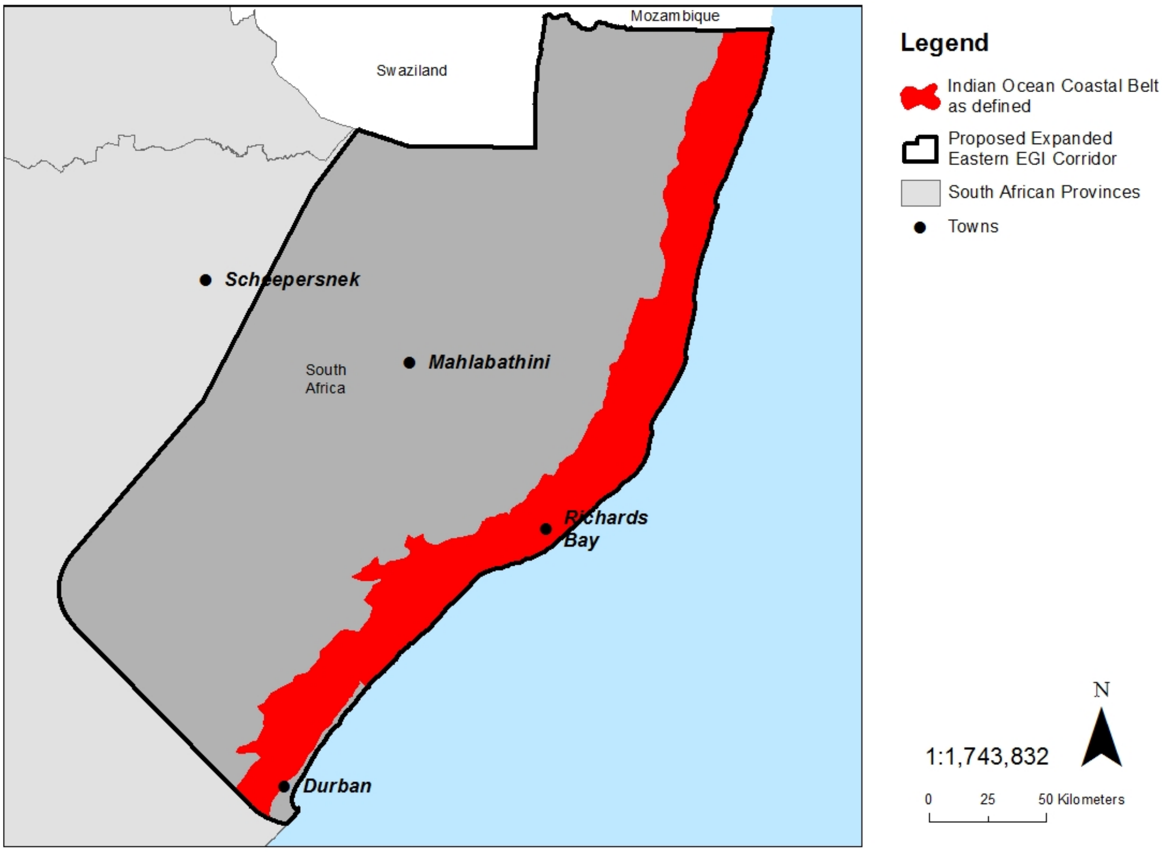


Figure 1: The extent of the IOCB as defined within the proposed expanded Eastern EGI corridor.

4 APPROACH AND METHODOLOGY

4.1 Study Methodology

The assessment of the proposed corridor and its 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 4.2 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 EGI development within the 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 EGI corridors and its intersections with the IOCB. The 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 EGI 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 2 of this report.

4.2 Data Sources

The following data and literature sources presented in Table 1 were considered and assessed in this report.

Table 1: A summary of data 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	DEA Protected Areas database 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.
Protected Area Expansion Areas	• DEA Priority areas for protected area expansion 2016	This data was provided by the CSIR and used without modification.
Critical Biodiversity Areas (CBA)	• Ezemvelo KZN Wildlife CBA 2016	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. The National data aligned with the "irreplaceable" layer of the KZN CBA. The "Optimal" and "Ecological Support Area" (ESA) layers provided additional sensitivity contrast.

Data title	Source and date of publication	Data Description
Private Nature Reserves 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 the data which includes areas that are recognised as game farms.
Stewardship	• 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 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	Vegetation Map as was the vegetation type conservation status data. This data set provides the conservation status of the specific vegetation types within KZN based on various attributes. This layer 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.
Ecoregions	• 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.

All the above features were cropped to the extent of the IOCB within the proposed Extended Eastern EGI corridor. Sourced data sets that did not illustrate any presence with the IOCB were discarded, as well as data that was not considered to be of ecological relevance. Assigning sensitivity rating to the layers was done based on a four-tier rating system (Section 7). 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-worth status and sensitivity were deemed to be directly related. Other simpler layers were assigned sensitivity ratings based on expert knowledge and the nature of the feature (Section 7.1).

4.3 Assumptions and Limitations

4.3.1 Spatial data

Much of the spatial information utilised in this investigation was sourced from Provincial and National institutions. While the data utilised may 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 the primary source nor by 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.

- As noted above, 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.
- 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.

A summary of all GIS data used is provided in Appendix 1.

4.3.2 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 (and other azonal vegetation types) were not classified as being part of the IOCB but may be evident at points within the corridor, particularly in the Maputaland region. The original data defining the extent of the IOCB was revised and the outer extent of the IOCB redefined to include such azonal and intra zonal vegetation types.

4.3.3 The IOCB and neighbouring Biomes

The IOCB makes up only a small portion of the corridor 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 be expected to arise.

4.3.4 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, such as protected areas. It is recommended that matters relating to fauna should be considered as an independent and site-specific aspect in terms of the construction and operation of the EGI (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 – areas of importance mentioned above have been included/covered or considered by other data sets, primarily protected areas and KZN CBAs. Faunal data was used as supplementary or supporting data for descriptive and illustrative purposes.

4.3.5 Information deficiencies

Available data for the study area is well established and of reasonable accuracy (Jewitt 2015 et. al.). 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. Attempts to verify the available data were undertaken with varying degrees of success. 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.

4.4 Relevant Regulatory Instruments

The legal environment that may be applicable to habitats found within the IOCB is presented in Table 2 below. These include various legal instruments that regulate activities within portions of the IOCB and include international, national and provincial, as well as municipal laws and regulations (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 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 form 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, 1997 (Act Number Act 9 of 1997)	According to the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu-Natal Nature Conservation Management Act, 1997 (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.
Municipal bylaws varied	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.

5 IMPACT CHARACTERISATION

In order to understand the potential impacts and identify sensitive features that may be affected by the construction and operation of the EGI, specifically power lines, it is important to consider and characterise the nature and extent of impacts associated with EGI development on relevant features. The following impacts have been identified and are discussed:

5.1 Habitat loss

Major power lines require a wide servitude that is rendered and maintained free of significant woody or larger plant species. Such a state facilitates the management and maintenance of the power lines. Establishment of a servitude will require the clearance of natural vegetation and regular vegetation management. These factors generally maintain the natural vegetation within the servitudes at an early seral stage, preventing secondary and more advanced seral processes (Figure 2a and 2b). Under some situations, such vegetation clearance may serve to bisect habitats and changes in vegetation form and structure may extend beyond the servitude boundary. The following habitat forms are likely to be affected:

- Natural forest, on account of the initial stringing requirements and the need to prevent the growth and establishment of trees. This may include Northern Coastal Forest, Scarp Forest and particularly threatened forest types such as Sand Forest.
- Grasslands – on account of the fact that grasslands are often considered preferential routes for power lines, due to the evident avoidance of felling activities and general bush clearing.
- Azonal vegetation – including scrub and swamp forest habitats, where features such as rivers and wetland environments are traversed.

5.2 Alien invasive plants

Electrical line servitudes are areas of high physical disturbance, that are subject to regular vehicular traffic and periodic clearance. This sustained level of disturbance presents suitable conditions for the establishment and spread of alien invasive plants. Servitudes often act as repositories and vector corridors of exotic plant propagules and thereby promote and facilitate the spread of alien invasive plants.

5.3 Faunal disturbance

With a loss of habitat and/or its transformation within both the servitude and areas immediately adjacent to them, such change is likely to affect faunal populations within particular areas, or alternatively give rise to change in species' behaviour. Thus the clearance of large swathes of land is likely to affect faunal populations both directly and indirectly and in the medium to long term lead to the ousting of specific faunal populations or alternatively promote the establishment of others. A case in point, may be the clearance of forest and establishment of a scrub or graminoid veld form within a servitude that will favour grazers but may lead to the ousting of frugivorous species that were reliant upon fruiting species. In addition, such transformation may also alter transitory niche or migratory routes of certain species or act as physical barriers to others. In the case of the latter, mortalities may arise through, for example collision, leading to avian mortalities (however, the impact on avifauna is subject to a separate specialist assessment (Appendix C.1.7 of the EGI Expansion SEA Report).

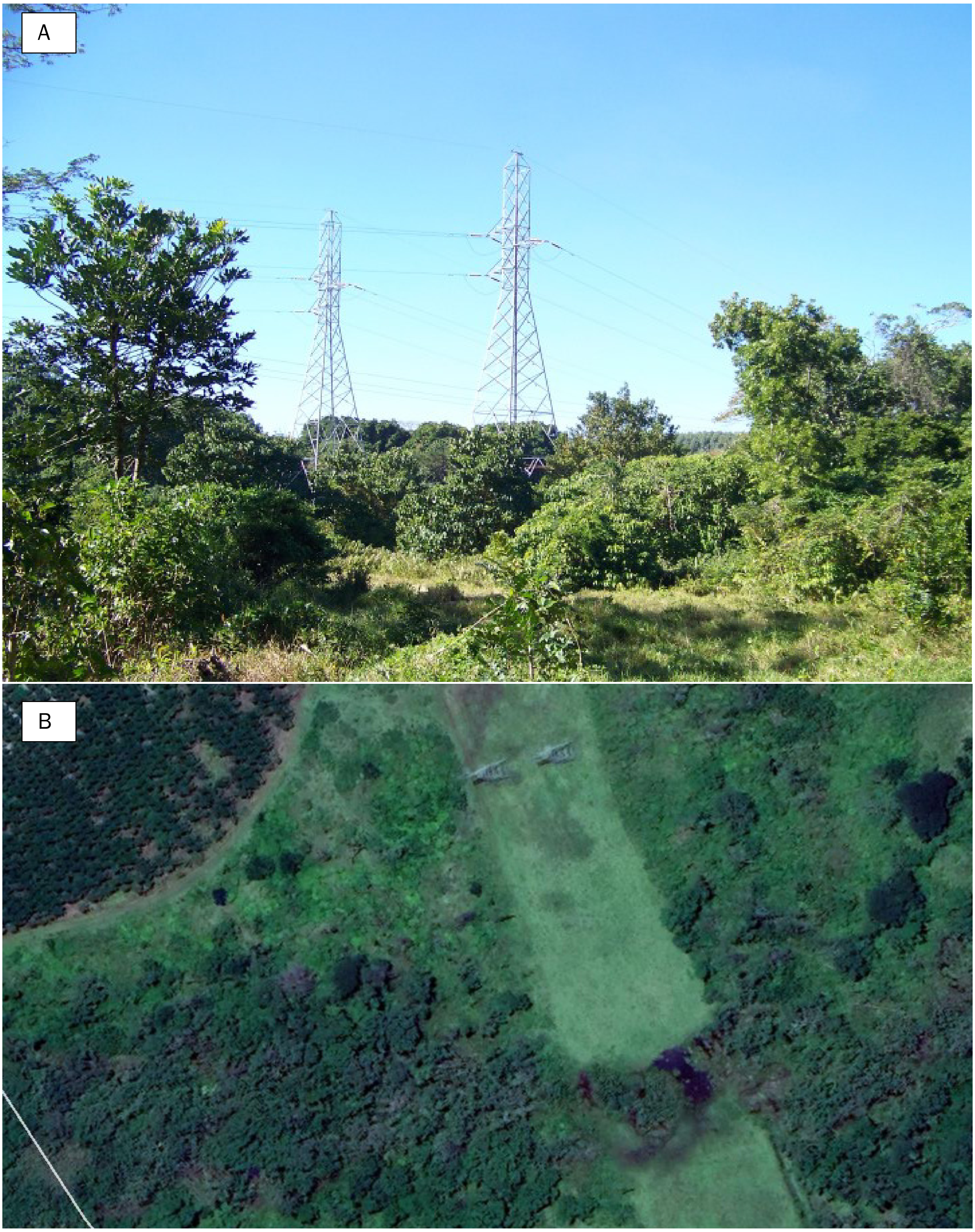


Figure 2: A) An example of vegetation clearance - a 132 kV line passing through a section of swamp forest near Port Durnford south of Richards Bay (Photo: SDP); and B) An aerial image of the same corridor pictured in (a), indicating extent of the cleared vegetation (Google Earth).

6 CORRIDOR DESCRIPTION

6.1 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
- CB 5 – Transkei Coastal Belt

The drivers, characteristics and conservation significance of the abovementioned five vegetation types are summarised in Table 3 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). Such meteorological regime plays a significant role in determining the form of habitats that are found within the IOCB (Mucina and Rutherford 2006, SDP 2015) and (see Table 4), 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 IOCB. 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 (Tinley, 1985), 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.

Table 3: The five defining vegetation groups of the Indian Ocean Coastal Belt (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 nonforest 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, same as CB 1.	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.,*

Vegetation Type	Distribution	Vegetation and Landscape Features	Geology and Soils	Climate	Endemic Taxa
					Anthospermum steryi, Erica abbottii, E. cubica var natalensis, Eriosema dregei, E. latifolium, E. luteopetalum, Euryops leiocarpus, Gnidia triplinervis, Leucadendron pondoense, 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.

Additionally, edaphic form and structure 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 4: 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: http://en.climate-data.org)

Associated with the five main IOCB 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 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 5 indicates the 11 vegetation units that are considered to be primarily “terrestrial” in nature and lie within or adjacent to the IOCB, as defined.

Where the establishment of the EGI serves to influence and change the ecosystem drivers, it should be expected that ecological change will result (e.g. the cessation of the fire regime).

Notably, of the eleven 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” (Table 5). Comparatively, two of the four forest types are considered “critically endangered”, while the rest are considered to be “least threatened” (Table 5). These ecological aspects are afforded some further consideration below. Figure 4 provides a spatial representation of the IOCB within the expanded Eastern EGI corridor and the various vegetation types associated with the IOCB as well as adjacent vegetation types. Often the boundary between the IOCB and adjacent vegetation types can be indistinct with areas of overlap occurring.

Table 5: Summary of the veld types encountered within or proximal to the IOCB including azonal and intrazonal vegetation units as well as key zonal units that may be encountered within the expanded Eastern EGI Corridor (Mucina and Rutherford 2006)

Vegetation Type	Code	Biome/Veg. Unit	Distribution	No. of endemic taxa	Conservation status (SANBI)	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 EGI 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 EGI
Maputaland Coastal Belt	CB1	IOCB	Mtunzini in KZN northwards to Southern Mozambique - landward up to 35km.	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 in iSimangaliso Wetland Park and Mozambique. Probable likelihood of interface with EGI corridor
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 EGI corridor
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 EGI corridor
Pondoland-Ugu Sandstone Coastal Sourveld	CB4	IOCB	Approximately from Port Shepstone to Port St Johns. Primarily coastal areas but up to 20kms inland at points	33	Endangered	Associated with rocky cliff-type environments. May be associated with EGI inland of Port Shepstone. Possible, but unlikely interface with EGI corridor inland / south coast of KZN
Transkei Coastal Belt	CB 5	IOCB	Coastal areas south of Port St Johns to Kei River. Undulating topography with grassland and valley forests	0	Least threatened/Not listed	Present within IOCB but with little likelihood of interface with EGI corridor

Vegetation Type	Code	Biome/Veg. Unit	Distribution	No. of endemic taxa	Conservation status (SANBI)	Comment
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	Azonal forest	Azonal 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 EGI 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 msl	1	Endangered	Under threat on coastal dunes. Includes "dune forest" (Acocks, 1954) which is under threat from mineral exploitation and settlement. Limited probability of interface with EGI corridor
Sand Forest	FOz8	Intrazonal forest	Fragmented patches - Mozambique (Tembe region) at between 20 - 160m msl	14	Least threatened/Not listed	Associated with paleo dunes in Northern KZN. Interface with EGI corridor likely in northern region of KZN

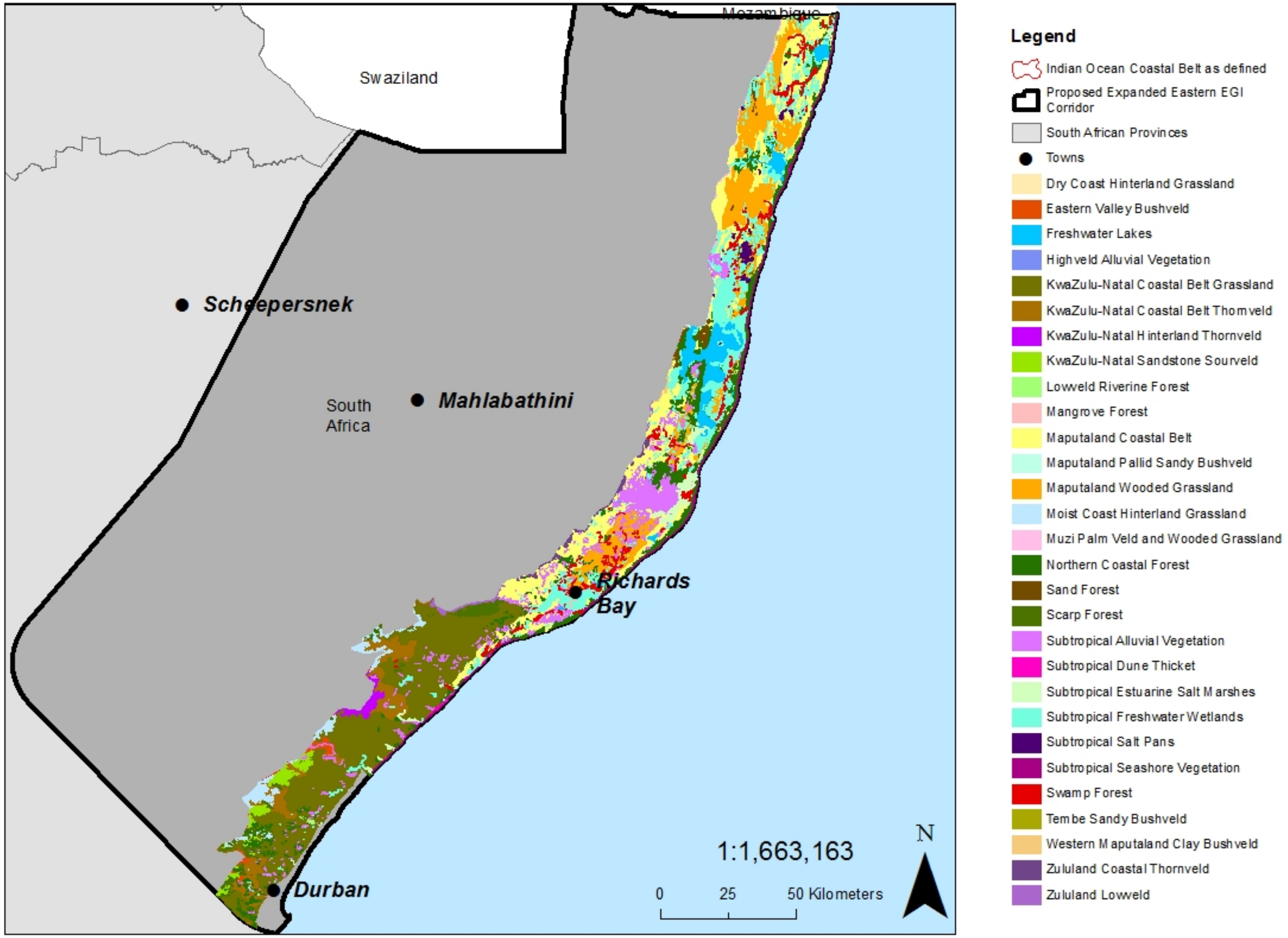


Figure 3: An overview of the vegetation types, including azonal vegetation of the IOCB affected by the expanded Eastern EGI corridor (SANBI 2012).

6.2 Vegetation types of the IOCB

A description of the vegetation types that characterise the IOCB (as defined by Mucina and Rutherford 2006) is provided below.

6.2.1 CB 1 – Maputaland Coastal Belt

The Maputaland Coastal Belt vegetation type is restricted to the north of the Expanded Eastern EGI corridor, primarily to areas north of Richards Bay. The habitat comprises of a grassland mosaic and often secondary forest dominated by species such as *Syzigium cordatum, Acacia natalitia* and *Phoenix reclinata* (Figure 4). 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, 2015) which would suggest that the vegetation unit is under increasing anthropogenic pressures.

Figure 4: Example of Maputaland Coastal Belt vegetation near Mbazwana (Photo: SDP).

6.2.2 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 5). 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 5: Example of Maputaland Wooded Grassland near Kwandalane (Photo: SDP).

6.2.3 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. The landscape comprises of a mosaic of grassland and forested habitat, the latter normally associated with lower elevations (Figure 6). Notably fire and grazing has played a significant role in the establishment of this veld type. The expanded Eastern EGI corridor may interface with this habitat in northern KZN, but the habitat form is not expected within the corridor through the City of Durban.

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 6: Typical KwaZulu-Natal Coastal Belt located near Mtunzini (Photo: SDP).

6.2.4 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 7). 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. This vegetation type does not occur within the expanded Eastern EGI corridor.

6.2.5 CB 5 – Transkei Coastal Belt

The Transkei Coastal Belt (Figure 8) is located along the coastline of the northern Eastern Cape southwards to beyond East London. This vegetation unit will not be affected by the expanded Eastern EGI corridor.

Figure 7: Pondoland-Ugu Sandstone Coastal Sourveld near Margate (Photo: SDP).

Figure 8: Transkei Coastal Belt located near Port St Johns (Photo: SDP).

6.2.6 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 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 (i.e. Appendix C.1.5 and Appendix C.1.6 of the EGI Expansion SEA Report). In addition, some consideration and expansion on those vegetation types that are most likely to be encountered in the IOCB is presented below, these vegetation forms being:

- FOa 1 Lowveld Riverine Forest
- FOz 5 Scarp Forest
- FOz 8 Sand Forest
- FOz 7 Northern Coastal Forest
- AZs 3 Subtropical Dune Thicket
- AZd 4 Subtropical Seashore Vegetation

Table 6: Azonal and intrazonal vegetation found within the Indian Ocean Coastal Belt (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	Moderately stratified forest with poor herb layer and some dominant shrubs.	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 racemose, 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
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
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
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

6.2.7 FOa 1 Lowveld Riverine Forest

Lowveld Riverine Forest is confined primarily to riverine environments in and around the northern regions of KZN, extending into 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 9), 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 9: Image of Lowveld Riverine Forest on Phongolo River. (Photo: SDP)

6.2.8 FOz 5 Scarp forest

Scarp forest is a stratified forest form that is primarily associated with cliffs and rocky krantzes (Figure 10). 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 & 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.

While the anthropogenic impact pressures on Scarp Forest are considered to be limited, the EGI, on account of its linear nature, may have some direct and more predictably indirect, impact on Scarp Forest as power lines traverse over valleys and escarpments. Indirect impacts are difficult to forecast but may relate to the influence that such lines have on fauna associated with this forest type, in particular avifauna.

Figure 10: Image showing Scarp Forest near Ongoye Forest between Mtunzini and Eshowe. (Photo: SDP)

6.2.9 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 (Figure 11). Sand Forest is likely to be encountered in small to moderate sized pockets within the IOCB. 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).*

Figure 11: Image of Sand Forest, located near Ndumo. (Photo: SDP)

6.2.10 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 at the coast (Acocks, 1954) (Figure 12). 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. Due to the ongoing clearance and loss of this forest form, Northern Coastal Forest is considered to be “endangered” from a conservation perspective, although such classification is perhaps misguided.

The EGI may interface with communities of Northern Coastal Forest in the north, where the corridor is situated proximal to the coastline, however much of the forest in this area lies within the iSimangaliso Wetland Park and should therefore remain outside of the final corridor alignment and associated EGI route.

Figure 12: Northern Coastal Forest within the iSimangaliso Wetland Park. (Photo: SDP)

6.2.11 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 AZd 4 to the near shore environment, this vegetation type is unlikely to be affected by the EGI.

6.2.12 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 Sub tropical 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 (Figure 13). This vegetation type is associated with recent dunes overlying calcretes. This vegetation type is also considered to be "least threatened" and is unlikely to be affected by the expanded Eastern EGI corridor.

Figure 13: Image of Subtropical Dune Thicket located near Sodwana Bay (Photo: SDP).

6.3 Threatened Plant Species

Figure 14 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 plants may be encountered. Clusters and potential “hotspots” appear to be concentrated in or around formally protected areas – Umlalazi Nature Reserve, Ongoye Forest and Isimangaliso Wetland Park – with isolated occurrences outside of these areas. No critically endangered species were identified by the data, with the threatened plant species present characterised as endangered or vulnerable.

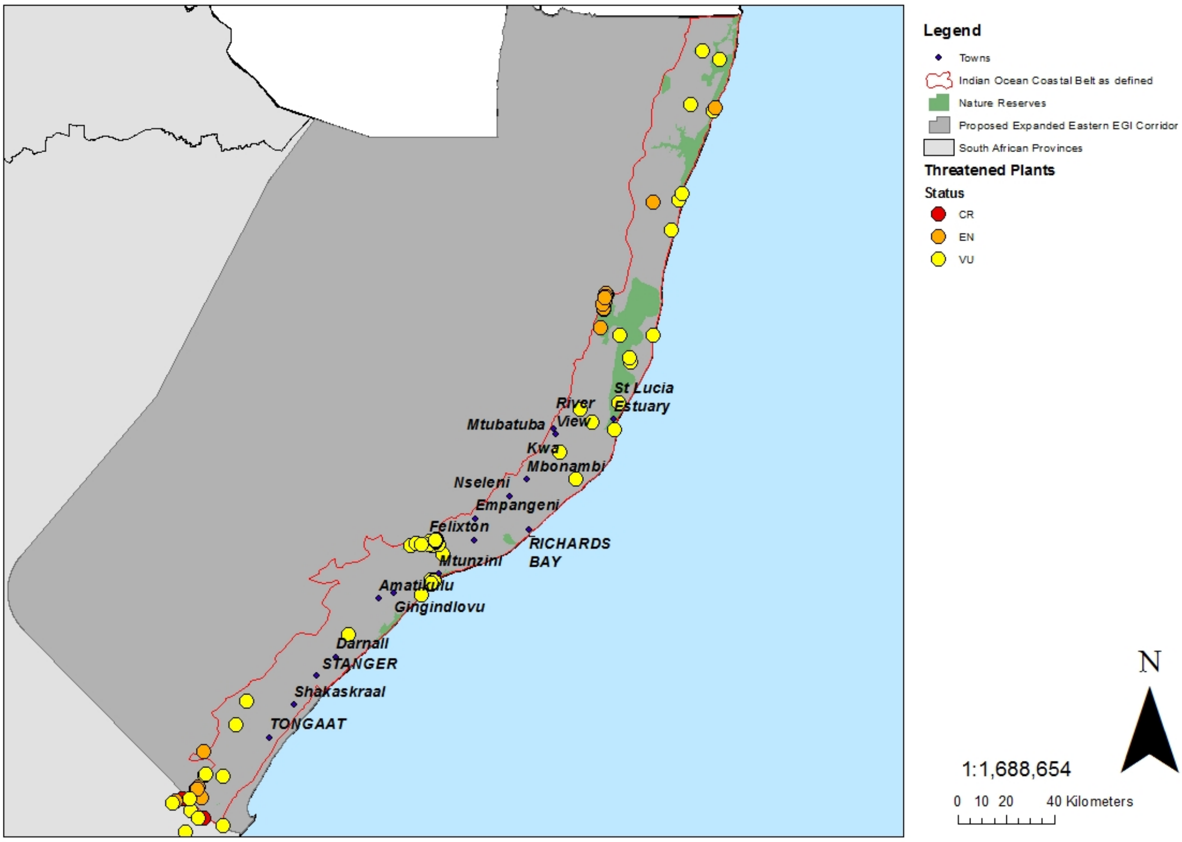


Figure 14: The distribution of recorded threatened plant species within the IOCB portion of the Expanded Eastern EGI Corridor.

With specific reference to Ongoye Forest, a review of the management plan (KZN Wildlife 2009) indicated a list of 18 plants of conservation value (Table 7). These included not only threatened plant species, but other plant species that are important endemics associated with the forest ecosystem or are representative of climax vegetation and habitat. One species is considered to be extinct in the wild. The importance of this and similar isolated pockets of natural vegetation within the IOCB cannot be overstated.

Table 7: Recorded plant species of conservation importance associated with the Ongoye Forest complex and Reserve.

Species	Category/Comment
Asclepias gordon-grayae	EN
Adenia gummifera	LC
Alchornea hirtella	Range outlier
Begonia dregei	EN
Bolusiella maudiae	Endemic
Dahlgrenodendron natalense	EN
Emplectanthus caudatus	Endemic
Encephalartos ngoyanus	VU
Dierama sp nov	Endemic
Melittia sutherlandii	LC, Keystone species for climax forest canopy
Olyra latifolia	Range outlier
Phyllanthus cedrelifolius	Range outlier
Protea caffra	Affected by habitat degradation
Streptocarpus wendlandii	Rare
Senecio ngoyanus	VU
Siphonochilus aethiopicus	CR
Stangeria eriopus	VU
Encephalartos woodii	EW - Extinct in the wild

6.4 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 line routes within the EGI corridor strategic plan for 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.

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 in the Expanded Eastern EGI Corridor (Figure 15). Of the 47 amphibian species present, only two were threatened (near threatened and endangered, Table 8). The reptile species present (17 in total) were all threatened with only one species being deemed "data deficient" and the other not having a listing category (Table 9). The lepidoptera or butterfly data lacked a clear species reference, but data indicated that the majority of species present were classified as endangered or threatened.

Table 8: Recorded amphibian species associated with the portion of the IOCB that falls within the extended Eastern EGI corridor.

Species	Common Name	Redlist Category
Afrixalus aureus	Golden Leaf-folding Frog	LC
Afrixalus delicatus	Delicate Leaf-folding Frog	LC
Afrixalus fornasini	Greater Leaf-folding Frog	LC
Afrixalus spinifrons	Natal Leaf-folding Frog	LC
Arthroleptis stenodactylus	Shovel-footed Squeaker	LC
Arthroleptis wahlbergii	Bush Squeaker	LC
Breviceps adspersus	Bushveld Rain Frog	LC
Breviceps mossambicus	Mozambique Rain Frog	LC
Breviceps sopranus	Whistling Rain Frog	LC
Cacosternum boettgeri	Boettger's Caco	LC
Cacosternum nanogularum	Small-throated Dainty Frog	LC
Cacosternum nanum	Bronze Caco	LC
Cacosternum rhythmum	Rhythmic Dainty Frog	LC
Chiromantis xerampelina	Grey Foam-nest Tree Frog	LC
Hemisus guttatus	Spotted Shovel-nosed Frog	NT
Hemisus marmoratus	Mottled Shovel-nosed Frog	LC
Hyperolius acuticeps	Sharp-nosed Reed Frog	LC
Hyperolius argus	Argus Reed Frog	LC
Hyperolius horstockii	Arum Lily Frog	LC
Hyperolius marmoratus	Painted Reed Frog	LC
Hyperolius pickersgilli	Pickersgill's Reed Frog	EN
Hyperolius poweri	Power's Reed Frog	LC
Hyperolius pusillus	Water Lily Frog	LC
Hyperolius semidiscus	Yellow-striped Reed Frog	LC

Species	Common Name	Redlist Category
Hyperolius tuberilinguis	Tinker Reed Frog	LC
Kassina maculata	Red-legged Kassina	LC
Kassina senegalensis	Bubbling Kassina	LC
Leptopelis mossambicus	Brown-backed Tree Frog	LC
Leptopelis natalensis	Natal Tree Frog	LC
Phyrynobatrachus acridcides	East African Puddle Frog	LC
Phyrynobatrachus mababiensis	Mababe Puddle Frog	LC
Phyrynobatrachus natalensis	Snoring Puddle Frog	LC
Phrynomantis bifasciatus	Banded Rubber Frog	LC
Ptychadena anchietae	Plain Grass Frog	LC
Ptychadena mascareniensis	Mascarene Grass Frog	LC
Ptychadena mossambicus	Broad-banded Grass Frog	LC
Ptychadena oxyrhynchus	Sharp-nosed Grass Frog	LC
Ptychadena porosissima	Striped Grass Frog	LC
Pyxicephalus adispersus	Giant Bull Frog	LC
Pyxicephalus edulis	African Bull Frog	LC
Schismaderma carens	Red Toad	LC
Strongylopus fasciatus	Striped Stream Frog	LC
Tomopterna cryptotis	Tremelo Sand Frog	LC
Tomopterna krugerensis	Knocking Sand Frog	LC
Tomopterna marmorata	Russet-backed Sand Frog	LC
Tomopterna natalensis	Natal Sand Frog	LC
Xenopus laevis	Common Platanna	LC

Table 9: Recorded reptile species associated with the IOCB within the extended Eastern EGI corridor.

Species	Common Name	Redlist Category
Bitis gabonica	Gaboon Adder	NT
Bradypodion caeruleogula	uMlalazi Dwarf Chameleon	EN
Bradypodion melanocephalum	KwaZulu Dwarf Chameleon	VU
Caretta	Loggerhead Turtle	VU
Chamaesaura macrolepis	Large-scaled Grass Lizard	NT
Chelonia mydas	Green Turtle	NT
Crocodylus niloticus	Nile Crocodile	VU
Cryptoblepharus boutonii	African Coral Rag Skink	EN
Dendroaspis angusticeps	Green Mamba	VU
Dermochelys coriacea	Leatherback Turtle	EN
Eretmochelys imbricata	Hawksbill Turtle	NT
Leptotyphlops sylvicolus	Forest Thread Snake	DD
Lycophidion pygmaeum	Pygmy Wolf Snake	NT
Macrelaps microlepidotus	Natal Black Snake	NT
Natriciteres olivacea	Olive Marsh Snake	NA
Pelusios rhodesianus	Variable Hinged Terrapin	VU
Scelotes inornatus	Durban Dwarf Burrowing Skink	CR

With reference to Figure 15, The Futululu and Dukuduku Forest areas as well as the Umfolozi floodplain between St Lucia and Mtubatuba indicate 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 found 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.

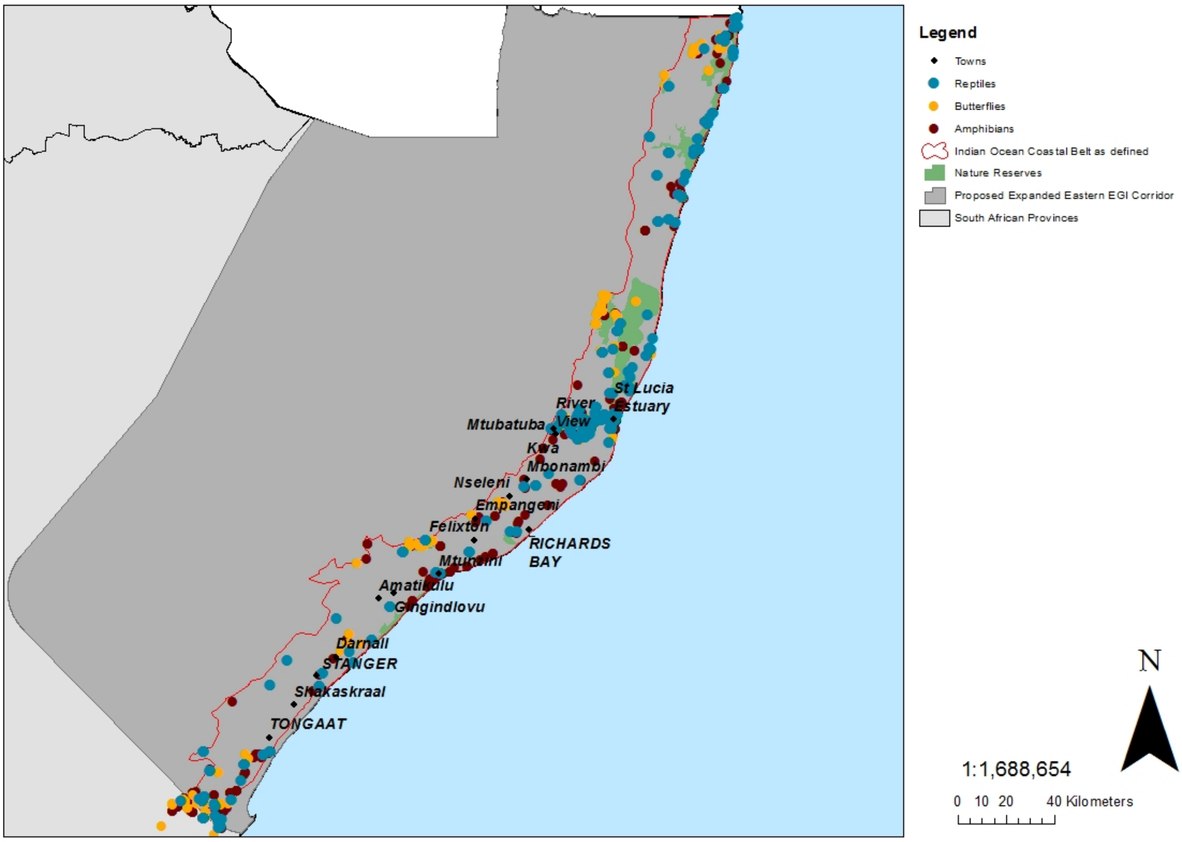


Figure 15: Distribution of recorded reptiles, amphibians and butterflies within the IOCB and expanded Eastern EGI corridor.

6.5 Transformation within the IOCB

The extent of the IOCB is as mentioned, limited, extending to a maximum of 50 km inland from the coast, at its widest point. As such, the expanded Eastern EGI corridor intersects with the IOCB only in its most eastern extent of the corridor (refer to Figure 1) and the IOCB accounts for about a third of the affected habitat within this corridor. The balance of the corridor, located to the west, falls within the Savanna biome.

Much of the IOCB has been subject to human settlement, initially in a highly dispersive manner with the advent of the Nguni tribes some 500 years ago, followed by more recent and rapid transformation arising from European settlement, which commenced approximately 150 years ago. Since that time, the land use within the IOCB has undergone significant change. Land uses have varied primarily according to economic impetuses, with agricultural practices evolving from initially livestock farming, through to crops as varied as coffee, cotton, timber and sugar cane (Figure 16). In the early 21st Century, land use within the IOCB can be considered to comprise primarily of the following:

- **Urban sprawl** – the expansion of existing urban nodes on account of inward migration of people to these areas has meant that towns and cities within the IOCB are rapidly extending. Attempts to contain urban expansion are not easy to implement as informal settlements arise on town peripheries and economic factors determine the levels of services that can be provided and afforded by residents. Generally, the so-called “ribbon effect” has arisen within the IOCB, which has seen urban settlement “creep” along the coastline of the east coast, effectively removing most of the more eastern extent of this biome.

- **Sugar cane cultivation.** Contributing to the loss of habitat within the IOCB, sugar cane cultivation is perhaps the most expansive agricultural activity in the region. Cane cultivation followed in the footprints of earlier farming practices and became more expansive following the end of the First World War.

- **Other agricultural practices**. As the global price of sugar and its demand has varied so too have agricultural practices, as producers look to maintain their farming enterprises. Contemporary commercial farming practices have seen investment in crops such as macadamia nut, moringa and pineapple, as well as silvicultural practices. The impact of these crops on the habitats within the IOCB remains to be seen.

- **Major infrastructure**. Significant infrastructure within the IOCB includes major highways and road infrastructure, which serve to dissect habitats, while projects such as dams, harbours and pipelines alter the eco-morphological drivers of various components of the IOCB.

Figure 16: An example of the extent to which transformation has occurred within the IOCB. This particular area is between Tinley Manor and Blythedale north of Durban. The only natural vegetation that remains occurs along the coastline with pockets of Northern Coastal Forest and Swamp Forest extending inland (Photo: SDP)

A description of the nature of the expanded Eastern EGI Corridor, is provided below in Table 10. The expanded Eastern EGI corridor intersects with the northern-most extent of the IOCB, which makes up a narrow band along the eastern extent of the corridor. Table 10 provides a brief overview of this habitat form.

Table 10: Summary of the nature and characteristics of the expanded Eastern EGI corridor.

Site	Brief description
Expanded Eastern EGI Corridor	The expanded Eastern EGI corridor extends from Durban to the Mozambique border. The IOCB within this corridor comprises of Maputaland Coastal Belt (CB 1), Maputaland Wooded Grassland (CB 2) and KwaZulu-Natal Coastal Belt. Subtropical Freshwater Wetlands, Swamp Forest and Lowveld Riverine Forest are three significant azonal vegetation types found within this section of the IOCB. A prominent protected area and land use feature is the Isimangaliso Wetland Park, a Ramsar Site of significance and World Heritage Site. Isimangaliso Wetland Park extends from Maphelane, just north of Richards Bay to Kosi Bay and extends inland to the Mkuze Nature Reserve. iSimangaliso includes significant areas of swamp forest and riverine habitat as well as CB1 and CB2. To the south, the IOCB, between Durban and Richards Bay the IOCB is largely transformed, with the exception of a few outliers of undisturbed and protected habitat, such as the Amatikulu Nature Reserve (Dokodweni/Nyoni area) and the Ongoye Forest, near Mtunzini. Apart from the abovementioned outliers of natural habitat, urban sprawl, the N2 freeway, extensive sugar cane farming and silviculture, as well as dune mining near Mtunzini are major disturbance factors within this section of the IOCB.

7 FEATURE SENSITIVITY MAPPING

In compiling a spatial representation of the interface between habitat forms within the IOCB a set of protocols based on the presence of certain features, including protected areas, as well as other land use management protocols was developed. Comment on these features and the development of “sensitivity criteria” is presented below.

7.1 Identification of feature sensitivity criteria

7.1.1 Protected areas

A number of statutory protected areas occur within the affected section of 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; and
- Beachwood Nature Reserve.

These protected areas are of *very high* conservation importance as many of them protect the last remaining primary habitats within sections of the IOCB. The inclusion of these features is deemed essential in identifying their spatial relationship with the corridor. These areas have been allocated a designation of *high level feature*.

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.

7.1.2 Protected area expansion focus areas

The National Protected Areas Expansion Strategy (NPAES) (South African Government, 2016) details the need for considering areas where land may be incorporated into the existing protected area network in order to improve ecological sustainability and representation, encompass conservation-worthy habitat and in so doing, increase resilience to climate change. The aim of the strategy is to identify priority areas for protected area expansion and to set in place the requisite administrative and legal mechanisms that would allow for such land to be gazetted as protected areas. The most recent version of this spatial data (2017) was utilised and treated as being a feature of high conservation importance.

7.1.3 Critical Biodiversity Areas

Critical Biodiversity Area data uses the occurrence of numerous “features” and “factors” (faunal or floral species; or vegetation types and habitats) to determine the biodiversity importance or *irreplaceability* of an area (Escott, 2012). The concept of critical biodiversity area mapping is that 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; and
- ESA – designated in this area as low level features.

7.1.4 Private Nature reserves and game farms

Private Nature Reserves and game farms include formally protected areas that are not managed by a conservation or governmental authority, but rather private landowners and companies. According to the data base, only one private nature reserve occurs in the IOCB, this being the Palmiet Nature Reserve, which was proclaimed in 2006, which is located within the Westville/Pinetown region of eThekwini.

7.1.5 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. The only example within the EGI Expansion Corridor is the Roosfontein Nature Reserve (Westville).

7.1.6 Forest Reserve

A forest reserve layer was provided by the CSIR/SANBI which contained one forest reserve in the IOCB, Mapelane. Mapelane Forest Reserve is part of the Isimangaliso Wetland Park and marks the most southern portion of this broad protected area. The Mapelane Forest Reserve is managed by the Isimangaliso Wetland Park Authority.

7.1.7 Ramsar Sites

A Ramsar Sites data layer was provided by the CSIR. Ramsar sites are wetlands designated as being of international importance under the UNESCO Convention on Wetlands or Ramsar Convention of 1971. Four Ramsar sites occur within the IOCB, in particular the following:

- Turtle Beaches/Coral Reefs of Tongaland;
- The St Lucia estuarine system;
- Kosi Bay estuarine system; and
- Lake Sibaya freshwater lake system.

All of the above wetlands fall within the Isimangaliso Wetland Park, a World Heritage Site.

7.1.8 World Heritage Sites

One World Heritage site falls within the IOCB, this being the Isimangaliso Wetland Park. Isimangaliso Wetland Park was designated as a World Heritage Site in 1999 and comprised of existing protected areas, as well as plantations and farmlands.

7.1.9 Vegetation

The updated SANBI Vegetation Map (2012) was utilised as the primary spatial data source for the compilation of a vegetation map of the IOCB and associated areas including azonal and intrazonal vegetation. Ezemvelo KZN Wildlife (Scott-Shaw and Escott 2011) compiled an updated vegetation conservation status map for KwaZulu-Natal and 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 was assigned, based on the conservation targets for vegetation types (Jewitt, 2016).

7.1.10 Landcover

The National Land Cover, modified layer, was utilised (SANBI, 2017) to determine areas of transformation as well as field crop boundary data (DAFF 2017) which identified current and old agricultural fields and land uses. Disturbance and habitat modification is an ubiquitous characteristic of the IOCB and this layer is essential for indicating the *status quo*. The other broad layers for KwaZulu-Natal, with the possible exception of the updated CBA data does not take full consideration of the status quo and are based on theoretical boundaries. Commercial agriculture has been a dominant land use for over 100 years in KZN and parts of the Eastern Cape and this land use has been a significant factor in influencing the nature of the IOCB in its current form and the concomitant changes brought about as a result of this needs to be considered.

7.1.11 Ecoregions

The ecoregion layer, provided by SANBI/CSIR (undated based on Burgess (2004)) was included at a broad scale. This layer forms a base layer behind the other data, to capture any areas not included in other feature/sensitivity layers. The eco-region layer is the least deterministic of the habitat information.

7.1.12 National Forests

The National Forest Inventory data (2016) indicates natural forest types and declared natural forests. The following forest types are found with the IOCB:

- Northern Coastal Forest;
- Scarp Forest;
- Swamp Forest;
- Mangrove Forest; and
- 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). As noted above, swamp forest and mangrove forest are considered under other specialist investigations.

7.1.13 Buffer zones

Default buffer zones were provided with the SANBI/CSIR data pack. The following buffers were provided:

- A 5 km buffer layer from all Nature Reserves/Protected Areas;
- A 10 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.

Due to the diverse land uses within the IOCB, there are very few examples where an unprotected natural area lies adjacent to a protected area or threatened habitat. Extensive agriculture and peri-urban sprawl has resulted in protected areas and remaining natural habitats being generally isolated. Therefore, the assignment of buffers is unlikely to facilitate protection or prevent habitat loss as most areas that will be included in the buffer zone would already be transformed. Although useful planning tools, in the IOCB, buffers should rather be assigned on a site by site basis during a detailed review of the power line routing within the corridor. Buffer widths are expected to be highly variable – even for the same feature – based on the setting.

Table 11 summarises the sensitive environmental features identified for this assessment.

Table 11: A summary of the relevant features assessed within the extended Eastern EGI corridor.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
Protected Areas	• National DEA SAPAD, 2017. • SANBI Protected Areas Database, 2011. • Ezemvelo KZN Wildlife Protected Areas updated 2015	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	• DEA 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	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. The National data aligned with the "irreplaceable" layer of the KZN CBA. The "Optimal" and "ESA" 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.

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
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 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 land use and agricultural layers (field crop boundaries) were retained and applied. These indicate the transformed areas that characterise much of the KZN coastal hinterland – sugar cane farms and plantations.
Ecoregions	• 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.
Buffer zones	• Assigned by SANBI/CSIR. Date unknown.	Simple buffer extents for Nature Reserves/Protected Areas, Game Farms and a coastal setback.

The various ratings have been provided in Table 12 below. In addition, buffer zones and comments regarding the assignment of buffer zones have been provided. Also see Appendix 1 for a summary of all GIS data utilised.

Table 12: Sensitivity ratings of the relevant environmental features of the IOCB in the expanded Eastern EGI corridor.

Feature Class	Feature Class Sensitivity	Prescribed Buffer Distance
1 km Coastline Buffer	Very High	Not applicable. Predetermined 1 km setback.
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 WHS falls within a protected area)
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	
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	None
	KZN Veg. Cons. Status "Endangered" - High	None
	KZN Veg. Cons. Status "Critical" – Very High	None
Ecoregion	Medium	None
Private Nature Reserves and Game farms	Private Nature Reserves – Very High	None
	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	

7.2 Feature maps

Figure 17 provides a visual representation of the features assessed in the review of the IOCB portion of the extended Eastern EGI corridor (as per Table 12 above). 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.

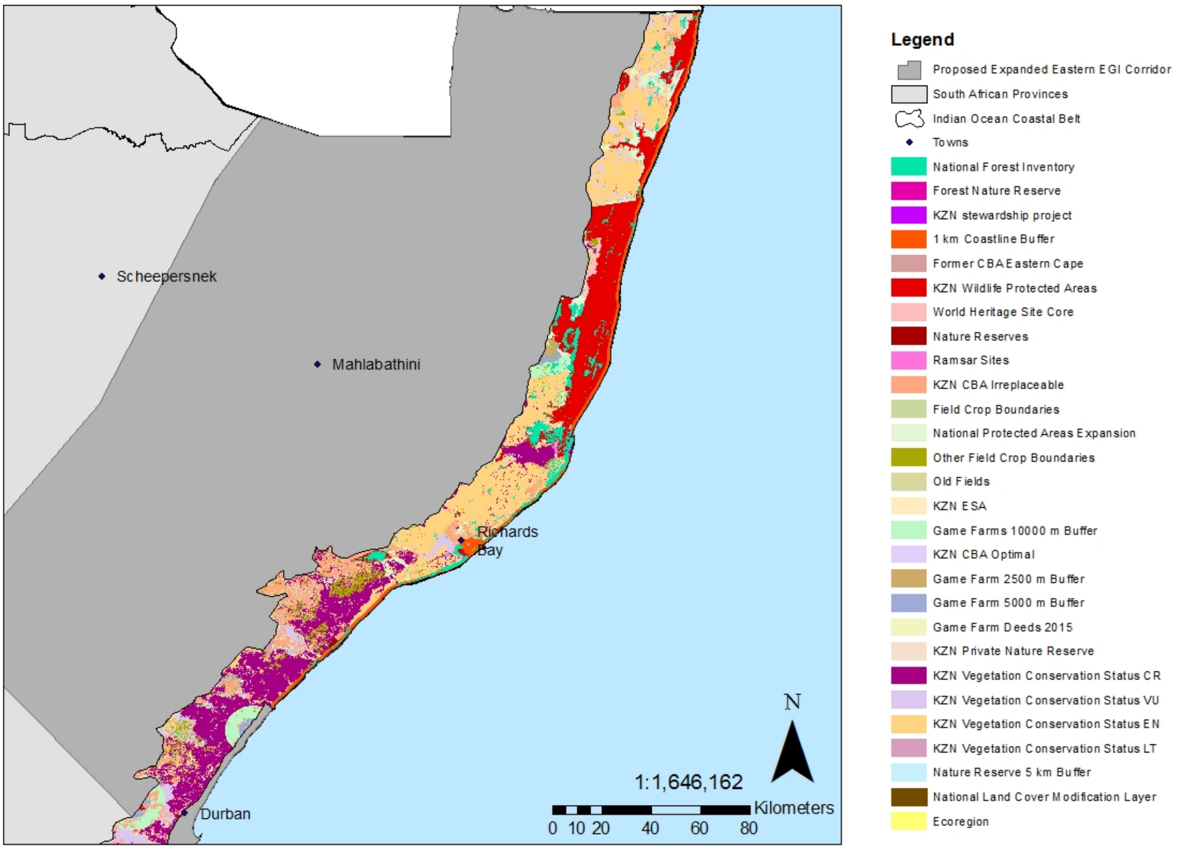


Figure 17: Features within the section of the IOCB affected by the expanded Eastern EGI corridor.

8 FOUR- TIER SENSITIVITY MAPPING

8.1 Default Sensitivity Map

The "default sensitivity map" displays the highest sensitivity category as the upper most map layer (Figure 18). This shows the most sensitive layers but is not necessarily a reflection of the *status quo*. This issue was discussed above with the inclusion of the *National Land Cover modified areas* layer as a fair representation of the *status quo*. Being representative of a disturbed environment, this layer is rated as having a low sensitivity and indicates transformed areas. This layer should also 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" equating 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 truly representative primary habitat remains and thus it is not accurate to consider such disturbed areas as of “very high” sensitivity as the drivers and primary attributes of this habitat have been removed.

8.2 Land Use (Priority) Map

Figure 19 below provides a contrast to Figure 18 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 as “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, 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 presence of the Isimangaliso Wetland Park. Areas which have not been transformed or allowed to “recover” to discernible and representative habitats, while other portions of the IOCB relevant to the expanded Eastern EGI corridor, are either protected, inaccessible or cannot be cultivated.

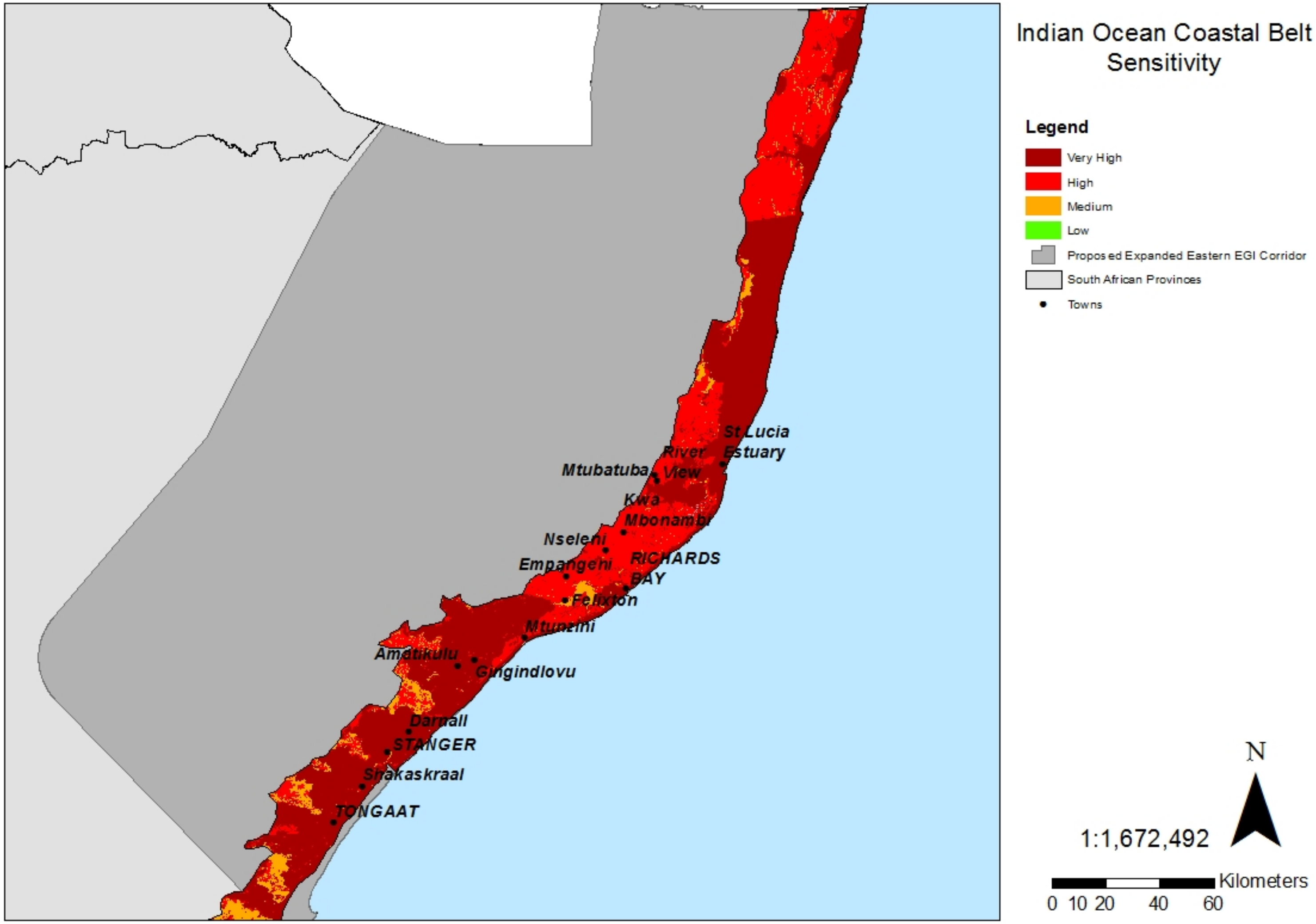


Figure 18: Sensitivity mapping for the portion of the IOCB affected by the expanded Eastern EGI corridor. Note that high and very high sensitivity areas are rated highest – compare it to Figure 19.

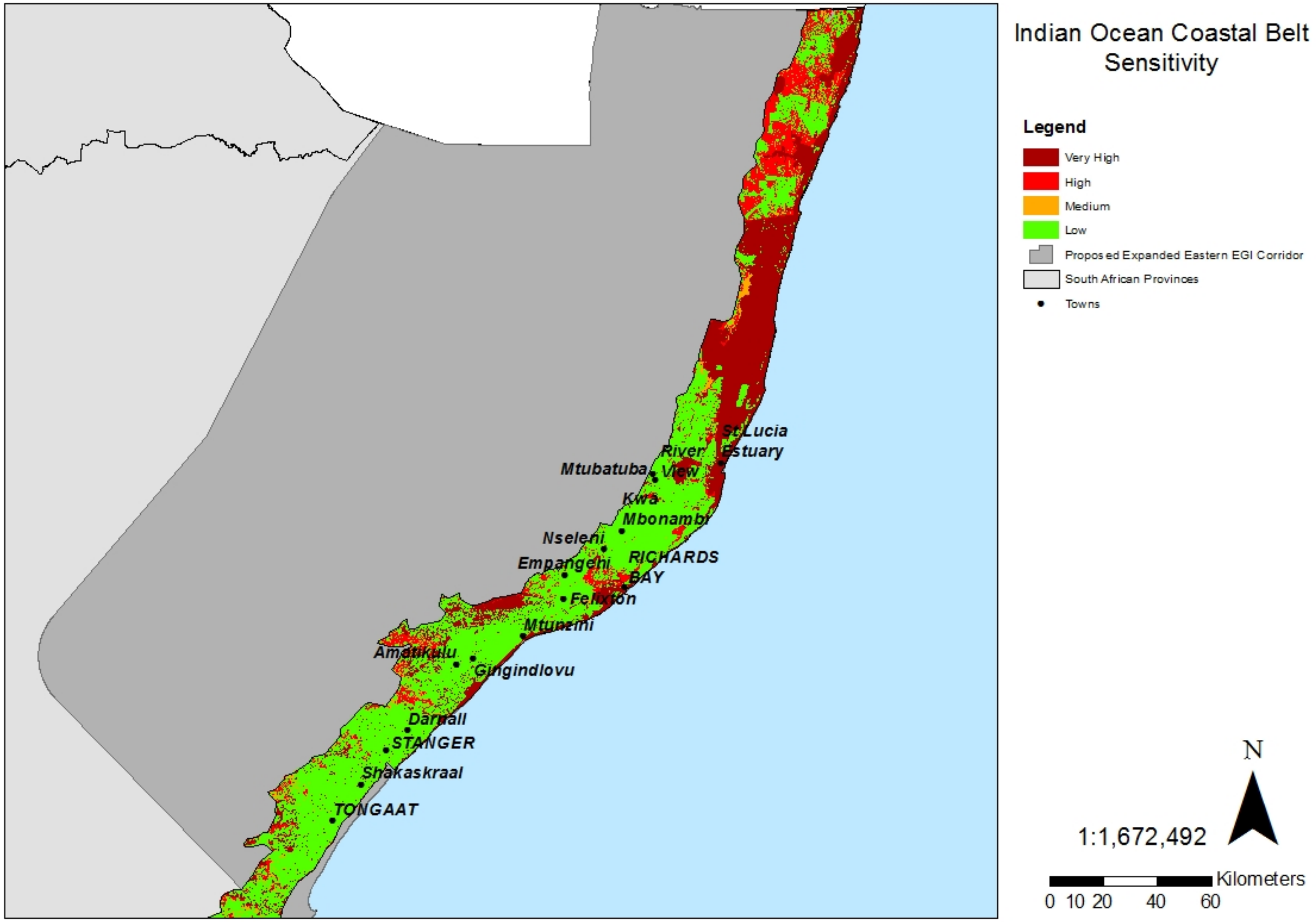


Figure 19: Sensitivity mapping for the portion of the IOCB affected by the expanded Eastern EGI corridor where the land use data – transformed areas have masked out/ filtered out. This is a more realistic representation of the status quo. Compare it to Figure 18.

9 KEY POTENTIAL IMPACTS AND MITIGATION

Table 13 provides the details of the key impacts likely to be associated with the extended Eastern EGI corridor.

From a broad perspective, it is to be understood that the sensitivity maps over emphasise certain habitat groups on account of the levels of importance presented in the CBA map and other datasets. However, it is clear that the proposed corridor is substantially wider than the actual power line servitude and therefore there is significant opportunity to avoid site specific and narrow or spatially constrained habitat forms, such as areas of Scarp Forest. Other areas will be impacted upon by the line servitude and the final alignment of such route within the EGI corridor will be evaluated on a site specific level to either avoid vegetation units or align with a servitude route that is of least impact from an ecological perspective. Where sensitive habitats cannot be avoided, mitigation measures have been proposed. At this strategic level, these are broad recommendations requiring further evaluation and refinement. Some may not be applicable to sections of the EGI route or be effective in mitigating certain impacts. The mitigation measures mentioned include the following:

- **Plant rescue** – Prior to the construction of the power line or clearance of the servitude, specific species of plant are to be removed from the servitude and relocated to a suitable area outside of the servitude. This approach is a more suitable method of rescue applicable to small plants or immature specimens.
- **Rehabilitation** – Where clearance or disturbance is temporary i.e. a site camp or access road, this area can be rehabilitated/revegetated. The aim of the rehabilitation/revegetation plan will need to match the receiving environment. If within an area of high sensitivity or low level disturbance, return of the affected land to a state approximating the pre-construction condition would be preferable. If within an area of low sensitivity and high disturbance, basic revegetation can be undertaken to establish ground cover and limit further degradation.
- **Offset** – This is a controversial form of mitigation that should only be considered as a last resort and only if absolutely necessary. Standard ideology dictates a *like for like* biodiversity offset at a set ratio (i.e. 1:2 ratio, 1Ha disturbed requires 2Ha of new habitat of the same type to be established or rehabilitated). This can be difficult to achieve due to environmental variables, feasibility (obtaining land, costs of management etc.) and a complete lack of guarantee/certainty of whether the offset habitat will a) be successful and b) if successful, will be representative of the transformed habitat. Other "means" of biodiversity offsets can also be applied, such as replacing the loss of protected trees, by planting the same species in the adjacent area (similar to plant rescue, but the specimens are sourced from off site and often in large numbers). The goals of this simpler form of offset are easier to achieve, monitor and assess. Any form of offset must be carefully selected in accordance with the receiving environment. Detailed site specific information is essential.
- **Site specific setbacks or buffers** – Setbacks or buffers assigned on a case by case basis where detailed information for the receiving environment and subject habitat is available. Such setbacks must be recommended and supported by ecologically sound reasoning.
- **Alien invasive plant control** – The control of alien invasive plant species within the power line servitude using suitable methods and resources may be deemed to be a form of "mitigation", particularly where this reinforces seral traits within the identified habitat.

Table 13: A description of key impacts likely to be associated with the establishment of the power lines within the Extended Eastern EGI corridor.

Key Impacts		Site Specific Descriptions	Possible Effect	Mitigations
Habitat Loss	Impact on protected and keystone species associated with vegetation clearance. Project Phase – Construction Phase.	There are some parts of the IOCB which have a high abundance of protected tree species such as *Sclerocarya birrea* and *Mimusops caffra* which are ecologically significant in their own right due to the variety of species associated with large tree specimens.	Loss of ecologically significant habitats associated with these species. Such loss is likely to be permanent and of high intensity – i.e. no pruning or trimming, simply total removal.	Areas with a high abundance of protected tree species should be avoided. Plant rescue of small specimens may be undertaken and transferred to outside of the servitude.
	Impact on natural forest areas associated with vegetation clearance Project Phase – Construction Phase	The northern portion of the IOCB supports a number of isolated forest habitats associated, the most common being Northern Coastal Forest. Other forest types such as Scarp Forest and azonal forests such as Swamp Forest and Lowveld Riverine Forest occur in places. The isolated nature of these forest areas make them important islands of natural habitat within an area that has been largely transformed by agriculture and other land uses. These forest habitats often support unique fauna and flora.	Loss of ecologically important habitat and unique flora and fauna associated with the specific conditions that occur within these forests. Such loss is likely to be permanent and of high intensity.	Areas of natural forest are to be avoided. Rehabilitation of the servitude area is not possible as the mature trees will impact on the servicing and maintenance of the power lines. Offset and plant rescue options may be considered following further onsite and detailed investigations.
	Impact on azonal vegetation types associated with vegetation clearance. Project Phase – Construction Phase	A number of azonal vegetation types occur within the IOCB. Most are isolated or restricted in extent. Most azonal habitats support unique species adapted to the prevailing conditions, which are unique.	Loss of azonal habitat and associated species. Loss of specialised and unique species. Such loss is likely to be permanent and of high intensity.	All azonal vegetation types are to be avoided within the IOCB. Rehabilitation and offset are not considered viable options due to the unique setting and drivers governing these vegetation types.
	Impact on conservation status due to vegetation clearance. Project Phase – Construction Phase	Land surrounding protected areas has conservation potential due to the possibility of protect area expansion and improved land management. Numerous extensive protected areas occur in the northern portion of the IOCB.	Establishing a major servitude through such areas can result in habitat degradation, reducing the significance of the habitat being protected. Establishing a servitude adjacent to an existing protected area may limit opportunities for expansion. Any loss that may occur is likely to be permanent but the intensity of the impact is likely to be low as the affected land will not be lost to conservation.	Avoid protected areas and so far as possible consider setbacks and potential expansion corridors at a site specific level.

Key Impacts		Site Specific Descriptions	Possible Effect	Mitigations
Faunal Disturbance	Impact on fauna associated with habitat loss. Project Phase – Construction Phase	Due to habitat loss as a result of agriculture and human settlement, the remaining fauna is restricted to limited natural and semi natural habitat.	Displacement of fauna is likely to occur following the loss of habitat. In some instances, range restricted species or populations may be lost. Any loss that may occur is likely to be permanent but the intensity of the impact is likely to only be medium to low due to the opportunity and ability of fauna to move.	Avoid remaining natural habitat and areas highlighted as important from a faunal diversity (CBA irreplaceable areas for example).
Alien Invasive Plants	Exotic invasion primarily by alien invasive plant species. Project Phase – Operational Phase	Power line servitudes are susceptible to invasion by a number of common and virulent alien invasive plant species within the IOCB. Some examples include *Chromolaena odorata, Tithonia diversifolia, Ricinus communis* and *Lantana camara.*	Increased spread in invasion footprint. Such servitudes act as vectors for alien invasive plant species. Invasion may encroach into neighbouring areas where invasion has been absent or low.	Implementation of a long term servitude management programme that includes a dedicated alien invasive plant control initiative. This may include: - regular monitoring and auditing of exotic species. - Identification of new species, - Cover and treatment application - Spatial rendition of above information

10 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

10.1 Planning phase

This SEA should be considered as the initial planning phase of the EGI. Within the Expanded Eastern EGI corridor and the eastern seaboard of South Africa, it is clear that much of the natural habitat within this area has been subject to transformation through anthropogenic interventions. To this end, the alignment of the servitudes within the corridor should use the following criteria to establish the most appropriate route for the power line:

- The outer extent of existing settlement – both formal and informal should be identified i.e. the peri-urban environment.
- Key infrastructure should be identified that traverses in a north-south direction, within the identified corridor. In particular the R61/N2 or the R102 roadways north of Durban should be considered as important routes with which to align directly, or in parallel, the final servitude, thereby consolidating impacts associated with a linear development.
- Disturbed agricultural or related lands under cultivation.

Given that the alignment of selected servitudes follows the above criteria, particular consideration should be given to the avoidance of the following:

- areas of distinct, closed canopy, natural forest;
- open, primary grassland environments;
- protected areas;
- areas considered to be CBAs or ESAs (not affected by transformation); and
- areas which may be considered to hold ecological significance under a secondary habitat regime (e.g. abandoned agricultural lands that lie within critically endangered, endangered or vulnerable vegetation units).

As indicated above, the IOCB biome has been and will continue to be subject to rapid transformation. While it is deemed appropriate to identify and utilise transformed lands to establish servitudes such as that envisaged in the EGI as opposed to utilising important natural habitats, it is important to recognise that secondary habitats offer important ecological services and opportunities to maintain faunal diversity, even under a rapidly changing land cover. Discernment and recognition of the growing importance of secondary habitat in KZN must accompany decision making on the final routing of power lines.

Further to, and in support of the above, consideration should be given to the impact of climate change on habitat within the IOCB. Figure 20 indicates the climate projections to 2100 provided through the Koppen-Geiger classification system and the expected warming trends in southern Africa. A significant warming trend is predicted along the eastern seaboard that will establish a climate similar to that of Maputo (*equatorial, winter dry*) spreading as far south as Port Elizabeth (Rubel & Kottek, 2010). Such change is likely to be driven by variation in the Inter Tropical Convergence Zone and the Limpopo high pressure and will result in an initially latent, but becoming more significant, change in floral communities and faunal populations. The impact of climate change must be considered in the detailed planning associated with the line routes, particularly where it is likely that vegetation units presently identified as endangered or critically endangered may be placed under increasing pressures.

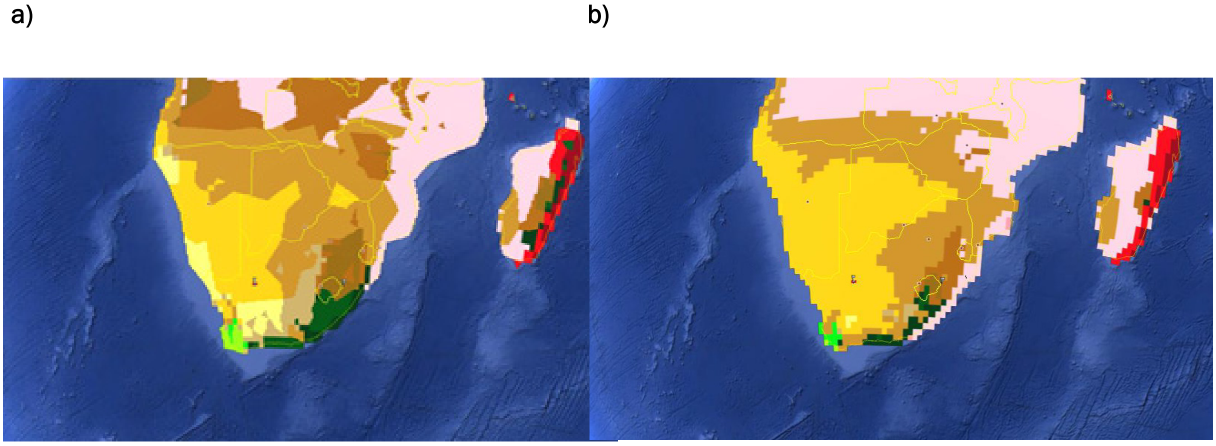


Figure 20: Koppen-Geiger modelling overlain on Google Earth imagery, indicating the expansion of Aw climate class (depicted in pink) which has its southern limit in and around Maputo during the period 2001 to 2025 (a) to a point approximately aligned with Port Elizabeth during the period 2076 to 2100 (b). (Source: Rubel & Kottek, 2010; http://koeppen-geiger.vu-wien.ac.at/)

10.2 Construction phase

It is difficult to provide management and best practice measures to be instituted broadly within a terrain as diverse as the coastal IOCB; however the following construction related measures should be implemented, where possible:

- Construction related servitudes must be limited, particularly where such activities are being undertaken in or close to areas of "high ecological sensitivity".
- Points of instability or of steep grade should be identified and stabilised, where required.
- Tower footprints should be cordoned off during the construction phase.
- The use of helicopters during the stringing of the lines should be used, particularly where lines traverse forest environments or steep inclines.
- Vegetation control and management around tower footings should be undertaken during and immediately after the construction of towers to prevent exotic weed invasion at these points.

10.3 Operations phase

General vegetation management procedures, including alien invasive plant management within the major power line routes should encompass the following;

- The monitoring of "sensitive habitats" where towers have been established either within or adjacent to such vegetation units, should be undertaken. Monitoring should include evaluation of change in adjacent habitat form and structure, as well as other more evident factors such as erosion and collapse related to the structures.
- Weed control using appropriate techniques in terms of an Alien Invasive Plant Management Plan.
- The application of the Eskom code of conduct relating to staff management on sites.

10.4 Rehabilitation and post closure

Specific rehabilitation measures will be applicable to the specific sites under consideration as well as the nature of such sites (e.g. forest or grassland habitat). In general two approaches may be taken at these sites, these being:

- **Revegetation and restoration**. This method may be considered to be a horticultural intervention, where the active planting of selected plant species is undertaken. Such interventions are often supported by environmental groupings and authorities, but are in themselves a means of driving seral process, often contrary to that which would be followed under a natural regime. It therefore follows that horticulturally driven interventions should be used prudently and judiciously within selected environments. Such actions are perhaps more applicable to areas of secondary vegetation.

- **Reinstatement** of habitat may be considered to follow a "managed seral process", where the natural succession process is allowed to proceed without the introduction of significant external elements, such as plant specimens. In this regard management is primarily restricted to the stabilisation of the area through minimal earth sculpting and the use of inert materials to stabilise slopes (geofabrics), while exotic weed control forms a key component of such action. This form of rehabilitation is applicable to climax forest environments and primary grasslands.

10.5 Monitoring requirements

Monitoring of habitat change in and around the selected line route within the corridor is considered the most applicable ecological management tool within the IOCB region. Such monitoring will be site specific but may include the following:

10.5.1 Pre-Construction

Where "sensitive habitats" are affected by construction activities, suitable baseline information should be gathered prior to the commencement of construction. Baseline information should include *inter alia:*

- Species composition on affected sites;
- Species composition within buffer zones; and
- Species composition over at least two transects that are aligned to other variables (slope, elevation etc.).

Such data would allow for the long term monitoring of change in habitats, as well as inform the appropriate rehabilitation methods and expected outcomes.

10.5.2 Construction phase

- The accurate delimiting of construction sites, particularly towers, in and around areas of ecological sensitivity. Such habitats should be afforded suitable buffers that do not impede construction but maintain the integrity of affected habitats.
- The monitoring of exotic weed invasion within natural habitats. Exotic weeds within the construction site and immediately adjacent to the site should be recorded.
- Construction phase monitoring must be undertaken according to an appropriate but regular time basis.

10.5.3 Rehabilitation

- Following the selection of appropriate rehabilitation methods monitoring of the following should be undertaken for a designated period:
    - Identification of exotic weed invasion and success of selected weed control measures.
    - Identification of recruitment of new species to site where the seral management process is adopted.
    - Identification of the "success" of repatriated or established plants, where horticultural intervention is selected.

10.5.4 Post-construction and operations

It would be useful to select a few sites within the EGI servitude that lie within sensitive environments and monitor the status of vegetation and habitat within these areas over an extended period. This may be undertaken through the establishment of a number of permanent transects in selected grasslands, scrub and forest environments. Other factors should also be monitored including rainfall etc. in order to correlate data. The objective of this monitoring would be to identify any severe change arising to adjacent habitat, or perhaps improvement in disturbed habitat over time, following the establishment of the EGI. Any negative outcomes from such evaluation should be met with a review of the operations undertaken in and around such habitats and consideration of other management interventions. Annual audits of the servitude need to be undertaken and management measures adjusted according to the observations.

11 REFERENCES

Acocks, J.P.H. 1954. Veld types of South Africa. Strelitzia. South Africa

Box, E. O. 1981. Macroclimate and plant forms: an introduction to predictive modelling in phytogeography. Vol. 1. Springer.

Burgess N, Hales JD, Underwood E, Dinerstein E, Olson D, Itousa I, Schipper J, Ricketts T and Newman K 2004. Terrestrial ecoregions of Africa and Madagascar. A conservation Assessment. Island Press, Washington D. C.

Department of Agriculture, Forestry and Fisheries, 2017. Agricultural field crop boundaries of South Africa.

Escott, B. 2012. KwaZulu Natal 2012, Critical Biodiversity Areas. EKZNW occasional presentation.

Ezemvelo KZN Wildlife. 2009. Integrated Management Plan: Ongoye Forest Nature Reserve, South Africa. Ezemvelo KZN Wildlife, Pietermaritzburg. 85pp. and 5 maps (4 x A4 and 1 x A3)

Ezemvelo KZN Wildlife. 2010. Terrestrial Systematic Conservation Plan: Minimum Selection Surface (MINSET). Unpublished GIS Coverage [tscp_minset_dist_2010_wll.zip], Biodiversity Conservation Planning Division, Ezemvelo KZN Wildlife, P. O. Box 13053, Cascades, Pietermaritzburg, 3202.

Gazette 34809 of 2011. Threatened terrestrial ecosystems in South Africa. Schedule to the National Environmental Management: Biodiversity Act, 2004. Act 10 of 2004.

Government of South Africa. 2010. National Protected Area Expansion Strategy for South Africa 2008. Pretoria. ISBN 978-1-919976-55-6

Jewitt, D. 2016. Vegetation type conservation targets, status and level of protection in KwaZulu-Natal in 2016. *Bothalia - African Biodiversity & Conservation.* 48 (1) 1-10

Jewitt D, Goodman PS, Erasmus BFN, O'Connor TG, Witkowski ETF (2015). 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

Kottek, M., Grieser, J., Beck, C., Rudolf, B. & Rubel, F. 2006. World map of the Köppen-Geiger climate classification updated. *Meteorologische Zeitschrift*, 15(3):259-263.

McCracken, 2008. Saving the Zululand Wilderness: An Early Struggle for Nature Conservation. Jacana.

Mucina, L. & Rutherford, M.R. 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Rubel, F. & Kottek, M. 2010. Observed and projected climate shifts 1901-2100 depicted by world maps of the Köppen-Geiger climate classification. *Meteorologische Zeitschrift,* 19(2):135-141. DOI: 10.1127/0941-2948/2010/0430.

SANBI (South African National Biodiversity Institute). (2012) Vegetation Map of South Africa, Lesotho and Swaziland [vector geospatial dataset] 2012.

SANBI (South African National Biodiversity Institute). 2018. Threatened Species Programme. http://redlist.sanbi.org/.

Scott-Shaw, R. & Escott, B.J. (*Eds.*) 2011. Kwazulu-Natal Provincial Pre-Transformation Vegetation Type Map – 2011. Unpublished GIS Coverage [kznveg05v2_011_wll.zip], Biodiversity Conservation Planning Division, Ezemvelo KZN Wildlife, P.O. Box 13053, Cascades, Pietermaritzburg, 3202.

SDP Ecological and Environmental Services. 2015. Transfrontier Park Conservation Initiative – iSimangaliso – PPMR Terrestrial Ecology and Dune Dynamics. For iSimangaliso Wetland Park WHS.

Tinley, K.L. 1985. Coastal dunes of South Africa. National Scientific Programmes Unit: CSIR. SANSP Report 109, 1985, pp 304. Pretoria

Van Wyk, A.E., & Smith, G.F. 2001. Regions of floristic endemism in southern Africa: a review with emphasis on succulents. Umdaus press. Hatfield South Africa

Yamamoto, S., 1996. Gap regeneration of major tree species in different forest types of

Japan. *Vegetatio*, 127(2):203-213.

Appendix 1: Description of GIS Data

GIS ID	Feature Class	Feature Name/ Ecosystem Type (if available)	Feature Sensitivity Rating	Feature Sensitivity Score	Buffer Sensitivity Rating	Buffer Sensitivity Score	Buffer Distance	Notes/Comments/Changes compared with Draft Corridor Environmental Constraints Map
KZN_Wildlife_PAs_IOCB	Protected Areas	Various Protected Areas	Very High	10	Medium	5	0-5 km	A new layer included to augment the Nature_Reserves IOCB layer. Buffer width to be confirmed on a site by site basis.
Nature_ReservesIOCB	Protected Areas	Various Protected Areas	Very High	10	Medium	5	0-5 km	The original rating of Very High was retained. Buffer width to be confirmed on a site by site basis.
National_protected_areas_expIOCB	Protected Area Expansion Areas	Priority Focus Areas, Areas under negotiation	Medium	4	NA	NA	NA	The original rating of Medium was retained.
KZN_CBA_irrepl_IOCB	Critical Biodiversity Areas	CBA Irreplaceable	High	7	NA	NA	NA	Downgraded from Very High. The original CBA layer was replaced by the latest KZN Wildlife CBA layers, which were assigned a separate sensitivity rating which aligned with their designation.
KZN_CBA_Optim_IOCB	Critical Biodiversity Areas	CBA Optimal	Medium	4	NA	NA	NA	Downgraded from Very High. The original CBA layer was replaced by the latest KZN Wildlife CBA layers, which were assigned a separate sensitivity rating which aligned with their designation.
KZN_ESA_IOCB	Critical Biodiversity Areas	Ecological Support Area	Low	2	NA	NA	NA	Downgraded from Very High. The original CBA layer was replaced by the latest KZN Wildlife CBA layers, which were assigned a separate sensitivity rating which aligned with their designation.

GIS ID	Feature Class	Feature Name/ Ecosystem Type (if available)	Feature Sensitivity Rating	Feature Sensitivity Score	Buffer Sensitivity Rating	Buffer Sensitivity Score	Buffer Distance	Notes/Comments/Changes compared with Draft Corridor Environmental Constraints Map
Gamefarm_deeds_2015IOCB	Private NR and game farms	Game Farms	Medium	5	Low Medium	1; 3	2.5 km to 10 km	The original Medium sensitivity rating was retained. Buffer zones as per Buffer Layer.
Forest_nature_reserve IOCB	Forest Nature Reserve	Mapelane Nature Reserve	Very High	10	NA	NA	NA	The original Very High sensitivity rating was retained. The only proclaimed Forest Nature Reserve in the IOCB.
Ramsar_sites_IOCB	Ramsar Sites	Turtle Beaches/Coral Reefs of Tongaland, St Lucia System, Kosi Bay, Lake Sibaya	High	8	NA	NA	NA	The original High sensitivity rating was retained. The Ramsar Site Is situated within the Isimangaliso Wetland Park.
WHS_coreIOCB	World Heritage sites	Isimangaliso Wetland Park	Very High	10	NA	NA	NA	The original Very High sensitivity rating was retained. The Protected Area buffer would be applicable.
KZN_VEG_CONS_ST_CR_IOCB	Vegetation	Various vegetation types within KZN	Very High	9	NA	NA	NA	The KZN Vegetation Conservation Status layers were new data, not originally included. A suitable sensitivity rating was assigned according to the designated conservation status.
KZN_VEG_CON_ST_VU_IOCB	Vegetation	Various vegetation types within KZN	High	7	NA	NA	NA	The KZN Vegetation Conservation Status layers were new data, not originally included. A suitable sensitivity rating was assigned according to the designated conservation status.
KZN_VEG_CONS_ST_EN_IOCB	Vegetation	Various vegetation types within KZN	Medium	4	NA	NA	NA	The KZN Vegetation Conservation Status layers were new data, not originally included. A suitable sensitivity rating was assigned according to the designated conservation status.
KZN_VEG_CON_ST_LT_IOCB	Vegetation	Various vegetation types within KZN	Low	2	NA	NA	NA	The KZN Vegetation Conservation Status layers were new data, not originally included. A suitable

GIS ID	Feature Class	Feature Name/ Ecosystem Type (if available)	Feature Sensitivity Rating	Feature Sensitivity Score	Buffer Sensitivity Rating	Buffer Sensitivity Score	Buffer Distance	Notes/Comments/Changes compared with Draft Corridor Environmental Constraints Map
								sensitivity rating was assigned according to the designated conservation status.
Thicket_veg_IOCB	Vegetation	Thicket vegetation	High	6	NA	NA	NA	The original High sensitivity rating was retained. Only a very slight portion of true thicket occurred within the revised IOCB boundary.
NLC_IOCB	Land cover	Built up, Cultivation, Natural (From plantation), Plantation, Plantation (Old fields), Secondary Natural, Mining	Low	0	NA	NA	NA	The original Low sensitivity rating was retained. This layer represents the modified and transformed pockets and is considered the layer most representative of the situation on the ground.
Old_fields_IOCB	Land cover	Old fields	Low	0	NA	NA	NA	The original Low sensitivity rating was retained.
OtherFCB_IOCB	Land cover	Old fields, Rain fed annual crop cultivation/planted pasture, Subsistence farming 1	Low	0	NA	NA	NA	The original sensitivity rating was High. The rating was downgraded to Low due to data representing disturbed areas.
FCB_IOCB	Land cover	Horticulture, shadenet	Low	0	NA	NA	NA	The original sensitivity rating was Very High. The rating was downgraded to Low due to data representing disturbed areas.
Ecoregions_IOCB	Eco region	Kwazulu-Cape coastal mosaic, Maputaland coastal forest mosaic, Maputaland-Pondoland bushveld and thickets	Medium	3	NA	NA	NA	The original Medium sensitivity rating was retained.
NFI_IOCB	National Forests	Declared Natural Forests	Very High	9	Medium	4	Up to 100 m	The original Very High rating was retained. Buffer width to be determined on a site by site basis.
Coastline_bufferIOCB	Buffer zones	Coastline buffer	Very High	9	NA	NA	NA	The original Very High rating was retained.
Gamefarm_2500m_IOCB	Buffer zones	Game farm 2500 m	Medium	3	NA	NA	NA	Originally rated as High sensitivity.

GIS ID	Feature Class	Feature Name/ Ecosystem Type (if available)	Feature Sensitivity Rating	Feature Sensitivity Score	Buffer Sensitivity Rating	Buffer Sensitivity Score	Buffer Distance	Notes/Comments/Changes compared with Draft Corridor Environmental Constraints Map
		buffer						This was downgraded to Medium to align with the downgrading of the Game Farm deeds layer.
game_farm_5000m_buff_IOCB	Buffer zones	Game farm 5000 m buffer	Medium	3	NA	NA	NA	The original Medium sensitivity was retained.
game_farms_10000mbuffer_IOCB	Buffer zones	Game farm 10000 m buffer	Low	1	NA	NA	NA	The original Low sensitivity was retained.
NatureReserve_buffer_IOCB	Buffer zones	Nature Reserve buffer	Medium	3	NA	NA	NA	The original Medium sensitivity was retained.

Appendix 2: 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 - EGI Expansion					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	1	2		Infrastructure is spelt incorrectly	Done
Catherine (Kate) Pringle	3	9-31		The following acronyms appear in the list but are missing from the text: PCE	Corrected. PCE is not applicable.
Catherine (Kate) Pringle	6	1-24		Is the summary meant to provide background or be an executive summary? If the latter, then the following information is missing: where is the IOCB, what methods were used in the assessment of potential impacts, what were the key findings, and what are the recommendations?	Minor addition made
Catherine (Kate) Pringle	6	12		The IOCB is characterised by given diverse… The word given should be removed.	Done
Catherine (Kate) Pringle	6	33		"Evaluate and recommend" may read better as "evaluate and provide recommendations on.."	Done
Catherine (Kate) Pringle	7	21		The should be this	Done
Catherine (Kate) Pringle	7	21-25		This is a very long sentence. I would suggest putting a full stop after impacts and staring the next sentence as follows: "It also offers opportunities to ameliorate…"	Addressed
Catherine (Kate) Pringle	7	35		with should be within	Done
Catherine (Kate) Pringle	7	35		There is a double space after avifauna	Done
Catherine (Kate) Pringle	9	5		There should be a full stop at the end of this bullet.	Done
Catherine (Kate) Pringle	10		Table 1	Re Ecoregion data. The data source is given as SANBI, but no date is provided. Please include the date.	Corrected
Catherine (Kate) Pringle	11	30-31		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.	Not applicable to EGI. Has been removed.
Catherine (Kate) Pringle	12	4		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	Reworded

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - EGI Expansion					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**
				this sentence to make this more explicit.	
Catherine (Kate) Pringle	12	13-21		Section 4.3.4 is a bit misleading when you read it for the first time without having read the rest of the report. The first time I read it; it seemed to imply 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.	Numerous changes made to this section. Hopefully it improves the clarity.
Catherine (Kate) Pringle	12	24		It is not clear how section 4.3.3 and section 4.3.5 differ from one another. Do they both relate to the impact of rapid land transformation on the accuracy of the data? Similarly, the problems with the faunal data are repeated.	This section has been reworked
Catherine (Kate) Pringle	12	29		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	Done
Catherine (Kate) Pringle	13		Table 2	All Acts in this table should have the Act No and date included e.g. National Environmental Management: Protected Areas Act 57 of 2003.	Done
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.	Same comment at Gas i.e. 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	Done

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - EGI Expansion					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
				Management Act 9 of 1997.	
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.	Removed, not relevant
Catherine (Kate) Pringle	15	20		I am not sure what you mean by "species ethos"?	Behaviour
Catherine (Kate) Pringle	17	15-16		This should be a single line space.	Noted
Catherine (Kate) Pringle	20	20		Will cessation of the fire regime really occur? Surely with an increase in grass rather than shrub species, fire could increase?	Managed area, therefore no burning
Catherine (Kate) Pringle	20	26		Table 5 is missing a bracket	Done
Catherine (Kate) Pringle	21		Table 5	I presume this data is based on Mucina and Rutherford 2006. The citation should be included in the figure heading.	Done
Catherine (Kate) Pringle	23		Figure 3	I presume this data is based on Mucina and Rutherford 2006. The citation should be included in the figure heading.	Done
Catherine (Kate) Pringle	24	1		I presume that section 6.2 summarises data from Mucina and Rutherford 2006. This should be referenced accordingly.	Added
Catherine (Kate) Pringle	24	6		Figure 4 should be followed by a full stop.	Done
Catherine (Kate) Pringle	25	7		Remove comma after CB3	Done
Catherine (Kate) Pringle	28		Table 6	All descriptions in the table should end with a full stop. The relevant citation should also be included in the table heading.	Done
Catherine (Kate) Pringle	36	10-15		This paragraph is repeated in the paragraph below.	First paragraph removed
Catherine (Kate) Pringle	41	9		There is a space missing between Table 10 and provides	Done
Catherine (Kate) Pringle	43	4		Should it be the protected area network?	No. It is the same as in the Gas Report
Catherine (Kate) Pringle	43	22		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.	If it falls outside the IOCB it will fall within the specific biome review. The data does include game farms, but the heading does not include this.
Catherine (Kate) Pringle	43	31		Programmes should be agreements. As I understand it, there is only one overarching Stewardship Programme in KZN.	Changed

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - EGI Expansion					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	45	6		The date of the National Land Cover should be included.	Dates are included
Catherine (Kate) Pringle	45	6-14		This section 7.1.10 does not discuss the field crop boundaries which are listed under land cover in Table 11. A description of this layer should be provided.	Brief description added
Catherine (Kate) Pringle	45	17		A date should be provided for the eco region layer both in the text and in Table 11	Done
Catherine (Kate) Pringle	47		Table 11	Ecoregion feature class. A date should be provided for the SANBI layer.	Done
Catherine (Kate) Pringle	47		Table 11	Re Ecoregion data. The data source is given as SANBI, but no date is provided. Please include the date.	Done
Catherine (Kate) Pringle	48		Table 12	KZN CBA Irreplaceable has 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	48		Table 12	Private nature reserves and game farms. Game farms are listed as being considered but this is not expressed in the text.	See above
Catherine (Kate) Pringle	53-54	1-21		This section focuses largely on habitat/flora. What about impacts on fauna and associated mitigation measures? These are listed in Table 13 but not discussed in the text.	Fauna sensitivities are being addressed by a separate specialist. It was stated in the report that faunal data was not incorporated into the sensitivity rating component of this report.
Catherine (Kate) Pringle	53-54	1-21		Are impacts on sense of place considered elsewhere? For example, having large lines running passed protected areas may negatively impact on the wilderness experience for visitors.	Considered by another specialist
Catherine (Kate) Pringle	53-54	1-21		I assume that the impact on birds is dealt with in a separate specialist report?	Yes
Catherine (Kate) Pringle	75-76			There are inconsistencies in the referencing styles. For example, some references include the title in inverted comma's others don't, some include the journal number in brackets others don't, the publisher place is missing from all book references. All references should be checked.	Addressed
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. These have been referenced accordingly
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	Same as the gas response i.e. 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

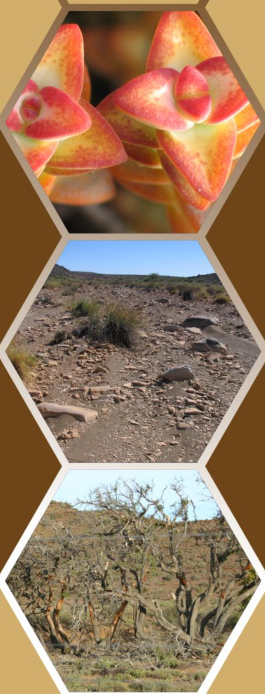
EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - EGI Expansion					Change has been effected in the report No change has been effected in the report (i.e. not required and supported by response by Specialist)
Expert Reviewer Name	Page Range	Line/s	Table/ Figure	Expert Reviewer Comments	Response from Specialist
				in the text.	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?	I think what is meant by that is additional GIS features, in addition to those provided by CSIR and SANBI or characteristics of the IOCB that need to be highlighted. I don't think EMF would be applicable at this scale. Ethekwini DMOSS and similar tools are too fine scale for a biome scale review.
Catherine (Kate) Pringle	General query			The TOR requires that the National Biodiversity Assessment 2011 is considered. How has this been done?	As per gas report response i.e. 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.	Considered by another specialist
Catherine (Kate)	General			Why did you undertake a risk assessment for the Gas pipeline but not	We were provided with a set template and worked to

EXPERT REVIEW AND SPECIALIST RESPONSES: Indian Ocean Coastal Belt Biome - EGI Expansion					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
Pringle	query			for the EGI? Is a risk assessment not necessary?	that template. Note from the CSIR: The EGI Expansion SEA followed the same template as that of the 2016 EGI SEA, which did not include a Risk Assessment.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.4

Biodiversity and Ecological Impacts (Terrestrial Ecosystems and Species) - Succulent and Nama Karoo Biomes



STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

NAMA KAROO, SUCCULENT KAROO AND DESERT BIOMES

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ABBREVIATIONS AND ACRONYMS

AIS	Alien Invasive Species
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
EGI	Electricity Grid Infrastructure
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
EN	Endangered
ESA	Ecological Support Area
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
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, at a strategic level, to identify the potential impacts on the Nama Karoo, Succulent Karoo and desert ecosystems as a result of constructing and maintaining electricity grid infrastructure (EGI) in the expanded Western EGI Corridor.

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. 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. The Succulent Karoo is bordered by the Desert biome in the north along the Orange River Valley, a desert ecosystem that is also uniquely high in plant and faunal diversity with a large variety of locally endemic species. Where the Succulent Karoo transitions into the Nama Karoo biome on its inland borders to the east, the high levels of succulence and endemism give way to arid ecosystems typified by a much lower biodiversity and few species of conservation concern.

The key potential impacts associated with construction, operation and maintenance of EGI within the expanded western EGI corridor include the following:

- Vegetation destruction, habitat loss and impact on plant species of conservation concern as a result of servitude clearance and construction of access routes, pylons and substations;
- Impact on faunal species of conservation concern;
- Alien plant invasion;
- Soil disturbance and increased erosion;
- Impact on Critical Biodiversity Areas and broad-scale ecological processes; and
- Cumulative impacts on habitat loss and broad-scale ecological processes.

The exceptionally high diversity of the Succulent Karoo and desert ecosystems together with a lack of adequate knowledge of most species’ responses to the EGI construction and operation makes it very difficult to assess the sensitivity with much confidence, especially the impacts of an extensive linear disturbance and potential habitat alteration. The effectiveness of the proposed mitigation also is difficult to assess for many faunal species, especially those with limited mobility and those which have narrow distributions and/or specific habitat requirements which confine them 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 overall environmental suitability of the expanded Western EGI Corridor in the Nama Karoo, Succulent Karoo and Desert biomes:

Corridor	Overall Suitability	Comment
Expanded Western EGI Corridor	Moderate suitability for EGI development	Succulent Karoo and desert ecosystems occupy the majority of the proposed expanded western EGI corridor, an area that is characterised by a significant density of High and Very High sensitivity features. These areas, which are typified by a high level of endemism and boast numerous plant and faunal species of conservation concern, should be avoided if at all possible. 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 EGI routing to follow based on more detailed mapping and corridor refinement as the overall undulating to flat topography, soils and present ecological state of this area are more conducive to EGI construction. Also, the lower sensitive areas located to the far eastern and south-eastern sections of the corridor should be considered for EGI routing.

2 INTRODUCTION

During 2016, the Council for Scientific and Industrial Research (CSIR) was tasked by the Department of Environment Affairs (DEA) and Eskom to undertake a Strategic Environmental Assessment (SEA) of a number of electrical grid infrastructure (EGI) corridors across South Africa. This study is an extension to the original EGI SEA for the expansion of EGI within two additional corridors of approximately 100 km wide, of which one includes a section linking South Africa and Namibia.

This assessment pertains to the expanded western EGI corridor, an area extending northwards from about Nuwerus to the Orange River along the South African west coast. This assessment aims to identify the potential impacts of constructing and maintaining EGI in the Nama and Succulent Karoo biomes, as well as the Desert biome of South Africa. The expanded eastern EGI corridor is not included within this assessment, as it does not intersect with either the Nama Karoo, Succulent Karoo or the Desert biomes.

EGI for purposes of this assessment include the following components:

- Power line servitudes (approximately 80 m wide (for a typical 756 kV line));
- Access and service roads (approx. 4 m during construction, then two-track during operation);
- Overhead power lines (≥ 400 kV) supported by various types of pylons (such as self-supporting lattice towers, guyed towers and monopole structures). Each pylon has an average footprint size of 1 ha during construction; and
- Transmission and distribution substations (each up to 70 ha in size).

Key environmental attributes of the Nama and Succulent Karoo biomes (including the Desert biome) in the proposed expanded western EGI corridor include:

- High diversity and endemism for succulent plants;
- High diversity and endemism for fauna, especially reptiles;
- Extensive degradation due to overgrazing (e.g. sheep and goats);
- 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 EGI 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.

3 SCOPE OF THIS STRATEGIC ISSUE

The expanded western EGI corridor is largely comprised of the Succulent Karoo biome with the Desert biome dominating the entire northern boundary of the corridor along the Orange River Valley. Only a relatively small patch of Nama Karoo biome can be found towards the eastern section of the corridor.

The purpose of this assessment is to identify the potential impacts of EGI construction and maintenance on biodiversity and ecology (terrestrial ecosystems, fauna and flora) within the Nama Karoo, Succulent Karoo and Desert biomes of South Africa. Aquatic ecosystems, including wetlands were excluded from this assessment as these are covered separately by other specialist studies in this SEA (Appendix C.1.6 of the EGI Expansion SEA Report). Furthermore, it recommends management actions and best practice mechanisms to avoid and minimise any potential impacts to sensitive Karoo and Desert ecosystems, as well as to guide sustainable development and environmental decision–making by authorities of proposed EGI 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.

4 APPROACH AND METHODOLOGY

4.1 Assessment Methodology

A desktop-level approach was utilised to assess terrestrial biodiversity and ecological sensitivity for the sections of the Nama Karoo, Succulent Karoo and Desert biomes that are situated within the proposed expanded western EGI corridor. A data layer package of available spatial datasets was provided by the South African National Biodiversity Institute (SANBI). These datasets were perused to identify features of biodiversity significance and conservation importance that would be applicable to this assessment. In addition to spatial data, available literature and background reports to the datasets, as well as the original EGI SEA report (DEA, 2016a) were consulted. The datasets described below in Table 1 were considered relevant to this assessment. For each relevant data field an assessment was made as to whether the field has very high, high, medium or low biodiversity sensitivity for the Nama Karoo, Succulent Karoo and Desert biome ecosystems, respectively. Both the Western Cape Biodiversity Spatial Plan (Pool-Stanvliet *et.al.*, 2017) and the Critical Biodiversity Areas (CBAs) of the Northern Cape (Holness and Oosthuysen, 2016) form two crucially important data sources on the presence of important biodiversity features and areas critical for conservation in the proposed expanded western EGI corridor.

4.2 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.
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).
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.
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.

Data Source	Summary
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 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). National Environmental Management: Biodiversity Act: National list of ecosystems that are threatened and in need of protection. Government Gazette, 558(34809): 1 – 544, December 9.	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

Data Source	Summary
http://bgis.sanbi.org/.	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.
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 expanded western EGI 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.* (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.
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.
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.
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.
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.

4.3 Assumptions and Limitations

The following assumptions and limitations are relevant to this assessment:

- 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 EGI construction and maintenance.
- 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 an 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.
- No fieldwork verification has taken place for the SEA.

4.4 Relevant Regulations and Legislation

Table 2. Key legislation, policies and plans pertaining to conservation management and planning in the Northern and Western 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	
1985	Land Use Planning Ordinance (Ordinance 15 of 1985) (governing former old Cape Province)
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)
Regional / Municipal	
2000	Municipal Systems Act (No. 32 of 2000)

5 IMPACT CHARACTERISATION

The development of EGI involves the construction of power lines, transmission and distribution substations as well as other associated infrastructure such as permanent access routes to maintain the EGI during operation.

This assessment assumes that the proposed EGI infrastructure will be developed for a typical 765 kV overhead power line which requires a servitude of 40 m on either side of the power line, as well as an additional 50 m on either side of the servitude to allow for the construction footprint or "development envelope". This calculates to a total width of 180 m (Figure 1) (DEA, 2016a). Building width restrictions are 22 – 40 m from the centre line and vegetation clearance for the servitude is required from the centre to the outer conductor plus an additional 10 m on either side. The minimum vertical clearance would be 8.5 m and the minimum horizontal clearance would be 5.5 m.

During construction each pylon has a footprint of about 1 ha or 166 ha per 100 km. This area is required to excavate and fill the foundations of the pylon, as well as assemble and then raise the pylon on-site. Transmission and distribution substations that can be up to 70 ha in extent will be distributed along the power line route and could have significant impacts on terrestrial ecosystems. Based on the 2016 EGI SEA, only one substation (i.e. powerline anchor point) is planned to occur in this expanded western EGI corridor and will be located near Springbok (DEA, 2016a).

During construction, access roads for service vehicles are generally around 4 m in width, but during operation of the power line these service roads can become a typical two-track for maintenance purposes. During construction, the disturbance footprint of such service roads is approximately 40 ha per 100 km of power line. The exact width of the service road as well as the present ecological state of the surrounding habitat will determine the severity of impact on site. Roads that are constructed on steep or uneven terrain, to make the site more accessible for heavy vehicles, will have a larger impact such as increased risk of soil erosion due to the cut and fill that is usually required. Special provision will have to be made in areas with deep, loose sand to ensure that the tracks do not grow wider or become multiple tracks as drivers seek to find easier routes.

The construction of EGI along a predetermined route will require temporary areas for construction camps, lay down areas (storage of materials) and borrow pits (permanent excavations). It is imperative that any disturbed areas and roads that will not be used for maintenance during the operational phase must be rehabilitated and monitored.

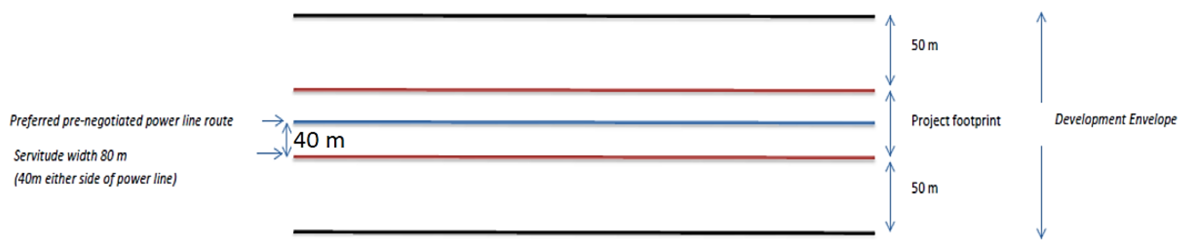

Figure 1. Servitude and construction footprint (or development envelope) for a typical 765 kV power line.

6 CORRIDOR DESCRIPTION

6.1 Demarcation of the study area

The expanded western EGI corridor that contains elements characteristic of the Nama Karoo and Succulent Karoo, as well as Desert biomes are shown in Table 3 and Figure 2 below.

Table 3. Distribution of the Nama Karoo, Succulent Karoo and Desert biomes in the expanded western EGI corridor relevant to this assessment.

Corridor	Biome	Province	Relevant Local Municipalities
Expanded Western EGI	Desert Nama Karoo Succulent Karoo	Northern Cape Western Cape	Kamiesberg, Nama Khoi, Richtersveld, Hantam and Matzikama

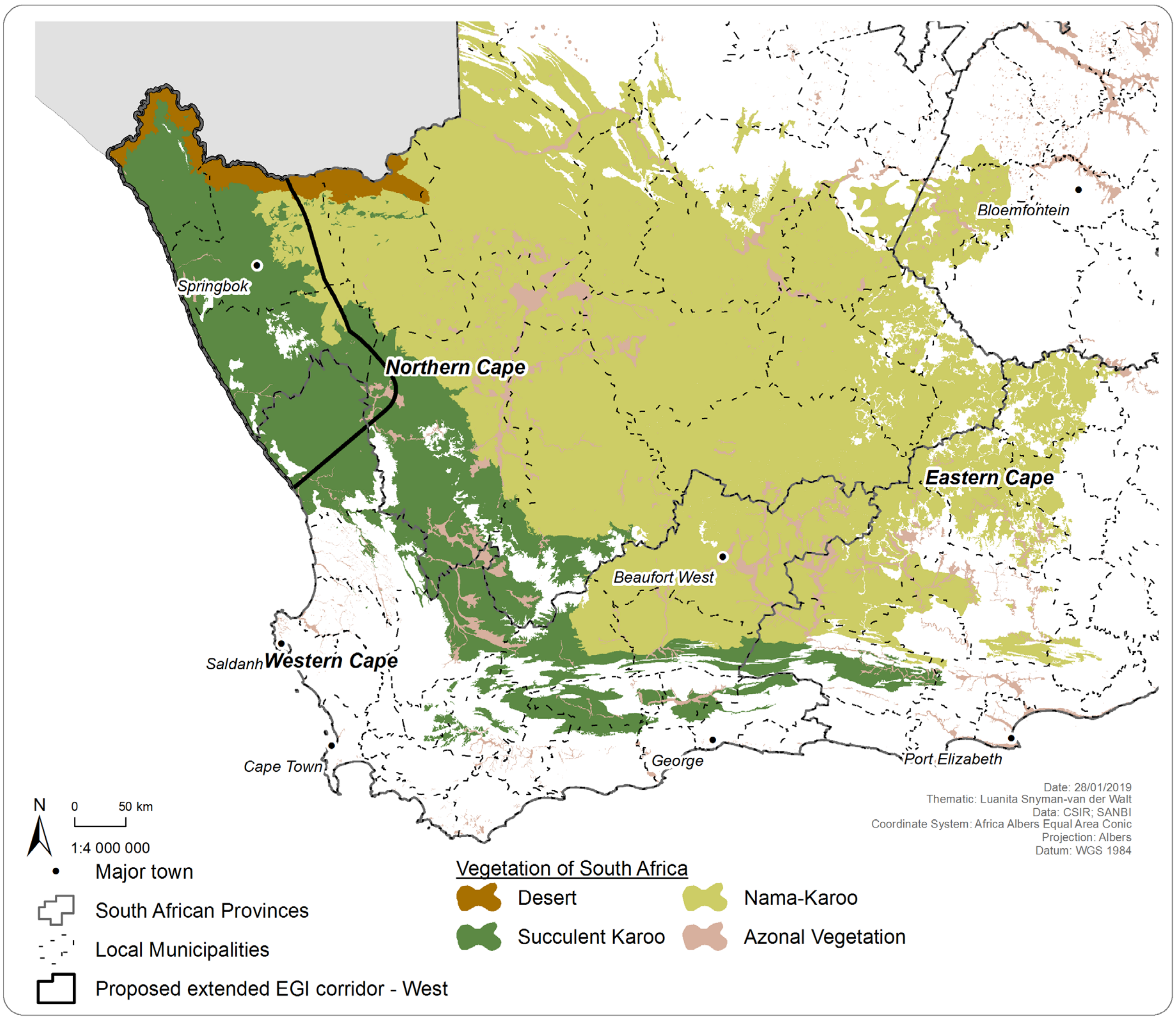

Figure 2. Map showing the distribution of the Nama Karoo, Succulent Karoo and Desert biomes in the expanded western EGI corridor relevant to this assessment.

6.2 Baseline environmental description of the Nama Karoo biome

6.2.1 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).

6.2.2 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 3). These three bioregions collectively boast 14 unique Nama Karoo vegetation types, two of which are present in the proposed expanded western EGI corridor (Figure 4). The two vegetation types are Bushmanland Arid Grassland and Bushmanland Sandy Grassland.

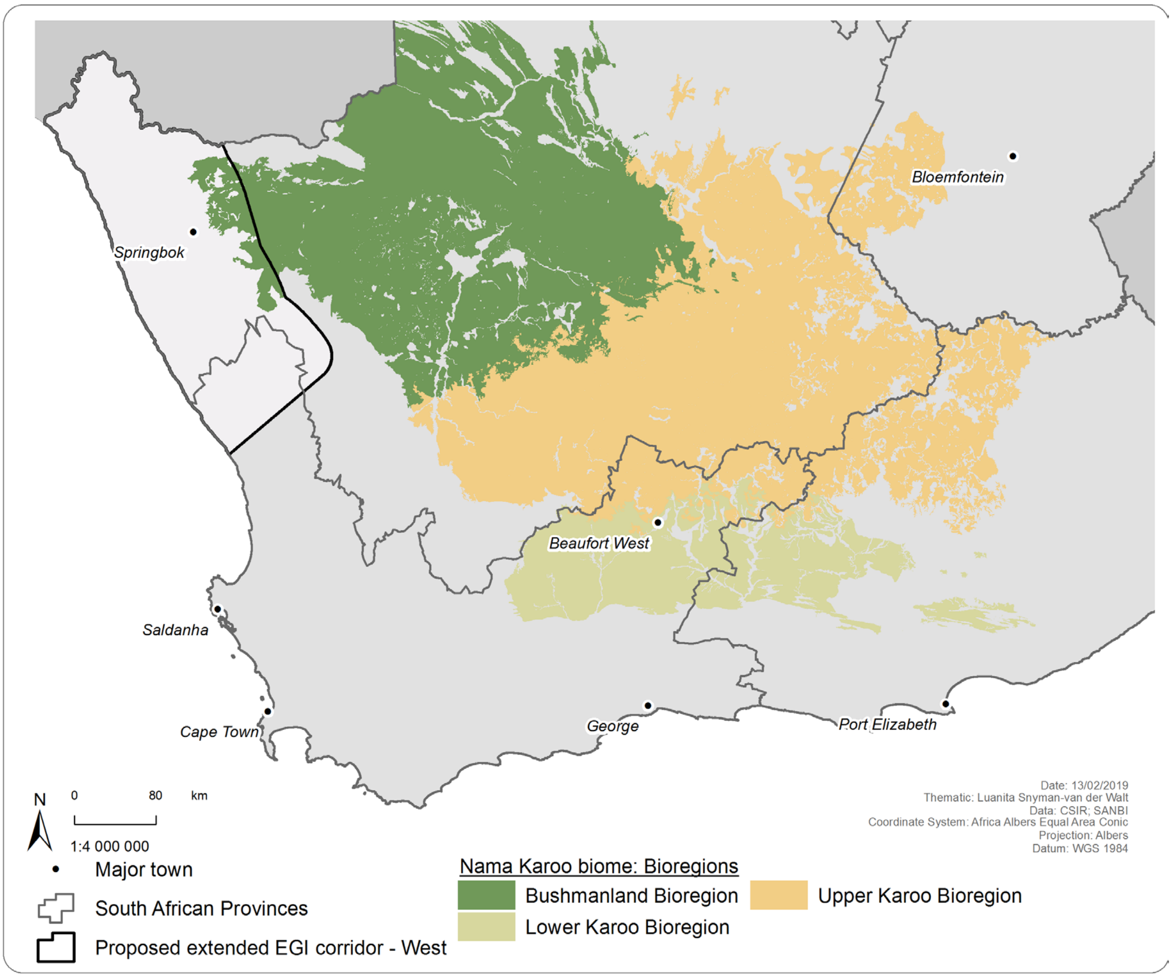

Figure 3. The Nama Karoo biome consists of three different bioregions.

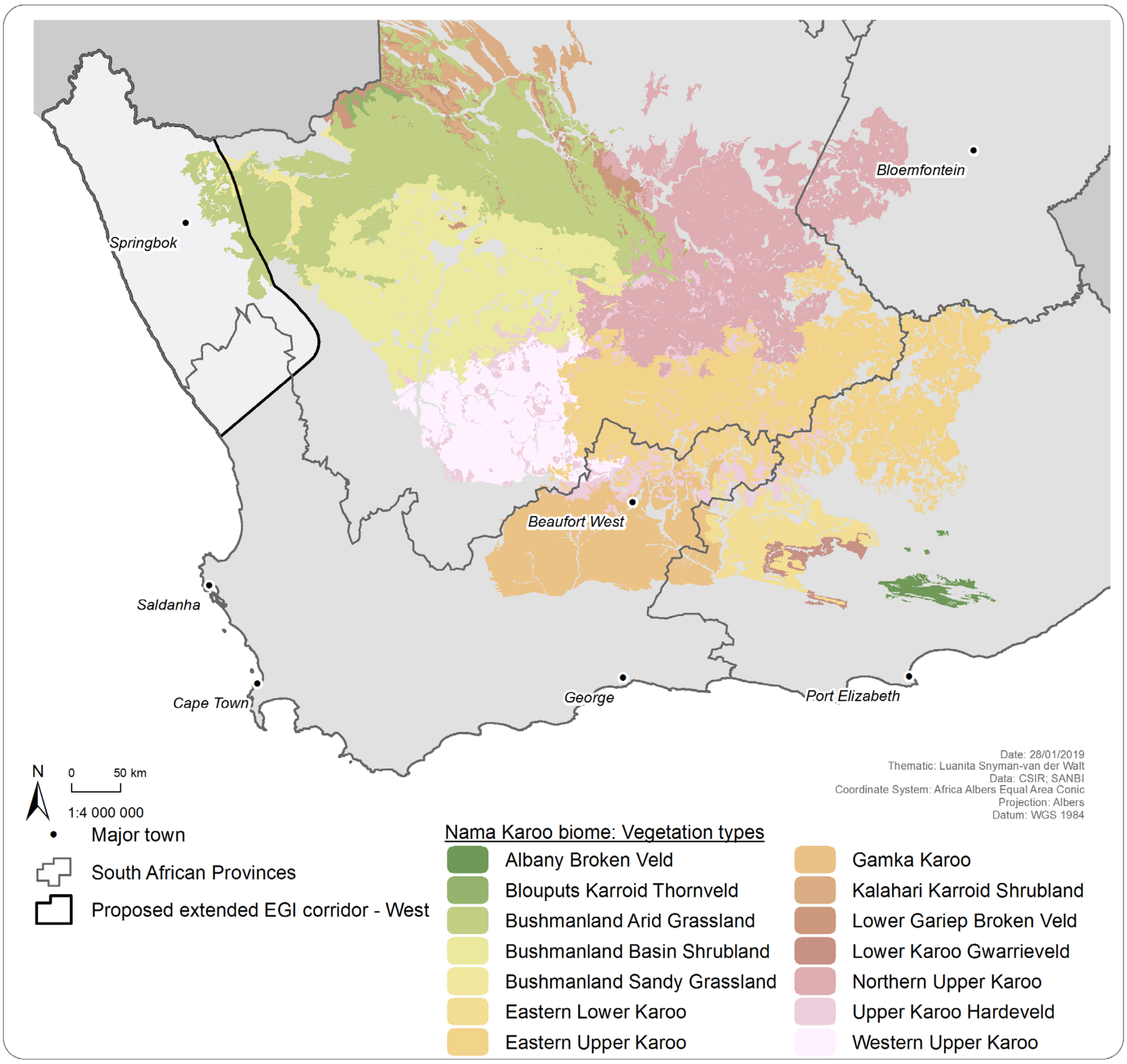

Figure 4. The Nama Karoo biome consists of 14 unique vegetation types.

6.2.3 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., *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.

6.2.4 Value of the Nama Karoo

6.2.4.1 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).

6.2.4.2 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).

6.3 Baseline environmental description of the Succulent Karoo biome

6.3.1 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).

6.3.2 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 5) comprising a total of 63 vegetation types (Figure 6). 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-four of these 63 Succulent Karoo vegetation types are all, or partly present within the proposed extended western EGI corridor. 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).

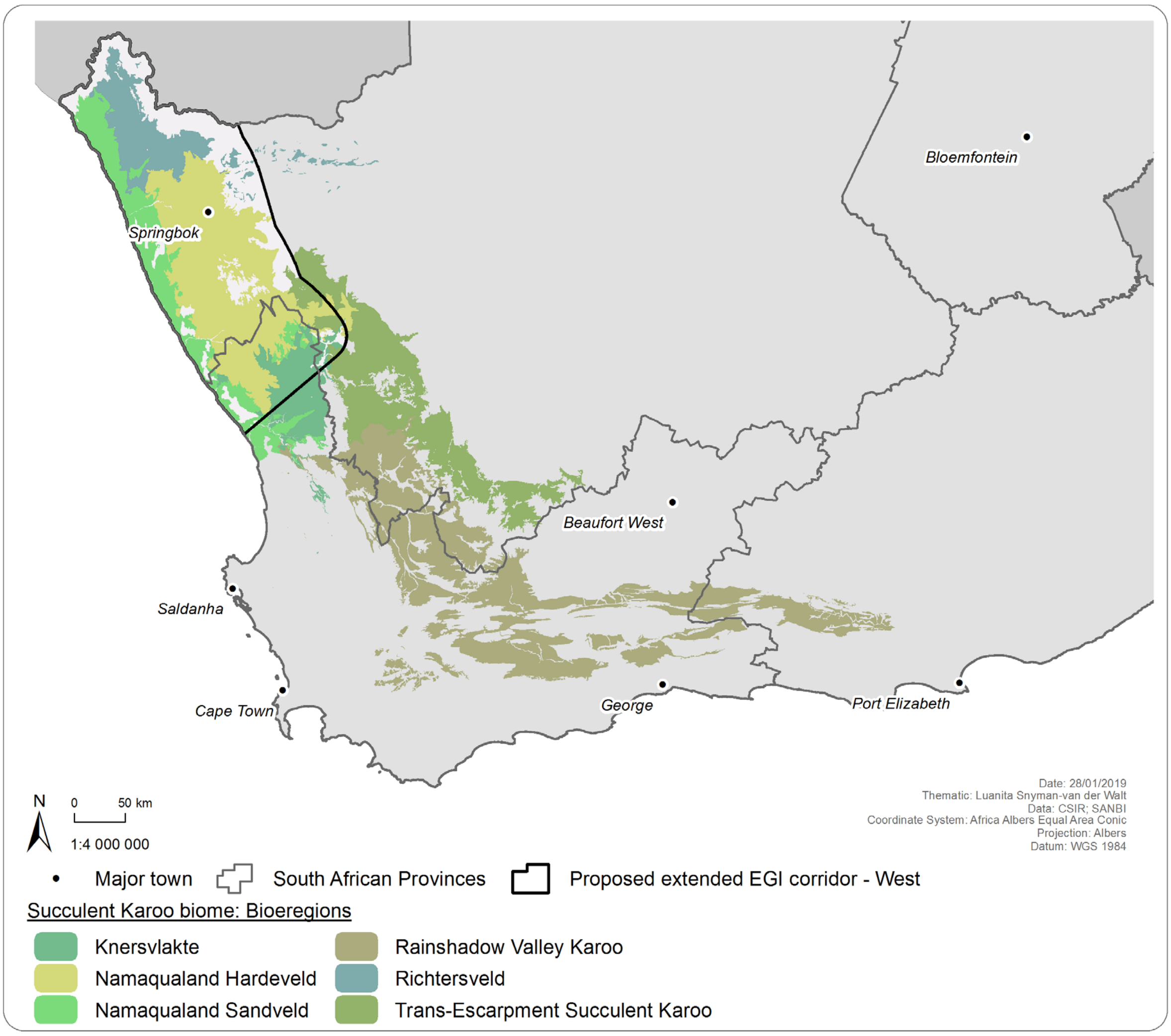

Figure 5. The Succulent Karoo biome consists of six different bioregions.

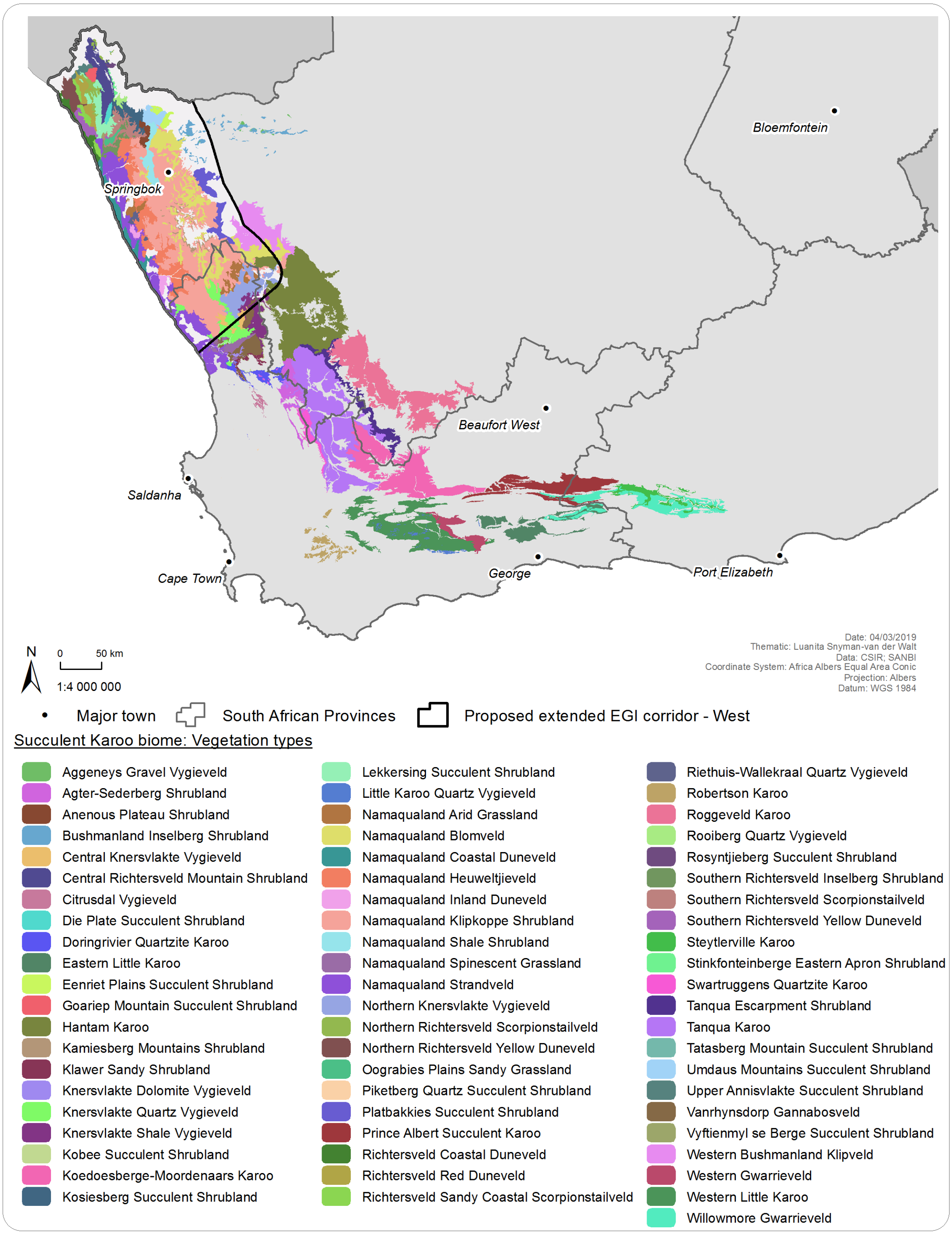

Figure 6. The Succulent Karoo biome comprises a total of 63 unique vegetation types.

6.3.3 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, Nababeep 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, also 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).

6.3.4 Value of the Succulent Karoo

6.3.4.1 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 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* subsp. *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*), Hartmann’s mountain zebra (*Equus zebra* subsp*. hartmannae*), klipspringer (*Oreotragus oreotragus*) 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 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. 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*).

Amphibians are poorly represented in the Succulent Karoo with just over 20 species. 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.

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).

6.3.4.2 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).

6.4 Baseline environmental description of the Desert biome

6.4.1 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 (Jürgens, 2006).

6.4.2 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 7), 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 8). All 15 of these Desert vegetation types are wholly or partially present in the proposed expanded western EGI corridor.

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 (Jürgens, 2006).

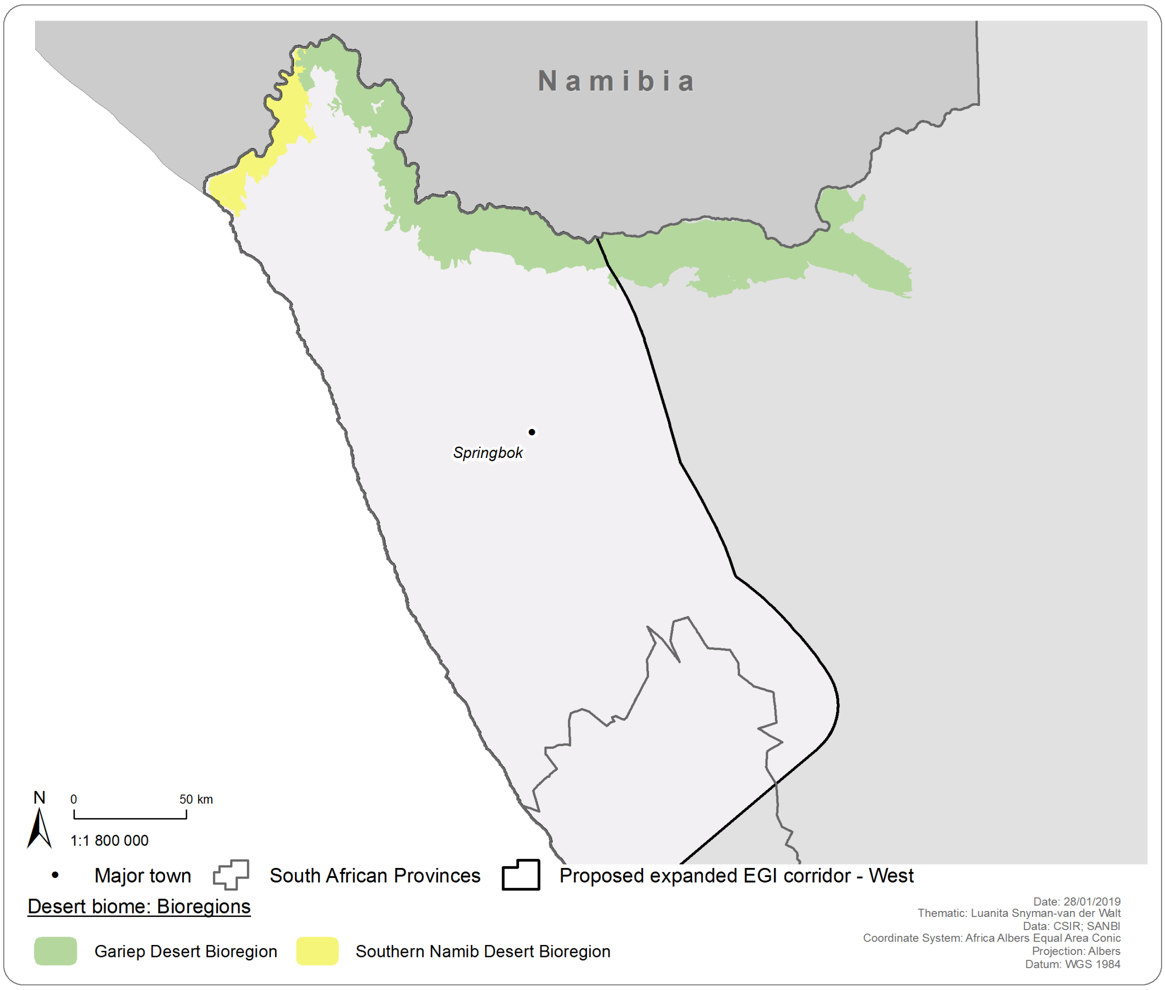

Figure 7. The Desert biome consists of two different bioregions.

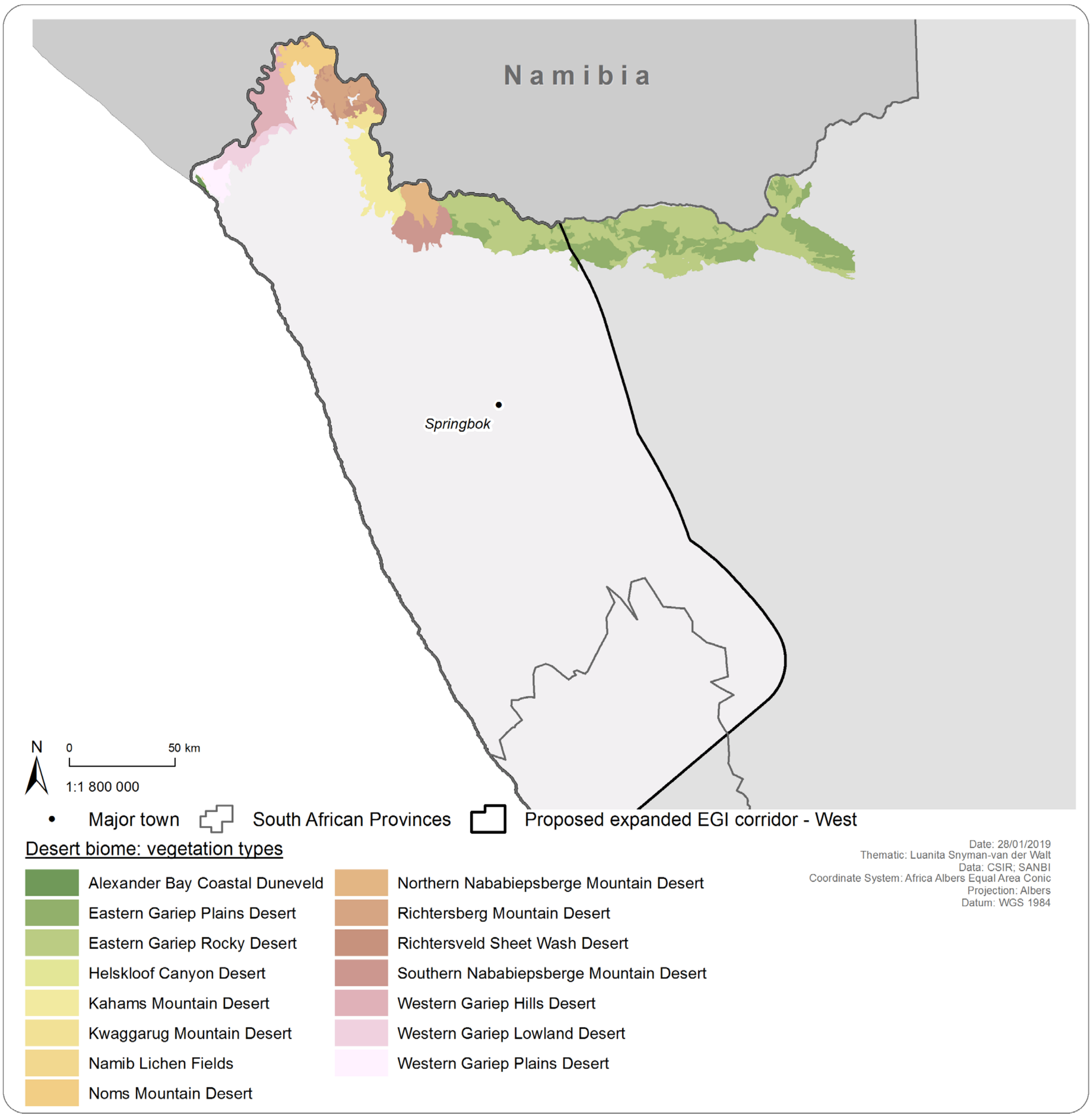

Figure 8. The Desert biome consists of 15 different types of desert habitat.

6.4.3 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 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).

6.4.4 Value of the Desert biome

6.4.4.1 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* subsp. *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).

6.4.4.2 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).

7 FEATURE SENSITIVITY MAPPING

7.1 Methodological approach to sensitivity mapping

The desktop-based 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 1000 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 or from 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.

7.2 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 and Western Cape provinces. This is summarised in Table 6.

The biodiversity feature data and critical biodiversity classification for the proposed expanded western EGI corridor falling into the Western Cape was obtained from the Western Cape Biodiversity Spatial Plan (2017). Biodiversity feature data and critical biodiversity classification for the proposed expanded western EGI corridor 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.
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 Natural Areas (or Veg types) which have a high abundance of Species of Conservation Concern = **High**	
		Veg types which are considered vulnerable to disturbance (dunes) = **High**	
Wetlands Layer 2018 NBA Layer	Wetlands	**High** in Succulent Karoo	Data generally taken as is.
		Low in Nama Karoo	
Rivers from the NFEPA – 1:250 000 layer (Note that these features are considered in the Freshwater	Stream Order 1-3	Stream Order was buffered as follows:	This is aimed at highlighting riparian areas. While the VegMap should capture riparian vegetation as an Azonal

Feature Class, Data Source and Date of Publication	Sensitivity Feature Class	Sensitivity Rating & Buffer	Data Description, Preparation and Processing
Assessment and are included for information purposes here. Refer to the Freshwater Assessment Report (Appendix C.1.6 of the EGI Expansion SEA Report) for feedback on sensitivity ratings in this regard).	4-5 6-7	1-3: 100 m 4-5: 500 m 6-7: 1000 m All classified as **Very High**	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 SEA	Classified as **High**	Custom layer based on the specialists' own knowledge and experience.

7.3 Feature map

7.3.1 Expanded Western EGI Corridor

This section highlights the different biodiversity features that have been combined to develop the overall sensitivity map. Features of conservation importance shown to occur within the boundaries of the proposed expanded western EGI corridor include inter alia formal protected areas and areas of significance to conservation planning such as CBAs and Ecological Support Areas (ESAs) (Figure 9).

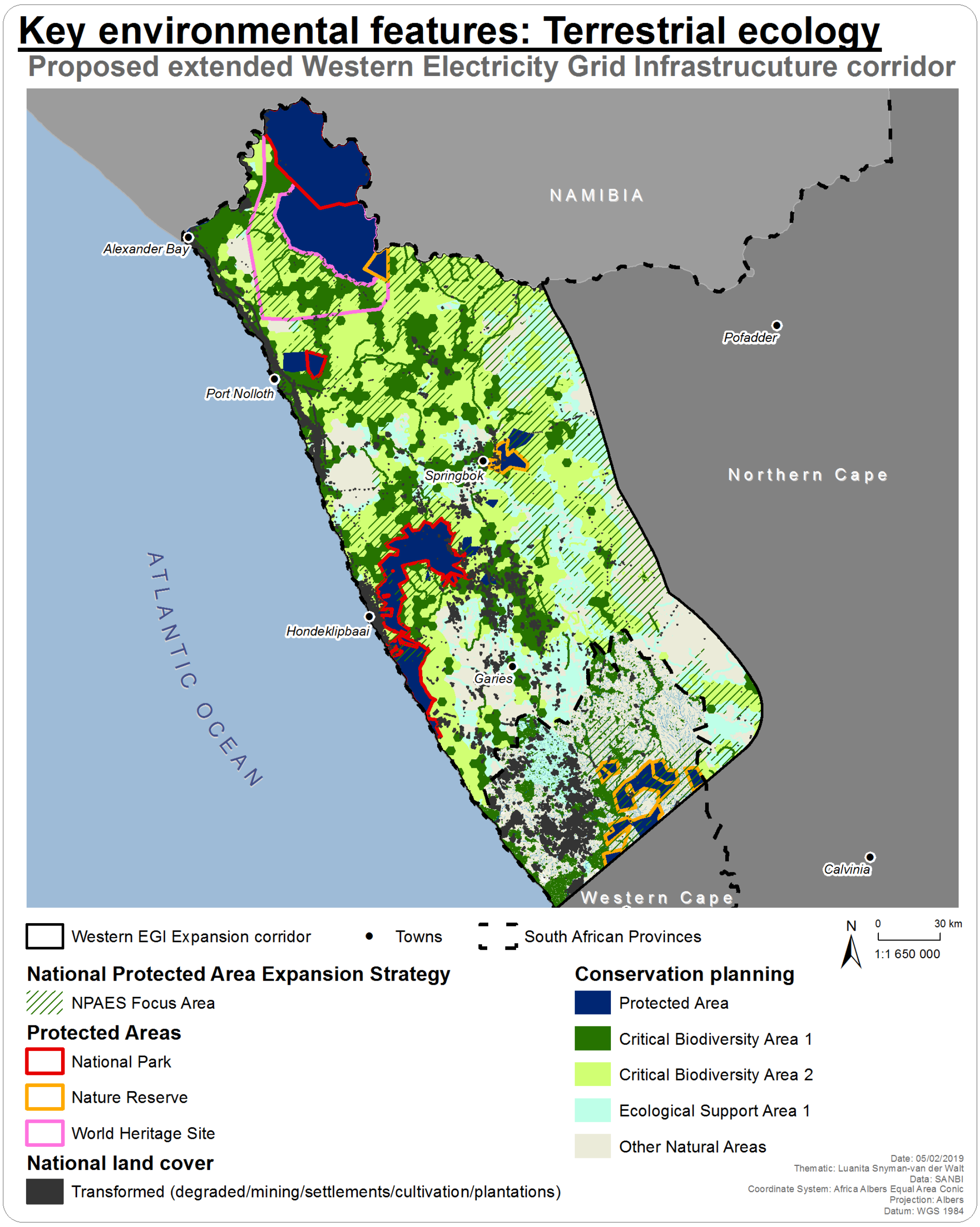

Figure 9. Key environmental features in the proposed expanded western EGI corridor.

8 FOUR-TIER SENSITIVITY MAPPING

The relative sensitivity mapping is based on a four-tier sensitivity classification using the following classes:

- Dark Red: Very High Sensitivity
- Red: High Sensitivity
- Orange: Moderate Sensitivity
- Green: Low Sensitivity

Multi-layered spatial analysis was used to create a sensitivity map based on biodiversity feature data and critical biodiversity classification characteristic of this area. The lowest sensitivity forms the base layer with the higher sensitivities progressively being overlaid. This results in the highest sensitivity being displayed for any given area that should be applied during planning and decision-making.

8.1 Expanded Western EGI Corridor

The majority of this expanded western EGI corridor is located within the Northern Cape Province with a small portion in the southern part of the corridor that is located in the Western Cape Province (Figure 10). The dominant features of the 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 Nababieps and the Orange River Mouth Provincial Nature Reserves, the latter including a Ramsar wetland. This arid environment is typified by desert and Karoo vegetation rich in succulents with a high level of species diversity 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 conservation 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 infrastructure construction due to the rugged, uneven terrain as well as the exceptional and unique 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 corridor is considered of 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. 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 crop fields and overgrazed 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.

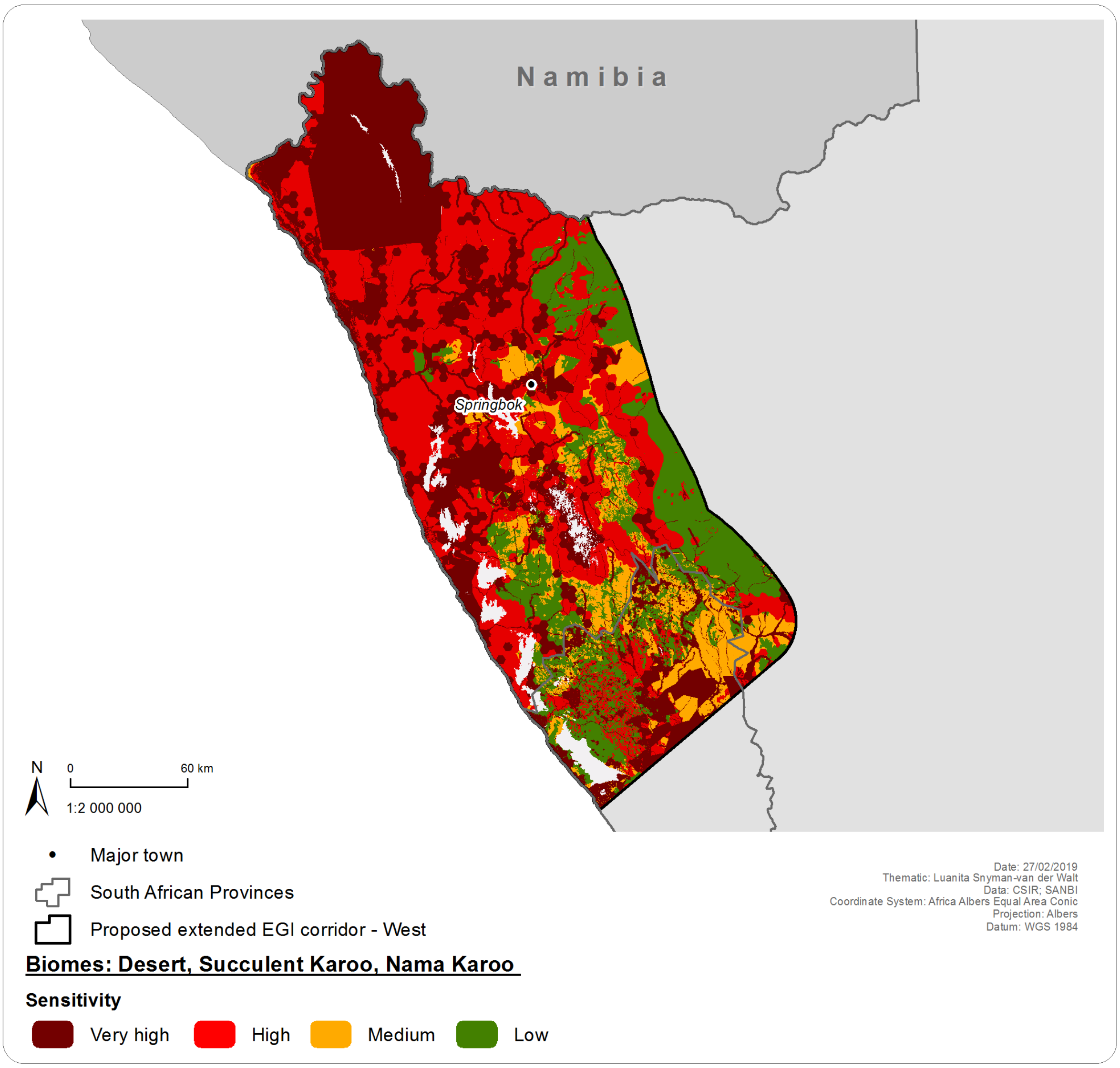

Figure 10. Sensitivity of Karoo and desert vegetation in the proposed expanded western EGI corridor.

9 KEY POTENTIAL IMPACTS AND MITIGATION

The key potential impacts associated with construction and operation of EGI within the expanded western EGI corridor include the following:

- Vegetation destruction, habitat loss and impact on plant species of conservation concern as a result of servitude clearance and construction of access routes, pylons and substations;
- Impact on fauna species of conservation concern;
- Alien plant invasion;
- Soil disturbance and increased erosion;
- Impact on CBAs and broad-scale ecological processes; and
- Cumulative impacts on habitat loss and broad-scale ecological processes.

The largest constraints on the construction of EGI 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 expanded western EGI 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 EGI routing to follow based on more detailed mapping and corridor refinement as the overall undulating to flat topography, soils and present ecological state of this area are more conducive to EGI 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 EGI routing.

Table 7. Key potential impacts on terrestrial features associated with EGI construction and operation with proposed management actions.

Key Impact	Description	Proposed management actions
Vegetation destruction, habitat loss and impact on plant species of conservation concern as a result of servitude clearance and construction of access routes, pylons and substations	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. rare succulents, orchids, etc. • 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 construction of substations on steep slopes (>25 degrees). *Construction*: • Avoid any unnecessary vegetation clearance beyond the servitude parameter; • 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

Key Impact	Description	Proposed management actions
		fences; • 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. **Rehabilitate** *Construction*: • 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; • 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 species of conservation concern	• Loss of faunal habitat and consequently loss of species of conservation concern; • Open deep excavations or trenches in the vicinity of the pylon laydown areas and substation sites can trap certain ground-dwelling animals with no shelter, water or food. Also, if these excavations fill with water, animals that cannot escape, drown; • Possible ensnarement of animals or ingestion of 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;	**Avoid** *Planning*: • Avoid identified areas of high fauna importance, including SCC. Consider very high sensitive are as "no-go" areas. *Construction*: • 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; • No construction should be done at night, as far as possible.

Key Impact	Description	Proposed management actions
	• Soil compaction may hamper subsoil movement of some animals, e.g. mole rats; • Increased human activities may cause animals to migrate away from their natural habitat; • Increased risk of poaching due to an increase in human activities and road access to formerly remote and inaccessible areas; • The maintenance road along the powerline corridor is considered a continued disturbance factor to fauna post-construction as it could potentially fragment habitats, allow for human traffic during operation of the power line and increase exposure to predation; • Electrocution on ground as tortoises and other small fauna that get stuck underneath or against electrical fences, should such electrified fencing be installed.	**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 or excavations; • 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; • Appropriate design of roads and other infrastructure where appropriate to minimise faunal impacts and allow fauna to pass through or underneath these features; • No electrical fencing within 30 cm of the ground as tortoises become stuck against such fences and are electrocuted to death; • 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; • Electrical fences, if installed, should be erected according to the norms and standards of the Nature Conservation Authorities in the Western and Northern Cape provinces. **Rehabilitate** *Operation*: • An Open Space Management Plan is required for the development, which makes provision for favourable management of the facility and the surrounding area for fauna.

Key Impact	Description	Proposed management actions
Alien plant invasion	• Removal of vegetation cover and topsoil can create pathways for the spread of invasive plant species; • Altered soil structure, moisture levels and light availability promotes the establishment of alien invasive plants.	**Avoid** *Construction*: • Avoid unnecessary disturbance of plant cover and topsoil; • Use existing roads as far as possible; • Do not use soil sources contaminated with alien invasive plant seeds 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 disturbance and habitat loss; • Potential smothering of vegetation due to soil accumulation in areas prone to high wind erosion; • Potential siltation of drainage lines.	**Avoid** *Construction*: • Avoid areas of high wind erosion vulnerability as much as possible; • Clearing of vegetation, compaction and levelling should be restricted to the footprint of the proposed development.

Key Impact	Description	Proposed management actions
		<u>**Minimise and Rehabilitate**</u> *<u>Construction</u>*: • Revegetation of cleared areas with monitoring and follow-up to ensure that rehabilitation is successful; • Use barriers, geotextiles, active rehabilitation and other measures such as gabions during and after construction to minimise soil movement at the site; • Roads should be provided with run-off structures; • Construction of access roads on steep inclines should be limited.
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 nearby CBA; • May affect the suitability of certain areas for inclusion in NPAES.	<u>**Avoid**</u> *<u>Planning and Construction</u>*: • Avoid CBAs as far as possible; • Avoid impact to restricted and specialised habitats such as cliffs, large rocky outcrops, quartz fields, pebble patches and rock sheets. <u>**Minimise**</u> *<u>Planning and Construction</u>*: • Minimise construction in ESAs as far as possible; • Minimise the development footprint as much as possible and rehabilitate cleared areas after construction; • Locate temporary-use areas such as construction camps and lay-down areas in previously disturbed areas as far as possible. <u>**Rehabilitate**</u> *<u>Operation</u>*: • Ensure that management of the EGI 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 (caused by blasting) to aquatic and terrestrial ecosystems, including soil-dwelling fauna; and • Loss of wilderness character; ecotourism opportunities and the potential of unspoilt conservation areas.	<u>**Avoid**</u> *<u>Planning and Construction</u>*: • Avoid CBAs as far as possible. <u>**Minimise**</u> *<u>Planning and Construction</u>*: • Minimise construction in ESAs as far as possible;

Key Impact	Description	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. **Rehabilitate** *Operation*: • Ensure that management of the EGI development occurs in a biodiversity-conscious manner in accordance with an Open Space Management Plan for the development.

10 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

10.1 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 EGI alignment to avoid locally sensitive features and populations of SCC. Should sections of the planned EGI 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 South African Council for Natural Scientific Professions (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 EGI 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 EGI 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.

10.2 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 EGI 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 or excavations 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 EGI route.

10.3 Operations phase

- If parts of the EGI such as substations 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 EGI 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 EGI 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 EGI.
- Ensure necessary precautions to prevent electric shock hazards by installing (i) barriers to prevent unauthorised climbing on transmission towers/pylons, and (ii) appropriate colour coding and warning signs on EGI facilities and structures.
- Regular alien clearing along the EGI route according to maintenance standards set by Eskom and as per the requirements of the Alien and Invasive Species Program 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 EGI servitude should be restricted to service and maintenance staff and affected landowners.

10.4 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.

- 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 functional type 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 plant species occurrence and erosion.

10.5 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 EGI 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 EGI. 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.
- Management of alien invasive species within the powerline corridor during operation requires chemical stump treatment and germination control.

11 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 power line route.

12 REFERENCES

Acocks, J. P. H. 1953. Veld types of South Africa. Memoirs of the Botanical Society of South Africa, 28:1–192.

Allsopp, N. 1999. Effects of grazing and cultivation on soil patterns and processes in Namaqualand. *Plant Ecology* 142:179–187.

Arcus. 2018. Bird Impact Assessment for the Kap Vley Wind Energy Facility and associated grid connection, Northern Cape Province. Impact Assessment Report.

Atkinson, D. 2007. People-centred environmental management and municipal commonage in the Nama Karoo. *Development of Southern Africa* Vol: 24, Issue 5: pp 707–724.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. and De Villiers, M.S. (Eds.). 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. Suricata Series No. 1. South African National Biodiversity Institute, Pretoria.

BirdLife South Africa (SA). 2015. Orange River Mouth Wetlands. Available at https://www.birdlife.org.za/

CapeNature. 2017. Western Cape Biodiversity Spatial Plan. Available at http://bgis.sanbi.org/.

Child M.F., Roxburgh L, Do Linh San E, Raimondo D, Davies-Mostert H.T. (Eds.). 2016. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Collins, N. 2017. National Biodiversity Assessment (NBA) 2018. Wetland Probability Map. Available at https://csir.maps.arcgis.com/apps/MapJournal/index.

Cowling, R.M. and Roux, P.W. 1987. The Karoo Biome: a preliminary synthesis. Part 2 – Vegetation and history. FRD, Pretoria.

Cowling, R.M. and Pierce, S.M. 1999. Namaqualand. A succulent desert. Fernwood Press, Cape Town.

Cowling, R.M. and Hilton-Taylor, C. 1999. Plant biogeography, endemism and diversity. Pp 42-56. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo, ecological patterns and processes. Cambridge University Press.

Cowling, R.M., Esler, K.J. and Rundel, P.W. 1999. Namaqualand, South Africa – an overview of a unique winter-rainfall desert ecosystem. *Plant Ecology* 142: 3–21.

Cramer, S. 2016. Uranium Mining Threatens the Karoo. Available at http://karoospace.co.za/uranium-mining-threatens-the-karoo/

Dean, W.R.J. and Milton, S.J. 2019. The dispersal and spread of invasive alien *Myrtillocactus geometrizans* in the southern Karoo, South Africa. *South African Journal of Botany* 121: 210–215.

Dean, W.R.J. and Milton, S.J. (Eds.) 1999. The Karoo: Ecological patterns and processes. Cambridge University Press, Cambridge.

Dean, W.R.J. and Milton, S.J. 1999. Animal foraging and food. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Dean, W.R.J., Seymour, C.L. and Joseph, G.S. 2018. Linear structures in the Karoo, South Africa, and their impacts on biota. *African Journal of Range and Forage Science* 35:3-4, pp223-232.

Department of Environmental Affairs (DEA). 2016a. Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. Report No: CSIR/02100/EMS/ER/2016/0006/B, CSIR, Stellenbosch. Prepared for the Department of Environmental Affairs (DEA), Pretoria.

Department of Environmental Affairs (DEA). 2016. National Protected Areas Expansion Strategy.

Department of Environmental Affairs (DEA). 2018. South African Protected Areas Database (SAPAD). Q2, 2018. Available at https://egis.environment.gov.za/.

Department of Environmental Affairs (DEA). 2019. Renewable Energy Data Release Schedule 2019 – 2020. Directorate: Enterprise Geospatial Information Management (EGIM), Department of Environmental Affairs (DEA), Pretoria. Available at https://egis.environment.gov.za/.

Desmet, P., Ellis, A. and Cowling, R. 1998. Speciation in the Mesembryanthemaceae. *Aloe* 35(2): 38-43.

Desmet, P.G. and Cowling, R.M. 1999. The climate of the Karoo, a functional approach. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Desmet, P.G. 2007. Namaqualand—A brief overview of the physical and floristic environment. *Journal of Arid Environments* 70: 570–587.

Driver, A., Desmet, P. G., Rouget, M., Cowling, R. M. and Maze, K. E. 2003. Succulent Karoo Ecosystem Plan Biodiversity Component Technical Report. Cape Town, Cape Conservation Unit, Botanical Society of South Africa.

Driver, A., Sink, K.J., Nel, J.L., Holness, S.H., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. and Maze, K. 2012. National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis report. South African National Biodiversity Institute & Department of Environmental Affairs, Pretoria.

Driver, A., Holness, S. and Daniels, F. 2017. Technical guidelines for CBA Maps: Guidelines for developing a map of Critical Biodiversity Areas & Ecological Support Areas using systematic biodiversity planning. First Edition (Beta Version), June 2017. South African National Biodiversity Institute, Pretoria.

Esler, K.J., Milton, S.J. and Dean, W.R. (Eds). 2006. Karoo veld ecology and management. Briza Publications, Pretoria.

Geoterraimage. 2015. South African National Land-Cover 2013-2014. Department of Environmental Affairs. Geospatial Data. Available at https://egis.environment.gov.za/.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V., and Brown, C.J. (Eds.). 1997. *The Atlas of Southern African Birds*. Johannesburg: BirdLife International.

Hawley, G., Desmet, P. and Berliner, D. 2017. Eastern Cape Biodiversity Conservation Plan Handbook. Draft version, December 2017. Eastern Cape Department of Economic Development, Environmental Affairs and Tourism, King Williams Town.

Hayes, A.Y. and Crane, W. 2008. Succulent Karoo Ecosystem Programme, Phase 2 (2009 – 2014). Consolidation and Securing Programme Sustainability. A Strategic Plan of Action for South Africa. Supported by the Critical Ecosystem Partnership Fund and South African National Biodiversity Institute. Pp 1-41.

Hoffmann, M.T. and Ashwell, A. 2001. Nature divided: land degradation in South Africa. University of Cape Town Press, Cape Town.

Hoffmann, M.T., Carrick, P.J., Gillson, L and West, A.G. 2009. Drought, climate change and vegetation response in the succulent Karoo, South Africa. *South African Journal of Science* 105: 54–60.

Hoffmann, M.T., Cousins, B., Meyer, T., Petersen, A. and Hendricks, H. 1999. Historical and contemporary land use and the desertification of the Karoo. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Hoffmann, M. T., Skowno, A., Bell, W., and Mashele, S. 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

Hoffmann, M. T., Todd, S., Ntshona, Z. and Turner, S. 2014. Land degradation in South Africa. Collection. University of Cape Town.

Holness, S. and Oosthuysen, E. 2016. Critical Biodiversity Areas of the Northern Cape: Technical Report. Northern Cape Department of Environment and Nature Conservation, Kimberley.

Holness, S., Driver, A., Todd, S., Snaddon, K., Hamer, M., Raimondo, D., Daniels, F., Alexander, G., Bazelet, C., Bills, R., Bragg, C., Branch, B., Bruyns, P., Chakona, A., Child, M., Clarke, R.V., Coetzer, A., Coetzer, W., Colville, J., Conradie, W., Dean, R., Eardley, C., Ebrahim, I., Edge, D., Gaynor, D., Gear, S., Herbert, D., Kgatla, M., Lamula, K., Leballo, G., Lyle, R., Malatji, N., Mansell, M., Mecenero, S., Midgley, J., Mlambo, M., Mtshali, H., Simaika, J., Skowno, A., Staude, H., Tolley, K., Underhill, L., van der Colff, D., van Noort, S. and von Staden, L. 2016. Biodiversity and Ecological Impacts: Landscape Processes, Ecosystems and Species. In Scholes, R., Lochner, P., Schreiner, G., Snyman-Van der Walt, L. and de Jager, M. (Eds.). 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/

Ihlenfeldt, H.D. 1994. Diversification in an arid world: The Mesembryanthemaceae. *Annual Review of Ecology and Systematics* 25:521-546.

International Union for the Conservation of Nature (IUCN). 2017. The IUCN Red List of Threatened Species. Available at http://www.iucnredlist.org/

Jacobs, K. and Jangle, R. 2008. Karoo Ecosystem Management Plan: Western Cape. Unpublished, The Nature Conservation Corporation, Cape Town.

Jonas, Z. 2004. Land use and its impacts on the Succulent Karoo. Master's Thesis. Department of Botany, Leslie Hill Institute for Plant Conservation, University of Cape Town, Rondebosch.

Jürgens, N. 1991. A new approach to the Namib region. I: Phytogeographic subdivision. *Vegetatio* 97: pp 21–38.

Jürgens, N. 2006. Desert Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 301–323.

Khavhagali, V.P. 2010. Importance, threats, status and conservation challenges of biodiversity in Northern Cape. *The Grassland Society of Southern Africa*. Vol 10 No. 4, pp 14–17.

Le Maitre, D.C., Forsyth, G.G., Dzikiti, S and Gush, M.B. 2016. Estimates of the impacts of invasive alien plants on water flows in South Africa. *Water SA* Vol. 42 No. 4, pp659–672.

Le Maitre, D., O'Farrell, P., Milton, S., Atkinson, D., De Lange, W., Egoh, B., Reyers, B., Colvin, C., Maherry, A., and Blignaut, J. 2009. Assessment and Evaluation of Ecosystem Services in the Succulent Karoo Biome. Report prepared by CSIR for the Succulent Karoo Ecosystem Programme (SKEP) Coordination Unit, SANBI.

Lloyd, J.W. 1999. Nama Karoo. In: J. Knobel (Ed). The magnificent natural heritage of South Africa. Sunbird Publishing, Cape Town, South Africa. Pp 84–93.

Lombard, A.T., Hilton-Taylor, C., Rebelo, A.G., Pressey, R.L. and Cowling, R.M. 1999. Reserve selection in the Succulent Karoo, South Africa: Coping with high compositional turnover. *Plant Ecology* 142(1-2): 35-55.

Lovegrove, B. 1993. The living deserts of southern Africa. Fernwood Press, Cape Town.

Low, A.B. and Rebelo A.G. 1996. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

McAuliffe, J.R., Hoffmann, M.T., McFadden, L.D., Jack, S. Bell, W. and King, M.P. 2019. Whether or not heuweltjies: Context-dependent ecosystem engineering by the southern harvester termite, *Microhodotermes viator*. *Journal of Arid Environments* (in press).

McAuliffe, J.R., Hoffmann, M.T., McFadden, L.D., Bell, W., Jack, S., King, M.P. and Nixon, V. 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.

Meadows, M. E. and Watkeys, M.K. 1999. Palaeoenvironments. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Mecenero S., Ball J.B., Edge D.A., Hamer M.L., Henning G.A., Krüger M., Pringle E.L., Terblanche R.F. and Williams M.C. (Eds). 2013. Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas. Saftronics, Johannesburg and Animal Demography Unit, University of Cape Town.

Milton, S. 2009. The basis for sustainable business in the Karoo: Bringing ecological and economic issues together. Paper presentation. Karoo Development Conference and Expo, Graaff-Reinet, Eastern Cape.

Milton, S.J. and Dean, W.R.J. 2012. Mining in the Karoo – Environmental Risks and Impacts. Paper presentation at the Karoo Development Conference, Beaufort West.

Milton, S. J., Zimmermann, H. G. and Hoffmann, J. H. 1999. Alien plant invaders of the Karoo: attributes, impacts and control. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Milton, S.J., Yeaton, R., Dean, W.R.J. and Vlok, J.H.J. 1997. Succulent Karoo. In: Cowling, R.M., Richardson, D.M. and Pierce, S.M. (Eds.). Vegetation of southern Africa. Cambridge University Press, Cambridge.

Minter, L.R. 2004. Atlas and red data book of the frogs of South Africa, Lesotho, and Swaziland. Animal Demography Unit, University of Cape Town.

Mucina, L., Rutherford, M.C., Palmer, A.R., Milton, S.J., Scott, L., Lloyd, J.W., Van der Merwe, B., Vlok, J.H.J., Euston-Brown, D.I.W., Powrie, L.W. and Dold, A.P. 2006a. Nama Karoo Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 221–299.

Mucina, L., Jürgens, N., Le Roux, A., Rutherford, M.C., Schmiedel, U., Esler, K., Powrie, L.W., Desmet, P.G. and Milton, S.J. 2006b. Succulent Karoo Biome. In: Mucina, L. and Rutherford, M.C. (Eds.). The Vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19, South African National Biodiversity Institute, Pretoria, pp. 221–299.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 24: 403 (6772): pp853-858.

Ndhlovu, T., Milton, S. and Esler, K.J. 2015. Effect of *Prosopis* (mesquite) invasion and clearing on vegetation cover in semi-arid Nama-Karoo rangeland, South Africa. *African Journal of Range and Forage Science*, Vol. 33:1 pp 11-19.

Ndhlovu, T., Milton-Dean, S.J. and Esler, K.J. 2011. Impact of *Prosopis* (mesquite) invasion and clearing on the grazing capacity of semiarid Nama Karoo rangeland, South Africa. *African Journal of Range and Forage Science,* Vol. 28:3 pp 129–137.

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.

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 (NFEPA) project. Pretoria: Water Research Commission, WRC Report No. K5/1801.

Noroozi, J., Talebi, A., Doostmohammadi, M., Rumpf, S.B., Linder, H.P. and Schneeweiss, G.M. 2018. Hotspots within a global biodiversity hotspot - areas of endemism are associated with high mountain ranges. Scientific Report. Nature 8:10345, pp 1–10.

Northern Cape Department of Environment and Nature Conservation (DENC). 2016. Critical Biodiversity Areas of the Northern Cape. Available at http://bgis.sanbi.org/.

Palmer, A.R. and Hoffmann, M.T. 1997. Nama-Karoo. In: Cowling, R.M., Richardson, D.M. and Pierce, S.M. (Eds.). Vegetation of southern Africa. Pp 167-188. Cambridge University Press, Cambridge.

Pool-Stanvliet, R., Duffell-Canham, A., Pence, G. and Smart, R. 2017. Western Cape Biodiversity Spatial Plan Handbook 2017. CapeNature and Department of Environmental Affairs and Development Planning, Western Cape Government, Cape Town.

Rahlao, S.J., Milton, S.J., Esler, K.J., Van Wilgen, B.W. and Barnard, P. 2009. Effects of invasion of fire-free arid shrublands by a fire-promoting invasive alien grass (*Pennisetum setaceum*) in South Africa. *Austral Ecology* 34: pp920–928.

Raimondo, D., Von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. and Manyama, P.A. (Eds.). 2009 (as updated in 2018). Red lists of South African plants 2009. Strelitzia 25. SANBI, Pretoria.

RAMSAR Sites Information Services. Available at www.ramsar.wetlands.org

Rebelo, A. G. 1997. Conservation. In: Cowling, R.M., Richardson, D.M. and Pierce, S.M. (Eds.). Vegetation of southern Africa. Cambridge University Press, Cambridge.

Rundel, P.W. and Cowling, R.M. 2013. Biodiversity of the Succulent Karoo. In: Levin, S.A. (Eds.) Encyclopedia of Biodiversity, Second Edition. Volume 1, pp. 485-490. Waltham, MA: Academic Press.

Rundel, P.W., Cowling, R.M., Esler, K.J., Mustart, P.J., van Jaarsveld, E. and Bezuidenhout, H. 1995. Winter growth phenology and leaf orientation in *Pachypodium namaquanum* (Apocynaceae) in the Succulent Karoo of the Richtersveld, South Africa. *Oecologia* 101: 472 – 477.

Rutherford, M.C. and Westfall, R.H. 1994. Biomes of southern Africa: An objective categorization. Memoirs of the Botanical Survey of South Africa. 63. 2nd edition. National Biodiversity Institute, Pretoria.

Rutherford, M.C. 1997. Categorization of biomes. In: Cowling, R.M., Richardson, D.M. and Pierce, S.M. (Eds.). Vegetation of southern Africa. Pp 91–98. Cambridge University Press, Cambridge.

Rutherford, M.C., Midgley, G.F., Bond, W.J., Powrie, L.W., Roberts, R. and Allsopp, J. 2000. Plant biodiversity In: Kiker, G. Climate change impacts in southern Africa. Report to the National Climate Change Committee, Department of Environment Affairs and Tourism, Pretoria.

Rutherford, M.C., Powrie, L.M. and Schultze, R.E. 1999. Climate change in conservation areas of South Africa and its potential impact on floristic composition: a first assessment. *Diversity and Distributions* 5: 253–262.

Skowno, A., Todd, S., Snaddon, K. and Ewart-Smith, J. 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

Smith, A.B. 1999. Hunters and herders in the Karoo landscape. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

South African Government Gazette. 2011. National Environmental Management: Biodiversity Act: National list of ecosystems that are threatened and in need of protection. Government Gazette, 558(34809): 1 – 544, December 9.

South African National Biodiversity Institute (SANBI). 2006 – 2018. The Vegetation Map of South Africa, Lesotho and Swaziland, Mucina, L., Rutherford, M.C. and Powrie, L.W. (Eds.), Online, http://bgis.sanbi.org/Projects/Detail/186, Version 2018.

South African National Biodiversity Institute (SANBI). 2009. National Protected Area Expansion Strategy Resource Document. South African National Biodiversity Institute, Department of Environmental Affairs, Pretoria.

South African National Biodiversity Institute (SANBI). 2011. National List of Threatened Ecosystems. Available at http://bgis.sanbi.org/.

South African National Biodiversity Institute (SANBI). 2012 (as updated in 2018). Vegetation Map of South Africa, Lesotho and Swaziland. Available at http://bgis.sanbi.org/.

South African National Biodiversity Institute (SANBI). 2017. Statistics: Red List of South African Plants Version 2017.1.

Southern Africa's Ramsar Sites (SARS). 2016. Orange River Mouth. Available at http://www.saramsar.com/

Stankey, G.H., Cole, D.N., Lucas, R.C., Peterson, M.E. and Frissell, S.S. 1985. The limits of acceptable change (LAC) system for wilderness planning. Washington, DC: U.S. Department of Agriculture.

Succulent Karoo Ecosystem Programme (SKEP). 2008. Rapid Appraisal Report. A discussion paper in preparation for strategic planning 2009 – 2014. SANBI, Kirstenbosch, Cape Town.

Taylor M. R. and Peacock, F. 2018. State of South Africa's Bird Report 2018. Johannesburg: BirdLife South Africa.

Todd, S.W., Hoffmann, M.T., Henschel, J.R., Cardoso, A.W., Brooks, M. and Underhill, L.G. 2016. The Potential Impacts of Fracking on Biodiversity of the Karoo Basin, South Africa. In: Glazwewski, J. and Esterhuyse, S. (Eds.). Hydraulic Fracturing in the Karoo: Critical Legal and Environmental Perspectives. First edition. Juta Press. Pp 278–301.

University of Cape Town (UCT). 1997. The Southern African Bird Atlas 1 (SABAP1). Animal Demography Unit, University of Cape Town.

University of Cape Town (UCT). 2007 - Present. The Southern African Bird Atlas 2 (SABAP2). Animal Demography Unit, University of Cape Town.

University of Cape Town (UCT). 2018a. MammalMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT). 2018d. FrogMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT).2018b. ReptileMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

University of Cape Town (UCT).2018c. ScorpionMap Database. Animal Demography Unit. Available at http://vmus.adu.org.za/

Van Jaarsveld, E. 1987. The succulent riches of South Africa and Namibia. *Aloe* 24:45-92.

Van Wilgen, B.W., Reyers, B., Le Maitre, D.C., Richardson, D.M. and Schonegevel, L. 2008. A biome-scale assessment of the impact of invasive alien plants on ecosystem services in South Africa. *Journal of Environmental Management* 89: pp336 –349.

Van Wyk, A.E. and Smith, G.F. 2001. Regions of floristic endemism in southern Africa. A review with emphasis on succulents. Umdaus Press, Hatfield.

Vernon, C.J. 1999. Biogeography, endemism and diversity of animals in the Karoo. In: Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Vlok, J.H.J., Euston-Brown, D. I. W. and Cowling, R. M. 2003. Acocks Valley Bushveld 50 years on: New perspectives on the delimitation, characterisation and origin of thicket vegetation. *South African Journal of Botany* 69: 27-51.

Walker, C., Milton, S.J., O'Connor, T.G., Maguire, J.M. and Dean, W.R.J. 2018. Drivers and trajectories of social and ecological change in the Karoo, South Africa. *African Journal of Range and Forage Science* 35:3-4, pp157-177.

Watkeys, M.K. 1999. Soils of the arid south-western zone of Africa. Dean, W.R.J. and Milton, S.J. (Eds.). The Karoo: Ecological Patterns and Processes. Cambridge University Press, Cambridge.

Williamson, G. 2010. Richtersveld – The Enchanted Wilderness. 2nd Ed. Umdaus Press, Hatfield. ISBN 978-919766-47-8, pp1–260.

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 - EGI Expansion					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**	**Specialist Response**
SJ Milton	**General comments**			I fully agree with the recommendations made in this management report. Where possible the EGI should be shifted to damaged areas of the coast or to the western extreme of the defined corridor. The report is logically and clearly presented; all statements and recommendations are adequately justified and appropriately referenced. My few comments below relate to writing style or need for additional detail.	Noted.
SJ Milton	5	33		with limited mobility and those which have narrow distributions add "those which"	Noted and updated.
SJ Milton	6	19		avoid double negative after "not" Change "neither" to either , and "nor" to or	Noted and updated.
SJ Milton	19	18		I suggest you name the two Nama Karoo vegetation types here.	Noted and updated.
SJ Milton	29		Fig 6	Pity about the colour palette used as the diversity of vegetation types in the study areas does not show up clearly	Noted. Map has been updated with a clearer colour palette.
SJ Milton	31	18		Probably need to point out that many endemics have very limited spatial ranges so are vulnerable to extinction through localised habitat damage.	Noted and updated.
SJ Milton	32		Caption Table 5	contained (not comprised)	Noted and updated.
SJ Milton	48	21		typified by (not of)	Noted and updated.
SJ Milton	53			Rehabilitate: Rehabilitate using locally indigenous plant species. Where feasible translocate savage plants. Where not feasible use a seed mix that includes both annuals and perennials.	Noted and updated.
SJ Milton	53			Rehabilitate: I tried to find out more about what you intend here and found this definition "The principles of landscape design are guidelines, or tools, that designers use to create attractive, pleasing and comfortable landscapes. The landscape design principles are proportion, order, repetition and unity". Given that most texts on landscape design seem to deal with gardening, would you please expand on these guidelines.	Noted and updated.

EXPERT REVIEW AND SPECIALIST RESPONSES: Karoo - EGI Expansion					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**	**Specialist Response**
SJ Milton	54			Not quite sure whether the concern is that something is ingesting the wildlife or the wildlife are ingesting something. Perhaps you mean "Possible ensnarement of animals or ingestion of waste due to materials such as cables and plastic left on site"	Noted and updated.
SJ Milton	56			Remove alien invasive plants and do what with the alien plants removed?	Noted and updated.

Strategic Environmental Assessment for the Expansion
of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.5

Biodiversity and Ecological Impacts (Aquatic Ecosystems and Species) - Estuaries

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

ESTUARIES

Integrating Author/s	Lara van Niekerk [1]
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ABBREVIATIONS AND ACRONYMS

CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
EFZ	Estuary Functional Zone
EGI	Electricity Grid Infrastructure
EIA	Environmental Impact Assessment
HDD	Horizontal Directional Drilling
IAP	Invasive Alien Plant
ICM	Integrated Coastal Management Act
KZN	KwaZulu-Natal
MAR	Mean Annual Runoff
MPA	Marine Protected Area
NEMA	National Environmental Management Act
NPAES	National Protected Areas Expansion Strategy
ROW	Right-of-way
SEA	Strategic Environmental Assessment
TDS	Total Dissolved Solids
ToPs	Threatened or Protected species
TSS	Total Suspended Solids
WUL	Water Use License

1 SUMMARY

This assessment aims, at a strategic level, to identify the potential impacts on estuaries of constructing and maintaining Electricity Grid Infrastructure (EGI) in two pre-identified routing corridors on the west and east coasts of South Africa.

Estuaries are highly productive and highly dynamic environments that require undisturbed “accommodation space” so that sedimentary processes can allow natural resetting of systems after floods and new channel configurations can establish. Estuaries support highly sensitive habitats and species of special concern. They play an important nursery function for estuarine and marine fish and crustaceans, which have economic value in subsistence, recreational and commercial fisheries in South Africa.

Key potential impacts of EGI development and operation to estuaries include:

- Alteration and destruction of estuarine habitat caused by infrastructure development, access roads and vegetation clearing;
- Altered estuarine physical and sediment dynamics caused by construction activities and infrastructure placement; e.g. infilling, altered channel migration, and increased mouth closure;
- Deterioration of water quality associated with the disturbance of sediment;
- Loss of connectivity and habitat fragmentation within estuaries and between estuaries, their upstream and freshwater catchments and downstream marine environments with associated ecological impacts.

These impacts are best avoided and mitigated at the design phase of EGI development. This can be achieved through the avoidance of placement of infrastructure, access roads and servitudes in Estuary Functional Zones (EFZs). These are areas of very high sensitivity. This report identifies and maps these areas. Additionally, coastal freshwater habitats in proximity to estuaries are identified as supporting habitat for estuaries. Impacts to these habitats have the potential to result in impacts to downstream estuaries, and they are consequently identified, within a 5 km buffer zone around EFZs, as areas of high sensitivity. Ideally these areas should also be avoided in the design phase and routing planned to avoid them. If unavoidable, mitigation measures must be undertaken to prevent damage to estuarine systems downstream.

2 INTRODUCTION

In January 2014 the Department of Environmental Affairs (DEA), mandated by Ministers and Members of the Executive Council (MinMec), commissioned the Council for Scientific and Industrial Research (CSIR) to undertake a Strategic Environmental Assessment (SEA) linked to SIP 10: Electricity Transmission and Distribution for all. This SEA (i.e. National DEA Electricity Grid Infrastructure (EGI) SEA) was aimed primarily at establishing routing corridors to enable the efficient and effective expansion of key strategic transmission infrastructure designed to satisfy national transmission requirements up to the 2040 planning horizon. The final EGI corridors, as an output of the 2016 EGI SEA, were gazetted in February 2018.

The current SEA commissioned by the DEA in 2017 considers the expansion of two of the corridors assessed in the 2016 SEA, specifically the Eastern and Western corridors (Figure 1).

Construction of EGI including transmission lines, interconnections, substations and road networks, have both positive and negative impacts at varying scales and at different stages of the power supply chain life cycle from extraction of fuels to construction and operational phases (Von Hippel and Williams, 2003). Evaluating potential impacts for the entire supply chain of EGI is important for optimising EGI interconnection opportunities and routing. Typically the environmental considerations of EGI development have received less emphasis than economic, technical and political issues, especially in developing regions, highlighting the importance of considering environmental impacts at an early stage (e.g. through conducting SEA’s) and identifying potential problems (e.g. routing of transmission lines through sensitive ecosystems, difficult terrain) (Von Hippel and Williams, 2003).

While a variety of environmental issues have been identified with the full life cycle of EGI, those related to impacts on estuarine ecosystems are the focus of this study.

3 SCOPE OF THIS STRATEGIC ISSUE UNDER EGI DEVELOPMENT

The primary objective of this study is to provide an assessment of estuarine ecosystems and associated biodiversity within the pre-identified expanded EGI corridors (Figure 1). The assessment will inform the SEA through identification of constraints (e.g. sensitive aquatic ecosystems, and critical areas for aquatic fauna and flora) and opportunities for the EGI development.

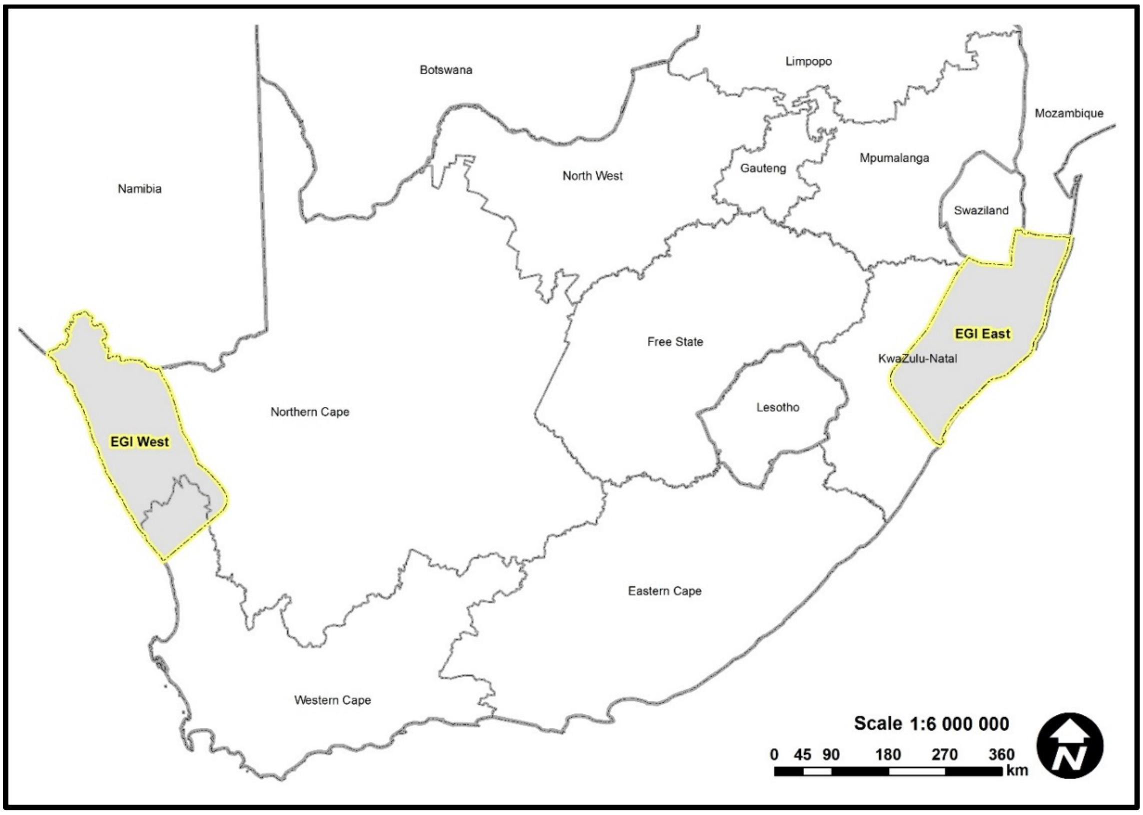

Figure 1: Overview of the proposed Expanded EGI corridors (East and West).

Potential impacts will result from the construction of the pylons, access and service roads, and maintenance of required servitudes in the Estuary Functional Zone (EFZ). During construction each pylon needed to support overhead powerlines can cause disturbance of an area of up to 1 ha. This area is needed in order to excavate and fill the foundations for each pylon, and for the assembly and raising of the pylon on-site. For each 100 km of 765 kV powerline this equates to disturbance and impact on an area of approximately 166 ha.

Vegetation clearing is needed for access during construction as well as for maintenance of a powerline. Initial access roads during construction are typically about 4 m wide, but this can reduce to simple two-tracks during the operation phase. Initial direct disturbance footprints of such roads are therefore approximately 40 ha per 100 km of powerline, but disturbance of wider areas and adjacent habitats can be expected over steep or uneven terrain due to the cut and fill that is usually required in order to make the site accessible for heavy vehicles. The powerline servitude needs to be maintained throughout the operational life of the powerline. Distance requirements for vegetation clearance in these servitudes depend on the nominal voltage of powerline (Table 1).

Table 1: Maximum servitude clearance distances (DEA, 2016).

Nominal Voltage	Maximum Vegetation Clearance
11 kV	4 m on either side of the centre line
22 kV	4 m on either side of the centre line
88 kV	5 m on either side of the centre line
132 kV	8 m on either side of the centre line
220 to 765 kV	From centre line to 10 m on either side of the outer conductors
533 kV DC	8 m either side of the centre line

Vegetation clearance involves the continuous trimming of vegetation where it is likely to encroach on the minimum vegetation clearance distance or where the vegetation will encroach on this distance before the next scheduled clearance. Minimum vegetation clearance distances are set by South African National Standards 10280 (safety regulations for overhead powerlines set in Table 2 below).

Table 2: Minimum vegetation clearance distances (DEA, 2016).

System nominal root mean square (r.m.s) voltage (kV)	Minimum Vertical Clearances (m)	Minimum Horizontal Clearances (m)
>1 up to and including 44	3	3
66	3.2	3
88	3.4	3
132	3.8	3
220	4.4	3
275	4.9	3
400	5.6	3.2
765	8.5	5.5

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.

4 APPROACH AND METHODOLOGY

The approach adopted to assess risks associated with EGI on estuaries relied on available databases and information sources. Estuarine sensitivities were identified based on this information and expert judgment. Spatial analysis was used to develop sensitivity maps and these formed the basis for assessment of potential impacts and identification of mitigation requirements and monitoring plans.

4.1 Key links with other assessments

This specialist assessment focused exclusively on the direct impact of the EGI on estuarine abiotic processes and biotic responses within the 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 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 waterbody but also all the habitats that support physical and biological processes that characterise an estuarine system. 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.1.6 of the EGI Expansion SEA Report (De Winnaar & Ross-Gillespie, 2018) to ensure that estuarine function and ecological integrity was not impacted by upstream development and infrastructure. **In this report inflowing coastal rivers just above an estuary and/or coastal wetlands and seeps adjacent to estuaries were collectively referred to as supporting coastal freshwater ecosystems.** The connectivity and dependencies of estuaries on these linked coastal freshwater systems is well recognised by estuarine scientists.

This report does not focus on estuarine birds as these were assessed in a standalone Avifauna specialist study (refer to Froneman & van Rooyen (2018) (Appendix C.1.7 of the EGI Expansion SEA Report).

4.2 Data sources

For this specialist study information on relevant estuaries within the proposed Expanded EGI corridors was obtained from available data sources. No additional field studies were undertaken. The data and information 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.
- 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, e.g. updated results from the National Estuary Botanical Database, Nelson Mandela University.

Key environmental attributes that were identified, and data sourced for this study included the demarcation of the EFZ, 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/operations were sourced from international literature, as well as expert judgement.

4.3 Assumptions and limitations

The following assumptions and limitation apply to this estuarine assessment:

- This assessment considered only impacts associated with the construction of the pylons, access/service roads and the maintenance the servitudes. Each pylon will require an area of up to 1 ha, that will be disturbed during construction. While vegetation clearing is needed for access and construction purposes, the maximum width to be cleared within the servitude varies between 4 and 30 m.
- 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 during the construction and operational phases.
- This assessment provides a broad-scale sensitivity rating for estuaries across 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.

- This assessment makes use of available secondary information, no fieldwork was undertaken and no additional raw data were collected and/or processed.
- All estuaries are important bird areas; however birds were not assessed in this estuarine study as they were dealt with in a separate Avifauna Assessment (refer to Froneman & Van der Merwe (2018) - Separate Annexure of the SEA Report for further details (Appendix C.1.7 of the EGI Expansion SEA Report).
- While not considered here explicitly, estuarine connectivity with inflowing rivers is of crucial importance. It is assumed that the Freshwater Assessment (De Winnaar & Ross-Gillespie, 2018 - Separate Annexure of the SEA Report for further details (Appendix C.1.6 of the EGI Expansion SEA Report) will deal with this aspect.

4.4 Relevant key legislation applicable to estuarine protection and use

Numerous pieces of legislation, policies and guidelines are applicable to the protection of estuarine aquatic ecosystems (Table 3). Critical aspects of these are the Recommended Ecological Categories as defined by the National Water Act (Act 36 of 1998, as amended) and set as desired states as part of the National Estuaries Biodiversity Plan (Turpie et al., 2012). In addition detailed Resource Quality Objectives for physical process, water quality, habitat and higher biota are set under the National Water Act (Act 36 of 1998, as amended). These provide the benchmark conditions which need to be maintained or restored in estuaries.

Table 3: Relevant key legislation applicable to the protection and use of estuaries.

Legislation	Specifications
National Environmental Management Act (Act 107 of 1998, as amended) and the associated Environmental Impact Assessment (EIA) Regulations of 2014 (as amended)	NEMA sets out the fundamental principles that apply to environmental decision making, some of which derive from international environmental law and others from the constitution. 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.” Of particular relevance to this assessment is Chapter 1(4r), which states that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. GNR 324, Listing Notice 3, of the NEMA EIA Regulations (2014, as amended in April 2017) identifies the EFZ as a sensitive area.
National Water Act (Act 36, 1998)	Preliminary Reserve Determination and Classification. Set desired state (“management class”) and measurable targets for water flow (“Reserve”), and water quality, habitat and biota in estuaries (“Resource Quality Objectives”) (these are set specifically for each estuary).
National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004) and National Protected Areas Expansion Strategy (NPAES)	Sets biodiversity targets for South Africa that need to be translated into site-specific targets for study area based on detailed quantitative assessments. These targets are articulated in the National Protected Areas Expansion Strategy (NPAES) (updated draft available from DEA). South Africa’s protected area network currently falls far short of sustaining biodiversity and ecological processes. The goal of the NPAES is to achieve cost-effective protected area expansion for ecological sustainability and increased resilience to climate change. It sets targets for protected area expansion, provides maps of the most important areas for protected area expansion, and makes recommendations on mechanisms for protected area expansion – this is relevant to estuaries included in the strategy. The National Estuarine Biodiversity Plan (Turpie et al., 2012) determined the core set of estuaries in need of formal protection to achieve biodiversity targets
Marine Living Resources Act (Act 18 of 1998)	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

Legislation	Specifications
	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 Environmental Management: Integrated Coastal Management Act (Act 24 of 2008, as amended) (ICM Act)	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 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 Environmental Management: Protected Areas Act (No. 57 of 2003	To provide, within the framework of national legislation, including the National Environmental Management Act, for the declaration and management of protected areas; to provide for co-operative governance in the declaration and management of protected areas; to effect a national system of protected areas in South Africa as part of a strategy to manage and conserve its biodiversity; to provide for a representative network of protected areas on state land, private land and communal land; to promote sustainable utilisation of protected areas for the benefit of people, in a manner that would preserve the ecological character of such areas; and to promote participation of local communities in the management of protected areas, where appropriate. This is relevant to estuaries in protected areas.
National Ports Act (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 housing ports.
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. South Africa is a signatory to the Ramsar Convention and is thus obliged to promote the conservation of listed wetlands and the 'wise management' of all others.
IUCN Red List of threatened species	Provides the most comprehensive inventory of the global conservation status of plant and animal species. Uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. The criteria used are relevant to all species and all regions of the world.
The Convention on Biological Diversity (1992)	Focused on the conservation of biological diversity, the sustainable use of its components, the fair and equitable sharing of the benefits from the use of genetic resources
Conservation of Agricultural Resources Act (CARA, Act 43 of 1983)	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).

4.5 Permit requirements

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

- Where necessary, a water use licence (WUL) process will be required to authorise certain activities as per Section 21 of the National Water Act (Act no. 36 of 1998) based on the Department of Water and Sanitation (DWS) assessment requirements for all wetlands that occur within 500 metres of the EGI development.

- Permits 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 of specific chemicals in marine waters and sediments to protect ecosystems.
- Permits likely to be required for any activities that may affect listed Endangered and/or Vulnerable species, Threatened or Protected species (ToPs), and/or regionally protected fauna and flora.

5 KEY ATTRIBUTES OF THE PROPOSED EXPANDED EGI CORRIDORS

5.1 Background

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) (Figure 2). Proactive planning and effective management of estuaries requires an understanding of changing estuarine patterns, processes and responses to global change pressures (i.e. those that arise directly from anthropogenic activities and climate change). As human population pressures escalate, the need for strategic management becomes increasingly evident (Boehm et al., 2017; Borja et al., 2017). Reactively protecting these ecosystems 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.

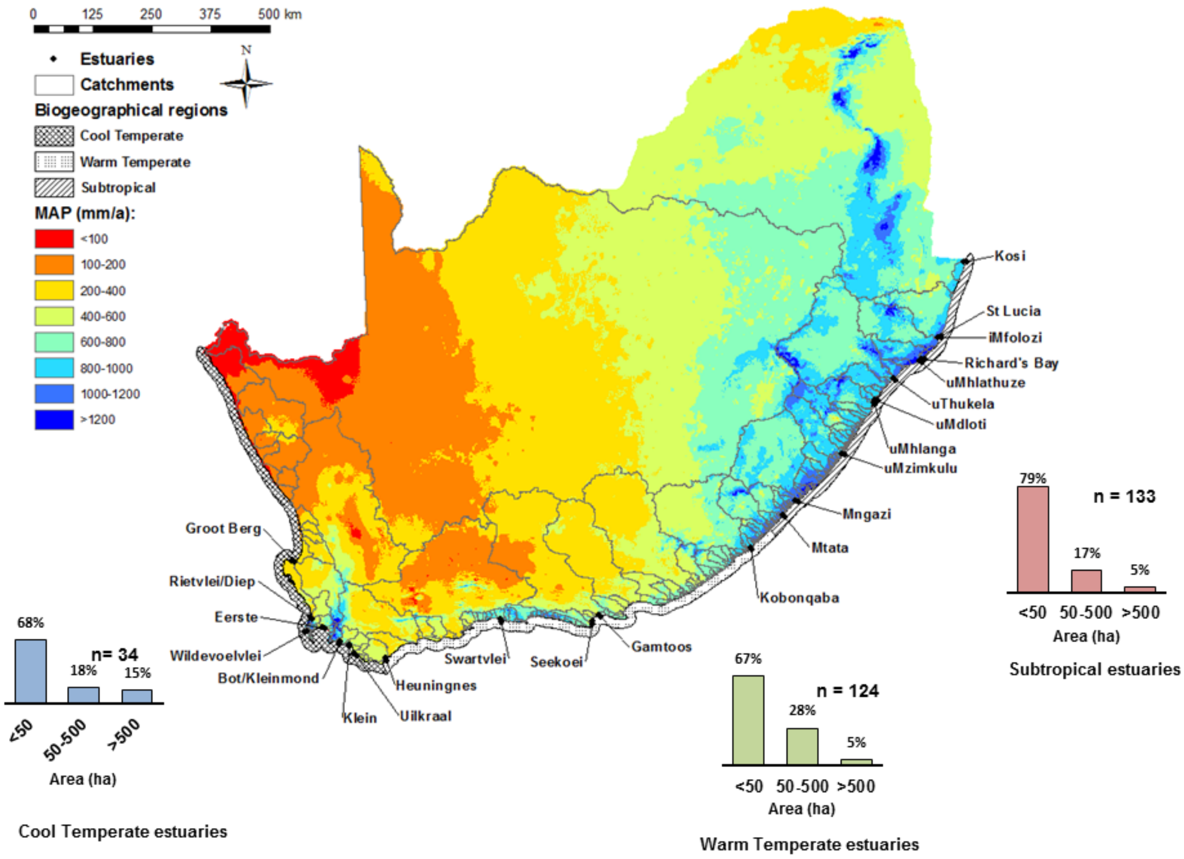

Figure 2: Map showing the three biogeographical regions, relative catchment size, mean annual precipitation (MAP) (in mm/a) and estuary size distribution (in ha) for South Africa (Van Niekerk et al. 2013).

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 2). 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 (in terms of health and functionality) by an expert panel (Van Niekerk and Turpie, 2012).

5.2 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 3). 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 powerlines and associated infrastructure 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.

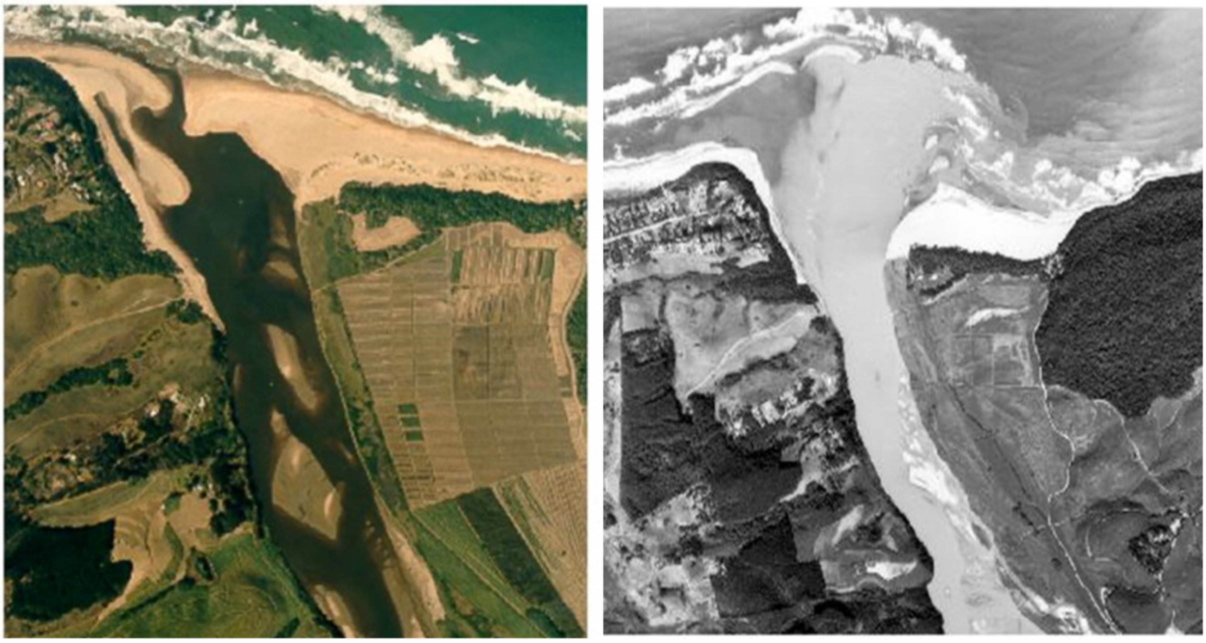

Figure 3: Thukela Estuary under low flow conditions with a stable channel meandering between sand banks (left) and the Thukela Estuary under resetting flood conditions with high volumes of sediment being eroded from the system (right).

5.3 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.

5.4 Species of special concern

5.4.1 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 4). 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 4 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.

5.4.2 Fish

The IUCN Red List of Threatened Species includes many fish that occur in estuaries in South Africa (IUCN, 2018). Table 5 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 5 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; 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 (IUCN, 2018). All estuaries in the corridors function as habitats and nurseries for Critically Endangered or Endangered fish species of high recreational or conservation importance.

5.4.3 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 Estuary Specialist Assessment (i.e. this report) and the Freshwater Specialist Assessment included in Appendix C.1.6 of the EGI Expansion SEA Report (De Winnaar and 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 4: 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 5: 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).

Scientific name	Common name	Red List status	Distribution (proposed Expanded EGI Corridor)
Syngnathus watermeyeri	Estuarine Pipefish	CR	East
Lithognathus lithognathus	White Steenbras	EN	West, East
Argyrosomus japonicus	Dusky Kob	EN**	East
Anguilla bicolor	Shortfin Eel	NT	East
Oreochromis mossambicus	Mozambique Tilapia	NT	West, East
Epinephelus malabaricus	Malabar Rockcod	NT	East
Pomatomus saltatrix	Elf	VU	West, East
Acanthopagrus vagus	Estuarine Bream	VU	East
Rhabdosargus globiceps	White Stumpnose	VU	West, East
Taenioides jacksoni	Bearded Goby	*LR/nt	East
Albula oligolepis	Smallscale Bonefish	DD	East
Hypseleotris cyprinoides	Golden Sleeper	DD	East
Oligolepis acutipennis	Sharptail Goby	DD	East
Megalops cyprinoides	Indo-Pacific Tarpon	DD	East
Liza dumerili	Groovy Mullet	DD	East
Microphis fluviatilis	Freshwater Pipefish	DD	East
Ambassis natalensis	Slender Glassy	LC	East
Anguilla marmorata	Marbled Eel	LC	East
Anguilla mossambica	African Longfin Eel	LC	East
Ablennes hians	Flat Needlefish	LC	East
Caranx ignobilis	Giant Trevally	LC	East
Caranx papuensis	Brassy Trevally	LC	East
Lichia amia	Garrick	LC	West, East
Scomberoides commersonnianus	Talang Queenfish	LC	East
Scomberoides lysan	Doublespotted Queenfish	LC	East
Chanos chanos	Milkfish	LC	East
Eleotris fusca	Dusky Sleeper	LC	East
Eleotris mauritiana	Widehead Sleeper	LC	East
Eleotris melanosoma	Broadhead Sleeper	LC	East
Elops machnata	Springer	LC	East
Stolephorus holodon	Natal Anchovy	LC	East
Stolephorus indicus	Indian Anchovy	LC	East
Thryssa setirostris	Longjaw Thryssa	LC	East
Gerres filamentosus	Threadfin Pursemouth	LC	East
Gerres longirostris	Smallscale Pursemouth	LC	East
Gerres oyena	Longtail Pursemouth	LC	East
Awaous aeneofuscus	Freshwater Goby	LC	East
Croilia mossambica	Burrowing Goby	LC	East
Favonigobius reichei	Tropical Sand Goby	LC	East
Glossogobius callidus	River Goby	LC	East
Glossogobius giuris	Tank Goby	LC	East
Oxyurichthys keiensis	Kei Goby	LC	East
Paratrypauchen microcephalus	Blind Goby	LC	East
Psammogobius biocellatus	Sleepy Goby	LC	East
Redigobius bikolanus	Bigmouth Goby	LC	East
Redigobius dewaali	Checked Goby	LC	East
Stenogobius kenyae	Kenyan River Goby	LC	East

Scientific name	Common name	Red List status	Distribution (proposed Expanded EGI Corridor)
Yongeichthys nebulosus	Shadow Goby	LC	East
Lobotes surinamensis	Tripletail	LC	East
Lutjanus argentimaculatus	River Snapper	LC	East
Monodactylus argenteus	Natal Moony	LC	East
Monodactylus falciformis	Cape Moony	LC	East
Chelon melinopterus	Giantscale Mullet	LC	East
Crenimugil crenilabis	Fringerlip Mullet	LC	East
Mugil cephalus	Flathead Mullet	LC	East
Myxus capensis	Freshwater Mullet	LC	East
Planiliza alata	Diamondscale Mullet	LC	East
Planiliza macrolepis	Largescale Mullet	LC	East
Valamugil buchanani	Bluetail Mullet	LC	East
Valamugil robustus	Robust Mullet	LC	East
Ophisurus serpens	Sand Snake-eel	LC	East
Sillago sihama	Silver Sillago	LC	East
Acanthopagrus berda	Black Bream	LC	East
Crenidens crenidens	Karenteen Seabream	LC	East
Diplodus capensis	Blacktail	LC	West, East
Rhabdosargus holubi	Cape Stumpnose	LC	West, East
Rhabdosargus sarba	Natal Stumpnose	LC	East
Rhabdosargus thorpei	Bigeye Stumpnose	LC	East
Hippichthys cyanospilos	Bluespeckled Pipefish	LC	East
Hippichthys heptagonus	Reticulated Pipefish	LC	East
Hippichthys spicifer	Bellybarred Pipefish	LC	East
Microphis brachyurus	Opossum Pipefish	LC	East
Amblyrhynchotes honckenii	Evileye Pufferfish	LC	East
Arothron immaculatus	Immaculate Pufferfish	LC	East
Chelonodon laticeps	Bluespotted Pufferfish	LC	East

5.5 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 benthic densities 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. Linear coastal infrastructure development (ribbon development) such as that potentially associated with the EGI development under consideration here holds regional scale risks for estuarine ecosystems.

Artificial breaching especially has emerged as a management dilemma in recent years, where conflict arises because of emergency breaching applications (or illegal breachings) to protect poorly planned development which are located within the EFZ and to close to estuarine back-flood levels. Back-flooding in estuaries is a predictable, natural (and necessary) system process. Premature artificial breaching should therefore not been seen as a solution for poorly planned infrastructure development as it has significant consequences for estuarine ecology. It results in shifts in seasonal connectivity patterns with the marine environment, reduced access to important biological (nursery and feeding) habitats, reduced productivity, increased susceptibility to alien species invasions and a decline in nursery function. Artificial breaching is a listed activity as it requires the removal of more than 5 m^3 of sand from a breach and therefore requires provincial and in some cases national government approval. Authorities are increasingly taking a strong stance against this practise as demonstrated by in recent court judgements in the case of the Klein Estuary and St Lucia/Mfolozi.

5.6 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 expanded EGI corridors under consideration here. Estuarine resources in these areas are described below and important ecological and socio-economic attributes of estuaries within each corridor are summarised in Appendix A, Table A.1.

5.6.1 Expanded Western EGI Corridor

In total seven estuaries fall within the Expanded Western EGI corridor. These have a combined estuarine habitat area of 5 300 ha (Figure 4). They include the Orange, Spoeg, Groen, Sout, Buffels, Swartlintjies and Olifants Estuaries. The Spoeg, Groen, Buffels and Swartlintjies are all small systems that extend less than 5 km into the proposed EGI corridor (Fielding, 2017). The remaining systems are longer and extend significant distances into the proposed EGI corridor (Olifants <20 km, Orange <10 km and Sout <10 km).

Three estuaries in this corridor (Swartlintjies, Spoeg and Groen) are in excellent or good condition (i.e. Categories A to B according to health status on the DWS scale, whereby “A” is near natural and “F” being extremely degraded) (Draft NBA, 2018). These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily (Fielding et al., 2017).

Of the seven estuaries in this corridor, the Orange and Olifants estuaries are of Very High biodiversity importance, ranking in the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). Four estuaries in the corridor are identified as national conservation priorities by the National Estuaries Biodiversity Plan (Turpie et al., 2012). These are the Orange, Spoeg, Groen and Olifants estuaries.

In addition two estuaries, the Olifants and Orange, 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 Orange, Spoeg, Groen, Sout and Olifants estuaries are also considered important as they support sensitive estuarine habitats such as intertidal and supratidal saltmarsh. The Buffels, Swartlintjies Groen, Spoeg and Sout are relatively small but recent studies on the ecological water requirements have highlighted their regional importance as a very limited wetland type habitat for estuarine and coastal birds along arid west coast (DWS, 2017).

5.6.2 Expanded Eastern EGI Corridor

In total, 21 estuaries fall within the Expanded Eastern EGI Corridor, with a combined estuarine habitat area of 55 700 ha (Figure 5). 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 St Lucia (<30 km), Thukela (<25 km), Mhlathuze (<15 km), Mfolozi (<15 km) and Kosi (<10 km).

Only five estuaries in this corridor are in an excellent or good condition (Categories A to B). These are Mdlotane, Matigulu/Nyoni, Mlalazi, Mgobezeleni and Kosi estuaries. These systems have a high sensitivity to change as they will degrade from their near pristine state relatively easily.

Durban Bay, Mlalazi, Mhlathuze, Mfolozi, St Lucia and Kosi estuaries are of Very High biodiversity importance, ranking amongst the top estuaries in South Africa (Turpie et al., 2002; Turpie and Clark, 2009). In addition Mgeni, Mhlanga, Mdloti, Tongati, Mhlali, Mdlotane, Zinkwasi, Thukela, Matigulu/Nyoni, Richards Bay and Nhlabane estuaries are rated as Important from a biodiversity perspective.

Seventeen estuaries in the corridor are identified as conservation priorities in the National Estuaries Biodiversity Plan (Turpie et al., 2012) and the KwaZulu-Natal Conservation Plan. These include Durban Bay, Mgeni, Mhlanga, Mhlali, Mvoti, Mdlotane, Zinkwasi, Thukela, Matigulu/Nyoni, Siyaya, Mlalazi, Mhlathuze, Richards Bay, Mfolozi, St Lucia, Mgobezeleni and Kosi estuaries.

Twelve estuaries 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). These include Durban Bay, Mgeni, Zinkwasi, Thukela, Matigulu/Nyoni, Mlalazi, Mhlathuze, Richards Bay, Nhlabane, Mfolozi, St Lucia and Kosi.

From a habitat diversity and abundance perspective, all the estuaries, with the exception of Mvoti, are considered important as they support sensitive estuarine habitats such as mangroves, swamp forest and saltmarsh (intertidal and/or supratidal).

6 FEATURE SENSITIVITY MAPPING

6.1 Identification of feature sensitivity criteria

A generic suite of environmental and socio-economic sensitivity indicators, which could be mapped on the basis of existing knowledge and datasets, and which were suitable for assessing potential risks associated with this type of development were selected (Table 6). Base maps were produced for each corridor demarcating the presence and locations of these sensitivity indicators. Based on expert opinion, each of these indicators was allocated a sensitivity rating (i.e. very high, high, medium, and low, as indicated in Table 6). This allowed for the translation of base maps into sensitivity maps for each of the study areas.

The feature maps are shown in Figure 4 and Figure 5 for the Expanded Western and Eastern EGI corridors respectively.

6.2 Sensitivity Mapping

All estuaries under consideration here can be regarded as being systems of very high sensitivity based on one or more of the listed criteria in Table 6, e.g. priority estuary for conservation, an important nursery system, and/or as a system supporting endangered Red listed species such as White Steenbras.

Because of estuarine connectivity with, and dependencies on wider floodplain and riverine habitats, and because habitat impacts in estuaries accumulate over temporal and spatial scales, estuaries cannot be assessed as discrete units as done in the case of terrestrial systems. For this assessment the EFZ of each estuary within the proposed corridors was buffered at 5 km intervals to reflect the sensitivity of estuaries and their associated inflowing rivers, wetlands and coastal seeps to potential infrastructure development. This approach also allowed assessment of potential cumulative impacts of a linear structure crossing a number of estuaries within a region. Relative sensitivity of zones within each of the corridors are illustrated in Figure 6 and Figure 7.

6.2.1 Expanded Western EGI Corridor

There is only one estuary (Olifants) in this corridor that stretches far inland (< 20 km), with most of other systems ending within 10 km of the coast. These areas are demarcated as of very high sensitivity to infrastructure development. The rivers, wetlands and coastal seeps adjacent or just above the estuaries, as demarcated by the 5 km buffer around the EFZs, are deemed zones of high sensitivity as they directly influence the quality and quantity of freshwater and sediments entering estuaries. Disturbance of their physical processes will in turn impact the downstream estuary health. The inflowing rivers, wetlands and coastal seeps adjacent or above the estuaries, as indicated by the 5 to 15 km buffer around the EFZs, are deemed zones of medium sensitivity as they indirectly influence the quality and quantity of freshwater and sediments entering estuaries.

6.2.2 Expanded Eastern EGI Corridor

There are a number of very large and high biodiversity importance estuaries in the Expanded Eastern EGI Corridor, including the St Lucia and Kosi estuarine lake systems. These areas are demarcated as of very high sensitivity to infrastructure development. The rivers, wetlands and coastal seeps adjacent or just above the estuaries (demarcated by the 5 km buffer around the EFZ) are zones of high sensitivity as they directly influence the quality and quantity of freshwater and sediments entering estuaries. Rivers, wetlands and coastal seeps adjacent or above the estuaries (in the 5 to 15 km buffer around the EFZs) are zones of medium sensitivity.

Table 6: Selected ecological sensitivity indicators and associated sensitivity ratings applicable to the proposed Expanded EGI corridors.

Sensitivity Indicator		Brief description/data source	Sensitivity Class	Zone of interest
Estuarine	Estuaries in Formally /desired protected areas	Marine, estuarine and terrestrial areas within the study area boundaries that are under formal protection or estuaries identified as desired protected areas in the National Estuaries Biodiversity Plan (Turpie et al., 2012).	Very High	EFZ
	Estuaries of high biodiversity importance	In South Africa, estuary biodiversity importance is based on the importance of an estuary for plants, invertebrates, fish and birds, using rarity indices (Turpie et al., 2002). 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 (Turpie et al., 2002, Appendix A).	Very High	EFZ
	Important nurseries	Estuaries that are critically important nursery areas for fish and invertebrate populations and make an important contribution towards estuarine and coastal fisheries (Lamberth and Turpie, 2003; Van Niekerk et al., 2017).	Very High	EFZ
	Important estuarine habitats	Estuaries that support important rare or sensitive habitats (saltmarsh, mangroves, swamp forest) that provide important ecosystem services (Van Niekerk et al., 2017).	Very High	EFZ
	Natural or near natural condition estuaries	Estuaries in good condition (designated by A or B health categories) are more sensitive to development (likely to degrade in overall condition if impacted by development) (Van Niekerk et al., 2017).	Very High	EFZ
	Estuaries that support species of conservation importance	Estuaries that support species of conservation importance (IUCN Red listed species that are Critically Endangered).	Very High	EFZ
Supporting habitats	Coastal rivers, wetlands and seeps above or adjacent to estuaries	Coastal rivers, wetlands and seeps adjacent or just above the estuaries that <u>directly</u> influence the quality and quantity of freshwater and sediments entering estuaries.	High	5 km buffer around EFZ
	Coastal rivers, wetlands and seeps	The coastal rivers, wetlands and seeps adjacent or just above the estuaries that <u>indirectly</u> influence the quality and quantity of freshwater and sediments entering estuaries.	Medium	5 - 15 km buffer around EFZ
	Terrestrial environment	Terrestrial environment that are not linked to aquatic processes that directly or indirectly influence estuaries.	Low	15 km or more from EFZ

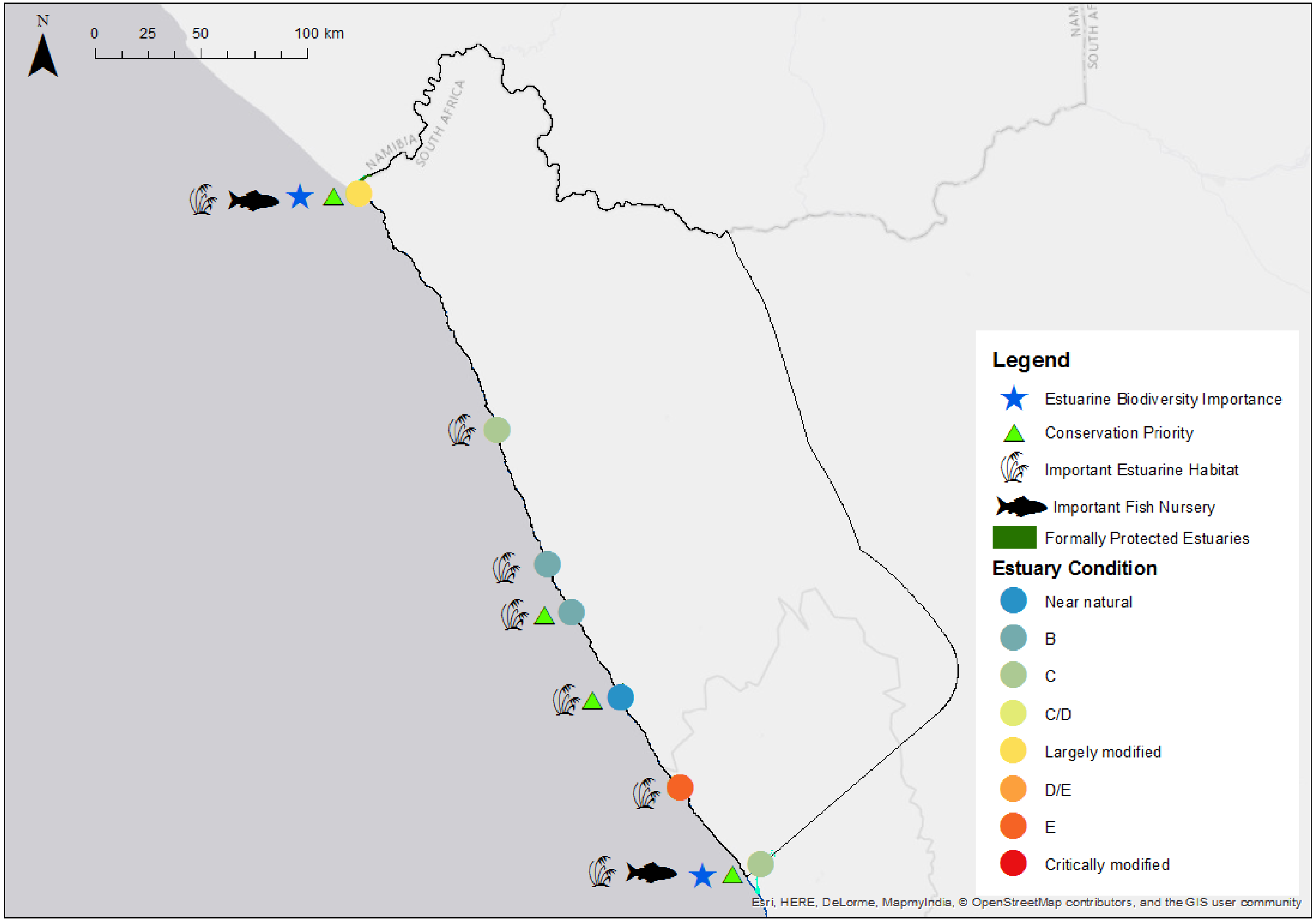

Figure 4: Estuarine feature map for the proposed Western Expanded EGI Corridor.

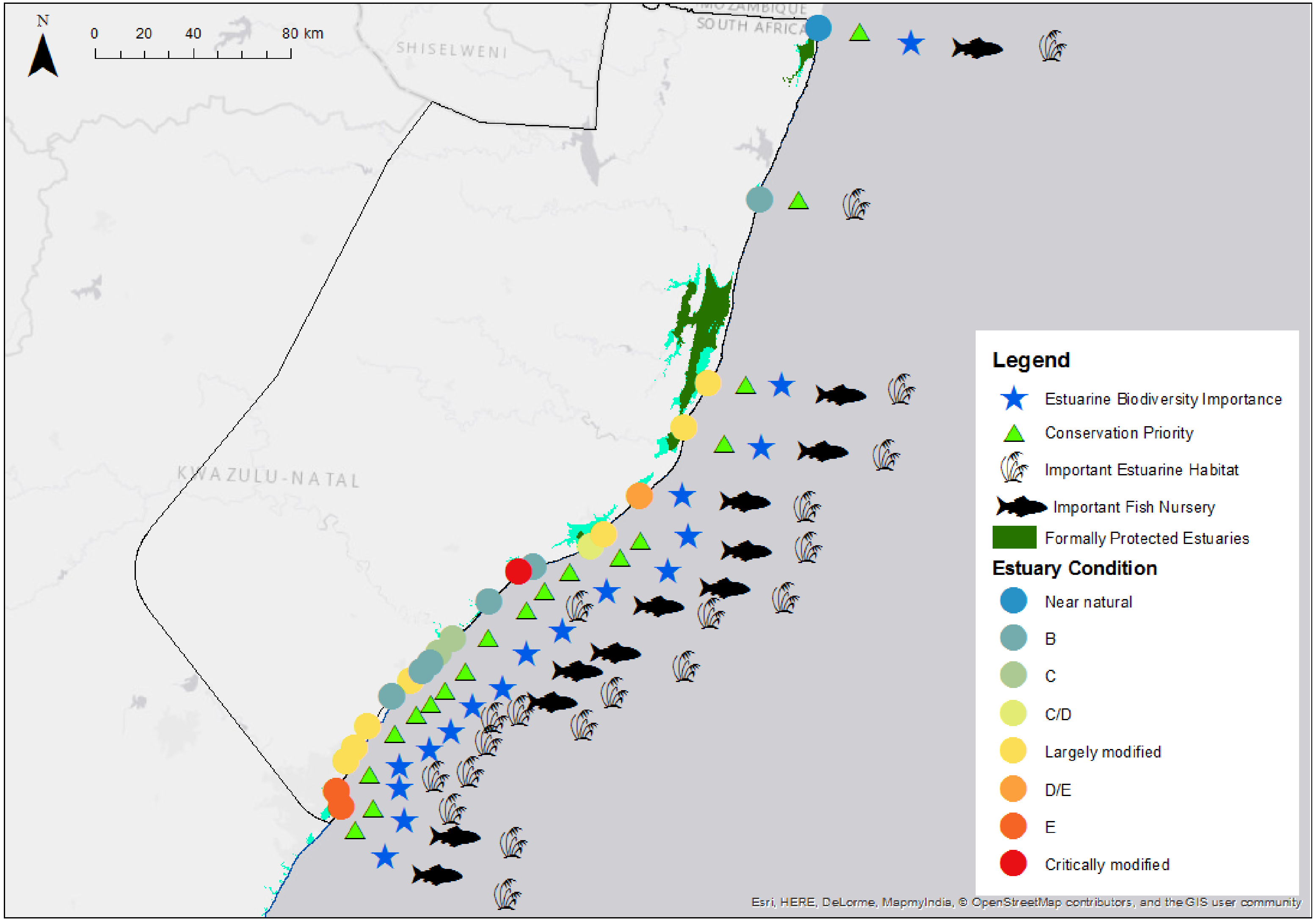

Figure 5: Estuarine feature map for the proposed Eastern Expanded EGI Corridor.

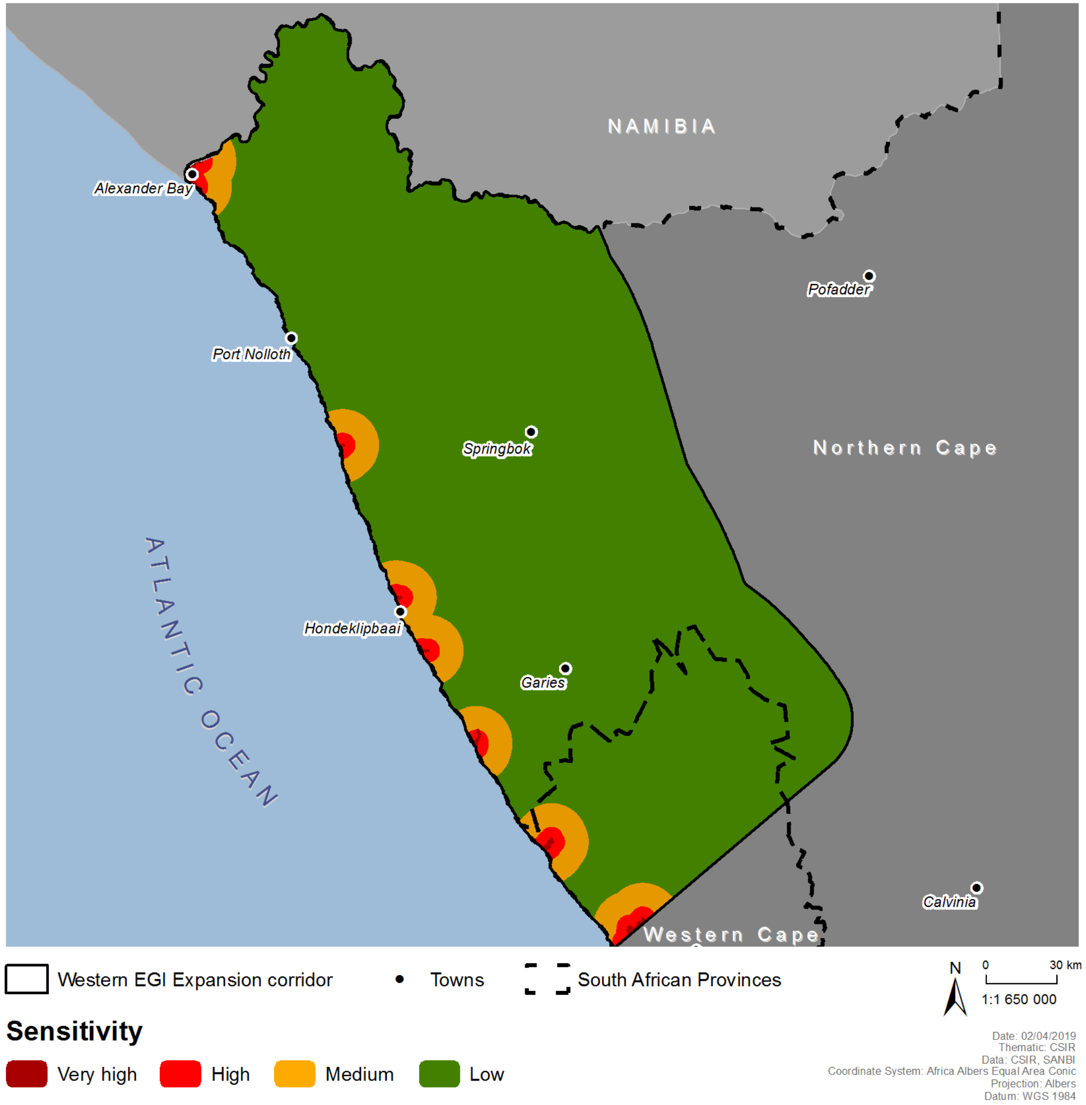

Figure 6: Sensitivity map for the estuaries, EFZ and associated features in the proposed Western Expanded EGI Corridor.

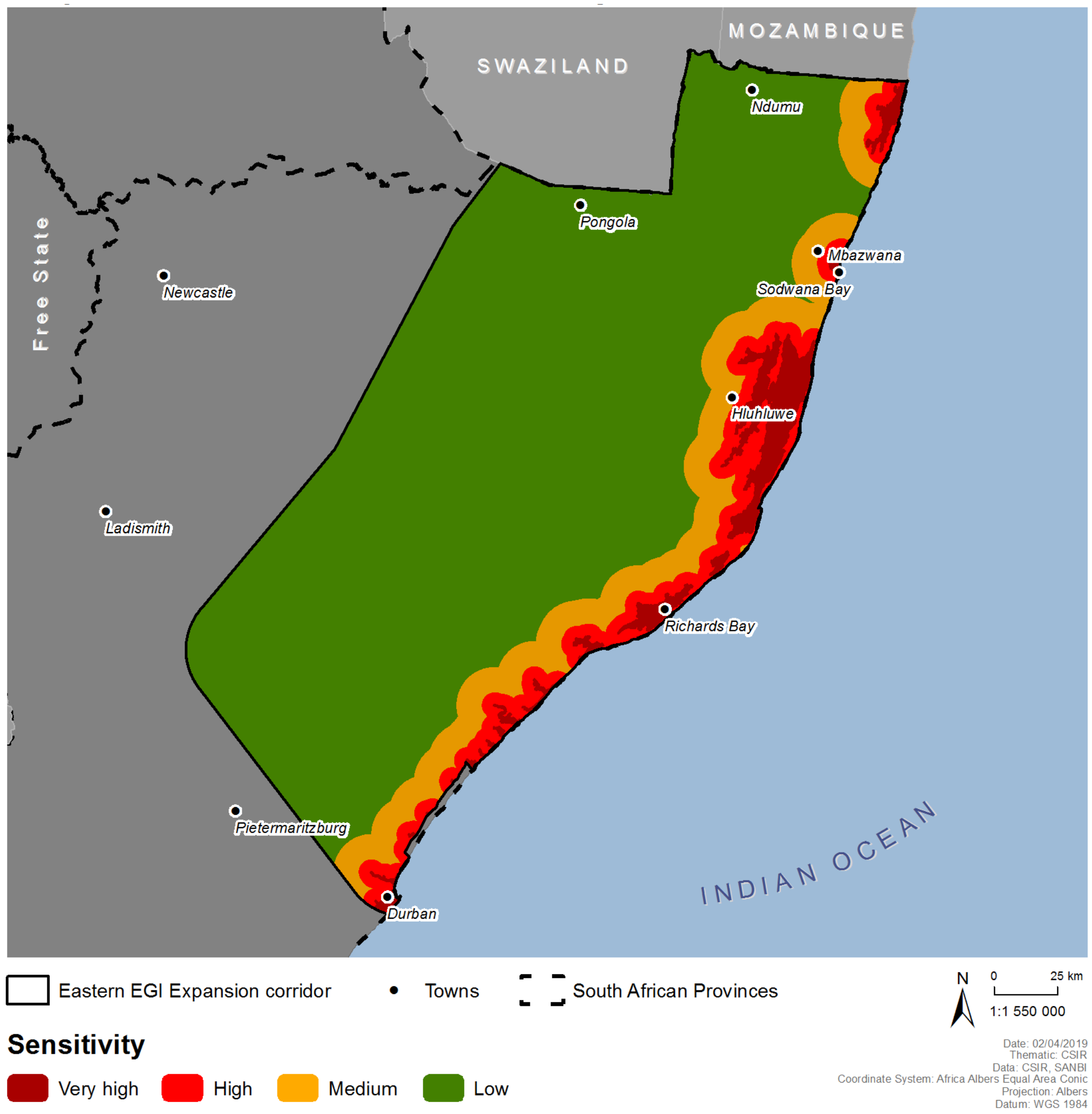

Figure 7: Sensitivity map for the estuaries, EFZ and associated features in the proposed Eastern Expanded EGI Corridor.

7 KEY POTENTIAL IMPACTS AND THEIR MITIGATION

The impacts associated with EGI range from those that are obvious (e.g. pylon construction and clearing areas for access/service roads) to those that are more subtle and which occur over longer timeframes (e.g. vegetation compositional changes from continued disturbance/clearing, disruption of long term sedimentary processes, deteriorating water quality, habitat fragmentation, and alien plant infestation). It is once again stressed that estuaries are highly dependent on the condition of the rivers flowing into them and/or adjacent wetlands. Cross reference is therefore made to the Freshwater Specialist Assessment (De Winnaar & Ross-Gillespie, 2018) (Appendix C.1.6 of the EGI Expansion SEA Report) to ensure that downstream estuarine functionality is not impacted on by infrastructure development.

The impacts to aquatic ecosystems associated with EGI were identified and discussed in detail as part of the 2016 EGI SEA. De Winnaar & Ross-Gillespie (2018) also highlight additional aquatic impacts as a result of the construction of pylons, substations, and associated EGI structures. Major impacts include:

- The **development of new access/services roads to enable construction**, as well as ongoing maintenance during the operational phase may result in the following impacts:
    - **Direct loss of estuarine and/or riparian vegetation** (and associated riparian buffers), including potentially sensitive/important habitat supporting species of conservation concern;
    - **fragmentation of estuarine hydrodynamic, sedimentary processes** and mouth dynamics (open/closed phases) causing changes in ecological patterns and processes, disruptions to species movement and dispersal, habitat connectivity, increased edge effects and disturbance, and establishment of invasive alien vegetation;
    - **Stormwater runoff** resulting in increased flows into receiving aquatic environments, often at discrete discharge points, with knock-on impacts such as bank erosion and collapse, scouring, channel incision, desiccation of estuarine/wetland/riparian soils and vegetation, increased turbidity, sedimentation and smothering of benthos. The combined effects will negatively affect the ecological integrity and ability of the estuarine and coastal freshwater ecosystems to function properly;
    - **Waste pollution and contamination** of aquatic environments from foreign materials (e.g. fuels/hydrocarbons, cement, and building materials) stockpiled or dumped and/or carried into estuarine and coastal freshwater ecosystems environments;
    - **Disruption of soil profile** through soil compaction/increased soil bulk density, reduced porosity, hydraulic conductivity, alter soil chemistry (soil pH, organic matter and nitrogen content);
    - **Compaction of soils and creation of preferential flow paths** with and adjacent to estuarine and upstream river/wetland habitats; and
    - **Direct loss of flora and fauna** (including species of conservation concern) that inhabit estuarine and upstream coastal freshwater ecosystems and adjacent buffer/fringe habitats.
- **Construction of substations and pylons and powerline servitudes –** The direct clearing and/or removal of vegetation to allow for the construction of substations and pylons, as well as to establish access/service roads to access the pylons and powerlines for on-going maintenance will result in impacts similar to those described above for the development of access roads, but which differ in terms of extent, duration and intensity. As noted above, the direct footprint of single pylon supporting a 765 kV powerline is 1 ha (including excavation, assembly and raising), while the development footprint for a substation extends up to 70 ha (including temporary construction camps, borrow pits, vehicle parking, and stock piles). Servitudes for accessing pylons/powerlines will require ongoing vegetation clearing to maintain an 8 m strip on either side of the centre line (for a 132 kV powerline) wherein grass/herbaceous vegetation regrowth is cut to a height of 8.5 m minimum vertical clearance (for a 765 kV line), and trees, in most cases, are removed.
    - In addition, pylon infrastructure may **alter estuarine physical dynamics, e.g. infilling, altered channel migrating, increased mouth closure.** Estuary channel morphology is highly dynamic. Estuarine channels can develop and migrate anywhere within the EFZ under the

influence of tidal flows, river flows and floods. Stabilising sections of the estuary morphology or floodplain for construction, operation and maintenance of EGI can lead to changes in long-term physical dynamics. Disruption of **channel and bed formation process will alter sediment structure, change estuary hydrodynamics, mouth dynamics, and ultimately impact catchment and marine connectivity**. This altered functioning of a system will ultimately affect the biota. Loss of estuarine productivity and connectivity will reduce nursery function and output to associated fisheries. **Given that estuary channels are highly dynamic and can develop and migrate anywhere in the EFZ, it is inevitable that infrastructure in the EFZ will disrupt estuarine physical processes. The nett result is that infrastructure will over time be exposed to erosion through channel migration resulting in a high risk of failure.**

- The sediment eroding from construction sites or cleared floodplains and servitudes could cause sediment deposition and accumulation in other parts of estuaries, causing drying out of floodplains, loss of water column habitat and premature mouth closure if the tidal flows are constricted. Changes in estuarine physical dynamics will lead to altered estuary productivity and biodiversity.
- Constricting or stabilizing channel migration will also ultimately **increase flood risk to riparian properties** as it will prevent estuarine channels from widening naturally under increased flows.
- **Deterioration of water quality associated with the disturbance of sediment and lack of stormwater management** leading to erosion and runoff, the use of water for construction and dust suppression, concrete/oil/hydraulic spills, and an overall need for strategic planning of water resource allocation. During the construction phase water quality may deteriorate as a result of sediment disturbance and/or the removal of estuarine vegetation, or pollution events, resulting in:
    - **decrease pH** as a result of disturbance of the anoxic sediment profiles characteristic of estuaries;
    - **increase the Total Dissolved Solids (TDS);**
    - **increase the Total Suspended Solids (TSS);**
    - **increase the organic matter content;** and/or
    - **Increase the nutrient content.**

This can have knock-on effects on the biota. It can result in algal blooms/eutrophication in estuaries, can cause anoxia or hypoxia and fish and invertebrate kills. Increased turbidity in clear water systems can lead to smothering of primary producers and disrupted predator-prey relationships.

- **Loss of connectivity and habitat fragmentation** as a result of EGI, and the associated access/services roads for ongoing maintenance, especially where areas are permanently impacted (e.g. through roads, substations and pylon bases). This presents a potential serious issue particularly to estuarine and associated coastal river fauna, and leads to populations becoming isolated, resulting in a reduction of inter-population connectivity and compromised genetic viability.
- **Habitat alteration and knock-on effects caused by Invasive Alien Plants (IAPs).** IAPs that already occur in the area are likely to encroach into and invade newly disturbed areas (such as construction camps, borrow pits, vehicle parking, and stock piles/ areas), as well as areas where conditions (such as soil moisture content) are changed because of development (e.g. areas around pylons/substations and along access roads). The spread of existing, and the introduction of new, problem plant species may be facilitated by movement of people and construction vehicles. IAP infestation within freshwater ecosystems will further degrade habitats and habitat availability for associated biota.

Overall, in this study impacts are characterised at the broadest scale in relation to the corridors as a means to identify preferred routes that will have the least possible impact on estuarine and associated coastal freshwater ecosystems and/or biota. Inappropriate routing of an EGI corridor could potentially impact areas with severe consequences for estuarine and associated coastal freshwater biodiversity. Taking this into consideration, it is important to acknowledge impacts at a finer scale in order to identify preferred alignments/positions of EGI within the two respective corridors.

The impacts described above are more broadly categorised below for further discussion in Table 7.

7.1 Design Phase

Many impacts potentially associated with the construction and operation of powerlines in the expanded EGI corridors can be avoided or mitigated in the design phase of the project by avoiding sensitive areas, most importantly avoiding development (placement of pylons, substations and other associated EGI structures) within EFZs. This will mitigate impacts associated with construction, as well as operation of such infrastructure. Impacts which can be mitigated at the design phase are:

- Loss of threatened/sensitive estuarine and supporting coastal river/wetland riparian habitat through clearing/infilling.
- Fragmentation of estuarine and supporting coastal river/wetland (mostly as a result of road construction).
- Alteration of hydrodynamic processes through disrupted estuarine morphological processes, interrupted surface and/or subsurface freshwater flows, as well as the concentration of water flows due to roads across floodplains, wetlands or rivers.

7.2 Construction Phase:

Construction phase impacts are associated with the development and installation of infrastructure (such as pylons, substations and associated EGI structures), and stringing of powerlines. These activities typically require development of access roads, laydown areas and construction camps. Impacts are:

- Physical destruction or damage of estuarine and supporting coastal river/wetland ecosystems by construction personnel and machinery operating within or in close proximity to drainage lines.
- Pollution (water quality deterioration) of estuarine and supporting coastal river/wetland ecosystems through the runoff of contaminants such as fuel, oil, concrete, wash-water, sediment and sewage into these ecosystems.
- Reduction in habitat quality through erosion and sedimentation of estuarine habitat and/or associated coastal wetlands and rivers.
- Erosion caused by loss of vegetation cover through site clearing and consequent sedimentation of estuarine and supporting coastal river/wetland ecosystems. Erosion is particularly a high risk in steep or incised systems.
- Excessive dust generation from road construction and vehicle traffic/haulage leading to impact on surrounding vegetation health and suspended solids/sediment entering nearby estuarine and supporting coastal river/wetland ecosystems.
- Disturbance of estuarine or freshwater aquatic and semi-aquatic fauna, as a result of the noise from construction teams and their machinery working within or in close proximity to aquatic ecosystem.
- Damage to vegetation from operating heavy machinery.

7.3 Operational Phase:

Operational phase impacts are typically associated with routine maintenance activities and occasional repairs needed. These activities typically require development (and maintenance) of a servitude as well as regular clearing of vegetation to meet national standards and safety regulations for overhead powerlines. Impacts include:

- Loss and/or reduction in estuarine and supporting coastal river/wetland habitat quality.
- Encroachment and proliferation of alien and invasive vegetation.
- Pollution (water quality deterioration) of estuarine/freshwater ecosystems and potential contamination of groundwater/subsurface drainage.

Table 7: Summary of key activities, impacts, possible effects and mitigations.

Activity	Key Impact	Possible Effect	Mitigation
Design Phase			
Placement of substations, foundations for pylons, construction camps, access roads and service roads within or close to the EFZ and/or coastal wetlands or rivers flowing into estuaries	Loss of threatened/ sensitive estuarine and supporting river/wetland riparian habitat through clearing/ infilling.	Removal of estuarine and/or coastal riparian vegetation, instream habitat, as well as adjacent terrestrial buffer habitat which could result in a loss of ecological functions and processes, aquatic biota (i.e. fauna and flora), and valuable ecosystem services.	Corridors to avoid all EFZs (very high sensitivity), and, if possible, avoid areas of high sensitivity.
	Fragmentation of estuarine and associated coastal freshwater habitat (mostly as a result of road construction)	Loss of ecosystem resilience and integrity through the disruption of biodiversity patterns and processes (e.g. fish movement/ migration)	Avoid road crossings and servitude clearance through estuaries and avoid and/or minimise these activities in associated coastal wetlands and rivers within 5 km of EFZ. Where it is not possible to avoid the crossing of inflowing rivers or wetlands, ensure that crossings are constructed 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, or similar adequate erosion control measures, with pipe crossings or culverts. As far as possible ensure access roads are linked to existing river crossings (e.g. bridges) to minimise disturbance from additional crossings.
	Alteration of hydrodynamic processes through disrupted estuarine morphological processes, interrupted surface and/or subsurface freshwater inflows, as well as the concentration of water flows due to roads traversing inflowing coastal wetlands or rivers.	Changes result in degradation of the ecological functioning of estuarine and coastal freshwater aquatic ecosystems that rely on a specific hydrological regime and associated hydrodynamics (mixing processes) to maintain their integrity. This also leads to geomorphologic impacts within systems.	Avoid road crossings and servitude clearance through estuaries. Avoid and/or minimise road crossings and servitude clearance through associated coastal wetlands / rivers within 5 km of the EFZ. Minimise the number of watercourse crossings for access roads. Ensure adequate watercourse crossings (i.e. culverts of the correct specification) are designed and constructed where roads traverse these areas so that the concentration of flow (particularly during high flow conditions) is minimised as far as possible.

Activity	Key Impact	Possible Effect	Mitigation
Construction Phase			
Establishment of construction camps or temporary laydown areas within or in close proximity to estuaries and associated wetlands or rivers	Physical destruction or damage of estuarine and supporting coastal river/wetland ecosystems by construction workers and machinery operating within or in close proximity to drainage lines.	Loss of both faunal and floral biodiversity and the ecosystem services provided by these habitats directly through clearing, and indirectly through poaching/hunting.	All estuaries and their associated inflowing coastal wetlands and rivers should be treated as "no-go" areas and appropriately demarcated as such. No vehicles, machinery, personnel, construction materials, cement, fuel, oil or waste should be allowed into these areas without the express permission of and supervision by an on-site Environmental Control Officer (ECO). All construction activities (including establishment of construction camps, temporary lay-down areas, construction of haul roads and operation of heavy machinery) associated with wetlands and rivers should take place during the dry season to reduce potential impacts to coastal freshwater ecosystems and downstream estuaries. No fishing or hunting should be allowed in the proximity of aquatic habitats.
Construction of substations, foundations for pylons, construction camps, access roads and service roads within or close to the EFZ and/or coastal wetlands or rivers flowing into estuaries	Erosion caused by loss of vegetation cover through site clearing and consequent sedimentation of aquatic ecosystems. Erosion is particularly a high risk in steep systems.	The sediment eroding from the construction site and denuded floodplain 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 can result in premature mouth closure if the tidal flows are constricted enough.	Avoid clearing of estuarine vegetation and associated coastal freshwater riparian vegetation. River/wetland bank stabilisation measures (gabions, eco logs, geofabric, sediment fences or similar adequate measures) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction. Appropriate rehabilitation procedures/measures should be planned.
Stockpiling of materials and washing of equipment within or in close proximity to estuaries and associated wetlands or watercourses	Pollution (water quality deterioration) of estuarine and supporting coastal river/wetland ecosystems through the runoff of contaminants such as fuel, oil, concrete, wash-water, sediment and sewage into these ecosystems.	Habitat degradation which results in the loss of resilience of ecosystems through the disruption of ecological processes and thus a loss of ecosystem integrity.	No construction activities within estuaries (i.e. EFZ). Construction activities associated with the establishment of access roads through associated coastal wetlands or rivers (if unavoidable) should be restricted to a working area of 10 m in width on either side of the road, and these working areas should be clearly demarcated. No vehicles, machinery,

Activity	Key Impact	Possible Effect	Mitigation
			personnel, construction material, cement, fuel, oil or waste should be allowed outside of the demarcated working areas.
Construction of haul roads for movement of machinery and materials	Reduction in habitat quality through erosion and sedimentation of estuarine habitat and/or associated coastal wetlands and rivers. Excessive dust generation from road construction and vehicle traffic/haulage leading to impact on surrounding vegetation health and suspended solids/sediment entering nearby estuarine and supporting coastal river/wetland ecosystems		There should be as little disturbance to surrounding vegetation 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. Furthermore dust suppression methods (e.g. spraying surfaces with water obtained from a suitable, licenced/approved source) should be used to minimise the transport of wind-blown dust.
Operation of heavy machinery within or in close proximity to an estuary or associated inflowing wetlands or rivers	Disturbance of estuarine or freshwater aquatic and semi-aquatic fauna, as a result of the noise from construction teams and their machinery working within or in close proximity to an aquatic ecosystem. Damage to vegetation from operating heavy machinery.		No fuel storage, refuelling, vehicle maintenance or vehicle depots should be allowed within 30 m of the edge of any estuary/river/wetlands or drainage lines.
			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.
			Vehicles and machinery should not be washed within 30 m of the edge of any estuary, river or wetland.
			No effluents or polluted water should be discharged directly into any estuary or associated coastal river or wetland.
			If construction areas are to be pumped of water (e.g. after rains), this water should be pumped into an appropriate settlement area, and not allowed to flow

Activity	Key Impact	Possible Effect	Mitigation
			straight into any estuary or associated coastal river or wetland.
			No spoil material, including stripped topsoil, should be temporarily stockpiled within 30 m of the edge of any estuary, river, wetland or drainage line. Estuarine or associated coastal aquatic 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, an estuarine or freshwater ecologist should be consulted for advice on the most suitable remediation measures.
			Workers should be made aware of the importance of not destroying or damaging the vegetation along estuaries and associated freshwater ecosystems, of not undertaking activities that could result in the pollution of estuaries, rivers 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 should be implemented to monitor vegetation changes and potential site impacts occurring during construction phase.
Operational Phase			
Clearing or trimming of natural estuarine and associated wetland or riparian vegetation	Loss and/or reduction in estuarine and supporting coastal river/wetland habitat quality	Degradation of ecological integrity and changes to species community composition as well as habitat structure	One of the options that could be explored to mitigate against the potential vegetation clearing/trimming impacts would be to consider constructing taller pylons in certain areas that are high enough to allow for the growth of relatively tall vegetation.

Activity	Key Impact	Possible Effect	Mitigation
	Growth stimulation, encroachment and proliferation of alien vegetation/invasive species		Fixed point photography could be used to monitor long-term vegetation changes and potential site impacts
Application of herbicides	Pollution (water quality deterioration) of estuarine/freshwater ecosystems and potential contamination of groundwater/subsurface drainage		Avoid the use of herbicides in close proximity (closer than 50 m) to the EFZ and within 10 km of EFZ of inflowing coastal wetlands/ rivers. Do not spray riparian/or wetland areas within 50 m of the coastal freshwater aquatic ecosystem.

8 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

8.1 Design and Planning phase

The careful and informed planning of EGI development through firstly establishing preferred powerline routes, determining suitable sites for substations, placement of pylons, and needs for ancillary infrastructure (e.g. access roads) has **the potential to greatly reduce impacts on estuarine and associated freshwater aquatic ecosystems through simply avoiding areas of very high sensitivity, and as far as possible avoiding areas of high sensitivity**. Where estuarine areas cannot be avoided, then a detailed investigation should be followed to determine whether the EGI alignment and development footprint can avoid the actual estuarine ecosystems (i.e. estuary) and associated aquatic and riparian buffers.

Where it is impossible to avoid estuaries and associated aquatic ecosystems and buffers altogether, then it will be necessary to undertake more detailed specialist studies, and if necessary investigate needs and opportunities for offsets. Preference should be given to position EGI within already disturbed/degraded areas. Mitigation specific to impact significance should be considered that is cognisant of the mitigation hierarchy, where very high significance impacts are avoided, while high and medium significance impacts are mitigated as far as possible. Offsets should only be considered once alternatives and mitigation measures have been exhausted. Indeed, in the case of estuaries there is very little if any potential for off sets. Any estuarine ecosystem that will be affected by EGI development within the proposed Expanded EGI Corridors must be subject to an appropriate site-specific estuarine specialist investigation.

8.2 Construction phase

Given the high sensitivity and ecological importance of estuaries it is recommended that clearing of estuarine vegetation and disturbance of estuarine processes be avoided, i.e., no EGI development should occur within the EFZs.

However, this phase may include the construction of pylons and substations, and stringing of transmission lines, as well as the construction of the access and service roads, and will thus include a number of impacts typical of construction activities (as described above), such as erosion and degradation/disturbance of coastal habitats and vegetation (including areas for access via roads and servitudes and movement of heavy machinery), and earthworks and vegetation/habitat clearing. Specific measures and actions required during the construction phase are presented in De Winnaar & Ross-Gillespie (2018) (Appendix C.1.6 of the EGI Expansion SEA Report), and Table 7 provides key measures applicable to protect downstream estuarine physical and ecological processes from knock-on effects. Additional measures to include are:

- Timing of construction activities should occur in the dry season as far as possible;
- Appointment and involvement of an ECO to provide oversight and guidance to all construction activities, as well as ensure full consideration and implementation of the Environmental Management Programme (EMPr); and
- Environmental monitoring (or biomonitoring) should be required pre-; during- and post-construction at strategically selected monitoring sites (refer to De Winnaar & Ross-Gillespie (2018) (Appendix C.1.6 of the EGI Expansion SEA Report) for more detail on coastal freshwater ecosystem requirements).

Some key mitigation measures to include from the perspective of protecting estuarine and coastal freshwater ecosystem processes are:

- Detailed site-specific assessment required if construction is planned for within the EFZ.
- An onsite ECO is required to provide oversight and guidance to all construction activities.
- Environmental monitoring or biomonitoring is required pre-, during- and post-construction at pre-selected monitoring sites. This should include fixed point photography or remote sensing should be implemented to monitor changes and long term impacts.

- Construction activities to occur, if possible, while the estuary mouth is open to minimise impacts to biodiversity.
- Dust suppression is required to prevent smothering of estuarine vegetation.

8.3 Operations phase

Assuming that EGI development does not occur in the EFZ as a result of very high sensitivity and ecological importance of estuaries, this phase will predominantly include activities typical of routine maintenance, such as clearing/trimming of coastal riparian or wetland vegetation within 5 km of the estuaries, as well as IAP control and application of herbicides. Specific measures and actions required during the operational phase are presented in De Winnaar & Ross-Gillespie (2018), but some key measures to include from the perspective of protecting estuarine processes are:

- Fixed point photography could be used to monitor long-term vegetation changes and potential site impacts.
- Avoid the use of herbicides in close proximity (closer than 50 m) to wetlands or rivers and do not disturb riparian/or wetland buffer areas.
- At all times care should be taken not to destabilise riparian areas and increase the sediment load down-stream to the estuary.

8.4 Rehabilitation and post-closure

Rehabilitation and post-closure measures would most likely be required for areas in and around pylons within or in proximity to estuarine and associated freshwater ecosystems (as indicated on sensitivity maps), as well as for areas degraded by access routes, operation of vehicles/heavy machinery, and servitudes infested by IAPs. In general, the following processes/procedures are recommended (James and King, 2010; De Winnaar & Ross-Gillespie, 2018):

- Initiation - rehabilitation project team and 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 - 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.

Additional points to be considered regarding rehabilitation of degraded areas within and adjacent to coastal freshwater and estuarine ecosystems include:

- IAP clearing and control – an IAP control programme should be developed and implemented based on site-specific details, including, but not limited to, types of IAPs, growth forms, densities and levels of infestation, potential dispersal mechanisms, and knock-on impacts to freshwater and estuarine ecosystems caused during implementation (e.g. herbicide drift and contamination);
- Erosion control and re-vegetation – the objective should be to establish indigenous vegetation cover as soon as possible, as well as to control and limit secondary impacts caused by rainfall-runoff. Where necessary geotextile fabrics, brush mattresses/bundles, geocells, and hydroseeding with a suitable grass seed mix should be considered, while more severe cases of erosion/bank collapse will require more advanced stabilisation methods (e.g. reshaping, planting, concrete blocks, riprap, and gabions/reno mattresses).

8.5 Monitoring requirements

Given the high sensitivity and ecological importance of estuaries it is recommended that EGI development should not occur within the EFZs. However, EGI development may involve construction and operation activity within or in proximity to coastal freshwater ecosystems such as rivers, wetlands and seeps that flow into estuaries. Where impacts to estuaries and/or coastal freshwater ecosystems within 5 km of estuaries cannot be avoided, monitoring measures should be implemented at a minimum; with additional supporting input from in-depth specialist studies where required.

For all construction activities within 5 km of an estuary, monitoring of a potential impact is recommended at sites to be determined in-field by qualified and experienced estuarine and/or freshwater ecosystems specialists. Sampling is required prior to construction taking place to allow for the establishment of the systems baseline condition (i.e. its state prior to development activities). Monthly monitoring is recommended for the duration of construction to evaluate trends, with summer and winter monitoring at three year intervals recommended thereafter during the operation phase.

Depending on the impact site, monitoring/sampling is to be conducted by estuarine/freshwater specialists with relevant qualifications and experience pertaining to estuarine sediment dynamics, physical processes, water quality and ecology (or freshwater aquatic ecology if in coastal freshwater ecosystem). Resource Quality Objectives (RQO) as set under the NWA provides the benchmark conditions to maintain in estuaries or rivers.

Monitoring effort should be appropriate to the nature and intensity of potential impacts, and information from monitoring should be used to inform and influence EGI development activities to prevent environmental damage, or ensure that remediation measures after the fact are successful in rehabilitating impacted habitats. This will require the development of case-specific monitoring plans, but some guidelines are presented here which are based on those developed for use in RQO studies. Table 8 8 details these monitoring requirements for estuaries, with critical features highlighted in blue. These requirements are specifically important in the event of construction within an estuary and its EFZ is impossible to avoid. Monitoring of water quality, microalgae, invertebrates, fish and birds should be conducted even if the estuary or EFZ is not directly impacted, but where upstream activities occur which may cause indirect impacts to an estuary (Table 8).

Note: There are no prescriptive estuarine methods for the monitoring of reptiles, amphibians and mammals. The monitoring programme should be implemented as prescribed by the Freshwater Ecosystems Specialist Assessment Report (De Winnaar & Ross-Gillespie, 2018) (Appendix C.1.6 of the EGI Expansion SEA Report).

Table 8: Requirements for monitoring ecological components of estuaries following direct and indirect impacts from EGI development.

	Ecological Component	Monitoring action	Temporal scale (frequency and when)	Spatial scale (no. stations)
In the event of direct impacts in EFZ	**Hydrodynamics**	Record water levels	Continuous	Near mouth
		Aerial photographs of estuary	During spring low tide Before construction, during operation, and every 3 years afterwards	Entire estuary
	Sediment dynamics	Bathymetric surveys: Series of cross-section profiles and a longitudinal profile collected at fixed 500 m intervals, but in more detail in the mouth (every 100 m). The vertical accuracy should be about 5 cm.	Before construction, during operation, and every 3 years afterwards	Entire estuary
		Set sediment grab samples (at cross section profiles) for analysis of particle size distribution (PSD) and origin (i.e. using microscopic observations)	Before construction, during operation, and every 3 years afterwards (with invert sampling)	Entire estuary
	Water Quality	Record longitudinal salinity and temperature (pH, dissolved oxygen, and suspended solids/turbidity profiles)	Summer and winter survey before construction, during operation, then every summer and winter survey every 3 years afterwards	Entire estuary (3-10 stations)
	Macrophytes	Ground-truthed maps; Record number of plant community types, identification and total number of macrophyte species, number of rare or endangered species or those with limited populations documented during a field visit; Record percentage plant cover, salinity, water level, sediment moisture content and turbidity on a series of permanent transects along an elevation gradient; Take measurements of depth to water table and ground water salinity in supratidal marsh areas	Summer survey before construction, during operation, then Summer survey every 3 years afterwards	Entire estuary
	Microalgae	Record relative abundance of dominant phytoplankton groups, i.e. flagellates, dinoflagellates, diatoms and blue-green algae. Chlorophyll-a measurements taken at the surface, 0.5 m and 1 m depths, under typically high and low flow conditions using a recognised technique, e.g. HPLC, fluoroprobe. Intertidal and subtidal benthic chlorophyll-a measurements.	Summer and winter survey before construction, during operation, then every summer and winter survey every 3 years afterwards	Entire estuary (5 – 10 stations)
	Invertebrates	Record species and abundance of zooplankton, based on samples collected across the estuary at each of a series of stations along the estuary; Record benthic invertebrate species and abundance, based on subtidal and intertidal core samples at a series of stations up the estuary, and counts of hole densities; Measures of sediment characteristics at each station.	Summer and winter survey before construction, during operation, then every Summer and winter survey every 3 years afterwards	Entire estuary (5 – 10 stations)

	Ecological Component	Monitoring action	Temporal scale (frequency and when)	Spatial scale (no. stations)
	Fish	Record species and abundance of fish, based on seine net and gill net sampling.	Summer and winter survey before construction, during operation, then every Summer and winter survey every 3 years afterwards	Entire estuary (5 – 20 stations)
	Birds	Undertake counts of all water associated birds, identified to species level.	Summer and winter surveys before construction, once off during operation, then Summer and winter survey every year	Entire estuary (3 – 5 sections)
In the event of indirect impacts (e.g. through relevant upstream impact within 10 km of an estuary)	Water Quality	Record longitudinal salinity and temperature (pH, dissolved oxygen, and suspended solids/turbidity profiles).	Summer and winter survey before construction, during operation, then every summer and winter survey every 3 years afterwards	Entire estuary (3-10 stations)
	Microalgae	Record relative abundance of dominant phytoplankton groups, i.e. flagellates, dinoflagellates, diatoms and blue-green algae. Chlorophyll-a measurements taken at the surface, 0.5 m and 1 m depths, under typically high and low flow conditions using a recognised technique, e.g. HPLC, fluoroprobe. Intertidal and subtidal benthic chlorophyll-a measurements.	Summer and winter survey before construction, during operation, then every summer and winter survey every 3 years afterwards	Entire estuary (5 – 10 stations)

	Ecological Component	Monitoring action	Temporal scale (frequency and when)	Spatial scale (no. stations)
	Invertebrates	Record species and abundance of zooplankton, based on samples collected across the estuary at each of a series of stations along the estuary; Record benthic invertebrate species and abundance, based on subtidal and intertidal core samples at a series of stations up the estuary, and counts of hole densities; Measures of sediment characteristics at each station	Summer and winter survey before construction, during operation, then every Summer and winter survey every 3 years afterwards	Entire estuary (5 – 10 stations)
	Fish	Record species and abundance of fish, based on seine net and gill net sampling.	Summer and winter survey before construction, during operation, then every Summer and winter survey every 3 years afterwards	Entire estuary (5 – 20 stations)

In cases where freshwater ecosystems within 5 km upstream of estuaries are likely to be affected by EGI development appropriate measures of monitoring should be considered, including (De Winnaar & Ross-Gillespie, 2018):

- 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 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 operational 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

The most critical information gap relates to the site specific sedimentary processes occurring within each estuary. Without this detailed estuary-specific sediment process understanding, predicting impacts of any structures within an estuary EFZ is difficult. Estuarine physical processes are highly dynamic requiring detailed information over long planning horizons, e.g. understanding the impacts of a 1:100 year flood.

To address this, the following detailed information is required at each estuarine system which may be affected by location of infrastructure, roads or servitudes within the EFZ. This detailed information would be required prior to the construction of the EGI, 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 a depth of > 20 m at estuaries with a high Mean Annual Runoff (MAR));
- Estimates of daily sediment loads from the catchment;
- Hourly flood hydrograph 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 level during a flood (before infilling occurs again).

10 REFERENCES

Adams, J, Fernandes, M, and Riddin, T, 2018. Chapter 6: Estuarine Habitat extent and trend. South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Environment. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol4/A

Adams, J., Rajkaran, A. & van der Colff, D. 2016a. *Avicennia marina* (Forssk.) Vierh. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Adams, J., Rajkaran, A. & van der Colff, D. 2016b. *Bruguiera gymnorrhiza* (L.) Lam. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Adams, J., Rajkaran, A. & van der Colff, D. 2016c. *Ceriops tagal* (Perr.) C.B.Rob. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30.

Adams, J., van der Colff, D. 2016. *Zostera capensis* Setch. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Appleton CC, Forbes AT and Demetriades NT (2009). The occurrence, bionomics and potential impacts of the invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) (Gastropoda: *Thiaridae*) in South Africa. *Zoologische Medelingen Leiden* 83(4):525-536.

Basson, GR, Bosman, DE & Vonkeman JK 2017. Proposed new uMfolozi River N2 Road Bridge. Hydrodynamic modelling of scour and hydrodynamic forces. *Stormwater Hydraulics*, STIAS, 10 Marais Road, Stellenbosch University.

Beck JS, A Kemp, AK Theron, P Huizinga and GR Basson (2004). Hydraulics of Estuarine Sediment Dynamics in South Africa: Implications for Estuarine Reserve Determination and the Development of Management Guidelines. WRC Report No. 1257/1/04. Pretoria, South Africa.

Boehm, A.B., Ismail, N.S., Sassoubre, L.M., Andruszkiewicz, E.A. 2017. Oceans in Peril: Grand Challenges in Applied Water Quality Research for the 21st Century. *Environmental Engineering Science* 34: 3-15.

Borja, A., Elliott, M., Snelgrove, P.V.R., Austen, M.C., Berg, T., Cochrane, S., Carstensen, J., Danovaro, R., Greenstreet, S., Heiskanen, A., Lynam, C.P., Mea, M., Newton, A., Patricio, J., Uusitalo, L., Uyarra, M.C., Wilson, C. 2017. Bridging the Gap Between Policy and Science in Assessing the Health Status of Marine Ecosystems. *Frontiers in Marine Science* 4:32.

Colloty, B.M., Adams, J.B., Bate, G.C. 2002. Classification of estuaries in the Ciskei and Transkei regions based on physical and botanical characteristics. *South African Journal of Botany* 68: 312-321.

Cooper, J.A.G. 2001. Geomorphological variability among microtidal estuaries from the wave-dominated South African coast. *Geomorphology* 40: 99-122.

Davies, B., Day, J. 1998. *Vanishing Waters*. University of Cape Town Press, Cape Town, South Africa.

De Winnaar, G. & Ross-Gillespie, V. 2018. Freshwater Ecosystems. *In* Snyman-van der Walt, L., Walsdorff, A. & Abed, R. (*Eds*.) Strategic Environmental Assessment for EGI Development. CSIR: Stellenbosch.

DEA (Department of Environmental Affairs) 2012. South African Water Quality Guidelines for coastal waters. Volume 2: Guidelines for recreational use.

DEA (Department of Environmental Affairs) 2016. Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. CSIR Report Number: CSIR/02100/EMS/ER/2016/0006/B. Stellenbosch.

Dettinger, M.D., Diaz, H.F. 2000. Global Characteristics of Stream Flow Seasonality and Variability. *Journal of Hydrometeorology* 1: 289-310.

DWA (Department of Water Affairs). 2013. Water Resource Protection and Assessment Policy Implementation Process. Resource Directed Measures for protection of water resources: Methodology for the Determination of the Ecological Water Requirements for Estuaries. Version 3. Pretoria.

DWAF (Department of Water Affairs and Forestry) 1995. South African water quality guidelines for coastal waters. Volume 1. Natural Environment. Volume 3: Mariculture, Volume 4: Industrial Use. Pretoria: Department of Water Affairs.

DWAF (Department of Water Affairs and Forestry) 2008. Water Resource Protection and Assessment Policy Implementation Process. Resource Directed Measures for protection of water resources: Methodology for the Determination of the Ecological Water Requirements for Estuaries. Version 2. Pretoria.

DWS (Department of Water and Sanitation) 2017. Determination of Ecological Water Requirements for Surface water (River, Estuaries and Wetlands) and Groundwater in the Lower Orange WMA. Buffels, Swartlintjies, Spoeg, Groen and Sout Estuaries Ecological Water Requirement. Authored by CSIR: L van Niekerk, J Adams, SJ Lamberth, S Taljaard for Rivers for Africa. DWS Report No: RDM/WMA06/00/ CON/COMP/0316.

Elliott, M. 2011. Marine science and management means tackling exogenic unmanaged pressures and endogenic managed pressures –A numbered guide. *Marine Pollution Bulletin* 62: 651-655.

Emanuel, B.P., Bustamante, R.H., Branch, G.M., Eekhout, S., Odendal, F.J. 1992. A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. *South African Journal of Marine Science* 12: 341-354.

Froneman, A. & Van Rooyen, C. 2018. Avifauna. *In* Snyman-van der Walt, L., Walsdorff, A. & Abed, R. (*Eds*.) Strategic Environmental Assessment for EGI Development. CSIR: Stellenbosch.

Fielding, P. 2017. Draft Management Plan for the Buffels Estuary. Report prepared for the Kamiesberg Local Municipality.

Fielding, P., Massey, V., Clark, B. 2017. Draft Management Plan for the Swartlintjies Estuary. Report prepared for the Kamiesberg Local Municipality.

Gillanders BM 2005. Using elemental chemistry of fish otoliths to determine connectivity between estuarine and coastal habitats. *Estuarine, Coastal and Shelf Science* 64: 47-57.

Gillanders, B.M., Kingsford, M.J. 2002. Impact of changes in flow of freshwater on estuarine and open coastal habitats and the associated organisms. *Oceanography and Marine Biology: An Annual Review* 40: 233-309.

Gray, J.S., Elliott, M. 2009. *Ecology of Marine Sediments. From Science to Management*, 2nd Edn. Oxford University Press, New York. 256 pp.

Griffiths, M.H., 1997. Management of South African dusky kob *Argyrosomus japonicus* (Sciaenidae) based on per-recruit models. *South African Journal of Marine Science*, 18: 213-228.

Harrison, T. D. 2002. Preliminary assessment of the biogeography of fishes in South African estuaries. *Marine and Freshwater Research* 53: 479-490.

IUCN 2012. 2001 IUCN Red List Categories and Criteria version 3.1. Second edition. *International Union for Conservation of Nature*, Gland, Switzerland. 32 pp.

IUCN 2018. The IUCN Red List of Threatened Species. Version 2018-1. <http://www.iucnredlist.org>. Downloaded on 05 July 2018.

James, C.S. and King, J.K. 2010. Ecohydraulics for South African Rivers: A review and guide. Pretoria: Water Research Commission, WRC Report No. TT 453/10.

Jerling, HR (2005) Zooplankton community changes in Nhlabane estuary, South Africa, induced by man-made structures and drought, African Journal of Aquatic Science, 30:1, 29-35, DOI: 10.2989/16085910509503831

Jezewski, W.A., Pyke, P.D., Roberts, C.P.R. 1984. Estuarine and Lake Freshwater Requirements. Department of Water Affairs and Forestry, Pretoria, South Africa. Technical Report No TR123.

Jones, N.E., Schmidt, B.J., Melles, S.J. 2014. Characteristics and distribution of natural flow regimes in Canada: a habitat template approach. *Canadian Journal of Fisheries and Aquatic Science* 71: 1616-1624.

Korpinen, S., Andersen, J. 2016. A global review of cumulative pressure and impact assessments in marine environments. *Frontier Marine Science* 3:153.

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.

Lynch, S.D. 2004. Development of a raster database of annual, monthly and daily rainfall for Southern Africa. WRC Report 1156/1/04, Water Research Commission, Pretoria, South Africa, pp 78.

Mirimin, L., Macey, B., Kerwath, S., Lamberth, S., Bester-van der Merwe, A., Cowley, P., Bloomer, P. and Roodt-Wilding, R., 2016. Genetic analyses reveal declining trends and low effective population size in an overfished South African sciaenid species, the dusky kob (*Argyrosomus japonicus*). *Marine and Freshwater Research* 67(2): 266-276.

Poff, N.L., Ward, J.V. 1989. Implications of Streamflow Variability and Predictability for Lotic Community Structure: A Regional Analysis of Streamflow Patterns. *Canadian Journal of Fisheries and Aquatic Sciences* 46: 1805-1818.

Rajkaran, A., Adams, J. & van der Colff, D. 2016. *Rhizophora mucronata* Lam. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Rajkaran, A., Adams, J. & van der Colff, D. 2017. *Lumnitzera racemosa* Willd. var. *racemosa*. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Ray GC 2005. Connectivities of estuarine fishes to the coastal realm. *Estuarine, Coastal and Shelf Science* 64: 18-32.

Reddering, J.S.V., Rust, I.C. 1990. Historical changes and sedimentary characteristics of southern African estuaries. *South African Journal of Science* 86: 425-428.

SANBI. 2017. *Xylocarpus granatum* J.König. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Schulze, R.E., Lynch, S.D. 2007. Annual Precipitation. In: Schulze, R.E. (Ed). 2007. South African Atlas of Climatology and Agrohydrology. WRC Report 1489/1/06, Section 6.2. Water Research Commission, Pretoria, RSA.

Schulze, R.E., Maharaj, M. 2007. Rainfall Seasonality. In: Schulze, R.E. (Ed). 2007. South African Atlas of Climatology and Agrohydrology. WRC Report 1489/1/06, Section 6.5. Water Research Commission, Pretoria, RSA.

Taljaard, S., Snow, G., Gama, P., Van Niekerk, L. 2009. Verification of a conceptual model of water quality for small temporarily open/closed estuaries: East Kleinemonde Estuary, South Africa. *Marine and Freshwater Research* 60: 234-245.

Turpie, J.K and Clark B 2009. Development of a Conservation Plan for temperate South African estuaries on the basis of biodiversity importance, ecosystem health and economic costs and benefits. CAPE programme.

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.

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.

Turpie, JK, Taljaard, S, Van Niekerk, L, Adams, J, Wooldridge, T, Cyrus, D, Clark, B & Forbes, N. 2013. The Estuary Health Index: a standardised metric for use in estuary management and the determination of ecological water requirements. WRC Report No. 1930/1/12. 90pp.

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, 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, 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.

Van Niekerk, L, Adams, JB Lamberth, SJ, MacKay, F, Taljaard, S, Turpie, JK, Ramhukad, C-L, South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Environment. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol4/A. Draft Report.

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.

Vivier, L and Cyrus, D.P. 1999. Dune Mining and the Nhlabane Estuary, South Africa: the Effect of a Dredger Crossing on the Zoobenthic Community, *Marine Pollution Bulletin*, Volume 39, Issues 1–12.

Von Hippel, D.F. and Williams, J.H. (2003). Environmental Issues for Regional Power Systems in Northeast Asia. In: *Third Workshop on Northeast Asia Power Grid Interconnections*. [online] Vladivostok: Russian Federation. Available at: http://nautilus.org/archives/energy/grid/2003Workshop/ [Accessed Mar. 2018].

von Staden, L. 2016. *Barringtonia racemosa* (L.) Roxb. National Assessment: Red List of South African Plants version 2017.1. Accessed on 2018/05/30

Vorwerk, P.D., Froneman, P.W., Paterson, A.W., Strydom, N.A., Whitfield, A.K., 2008. Biological responses to a resumption in river flow in a fresh water deprived, permanently open southern African estuary. *Water SA* 34: 597-604.

Whitfield, A.K. 1998. Biology and ecology of fishes in Southern African estuaries. *Icthyological Monograph of the J.L.B. Smith Institute of Ichthyology* 2: 1-223.

Whitfield, A.K., 1992. A characterization of southern African estuarine systems. *Southern African Journal of Aquatic Sciences* 18: 89-103.

Whitfield, A., Elliott, M. 2011. Ecosystem and Biotic Classifications of Estuaries and Coasts. In: Wolanski E and McLusky DS (eds.) *Treatise on Estuarine and Coastal Science*, Vol 1. Academic Press, Waltham, pp. 99-124.

Appendix A : Summary of important environmental and socio-economic attributes of estuaries in each of the Corridors

Table A1: Summary of important environmental and socio-economic attributes of estuaries in the proposed Expanded EGI corridors.

Estuary	Distance in km from corridor coastal boundary							Reference Mean Annual runoff (m3x106)	Flood risk	Biodiversity Importance rating	Conservation Priority set (NBA 2012 Biodiversity Plan)	Estuary health (A=Natural, F=Severely degraded)	Important Fish Nursery (5=High, 1+Low)	Important Estuarine habitat (ha)					Total habitat area (ha)
	0-5	5-10	10-15	15-20	20-25	25-30	30-35							Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Mangroves	Swamp forest	
Western Corridor																			
Orange	x	x						10833.01	x	Very Important	SA/CAPE	D	5	144	602	1	0	0	3633
Buffels	x							9.33		Ave Importance		D	1	0	0.33	0	0	0	9.99
Swartlientjies	x							0.21		Ave Importance		B	1	0	0	0	0	0	0
Spoeg	x							1.07	x	Ave Importance	SA	A/B	2	0	31.3	0	0	0	32.21
Groen	x							0.46	x	Ave Importance	SA	B	1	0	12	0	0	0	31
Sout	x	x						1.50		Ave Importance		E	1	0	140.2	0	0	0	271.12
Olifants	x	x	x	x				1070.10	x	Very Important	SA/CAPE	C	5	91.9	849.1	47.7 4	0.0	0	1353.6 8

Estuary	Distance in km from corridor coastal boundary							Reference Mean Annual runoff (m3x106)	Flood risk	Biodiversity Importance rating	Conservation Priority set (NBA 2012 Biodiversity Plan)	Estuary health (A=Natural, F=Severely degraded)	Important Fish Nursery (5=High, 1+Low)	Important Estuarine habitat (ha)					Total habitat area (ha)
	0-5	5-10	10-15	15-20	20-25	25-30	30-35							Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Mangroves	Swamp forest	
Eastern Corridor																			
Durban Bay	x	x						36.33	x	Very Important	SA	E	5	0.0	0.0	8	16.0	5	1148
Mgeni	x	x	x					671.30	x	Important	SA	E	3	8.4	0.0	1	31.7	0.5	107.79
Mhlanga	x							13.34		Important	SA	D	1	0.0	0.0	0	0.0	0.2	82.78
Mdloti	x							100.19	x	Important		D	1	0.0	0.0	0	0.0	7.8	58.1
Tongati	x							70.79	x	Important		D	1	0.0	0.0	0	0.0	3.4	37.3
Mhlali	x							56.26	x	Important	SA	C/D	1	0.0	0.0	0	0.0	7	42
Mvoti	x							374.66	x	Ave Importance	SA	D	1	0.0	0.0	0	0.0	2	111
Mdlotane	x							6.04		Important	SA	B	1	0.0	0.0	0.71	0.0	12.33	25.42
Nonoti	x							36.24		Ave Importance		C	1	0.0	0.0	2.5	0.0	1	27
Zinkwasi	x							14.49		Important	SA	B/C	5	0.0	0.0	0	0.0	11.28	71.16
Tugela/Thukela	x	x	x					3753.60	x	Important	KZN priority	C	3	0.0	0.0	0	0.0	0.27	133.32
Matigulu/Nyoni	x	x						192.27	x	Important	SA	B	5	0.0	0.0	0.5	0.0	2	127
Siyaya	x							6.50		Ave Importance	SA	F	1	0.6	0.0	0.08	0.0	3.72	9.52
Mlalazi	x	x						164.31	x	Very Important	SA	B	5	0.0	39.3	0.001	60.7	3.46	238.771
Mhlathuze	x	x						645.00	x	Very Important	SA	C/D	5	60.0	0.0	28.5	652.1	0	1714.6
Richards Bay	x	x	x					0.00		Important	SA	D	5	52.0	0.0	0	267.	16	2044

Estuary	Distance in km from corridor coastal boundary							Reference Mean Annual runoff (m3x106)	Flood risk	Biodiversity Importance rating	Conservation Priority set (NBA 2012 Biodiversity Plan)	Estuary health (A=Natural, F=Severely degraded)	Important Fish Nursery (5=High, 1+Low)	Important Estuarine habitat (ha)					Total habitat area (ha)
	0-5	5-10	10-15	15-20	20-25	25-30	30-35							Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Mangroves	Swamp forest	
																	0		
Nhlabane (Present)	x	x						29.00		Important		D/E	3	0.0	0.0	1.1	0.0	0.3	14.4
Mfolozi	x	x	x					885.00	x	Very Important	SA	D	5	0.0	0.0	0	78.2	1683.1	3458.5
St Lucia	x	x	x	x	x	x		417.89	x	Very Important	SA	D	5	414.7	0.0	431.5	209.5	17.4	40832.8
Mgobezeleni	x							0.00		Ave Importance	SA	B	1	0.0	0.0	0	4.5	4	15.3
Kosi	x	x						0.00		Very Important	SA	A/B	5	58.0	229.0	652	71.0	869	5396

Appendix B: Peer Review and Specialist Response Sheet

Peer Reviewer: Professor Janine Adams; Nelson Mandela University

EXPERT REVIEW AND SPECIALIST RESPONSES: Estuaries - EGI Expansion					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 the Specialist**
Janine Adams	whole document			Don't use etc., check throughout document	This has been corrected throughout the report
Janine Adams	pg 10			This will set targets for use of specific chemicals in marine waters….	This has been updated
Janine Adams	pg 21	14		every estuary along this coast	This has been corrected on Page 22 (assumed peer reviewer is referring to page 22 - as for the Gas Report)
Janine Adams	pg 22	44		which are located within the EFZ and close to….	This has been updated
Janine Adams	pg 29, 30		Figures 5 & 6	Change sensitive to Sensitivity map	This has been corrected - it is assumed the peer reviewer is referring to Figure 6 and 7.
Janine Adams	pg 33	13-14		The nett result is that infrastructure will over time be exposed to erosion…..	This has been corrected
Janine Adams	pg 41	21		any estuarine ecosystem	This has been corrected
Janine Adams	pg 43	31		where required	This has been corrected
Janine Adams	pg 48	18		monitor	This has been corrected
Janine Adams	pg 48	22-23		Without this detailed estuary-specific sediment process understanding, predicting impacts of any structures within an estuary EFZ is difficult.	This has been corrected
Janine Adams	pg 49-53			check that species names are in italics	This has been corrected
Janine Adams	pg 49			correct spelling of Fernandes	This has been corrected
Janine Adams			OVERVIEW	The report is technically sound, these review comments relate only to typos and formatting.	Noted

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.6

Biodiversity and Ecological Impacts (Aquatic Ecosystems and Species) - Wetland and Rivers

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

FRESHWATER ECOSYSTEMS

Contributing Authors	Gary de Winnaar[1], Dr Vere Ross-Gillespie[1]

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ABBREVIATIONS AND ACRONYMS

ADU	Animal Demographic Unit
ASPT	Average Score Per Taxon
BSP	Biodiversity Sector Plan
CBA	Critical Biodiversity Area
C-Plan	Conservation Plan
CR	Critically Endangered
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EGI	Electrical Grid Infrastructure
EI	Ecological Importance
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
EN	Endangered
ES	Ecological Sensitivity
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
HGM	Hydrogeomorphic
IHI	Index of Habitat Integrity
IUCN	International Union for Conservation of Nature
LC	Least Concern
NBA	National Biodiversity Assessment (2011)
NFEPA	National Freshwater Ecosystem Priority Areas
PA	Protected Area - statutory
PES	Present Ecological State
QV	Quality Value
SA	South Africa
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System
SEA	Strategic Environmental Assessment
Spp	Species
SQ4	Sub-quaternary catchment
ToPs	Threatened or Protected Species
TSP	Threatened Species Programme
VU	Vulnerable
WULA	Water Use License Application

1 SUMMARY

This assessment aims to identify the potential impacts of constructing and maintaining Electricity Grid Infrastructure (EGI) to freshwater ecosystems and biodiversity in two proposed Expanded EGI corridors the North Eastern and North Western coasts of South Africa.

The proposed Western Expanded EGI corridor is characterised by a drier climate and resultantly more ephemeral / non-perennial aquatic systems, thus with an anticipated lower sensitivity to EGI development. Conversely the proposed Western Expanded EGI corridor contains permanent aquatic features and is anticipated to be overall more sensitive to EGI development.

The key risks to freshwater ecosystems associated with EGI development includes:

- Direct loss of riparian and wetland vegetation;
- Fragmentation of freshwater ecosystems and flow patterns;
- Waste pollution and contamination of aquatic environments;
- Compaction of soils and creation of preferential flow paths with and adjacent to wetland and river habitats;
- Increased erosion;
- Infestation of alien invasive plants in aquatic systems; and
- Disturbance to and mortality of fauna.

In order to reduce potential impacts of EGI development on freshwater ecosystems (including habitat and biodiversity), sub-quaternary catchments classified with a very high or high sensitivity should be avoided as far as possible. Where avoidance of sensitive sub-quaternary catchments is not possible, detailed desktop investigations should be conducted, followed by specialist in-field assessments and verification. This will determine whether the fine-scale, micro-sited EGI alignment and development footprints can avoid the freshwater ecosystems (i.e. wetland and river habitats) and associated buffers within identified sensitive sub-quaternary catchments. Following this assessment, appropriate management actions may be determined and implemented as required.

2 INTRODUCTION

In January 2014 the Department of Environmental Affairs (DEA), mandated by Ministers and Members of the Executive Council (MinMec), commissioned the Council for Scientific and Industrial Research (CSIR) to undertake a Strategic Environmental Assessment (SEA) linked to SIP 10: Electricity Transmission and Distribution for all. The SEA, entitled "the national Department of Environmental Affairs Electricity Grid Infrastructure Strategic Environmental Assessment" was aimed primarily at establishing routing corridors to enable the efficient and effective expansion of key strategic transmission infrastructure designed to satisfy national transmission requirements up to the 2040 planning horizon. Preliminary Eskom corridors were assessed collaboratively in 2016 (DEA, 2016) by a number of specialists and institutions, however, since then refinements have been made to the routing/corridors. The CSIR together with Eskom, the South African National Biodiversity Institute (SANBI) and a number of experts worked collaboratively to undertake high impact assessments of key biophysical factors related to the refined routing corridors. The SEA process also provides a platform for coordination between the various authorities responsible for issuing authorisations, permits or consents and thereby will further contribute to a more streamlined environmental authorisation process (DEA, 2016).

Construction of Electricity Grid Infrastructure(EGI) including transmission lines, interconnections, substations and road networks have both positive and negative impacts at varying scales and at different stages of the power supply chain life cycle from extraction of fuels to construction and operation phases (Von Hippel and Williams, 2003). Evaluating potential impacts for the entire supply chain of EGI is important for optimising EGI interconnection opportunities and routing. Typically the environmental considerations of EGI development have received less emphasis than economic, technical and political issues, especially in developing regions, highlighting the importance of considering environmental impacts at an early stage (e.g. through conducting SEA's) and identifying potential problems (e.g. routing of transmission lines through/over sensitive ecosystems, difficult terrain) (Von Hippel and Williams, 2003).

While a variety of environmental issues have been identified with the full life cycle of EGI including amongst others: air pollutant emissions (local and regional), both particulate and the precursors of acid precipitation, water pollution, solid waste generation, land use impacts, disturbance to wildlife, loss of biodiversity and habitat and also human health; those related to impacts on freshwater ecosystems are the focus of this study and are discussed in detail in the following sections.

3 SCOPE OF THIS STRATEGIC ISSUE

This strategic issue focuses on impacts/threats to freshwater ecosystems, specifically the assessment of biodiversity and ecological impacts linked to rivers and wetlands as part of the SEA for the identification of energy corridors, as well as to provide management measures for the expansion of EGI for South Africa.

The primary objective of this study will be to provide an assessment of freshwater ecosystems (i.e. rivers and wetlands) and associated biodiversity within pre-identified corridors as supplied by the CSIR (Figure 1). The assessments will inform the SEA through identification of constraints (e.g. sensitive rivers and wetland ecosystems, critical areas for aquatic fauna and flora, etc.) and opportunities for the EGI development.

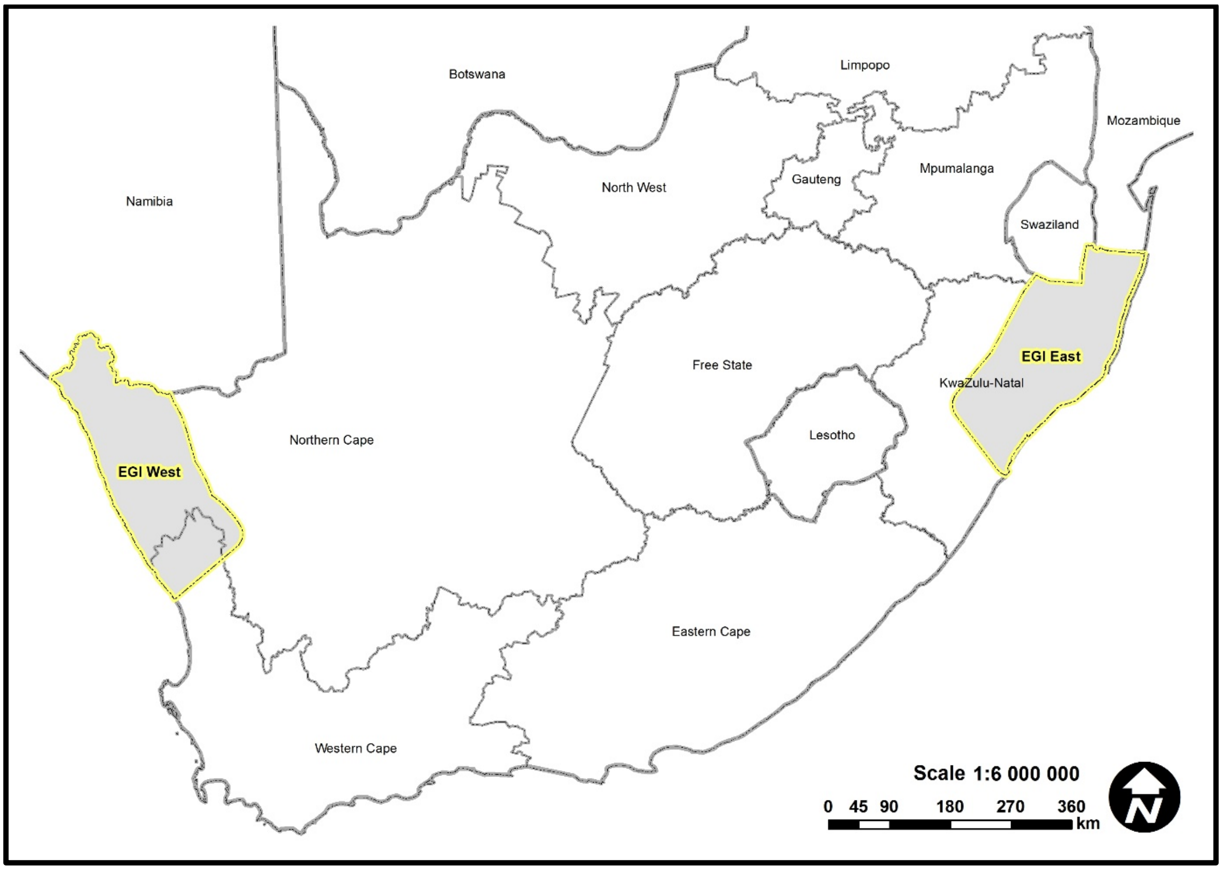

Figure 1: Overview of the proposed EGI corridors (East and West).

This assessment is focused primarily on the interpretation of existing data and is based on defensible and, if available, standardised and recognised methodologies. The focus is primarily to review the environmental wall to wall mapping outputs produced by the CSIR and SANBI (specifically relating to the additional EGI corridors), and to discuss the direct, indirect and cumulative impacts. Any gaps in information linked to aquatic biodiversity associated with rivers and wetlands with respect to the expanded EGI were identified as potential shortcomings needing to be addressed through further screening and ground-truthing assessments.

The study methodology developed as part of this project is intended to inform future SEAs in terms of specialist assessment methodologies. The study also incorporates a review of available data and information (e.g. the CSIR environmental wall to wall mapping, SANBI datasets, etc.), and builds on discussions with the relevant organisations related to aquatic ecosystems and biodiversity (e.g. SANBI, National Department of Water and Sanitation (DWS), etc.). This is to ensure that the outcomes of the study are accepted by these agencies, and will be taken into consideration for future authorisation and commenting within the areas assessed.

The assessment of freshwater ecosystems and biodiversity includes the following:

- Review of existing literature (including the latest research undertaken both locally, nationally and internationally), mapping/aerial photographs, and habitat and species data to compile a baseline description applicable to each corridor;
- Identification of any additional features of interest (large waterfalls, spray zones, etc.) or any gaps in information within the corridors not identified in the existing sensitivity analysis, making use of datasets made available through the draft environmental constraints map and additional information sourced by the specialist;
- High level distribution mapping for sensitive aquatic species occurring within South Africa;
- Review and update, where required, the environmental sensitivity/attribute map for the proposed additional EGI corridors provided by the CSIR and SANBI and develop/verify the approach for classing each sensitivity feature according to a four-tiered sensitivity rating system (i.e. very high, high, medium or low);
- Assess the proposed corridors in terms of the potential impacts associated with the construction and operation of EGI, taking cognisance of the relative sensitivity of areas, and outline proposed management actions to enhance benefits and avoid/reduce/offset negative impacts – this was done as per the impact assessment methodology provided by the CSIR Project Team;
- Based on the findings of the assessment, provide the relevant information and produce an updated four-tiered sensitivity map related to the field of expertise and the relevant corridors.
- Provide input to the pre-construction site specific environmental assessment protocol (e.g. additional information and level of assessment required in each sensitivity category before an authorisation with respect to aquatic biodiversity impacts), checklist, norms or standards, and Environmental Management Programme (EMPr) for the development of the expanded EGI.

Further to the above scope of work, the following information and data was considered as a minimum as part of the study, with more recent data consulted as appropriate:

- The latest Systematic Biodiversity Plans relevant to the study area, including input layers where applicable, as well as relevant land-use and impact assessment guidelines associated with these plans, e.g. the National Freshwater Ecosystem Priority Areas (NFEPA) technical report (Nel *et al.* 2011), and its associated implementation manual (Driver *et al.*, 2011).
- The 2011 National Biodiversity Assessment (NBA), including its spatial layers (specifically layers that were not used for the environmental constraints map), but that are relevant at a finer scale (Nel and Driver, 2012).
- The latest species information available for the study area in particular, but not limited to sensitive species that are dependent on these riparian zones, including specific Red Listed plants (Raimondo *et al.*, 2009), butterflies, (Mecenero *et al.*, 2013), reptiles (Bates *et al.*, 2014).
- Fine-scale spatial biodiversity information, e.g. additional wetland or species information that may not have been included in a systematic biodiversity plan.

It is important to note that the outputs from this study will form the basis of a planning and decision-support document for EGI development in the respective corridors. The aim of the planning document will be to inform and focus further aquatic project-level assessments (as they relate to rivers and wetlands) with respect to EGI development in the respective corridors (i.e. serve as a scoping exercise).

The key deliverables and reporting requirements of this project include:

- Specialist Assessment Report based on a specialist report template provided by the CSIR for the SEA, for review and comment, but covering the following:
    - Summary of key points, including degree-of-certainty terms;
    - Introduction – brief discussion of the essential background on the Strategic Issue;
    - Definition of issue scope and key terms;
    - Key attributes and sensitivities of the study areas towards the development of powerlines and associated infrastructure within the additional EGI corridors - baseline description of each proposed corridor (study area) relating to the issue topic and spatial sensitivity analysis (for spatially explicit topics), inclusive of a literature review in line with the strategic issue;
    - Description of methodology and approach to the study;
    - Description of the key potential impacts (positive and negative, including direct, indirect and cumulative) that are associated with EGI activities relating to the issue topic (inferred and distilled from the Project Description document provided to Authors), and their spatial and temporal distributions, including required mitigation measures;
    - The sensitivity delineation should be undertaken in the context of the development of EGI including transmission lines, distribution lines and substations
    - The results of a structured risk and opportunity assessment which evaluates the impacts, with and without mitigation, for each study area, and clearly defines consequence terms;
    - Updated four-tiers sensitivity map;
    - Outline proposed mitigation measures and management actions to enhance benefits and avoid/reduce/offset negative impacts for construction and operation phase. This will form part of the EMPr;
    - Best practice and management guidelines for EGI development (including inputs in the norms or standards, and the Site Specific Environmental Assessment Protocols and Checklist), monitoring requirements and recommendations for future site-specific assessment in relation to the Strategic Issue;
    - Gaps in knowledge; and
    - References.
- Geographic Information System (GIS) Assessment Dataset and additional information sourced by the specialist;
- Metadata for the Assessment Dataset (DEA metadata template, must be used - template will be provided upon appointment);
- GIS based four-tiered consolidated sensitivity map of all sensitivity features identified through the assessment showing the location and spatial extent for each sensitivity feature and associated buffering. The sensitivity rating should be illustrated according to the following coloration scheme: Dark Red/Very High, Red/High, Orange/Medium, Green/Low; and
- A guideline on the interpretation and implementation of the four tier maps as well as permit requirements (where applicable) for each corridor. This section should also make recommendations on requirements for additional terrestrial and aquatic biodiversity specialist studies (if any) within the different tiers of sensitivity specialist before an authorisation can be considered. Recommendations should be focused around the objective of streamlining without compromising environmental protection. This information will be incorporated into the Decision-Making tools that will ultimately govern development in the corridors.

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 3 of this report.

4 APPROACH AND METHODOLOGY

4.1 Study Methodology

The study was based on a combination of desktop assessments building on strengths of GIS mapping and geospatial analyses, and builds on meetings and discussions with relevant authorities and experts. This ensured a thorough interpretation of existing data incorporating defensible and rigorous methodologies. The following steps outlined below were followed.

4.1.1 Briefing session

A representative from the GroundTruth team attended a one-day briefing session at the CSIR in Stellenbosch to meet the Integrating Authors and Contributing Authors to discuss and define the assessment phase of the project. The briefing session served to refine/agree on the scope of work, deliverables and timing, as well as to make sure all available data and information from the CSIR could be obtained upfront and as timeously as possible.

4.1.2 Literature review and data collation

The accuracy of information generated for the SEA is only as good as the information on which they are derived. Thus, as far as possible, the quality and validity of data obtained for the assessment of aquatic biota and ecosystems has been reviewed and refined to allow for integration to an appropriate scale/resolution. This process included the collation of datasets from a variety of sources, which were subsequently reviewed and assessed for suitability/relevance for the spatial assessments associated with freshwater rivers and wetlands. The datasets used in this component of the SEA, and sources where the data was obtained are indicated in Section 4.2.

4.1.3 Assigning a suitable spatial scale for analysis

All spatial data obtained for the freshwater ecosystem component were considered in terms of a suitable spatial unit/scale of measurement deemed practical for the purpose of assessing the expanded EGI corridors, as well as the alignment of associated infrastructure within the corridors. The sub-quaternary (SQ4) catchments for South Africa was decided as the most appropriate scale for the spatial analyses and assessment of freshwater ecosystems within the SEA corridors. This allowed for the scaling up of data to assess the corridors relative to each other.

4.1.4 Analysis and integration of GIS data

All spatial/GIS data obtained for the freshwater component were assessed firstly in terms of applicability/suitability, then merged/joined with other layers, then clipped according to the relevant EGI corridors as provided by the CSIR in order to assess the sensitivity-level of the corridors. All spatial analyses were undertaken using ArcGIS 10 software (version 10.4.1).

4.1.5 Application of metrics for sensitivity analyses

<u>River threat status and sensitivity:</u>
Threat status has been applied to river ecosystems as per thresholds defined in the Freshwater Component of the 2011 South African NBA (Nel and Driver, 2012), but using updated Present Ecological State (PES) information. The 2011 NBA used PES data from 2000 (Kleynhans, 2000) whereas the report here draws on the more recent PES, EI (Ecological Importance) and ES (Ecological Sensitivity) data from DWS (2014).

In addition to the threat status calculation, a metric was developed to integrate EI and ES component scores from the 2014 DWS study, the derived threat status (as above), as well as stream order. EI and ES scores represent ecological importance and sensitivity scores for freshwater ecosystems as separate, yet complimentary, components of PES. They are not currently accounted for in the threat status calculation, which uses river length and overall PES category/river health condition, but nevertheless provide valuable information regarding ecological sustainability. EI refers to biophysical aspects in the reach that relates to its capacity to function sustainably, whereas ES considers reach attributes that relate to the sensitivity of biophysical components to general environmental changes such as flow, physico-chemical and geomorphic modifications. EI and ES categories were ranked as scores from one to four (i.e. very low and Low = 1, moderate = 2, high = 3, and very high = 4), along with threat status (i.e. Critically Endangered or CR = 4, Endangered or EN = 3, Vulnerable or VU = 2, Least Concern or LC = 1). These scores were then considered in relation to stream order as per the following equation, such that the higher the score, the higher the overall sensitivity of the river ecosystem:

River Sensitivity = Threat Score + (EI Score + ES Score / Stream Order)

In basic terms, the higher the score the more sensitive the freshwater system. In addition, the metric favours higher order streams in the catchment which feed downstream systems.

<u>Wetlands threat status and sensitivity:</u>
The extent and distribution of wetland ecosystems (and their importance and sensitivity) was defined using a variety of available wetland datasets. These datasets cover a range of scales (i.e. national and provincial, down to fine-scale mapping for certain local municipalities), and include a variety of information pertaining to wetland habitats, such as wetland types, condition and conservation importance. The objective of the wetland mapping was to define areas containing wetland habitat in terms of sensitivity and importance based on the information available. A composite wetland layer was developed with this in mind, and followed a systematic process of sourcing, reviewing/analysing, cleaning and collating relevant datasets for each province. Provincial datasets were then collated, and routinely cleaned of any redundant data. Field attributes contained in the combined wetland coverage were categorised using four sensitivity classes as summarised in Table 1. A hierarchical selection process was followed to assign the highest sensitivity to each wetland feature contained in combined coverage.

Table 1: Criteria for assigning sensitivity classes for wetland attributes

Sensitivity class/value	Wetland attribute
Low sensitivity (sensitivity value = 1)	Wetland probability, non-NFEPA wetlands, least threatened wetlands, other natural areas (ONAs) as aquatic features, protected aquatic features.
Medium sensitivity (sensitivity value = 2)	NFEPA wetlands, nearly threatened wetlands, ecological support areas (ESAs) as aquatic features.
High sensitivity (sensitivity value = 3)	Ramsar site wetlands, KZN priority wetlands, Endangered or Vulnerable wetlands, optimal critical biodiversity areas (CBA2s) as aquatic features.
Very high sensitivity (sensitivity value = 4)	Critically Endangered wetlands, irreplaceable critical biodiversity areas (CBA1s) as aquatic features.

Due to large size of the combined wetland coverage, it was deemed practical to remove wetland features smaller than 0.50 and 0.25 hectares for the low and medium sensitivity classed wetlands. For the Western Cape, a more rigorous cleaning process was required due to the impractical file sizes that were created as a result of combining multiple fine-scale datasets. Thus for the Western Cape, aquatic CBA features less than one hectare, and aquatic ESA features less than two hectares were removed. Furthermore, it was found that the ESA layers were particularly cumbers, so only ESA features that are connected to CBAs were included in the final wetland layer for the Western Cape.

The threat status of wetlands was defined using the national wetland vegetation groups (Nel and Driver, 2012). Wetlands occurring within a particular wetland vegetation group (or region) were assigned the threat category of that region, and then allocated a threat score (i.e. CR = 4, EN = 3, VU = 2, LC = 1). The threat scores were combined with the initial wetland sensitivity values (based on Table 1) by adding the scores and values together to produce an overall risk/sensitivity score of wetlands within the study area.

In order to account for the aerial extent of wetland habitat, the risk/sensitivity scores for each wetland feature were multiplied by the proportion of wetland (of a particular risk/sensitivity) within each SQ4 catchment. These area-weighted risk/sensitivity scores were then summed together for each SQ4 catchment, and then collapsed into the four sensitivity classes using a quantile data split.

The final result of the wetland integration and spatial analysis was a SQ4 coverage showing areas of low, medium, high and very high sensitivity taking into account threat status, and importance/sensitivity and extent of wetland habitat. However, it is also prudent to consult the combined wetland feature map, which displays the actual sensitivity scores for each wetland feature.

Freshwater biota (species and families):
Information of freshwater biota was used as an additional level of detail in order to assess the sensitivity/importance of SQ4 catchments within the EGI corridors. To achieve this, taxonomic groups that are representative of freshwater ecosystems were considered, especially where data of known localities was found to be sufficiently detailed and accessible. These groups include: freshwater plants, aquatic macro-invertebrates, dragonflies/damselflies (i.e. Family: Odonata), freshwater fish, amphibians, obligate reptiles and obligate mammals. Information of the conservation status/importance of species from these taxonomic groups was considered particularly important in terms of being able to establish the sensitivity of areas. To achieve this, data of Red Listed species was sourced to obtain the latest available assessments (global and national) of species done according to the International Union for Conservation of Nature (IUCN) criteria and Red Listing requirements (IUCN, 2012). Species selected primarily for this study included freshwater species of conservation importance, i.e. species listed as Threatened (i.e. Critically Endangered, Endangered and Vulnerable), Near Threatened and Data Deficient.

Freshwater plants (Kingdom: Plantae):
The conservation status of a large number of plants occurring within South Africa has been assessed by Raimondo *et al.* (2009). As with the other taxa, freshwater plants listed as Threatened, Near Threatened and Data Deficient were selected for this study, which includes 40 species of plants (Appendix 1) that inhabit a range of freshwater habitats, broadly including wetlands, rivers and riparian areas. Point localities (approximately 661 records) for the selected plant species were obtained from the SANBI Threatened Species Programme (TSP) database (SANBI, 2018). As with the other taxonomic groups, these point records were assigned to SQ4 catchments to derive a presence/absence coverage, which were then classified into the four sensitivity classes (i.e. low, medium, high, very high).

Aquatic macro-invertebrates (Class: Insecta):
Species-level data for invertebrates is generally limited or biased toward certain groups (e.g. butterflies and dragonflies/damselflies), however, family-level data is more obtainable. Furthermore, families of most macro-invertebrates (94 families) have variable tolerances to water quality and quantity impacts with specific Quality Values (QV - an indication of their sensitivity to land use and water quality/quantity impacts ranging from 1 to 15) - this is the basis of river health biomonitoring.

Point localities for the 94 macro-invertebrate families recorded from a total of 4 350 river sites in South Africa, of which 11 (or 0.2%) and 348 (or 8%) are located within the western and eastern EGI corridors respectively, were assigned to a 1:10 000 grid vector. For each grid cell the total diversity was calculated from which two separate but complementary indices were then derived, namely:

- South African Scoring System (SASS) Score - sum of all families multiplied by their respective QV as occurring within a particular grid cell; and
- Average Score Per Taxon (ASPT) - the SASS Score divided by the total number of recorded families for a particular grid cell.

SASS Scores and ASPT values were then assigned to a river ecoregion (Level 2) by selecting grid cells where more than half of the grid cell falls within a particular ecoregion. Average SASS Scores and ASPT values was calculated for each river ecoregion using all grid cell data within each ecoregion. Average ASPT values were then classified into four sensitivity classes (i.e. low, medium, high, very high) using a Quantile split in the dataset using ArcGIS 10 software (version 10.4.1).

Dragonflies and Damselflies (Family: Odonata):
All species of Odonata (i.e. dragonflies and damselflies) have been assessed in terms of their conservation status/importance within South Africa (IUCN, 2017; Samways and Simaika, 2016). Species listed as Threatened, Near Threatened and Data Deficient, were selected for this study, which includes 13 listed species (Appendix 2). Point localities (approximately 164 records) where these conservation important dragonflies and damselflies have been recorded were obtained from the SANBI (TSP) database (SANBI, 2018). Point records were assigned to SQ4 catchments to derive a presence/absence coverage of each species per catchment. The SQ4 catchments were then classified into four sensitivity classes (i.e. low, medium, high, very high) based on the presence/absence of conservation important dragonflies and damselflies where catchments supporting Critically Endangered species have a "very high" sensitivity, Endangered and Vulnerable species have a "high" sensitivity, Near Threatened and Data Deficient species have a "medium" sensitivity, and all remaining catchments not known to support conservation important species have a "low" sensitivity.

Freshwater Fish (Class: Actinopterygii):
Most of the freshwater fish that occur within South Africa have been recently assessed and are now Red Listed, with only a few species still requiring assessments (Coetzer, 2017). Twelve species of conservation importance were selected for this study (Appendix 2). Point localities (approximately 233 records) for nine of these selected species were obtained from the Global Biodiversity Information Facility (GBIF) database via the South African Institute for Aquatic Biodiversity (SAIAB). These point records were assigned to SQ4 catchments to derive a coverage of presence or absence of each species per catchment based on known point locations. Distribution data for the other three selected fish species was spatially defined by selecting SQ4 catchments where each species occurs as inferred from the IUCN Red List of Threatened Species Map Viewer (IUCN, 2017). As with dragonflies and damselflies, all SQ4 catchments were then classified into four sensitivity classes (i.e. low, medium, high, very high) based on the presence/absence of conservation important freshwater fish.

Amphibians (Order: Anura):
The conservation status of most amphibians occurring within South Africa has been assessed by Minter *et al.* (2004). As with the other freshwater taxa, amphibians listed as Threatened, Near Threatened and Data Deficient selected for this study includes eight listed species (Appendix 2). Point localities (approximately 2 248 records) for these selected species were obtained from the SANBI (TSP) database (SANBI, 2018). These point records were assigned to SQ4 catchments to derive a coverage of presence or absence of each species per catchment based on the known point locations. The SQ4 catchments were then classified into four sensitivity classes (i.e. low, medium, high, very high) based on the presence/absence as done for the other freshwater taxonomic groups.

Reptiles (Order: Reptilia):
The conservation status of most reptiles (i.e. terrapins, geckos, lizards, chameleons, and snakes) that occur within South Africa have been assessed by Bates *et al.* (2014). Reptiles listed as Threatened, Near Threatened and Data Deficient selected for this study includes four listed species (Appendix 2). In addition, only those reptiles that are defined as freshwater ecosystem obligates (i.e. species that is entirely or mostly dependent on aquatic, wetland and riparian habitats to exist) were considered. Point localities (approximately 1 477 records) for these selected species were obtained from the SANBI (TSP) database (SANBI, 2018). These point records were assigned to SQ4 catchments to derive a coverage of presence or absence of each species per catchment based on the known point locations. The SQ4 catchments were then classified into four sensitivity classes (i.e. low, medium, high, very high) based on the presence/absence as done for the other freshwater taxonomic groups.

Mammals (Order: Mammalia):
The conservation status of most mammals that occur within South Africa have been assessed by Child *et al.* (2016). As with the other taxa, only mammals listed as Threatened, Near Threatened and Data Deficient were selected for this study, which includes eight listed species (Appendix 2). In addition, only those mammals that are defined as freshwater ecosystem obligates (i.e. species that is entirely or mostly dependent on aquatic, wetland and riparian habitats to exist) were considered. Point localities

(approximately 494 records) for these selected species were obtained from the SANBI (TSP) database (SANBI, 2018). These point records were assigned to SQ4 catchments to derive a coverage of presence or absence of each species per catchment based on the known point locations. The SQ4 catchments were then classified into four sensitivity classes (i.e. low, medium, high, very high) based on the presence/absence as done for the other freshwater taxonomic groups.

4.1.6 Integration of taxonomic groups

Sensitivity values of the aforementioned taxonomic groups, ranging from one to four (i.e. low to very high sensitivity), were combined into a single layer in order to calculate overall biotic sensitivity for each SQ4 catchment. Linear weightings were applied to each of the groups based on the ability of respective species being able to escape/disperse away from disturbance and impacts to habitats. Plants being sedentary were thus given the highest weighting of five, followed by amphibians (weighting of four), fish (weighting of three), dragonflies and damselflies (weighting of two), and macro-invertebrates (weighting of one). The weighted sensitivity values were summed together to produce a total score for each SQ4 catchment, which were then collapsed into the four sensitivity classes using a quantile data split.

4.1.7 Producing integrated four tier sensitivity maps

The sensitivity maps produced for rivers, wetlands and combined freshwater biota were also integrated into a single layer by summing the sensitivity values for each component. 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 electrical infrastructure in order to reduce impacts on freshwater ecosystems and associated biodiversity.

4.2 Data Sources

Table 2: Data used in this assessment.

Data title	Source and date of publication	Data Description
SQ4 sub-quaternary drainage regions (referred to as SQ4 catchments)	DWS (2009)	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 proposed Expanded EGI corridors include 761 SQ4 catchments ranging from 0.25 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 *et al.* (2005)	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 12 Level 1 and 29 Level 2 River Ecoregions occur within the proposed Expanded EGI corridors.
River Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (ES)	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 conducted in 2013.
NFEPA rivers and wetlands	Nel *et al.* (2011)	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 (2018)	Distribution and extent of areas that contain wetlands of international importance in South Africa.
National Wetland Vegetation Groups	Nel and Driver (2012)	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.

Data title	Source and date of publication	Data Description
Provincial Wetland Probability Mapping	Collins (2017)	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.
KwaZulu-Natal Freshwater Systematic Conservation Plan	Ezemvelo KZN Wildlife (2007)	This is the freshwater planning unit surface for KZN based on the 2007 Freshwater Systematic Conservation Plan (FSCP) run by Dr. Nick Rivers-Moore using MARXAN using catchment planning units. Catchments “earmarked” for freshwater conservation were selected as CBAs for this study as these areas represent optimal biodiversity areas required to meet biodiversity targets.
KwaZulu-Natal Vegetation Types	Scott-Shaw and Escott (2011)	This coverage represents an update of the KZN vegetation map as completed in September 2009. Several additions have been made which is represented in the Appendix 1 of the KwaZulu-Natal Vegetation Type Description Document for Vegetation Map 2011. These additions were made based on data that was received in an effort to make the map more current and representative of KZN’s vegetation. The coverage includes a variety of wetland types with conservation statuses that are specific to KZN conservation planning.
Western Cape Biodiversity Spatial Plans (fine-scale mapping)	CapeNature (2017)	The Western Cape Biodiversity Spatial Plans (WCBSP) are products of a systematic biodiversity planning process that maps terrestrial and aquatic CBAs and ESAs that require safeguarding to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services. These spatial priorities are used to inform sustainable development in the Western Cape Province. Mapping regions for the BSPs include: Beaufort West, Berg River, Bitou, Breede Valley, Cape Agulhas, Cederberg, City of Cape Town, Drakenstein, George, Kannaland, Knysna, Laingsburg, Langeberg, Mossel Bay, Oudtshoorn, Overstrand, Prince Albert, Saldanha Bay, Swellendam, Theewaterskloof and Witzenberg. Aquatic CBAs and ESAs were selected for all the BSPs and merged together to create a complete BSP for the Western Cape.
Northern Cape Critical Biodiversity Areas	Northern Cape Department of Environment and Nature Conservation (2016)	Coverage of Aquatic Critical Biodiversity Areas as obtained from the Northern Cape Biodiversity Conservation Plan (BCP). Coverage of CBAs for the Northern Cape based on a Systematic Conservation Planning approach that incorporates data on biodiversity features (incorporating both pattern and process, and covering terrestrial and inland aquatic realms), condition, current Protected Areas and Conservation Areas, and opportunities and constraints for effective conservation.
Northern Cape District Municipality Aquatic Critical Biodiversity Areas	Botanical Society of South Africa (2007; 2008)	Identified and mapped aquatic CBAs for selected municipalities within the Northern Cape namely, Hantam District Municipality (2007) and Namakwa District Municipality (2008). CBAs are derived from one are many biodiversity features used in the mapping. Aquatic CBAs were selected and integrated with the more recent provincial mapping.

Data title	Source and date of publication	Data Description
Freshwater aquatic plants	Raimondo *et al.* (2009), with spatial data provided by SANBI (2018)	Point locations (from a total of 661 records) of conservation important plant species (40 species) that inhabit wetland, river and riparian habitats.
Dragonflies and damselflies (Odonata)	IUCN (2017) and Samways and Simaika (2016), with spatial data provided by SANBI (2018)	Point locations of dragonflies and damselflies taken from a total of 164 records for these selected species within South Africa for the EGI Corridors. This data includes records of the conservation important Odonata selected for this assessment.
Aquatic macro-invertebrates	DWS (2015)	Point shapefiles of 94 aquatic macro-invertebrate families recorded from 359 monitoring sites on rivers within South Africa, of which 11 (or 0.2%) and 348 (or 8%) are located within the western and eastern EGI corridors respectively.
Freshwater fish	Coetzer (2017)	Point locations for freshwater fish for South Africa taken from a total of 233 records. This data includes records for approximately half of the conservation important fish in South Africa.
Fish distributions	International Union for the Conservation of Nature (2017)	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 three of the selected fish species.
Amphibians	Minter *et al.* (2004), with spatial data provided by SANBI (2018)	Point locations of amphibians was taken from a total of 2 248 records for these selected species within South Africa for the EGI Corridors.
Reptiles	Bates *et al.* (2014), with spatial data provided by SANBI (2018)	Point locations of reptiles was taken from a total of 1 477 records for these selected species within South Africa for the EGI Corridors.
Mammals	Child *et al.* (2016), with spatial data provided by SANBI (2018)	Point locations of mammals was taken from a total of 494 records for these selected species within South Africa for the EGI Corridors.

4.3 Assumptions and Limitations

Table 3: Assumptions and limitations.

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
This is a desktop assessment of biodiversity sensitivity based largely on existing datasets, with some expert review and input from the consultant team.			
Suitable spatial scale and unit for analysis	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.	Data outputs as points or grid cells.	Data representing freshwater ecosystems and biota are contained and displayed using sub-quaternary catchments units. The integration of all data according to a suitable scale will be undertaken by CSIR.
Data accuracy and reliability	Use of existing datasets that have been verified, with some datasets further refined at the desktop level.	Ground-truthing and further infield verification of datasets.	Existing datasets are assumed accurate until such a time as they have been accurately verified.
Potential species-level data sampling bias	Available species datasets, including freshwater plants, aquatic invertebrates, dragonflies and damselflies, fish, amphibians, reptiles (freshwater obligates) and mammals (freshwater obligates)	Ground-truthing and further infield verification of datasets.	Species-level datasets are inherently biased by sampling effort. Datasets used in this study are likely to contain such bias and this has not been adjusted for or improved.
Wetland classification according to HGM units not available for all wetlands layers	The conservation importance/threat status of wetlands was determined using the national wetland vegetation groups.	Verification of HGM units and determination of wetland conservation/ threat status according to HGM type.	The spatial resolution of characterising the threat status of wetland is considered sufficient for the scale of study and ensures that the output layers are contiguous.
Occurrence of species, including Critically Endangered, Endangered, Vulnerable and other species of conservation concern is not exhaustive	Only point data for species of conservation concern was used based on current availability and sources.	Ground-truthing/ verification of species presence/absence from all areas, as well as modelled distribution data.	The latest available conservation assessments for species is considered conservative as additional records/localities overtime tend to reduce the threat status of a particular species. Added precaution is included in the GIS layers whereby point data has been assigned to sub-quaternary catchments.

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Protected Areas layers	No protected areas layer data was included	Protected Areas layers were not used in this study.	Aquatic ecosystems and features are inherently less sensitive given the levels of protection. Protected areas 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.
Working with large datasets, particularly fine-scale plans	The fine-scale GIS layers have been thinned out to make processing more efficient - allowing a suitable fine scale resolution for strategic planning, whilst ensuring efficient processing.	Small wetland fragments from fine-scale GIS data layers were excluded, and scaled according to sensitivity.	Site specific studies will utilise all information available (SEA threat and sensitivity layers) as well as the detailed fine-scale GIS layers. Such fine-scale detail is potentially excessive at the strategic planning phase.

4.4 Relevant Regulatory Instruments

A detailed list and description of all relevant regulatory instruments associated with freshwater ecosystems at an international, national scale, as well as provincial scale as per the compendium of South African Environmental Legislation (van der Linde, 2006) for each focus area is provided in Table 4.

Table 4: International, national and provincial regulatory instruments relevant to freshwater ecosystems.

Instrument	Key objective	Feature
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. South Africa is a signatory to the Ramsar Convention and is thus obliged to promote the conservation of listed wetlands and the 'wise management' of all others.	Ramsar Wetlands
IUCN Red List of threatened species	Provides the most comprehensive inventory of the global conservation status of plant and animal species. Uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. The criteria used are relevant to all species and all regions of the world.	Species diversity
The Convention on Biological Diversity (1992)	Focused on the conservation of biological diversity, the sustainable use of its components, the fair and equitable sharing of the benefits from the use of genetic resources	Species diversity
Regional Instrument		
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	Transboundary Rivers
National Instrument		
National Environmental Management Act (Act 107 of 1998), as amended	NEMA sets out the fundamental principles that apply to environmental decision making, some of which derive from international environmental law and others from the constitution. The National Environmental Management Act of 1998 (NEMA), outlines measures	Relevant to rivers and wetlands during all phases

Instrument	Key objective	Feature
	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.” Of particular relevance to this assessment is Chapter1(4r), which states that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.	
NEMA EIA 2014 Regulations, as amended April 2017 (Government Gazette 40772)	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, including freshwater 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 environmental impact assessment.	Relevant for planned EGI construction/ development in proximity to wetlands, rivers and critical biodiversity areas
Water Research Act (Act 34 of 1971)	Promotes water related research	All water resources, and associated ecosystems
National Water Act (Act 36, 1998)	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 (WULA) or General Authorisation (GA), irrespective of the condition of the affected watercourse. Includes international management of water.	Relevant to rivers and wetlands during all phases
National Water Resource Strategy (NWRS) 2004 and NWRS2 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	All rivers, wetlands and freshwater resources
The Water Services Act, (No. 108 of 1997 (RSA, 1997a)	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 by water	Water resource allocation to EGI infrastructure - during construction and operation phases. Relevant to water resources in the vicinity of EGI.

Instrument	Key objective	Feature
	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	
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. Activity 12 in Listing Notice 3 (of the 2014 EIA Regulations (as amended) in Government Notice R324 of 2017) relates to the clearance of 300 m^2 or more of vegetation, within Critical Biodiversity Areas.	Relevant to rivers and wetlands, critical biodiversity areas, threatened ecosystems and endangered species during all phases
Draft biodiversity offset policy	A Draft National Biodiversity Offset Policy was recently 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.	River and wetland ecosystems and associated fauna and flora
National Environmental Management: Protected Areas Act (No. 57 of 2003 as amended) {NEM:PPA}	To provide, within the framework of national legislation, including the National Environmental Management Act, for the declaration and management of protected areas; to provide for co-operative governance in the declaration and management of protected areas; to effect a national system of protected areas in South Africa as part of a strategy to manage and conserve its biodiversity; to provide for a representative network of protected areas on state land, private land and communal land; to promote sustainable utilisation of protected areas for the benefit of people, in a manner that would preserve	Any protected areas - and related freshwater ecosystems affected by EGI development

Instrument	Key objective	Feature
	the ecological character of such areas; and to promote participation of local communities in the management of protected areas, where appropriate.	
Resource Directed Measures including: the Ecological Reserve, National Water Resource Classification System (NWRCS) and Resource Quality Objectives (RQO's)	The main objective of the Chief Directorate: Resource Directed Measures (RDM) is to ensure protection of water resources, as described in Chapter 3 of the South African National Water Act - 1998 (No. 36 of 1998) and other related water management legislation and policies. The role of RDM 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 EWR's and changes in ecosystem services, identify scenarios within IWRM, draft management classes, produce RQO's (EcoSpecs, water quality), Gazette class configuration	Benchmark used for monitoring and evaluation of freshwater resources especially rivers in relation to the Reserve.
National Environmental Management Waste Act (No. 59 of 2008)	Minimising the consumption of natural resources; avoiding and minimising the generation of waste; reducing, re-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.	Relevant to construction and operation phase of EGI which may impact rivers and wetlands
Conservation of Agricultural Resources Act (CARA, Act 43 of 1983).	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	Rivers and wetlands

Instrument	Key objective	Feature
	within the flood area or 10 m outside this area (unless already under cultivation).	
Provincial Instrument		
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	Rivers and wetlands
Western Cape		
Nature and Environmental Conservation Ordinance (Ordinance 19 of 1974; amended in 2000).	This ordinance is applicable in the Western Cape, Eastern Cape, Northern Cape and parts of the North West Province. This ordinance provides measures to protect the natural flora and fauna, as well as listing nature reserves in these provinces. This ordinance was amended in 2000 to become the Nature Conservation Laws Amendment Act. Lists of endangered flora and fauna can be found in this act.	Species diversity
KwaZulu-Natal		
KwaZulu-Natal Nature Conservation Act, 1992 (Act 29 of 1992) as an amendment to the Natal Nature Conservation Ordinance (No. 15 of 1974)	According to the Natal Nature Conservation Ordinance No. 15 of 1974 and the KwaZulu-Natal Nature Conservation Act, 1992 (Act 29 of 1992), 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).	Species diversity
Ezemvelo KZN Wildlife Guideline: Biodiversity Impact Assessment in KwaZulu-Natal	Provides guidelines for developers, applicants, environmental consultants and specialists to ensure that projects investigation timeframes are accurately determined, that feasibility studies accurately determine fatal flaws regarding biodiversity, and that the scope and reporting requirements of specialist studies allow for informed and sustained decisions to be made in terms of biodiversity.	Conservation and protection of river and wetland habitats and associated fauna and flora
South Barrow Loan and Ext Powers Ordinance 12 of 1920	Regulates water pollution	Rivers and wetlands

Instrument	Key objective	Feature
South Shepstone Loan and Extended Powers Ordinance 20 of 1920	Regulates water pollution and other pollutants	Rivers and wetlands
Water Services Ordinance 27 of 1963	Regulates matters relating to water , water pollution and sewage	Rivers and wetlands
Kloof Loan and Extended Powers Ordinance 16 of 1967	Regulates water pollution and other pollutants	Rivers and wetlands
Umhlanga Extended Powers and Loan Ordinance 17 of 1975	Regulates water pollution within Umhlanga and surrounding areas	Rivers and wetlands
Durban Extended Powers Cons Ordinance 18 of 1976	Regulates water pollution and other pollutants	Rivers and wetlands
Kwa-Zulu and Natal Joint Services Act 84 of 1990	Regulates pollution of land water and waste management	Rivers and wetlands
Northern Cape Province		
Divisional Councils Ordinance 18 of 1976	Provides for the regulation and control of effluents refuse and storm water	EGI development affecting rivers and wetlands
Nature and Environmental Conservation Ordinance (Ordinance 19 of 1974; amended in 2000).	This ordinance is applicable in the Western Cape, Eastern Cape, Northern Cape and parts of the North West Province. This ordinance provides measures to protect the natural flora and fauna, as well as listing nature reserves in these provinces. This ordinance was amended in 2000 to become the Nature Conservation Laws Amendment Act. Lists of endangered flora and fauna can be found in this act.	Species diversity

5 IMPACT CHARACTERISATION

The impacts associated with EGI range from those that are direct (e.g. pylon construction and clearing areas for servitudes) to those that are more subtle (indirect) and which occur over longer timeframes (e.g. vegetation compositional changes from continued disturbance/clearing, habitat fragmentation, hydrological alteration, and alien plant infestation). The main impacts to freshwater ecosystems associated with EGI were identified and discussed in detail in the freshwater specialist component of the 2016 EGI SEA (Todd *et al.*, 2016). The majority of the impacts identified in this assessment are relevant to the scope of the present study, and have been contextualised here in relation to the following activities and their associated impacts to aquatic ecosystems and biota.

- **Activity: Construction of substations and pylons and powerline servitudes** – The direct clearing and/or removal of vegetation to allow for the construction of substations and pylons, as well as to establish servitudes to access the pylons and powerlines for on-going maintenance.
- Impacts:
    - Similar impacts to the development of access roads (as below), but differing in terms of extent, duration and intensity.
    - The direct footprint of single pylon supporting a 765 kV powerline is 1 ha (including excavation, assembly and raising), while the development footprint for a substations extends up to 70 ha (including temporary construction camps, borrow pits, vehicle parking, stock piles, etc.).
    - Servitudes for accessing pylons/powerlines will require ongoing vegetation clearing to maintain an eight-metre strip wherein grass/herbaceous vegetation regrowth is cut to a height of 20 cm, and trees in most cases are removed (DEA, 2016).

- **Activity: Developing access roads** – Development of new access roads to enable construction, as well as ongoing maintenance during the operational phase may result in the following impacts:
- Impacts:
    - Direct loss of riparian and wetland vegetation (and associated buffers), including potentially sensitive/important freshwater ecosystems and/or habitat supporting species of conservation concern;
    - Fragmentation of freshwater ecosystems and flow patterns, resulting in an indirect loss of ecological patterns and processes such as species movement and dispersal, habitat connectivity, increased edge effects and disturbance, establishment of invasive alien vegetation, etc.;
    - Stormwater runoff resulting in increased flows (hydrological alteration) within receiving aquatic environments, particularly in relation to runoff discharge points, which in turn has a number of indirect issues such as bank erosion and collapse, scouring and channel incision, headcut erosion, desiccation of wetland/riparian soils and vegetation, increased turbidity, sedimentation and smothering of benthos. The combined effects will negatively affect the ecological integrity and ability of the freshwater ecosystems to function properly;
    - Waste pollution and contamination of aquatic environments from foreign materials (e.g. fuels/hydrocarbons, cement, and building materials) being dumped and/or carried into aquatic environments;
    - Compaction of soils and creation of preferential flow paths with and adjacent to wetland and river habitats; and
    - Direct loss of flora and fauna (including Threatened or other species of conservation concern) that inhabit wetland/river ecosystems and adjacent buffer/fringe habitats, including accidental road kills caused by increased traffic on both existing and new roads.

In addition to the main activities and key impacts resulting from EGI development and operation, other **more specific impacts** that may occur as a result include:

- **Habitat fragmentation** – one of the more concerning issues of linear developments such as transmission lines is the fragmentation of freshwater ecosystems and associated buffers, especially where areas are permanently impacted. This presents a serious issue particularly to fauna, and leads to populations becoming more isolated, resulting in a reduction of inter-population connectivity and compromised genetic viability. For example, inappropriately designed and constructed river crossings could prevent fish from moving/migrating freely within a river system. Habitat fragmentation also has the potential to exacerbate impacts to freshwater ecosystems, such as through altering micro-climatic conditions (e.g. fire, wind, desiccation, etc.). These alterations in turn affect the perimeter of wetland and riparian habitats resulting in edge effects and development of transitional habitats. This presents a favourable situation for invasive alien plants (IAPs) to establish, with knock-on effects for freshwater ecosystem and associated fauna and flora (as discussed in the following point).

- **Habitat alteration and knock-on effects caused by IAPs** – IAPs that already occur in the area are likely to invade newly disturbed areas, by gradual (or even rapid) encroachment into disturbed areas (e.g. temporary construction camps, borrow pits, vehicle parking, stock pile areas, etc.), transitional habitats, as well as around pylons/substations and along access roads. The spread of existing, and the introduction of new problem, plant species may be facilitated by movement of people and construction vehicles. IAP infestation within freshwater ecosystems will further degrade habitats and habitat availability for associated biota. Secondary impacts (or caused by IAPs) include, but are not limited to:
  - Competition with native plant species, especially when considering the severity of allelopathic influences caused by certain IAP (e.g. *Acacia mearnsii*);
  - Shading of banks and instream habitats, which in turn impacts on water temperatures and freshwater fauna and flora that are intolerant;
  - Shift in allochthonous and autochthonous organic compounds within wetland and river ecosystems;
  - Bank instability, erosion and collapse, with exacerbated deposition of sediments and debris; and
  - In more severe cases, reduced water availability due to excessive water consumption from most IAPs (in particular, deep-rooted tree species such as *Eucalyptus* species *(spp.)*).
- **Mortality of fauna** – Earthworks and excavations would mainly affect fossorial fauna (i.e. animal adapted to living underground), as well as small, less-mobile fauna (e.g. amphibians, as well as freshwater obligate reptiles and shrews/rodents). Mortality of fauna from accidental collisions due to the movement of vehicles/machinery across the site would also be an issue for smaller, less mobile species of fauna. Illegal hunting/poaching could also present a significant impact during the construction phase whereby certain personnel/contractors engage in such activities.
- **Disturbance of fauna** – Certain fauna are more susceptible to impacts from increased noise and/or artificial lighting. Artificial lighting in and around substations may for example have a significant impact on normal life cycles of adult forms of aquatic macro-invertebrates, as well as increased mortality rate. Noise impacts will affect noise-sensitive mammals, particularly larger mammals such as Otter species and Servals. Noise and light impacts ultimately result in the displacement of fauna away from the noise impact area, but is expected to be temporary, and restricted to the construction phase.

Rudman *et al.* (2017) highlights additional freshwater impacts associated with concentrated solar power construction sites, which are relevant in this case in terms of the construction of EGI (e.g. pylons, substations, etc.). Main impacts identified by the authors stem from the lack of stormwater management at construction sites leading to erosion and runoff, the use of water for construction and dust suppression, concrete/oil/hydraulic spills, and an overall need for strategic planning of water resource allocation.

Overall, in this study impacts are characterised at the broadest scale in relation to the corridors as a means to identify preferred routings that will have the least possible impact on freshwater ecosystems and/or associated biota. Nevertheless, an inadequately positioned alignment through a particular corridor could potentially impact areas with severe consequences for freshwater biodiversity. Taking this into consideration, it is thus important to acknowledge impacts at a finer scale (i.e. sub-quaternary catchment) in order to identify preferred alignments/positions of EGI within the two respective corridors. Lastly, data within the catchments at a site specific/habitat scale have been interrogated to guide the finer alignment of infrastructure, as well as inform the specialist assessments required and the mitigation measures.

6 CORRIDORS DESCRIPTION

A description of the freshwater ecosystems within corridors that stand to be impacted by the development of EGI in South Africa are presented in Table 5. These descriptions are provided together with a summary of the existing drivers and pressures, relating primarily to land use, within these corridors.

Table 5: Description of freshwater ecosystems and species of the proposed Expanded EGI corridors, including existing drivers and pressures.

Site	Brief description	Existing drivers and pressures
Expansion of Western Corridor	**Rivers** are predominantly non-perennial/ephemeral in character. A small proportion (~10%) of the rivers are classified as perennial/permanently - flowing rivers, largely the Orange River and other smaller rivers (e.g. Doring, Olifants and Sout Rivers). Non-perennial systems that dominate the corridor include the Holgat, Kamma, Buffels Swartlintjies, Groen and Goergap. Most of the river habitats fall within the Namaqua Highland Ecoregion (48%), followed by the Western Coastal Belt (26%), and the Orange River Gorge (16%). Only 4% of the river habitat is considered to be Threatened (i.e. Endangered and Vulnerable). The Doring River and the lower Olifants River are the only flagship/free-flowing rivers in the corridor. The PES of rivers is generally good, with less than 25% of the rivers assessed to be in either a fair, poor or very poor state. **Overall river sensitivity for the Western EGI Corridor is as follows: very high (1%), high (31%), medium (26%), and low (42%).** **Wetland habitats** occupy a low proportion of the corridor (~1%) owing to the xeric climatic conditions of the Succulent Karoo. Nevertheless, the area supports up to 57 wetland types dominated by floodplain wetland habitat along the lower Gariep River and channelled-valley bottom wetlands within the Namaqualand Hardeveld region, as well as a number of endorheic pans that are more unique to the region. One Ramsar wetland occurs within the corridor, and is located at the mouth of the Gariep River. A small proportion of the wetlands in the corridor are characterised as NFEPA wetlands, which predominantly include floodplain wetlands along the Gariep River and seeps within the Namaqualand Hardeveld region. **Overall wetland sensitivity for the Western EGI Corridor is as follows: very high (3%), high (22%), medium (46%), and low (29%).** **Threatened aquatic biota:** One Endangered fish, *Pseudobarbus phlegethon* occurs in the Olifants River, which flows through the extreme south-western corner of the Western EGI Corridor. There are also two Near Threatened fish (i.e. *Labeobarbus seeberi* and *Pseudobarbus serra*) that occur in the corridor. Two notable amphibians occur in the north western parts of the corridor, namely *Breviceps macrops* (Near Threatened), which inhabits sandy habitats along	Approximately 95% of the Western Corridor comprises land that is largely natural, thus only a 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. Key impacts include: • Pollution from application of fertilizers, herbicides and pesticides, as well as point-source discharges from urban centres (e.g. Bitterfontein, 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

<table>
<tr><th>Site</th><th>Brief description</th><th>Existing drivers and pressures</th></tr>
<tr><td></td><td>Namaqualand coast, 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. The Spotted-necked Otter Hydrictis maculicollis (Vulnerable) has been recorded near the mouth Gariep River. Two Vulnerable plants, Isoetes eludens and Oxalis dines, and four Near Threatened plants occur as a few isolated populations in the corridor. Overall species sensitivity for the Western EGI Corridor is as follows: very high (0%), high (6%), medium (36%), and low (58%).</td><td>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.</td></tr>
<tr><td>Expansion of Eastern Corridor</td><td>Rivers within the Eastern EGI Corridor are predominantly perennial/permanently-flowing (87%), majority of which occur in the North Eastern Uplands, Lowveld and North Eastern Coastal Belt ecoregions. Major river systems include the Mkuze, Phongolo, Mfolozi, Thukela, Mhlatuze and Mvoti Rivers that drain across the width of the corridor into the Indian Ocean. Up to 16% of the river habitat is considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). This corridor contains the following remaining flagship/free-flowing rivers in the country, namely: the Mfolozi and Thukela River systems, and the Mkuze River and one of its tributaries, the Msunduzi. The PES of rivers is fairly good, with 50% of the rivers assessed to be in a natural/good condition, while 35% are in a fair condition and 15% are in a poor/very poor condition. Overall river sensitivity for the Eastern EGI Corridor is as follows: very high (21%), high (38%), medium (39%), and low (2%).

Wetland habitats within the Eastern EGI Corridor occupy a notable proportion of the corridor (~10%) comprising up to 83 different wetland types dominated by channelled-valley bottom wetlands and 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 large proportion (~65%) of the wetlands in the corridor are characterised as NFEPA wetlands, a third of which is made up of channelled-valley bottoms, floodplains, seeps and valley-head seeps within the Indian Ocean Coastal Belt region. Overall wetland sensitivity for the Eastern EGI Corridor is as follows: very high (3%), high (22%), medium (54%), and low (21%).

Threatened aquatic biota: The only Critically Endangered Odonata for South Africa occurs along the Phongolo River in the north-western corner of the Eastern EGI Corridor, namely Chlorocypha consueta. The Endangered Diplacodes pumila also occurs in the corridor along with seven species listed as Vulnerable and four species listed as Near Threatened. Two Endangered fish,</td><td>Approximately 65% of the Eastern Corridor comprises land that is largely natural, with a significant proportion of the area protected by existing conservation areas (e.g. Isimangaliso Wetland Park, Hluhluwe-Imfolozi Game Reserve, Tembe Elephant Park, Ndumo Game Reserve, Ithala Game Reserve). The remaining area has been transformed largely by cultivation, plantations, urbanisation and rural settlements. Impacts on freshwater ecosystems caused by land use activities associated within these transformed areas vary across the landscape, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity. Key impacts 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, etc.) 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. Inanda, Hazelmere and Goedertrouw and Pongolapoort Dams), inter-basin transfers, WWTW 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;</td></tr>
</table>

Site	Brief description	Existing drivers and pressures
	Marcusenius caudisquamatus and *Silhouettea sibayi*, occur predominantly within coastal rivers within the corridor, as well as two species listed as Vulnerable, including the widespread *Oreochromis mossambicus*. The corridor also supports three Near Threatened and two Data Deficient fish species. Two Endangered amphibians, *Hyperolius pickersgilli* and *Natalobatrachus bonebergi*, also occur along the coastal areas, while the Endangered *Leptopelis xenodactylus* occurs more inland at isolated localities. Threatened reptiles include *Bradypodion melanocephalum*, which often occurs in vegetation along rivers and adjacent to wetlands, and *Pelusios rhodesianus*, which is known from a few water bodies along the coastal region – both are listed as Vulnerable. Up to eight Red Listed mammals occur within the Eastern Corridor, including five rodents/shrews, as well as Spotted-necked Otter *Hydrictis maculicollis* and Cape Otter *Aonyx capensis*. One Critically Endangered plant, *Kniphofia leucocephala*, occurs in isolation in the Richards Bay area. There are also five Endangered, 16 Vulnerable, 12 Near Threatened freshwater plants occurring within the corridor. **Overall species sensitivity for the Eastern EGI Corridor is as follows: very high (23%), high (11%), medium (30%), and low (36%).**	• 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 has 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).

7 FEATURE SENSITIVITY MAPPING

7.1 Identification of feature sensitivity criteria

Table 6 provides a list and description of the sensitivity criteria considered during this assessment for the proposed Expanded EGI corridors.

Table 6: Data and criteria used to assign sensitivity to freshwater ecosystems within the proposed Expanded EGI corridors.

Category	Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
Freshwater ecosystems	Wetlands	Combined wetlands layer comprising: NFEPA (2011); Provincial Wetland Probability Mapping (2017); Fine scale planning - Western Cape (2017); Conservation Plans, Biodiversity Sector Plans (BSP's), and Critical Biodiversity Areas (CBA's) and Ecological Support Areas (ESAs) - KZN (2007) and Northern Cape (2016); National wetland vegetation groups (2012); KZN wetlands/vegetation types (2011); KZN Priority Wetlands; Ramsar Sites.	The combined wetland layer was processed according to two metrics as described in more detail in Section 4.1. **Threat:** National Wetland Vegetation Groups (2012) **Sensitivity:** Ramsar wetlands, Threatened wetlands, Irreplaceable and Optimal CBAs as aquatic features, KZN priority wetlands, NFEPA wetlands, ESAs as aquatic features, wetland probability mapping, and ONAs as aquatic features.
	Rivers	PES, EI and ES DWS Resource Quality Information Services (2014), using the NFEPA rivers coverage (2011)	Metrics were applied that integrate data pertaining to river ecosystems to define river threat status and river importance/sensitivity (as described in Section 4.1). PES, river types and river length were used to derive river threat using updated PES data (2014) based on thresholds defined in the 2011 NBA. River sensitivity/importance was based on the 2014 EI and ES dataset. Overall river sensitivity scores were determined as: Threat Score (PES score and river length as per NBA) + (EI+ES score/ Stream Order)
Freshwater biota	Flora: Plants	Raimondo *et al.* (2009), with spatial data provided by SANBI (2018) as part of the TSP database	Species of conservation concern, and their respective conservation status (i.e. CR, EN, VU, NT, DD and rare), that inhabit freshwater ecosystems and adjacent fringe habitats/ buffers were selected based on known point localities, and assigned to sub-quaternary (SQ4) catchments. The SQ4
	Fauna: Aquatic macro-invertebrates	DWS Resource Quality Information Services (2015)	

<table>
<tr><th>Category</th><th>Feature Class</th><th>Data Source + Date of Publications</th><th>Data Description, Preparation and Processing</th></tr>
<tr><td rowspan="5"></td><td>Fauna:
Odonata</td><td>IUCN (2017) and Samways and Simaika (2016), with spatial data provided by SANBI (2018) as part of the TSP database</td><td rowspan="5">catchments were then classified into four sensitivity classes based on presence/ absence of selected freshwater fauna and flora (i.e. low = no occurrence, medium = rare or NT, high = VU or EN, very high = CR or DD). See approach and methodology section for more details pertaining to data preparation and processing applied to each of the taxonomic groups.

ASPT values for aquatic macro-invertebrate families as recorded from various river sampling sites was used to defined importance/sensitivity of DWS Level 2 Ecoregions.</td></tr>
<tr><td>Fauna:
Fish</td><td>Coetzer (2017), with spatial data provided from the SAIAB, and International Union for the Conservation of Nature (2017).</td></tr>
<tr><td>Fauna: Amphibians</td><td>Minter et al. (2004), with spatial data provided by SANBI (2018) as part of the TSP database</td></tr>
<tr><td>Fauna:
Reptiles
(freshwater ecosystem obligate)</td><td>Bates et al. (2014), with spatial data provided by SANBI (2018) as part of the TSP database</td></tr>
<tr><td>Fauna:
Mammals
(freshwater ecosystem obligate)</td><td>Child et al. (2016), with spatial data provided by SANBI (2018) as part of the TSP database</td></tr>
</table>

The feature types considered in the sensitivity analysis and the rating given to each feature and buffered area is indicated in the table below.

Table 7: Sensitivity ratings assigned to freshwater ecosystem features in both the proposed Expanded EGI corridors.

Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
Wetlands: Critically Endangered wetlands and Irreplaceable CBAs (aquatic)	Very High	200 m
Wetlands: Ramsar wetlands, KZN priority wetlands, Endangered or Vulnerable wetlands, Optimal CBA (aquatic)	High	100 m
Wetlands: NFEPA wetlands, Near Threatened wetlands and ESA (aquatic)	Medium	50 m
Wetlands: probable wetland, non-NFEPA wetlands, least threatened wetlands, ONA (aquatic), formally protected aquatic features	Low	32 m
River ecosystems (including instream and riparian habitats)	Very High	200 m
	High	100 m
	Medium	50 m
	Low	32 m
Freshwater fauna and flora: Critically Endangered or Data Deficient species	Very High	N/A – all species of conservation concern localities are assigned to sub-quaternary (SQ4) catchments, thereby presenting a variable buffer.
Freshwater fauna and flora: Endangered or Vulnerable species	High	
Freshwater fauna and flora: Near Threatened or Rare species	Medium	
Freshwater fauna and flora: Least Threatened species	Low	

7.2 Feature maps

7.2.1 Expanded Western Corridor

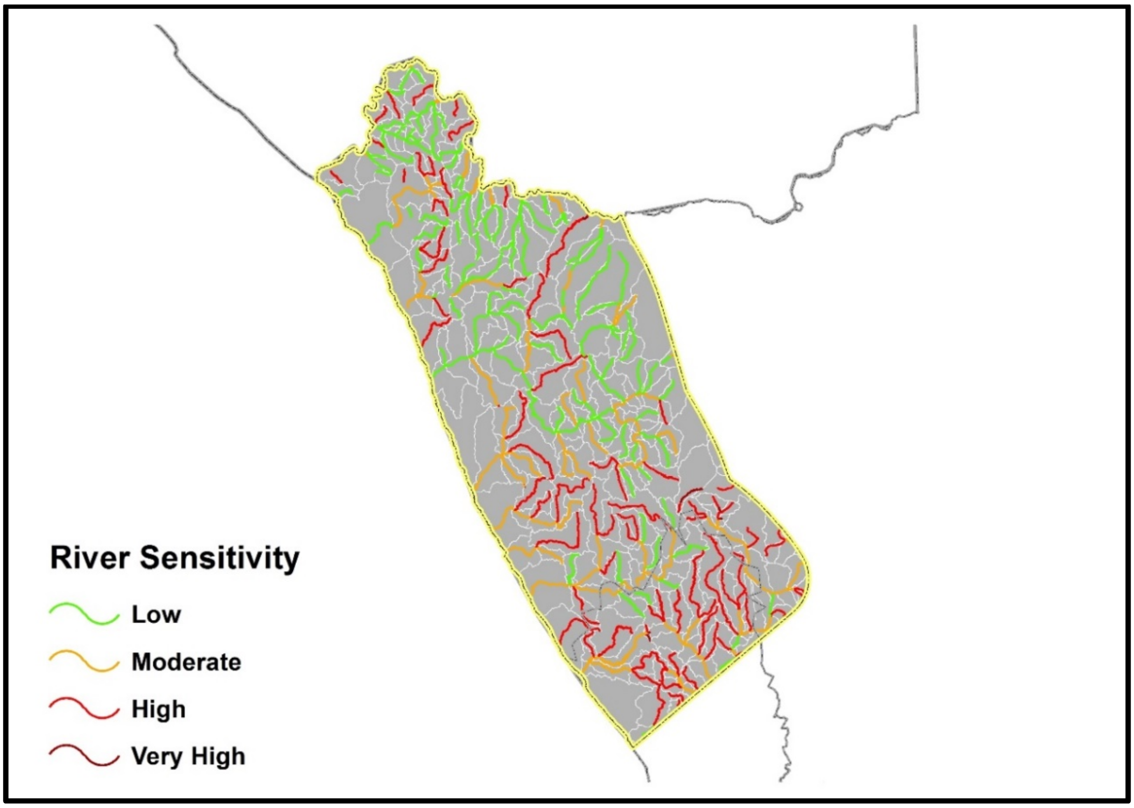

Figure 2: River threat status and sensitivity calculated for the expanded western EGI corridor using PES, EI and ES data from DWS (2014).

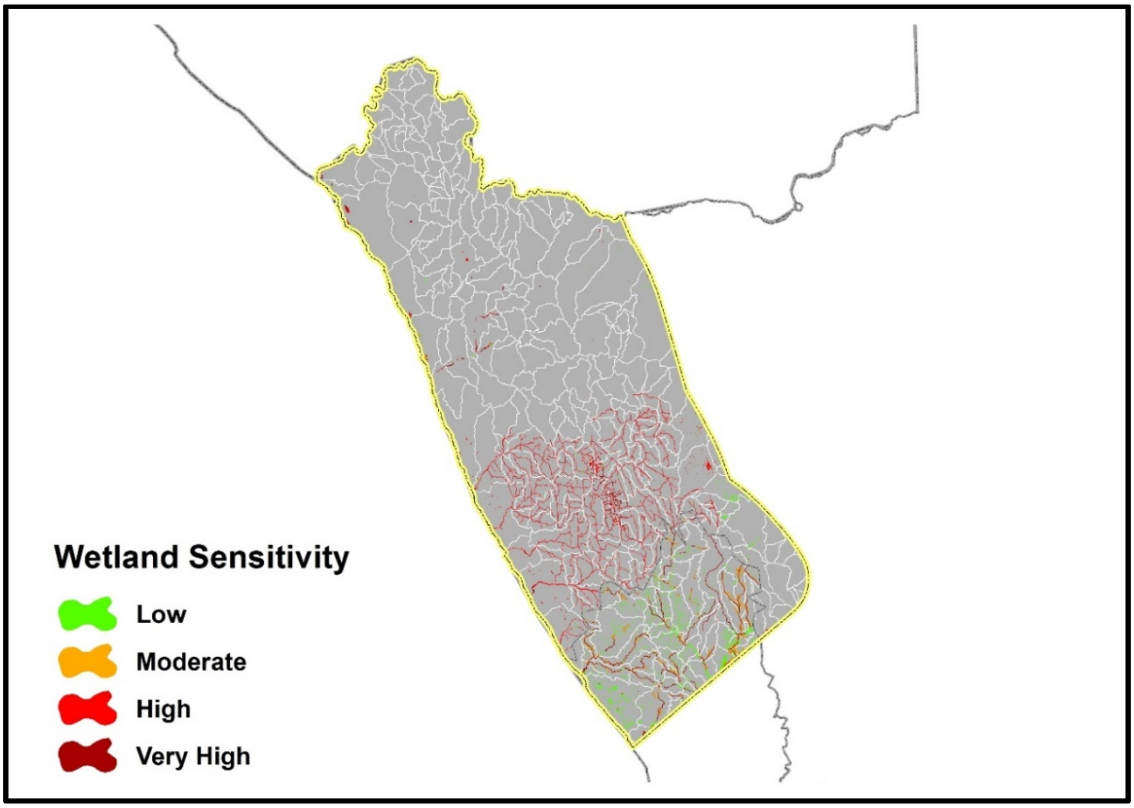

Figure 3: Wetland threat status and sensitivity calculated for wetland features in the expanded western EGI corridor.

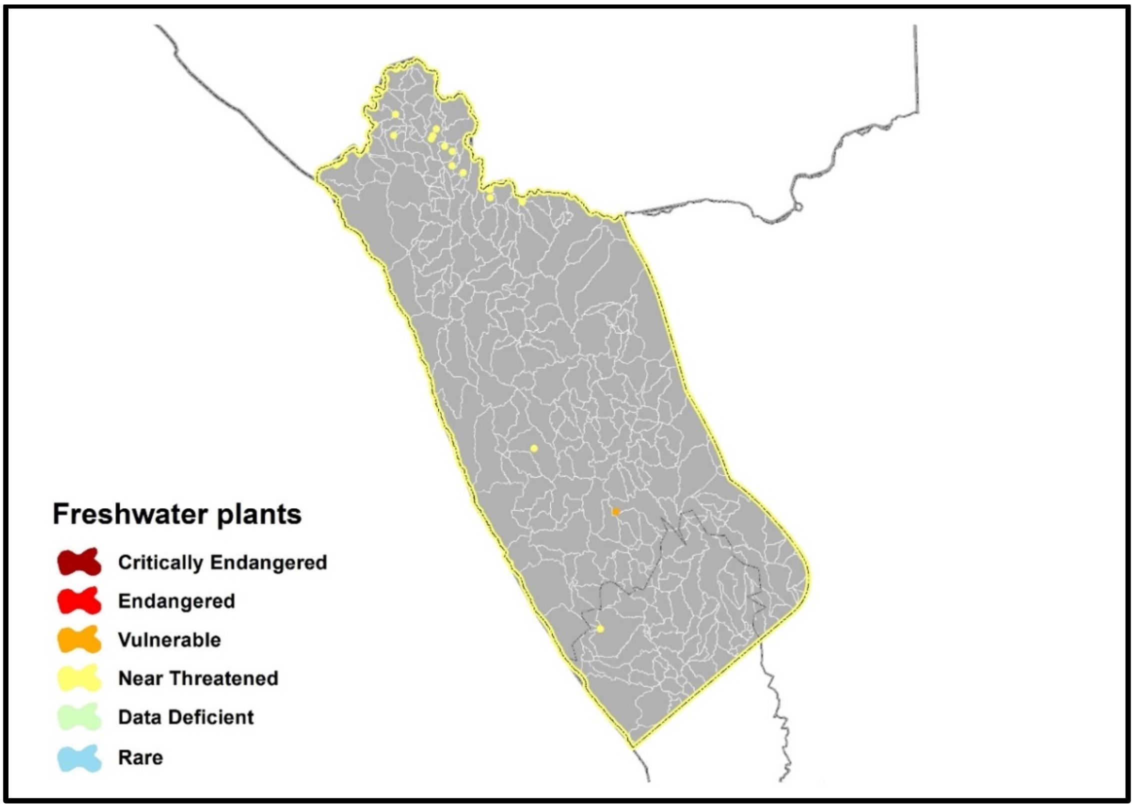

Figure 4: Occurrence of freshwater plants of conservation concern in the expanded western EGI corridor.

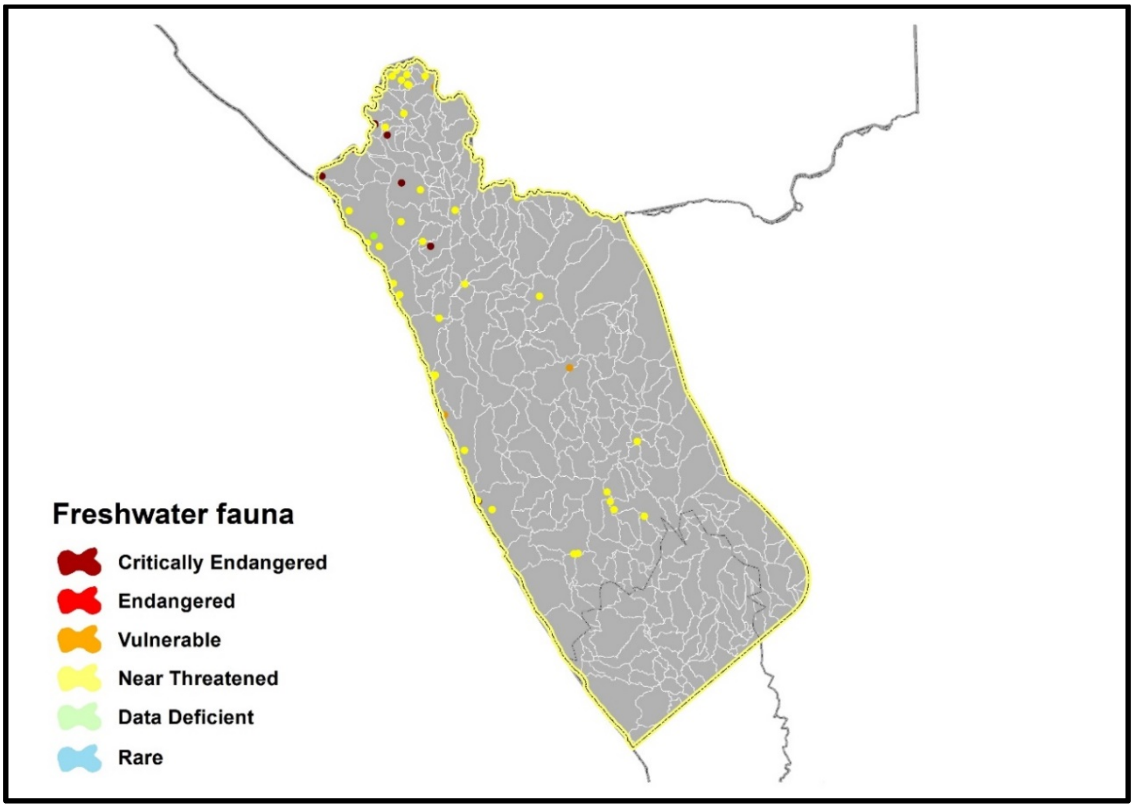

Figure 5: Occurrence of freshwater fauna (dragonflies, damselflies, fish, amphibians, reptiles and mammals) of conservation concern in the expanded western EGI Corridor.

7.2.2 Expanded Eastern Corridor

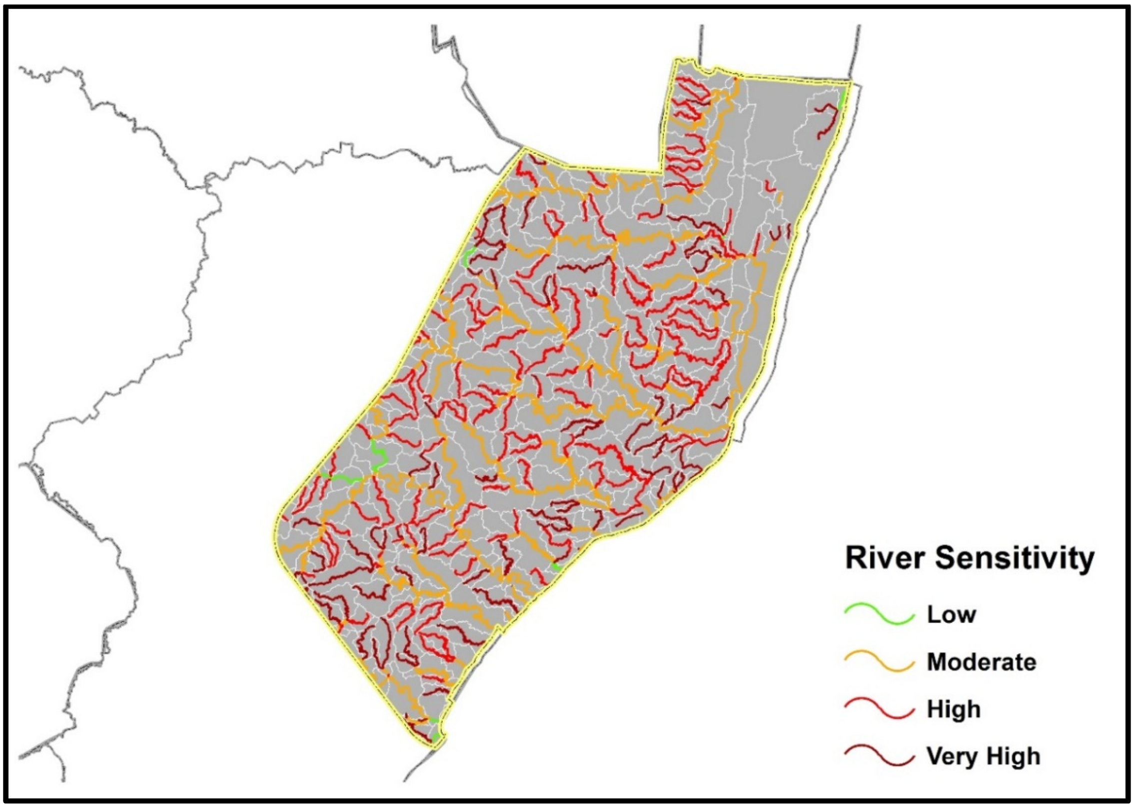

Figure 6: River threat status and sensitivity of river features calculated for the expanded eastern EGI corridor using PES, EI and ES data from DWS (2014).

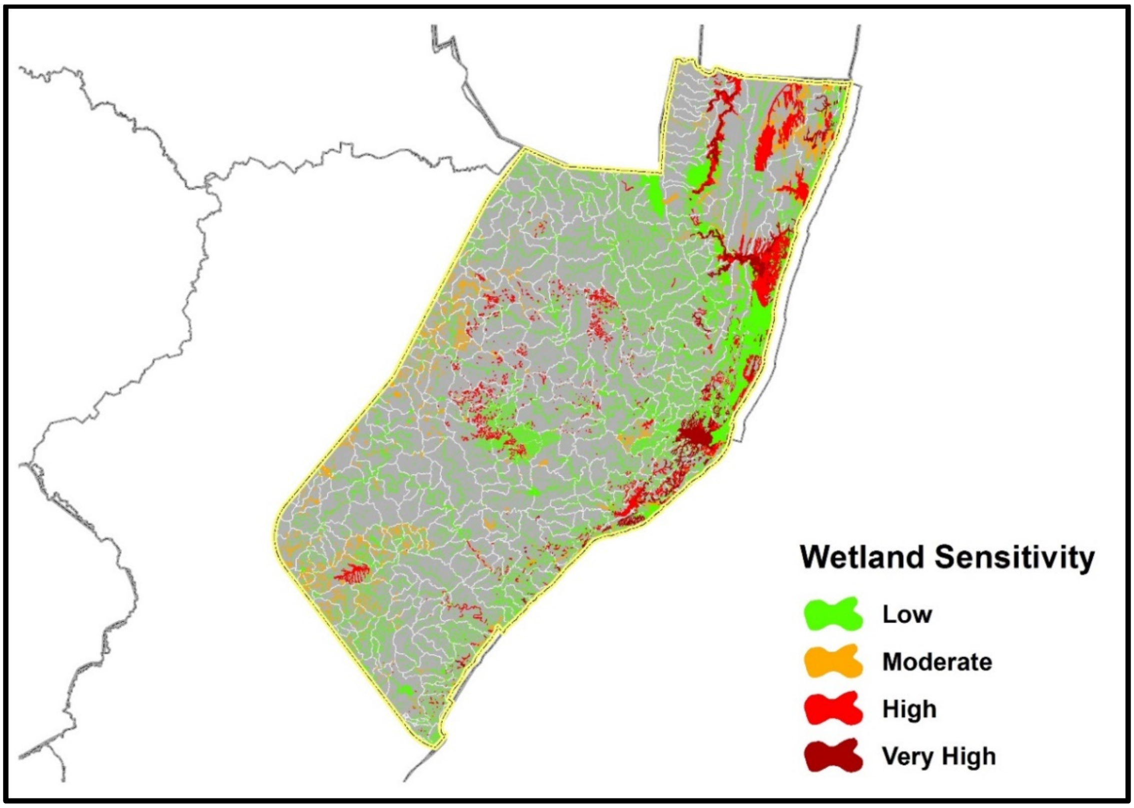

Figure 7: Wetland threat status and sensitivity calculated for wetland features in the expanded eastern EGI corridor.

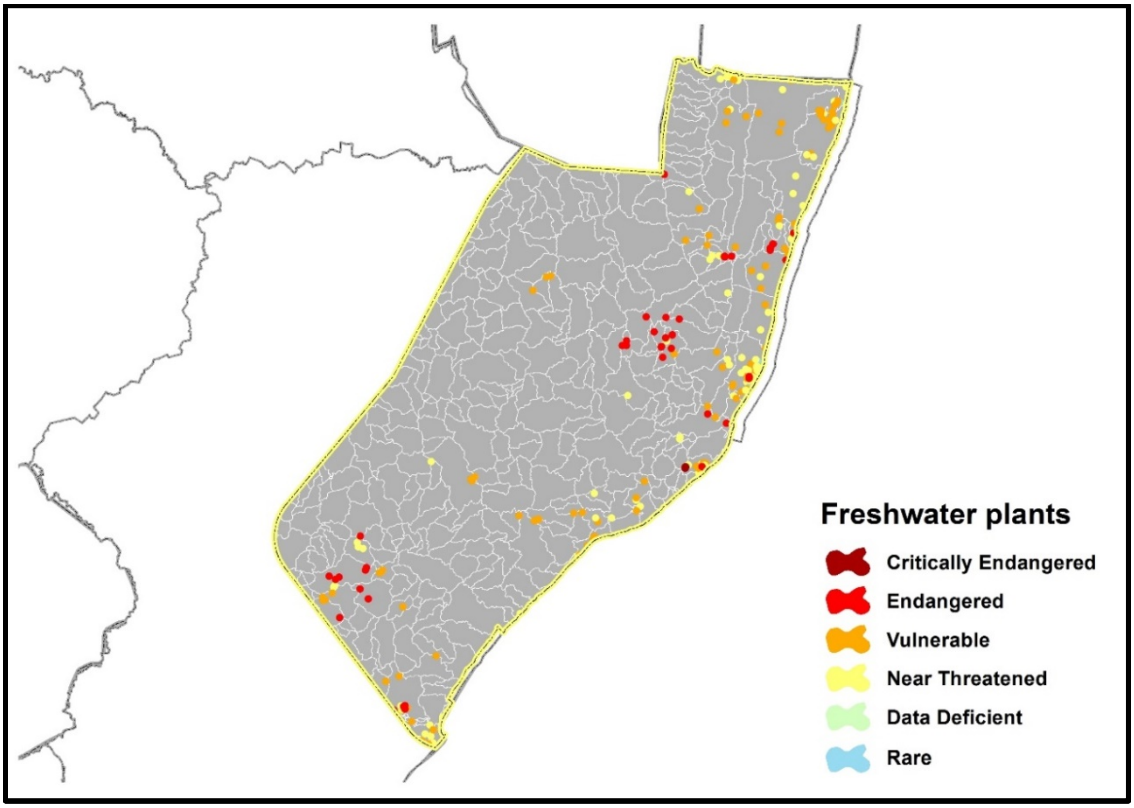

Figure 8: Occurrence of freshwater plants of conservation concern in the expanded eastern EGI corridor.

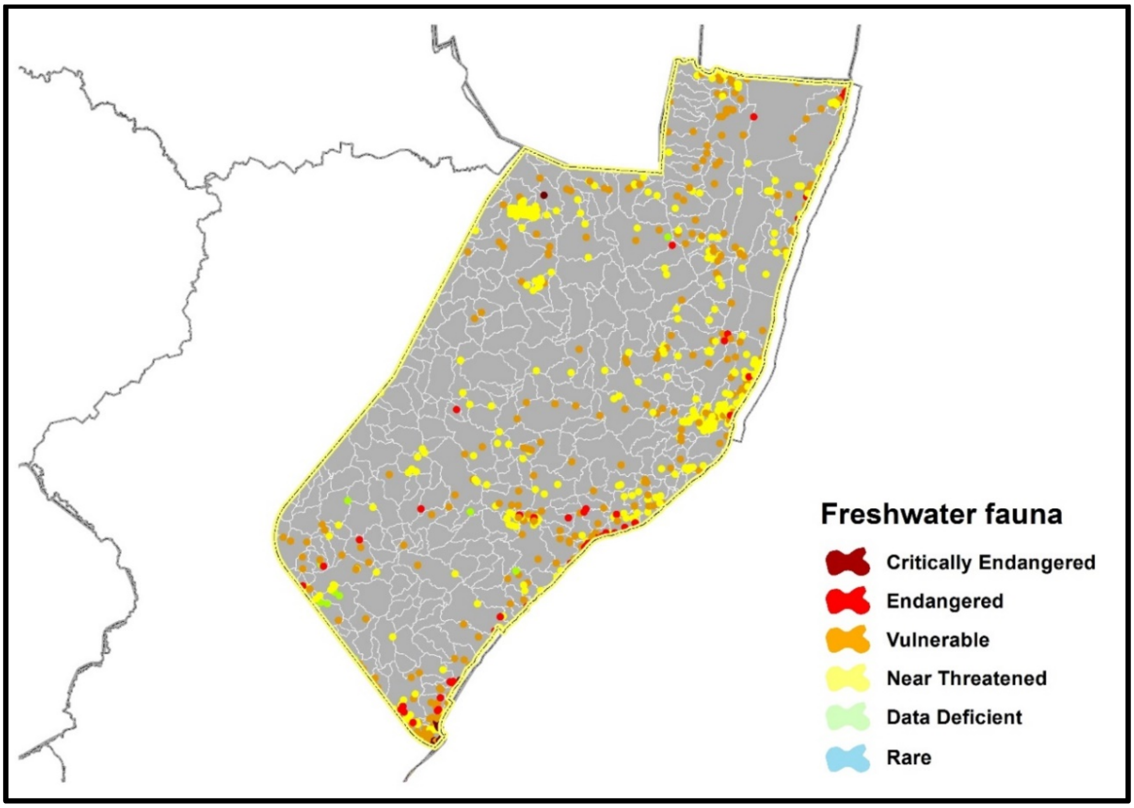

Figure 9: Occurrence of freshwater fauna (dragonflies, damselflies, fish, amphibians, reptiles and mammals) of conservation concern in the expanded eastern EGI Corridor.

8 FOUR-TIER SENSITIVITY MAPPING

8.1 Expanded Western Corridor

8.1.1 Rivers

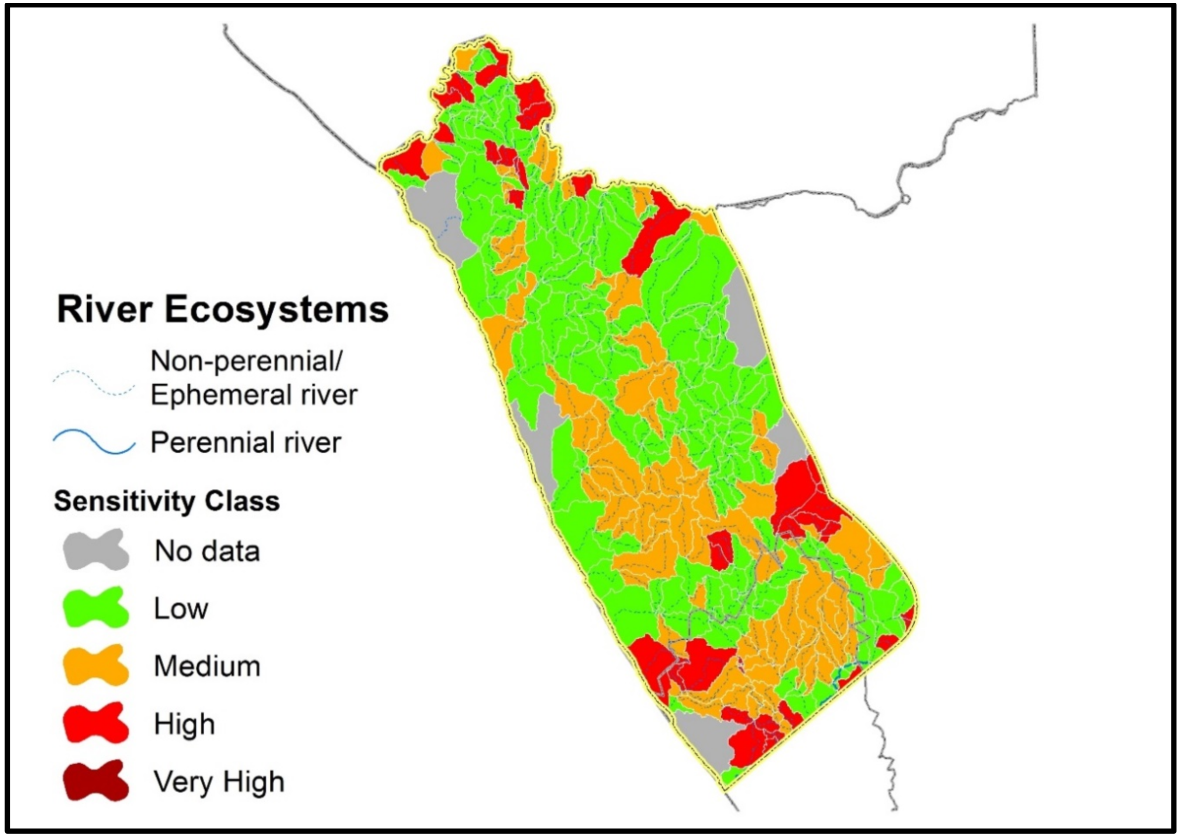

Figure 10: River threat status and sensitivity calculated for sub-quaternary catchments in the expanded western EGI corridor using PES, EI and ES data from DWS (2014).

8.1.2 Wetlands

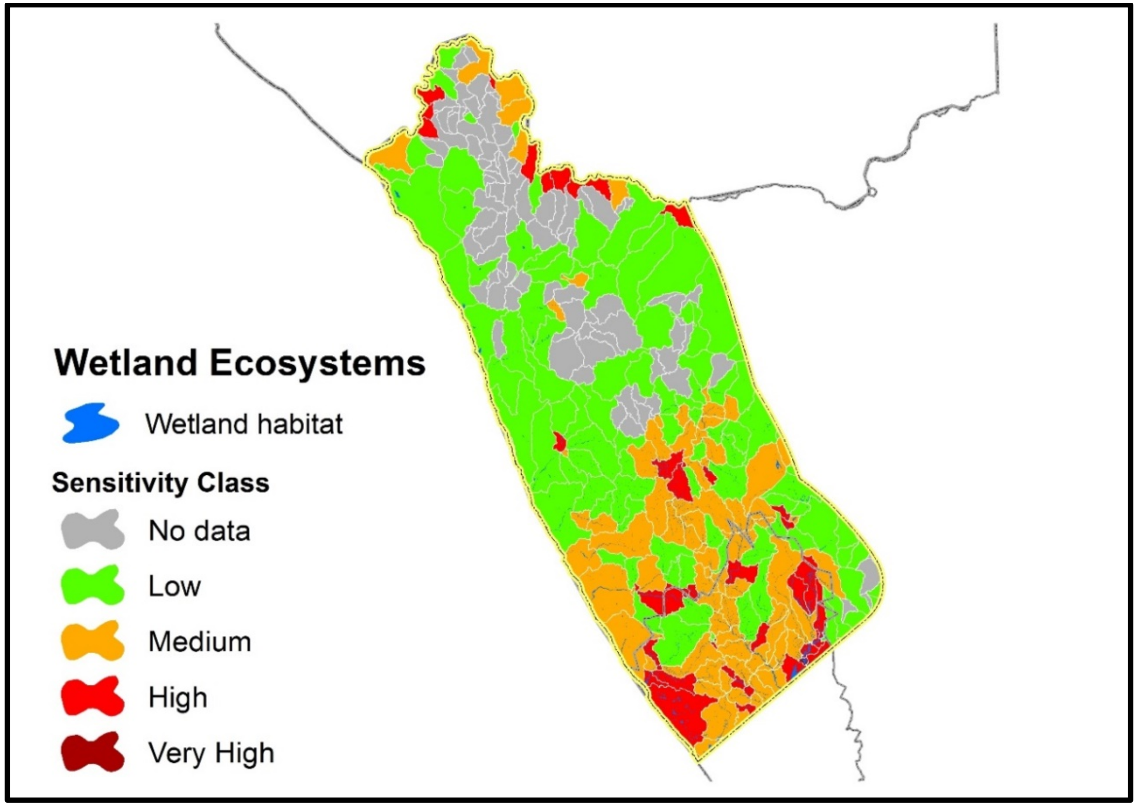

Figure 11: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the expanded western EGI corridor.

8.1.3 Freshwater biota (fauna and flora)

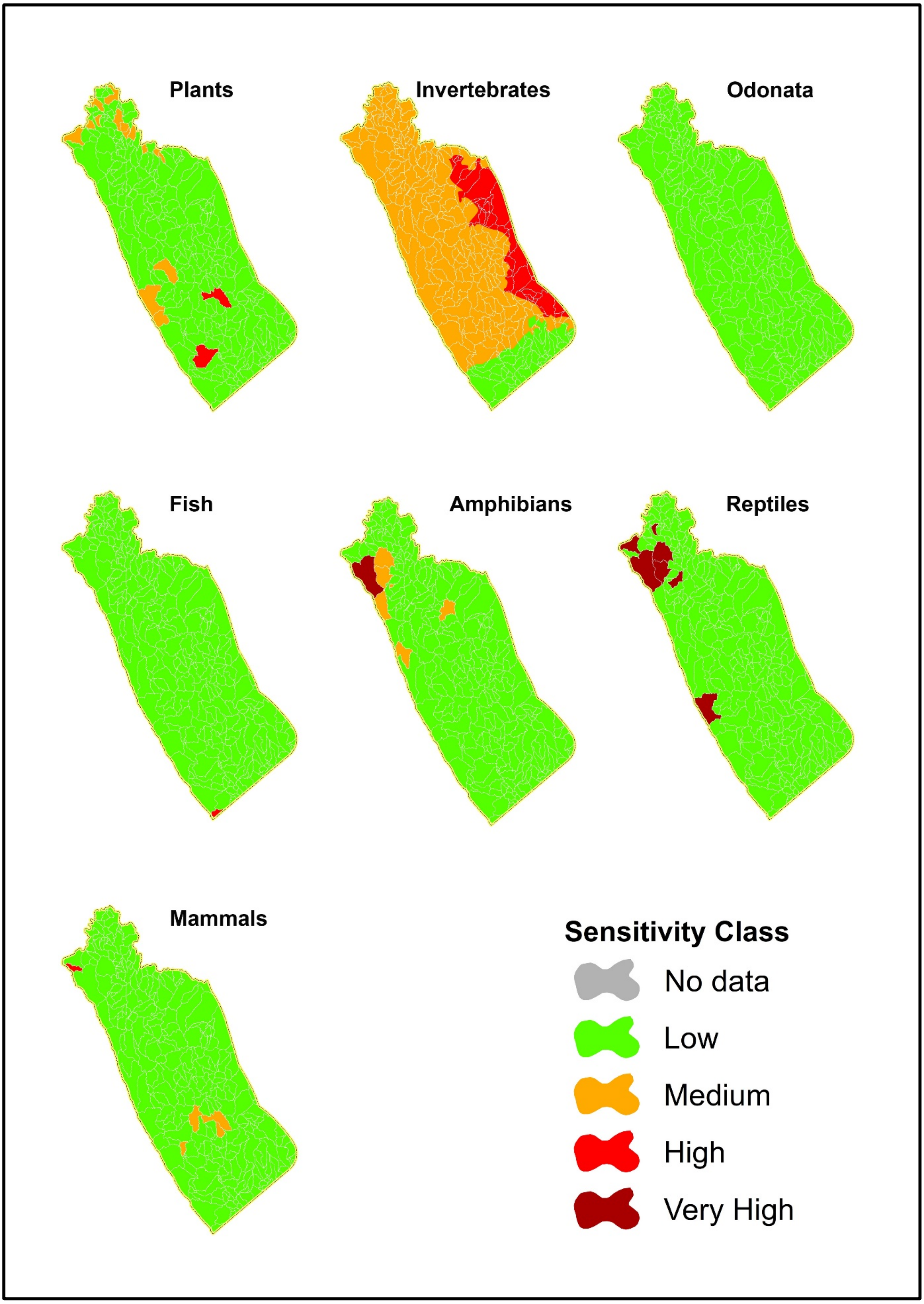

Figure 12: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the expanded western EGI corridor in relation to sub-quaternary catchments.

8.1.4 Freshwater ecosystems and biota (combined)

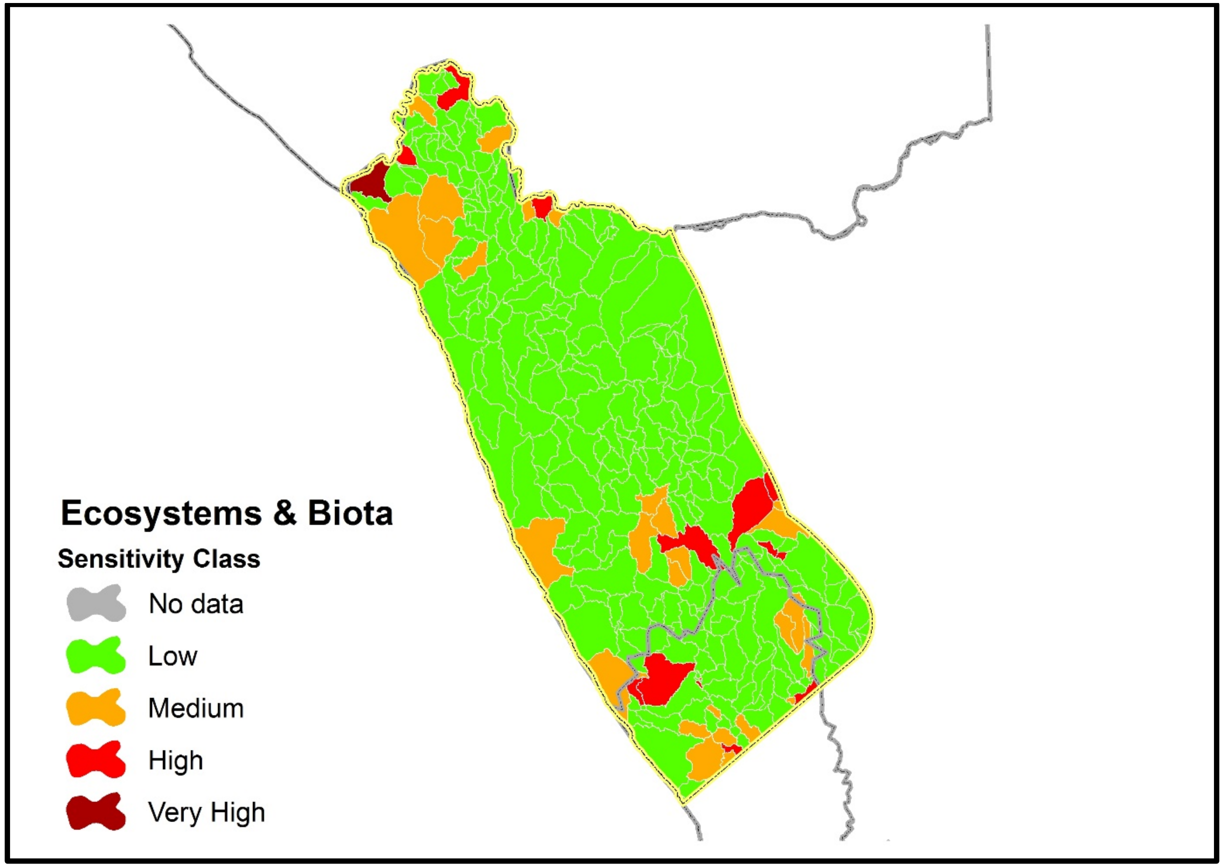

Figure 13: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the expanded western EGI corridor.

8.2 Expanded Eastern Corridor

8.2.1 Rivers

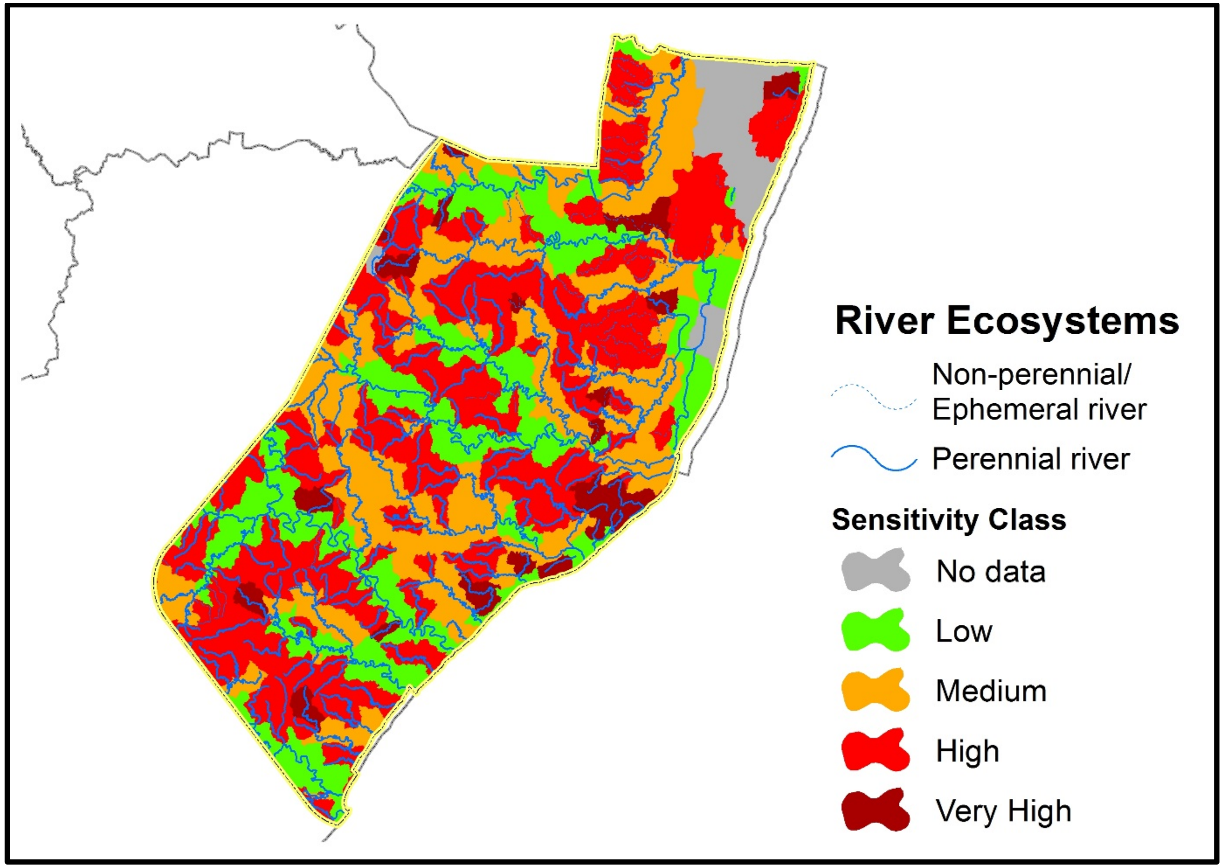

Figure 14: River threat status and sensitivity calculated for sub-quaternary catchments in the expanded eastern EGI corridor using PES, EI and ES data from DWS (2014).

8.2.2 Wetlands

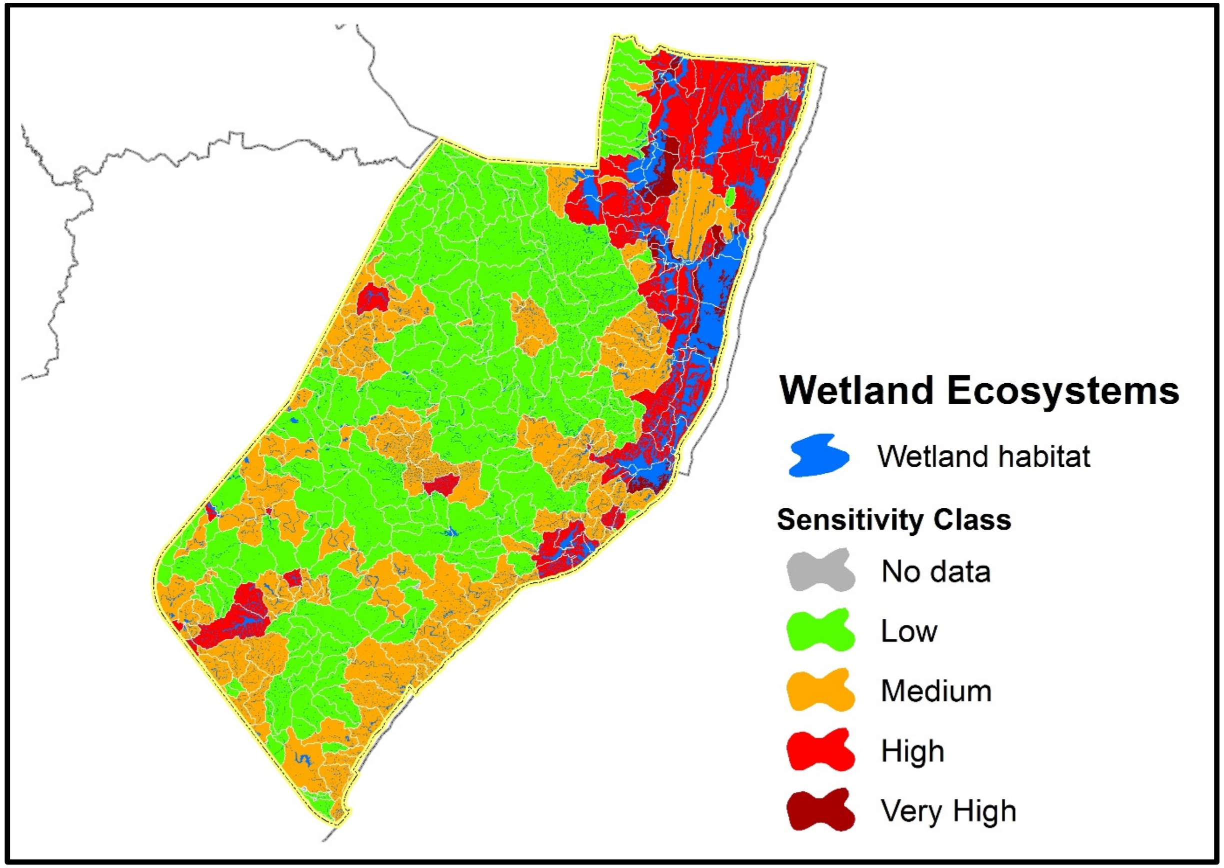

Figure 15: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the expanded eastern EGI corridor.

8.2.3 Freshwater biota (fauna and flora)

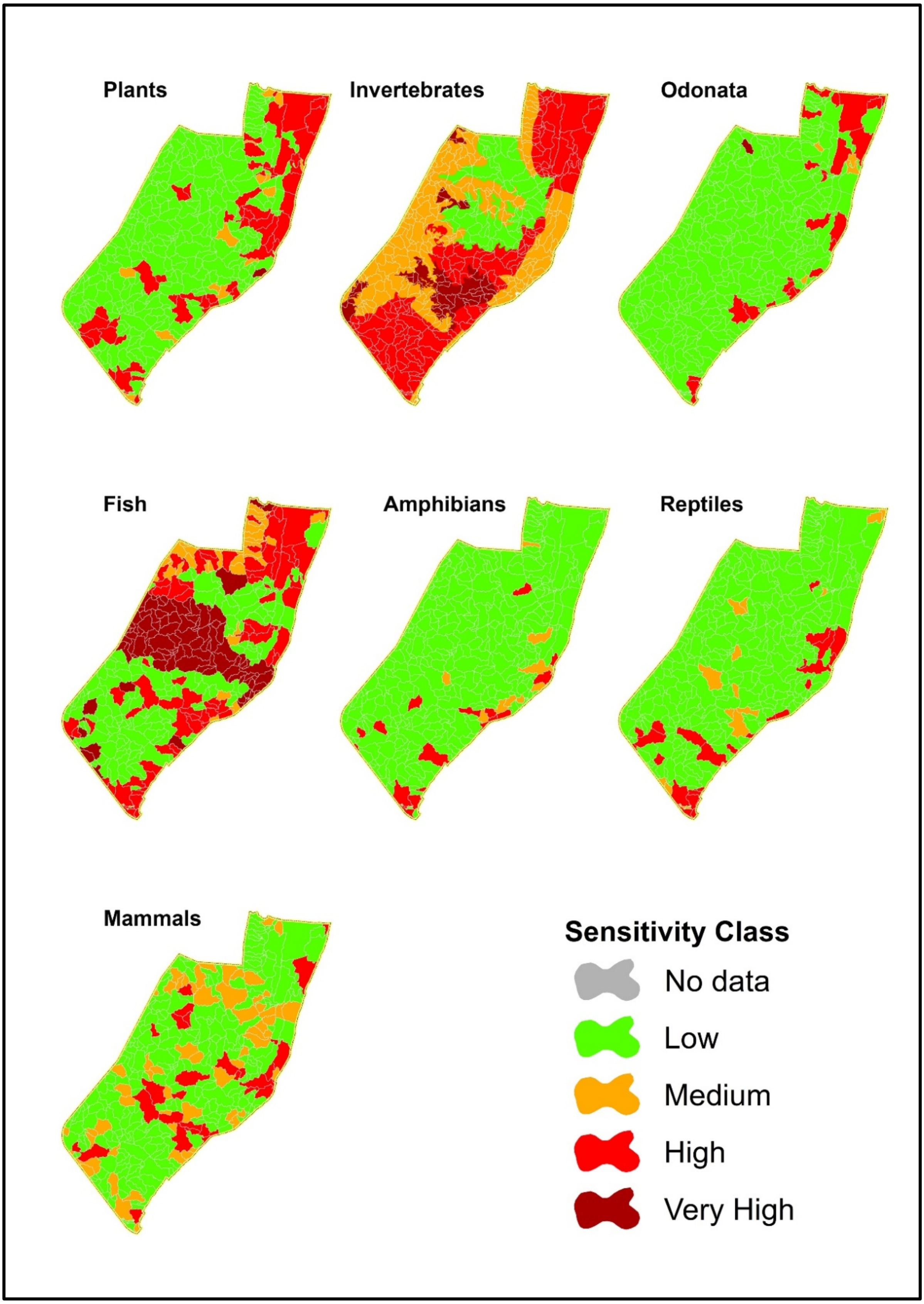

Figure 16: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the expanded eastern EGI corridor in relation to sub-quaternary catchments.

8.2.4 Freshwater ecosystems and biota (combined)

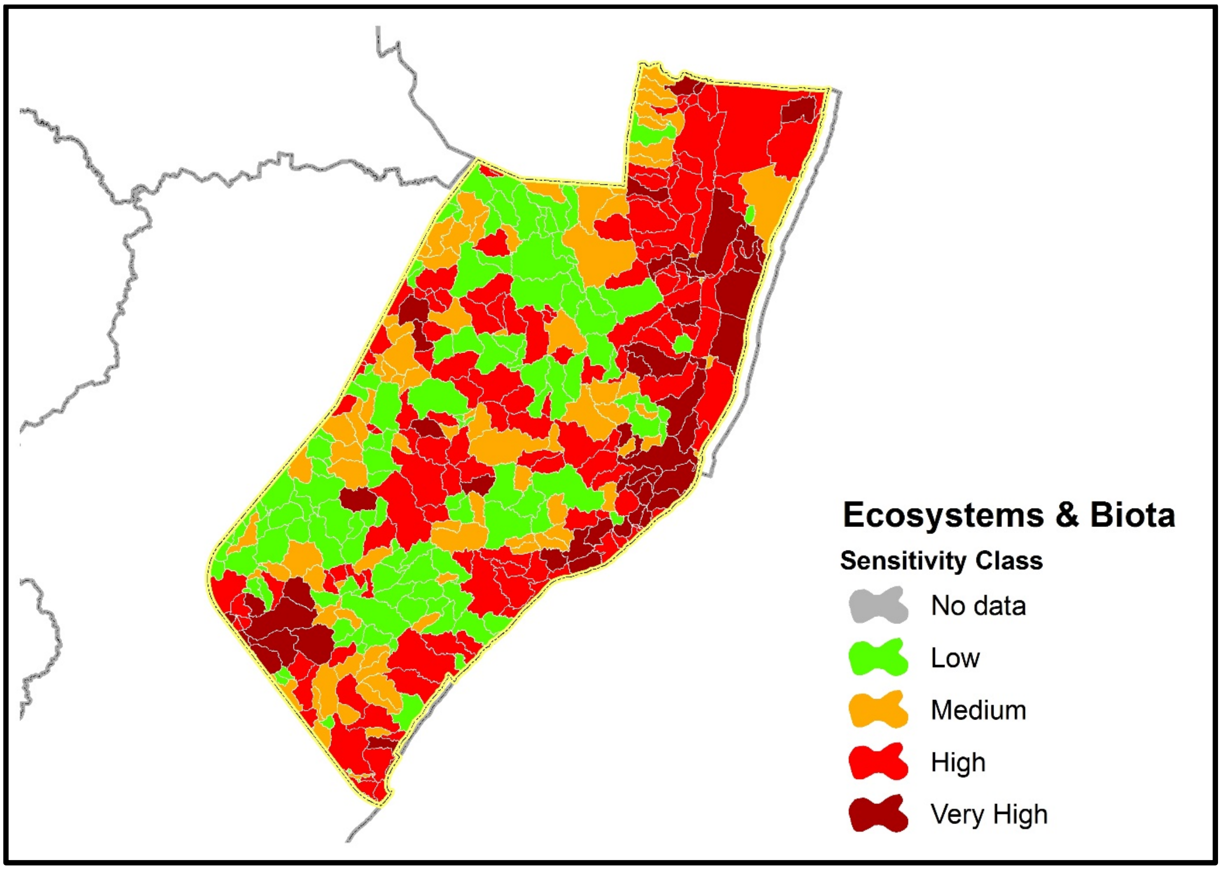

Figure 17: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the expanded eastern EGI corridor

9 KEY POTENTIAL IMPACTS AND MITIGATION

The following table provides detail in terms of key impacts and possible effects on freshwater ecosystems and associated fauna and flora that are linked to Expanded EGI project phases and developmental activities. Mitigation measures are included to ensure that impacts are avoided where necessary and/or minimised in terms of mitigation hierarchy. Site-specific concerns regarding freshwater biodiversity that is of particular importance/sensitivity are also provided according to each corridor as a summary of the sensitivity maps as presented in Sections 7 and 8.

Table 8: Key potential impacts to freshwater ecosystems by EGI development and respective mitigation measures.

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
Design phase	Placement of substations, foundations for pylons, construction camps and access roads within or close to wetlands or rivers (including associated buffer habitat).	Loss of freshwater habitat through clearing/ infilling of wetlands and rivers and associated buffer habitat, potentially including threatened/ sensitive ecosystems.	Removal of wetland and riparian vegetation, instream habitat, as well as adjacent terrestrial buffer habitat which could result in a loss of ecological functions and processes, freshwater biota (i.e. fauna and flora), and valuable ecosystem services.	Western Corridor: In terms of freshwater ecosystems the Western Corridor is dominated by non-perennial (or ephemeral) river systems, some of which are Endangered on the basis that they are represent a specific type of river habitat that is in a natural/near-natural condition. These are largely along the eastern sections of the corridor (e.g. the Kirrie and Saraip se Laagte). Other notable rivers include sections of the Brak, Buffels, Groen, Skaap and Swartlintjies, located roughly in the centre of the corridor and currently in a natural condition. Only a very small proportion of the Western Corridor supports wetland habitat. Nevertheless this includes isolated occurrences of highly sensitive endorheic pans along the western boundary of the corridor that are associated with the Critically Endangered Northwest Sand Fynbos, as well as floodplain wetlands along the Gariep River that are part of the Endangered Gariep Desert. One Ramsar wetland occurs just upstream of the mouth of the Gariep River, and a small proportion of wetlands are characterised as NFEPAs, predominantly in the form of the floodplain wetland along the Gariep River and seeps within the Namaqualand Hardeveld region.	Sub-corridors to avoid catchments with very high sensitivity, and try to avoid catchments with a medium to high sensitivity. However, where this is unavoidable, placement of pylons and infrastructure within these catchments (as well as catchments with a low sensitivity) should as far as possible avoid freshwater ecosystems or areas of these systems that are deemed to be sensitive or of concern (as a result of separate groundtruthing/assessments) as well as their associated buffers.. Other mitigation measures can include specific design features, reduced development footprints, options for specific placement of infrastructure relative to the identified threat.(i.e. a sensitive frog species may have a specific habitat requirement in a small area which can be worked around). Sub-corridor screening, validation and walk-throughs may be required to determine buffer areas, sensitivity etc.
		Fragmentation of aquatic habitat (which may result from clearance due to road construction, and	Loss of ecosystem resilience and integrity through the disruption of		Avoid and/or minimise road crossings through wetlands and rivers. Where this is not

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
		other activities).	biodiversity patterns and processes (e.g. fish movement/ migration)	There are no known freshwater flora occurring within the Western Corridor that are either Critically Endangered, Endangered or Data Deficient. Only two exceptional freshwater fauna occur in the corridor, namely the Data Deficient amphibian, *Breviceps branchi*, and the Critically Endangered reptile, *Pachydactylus rangei*. Eastern Corridor: Extensive areas of the Eastern Corridor support wetlands of international, national and regional significance, including four Ramsar wetlands, KZN priority wetlands, Critically Endangered wetlands (e.g. Swamp Forests, Lowveld Riverine Forest, and Lowveld Floodplain Grasslands). The Eastern Corridor also contains a number of river systems that generally flow in an easterly direction into the Indian Ocean. Included is the Nsuze River, a pristine/near-natural system that flows through the central parts of the corridor. Other notable rivers include several NFEPA rivers, which are nationally recognised as "flagship" rivers (e.g. Thukela, Black Mfolozi and Mkuze Rivers). Exceptional freshwater flora that occur within the Eastern Corridor include the only known population of the Critically Endangered *Kniphofia leucocephala* at Langepan Vlei near Richards Bay, as well as several Endangered species such as *Albizia suluensis, Asclepias*	possible, ensure that appropriate crossings are constructed 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. As far as possible ensure access roads are linked to existing river crossings (e.g. bridges) to minimise disturbance from additional crossings.
		Hydrological alteration largely through 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. This also leads to geomorphologic impacts within systems.		Avoid and/or minimise road crossings through wetlands and rivers. Minimise the number of watercourse crossings for access roads. Ensure adequate watercourse crossings (i.e. culverts of the correct specification) are designed and constructed where roads traverse these areas so that the concentration of flow (particularly during high flow conditions) is minimised as far as possible.
		Erosion caused by loss of vegetation cover through site	Alterations in moisture availability and soil		Avoid clearing of indigenous vegetation where possible Bank

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
		clearing and consequent sedimentation of aquatic ecosystems. Erosion is particularly a high risk in steep systems, and in drainage lines that lack channel features and are naturally adapted to lower energy runoff with dispersed surface flows (such as unchannelled valley-bottom wetlands).	structure can promote the invasion of weedy and/or alien species at the expense of more natural vegetation and thus a loss of habitat integrity and/or biodiversity.	*gordon-grayae, Geranium ornithopodioides, Kniphofia latifolia* and *Mondia whitei.* Exceptional freshwater fauna that occur within the Eastern Corridor include the only Critically Endangered dragonfly for South Africa, *Chlorocypha consueta*, which occurs along the Phongolo River in the north-western corner of the corridor. Other notable freshwater fauna include the Endangered dragonfly, *Diplacodes pumila*, the Endangered fish, *Marcusenius caudisquamatus* and *Silhouettea sibayi*, and the Endangered amphibians, *Hyperolius pickersgilli, Natalobatrachus bonebergi,* and *Leptopelis xenodactylus*.	stabilisation measures (gabions, eco logs, geofabric, sediment fences) are required when wetland or watercourse banks steeper than 1:5 are denuded during construction. Appropriate rehabilitation procedures/measures should be planned which may include relocation of sensitive plant species.
Construction phase	Establishment of construction camps or temporary laydown areas within or in close proximity to wetlands or rivers	Physical destruction or damage of freshwater ecosystems by 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 within or in close proximity to wetlands or watercourses.	Loss of both faunal and floral biodiversity and the ecosystem services provided by these habitats directly through clearing, and indirectly through poaching/hunting.		All wetlands and watercourses should generally be treated as “no-go” areas and appropriately demarcated as such. However, with additional screening/groundtruthing assessments there may be an opportunity to apply for special permits to work in and around these areas if avoidance is not possible. No vehicles, machinery, personnel, construction materials, cement, fuel, oil or waste should be allowed into these areas without the express permission of and supervision by an on-site Environmental Control Officer (ECO). All construction activities (including establishment of construction camps, temporary

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
					lay-down areas, construction of haul roads and operation of heavy machinery), should take place during the dry season to reduce potential impacts to freshwater ecosystems, if possible. Furthermore, construction camps, toilets, temporary laydown areas and haul roads should be located outside of the recommended buffer areas around wetlands and watercourses, and should be rehabilitated following construction.
	Stockpiling of materials and washing of equipment within or in close proximity to wetlands or watercourses	Pollution (water quality deterioration) of freshwater ecosystems through the runoff of contaminants such as fuel, oil, concrete, wash-water, sediment and sewage into these ecosystems.	Habitat degradation which results in the loss of resilience of ecosystems through the disruption of ecological processes and thus a loss of ecosystem integrity		Stockpiling and washing areas should be clearly demarcated and sign posted. These areas should be set back outside of the buffer zone of freshwater ecosystems - 30 m of the edge of any wetlands or drainage lines/rivers. No vehicles, machinery, personnel, construction material, cement, fuel, soap/detergents, oil or waste should be allowed outside of the demarcated stockpiling/washing areas.
	Construction of haul roads for movement of machinery and	Reduction in habitat quality through erosion and sedimentation of wetlands and rivers			There should be as little disturbance to surrounding vegetation as possible when construction activities are

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
	materials	Excessive dust generation from road construction and vehicle traffic/haulage leading to impact on surrounding vegetation health and suspended solids/sediment entering nearby watercourses			undertaken, as intact vegetation adjacent to construction areas will assist in the control of sediment dispersal from exposed areas. Furthermore dust suppression methods (e.g. spraying surfaces with water) should be used to minimise the transport of wind-blown dust
	Excavation of borrow pits for road construction	Can act as pitfall traps for amphibians and other terrestrial species leading to unnecessary death of species.			Excavations and construction of borrow pits for road construction should be located outside of the recommended buffer areas around wetlands and watercourses and should be rehabilitated following construction. Pits or excavations should be checked regularly by the on-site ECO and plans put in place for species rescue and relocation.
	Operation of heavy machinery within or in close proximity to wetlands or watercourses and placement of associated vehicle maintenance/ refuelling depots	Disturbance of aquatic and semi-aquatic fauna, as a result of the noise from construction teams and their machinery working within or in close proximity to wetlands and rivers. Damage to vegetation from operating heavy machinery			As far as possible heavy machinery should not be operated in wetlands / water course and their associated buffers. If this is unavoidable then all operations should be managed by an on-site ECO, with further screening/ groundtruthing assessments conducted on an ad-hoc basis. Relocation of sensitive flora and fauna may be required prior to

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
					operation.
					No fuel storage, refuelling, vehicle maintenance or vehicle depots should be allowed within 30 m of the edge of any wetlands or drainage lines. 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
					Vehicles and machinery should not be washed within 30 m of the edge of any wetland or watercourse.
					No effluents or polluted water should be discharged directly into any watercourse or wetland areas.
					If construction areas are to be pumped of water (e.g. after rains), this water should be pumped into an appropriate settlement area, and not allowed to flow straight into any

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
					watercourses 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.
					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

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
					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
Operational Phase	Clearing or trimming of natural wetland or riparian vegetation	Loss and/or reduction in habitat quality Growth stimulation of alien vegetation/invasive species	Degradation of ecological integrity and changes to species community composition as well as habitat structure		One of the options that could be explored to mitigate against the potential vegetation clearing/trimming impacts would be to consider constructing taller pylons in certain areas that are high enough to allow for the growth of relatively tall vegetation. Fixed point photography could be used to monitor long-term vegetation changes and potential site impacts
	Application of herbicides	Pollution (water quality deterioration) of freshwater ecosystems and potential contamination of groundwater/subsurface drainage			Avoid the use of herbicides in close proximity (close than 50 m) to wetlands or rivers and do not disturb riparian/or wetland buffer areas
	Operation of high-voltage transmission lines above freshwater ecosystems.	Disturbance to aquatic fauna due to the noise and electromagnetic field (EMF) from the transmission line.			There is no way to mitigate against the noise- and EMF-related disturbance to aquatic and semiaquatic fauna potentially associated with the operation of the proposed power

Project Phase	Activity	Key Impact	Possible Effect	Site Specific Description Summary	Mitigation
					line and associated substations and switching stations, and it is difficult to predict how significant this potential impact could be. The light-related disturbance from the substations and switching station could be mitigated to some degree by minimising the amount of lighting at these facilities and by using low intensity lights that are directed exclusively to the areas where night-time lighting is required.

10 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

This section provides “best practice” (or “good practice”) guidelines and management actions (including relevant standards and protocols) 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. These guidelines and monitoring requirements must also take into consideration mitigation measures provided in Section 9.

10.1 Planning phase

The planning phase for EGI development through firstly establishing preferred powerline alignments, then determining sites for substations, placement of pylons, and needs for ancillary infrastructure (e.g. access roads, water abstraction points, etc.) has the potential to greatly reduce impacts on freshwater ecosystems and associated fauna and flora through simply avoiding areas of very high sensitivity, and as far as possible avoiding areas of high sensitivity. In order to significantly reduce potential impacts on freshwater biodiversity, sub-quaternary catchments classified with a very high or high sensitivity should be avoided. Where these areas cannot be avoided, a detailed desktop investigation should be followed to determine whether the EGI alignment and development footprint can avoid the actual freshwater ecosystems (i.e. wetland and river habitats) and associated buffers (as per Section 7.1). This process should also be followed for all other sub-quaternary catchments (including medium and low sensitivities).

Where it is impossible to avoid freshwater ecosystems (i.e. wetland and river habitats) and associated buffers altogether, it will be necessary to undertake more detailed specialist studies, impacts assessments, and if necessary investigate needs and opportunities for offsets. Preference should be given to position EGI within already disturbed/degraded areas (e.g. freshwater ecosystems and buffers that are already invaded by IAPs). Mitigation specific to impact significance should be considered that is cognisant of the mitigation hierarchy, where very high significance impacts are avoided, while high and medium significance impacts are mitigated as far as possible. Offsets should only be considered once alternatives and mitigation measures have been exhausted, and in instances where it is provided that there are significant residual impacts due to the proposed development. Any freshwater ecosystems that will be affected by EGI development must be subject to a project level assessment.

10.2 Construction phase

This phase may include the construction of pylons and substations, and stringing of transmission lines, and will thus include a number of impacts typical of construction activities, such as disturbance to wildlife through noise/light pollution, creation of dust, erosion and degradation/disturbance of habitats and vegetation (including areas for access via roads and servitudes and movement of heavy machinery), and bulldozing and vegetation/habitat clearing. Specific measures and actions required during the construction phase are presented in Section 9, but key to the process to include:

- Timing of construction activities to occur in the dry season as much as possible;
- Appointment and involvement of an ECO to provide oversight and guidance to all construction activities, as well as ensure full consideration and implementation of the EMPr; and
- Environmental monitoring (or biomonitoring) required for pre-construction, during construction and post construction at strategically selected monitoring sites based on additional detail specified in Section 10.5 below.

10.3 Operations phase

This phase will predominantly include activities typical of routine maintenance, such as clearing/trimming of natural wetland or riparian vegetation (to maintain required height clearance of transmission lines over vegetation), IAP control and application of herbicides, and operation of high-voltage transmission lines. Specific measures to be considered are provided in in Section 9.

10.4 Rehabilitation and post closure

Rehabilitation and post-closure measures would most likely be required for areas in and around pylons 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.

Additional points to be considered regarding rehabilitation of degraded areas within and adjacent to freshwater ecosystems include:

- IAP clearing and control – an IAP control programme should be developed and implemented based on site-specific details, including, but not limited to, types of IAPs, growth forms, densities and levels of infestation, potential dispersal mechanisms, knock-on impacts to freshwater ecosystems caused during implementation (e.g. herbicide drift and contamination), etc.;
- Erosion control and re-vegetation – the objective should be to establish indigenous vegetation cover as soon as possible, as well as to control and limit secondary impacts caused by rainfall-runoff. Where necessary geotextile fabrics, brush mattresses/bundles, geocells, and hydroseeding with a suitable grass seed mix should be considered, while more severe cases of erosion/bank collapse will require more advanced stabilisation methods (e.g. reshaping, planting, concrete blocks, riprap, gabions/reno mattresses, etc.).

10.5 Monitoring requirements

Sites/areas where freshwater ecosystems are likely to be affected by EGI 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 (biannual monitoring during the operational phase is not necessary for transmission lines or pylons);
- A single sample can be collected at closure, with additional sampling events 3 and 6 months post closure; and
- Fixed point photography to monitor changes and long term impacts.

11 CONCLUSIONS AND FURTHER RECOMMENDATIONS

Biodiversity impacts, unfortunately, are unavoidable when developing large-scale projects such as national-scale EGI. This is particularly the case when considering that these linear developments need to avoid human settlement (and other areas with anthropogenic significance, e.g. large/viable agricultural areas) as much as possible to prevent socio-economic impacts. Despite this, impacts to local and regional biodiversity assets can be substantially reduced through careful strategic level planning and design which consider areas of concern.

The sensitivity maps presented herein are based on specifically developed methods that enabled spatial integration of a broad suite of data depicting freshwater ecosystems and associated fauna and flora. Outputs include a series of four-tiered sensitivity maps that are intended to be used proactively in terms of planning EGI development footprint areas and pathways for transmission lines, including servitude negotiations and potential land acquisitions, such that environmental impacts to freshwater ecosystems are minimised. The sensitivity maps provided in this SEA, are seen as an improvement from those provided in the 2016 EGI SEA in that they provide sensitivity assessments using a greater suite of data sets, the most up-to-date data, and assessments at higher resolutions (through the inclusion of fine-scale mapping across the country and at the catchment scale). The maps also indicate those areas where development is likely to be able to proceed with minimal risk and needs for project level assessments.

The sensitivity maps and desktop analyses can also be used for any other planned development within the corridors that may impact freshwater ecosystems. Potential impacts and associated mitigation measures identified in this SEA are related specifically to EGI and are not generally applicable to other types of development.

Transmission line routing will need to include an integration of all specialist studies and GIS layers to develop something akin to a Marxan cost surface. It is assumed that a measure of slope will be factored in the routing optimisation, as it is applicable across a number of specialist fields. Specialist input will still be required to aid in the identification of the preferred option and refine the final powerline route through the identified corridor/s based on more detailed desktop and infield assessments. Ultimately, transmission line routing and development should avoid areas of very high sensitivity, and as far as possible avoid areas a high sensitivity. Where this is not possible, more site-specific specialist studies will need to be conducted to include further desktop verification with ground-truthing. Specific considerations for additional specialist studies include:

- Details for more sensitive areas, and
- Catchment-scale evaluation and oversight;
- Confirmation of occurrence of species conservation concern through range/habitat modelling and field surveys;
- Identify primary receivers, major impacts and most effective site-specific mitigation measures along with sensitivity specific mitigation measure; and
- Undertake pre-construction walk-throughs.

12 REFERENCES

ADU, (2017). Animal Demography Unit: FrogMAP Virtual Museum. [online] Available at: http://vmus.adu.org.za/?vm=FrogMAP [Accessed Feb. 2018].

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. and de Villiers, M. (eds.) (2014). Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. South African National Biodiversity Institute, Pretoria: Suricata 1, p. 485.

CapeNature. (2017). The Western Cape Biodiversity Spatial Plan Handbook. Authored by Pool-Stanvliet, R., Duffell-Canham, A., Pence, G. & Smart, R. Stellenbosch: CapeNature.

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.

Coetzer W (2017). Occurrence records of southern African aquatic biodiversity. Version 1.10. The South African Institute for Aquatic Biodiversity. Occurrence dataset https://doi.org/10.15468/pv7vds accessed via GBIF.org on 2018-09-05.

Collins, N (2017). National Biodiversity Assessment (NBA) 2018. Wetland Probability Map. Available at: https://csir.maps.arcgis.com/apps/MapJournal/index.html?appid=8832bd2cbc0d4a5486a52c843daebcba # [Accessed Feb. 2018].

DEA, (2016). Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. CSIR Report Number: CSIR/02100/EMS/ER/2016/0006/B. Stellenbosch. Report prepared for the Department of Environmental Affairs DEA.

Driver, A., J. L. Nel, K. Snaddon, K. Murray, D. J. Roux, L. Hill, E. R. Swartz, J. Manuel, and N. Funke. (2011). Implementation manual for freshwater ecosystem priority areas. Water Research Commission, WRC Report No. K5/1801/1/11.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. [online] Department of Water and Sanitation RQIS-RDM, Pretoria. Available at: https://www.dwa.gov.za/iwqs/rhp/eco/peseismodel.aspx [Accessed Feb. 2018].

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. [online] Department of Water and Sanitation RQIS-RDM, Pretoria. Available at: http://www.dwa.gov.za/iwqs/gis_data/ [Accessed Feb. 2018].

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/ [Accessed Feb. 2018].

EKZNW (2007). Archived KZN SCP: Freshwater Systematic Conservation Plan. Available at: http://bgis.sanbi.org/SpatialDataset/Detail/333

IUCN, (2012). Guidelines for application of IUCN Red List Criteria at Regional and National Levels: Version 4.0. IUCN: Gland, Switzerland, and Cambridge, UK, p.41.

IUCN, (2017). The IUCN Red List of Threatened Species, 2017.3. [online] Available at: http://www.iucnredlist.org/ [Accessed Feb. and Mar. 2018].

James, C.S and King, J.M. (2010). Ecohydraulics for South African Rivers: A Review and Guide. Water Research Commission, WRC Report No. TT 453/10. The publication of this report emanates from a project entitled: South African Handbook on Environmental River Hydraulics (WRC Project No. K5/1767).

Kleynhans, C. J. (2000). Desktop estimates of the ecological importance and sensitivity categories (EISC), default ecological management classes (DEMC), present ecological status categories (PESC), present attainable ecological management classes (present AEMC), and best attainable ecological management class (best AEMC) for quaternary catchments in South Africa. *Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.*

Kleynhans, C. J., Thirion, C and Moolman, J. (2005). A Level I River Ecoregion classification System for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria, South Africa.

Mecenero, S., Ball, J.B., Edge, D.A., Hamer, M.L., Hening, G.A., Krüger, M., Pringle, E.L., Terblanche, R.F. and Williams, M.C. (eds) (2013). Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas. Johannesburg: Saftronics (Pty) Ltd., and Cape Town: Animal Demography Unit, p. 676.

Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. and Kloefder, D. (eds) (2004). Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland. Washington, U.S.A: Smithsonian Institute, Volume 9 of the Monitoring and Assessment of Biodiversity Series, p. 360.

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.

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. K5/1801/2/11.

Raimondo, D., von Staden, L., Foden, W., Victor, J.E., Helme, N.A., Turner, R.C., Kamundi, D.A. and Manyama, P.A. (2009). Red List of South African Plants. Pretoria: South African National Biodiversity Institute, Strelitzia 25, p. 668.

Rudman, J., Gauché, P. and Esler, K.J. (2017). Direct environmental impacts of solar power in two arid biomes: An initial investigation. South African Journal of Science, 113, pp. 1-13.

Samways, M.J. and Simaika, J.P. (2016). Manual of Freshwater Assessment for South Africa: Dragonfly Biotic Index. South African National Biodiversity Institute, Pretoria: Suricata 2, p. 224.

SANBI, (2017). Red List of South African Plants: An online checklist. Version 2017.1. [online] Available at: redlist.sanbi.org [Accessed Feb. and Mar. 2018].

SANBI, (2018). Threatened Species Programme. [online] Available at: http://redlist.sanbi.org/ [Accessed Feb. and Mar. 2018]- Data requested from SANBI.

Scott-Shaw, C.R. and Escott, B.J. (eds.) (2011). KwaZulu-Natal Provincial Pre-Transformation Vegetation Type Map – 2011. Pietermaritzburg: Ezemvelo KZN Wildlife Biodiversity Conservation Planning Division, kznveg05v2_1_11_wll.zip (unpublished GIS coverage).

Todd, S., Kirkwood, D., Snaddon, K. and Ewart-Smith, J. (2016). Terrestrial and Aquatic Biodiversity Scoping Assessment Specialist Report. In: Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. Report prepared by the CSIR, DEA, Eskom and SANBI, Appendix C.3, pp. 1-169.

Van der Linde, M. (2006). Compendium of South African Environmental Legislation. Pretoria University, Pretoria, South Africa: Pretoria University Law Press (PULP), p. 573.

Von Hippel, D.F. and Williams, J.H. (2003). Environmental Issues for Regional Power Systems in Northeast Asia. In: Third Workshop on Northeast Asia Power Grid Interconnections. [online] Vladivostok: Russian Federation, pp. 63 . Available at: http://nautilus.org/archives/energy/grid/2003Workshop/Env_Issues_DVH_JW_final_pdf.PDF [Accessed Mar. 2018].

APPENDICES

Appendix 1: Selected flora used in the assessment of freshwater biota

Family	Species	Conservation status
Fabaceae	*Albizia suluensis*	EN
Apocynaceae	*Asclepias gordon-grayae*	EN
Apocynaceae	*Aspidonepsis cognata*	NT
Salviniaceae	*Azolla pinnata subsp. africana*	NT
Plantaginaceae	*Bacopa monnieri*	NT
Rhizophoraceae	*Cassipourea gummiflua var. verticillata*	VU
Asteraceae	*Cotula filifolia*	NT
Amaryllidaceae	*Crinum moorei*	VU
Cyperaceae	*Cyathocoma bachmannii*	VU
Cyperaceae	*Cyperus sensilis*	NT
Apocynaceae	*Ectadium virgatum*	NT
Eriocaulaceae	*Eriocaulon mutatum var. angustisepalum*	VU
Zygophyllaceae	*Fagonia rangei*	NT
Cyperaceae	*Fimbristylis aphylla*	VU
Geraniaceae	*Geranium ornithopodioides*	EN
Hydrostachyaceae	*Hydrostachys polymorpha*	VU
Isoetaceae	*Isoetes eludens*	VU
Asphodelaceae	*Kniphofia latifolia*	EN
Asphodelaceae	*Kniphofia leucocephala*	CR
Hydrocharitaceae	*Lagarosiphon cordofanus*	VU
Alismataceae	*Limnophyton obtusifolium*	NT
Onagraceae	*Ludwigia leptocarpa*	NT
Marsileaceae	*Marsilea fenestrata*	NT
Apocynaceae	*Mondia whitei*	EN
Najadaceae	*Najas setacea*	VU
Amaryllidaceae	*Nerine pancratioides*	NT
Lythraceae	*Nesaea crassicaulis*	NT
Lythraceae	*Nesaea wardii*	VU
Lamiaceae	*Ocimum reclinatum*	VU
Hydrocharitaceae	*Ottelia exserta*	NT
Oxalidaceae	*Oxalis dines*	VU
Oxalidaceae	*Oxalis disticha*	NT
Poaceae	*Panicum sancta-luciense*	Rare
Arecaceae	*Raphia australis*	VU
Santalaceae	*Thesium polygaloides*	VU
Scrophulariaceae	*Torenia thouarsii*	VU
Lentibulariaceae	*Utricularia benjaminiana*	NT
Lentibulariaceae	*Utricularia foliosa*	VU
Lemnaceae	*Wolffiella denticulata*	VU
Xyridaceae	*Xyris natalensis*	NT

Appendix 2: Selected fauna according the taxonomic groups used in the assessment of freshwater biota

Family	Species name	Common name	Conservation status
Dragonflies and Damselflies (Odonata)			
Coenagrionidae	*Aciagrion gracile*	Graceful Slim	VU
Coenagrionidae	*Agriocnemis gratiosa*	Gracious Wisp	VU
Chlorocyphidae	*Chlorocypha consueta*	Ruby Jewel	CR
Libellulidae	*Diplacodes pumila*	Dwarf Percher	EN
Aeshnidae	*Gynacantha villosa*	Brown Duskhawker	VU
Corduliidae	*Hemicordulia africana*	African Emerald	NT
Lestidae	*Lestes dissimulans*	Cryptic Spreadwing	VU
Lestidae	*Lestes ictericus*	Tawny Spreadwing	VU
Lestidae	*Lestes uncifer*	Sickle Spreadwing	VU
Libellulidae	*Olpogastra lugubris*	Bottletail	NT
Libellulidae	*Orthetrum robustum*	Robust Skimmer	NT
Libellulidae	*Parazyxomma flavicans*	Banded Duskdarter	VU
Libellulidae	*Trithemis werneri*	Elegant Dropwing	NT
Fish			
Amphiliidae	*Amphilius natalensis*	*Natal Mountain Catfish*	DD
Poeciliidae	*Aplocheilichthys myaposae*	*Natal Topminnow*	NT
Cyprinidae	*Barbus eutaenia*	*Orangefin Barb*	DD
Cyprinidae	*Engraulicypris gariepenus*		NT
Cyprinidae	*Labeo rubromaculatus*	*Tugela Labeo*	VU
Cyprinidae	*Labeo seeberi*	Clanwilliam Sandfish	EN
Cyprinidae	*Labeobarbus nelspruitensis*	*Incomati Chiselmouth*	NT
Mormyridae	*Marcusenius caudisquamatus*		EN
Cichlidae	*Oreochromis mossambicus*	Mozambique Tilapia	VU
Cyprinidae	*Pseudobarbus phlegethon*	*Fiery Redfin*	EN
Cyprinidae	*Pseudobarbus serra*	*Clanwilliam Sawfi*	NT
Gobiidae	*Silhouettea sibayi*	*Sibayi Goby*	EN
Amphibians			
Brevicipitidae	*Breviceps bagginsi*	Bilbo's Rain Frog	NT
Brevicipitidae	*Breviceps branchi*	Branch's Rain Frog	DD
Brevicipitidae	*Breviceps macrops*	Desert Rain Frog	NT
Bufonidae	*Capensibufo deceptus*	Deception Peak Mountain Toadlet	DD
Hemisotidae	*Hemisus guttatus*	Spotted Shovel-nosed Frog	NT
Hyperoliidae	*Hyperolius pickersgilli*	Pickersgill's Reed Frog	EN
Arthroleptidae	*Leptopelis xenodactylus*	Long-toed Tree Frog	EN
Pyxicephalidae	*Natalobatrachus bonebergi*	Kloof Frog	EN
Reptiles			
Chamaeleondidae	*Bradypodion melanocephalum*	KwaZulu Dwarf Chamaeleon	VU
Lamprophiidae	*Macrelaps microlepidotus*	KwaZulu-Natal Black Snake	NT
Gekkonidae	*Pachydactylus rangei*	Namib Web-footed Gecko	CR
Pelomedusidae	*Pelusios rhodesianus*	Variable Hinged Terrapin	VU
Mammals			
Carnivora	*Aonyx capensis*	Cape Clawless Otter	NT
Carnivora	*Leptailurus serval*	Serval	NT
Carnivora	*Hydrictis maculicollis*	Spotted-necked Otter	VU
Eulipotyphla	*Crocidura mariquensis*	Swamp Musk Shrew	VU
Eulipotyphla	*Myosorex sclateri*	Sclater's Forest Shrew	VU
Rodentia	*Dasymys incomtus*	African Marsh Rat	NT
Rodentia	*Otomys auratus*	Vlei Rat	NT
Rodentia	*Otomys laminatus*	Laminate Vlei Rat	NT

Appendix 3: Peer Review and Specialist Response Sheet

Peer Reviewer: Duncan Hay, Catherine Pringle, and Leo Quayle, Institute of Natural Resources

EXPERT REVIEW AND SPECIALIST RESPONSES: Freshwater - EGI Expansion					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 Specialists**
Kate Pringle	5	1-30		This section has different line spacing to the rest of the report.	Corrected
Kate Pringle	5	23-29		This is a very long sentence. I suggest shortening.	For clarity, the sentence has been split into three sentences.
Kate Pringle	6	2		"the Eskom" - "the" should be removed	Corrected
Kate Pringle	6	9		Electricity grid infrastructure does not need to be written in full again as the acronym has already been provided in the previous section	This was previously abbreviated in the summary but needs to be abbreviated again in the first section of the main report.
Kate Pringle	7	19		build should be builds	Corrected
Kate Pringle	8	8		Why does the freshwater assessment identify caves, geology and roosts?	This was a generic sentence copied from CSIR template. It has been reworded to relate to freshwater features such as waterfalls, spray zones etc.
Kate Pringle	8	32		Further the above - should this not be further to the above?	Corrected
Kate Pringle	9	6		I think it would be good to mention that the species information relates to freshwater-dependent species and not all plants, butterflies and reptiles	Edited
Kate Pringle	12	10		PES should be written in full	PES was already written in full in this section
Kate Pringle	12	11		EI and ES should be written in full	Corrected
Kate Pringle	12	12		DWS should be written in full	DWS has already been abbreviated in Section 3 on Page 8.
Kate Pringle	12	30-33		It is unclear why stream order has been included in determining river sensitivity. Could you provide additional justification for this?	Higher stream order usually represents smaller, faster flowing, lower volume rivers higher in the catchment which are more sensitive to impacts.
Kate Pringle	13		Table 1	I would suggest that Ramsar sites be included in the very high sensitivity class	The reason why Ramsar sites were given a "high" sensitivity and not given a very high sensitivity is because they are protected to some extent. We feel that highly sensitive systems outside of protected areas and other conservation areas are more sensitive as they are more likely to be impacted by development.
Kate Pringle	23		Table 3	HGM should be written in full	HGM is already abbreviated in Table 2 on Page 22.

EXPERT REVIEW AND SPECIALIST RESPONSES: Freshwater - EGI Expansion					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 Specialists**
Kate Pringle	24		Table 4	The relevant acts, strategies and policies are a bit muddled in this table. I would reorder the national instruments so that NEMA appears first as the framework legislation followed by the various specific environmental management acts (SEMAs) e.g. National Water Act. I would also then list the associated instruments, policies and strategies under the relevant act e.g. the EIA regs under NEMA and the RQOs under the National Water Act.	No changes done. The table has been ordered as per CSIR suggestions and flow from international instruments/legislation down to provincial/regional legislation
Kate Pringle	29		Table 4	Is it necessary to list all the extended power ordinances?	These are not power ordinances but conservation ordinances relevant to freshwater. We just wanted to be thorough.
Kate Pringle	31	3-5		Are these not better classified as direct and indirect impacts?	Changed to 'direct' and 'indirect'
Kate Pringle	31-34			This section is very similar to Section 9. Presumably Section 5 should focus on broad impacts and section 9 specific impacts and mitigation. It might be useful to list similar key impacts (as per section 9) and provide an associated description. This would help the reader to match the broad impacts and proposed mitigation measures.	This is probably linked more to the templates that were provided, which guided our reporting process, noting that there were changes made to the reporting structure and formats, particularly in the gas report.
Kate Pringle	31	13		I would suggest listing construction of substations and powerlines first as this is the primary activity.	Changed
Kate Pringle	32	3		Threatened **or** other species	Corrected
Kate Pringle	32	32		which should be with	Corrected
Kate Pringle	33	14		In severe more cases?	Corrected to "In more severe cases"
Kate Pringle	36		Table 5	"Heavily infested areas is having an impact" should be "heavily infested areas **are** having an impact"	Corrected to "heavily infested areas have a significant impact…"
Kate Pringle	37		Table 5	NFEPA wetlands….floodplains, seeps…	Corrected
Kate Pringle	40		Table 7	Ramsar wetlands should be very high	The reason why Ramsar sites were given a "high" sensitivity and not given a very high sensitivity is because they are protected to some extent. We feel that highly sensitive systems outside of protected areas and other conservation areas are more sensitive as they are more likely to be impacted by development.
Kate Pringle	66	25		2017 should be in brackets	Corrected
Kate Pringle	68	3		CJ should be C.J.	Corrected
	General comment			Have birds been considered elsewhere? There are several key wetland species such as cranes which may be significantly impacted by powerlines.	Avifauna assessment will cover impacts to birds

EXPERT REVIEW AND SPECIALIST RESPONSES: Freshwater - EGI Expansion					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 Specialists**
Kate Pringle	General comment			The report largely focuses on aquatic biodiversity. Other important freshwater aspects, particularly water production by ecological infrastructure has not been considered. For example, strategic water source areas (SWSAs) have not been mentioned. Although the SWSAs likely to be impacted in the eastern corridor are relatively small they should be noted and avoided. Of greater concern are the extensive groundwater strategic water source areas in this corridor. In addition, most of the wetland resources in northern KZN are groundwater driven. Has groundwater been considered elsewhere? If not, this is a major oversight that must be addressed. If the groundwater has been addressed elsewhere, it would be helpful to cross-reference.	Note from the Project Team: The EGI is not expected to be deep enough to impact significantly on groundwater resources and deep aquifers. The specialists believe that the consideration of groundwater is not a major concern as aquatic systems are not driven significantly by groundwater resources, and the impacts from gas pipelines will be minor (and non-existent for EGI). However, this assumes that we are referring to (deeper) groundwater and not subsurface flows. Nevertheless, the following impact has been assessed in the Freshwater EGI Report: Pollution (water quality deterioration) of freshwater ecosystems and potential contamination of groundwater/subsurface drainage. Note that Strategic Water Source Areas (SWSAs) - Surface and Groundwater (Dataset: Council for Scientific and Industrial Research (CSIR), April 2018) has been used in the Environmental Sensitivity Analysis, and has been rated with a HIGH Sensitivity. This will be captured in the Environmental Sensitivity Map in the SEA Report, as well as in the Integrated Biodiversity Assessment Chapter.
Kate Pringle	General comment			Have estuaries been considered elsewhere? The Orange river mouth wetland/estuary has been noted but none of those in KZN.	Estuaries are not considered in the Freshwater Assessment but are the subject of a separate dedicated specialist assessment.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.7

Biodiversity and Ecological Impacts - Avifauna

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

AVIFAUNA

Contributing Authors	Chris van Rooyen Albert Froneman

[1] Chris van Rooyen Consulting

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ABBREVIATIONS AND ACRONYMS

BFD	Bird Flight Diverter
BLSA	Birdlife South Africa
CR	Critically Endangered
ECO	Environmental Control Officer
EGI	Electricity Grid Infrastructure
EN	Endangered
EWT	Endangered Wildlife Trust
IBA	Important Bird Area
IFC	International Finance Corporation
LED	Light Emitting Diode
NMU	Nelson Mandela University
NT	Near threatened
QDGC	Quarter Degree Grid Cell
SABAP1	Southern African Bird Atlas Project 1
SABAP2	Southern African Bird Atlas Project 2
SANBI	South African National Biodiversity Institute
SEA	Strategic Environmental Assessment
VU	Vulnerable

1 SUMMARY

The table below provides a summary of the most important findings of the study, as well as an overall suitability rating for each Expanded EGI Corridor.

Corridor	Overall Suitability	Comment
Expanded Western Corridor	Moderate suitability for power line infrastructure development. Abundance of High Sensitivity areas is due to the overall very low human population, with most of the natural habitat relatively untransformed. This, coupled with the occurrence of several high-risk species has resulted in the majority of the habitat receiving a High Sensitivity rating.	Key issues are the following: • Greater Flamingo collisions at waterbodies. • Kori Bustard collisions in the Nama and Succulent Karoo. • Black Stork collisions and displacement at waterbodies, drainage lines and cliffs. • Blue Crane collisions at cultivated commercial fields and waterbodies. • Great White Pelican collisions at waterbodies and along the coast. • Lesser Flamingo collisions at waterbodies and along the coast. • Ludwig's Bustard collisions in the Nama and Succulent Karoo. • Martial Eagle electrocutions and displacement of breeding birds on transmission lines in the Nama and Succulent Karoo. • Secretary bird collisions in the Nama and Succulent Karoo. • Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites throughout the corridor. • Caspian Tern collision at large waterbodies throughout the corridor.
Expanded Eastern Corridor	Moderate suitability for power line infrastructure development. The dense human population has resulted in large-scale transformation of the natural habitat, resulting in large sections of the corridor rated as Low Sensitivity. However, the remaining natural areas support a wide variety of power line sensitive Red Data species, resulting in many areas being rated as High or Very High.	Key issues are the following: • African Marsh-harrier collisions throughout the corridor. • Southern Ground Hornbill collisions, electrocutions and displacement throughout the corridor. • Black Stork collisions and displacement at waterbodies, cliffs and drainage lines throughout the corridor. • Blue Crane collisions and disturbance of breeding birds in grassland and wetland areas in Grassland. • Cape Vulture electrocutions, disturbance at breeding colonies and roosts throughout the corridor. Collisions and electrocutions at vulture restaurants. • Denham's Bustard collisions in grassland areas throughout the corridor. • Great White Pelican and Pink-backed Pelican collisions and displacement at waterbodies in Indian Ocean Coastal Belt. • Greater and Lesser Flamingo collisions at waterbodies throughout the corridor. • Grey Crowned Crane collisions at wetlands and cultivated commercial fields in Grassland and Indian Ocean Coastal Belt. Displacement of breeding birds in wetlands in Grassland and Indian Ocean Coastal Belt. • Secretarybird collisions throughout the corridor except Indian Ocean Coastal Belt.

Corridor	Overall Suitability	Comment
		• Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites. • Wattled Crane collisions and displacement at wetlands in Grassland. • Southern Bald Ibis collision and displacement at cliffs in Grassland. • Blue Swallow displacement due to habitat destruction in the KwaZulu – Natal mistbelt in the Grassland biome. • Displacement due to disturbance and habitat destruction at nest localities of Bateleur, Lappet-faced Vulture, Marabou Stork, Martial Eagle, Secretarybird, Tawny Eagle, Southern, White-backed Vulture, Hooded Vulture and White-headed Vulture in Savannah, African Crowned Eagle and Banded Snake-Eagle in Forest, and Pel's Fishing Owl at rivers and waterbodies in the northern part of the corridor. • Saddle-billed Stork and Yellow-billed Stork collisions at waterbodies in Savanna.

2 INTRODUCTION

The most prominent direct negative impact on birds by electricity infrastructure in South Africa are mortality through electrocution and collisions (Ledger and Annegarn, 1981; Ledger, 1983; Ledger, 1984; Hobbs and Ledger, 1986a; Hobbs and Ledger, 1986b; Ledger, et al., 1992; Verdoorn, 1996; Kruger and Van Rooyen, 1998; Van Rooyen, 1998; Kruger, 1999; Van Rooyen, 1999; Van Rooyen, 2000; Van Rooyen, 2007; Lehman et al*.,* 2007; Jenkins et al., 2010; Shaw, 2013).

Electrocution refers to the scenario where a bird is perched or attempts to perch on the electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components. The electrocution risk is largely determined by the pole/tower design (APLIC, 1996). In South Africa, large raptors and particularly vultures, are most prone to electrocution on electricity infrastructure (Ledger and Annegarn, 1981; Ledger, 1984; Verdoorn, 1996; Van Rooyen, 1998; Kruger et al., 2004; Boshoff et al., 2011).

Collision mortality is probably the biggest threat posed by transmission lines to birds in South Africa (Van Rooyen, 2004). Most heavily impacted upon are bustards, storks, cranes and various species of waterbirds (Jenkins et al., 2010). These species are mostly heavy-bodied birds with limited manoeuvrability, which makes it difficult for them to take the necessary evasive action to avoid colliding with power lines (Van Rooyen, 2004). Shaw (2013: 3 - 4) provides a concise summary of the phenomenon of avian collisions with power lines:

"The collision risk posed by power lines is complex and problems are often localised. While any bird flying near a power line is at risk of collision, this risk varies greatly between different groups of birds, and depends on the interplay of a wide range of factors (APLIC, 2012). Bevanger (1994) described these factors in four main groups – biological, topographical, meteorological and technical. Birds at highest risk are those that are both susceptible to collisions and frequently exposed to power lines, with waterbirds, gamebirds, rails, cranes and bustards usually the most numerous reported victims (Bevanger, 1998; Rubolini et al., 2005; Jenkins et al., 2010).

The proliferation of man-made structures in the landscape is relatively recent, and birds are not evolved to avoid them. Body size and morphology are key predictive factors of collision risk, with large-bodied birds with high wing loadings (the ratio of body weight to wing area) most at risk (Bevanger 1998; Janss 2000). These birds must fly fast to remain airborne, and do not have sufficient manoeuvrability to avoid unexpected obstacles. Vision is another key biological factor, with many collision-prone birds principally *using lateral vision to navigate in flight, when it is the lower-resolution, and often restricted, forward vision that is useful to detect obstacles (Martin & Shaw, 2010; Martin, 2011; Martin et al., 2012). Behaviour is important, with birds flying in flocks, at low levels and in crepuscular or nocturnal conditions at higher risk of collision (Bevanger, 1994). Experience affects risk, with migratory and nomadic species that spend much of their time in unfamiliar locations also expected to collide more often (Anderson, 1978; Anderson, 2002). Juvenile birds have often been reported as being more collision-prone than adults (e.g. Brown et al., 1987; Henderson et al., 1996).*

Topography and weather conditions affect how birds use the landscape. Power lines in sensitive bird areas (e.g. those that separate feeding and roosting areas, or cross flyways) can be very dangerous (APLIC, 2012; Bevanger, 1994). Lines crossing the prevailing wind conditions can pose a problem for large birds that use the wind to aid take-off and landing (Bevanger, 1994). Inclement weather can disorient birds and reduce their flight altitude, and strong winds can result in birds colliding with power lines that they can see but do not have enough flight control to avoid (Brown et al., 1987; APLIC, 2012).

The technical aspects of power line design and siting also play a big part in collision risk. Grouping similar power lines on a common servitude or locating them along other features such as tree lines, are both approaches thought to reduce risk (Bevanger, 1994). In general, low lines with short span lengths (i.e. the distance between two adjacent pylons) and flat conductor configurations are thought to be the least dangerous (Bevanger, 1994; Jenkins et al., 2010). On many higher voltage lines, there is a thin earth (or ground) wire above the conductors, protecting the system from lightning strikes. Earth wires are widely accepted to cause the majority of collisions on power lines with this configuration because they are difficult to see, and birds flaring to avoid hitting the conductors often put themselves directly in the path of these wires (Brown et al.. 1987; Faanes, 1987; Alonso et al., 1994a; Bevanger 1994)."

From incidental record keeping by the Endangered Wildlife Trust (EWT), it is possible to give a measure of what species are generally susceptible to power line collisions in South Africa (see Figure 1). This list is far from comprehensive as only a fraction of mortalities are ever reported (Kruger, 1999; Shaw, 2013).

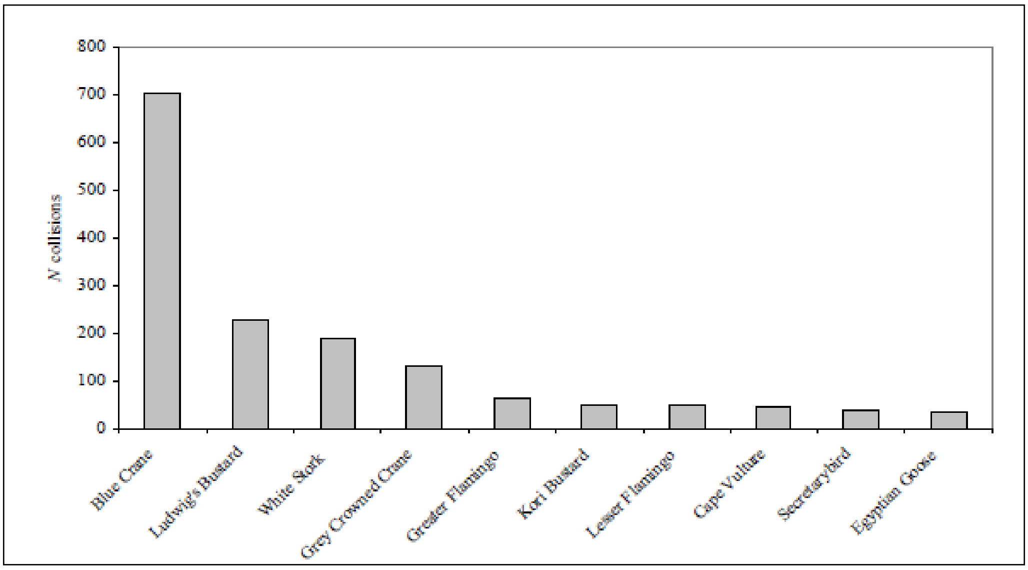


Figure 1: The top 10 collision prone bird species in South Africa, in terms of reported incidents contained in the Eskom/EWT Strategic Partnership central incident register 1996 - 2008 (Jenkins et al., 2010).

The Blue Crane (*Anthropoides paradiseus*) is by far the most frequently reported, which is unsurprising given that this bird is well known, conspicuous, and commonly inhabits intensively farmed landscapes (Shaw, 2013). Power line collisions are also accepted as a key threat to bustards (Raab et al., 2009; Raab et al*.,* 2010; Jenkins & Smallie, 2009; Barrientos et al*.,* 2012, Shaw, 2013). In a comprehensive study, carcass surveys were performed under high voltage transmission power lines in the Karoo for two years, and low voltage distribution lines for one year. Ludwig's Bustard (*Neotis ludwigii*) was the most common collision victim (69% of carcasses), with bustards generally comprising 87% of mortalities recovered. Total annual mortality was estimated at 41% of the Ludwig's Bustard population, with Kori Bustards (*Ardeotis kori*) also dying in large numbers (at least 14% of the South African population killed in the Karoo alone). Karoo Korhaan (*Eupodotis vigorsii*) was also recorded, but to a much lesser extent than Ludwig's Bustard. The reasons for the relatively low collision risk of this species probably include their smaller size (and hence greater agility in flight), as well as their more sedentary lifestyles, as local birds are familiar with their territory and are less likely to collide with power lines (Shaw, 2013).

Despite doubts about the efficacy of line marking to reduce the collision risk for bustards (Jenkins et al*.,* 2010; Martin et al*.,* 2010), there are numerous studies which prove that marking a line with PVC spiral type Bird Flight Diverters (BFDs) generally reduce mortality rates (e.g. Sporer et al*.,* 2013; Barrientos et al*.,* 2011; Jenkins et al*.,* 2010; Alonso & Alonso, 1999; Koops & De Jong, 1982), also to some extent for bustards (Barrientos et al*.,* 2012; Hoogstad, 2015 pers.comm). Beaulaurier (1981) summarised the results of 17 studies that involved the marking of earth wires and found an average reduction in mortality of 45%. Barrientos et al*.* (2011) reviewed the results of 15 wire marking experiments in which transmission or distribution wires were marked to examine the effectiveness of flight diverters in reducing bird mortality. The presence of flight diverters was associated with a decrease of 55–94% in bird collisions. Koops and De Jong (1982) found that the spacing of the BFDs were critical in reducing the mortality rates - mortality rates are reduced up to 86% with a spacing of 5 metres, whereas using the same devices at 10 metre intervals only reduces the mortality by 57%. Barrientos et al*.* (2012) found that larger BFDs were more effective in reducing Great Bustard collisions than smaller ones. Line markers should be as large as possible, and highly contrasting with the background. Colour is probably less important as during the day the background will be brighter than the obstacle with the reverse true at lower light levels (e.g. at twilight, or during overcast conditions). Black and white interspersed patterns are likely to maximise the probability of detection (Martin et al*.* 2010).

During the construction and maintenance of power lines and substations, some habitat destruction and transformation inevitably takes place. This happens with the construction of access roads, the clearing of servitudes and the levelling of substation yards. Servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, to prevent vegetation from intruding into the legally prescribed clearance gap between the ground and the conductors and to minimize the risk of fire under the line, which can result in electrical flashovers. These activities have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through transformation of habitat, which could result in temporary or permanent displacement.

Apart from direct habitat destruction, the above-mentioned construction and maintenance activities also impact on birds through disturbance, particularly during breeding activities. Disturbance of breeding individuals could lead to breeding failure through abandonment of the nest or through exposing the eggs and nestlings to predation when the adult birds temporarily leave the nest area (Hockin et al*.,* 1992).

3 PROJECT SCOPE AND TERMS OF REFERENCE

The terms of reference for this report are as follows:

- Review of existing literature to compile a baseline description applicable to each proposed Expanded Electricity Grid Infrastructure (EGI) corridor;
- Compilation of a shortlist of bird species that are sensitive to power lines that are likely to occur in each corridor;

- Identification of avifaunal sensitivity features (e.g. habitat classes, roosts and colonies etc.) within each corridor;
- Development of an approach for classing each sensitivity feature in each corridor according to a four-tiered sensitivity rating system i.e. Very High, High, Medium or Low;
- Assessment of the proposed corridor in terms of the potential impacts associated with the construction and operation of power lines on priority species and their habitats;
- Description of proposed management actions to enhance benefits and avoid/reduce/offset negative impacts in each corridor;
- Based on the findings of the assessment, the compilation of a four-tiered sensitivity map related to potential impact on avifauna in each corridor;
- Provision of input into the pre-construction site specific environmental assessment protocol (Decision-Making Tools) for each corridor i.e. the additional information and level of assessment which is required in each sensitivity category before an authorisation (or similar) with respect to avifauna should be considered.

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 2 of this report.

4 APPROACH AND METHODOLOGY

4.1 Study Methodology

Below is a summary of the methods followed to compile the report.

- The Southern African Bird Atlas 2 (SABAP2) data was obtained from the Animal Demography Unit at the University of Cape Town for each pentad in each corridor. A pentad grid cell covers 5 minutes of latitude by 5 minutes of longitude (5'× 5'). Each pentad is approximately 8km × 7.6km.

- Due to the large number of pentads (n = 1372), the pentads were consolidated into Quarter Degree Grid Cells (QDGC). A QDGC is the equivalent of a 1:50 000 topographical map and covers an area of 15 minutes of latitude by 15 minutes of longitude (25km x 27.4km) or approximately 640 square kilometres. From this a consolidated species list was compiled for each biome in each corridor by pooling all the data for the QDGCs which overlapped with a specific biome within a corridor. The total number of QDGCs for both corridors amounted to 175.

- All avifaunal species that could potentially be impacted by electricity infrastructure were identified for each biome within each corridor using the SABAP2 data as the main source of information. Where there was no SABAP2 data available (n = 2), data from the Southern African Bird Atlas 1 (SABAP1) was used.

- The list of avifaunal species was refined to a list of power line sensitive Red Data priority species for each biome within each corridor. The list was compiled by using the following criteria:
    - Electrocution and collision: Morphology, behaviour, habitat, historical records;
    - Displacement of breeding individuals: Habitat; and
    - SABAP2 reporting rate: A reporting rate of 5% or higher for the species in the biome.

- Bird habitat classes and key sensitivity features were identified for each biome within each corridor (see 4.2.and 7.1 below for a complete list of data sources and sensitivity features).

- The potential negative impacts on avifauna by the electricity grid was identified as:
    - Electrocutions[1];
    - Collisions; and
    - Displacement of breeding individuals

[1] The Eskom Land and Biodiversity Standard (2016) states that “all designs of new power lines and supporting infrastructure for power generation must be evaluated for the risk it could pose to wildlife and no design which has a high risk, or a record of it causing mortalities to wildlife, shall be used.” However, it was assumed that Eskom might not be the only entity building power lines in future; therefore, it cannot automatically be assumed that all future distribution pole designs will be electrocution friendly.

- The probability of the respective impacts occurring in a habitat class was rated for each priority species to arrive at a **species-specific probability score** for each impact, within each habitat class, within each biome, within each corridor. Probabilities for the respective impacts occurring were rated according to the below scale:
  - 0 = the impact is highly unlikely to occur
  - 1 = the impact is unlikely to occur
  - 2 = the impact could possibly occur
  - 3 = the impact will most likely occur

- The species-specific probability score was multiplied by a weighted Red Data status score for each priority species to arrive at a **species-specific habitat sensitivity score** for each species, for each habitat class, within each biome, within each corridor. The Red Data status were assigned weighted scores according to the below scale:
  - Near threatened = 2
  - Vulnerable = 4
  - Endangered = 8
  - Critically endangered = 16

- An **aggregated habitat sensitivity score** for each habitat class within each biome, within each corridor was calculated by summing the species-specific probability scores for that particular habitat class:
  - Low = 0
  - Medium = 1 - 177
  - High = 178 - 354
  - Very High = 355 - 532

- A four-tiered consolidated sensitivity map of all habitat classes indicating their spatial extent in each of the corridors was developed with GIS, using the habitat sensitivity scores of the various habitat classes. The sensitivity ratings were illustrated according to the following classification scheme: Dark Red/Very High, Red/High, Orange/Medium, Green/Low.

- A number of key sensitivity features not related to habitat classes were buffered and allocated a default Dark Red/Very High sensitivity rating (e.g. vulture colonies, Black Stork nests, vulture restaurants etc.).

- Recommendations were compiled for each corridor on what assessments need to be undertaken in each of the sensitivity classes which will be incorporated into the Decision-Making Tools.

4.2 Data Sources

Table 1 presents a detailed list and description of all data sources on which the assessment is based, and from which sensitive features/criteria are extracted.

Table 1: Data sources on which the avifauna assessment is based.

Data title	Source and date of publication	Data Description
The Southern African Bird Atlas 1 (SABAP1)	Animal Demography Unit, University of Cape Town, 1997.	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 km². Fieldwork was conducted mainly in the five-year period 1987–1991, but the project coordinators included all suitable data collected from 1980–

Data title	Source and date of publication	Data Description
		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 Atlas 2 (SABAP2)	Animal Demography Unit, University of Cape Town, 1 July 2007 to present, ongoing. Accessed in February 2018.	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). 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 (BLSA) 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 volunteers. 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.
2013 - 2014 South African National Land-Cover Dataset	DEA, February 2015 (https://egis.environment.gov.za/)	The 2013-14 South African National Land-cover dataset produced by GEOTERRAIMAGE as a commercial data product has been generated from digital, multi-seasonal Landsat 8 multispectral imagery, acquired between April 2013 and March 2014. The data set was procured by the Department of Environmental Affairs for public use. In excess of 600 Landsat images were used to generate the land-cover information, based on an average of 8 different seasonal image acquisition dates, within each of the 76 x image frames required to cover South Africa. The land-cover dataset, which covers the whole of South Africa, is presented in a map-corrected, raster format, based on 30x30m cells equivalent to the image resolution of the source Landsat 8 multi-spectral imagery. The dataset contains 72 x land cover / use information classes, covering a wide

Data title	Source and date of publication	Data Description
		range of natural and man-made landscape characteristics. Each data cell contains a single code representing the dominant land-cover class (by area) within that 30x30m unit, as determined from analysis of the multi-date imagery acquired over that image frame. The original land-cover dataset was processed in UTM (north) / WGS84 map projection format based on the Landsat 8 standard map projection format as provided by the USGS3. The final product is available in UTM35 (north) and (south), WGS84 map projections and Geographic Coordinates, WGS84.
The biomes of South Africa as contained in the National Vegetation Map of South Africa (2012)	The Vegetation Map of South Africa, Lesotho and Swaziland by Mucina and Rutherford (eds.), 2006, with the spatial product updated in 2012.	The descriptions of vegetation types are given for each biome and include a general introduction to each biome, details about how each vegetation type relates to previously published vegetation maps, distribution, vegetation and landscape features, geology and soils, climate, important taxa, biogeographically important taxa, endemic taxa, conservation, and remarks.
The crane, raptor and vulture nest databases of the Endangered Wildlife Trust (EWT)	Endangered Wildlife Trust accessed February 2018	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 sampled. All recorded nesting sites were included, no verification of current status of nests were conducted.
National vulture restaurant database	VulPro, March 2017 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.
List of eagle nests on Eskom transmission lines in the Karoo	Endangered Wildlife Trust, 2006	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.
Information on the 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.
The national register of Cape Vulture colonies	VulPro, Endangered Wildlife Trust, NMMU 2018	The dataset contains a georeferenced list of Cape Vulture breeding and roosting colonies.
A map of Blue Swallow breeding areas	Ezemvelo KZN Wildlife, March 2018	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.
Information on potential nesting areas of Southern Ground Hornbills.	Mabula Ground Hornbill Project, March 2018.	The data consists of a list of pentads where the species was sighted in Kwa-Zulu-Natal. Data was provided in pentad format. The assumption was made that the species would be breeding within the pentad.
Information on various Red Data species nests obtained from the	CSIR, 2015	The data comprise nest localities of Black Harrier, Martial Eagle, Verreaux's Eagle, Blue Crane, Lanner Falcon, in the solar and wind focus areas which

Data title	Source and date of publication	Data Description
Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa.		overlaps with the corridors.
Information on the localities of Southern Bald Ibis breeding colonies.	BLSA 2015. 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.
Nests localities of various Red Data species.	Ezemvelo KZN Wildlife 2018	Nests localities of Bateleur, Black Stork, African Crowned Eagle, Lappet-faced Vulture, Marabou Stork, Martial Eagle, Secretarybird, Tawny Eagle, White-backed Vulture and White-headed Vulture.
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.

4.3 Assumptions and Limitations

4.3.1 Assumptions

- It is assumed that the data layers used are reasonably accurate. Field verification will have to take place on a site by site basis linked to development proposals.

4.3.2 Limitations

- Due to the relatively coarse resolution of a QDGC (25 x 27.4km) sometimes species were recorded within a QDGC which contains more than one biome, some of which it is unlikely to occur in. In such an instance professional judgment was used to assess the potential for a species to occur in a given habitat and it was taken into account in the risk rating process.
- Only existing published and unpublished datasets were used with limited desktop verification.
- Some avifaunal specialist did not respond to data requests.
- The recommendations put forward here should be seen as generic and not replacing the project-specific recommendations which will be generated at the Environmental Authorisation level for an individual project.
- Due to the wide scope of the assessment, it is not possible to determine limits of acceptable change with a great deal of accuracy for each species in each corridor. For that, accurate data on population figures is required, as well as comprehensive data on the biology of each species, in order to model the effect of the envisaged impacts on the population. Information on that level is lacking for the majority of the species. Modelling impact at population level is a complicated process which falls outside the scope of this project.

The potential impact of power line developments on avifauna in South Africa is relatively well studied, but important information is still lacking.

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 power lines - more scientifically verifiable knowledge of the disturbance thresholds of these species would improve predictive capabilities.
- The actual mortality of power line sensitive Red Data species will always remain unknown. The impact of mortality on these populations is therefore difficult to assess, and needs to be deduced from the available, incomplete data currently available.
- Published, scientifically verified results from the experiments performed by the EWT to test the efficacy of Bird Flappers to prevent collision mortality is eagerly awaited.

4.4 Relevant Regulatory Instruments

Table 2 presents a detailed list and description of relevant regulatory instruments associated with the field of expertise at international, national scale, as well as provincial scale.

Table 2: International, national and provincial regulatory instruments relevant to avifauna.

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 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.
International Finance Corporation (IFC) Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	To protect and conserve biodiversity. To maintain the benefits from ecosystem services. To promote the sustainable management of living natural resources 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.
National Instrument	
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. Activity 12 in Listing Notice 3 (Government Notice R324 of 7 April 2017) relates to the clearance of 300 m^2 or more of vegetation, within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004.
National Environmental Management: Protected Areas Act, 2003. (Act 57 of	To provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural

Instrument	Key objective
2003)	landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; and for matters in connection therewith.
National Environmental Management Act,1998 (Act 107 of 1998)	Promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development;
Environment Conservation Act, 1989 (Act 73 of 1989)	To provide for the effective protection and controlled utilization of the environment and for matters incidental thereto.
National Water Act, 1998 (Act 36 of 1998)	Part 3, The Reserve: The ecological reserve relates to the water required to protect the aquatic ecosystems of the water resource.
Provincial Instrument	
KwaZulu Nature Conservation Act, 1992 (Act 29 of 1992) still in force	Provides for the protection of fauna and flora in those areas that formed part of the former KwaZulu.
Mpumalanga Nature Conservation Act Of 1998.	Provides for the protection of fauna and flora in the Mpumalanga Province.
Natal Nature Conservation Ordinance 15 of 1974 (still in force)	Provides for the protection of fauna and flora in those areas that form part of the former Natal province.
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.
Northern Cape Nature Conservation Act, 2009 (Act 10 of 2009)	To provide for the sustainable utilization of wild animals, aquatic biota and plants: to provide for the implementation 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.
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 Eastern Cape (former Cape Province).

5 IMPACT CHARACTERISATION

The impacts of power lines on birds can be summarised as follows:

- Electrocution: This happens when a large bird makes contact with two live components simultaneously, or a live and earthed component. This results in a short circuit as a result of which the bird is electrocuted. Electrocution risk is a function of the pole configuration and the size of the bird. In South Africa, large raptors and vultures are most vulnerable to electrocutions, on voltages of 11kV up to 132kV (Van Rooyen 1998).
- Collisions: In this instance, injury or death of the bird is caused by the bird colliding at high speed with the power line infrastructure, usually the earthwire of transmission and sub-transmission lines (>66kV), or the conductors themselves in the case of reticulation lines (11 – 33kV). In South

Africa, most heavily impacted upon are bustards, storks, cranes and various species of waterbirds (Jenkins et al. 2010).

- Displacement due to habitat destruction: During the construction and maintenance of power lines and substations, some habitat destruction and transformation inevitably takes place. This happens with the construction of access roads, the clearing of servitudes and the levelling of substation yards. These activities have an impact on birds breeding, foraging and roosting in or in close proximity of the servitude through transformation of habitat, which could result in temporary or permanent displacement.
- Displacement due to disturbance: Apart from direct habitat destruction, the above-mentioned construction and maintenance activities also impact on birds through disturbance, particularly during breeding activities. Disturbance of breeding individuals could lead to breeding failure through abandonment of the nest or through exposing the eggs and nestlings to predation when the adult birds temporarily leave the nest area.

Please see Section 1: Introduction for a detailed discussion of the impacts listed above.

6 CORRIDORS DESCRIPTION

The point of departure was the delineation of the corridor according to biomes present in the corridor, and then extracting the power line sensitive Red Data species recorded by SABAP 2 within that biome[2]. It is generally accepted that vegetation structure, rather than the actual plant species, influences bird species distribution and abundance (Harrison et al., 1997). The description of the biomes largely follows the classification system used in the Atlas of Southern African Birds (SABAP1)) (Harrison et al. (1997) supplemented with material from Mucina and Rutherford (2006). The criteria used by the SABAP1 authors to amalgamate botanically defined vegetation units, or to keep them separate were: (1) the existence of clear differences in vegetation structure, likely to be relevant to birds, and (2) the results of published community studies on bird/vegetation associations.

The biome descriptions used in in this report are as follows:

- <u>Fynbos</u>: Fynbos is dominated by low shrubs and has two major vegetation divisions: fynbos proper characterised by restioid, ericoid and proteoid components; and renosterveld, dominated by *Asteraceae*, specifically Renosterbos *Elytropappus rhinocerotis*, with geophytes and some grasses.
- <u>Succulent Karoo</u>: The Succulent Karoo falls within the winter rain-fall region in the far west, and is characterised by succulent shrubs, particularly *Mesembryanthemaceae* and a particular paucity of grass cover and trees, except in the Little Karoo of the Western Cape Province, where tree cover is relatively well developed.
- <u>Nama Karoo</u>: The Nama Karoo vegetation largely comprises low shrubs and grasses; peak rainfall occurs in summer. Trees, e.g. *Vachellia karoo* and aline species such as Mesquite *Prosopis glandulosa* are mainly restricted to water courses where fairly luxuriant stands can develop especially in the Eastern Cape Province, and along the Orange River. In comparison to the Succulent Karoo, the Nama Karoo has a higher proportion of grass and tree cover.
- <u>Savanna</u>: Savanna is defined here as having a grassy understorey and a distinct woody upper storey of trees and tall shrubs. Tree cover can range from sparse to almost closed-canopy cover. The relatively arid fine-leaved, typically *Vachellia*-dominated woodland types typically occur in the drier western regions, while the mesic, pre-dominantly broadleaved woodlands typically occur in the wetter eastern regions.
- <u>Forest:</u> Consists of coastal and Afro-montane forest. The tree canopy cover in forests are continuous and mainly comprises evergreen tree species. Below the canopy, vegetation is multi-

[2] It should be noted that due to the relatively coarse resolution of a QDGC (25 x 27.4km) sometimes species were recorded within a QDGC which contains more than one biome, some of which it is unlikely to occur in. In such an instance professional judgment was used to assess the potential for a species to occur in a given habitat and was taken into account in the risk rating process.

layered. The tall, dense trees result in little ground vegetation and a thick leaf litter. Forests only occur in frost-free regions with relatively high rainfall and protected from fires.

- Grassland: The dominant vegetation comprises grasses, with geophytes and herbs also well-represented. These grasslands are maintained largely by a combination of relatively high summer rainfall, frequent fires, frost and grazing, which preclude the presence of shrubs and trees. Sweet grasslands are fond in lower rainfall areas, are taller and less dense, have a lower fibre content and retain nutrients in the leaves during winter. Sour grasslands occur in higher rainfall regions and are characterized by being shorter and denser in structure, having a high fibre content and a tendency to withdraw nutrients to the roots during winter.
- Desert: The dominant vegetation comprises grassland dominated by "white grasses", some spinescent (*Stipograstis* species) on flats with additional shrubs and herbs in the drainage lines or on more gravelly or loamy soil next to mountains. Hills and mountains are dominated by bare outcrops with very sparse shrubby vegetation in crevices, sometimes with localised grassland areas.
- Indian Ocean Coastal Belt/East Coast Littoral: This is a mosaic of coastal forest, sand forest, coastal thicket, coastal grasslands and mangroves. It is typically moist and tropical to sub-tropical.
- Azonal vegetation: This refers to distinctive vegetation types not restricted to a specific biome but occurring across several biomes. In azonal vegetation special substrate (special soil types or bedrocks) and/or hydrogeological conditions (waterlogging, flooding, tidal influence) exert an overriding influence on floristic composition, structure and dynamics over macroclimate. Azonal vegetation are mostly found in freshwater wetlands, alluvial zones, salt pans, estuaries, seashores, and dunes.

Figure 2 provides an overview of the various biomes within South Africa, as well as the proposed Expanded EGI corridors (and the gazetted EGI corridors).

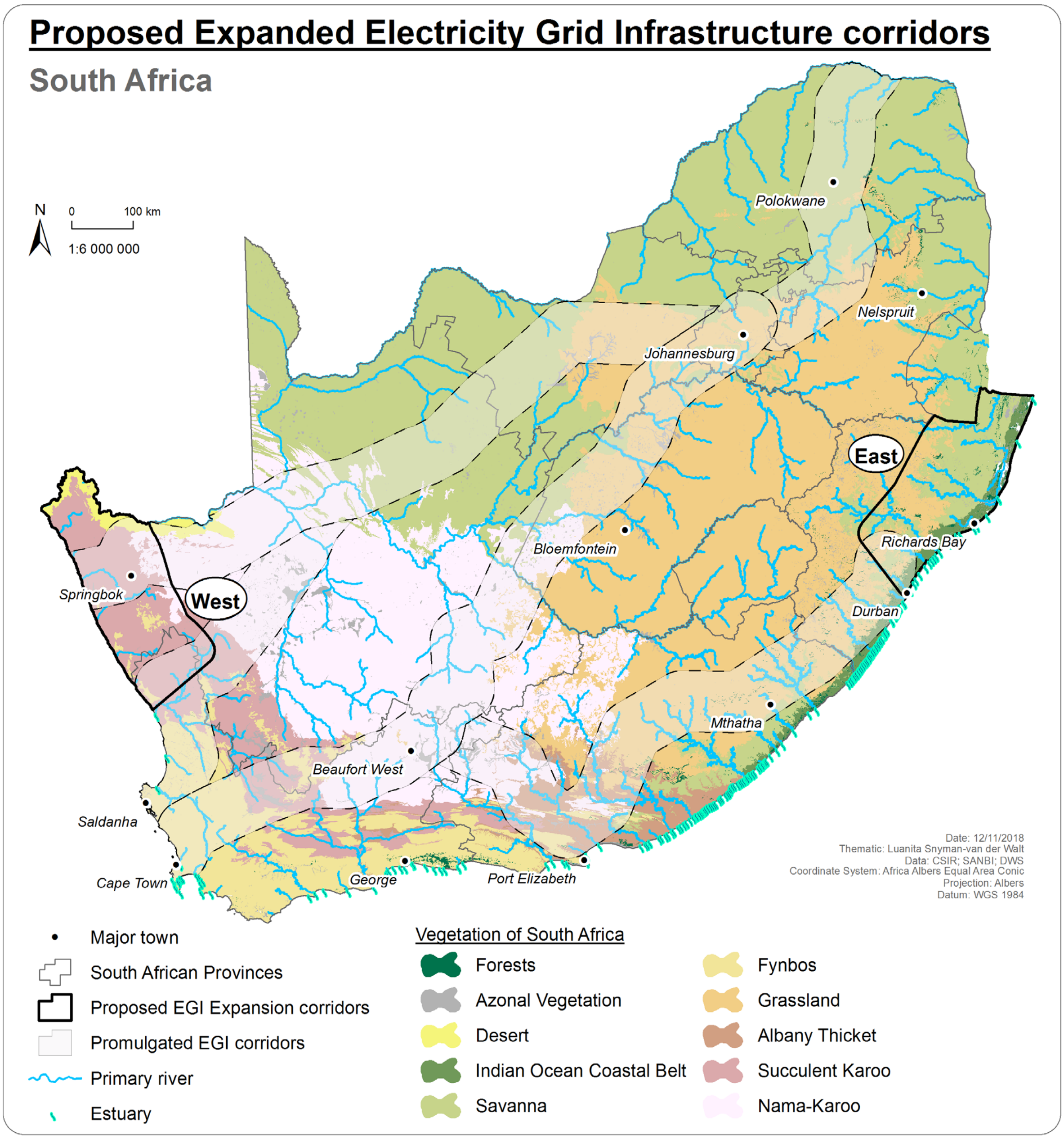


Figure 2: Overview of the Biomes within South Africa and the Proposed Expanded EGI Corridors

Table 3: Environmental description of the proposed EGI extended corridors.

Corridor	Brief description
Expanded Western Corridor	The Expanded Western Corridor contains 4 biomes, as well as Azonal vegetation. These are: • Desert • Fynbos • Nama-Karoo • Succulent Karoo The following power line sensitive Red Data species were identified and rated for potential impacts in each biome, extracted from a total of 90 QDGCs. NT = Near threatened VU = Vulnerable EN = Endangered CR = Critically Endangered

Species	Status	Fynbos	Succulent Karoo	Nama Karoo	Desert	Azonal
African Marsh-Harrier	EN	x				x
Black Harrier	EN	x	x	x	x	
Black Stork	VU	x	x	x	x	x
Blue Crane	NT	x	x			x
Caspian Tern	VU					x
Greater Flamingo	NT	x	x	x	x	x
Karoo Korhaan	NT	x	x	x	x	
Lanner Falcon	VU	x	x	x	x	x
Lesser Flamingo	NT	x	x	x	x	x
Ludwig's Bustard	EN	x	x	x	x	
Maccoa Duck	NT					x
Martial Eagle	EN	x	x	x	x	
Secretarybird	NT	x	x	x		
Southern Black Korhaan	VU	x	x			
Verreaux's Eagle	VU	x	x	x	x	
Great White Pelican	VU					x
Kori Bustard	NT		x			

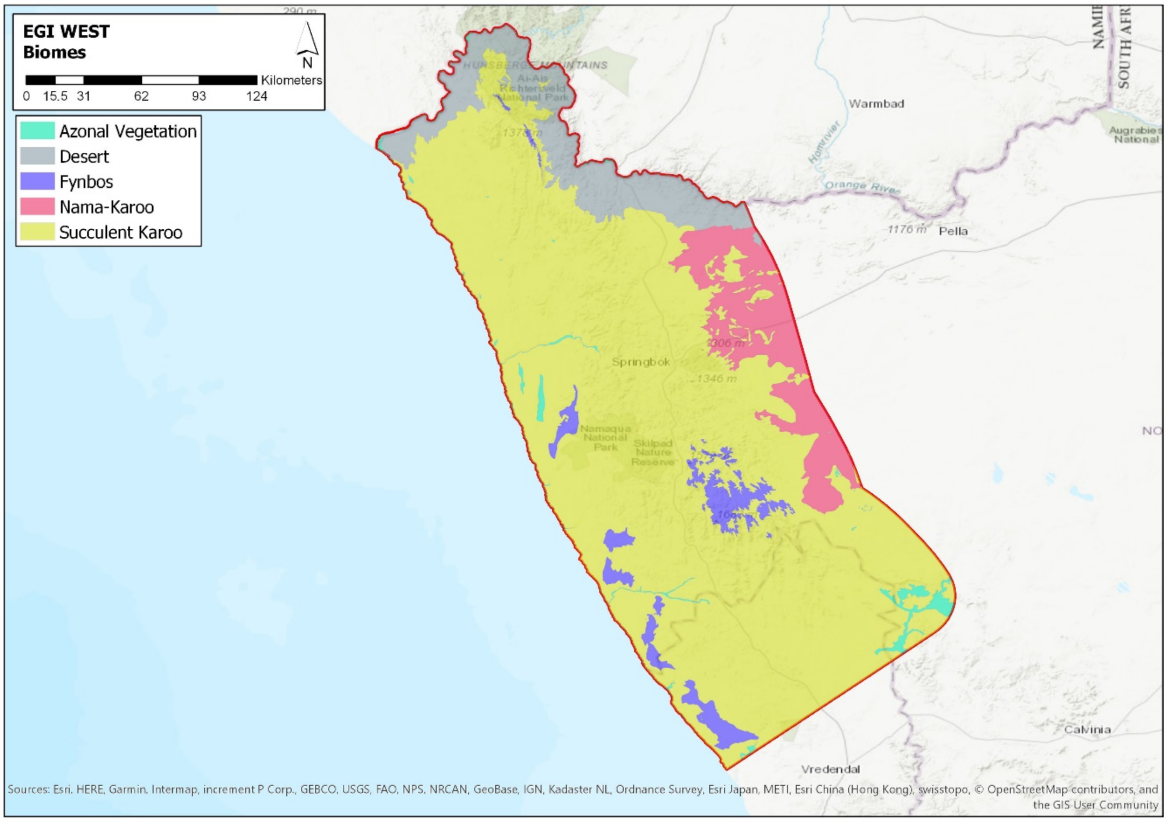
Corridor	Brief description
	

Figure 3: Biomes of the Expanded Western EGI Corridor.

Corridor	Brief description
Expanded Eastern Corridor	*The Expanded Eastern Corridor contains four biomes, as well as Azonal vegetation. These are* • Forests • Grassland • Indian Ocean Coastal Belt • Savanna *The following power line sensitive Red Data species were identified and rated for potential impacts in each biome, extracted from a total of 85 QDGCs.* *NT = Near threatened* *VU = Vulnerable* *EN = Endangered* *CR = Critically Endangered*

Species	Status	Savanna	Grassland	Forest	Indian Ocean Coastal Belt	Azonal
African Marsh-Harrier	EN	x	x		x	x
Abdim's Stork	NT		x			x
Black Harrier	EN		x			
Black Stork	VU	x	x		x	x
Cape Parrot	EN			x		
Caspian Tern	VU					x
Greater Flamingo	NT				x	x
Lanner Falcon	VU	x	x	x	x	x
Lesser Flamingo	NT				x	x
Maccoa Duck	NT					x
Martial Eagle	EN	x	x		x	
Secretarybird	NT	x	x			
Lappet-faced Vulture	EN	x				
Verreaux's Eagle	VU	x	x			
Marabou Stork	NT	x			x	x
Denham's Bustard	VU		x		x	
Pink-backed Pelican	VU					x
Saddle-billed Stork	EN					x
Southern Bald Ibis	VU		x			
Burchell's Courser	VU		x			
Cape Vulture	EN	x				
Southern Ground-Hornbill	EN	x			x	
Tawny Eagle	EN	x				
Wattled Crane	CR		x			x
African Grass-Owl	VU		x			x
Grey Crowned Crane	EN		x		x	x
White-bellied Korhaan	VU	x	x		x	
White-backed Vulture	CR	x				
Yellow-billed Stork	EN					x
African Crowned Eagle	VU			x		
African Finfoot	VU					x
African Pygmy-Goose	VU					x
Bateleur	EN	x				
Great White Pelican	VU					x
Hooded Vulture	CR	x				
Pel's Fishing-Owl	EN					x

Corridor	Brief description						
	Southern Banded Snake-Eagle	CR				x	
	White-headed Vulture	CR	x				
	White-backed Night-Heron	VU					x
	Black-rumped Buttonquail	EN		x			
	Orange Ground-thrush	NT					
	Spotted Ground-thrush	EN			x		

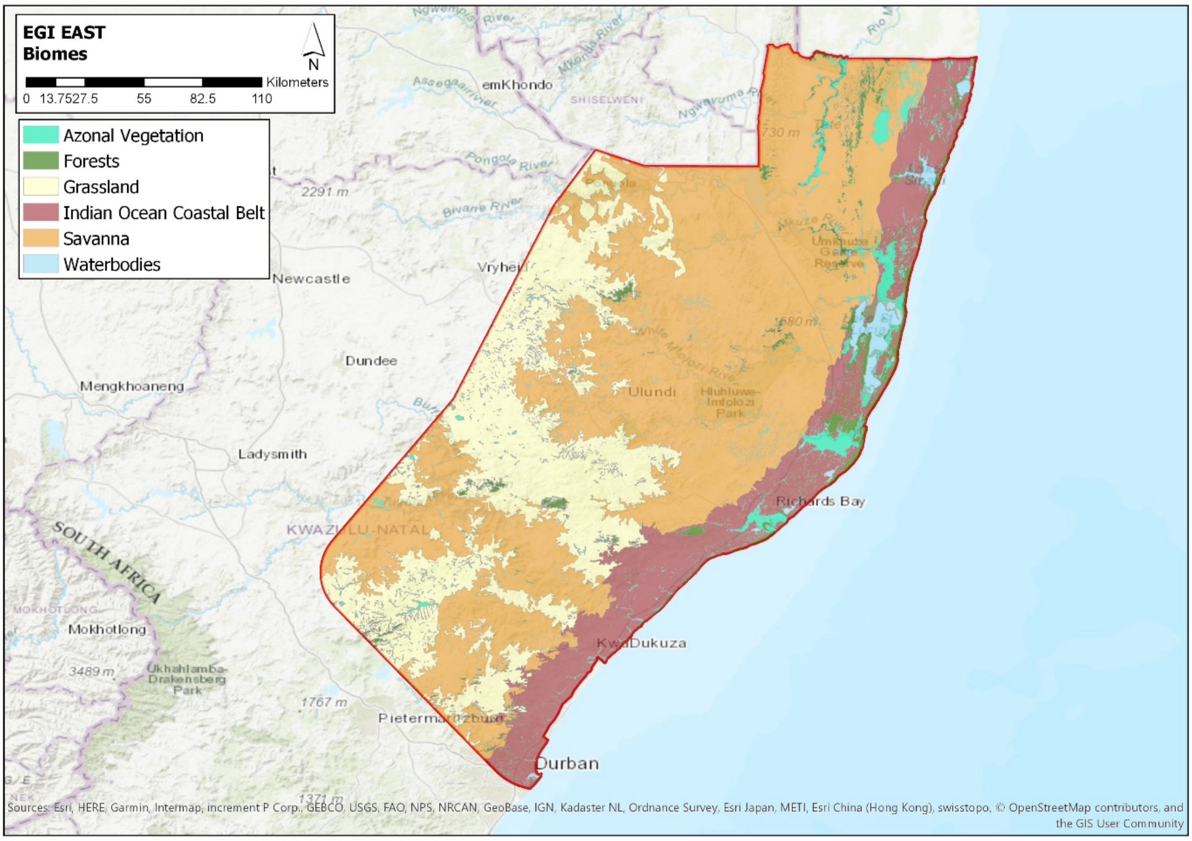


Figure 4: Biomes of the Expanded Eastern EGI Corridor.

7 FEATURE SENSITIVITY MAPPING

7.1 Identification of feature sensitivity criteria

Table 4: Description and sources of data used for the avifauna sensitivity analysis.

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
Wetlands and waterbodies: Water permanent	South African National Land-Cover Dataset, 2015	Areas of open, surface water, that are detectable on all image dates used in the Landsat 8 based water modelling processes. Permanent water extent typically refers to the minimum water extent, which occurs throughout the 2013-14 assessment period. Includes both natural and man-made water features.	West and East
Wetlands and waterbodies: Water seasonal	South African National Land-Cover Dataset, 2015	Areas of open, surface water, that are detectable on one or more, but not all image dates used in the Landsat 8 based water modelling processes. Seasonal water extent typically refers to the maximum water extent, which may only occur for a limited time within the 2013-14 assessment period. Includes both natural and man-made water features.	West and East
Wetlands and waterbodies: Wetlands	South African National Land-Cover Dataset, 2015	Wetland areas that are primarily vegetated on a seasonal or permanent basis. Defined on the basis of seasonal image identifiable surface vegetation patterns (not subsurface soil characteristics. The vegetation can be either rooted or floating. Wetlands may be either daily (i.e. coastal), temporarily, seasonal or permanently wet and/or saturated. Vegetation is predominately herbaceous. Includes but not limited to wetlands associated with seeps/springs, marshes, floodplains, lakes/pans, swamps, estuaries, and some riparian areas. Wetlands associated with riparian zones represent image identified vegetation along the edges of watercourses that show similar spectral characteristics to nearby wetland vegetation. Excludes Mangrove swamps. Permanent or seasonal open water areas within the wetlands are classified separately (Appendix C.1.6 of the EGI Expansion SEA Report). Seasonal wetland occurrences within commercially cultivated field boundaries are not shown, although they have been retained within subsistence level cultivation fields.	West and East
Indigenous Forest	South African National Land-Cover Dataset, 2015	Natural / semi-natural indigenous forest, dominated by tall trees, where tree canopy heights are typically > ± 5m and tree canopy densities are typically > ± 75 %, often with multiple understory vegetation canopies.	East
Thicket/dense bush	South African National Land-Cover Dataset, 2015	Natural / semi-natural tree and / or bush dominated areas, where typically canopy	West and East

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
		heights are between 2 - 5 m, and canopy density is typically > ± 75%, but may include localised sparser areas down to ± 60%. Includes dense bush, thicket, closed woodland, tall, dense shrubs, scrub forest and mangrove swamps. Can include self-seeded bush encroachment areas if sufficient canopy density.	
Woodland/open bush	South African National Land-Cover Dataset, 2015	Natural / semi-natural tree and / or bush dominated areas, where typically canopy heights are between ± 2 - 5 m, and canopy densities typically between 40 - 75%, but may include localised sparser areas down to ± 15 - 20 %. Includes sparse – open bushland and woodland, including transitional wooded grassland areas. Can include self-seeded bush encroachment areas if canopy density is within indicated range. In the arid western regions (i.e. Northern Cape), this cover class may be associated with a transitional bush / shrub cover that is lower than typical Open Bush / Woodland cover but higher and/or more dense than typical Low Shrub cover.	West and East
Grassland	South African National Land-Cover Dataset, 2015	Natural / semi-natural grass dominated areas, where typically the tree and / or bush canopy densities are typically < ± 20 % but may include localised denser areas up to ± 40 %, (regardless of canopy heights). Includes open grassland, and sparse bushland and woodland areas, including transitional wooded grasslands. May include planted pasture (i.e. grazing) if not irrigated. Irrigated pastures will typically be classified as cultivated, and urban parks and golf courses etc under urban.	West and East
Shrubland fynbos	South African National Land-Cover Dataset, 2015	Natural / semi-natural low shrub dominated areas, typically with < ± 2m canopy height, specifically associated with the Fynbos Biome. Includes a range of canopy densities encompassing sparse to dense canopy covers. Very sparse covers may be associated with the bare ground class. Note that taller tree / bush / shrub communities within this vegetation type are typically classified separately as one of the other tree or bush dominated cover classes.	West
Low shrubland	South African National Land-Cover Dataset, 2015	Natural / semi-natural low shrub dominated areas, typically with ≤ 2m canopy height. Includes a range of canopy densities encompassing sparse to dense canopy covers. Very sparse covers may be associated with the bare ground class. Typically associated with low, woody shrub, karoo-type vegetation communities, although can also represent locally degraded vegetation areas where there is a significantly reduced vegetation cover in comparison to surrounding, less impacted vegetation cover, including long-term wildfire scars in some mountainous areas in the western Cape. Note that taller tree / bush / shrub communities within this vegetation type are typically classified separately as one of the other tree or bush dominated cover classes.	West and East
Cultivated commercial fields rainfed	South African National Land-Cover Dataset, 2015	Cultivated lands used primarily for the production of rain-fed, annual crops for commercial markets. Typically represented by large field units, often in dense local	West and East

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
		or regional clusters. In most cases the defined cultivated extent represents the actual cultivated or potentially extent.	
Cultivated commercial pivots	South African National Land-Cover Dataset, 2015	Cultivated lands used primarily for the production of centre pivot irrigated, annual crops for commercial markets. In most cases the defined cultivated extent represents the actual cultivated or potentially extent.	West and East
Cultivate orchards and vines	South African National Land-Cover Dataset, 2015	Cultivated lands used primarily for the production of both rain-fed and irrigated permanent crops for commercial markets. Includes both tree, shrub and non-woody crops, such as citrus, tea, coffee, grapes, lavender and pineapples etc. In most cases the defined cultivated extent represents the actual cultivated or potentially extent.	West and East
Cultivated subsistence	South African National Land-Cover Dataset, 2015	Cultivated lands used primarily for the production of rain-fed, annual crops for local markets and / or home use. Typically represented by small field units, often in dense local or regional clusters. The defined area may include intra-field areas of non-cultivated land, which may be degraded or use-impacted, if the individual field units are too small to be defined as separate features.	West and East
Cultivated sugar cane	South African National Land-Cover Dataset, 2015	Commercial, pivot irrigated fields that appear to be used continuously for growing sugarcane on the majority of multi-date Landsat images used in the 2013-14 analysis period. Also includes commercial and semi-commercial / emerging farmer status, non-pivot fields that appear to be used continuously for growing sugarcane on the majority of multi-date Landsat images used in the 2013-14 analysis period.	East
Plantations	South African National Land-Cover Dataset, 2015	Planted forestry plantations used for growing commercial timber tree species. The class represents mature tree stands which have approximately 70% or greater tree canopy closure (regardless of canopy height), on all the multi-date Landsat images in the 2013-14 analysis period. The class includes spatially smaller woodlots and windbreaks with the same cover characteristics. It also includes young tree stands that have approximately 40 - 70% tree canopy closure (regardless of canopy height), clear-felled stands and spatially smaller woodlots and windbreaks with the same cover characteristics.	West and East
Industrial	South African National Land-Cover Dataset, 2015	Mining activity footprint, based on pure, non-vegetated, bare ground surfaces. Includes extraction pits, tailings, waste dumps and associated surface infrastructure such as roads and buildings (unless otherwise indicated), for both active and abandoned mining activities. Class may include open cast pits, sand mines, quarries and borrow pits etc. also includes mining activity footprint, based on semi-bare ground surfaces, which may be sparsely vegetated. Includes extraction pits, tailings, waste dumps and associated surface infrastructure such as roads and buildings (unless otherwise indicated) and surrounding dust-impacted areas, for both active	West and East

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
		and abandoned mining activities. Water bodies inside mining areas which represent permanent and non-permanent water extents are also included. Areas containing buildings and large surface infrastructure associated with the extraction, processing or administration of the associated mining area are also included.	
Bare	South African National Land-Cover Dataset, 2015	Non-vegetated donga and gully features, typically associated with significant natural or man-induced erosion activities along or in association with stream and flow lines. The mapped extent of the dongas and gullies is represented by bare ground conditions in all or the majority of the multi-date Landsat images used in the land-cover modelling. Note that these erosion features are significantly better represented both spatially and numerically in the wetter, more lush regions of the country where the non-vegetated erosion surface is significantly different from the surrounding vegetation cover (i.e. bushveld and grassland regions). In general, sparsely vegetated sheet eroded areas and degraded areas with significantly reduced local vegetation cover are not included in this class but will be represented by local areas of low shrub or bare ground. Also included are bare, non-vegetated ground, with little or very sparse vegetation cover (i.e. typically < ± 5 - 10 % vegetation cover), occurring as a result of either natural or man-induced processes. Includes but not limited to natural rock exposures, dry river beds, dry pans, coastal dunes and beaches, sand and rocky desert areas, very sparse low shrublands and grasslands, surface (sheet) erosion areas, severely degraded areas, and major road networks etc. May also include long-term wildfire scars in some mountainous areas in the Western Cape.	West and East
Urban	South African National Land-Cover Dataset, 2015	Areas containing the following: • high density buildings and other built-up structures associated with mainly non-residential, commercial, administrative, health, religious or transport (i.e. train station) activities; • buildings and other built-up structures associated with mainly non-residential, industrial and manufacturing activities, including power stations; • high density buildings and other built-up structures typically associated with informal, often non-regulated, residential housing; • variable density buildings and other built-up structures typically associated with formal, regulated, residential housing; • buildings, other built-up structures and open sports areas typically areas associated with schools and school sports grounds. • Areas containing a low density mix of buildings, other built-up structures within open areas, which may or may not be cultivated, that are representative of both	West and East

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
		formally declared agricultural holdings, and similar small holdings / small farms, typically located on the periphery of urban areas. • Areas containing a low density mix of buildings, other built-up structures associated with golf courses. The class includes both residential golf estates and non-residential golf courses, and typically represents the border extent of the entire estate or course. • Areas containing high density buildings and other built-up structures typically associated with formal, regulated, residential housing associated with townships and "RDP" type housing developments. • Areas containing variable density structures typically associated with rural villages, including both traditional and modern building formats. • Areas containing variable densities of buildings other built-up structures, or no structures at all, that are not clearly identifiable as one of the other Built-Up classes. May include runways, major infrastructure development sites, holiday chalets, roads, car parks, cemeteries etc.	
Drainage lines	National Freshwater Ecosystem Priority Areas Project (NFEPA), 2011	The National Freshwater Ecosystem Priority Areas (NFEPA) project identifies a national network of freshwater priorities for conservation and explores institutional mechanisms for their implementation.	West and East
Nest sites, roosts and colonies of Red Data species	• The crane and raptor nest databases of the Endangered Wildlife Trust (EWT); 2018	• Nest sites of Martial Eagle, Verreaux's Eagle, Tawny Eagle, Bateleur, White-backed Vulture, Lappet-faced Vulture, Black Harrier, Lanner Falcon, Blue Crane, Wattled Crane, Grey Crowned Crane.	East
	• The Endangered Wildlife Trust's database of eagles nesting on transmission lines in the Karoo; 2006	• Martial Eagle, Verreaux's Eagle and Tawny Eagle nests on transmission lines in the Karoo.	West
	• A map of Blue Swallow breeding areas obtained from Ezemvelo KZN Wildlife; 2018	• Blue Swallow breeding areas in KwaZulu-Natal	East
	• Information on the locality of various Red Data raptor nests. Received from various avifaunal specialists working on renewable energy projects, 2010 – 2018.	• Nest localities of Martial Eagle, African Crowned Eagle, Verreaux's Eagle, Tawny Eagle, White-backed Vulture, Black Harrier and Wattled Crane at renewable energy development sites.	West and East
	• Information on potential nesting areas of Southern Ground Hornbills, Mabula Ground Hornbill Project, 2018.	• Potential nest areas of Southern Ground Hornbill.	East
	• Information on various Red Data species nests and vulture colonies obtained from the Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa, 2015.	• The data comprise nest localities of Black Harrier, Martial Eagle, Verreaux's Eagle, Blue Crane, Lanner Falcon, in solar and wind focus areas.	West

Sensitivity Feature Class (Habitat class)	Data Source + Date of Publications	Data Description, Preparation and Processing	Relevant Corridors Phases
	• Information on the locality of Southern Bald Ibis breeding colonies, BLSA, 2015.	• Information from Dr. Kate Henderson's PhD on the locality of Southern Bald Ibis roost and colonies.	East
	• National vulture restaurant database obtained from VulPro in March 2017	• The best currently available data on the location of vulture restaurants.	East
	• The register of Cape Vulture colonies obtained from VulPro, NMMU and Ezemvelo KZN Wildlife, 2018	• The best currently available data on the location of Cape Vulture colonies.	East
	• Information on various Red Data species nests obtained from Ezemvelo KZN Wildlife, 2018.	• Nests localities of Bateleur, Black Stork, African Crowned Eagle, Lappet-faced Vulture, Marabou Stork, Martial Eagle, Secretarybird, Tawny Eagle, White-backed Vulture and White-headed Vulture.	East

Below are all feature types considered in the sensitivity analysis and the rating given to each feature and buffered area, where applicable (Table 5). Details on each individual feature ratings are available on request in spreadsheet format. An example of how it was calculated is included as Appendix 1.

Table 5: Avifauna sensitivity features and ratings.

Corridor	Biome	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
Expanded Western Corridor	Azonal Vegetation	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated vines	Medium	
		Drainage lines	Medium	
		Grassland	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Shrubland fynbos	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Medium	500m
		Woodland/Open bush	Medium	
	Desert	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated commercial pivots	Medium	
		Cultivated orchards	Medium	
		Cultivated vines	Medium	
		Drainage lines	Medium	
		Grassland	High	
		Industrial	Low	
		Low shrubland	High	
		Shrubland fynbos	High	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Medium	500m
		Woodland/Open bush	Medium	
	Fynbos	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated subsistence	Medium	
		Drainage lines	Medium	
		Grassland	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Shrubland fynbos	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Medium	500m
		Woodland/Open bush	Medium	
	Nama-Karoo	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Drainage lines	Medium	
		Grassland	High	
		Industrial	Low	
		Low shrubland	High	
		Shrubland fynbos	High	

Corridor	Biome	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
		Thicket /Dense bush	Medium	
		Wetlands and waterbodies (500m buffer)	Medium	500m
		Woodland/Open bush	Medium	
	Succulent Karoo	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated commercial pivots	Medium	
		Cultivated subsistence	Medium	
		Cultivated vines	Medium	
		Drainage lines	Medium	
		Grassland	High	
		Industrial	Low	
		Low shrubland	High	
		Plantations	Medium	
		Shrubland fynbos	High	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Medium	
		Woodland/Open bush	Medium	
Expanded Eastern Corridor	Azonal Vegetation	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated commercial pivots	Medium	
		Cultivated orchards	Medium	
		Cultivated subsistence	Medium	
		Cultivated sugar cane	Medium	
		Drainage lines	High	
		Grassland	Medium	
		Indigenous Forest	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Very high	500m
		Woodland/Open bush	High	
	Forests	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated orchards	Medium	
		Cultivated subsistence	Medium	
		Cultivated sugar cane	Medium	
		Drainage lines	Medium	
		Grassland	Medium	
		Indigenous Forest	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	Medium	500m
		Woodland/Open bush	Medium	
	Grassland	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	

Corridor	Biome	Feature Class	Feature Class Sensitivity	Buffer Distance Sensitivity
		Cultivated commercial pivots	Medium	
		Cultivated orchards	Medium	
		Cultivated subsistence	Medium	
		Cultivated sugar cane	Medium	
		Drainage lines	Medium	
		Grassland	High	
		Indigenous Forest	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	High	500m
		Woodland/Open bush	High	
	Indian Ocean Coastal Belt	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated orchards	Medium	
		Cultivated subsistence	Medium	
		Cultivated sugar cane	Medium	
		Drainage lines	Medium	
		Grassland	Medium	
		Indigenous Forest	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	High	500m
		Woodland/Open bush	High	
	Savanna	Bare	Medium	
		Cliffs (1km buffer)	Medium	1km
		Cultivated commercial fields rainfed	Medium	
		Cultivated commercial pivots	Medium	
		Cultivated orchards	Medium	
		Cultivated subsistence	Medium	
		Cultivated sugar cane	Medium	
		Drainage lines	High	
		Grassland	High	
		Indigenous Forest	Medium	
		Industrial	Low	
		Low shrubland	Medium	
		Plantations	Medium	
		Thicket /Dense bush	Medium	
		Urban (500m buffer)	Low	500m
		Wetlands and waterbodies (500m buffer)	High	500m
		Woodland/Open bush	Very high	
All phases	Key sensitivity features	Nest sites of Red Data species	Very high	2.5km
		Cape Vulture colonies and vulture restaurants	Very high	5km

7.2 Feature maps

7.2.1 Expanded Western Corridor

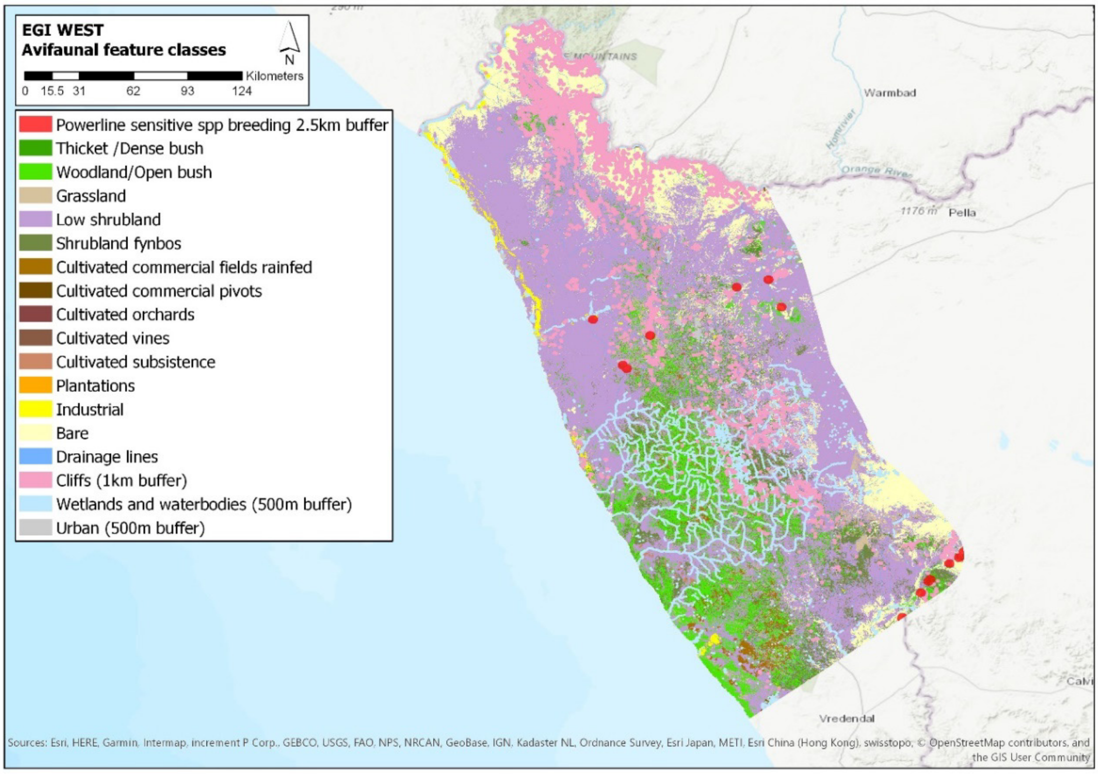


Figure 5: Sensitive environmental features of importance to avifauna in the Expanded Western Corridor.

7.2.2 Expanded Eastern Corridor

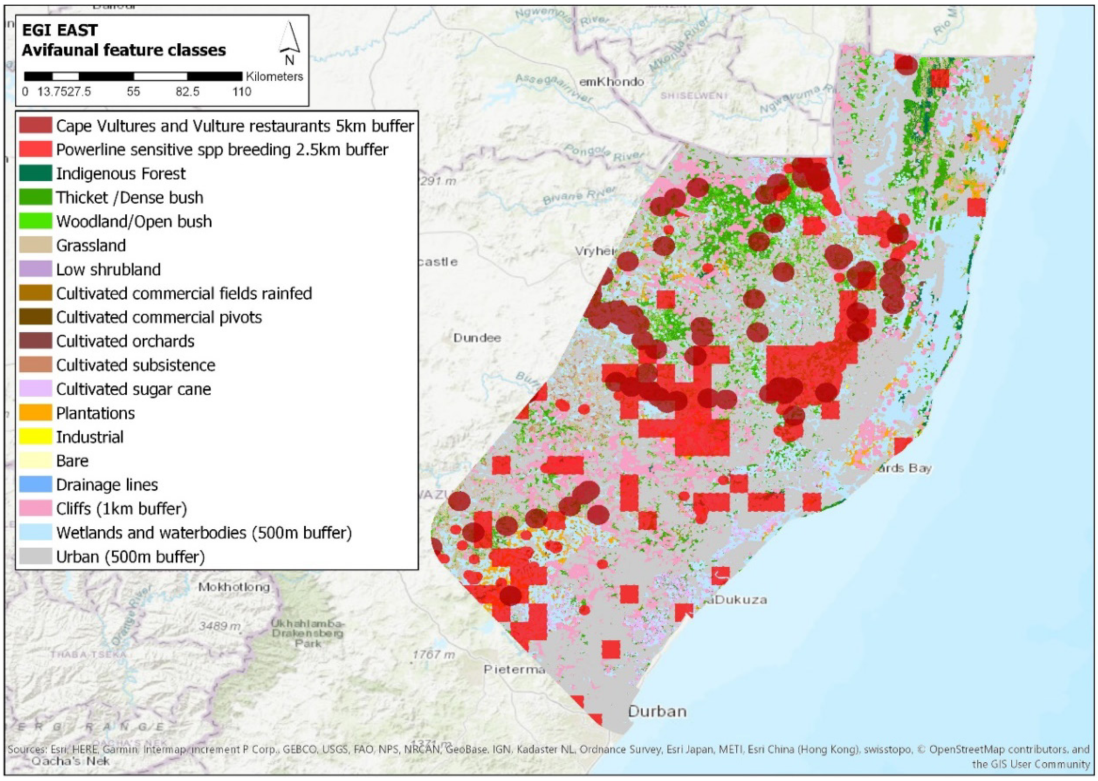


Figure 6: Sensitive environmental features of importance to avifauna in the Expanded Eastern Corridor.

8 FOUR- TIER SENSITIVITY MAPPING

The relative sensitivity mapping will follow a four tier sensitivity classes approach with:

- Dark Red: Very High Sensitivity
- Red: High Sensitivity,
- Orange: Medium Sensitivity
- Green: Low Sensitivity

8.1 Four Tier sensitivity maps

8.1.1 Expanded Western Corridor

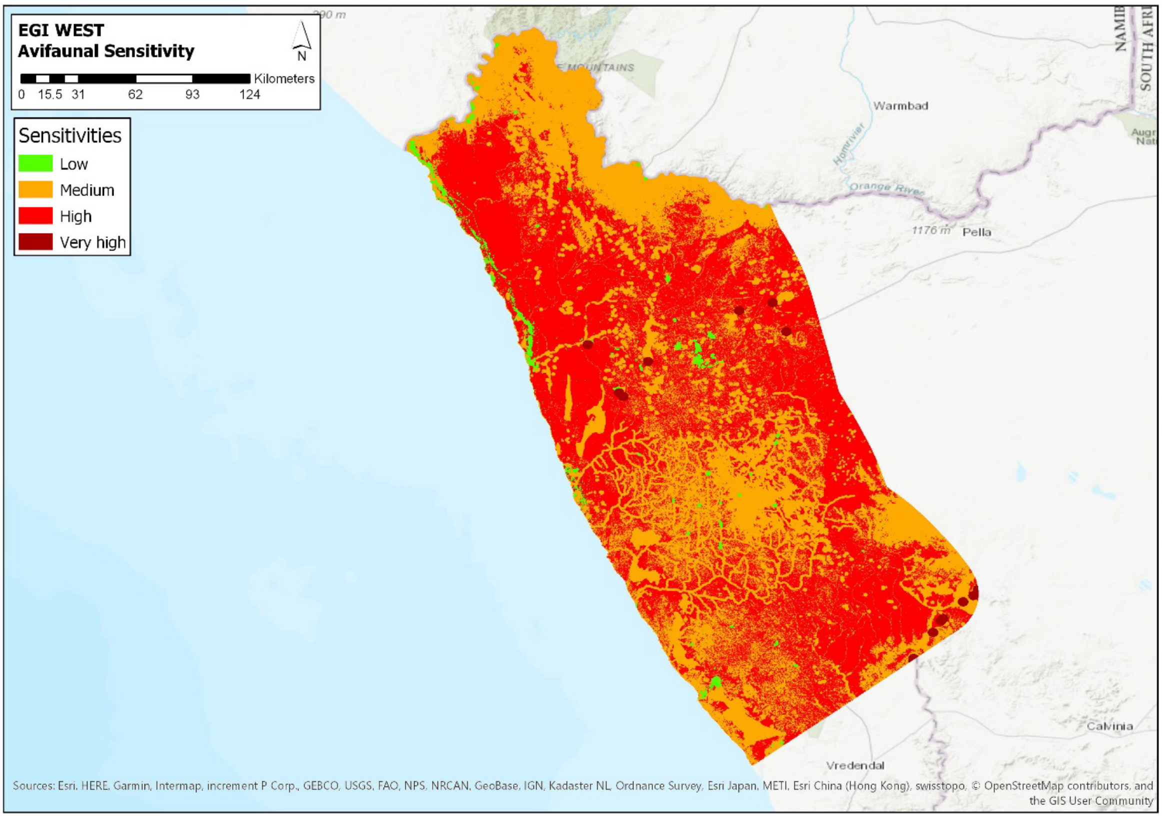


Figure 7: Avifauna sensitivity map for the Expanded Western Corridor.

8.1.2 Expanded Eastern Corridor

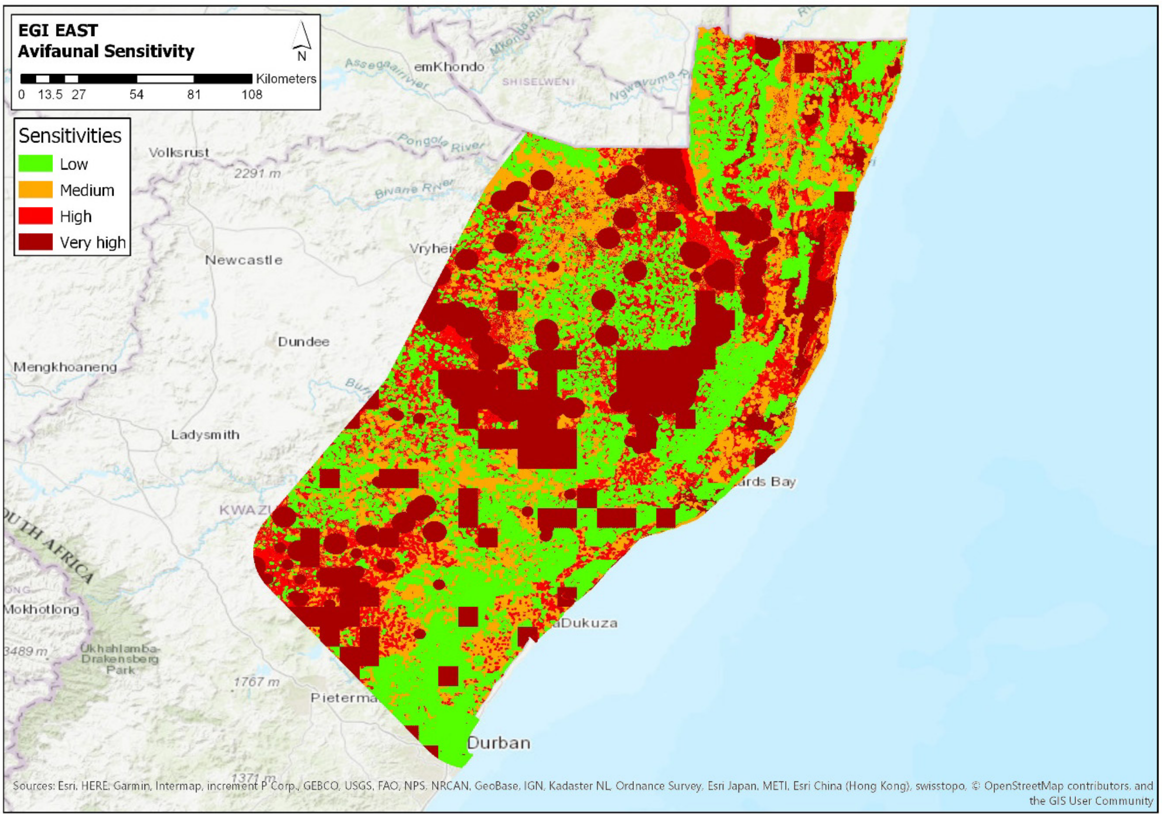


Figure 8: Avifauna sensitivity map for the Expanded Eastern Corridor.

9 KEY POTENTIAL IMPACTS AND MITIGATION

Table 6: Key potential impacts on avifauna associated with the development of EGI, and suggested mitigation measures.

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
Expanded Western Corridor	• Mortality of power line sensitive Red Data species through collisions • Mortality of power line sensitive Red Data species through electrocutions • Displacement of Red Data species due to habitat destruction and disturbance	Greater Flamingo collisions at waterbodies.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal light emitting diode (LED) mitigation devices.
		Kori Bustard collisions in the Nama and Succulent Karoo.	Multiple casualties could destabilise the population and result in a negative population growth (Shaw, 2013).	Mark power lines with BFDs.
		Black Stork collisions and displacement at waterbodies, drainage lines and cliffs.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies and across drainage lines with BFDs. Search suitable cliffs for nest sites and buffer nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the Environmental Control Officer (ECO). An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain, if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Blue Crane collisions at cultivated commercial fields and waterbodies.	Multiple casualties could destabilise the population and result in a negative population growth (Shaw et al. 2010)	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
				effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Great White Pelican collisions at waterbodies and along the coast	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with BFD.
		Lesser Flamingo collisions at waterbodies and along the coast.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices.
		Ludwig's Bustard collisions in the Nama and Succulent Karoo.	Multiple casualties could destabilise the population and result in a negative population growth (Shaw 2013).	Mark power lines with BFDs.
		Martial Eagle electrocutions and displacement of breeding birds on transmission lines in the Nama and Succulent Karoo.	Multiple casualties and disturbance of breeding birds could destabilise the population.	Use only bird-friendly power line designs. Investigate all suitable transmission and sub-transmission lines (≤66kV) for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Secretary bird collisions in the Nama and Succulent Karoo.	Multiple casualties could destabilise the population.	Mark power lines with BFDs
		Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites throughout the corridor.	Multiple casualties could destabilise the population. The species upgraded from not threatened to vulnerable in the	Use only bird-friendly power line designs. Investigate all suitable cliff sites for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
			2014 national Red Data list.	once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Caspian Tern collision at large waterbodies throughout the corridor.	Multiple casualties could destabilise the population.	Mark power lines with BFDs.
Expanded Eastern Corridor	• Mortality of power line sensitive Red Data species through collisions • Mortality of power line sensitive Red Data species through electrocutions • Displacement of Red Data species due to habitat destruction and disturbance	African Marsh-harrier collisions throughout the corridor.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines with BFD's
		Southern Ground Hornbill collisions, electrocutions and displacement throughout the corridor.	Multiple casualties and displacement of breeding birds could destabilise the population.	Use only bird-friendly power line designs. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Black Stork collisions and displacement at waterbodies, cliffs and drainage lines throughout the corridor.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies and across drainage lines with BFDs. Search cliff areas for nest sites and buffer these by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
				enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Blue Crane collisions and disturbance of breeding birds in grassland and wetland areas in Grassland.	Multiple casualties could destabilise the population and result in a negative population growth (Shaw et al. 2010)	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer nest sites by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Cape Vulture electrocutions, disturbance at breeding colonies and roosts throughout the corridor. Collisions and electrocutions at vulture restaurants.	Multiple casualties and disturbance of breeding birds could destabilise the population and lead to population decline.	Use only bird-friendly designs. Buffer breeding colonies and vulture restaurants by 5 km. Should the full extent of the buffering at vulture restaurants and breeding colonies not be practically possible, the areas must be thoroughly investigated by an avifaunal specialist and those power lines that could pose a collision threat to vultures must be identified and marked with BFDs. In addition, it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Denham's Bustard collisions in grassland areas throughout the corridor.	Multiple casualties could destabilise the population.	Mark power lines with BFDs

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
		Great White Pelican and Pink-backed Pelican collisions and displacement at waterbodies in Indian Ocean Coastal Belt.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies BFDs.
		Greater and Lesser Flamingo collisions at waterbodies throughout the corridor.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices.
		Grey Crowned Crane collisions at wetlands and cultivated commercial fields in Grassland and Indian Ocean Coastal Belt. Displacement of breeding birds in wetlands in Grassland and Indian Ocean Coastal Belt.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Secretarybird collisions throughout the corridor except Indian Ocean Coastal Belt.	Multiple casualties could destabilise the population.	Mark power lines with BFDs
		Verreaux's Eagle electrocutions, collisions and displacement of breeding birds at cliff sites.	Multiple casualties could destabilise the population.	Use only bird-friendly power line designs. Investigate all suitable cliff sites for nests and buffer by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
		Wattled Crane collisions and displacement at wetlands in Grassland.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m of the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with nocturnal LED mitigation devices. Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Southern Bald Ibis collision and displacement at cliffs in Grassland.	Multiple casualties could destabilise the population.	Investigate all suitable cliff sites for nests and buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Blue Swallow displacement due to habitat destruction in the KwaZulu–Natal mistbelt in the Grassland biome.	Habitat destruction, especially the destruction of suitable nest holes could destabilise the population and contribute to the negative population growth.	Buffer all known Blue Swallow breeding habitat by 2.5 km. Should the full extent of the buffering not be practically possible, a thorough investigation must be conducted by a suitably experienced avifaunal specialist with experience of Blue Swallows to identify any potential nesting holes, which must then be appropriately buffered, in consultation with EKZN Wildlife and BLSA to prevent destruction of the nest holes.
		Displacement due to disturbance and habitat destruction at nest localities of Bateleur, Lappet-faced Vulture, Marabou Stork,	Disturbance of breeding birds could lead to temporary or even permanent abandonment of breeding efforts. Destruction	Buffer all nests by 2.5 km. Should the full extent of the buffering not be practically possible it would require management of the potential impacts on the breeding birds once construction commences, which would necessitate the involvement of the

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigation
		Martial Eagle, Secretarybird, Tawny Eagle, Southern, White-backed Vulture, Hooded Vulture and White-headed Vulture in Savannah, African Crowned Eagle and Banded Snake-Eagle in Forest, and Pel's Fishing Owl at rivers and waterbodies in the northern part of the corridor.	of nesting trees could displace birds from the area.	avifaunal specialist and the ECO. An effective communication strategy should be implemented whereby the avifaunal specialist is provided with a construction schedule which will enable him/her to ascertain if, when and where breeding birds could be impacted by the construction activities. This could then be addressed through the timing of construction activities during critical periods of the breeding cycle.
		Saddle-billed Stork and Yellow-billed Stork collisions at waterbodies in Savanna.	Multiple casualties could destabilise the population.	Avoid routing power lines within 500 m from the edge of waterbodies found to be suitable for the species, and if unavoidable, mark power lines at waterbodies with BFDs

10 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

10.1 Planning phase

Table 7: Planning phase framework for the investigation, assessment and mitigation of EGI development on avifauna.

Stage	Activity summary	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
Planning	• Identification of potential power line routes.	• Identification of technically feasible assessment corridor alternatives for assessment during the project specific assessment process.	• A suitably qualified avifaunal specialist should be appointed to conduct an avifaunal impact assessment study. The specialist should proceed as follows: ○ The centre line of each assessment corridor must be determined. ○ A 2km buffer zone must be drawn around the centre line of each assessment corridor. ○ The sum total area of each habitat sensitivity class in the assessment corridor must be calculated, based on the four-tier avifaunal sensitivity map. ○ The procedure to follow for the avifaunal assessment of each assessment corridor alternative must be determined, based on the majority sensitivity class in the corridor. Depending on the representation of sensitivity classes in the corridor, this may be a combination of procedures. • The specialist must make a recommendation on whether the power line may proceed or not, based on the anticipated impacts on Red Data avifauna, and must identify a preferred corridor which will have the least impact on Red Data avifauna, i.e. one which **avoids** Very High and High sensitive areas as much as possible. • If the power line project may proceed, the specialist must describe suitable mitigation measures to be implemented, based on the type of impacts that are foreseen and Red Data species to be impacted (see Section 9).

10.2 Construction phase

Table 8: Construction phase framework for the investigation, assessment and mitigation of EGI development on avifauna.

Stage	Activity summary	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
Construction	Establishment of tower positions and vegetation clearing in the servitude.	• Access Negotiations • Tower Pegging • Vegetation clearing in servitude • New gate installation	If a feasible corridor alternative is identified and authorisation or similar is obtained to proceed with the project, the procedure is as follows: • Once the tower positions have been pegged, a walk-through should be conducted by a suitably qualified avifaunal specialist to identify all active Red Data nests in the servitude and immediately adjacent areas prior to the commencement of the servitude clearing. Due to the length of time between the authorisation (or similar) of the project and the commencement of construction activities, the nest surveys (if any) conducted during the planning phase will have to be repeated. This is usually only applicable in Very High and High sensitivity areas but depending on the circumstances of each project and the professional opinion of the specialist, this may have to be extended to Medium and Low sensitivity areas as well. The width of the corridor to be surveyed will be determined by the species which are likely to breed there. • Should such a nest be discovered, the avifaunal specialist should 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. • During the walk-through, the specialist must also identify sections of line to be marked with BFDs.
	• Assembling of the power line	• Foundation nominations (for main structure and anchors) • Excavation of foundation • Foundation steelwork (reinforcing) • Foundation (concrete) pouring • Delivery of tower steelwork • Assembly team / Punching and painting • Erection • Stringing • Sag and tension	• If it has been established during the walk-through that a breeding pair of Red Data species could be displaced, appropriate management measures would need to be implemented, the nature of which will depend on the Red Data 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: • The eggs and/or chicks must be removed to a rehabilitation facility if the nest will be destroyed. • Construction activities must be timed to avoid the disturbance of the breeding birds during critical phases of the breeding cycle. • Activities must be restricted to the servitude width. • No access must be allowed to property/habitat beyond the servitude. • Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads. • BFDs must be fitted to those sections of the line which were identified during the walk-through.
	• Rehabilitation	• Low vehicle and people intensity work	• Activities must be restricted to the servitude width. • No access must be allowed to property/habitat beyond the servitude.

Stage	Activity summary	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
		• Seeding of the servitude • Ground application using all-terrain vehicles, agricultural equipment, seed drills etc. • Minimal people and equipment on site	• Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads. • People and equipment must be restricted to a minimum to execute the on-site work. • A suitably qualified rehabilitation expert must be appointed to manage the process in order to recreate the natural environment as best as possible.

10.3 Operations phase

Table 9: Operations phase framework for the investigation, assessment and mitigation of EGI development on avifauna.

Stage	Activity Summary description	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
Operations	Aerial and ground surveillance activities to: • identify any potential 3rd party incursions onto the servitude. • identify areas of servitude instability that could potentially affect the integrity of the power line. • to identify areas where there is potential surface erosion. • To inspect the electrical hardware.	• Aerial line patrol – varies in frequency depending on location • Walking/driving the power line servitude. Occurs typically at least once every 3 years in the case of transmission lines.	• If possible, patrols should be scheduled to occur outside of breeding window of Red Data species, especially large raptors breeding on transmission lines. • Once-off pass through should be planned vs. "in and out' to limit potential disturbance to birds.
Operations	The repair and maintenance of electrical hardware on the pylons.	• Cleaning of insulators • Replacement of faulty insulators • Removal/trimming of conductive nesting material which compromises electrical clearances. • Maintenance of access gates • Maintenance and repair of servitude track • Vegetation cutting in the servitude.	• If feasible, repairs should be scheduled outside the breeding window of Red Data species, especially large raptors breeding on the power line. • Temporary removal of a nestlings and/or eggs by a qualified expert for the duration of the repair activities might be necessary. • Problem nests to be relocated to a different location on the tower to prevent pollution of insulators and eliminate the risk of streamer faulting, through the use of nesting platforms.

10.4 Rehabilitation and post closure

Table 10: Rehabilitation and post closure framework for the investigation, assessment and mitigation of EGI development on avifauna.

Stage	Activity Summary description	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
Decommissioning	Dismantling of power line	• Dismantling of the towers and the disposal or recycling of the material	• A walk-through should be conducted by a suitably qualified avifaunal specialist to identify all active Red Data nests in the servitude, including those on the pylons, and immediately adjacent areas prior to the commencement of the dismantling operations. • Should such a nest be discovered, the avifaunal specialist should 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 dismantling operations. • If it has been established during the walk-through that a breeding pair of Red Data species will be displaced, appropriate management measures would need to be implemented, the nature of which will depend on the Red Data 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: o The eggs and/or chicks must be removed to a rehabilitation facility if the nest will be destroyed. o Dismantling activities must be timed to avoid the disturbance of the breeding birds during critical phases of the breeding cycle. • Activities must be restricted to the servitude width. • No access must be allowed to property/habitat beyond the servitude. • Maximum use must be made of existing access roads to prevent the unnecessary construction of new roads.

10.5 Monitoring requirements

Table 11: Avifauna monitoring requirements for EGI developments.

Stage	Activity Summary description	Activity	Suggested best practices for the assessment and mitigation of impacts on avifauna
Operations	None	• None	• Depending on the sensitivity of the power line, post-construction monitoring may be required for a specific period to assess the effectiveness of BFDs, and to identify additional sections of line to be fitted with BFDs.

11 CONCLUSIONS AND FURTHER RECOMMENDATIONS

In the terms of reference for this report received from the CSIR, it was specifically stated that the sensitivity delineation should be undertaken in the context of all EGI including transmission lines, distribution lines and substations. The implication of this was that electrocution as a source of mortality had to be taken into account in the risk assessment, because the vast majority of bird electrocutions happen on the smaller distribution structures, and not the large transmission structures (Lehman et al. 2007)[3]. It was assumed that future distribution infrastructure could potentially be a source of electrocution mortality. However, the Eskom Land and Biodiversity Standard (2016) states that "all designs of new power lines and supporting infrastructure for power generation must be evaluated for the risk it could pose to wildlife and no design which has a high risk, or a record of it causing mortalities to wildlife, shall be used." It was further assumed that Eskom might not be the only entity building power lines in future; therefore it cannot automatically be assumed that all future distribution pole designs will be electrocution friendly. However, should this assumption be wrong, and Eskom continues to build the vast majority of future distribution lines, it could be argued that electrocution of birds has effectively been eliminated as a source of mortality on future distribution lines. It might therefore be a useful exercise to repeat this analysis without electrocution, as it may have a significant impact on the outcome of the analysis, in that it may reduce the risk rating of some of the habitat classes.

There are currently no accepted best practice guidelines for the investigation and assessment of potential impacts of electricity infrastructure on avifauna. The methods and level of investigation that is required are left up to the individual avifaunal specialist. There is a strong need for a set of best practice guidelines to be compiled to standardise methodology, along the lines of the best practice guidelines which was developed for the assessment of impacts of wind energy developments on avifauna[4].

It is understood that DEA are acting to reduce the assessment requirements for any EGI development inside of the expanded EGI corridors (once gazetted) from an EIA to a Basic Assessment (BA) or possibly to be exempted from environmental authorisation, provided that the Minimum Information Requirements or Standards and Generic EMPr (being compiled as part of this SEA) are complied with. This will be done by utilising provisions within NEMA. Currently the construction of facilities or infrastructure for transmission or distribution of electricity with a capacity >275KV outside of an urban area or industrial complexes requires a full EIA to be undertaken. However, Government Notice 113 in Government Gazette 41445 published on 16 February 2018 deals with the gazetting of the EGI corridors that were the subject of the 2016 EGI SEA, which specifies that development of this type within the gazetted corridors will no longer require a full EIA, but rather a BA. It is important to note that the level of investigation required for avifaunal impacts are not governed by the size of the line, because the impacts associated with power lines often have little to do with the size of the line, e.g. as pointed out above, distribution lines are far more dangerous from an electrocution perspective than transmission lines. Whether the avifaunal investigations form part of an EIA or a BA is irrelevant for the avifaunal investigation process. The minimum standards of the latter are determined by the envisaged impacts, not the legal process. Even though the present report does not offer many immediate opportunities to directly streamline the development authorisation process, the findings still have considerable worth for both DEA and the industry. By highlighting and mapping the avian sensitivities within each corridor at this scoping level, the SEA offers developers early clarity on the bird-related obstacles they are likely to encounter at any given location within each of the corridors. Hence there is greater certainty in pursuing development options, and less likelihood of unexpected and costly delays. The value of this indirect streamlining function should not be underestimated.

[4] See Jenkins A R; Van Rooyen C S; Smallie J J; Anderson M D & Smit H A. 2011. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa. Endangered Wildlife Trust and Birdlife South Africa.

12 REFERENCES

A F. Boshoff, J C. Minnie, C J. Tambling & M D. Michael. 2011. The impact of power line-related mortality on the Cape Vulture *Gyps coprotheres* in a part of its range, with an emphasis on electrocution. Bird Conservation International (2011) 21:311–327.

Avian Power Line Interaction Committee (APLIC), 1996. Suggested practices for raptor protection on power lines – the state of the art in 1996. Edison Electric Institute and Raptor Research Foundation, Washington, DC, USA.

BLSA (BirdLife South Africa). 2014. White-winged Flufftail confirmed sightings 2000 – 2014. https://www.birdlife.org.za/.

BLSA (BirdLife South Africa). 2015. Nest localities of Southern Bald Ibis. https://www.birdlife.org.za/

BLSA (BirdLife South Africa). 2018a. A list of potential Bush Blackcap, Spotted Ground-Thrush and Orange Ground-Thrush breeding habitat. https://www.birdlife.org.za/.

BLSA (BirdLife South Africa). 2018b. Yellow-breasted Pipit core distribution mapping. https://www.birdlife.org.za/.

BLSA (BirdLife South Africa). 2018c. Rudd's Lark core distribution mapping. https://www.birdlife.org.za/.

BLSA (BirdLife South Africa). 2018d. Botha's Lark core distribution mapping. https://www.birdlife.org.za/.

D. Hockin, M. Ounsted, M. Gormant, D. Hillt, V. Kellert and M. A. Barker. 1992. Examination of the Effects of Disturbance on Birds with Reference to its Importance in Ecological Assessments. Journal of Environmental Management (1992) 36,253-286.

Eskom Sustainability Division. 2016. Eskom Land and Biodiversity Standard.

Group on Birds of Prey and Owls, Berlin, Germany, and MME/ BirdLife Hungary, Budepest, pp. 437–441.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V & Brown, C.J. (eds). 1997. The atlas of southern African birds. Vol 1 & 2. BirdLife South Africa, Johannesburg.

Hobbs, J.C.A. & Ledger J.A. 1986a. The Environmental Impact of Linear Developments; Power lines and Avifauna. Proceedings of the Third International Conference on Environmental Quality and Ecosystem Stability. Israel, June 1986.

Hobbs, J.C.A. & Ledger J.A. 1986b. Power lines, Birdlife and the Golden Mean. Fauna and Flora, 44:23-27.

Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conservation International 20: 263-278.

Kruger, R. & Van Rooyen, C.S. 1998. Evaluating the risk that existing power lines pose to large raptors by using risk assessment methodology: The Molopo Case Study. Proceedings of the 5th World Conference on Birds of Prey and Owls. August 4-8, 1998. Midrand, South Africa.

Kruger, R. 1999. Towards solving raptor electrocutions on Eskom Distribution Structures in South Africa. Bloemfontein (South Africa): University of the Orange Free State. (M. Phil. Mini-thesis).

Kruger, R., Maritz, A., van Rooyen, C., 2004. Vulture electrocutions on vertically configured medium voltage structures in the Northern Cape Province, South Africa. In: Chancellor, R.D., Meyburg, B.-U. (Eds.), Raptors Worldwide. World Working

Ledger, J. 1983. Guidelines for Dealing with Bird Problems of Transmission Lines and Towers. Eskom Test and Research Division. (Technical Note TRR/N83/005).

Ledger, J.A. & Annegarn H.J. 1981. Electrocution Hazards to the Cape Vulture (Gyps coprotheres) in South Africa. Biological Conservation 20:15-24.

Ledger, J.A. 1984. Engineering Solutions to the Problem of Vulture Electrocutions on Electricity Towers. The Certificated Engineer, 57:92-95.

Ledger, J.A., J.C.A. Hobbs & Smith T.V. 1992. Avian Interactions with Utility Structures: Southern African Experiences. Proceedings of the International Workshop on Avian Interactions with Utility Structures. Miami (Florida), Sept. 13-15, 1992. Electric Power Research Institute.

Lehman, R.N., Kennedy, P.L. & Savidge, J.A. (2007). The state of the art in raptor electrocution research: a global review. Biological Conservation 136: 159-174.

Mucina. L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

Shaw, J.M. 2013. Power line collisions in the Karoo: Conserving Ludwig's Bustard. Unpublished PhD thesis. Percy FitzPatrick Institute of African Ornithology, Department of Biological Sciences, Faculty of Science University of Cape Town May 2013.

Steven W. Evans and H. Bouwman.2010. Historical and current distribution, population size, and possible migration routes of the Blue Swallow Hirundo atrocaerulea in Africa. Bird Conservation International (2010) 20:1–15. ª BirdLife International, 2010 doi:10.1017/S0959270910000158

Van Rooyen, C.S. 1998. Raptor mortality on power lines in South Africa. Proceedings of the 5th World Conference on Birds of Prey and Owls. Midrand (South Africa), Aug.4 – 8, 1998.

Van Rooyen, C.S. 1999. An overview of the Eskom-EWT Strategic Partnership in South Africa. EPRI Workshop on Avian Interactions with Utility Structures Charleston (South Carolina), Dec. 2-3 1999.

Van Rooyen, C.S. 2000. An overview of Vulture Electrocutions in South Africa. Vulture News, 43: 5-22. (Vulture Study Group, Johannesburg, South Africa).

Van Rooyen, C.S. 2004. The Management of Wildlife Interactions with overhead lines. In The fundamentals and practice of Overhead Line Maintenance (132kV and above), pp217-245. Eskom Technology, Services International, Johannesburg.

Van Rooyen, C.S. 2007. Eskom-EWT Strategic Partnership: Progress Report April-September 2007. Endangered Wildlife Trust, Johannesburg.

Verdoorn, G.H. 1996. Mortality of Cape Griffons *Gyps coprotheres* and African Whitebacked Vultures *Pseudogyps africanus* on 88kV and 132kV power lines in Western Transvaal, South Africa, and mitigation measures to prevent future problems. Proceedings of the 2nd International Conference on Raptors: Urbino (Italy), Oct. 2-5, 1996.

Appendix 1: Example of a ratings table to calculate the sensitivity scores of the habitat classes

mes	l_Habitat	ck Harrier elec	ck Harrier coll	ck Harrier disp	ck Harrier sum	ck Harrier RDs	ck Harrier score	ck Stork elec	ck Stork coll	ck Stork disp	ck Stork sum	ck Stork RDs	ck Stork score	e Crane elec	e Crane coll	e Crane disp	e Crane sum	e Crane RDs	e Crane score	pian Tern elec	pian Tern coll	pian Tern disp	pian Tern sum	pian Tern RDs	pian Tern score	at White Pelican elec	at White Pelican coll	at White Pelican disp	at White Pelican sum	at White Pelican RDs	at White Pelican score	ater Flamingo elec	ater Flamingo coll	ater Flamingo disp	ater Flamingo sum	ater Flamingo RDs	ater Flamingo score	oo Korhaan elec	oo Korhaan coll	oo Korhaan disp	oo Korhaan sum	oo Korhaan RDs	oo Korhaan score
Nama-Karoo	Bare				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Nama-Karoo	Cliffs (1km buffer)				0	8	0	2	2	2	6	4	24				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Nama-Karoo	Drainage lines				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Nama-Karoo	Grassland		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Nama-Karoo	Industrial				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Nama-Karoo	Low shrubland		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Nama-Karoo	Shrubland fynbos		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Nama-Karoo	Thicket /Dense bush				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Nama-Karoo	Wetlands and waterbodies (500m buffer)				0	8	0	2	2	2	6	4	24				0	2	0		2	1	3	4	12				0	4	0		2	2	4	2	8				0	2	0
Nama-Karoo	Woodland/Open bush				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Bare				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Cliffs (1km buffer)				0	8	0	2	2	2	6	4	24				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Cultivated commercial fields rainfed				0	8	0				0	4	0		2	2	4	2	8				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Cultivated commercial pivots				0	8	0				0	4	0		2	2	4	2	8				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Cultivated subsistence				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Cultivated vines				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Drainage lines				0	8	0	2	2	2	6	4	24				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Grassland		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Succulent Karoo	Industrial				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Low shrubland		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Succulent Karoo	Plantations				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Shrubland fynbos		2	2	4	8	32				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0		2	2	4	2	8
Succulent Karoo	Thicket /Dense bush				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Urban (500m buffer)				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0
Succulent Karoo	Wetlands and waterbodies (500m buffer)				0	8	0	2	2	2	6	4	24		2	2	4	2	8		2	1	3	4	12				0	4	0		2	2	4	2	8				0	2	0
Succulent Karoo	Woodland/Open bush				0	8	0				0	4	0				0	2	0				0	4	0				0	4	0				0	2	0				0	2	0

The table above is an excerpt of the ratings table for the Expanded Western Corridor to serve as an illustration of how the ratings were calculated.

elec = electrocution
coll = collision
disp = displacement
RD's = Red Data scores

The probability of the respective impacts occurring in a habitat class was rated for each priority species to arrive at a species-specific probability score for each impact, within each habitat class, within each biome, within each corridor. Probabilities for the respective impacts occurring were rated according to the below scale:

- 0 = the impact is highly unlikely to occur
- 1 = the impact is unlikely to occur
- 2 = the impact could possibly occur
- 3 = the impact will most likely occur

Appendix 2: Peer Review and Specialist Response Sheet

Peer Reviewer: Jonathan Booth and Robin Colyn, Birdlife South Africa

EXPERT REVIEW AND SPECIALIST RESPONSES: Avifauna - EGI Expansion					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**	**Specialist Response**
R.Colyn	9 - 10	46	Study Methodology inset	Bullet point 9: aggregated habitat sensitivity score - low and medium score threshold overlap, i.e. Low = 2, Medium = 1 - 177	This is typo. It should be Low = 0. It has been rectified.
R.Colyn	8-10	46	Study Methodology inset	Methodology is well suited for the proposed scope of works - incorporates extensive threatened species data sources and utilises fine scale spatial layers.	Noted with appreciation
R.Colyn	10-11	7	Table 1	With reference to SABAP2 data used: "More than 36% of pentads have four or more lists." Were pentads with four or more cards submitted only used for analyses? Were full protocol and incidental records utilised? My reasoning here is that with range restricted, elusive and low density species it would be imperative to use all available data to represent them on these landscape level scales.	All pentads where data was collected were used irrespective of the number of lists. When SABAP2 data was lacking, it was supplemented with SABAP1 data.
R.Colyn	17 - 18	40	Table 3	Barlow's Lark (NT) and Red Lark (VU) - displacement through loss of habitat?	The habitat in the Expanded Western Corridor is such that little if any vegetation clearing will be required in the power line servitudes. Displacement due to habitat transformation in the powerline servitudes should therefore not be an issue.
R.Colyn	19-20	1	Table 3	Black-rumped Buttonquail (EN)? In addition to displacement, we have found numerous Kurrichane Buttonquail and Common Quail under transmission lines in a nature reserve within the eastern Free State. This could be suggestive of a greater vulnerability than expected.	We have added the species as suggested
R.Colyn	20		Table 3	Remove "CR" from Southern Banded Snake Eagle species name.	Done
R.Colyn	20		Table 3	Orange Ground (NT) and Spotted Ground Thrush (EN) along corridors between climax forest patches (i.e. listed as thicket/dense bush on Land Cover 2014) - displacement?	We have added the species as suggested
J. Booth	13	18		"Some avifaunal specialists did not respond to data requests" - has this resulted in any significant gaps in data? Would it be beneficial if the authors were allowed more time to collect possible missing data in order to increase the level of confidence	It will never be possible to include all available data from all specialist sources and it is envisaged that such information gaps will be addressed during the site specific assessments to be conducted. See

EXPERT REVIEW AND SPECIALIST RESPONSES: Avifauna - EGI Expansion					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**	**Specialist Response**
				in their results?	second last point below.
J. Booth	13	19 - 21		BirdLife South Africa strongly supports this statement; given inherent SEA limitations, the SEA must not preclude a full EIA (and not just a Basic Assessment) taking place at the individual project level.	The level of investigation will not be determined by the legal procedure (BA or EIA) but by the habitat sensitivity level.
J. Booth	29	6	Table 5	Could the authors describe how various buffer distances were calculated / what informed the buffer distances?	Buffer distances were defined based on our professional judgment of the extent of the potential impact of the EGI on avifauna within the defined habitat classes - wetlands and waterbodies have 500 m buffer and medium to very high sensitivity depending on the biome.
J. Booth	42	4	Table 7	For Very High and High Sensitivity Class: Provincial conservation authorities and any regional conservation NGO's (e.g. Wilderness Foundation and Nature's Valley Trust in the Eastern Cape; Wildlands Conservation Trust in KwaZulu-Natal) should also be notified of any development proposals.	This was added as recommended.
J. Booth	43		Table 7	Under Permit Requirements (if any) column, in some instances the following is required: "If the development overlaps with an IBA, BLSA and the EWT should be notified of any development proposals." This should include Key Biodiversity Areas (KBAs), as it is likely that in the coming years and possibly before final pipeline planning commences, IBAs will transition to KBAs.	This was added as recommended.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.1.8

Biodiversity and Ecological Impacts - Bats

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

BATS

Contributing Authors	Kate MacEwan[1,2]

[1] Inkululeko Wildlife Services (Pty) Ltd.
[2] South African Bat Assessment Association Panel

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TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

AoO	Area of Occupancy
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
EGI	Electricity Grid Infrastructure
EIA	Environmental Impact Assessment
EMPr	Environmental Management Programme
EWT	Endangered Wildlife Trust
EoO	Extent of Occurrence
IWS	Inkululeko Wildlife Services
NEMA	National Environmental Management Act
SABAA	South African Bat Assessment Association
SABAAP	South African Bat Assessment Association Panel
SEA	Strategic Environmental Assessment
WEF	Wind Energy Facility

SUMMARY

A Strategic Environmental Assessment (SEA) methodology is being adopted to expand the electricity grid infrastructure (EGI) power corridors (that were assessed as part of a separate SEA Process which concluded in 2016). Inkululeko Wildlife Services (IWS) were appointed as the bat specialist to provide input into high level strategic mapping, provide guidance on the site specific assessment requirements that should be followed in each of the four sensitivity tiers, and provide input into some of the high level potential impacts relevant to bats and the EGI expansion. This high level assessment is deemed suitable for an SEA study of this nature and where necessary, future site-specific investigations and appropriate specialist studies will provide more detail.

Terrestrial ecoregions, geology, known bat roosts, vegetation, irrigated agricultural areas, urban areas, eroded areas, wetlands, rivers, dams and extent of occurrence of conservation important bat species were selected as key environmental features relevant to bats. These features were mapped per corridor and then each feature or feature sub-class was assigned a sensitivity class and, where appropriate, a buffer.

Very High sensitivity areas were considered as such due to very high roosting and/ or foraging potential and/ or due to very high bat activity levels and/ or potential occurrence of Vulnerable, Data Deficient or Endangered species. These areas are probably unsuited to development from a bat perspective owing to the very high bat importance. High sensitivity areas were considered to have high roosting and/ or foraging potential and/ or due to high bat activity levels. These areas are potentially unsuited to development from a bat perspective owing to the high bat importance. Medium sensitivity areas were considered to have moderate roosting and/ or foraging potential and/ or due to moderate bat activity levels and/ or due to unknown bat activity levels and/ or potential occurrence of Near-threatened or Rare species. These areas are potentially more suitable for development from a bat perspective, but potential on-site sensitivities must be fully investigated and effective mitigation options clearly identified. Low sensitivity areas were considered to have low roosting and/ or foraging potential and/ or due to low bat activity levels and no known occurrence of conservation important species. These areas are probably the most suitable for development compared with the Medium to Very High sensitivity areas.

The potential impacts to bats by the EGI developments in the proposed Expanded EGI corridors could include roost disturbance and foraging habitat loss associated with clearing the right of way during the construction phase, as well as electrocution and electromagnetic interference in the operational phase. It must be noted that there are no reported cases in South Africa, however, large fruit bats further north in Africa and in Asia and Australia have been reported to be electrocuted by power lines. In addition, there are no reported cases of the impact of electromagnetic interference on bats, however, it is unknown as to whether electromagnetic radiation interferes with bat echolocation.

Measures to avoid and minimise impacts would include, in the planning phase, staying away from Very High and High sensitivity areas. Where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist), Bat Assessments, including field work, must be performed to inform whether the project would have adverse effects on bats and to make informed mitigation recommendations. The main recommendation could be micro-siting to avoid key roosts or foraging habitat and flight paths.

1 INTRODUCTION

A Strategic Environmental Assessment (SEA) methodology is being adopted to expand the electricity grid infrastructure (EGI) power corridors (that were assessed as part of a separate SEA Process which concluded in 2016). The Council for Scientific and Industrial Research (CSIR) (in collaboration with the South African National Biodiversity Institute (SANBI)) were appointed by the Department of Environmental Affairs (DEA) to undertake the EGI Expansion SEA. As such, the CSIR appointed Inkululeko Wildlife Services (IWS) as an independent, suitably qualified bat (order Chiroptera) specialist to provide expert high level bat input on the impacts of the development of a power line network.

Bats (Order: Chiroptera), the second most diverse mammal group on the planet, provide vital ecosystem services. They warrant consideration and protection at the very least due to their economic value, although tourism and biodiversity heritage value is also very important. Insectivorous bats are known to eat up to their body weight in insects daily; much of their prey considered pests. They thus act as vital pest-control agents, and their value has been estimated at $1bn in global savings in the agricultural industry (Kalka *et al*., 2008; Kunz *et al*., 2011; Maine and Boyles, 2015). Gonsalves *et al*. (2013) found that they have also proven to be effective at controlling mosquitoes carrying the Malaria parasite, a disease which ravages the African continent and is spread over many parts of South Africa. Fruit and nectar-eating bats are known to act as vectors for seed dispersal and pollination of 528 plant species - both important agricultural crops and naturally occurring species (Fleming, Geiselman and Kress, 2009). Cave-dwelling bats play important roles in nutrient cycling via the production of guano, a vital input of energy in most cave systems (IUCN SSC, 2014). Bats are thus important keystone species for most ecosystems and act as a good indicator of ecosystem health.

It is well described that certain bird families are severely impacted by power lines (Jenkins *et al*., 2010), however, less is known about the impacts on bats. This particular project may present some danger to bats which are already nationally and globally under severe pressure due to disease, roost disturbance, habitat decline (IUCN SSC 2014) and wind energy (Arnett and Baerwald, 2013; MacEwan, 2016). Of the literature which is available, it has been reported that certain fruit bat species (Pteropodidae) in Asian and Australasian countries have fallen victim to electrocution due to power lines (Martin, 2011; Rajeshkumar *et al*., 2013). This effect was exemplified in a study by Krystufek (2009) on Indian flying foxes (*Pteropus giganteus*) in the Sri Lankan Paradeniya Botanic Garden. The study revealed that dead bats were regularly found hanging on the power lines and that on one particular day as many as 74 carcasses were found over a 3 km stretch of power line.

The potential impacts to bats during the construction phase could include roost disturbance and foraging habitat loss associated with clearing the right of way (which is expected to continue into the operational phase) and sensory disturbance due to increased levels of noise and dust associated with heavy vehicles and other machinery. During the operational phase, bats (particularly fruit bats) could potentially be negatively impacted by electrocution by power lines and to a lesser extent collision with them. Other potential impacts associated with the operational phase include electromagnetic radiation emitted by the power lines and its potential repellent effects, which may in turn lead to habitat fragmentation of certain species. Electromagnetic radiation is also said to have behavioural effects on bats and rats (Nicholls & Racey, 2007; Nicholls & Racey, 2009). The impacts suggested may be compounded if the power line is erected along bat migratory routes.

2 SCOPE OF THIS STRATEGIC ISSUE

- Attend a briefing session at the beginning of the specialist assessment process and a multi-author team workshop to discuss the first draft report (V1).
- Provide a brief report and/or GIS files of key bat features for the EGI expansion corridor features.
- Provide input into the key features mapping from a bat perspective.
- Provide bat input into the environmental four tier sensitivity map.
- Develop/ verify the approach for classing each sensitivity feature according to a four-tiered sensitivity rating system.
- Identify any gaps in information and based on the findings of the assessment.

3 APPROACH AND METHODOLOGY

As per the terms of reference supplied, the current high level study was based on a brief desktop review and high level strategic mapping.

3.1 Desktop Review

- Analysis of IWS collected bat call data from over 25 Wind Energy facility (WEF) Monitoring Studies within the various Terrestrial Ecoregions to determine an average annual bat activity level per Ecoregion for comparative analysis;
- Based on several years of experience and literature reviews, assessment of environmental parameters relevant to bat ecology and their distributions;
- A list of bat species of conservation importance was compiled for each of the two expanded EGI corridors.

3.2 Spatial Data Analysis

Whilst various environmental parameters and spatial data sources were considered for the bat sensitivity spatial mapping exercise, only those parameters considered important for bats, as either important for roosting or foraging or of conservation significance were selected and used. The relevant sensitive environmental spatial layers were selected on the maps and buffered according to defendable criteria. This is further explained in Sections 3.4, o and 0.

3.3 Impact characterisation

Whilst a detailed impact assessment was not undertaken, this report does discuss some of the potential impacts relevant to bats and power line development and does provide guidance on the site specific assessment requirements that should be followed in each of the four sensitivity tiers. This high level assessment is deemed suitable for an SEA study of this nature and where necessary the site specific specialist studies will provide more detail.

3.4 Feature identification, description and data sources

Bat sensitive features and the sources of information used to map them are provided in Table 1.

Table 1: Data sources used in this assessment.

Sensitivity Feature Class	Source and Date of Publication	Data Description and Processing
Terrestrial Ecoregions	Terrestrial Ecoregions. 2009. The Nature Conservancy, Arlington, VA. Available at http://maps.tnc.org/gis_data.html	The terrestrial ecoregions (Olson *et al*., 2001) were clipped to the South African Borders, Swaziland and Lesotho Borders. From numerous monitoring assessments, IWS 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	Council for Geosciences SA, 1997	Geology wr90 shapefile and Geology_Geoscience shapefile. Limited metadata are available but date of creation is 1997. Four main lithologies were selected as relevant to bats in terms of roosting potential: Limestone, Dolomite, Arenite and Sedimentary and Extrusive rock
Bat Roosts	Database from a collection of scientists, collated by the CSIR in 2017 and desktop refined by IWS in 2018. Main sources were: Bats KZN database, IWS database, Herselman and Norton (1985), Wingate (1983), Rautenbach (1982), David Jacobs database, Animalia database	A few of the points were removed, as IWS knows them to not be true bat roost locations. 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.
Vegetation	2013 – 2014 South African National Land-Cover Dataset. Created by GeoterraImage for the DEA, Pretoria. Version 05, February 2015. Available at https://egis.environment.gov.za/data_egis/data_download/current or http://bgis.sanbi.org/Projects/Detail/44	The following land cover classes were used: thicket/dense bush, plantations and indigenous forest (LC classes 4, 5, 32 and 33). For detailed descriptions of these classes please see Appendix A in http://www.geoterraimage.com/uploads/GTI%202013-14%20SA%20LANDCOVER%20REPORT%20-%20CONTENTS%20vs%2005%20DEA%20OPEN%20ACCESS%20vs2b.pdf Forests, plantations and thick bush provide refuge for several species of bats.
Irrigated Agricultural Areas	2013 – 2014 South African National Land-Cover Dataset. Created by GeoterraImage for the DEA, Pretoria. Version 05, February 2015. Available at https://egis.environment.gov.za/data_egis/data_download/current or http://bgis.sanbi.org/Projects/Detail/44	The following land cover classes were used: Vines, Subsistence cultivation, Pineapple agriculture, sugarcane plantations, commercial fields, and commercial pivots (LC classes 16-31). For detailed descriptions of these classes please see Appendix A in http://www.geoterraimage.com/uploads/GTI%202013-14%20SA%20LANDCOVER%20REPORT%20-%20CONTENTS%20vs%2005%20DEA%20OPEN%20ACCESS%20vs2b.pdf
Built-up and disturbed areas	2013 – 2014 South African National Land-Cover Dataset. Created by Geoterra Image for the DEA, Pretoria. Version 05, February 2015. Available at https://egis.environment.gov.za/data_egis/data_download/current or http://bgis.sanbi.org/Projects/Detail/44	The following land cover classes were used: Commercial, Industrial, Informal Settlements, Residential Areas, Schools and Sports Grounds, Smallholdings, Gold Courses, Townships, Villages and other built-up areas (LC classes 42-72), as well as erosion and dongas (LC class 40). For detailed descriptions of these classes please see Appendix A in http://www.geoterraimage.com/uploads/GTI%202013-

Sensitivity Feature Class	Source and Date of Publication	Data Description and Processing
		14%20SA%20LANDCOVER%20REPORT%20-%20CONTENTS%20vs%2005%20DEA%20OPEN%20ACCESS%20vs2b.pdf.
Wetlands and Dams	Wetlands = National Freshwater Ecosystem Priority Areas (NFEPA). CSIR. July 2011. Dams = dams500g_wgs84 shapefile. Dept. Water and Sanitation.	Wetlands and dams provide drinking and foraging opportunities for bats.
Main Rivers	Rivers = wriall500_primary shapefile. Dept. Water and Sanitation	There is strong support for the importance of rivers and riparian areas for bats (Serra-Cobo *et al*., 2000; Akasaka *et al*., 2009; Hagen & Sabo, 2012).
Bat species occurrence data	Database from a collection of scientists and organisations. Collated by SANBI and the EWT in 2016 for use in the National Bat Red Data listings.	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 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.

3.5 Bat species of conservation importance relevant to the corridors

The bat species listed in Table 2 are of Conservation Importance and are found within the proposed EGI expanded corridors.

Table 2: Red Data, high risk of fatality and rare bat species that occur in the proposed expanded EGI corridors which are sensitive to development (LC = Least Concern; NT = Near Threatened; VU = Vulnerable; EN = Endangered).

Species Name	Common Name	Conservation Status (Child *et al*, 2016)	Expanded Corridor Phase
Cistugo seabrae	Angolan Hairy Bat	NT (Jacobs *et al*., 2016a)	Western
Cloeotis percivali	Short-eared Trident Bat	EN (Balona *et al*., 2016)	Eastern
Epomophorus wahlbergi	Wahlberg's Epauletted Fruit Bat	LC (Schoeman *et al*., 2016)	Eastern
Kerivoula argentata	Damara Woolly Bat	NT (Monadjem *et al*., 2016a)	Eastern
Laephotis namibensis	Namib Long-eared Bat	VU (Jacobs *et al*., 2016b)	Western
Miniopterus inflatus	Greater long-fingered bat	NT (Richards *et al*. 2016a)	Eastern
Neoromicia rendalli	Rendall's serotine	LC (Monadjem *et al*., 2016b) Rare in SA	Eastern
Otomops martiensseni	Large-eared free-tailed Bat	NT (Richards *et al*., 2016b)	Eastern
Rhinolophus blasii	Peak-saddle Horseshoe Bat	NT (Jacobs *et al*., 2016c)	Eastern
Rhinolophus swinnyi	Swinny's Horseshoe Bat	VU (Jacobs *et al*., 2016d)	Eastern
Rousettus aegyptiacus	Egyptian Rousette Bat	LC (Markotter *et al*., 2016)	Eastern
Scotoecus albofuscus	Thomas' House Bat	NT (Richards *et al*., 2016c)	Eastern
Scotophilus nigrita	Giant Yellow House Bat	NT (Fernsby *et al*., 2016)	Eastern
Taphozous perforatus	Egyptian Tomb Bat	NT (Richards *et al*., 2016d)	Eastern

3.6 Bat feature and sensitivity maps

The features listed in Table 3 have been mapped and then in a separate series of maps, assigned varying sensitivities according to their bat importance. Where appropriate, buffers with a specific sensitivity have been assigned. The exact bat roost points have remained confidential in order to protect the roosts.

Table 3: Bat feature classes, sensitivities and buffers

Feature Class	Feature Sub-class	Feature Sub-class Sensitivity	Buffer Distance	Buffer Sensitivity
Ecoregions	KwaZulu-Cape Coastal Forest Mosaic	High	None	None
	Maputuland Coastal Forest Mosaic	High	None	None
	Maputuland-Pondoland Bushlands and Thickets	High	None	None
	Nama Karoo	Low	None	None
	Drakensberg Montane Grasslands, Woodlands and Forest	Medium	None	None
	Southern African Mangroves	Low	None	None
	Zambesian and Mopane Woodlands	Medium	None	None
	Montane Fynbos and Renosterveld	Low	None	None
	Succulent Karoo	Low	None	None
Geology	Limestone	Very High	200 m	Very High
	Dolomite	Very High	200 m	Very High
	Arenite	Medium	200 m	High
	Sedimentary and Extrusive Rock	Medium	200 m	Medium
Bat Roosts	Bat Roost Points	Very High	500 m	Very High
Land Cover: Vegetation	Indigenous Forest: Very High	Very High	200 m	Very High
	Plantations / Woodlands: Young and Mature	Medium	200 m	Medium
	Thicket/ Dense Bush	Medium	200 m	Medium
Irrigated Agricultural Areas	All irrigated crops	Medium	None	None
Land Cover: Urban Built-up Areas	Urban Areas	Medium	None	None
	Disturbed Land (Eroded)	Low	None	None
Wetlands	All Wetlands	Very High	200m	High
Rivers	Major Perennial Rivers	Very High	200m	Very High
Dams	Farm Dams and Natural Dams	Very High	200m	High
Extent of Occurrence (EoO) is defined as the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the known, inferred or	*Cistugo seabrae*	Medium	No additional buffer on the EoO, but there is a 50 km buffer on the individual record points	
	Cloeotis percivali	Medium		
	Epomophorus wahlbergi	Medium		
	Kerivoula argentata	Medium		

Feature Class	Feature Sub-class	Feature Sub-class Sensitivity	Buffer Distance	Buffer Sensitivity
projected sites of present occurrence of a taxon, excluding cases of vagrancy (IUCN, 2012). Only species, where their EoO overlaps with the EGI expansion areas were included.	*Laephotis namibensis*	Medium		
	Miniopterus inflatus	Medium		
	Neoromicia rendalli	Medium		
	Otomops martiensseni	Medium		
	Rhinolophus blasii	Medium		
	Rhinolophus swinnyi	Medium		
	Rousettus aegyptiacus	Medium		
	Scotoecus albofuscus	Medium		
	Scotophilus nigrita	Medium		
	Taphozous perforates	Medium		

4 FEATURE MAPS AND FOUR-TIERED SENSITIVITY MAPS

The bat feature and sensitivity maps constructed for each of the proposed expanded EGI corridors, using the criteria specified in Table 3 above, are presented in Figure 1 to Figure 4. Note, bat roosts are not indicated in the feature maps, but have been considered in this assessment and buffered by a distance of 500 m.

4.1 Expanded Western Corridor

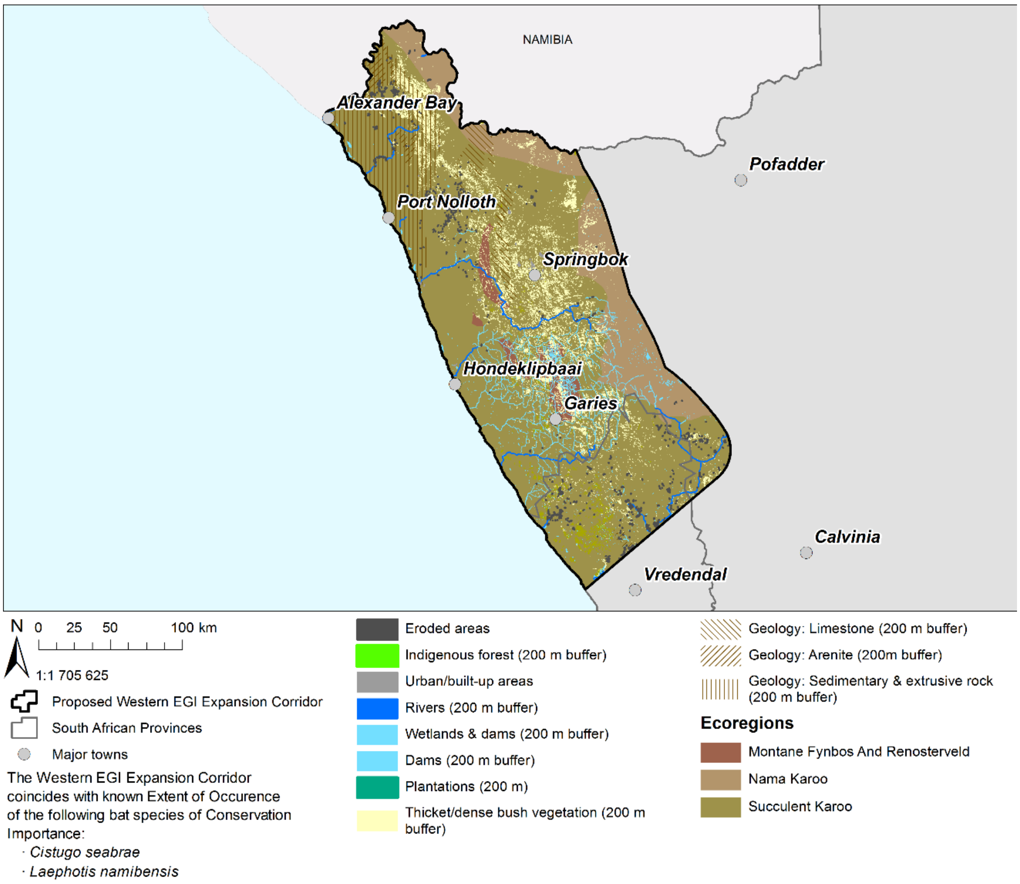


Figure 1: Key habitat features for bats, as well as an indication of the species of Conservation Importance that may be encountered in the proposed expanded Western EGI corridor.

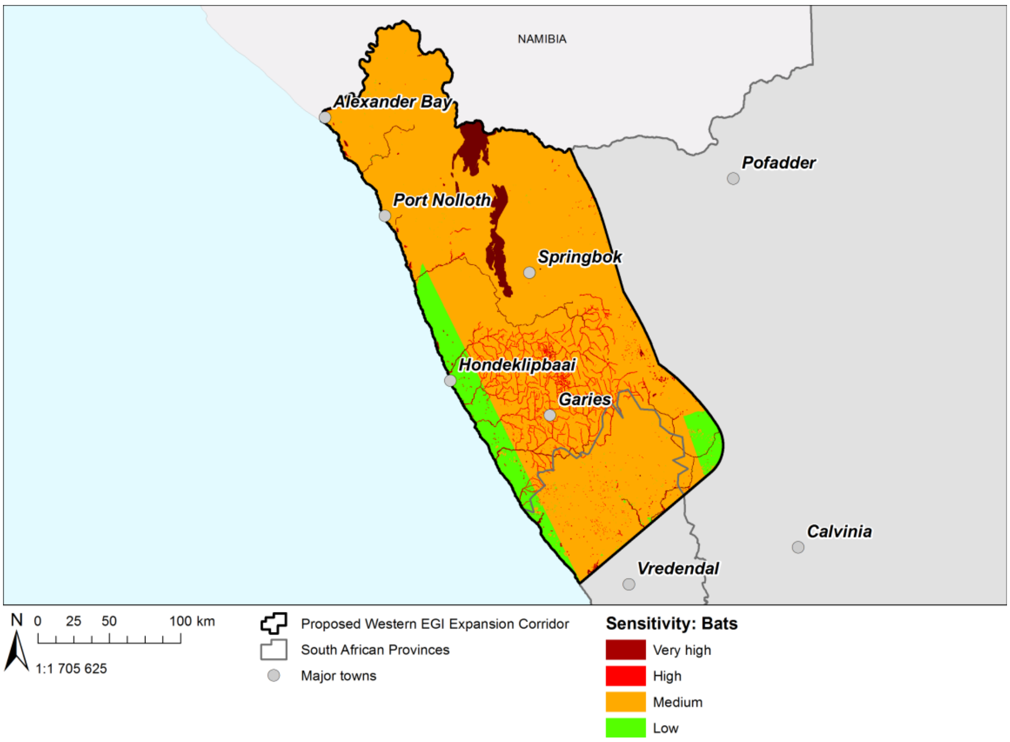


Figure 2: Bat sensitivity map for the proposed expanded Western EGI corridor.

4.2 Expanded Eastern Corridor

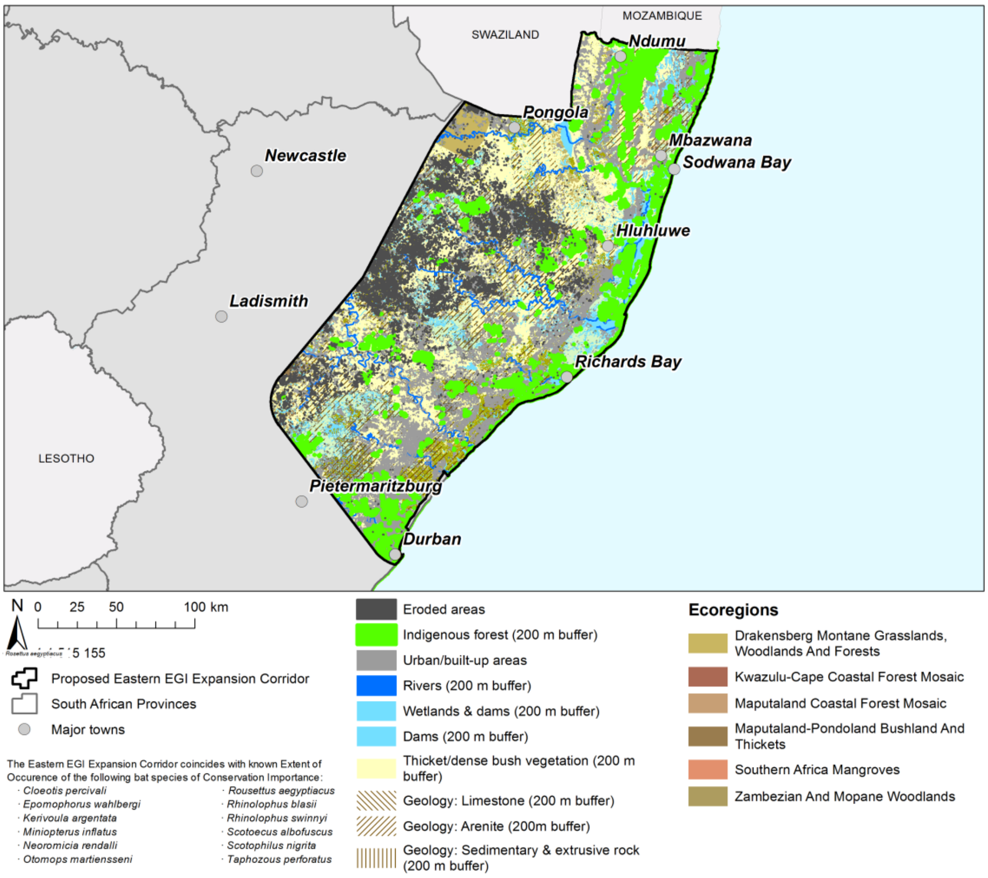


Figure 3: Key habitat features for bats, as well as an indication of the species of Conservation Importance that may be encountered in the proposed expanded Eastern EGI corridor.

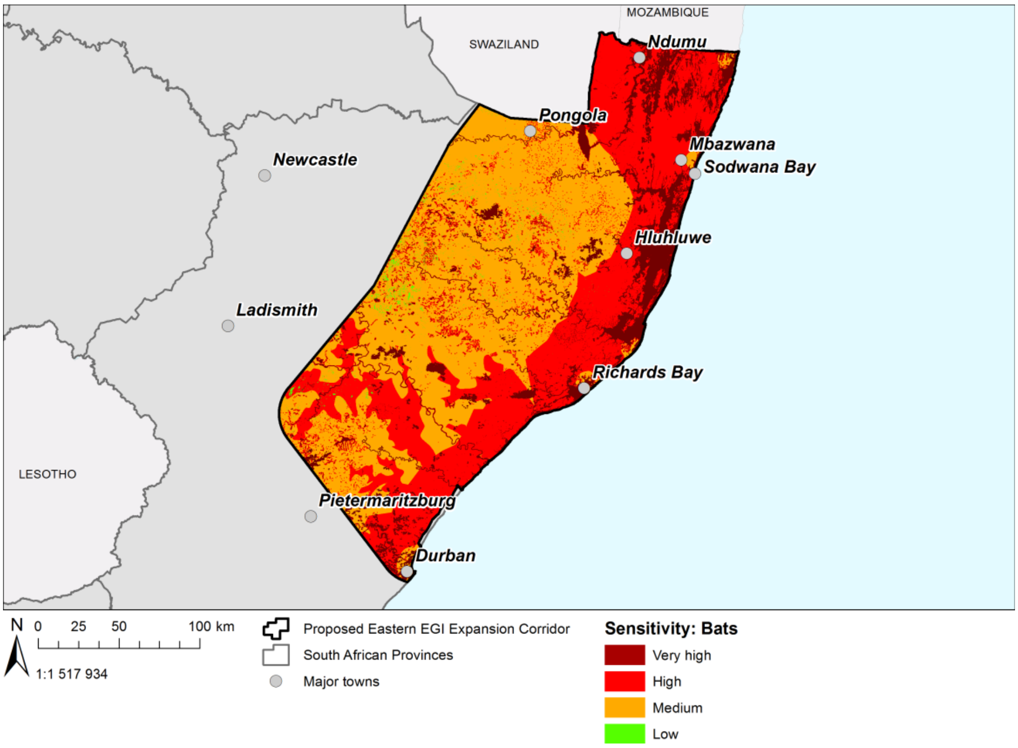


Figure 4: Bat sensitivity map for the proposed expanded Eastern EGI corridor.

5 KEY POTENTIAL IMPACTS AND MITIGATION

Southern Africa has eleven genera of fruit bats, comprising 21 species (Simmons, 2005). Three of these species commonly occur in South Africa. These species may potentially be affected by the development; however, no record of bat fatalities due to power line infrastructure exists to date in South Africa. Collision related impacts may be compounded if the power line is erected along established migratory pathways.

Whether or not electromagnetic radiation will affect flying bats or interfere with the echolocation of insectivorous bats during foraging is unknown. Options for mitigating the effects of electromagnetic radiation is limited, but will be best achieved by avoiding the areas where bats may congregate for prolonged periods such at roost sites or around surface water and irrigated croplands.

Construction activities, such as digging and blasting for pylon foundations and vehicle movement could cause noise, dust and vibrational disturbances to roosting colonies, especially during the breeding season from approximately October to March. 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 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. Potential impacts on bats include but are not limited to (Table 4):

Table 4: Potential impacts from EGI development to bats, and recommended mitigation actions.

Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
Displacement and disturbance	During the construction phase, particularly the erection of pylons. The clearing of vegetation, digging and drilling of foundations, noise and vibrations from construction activities.	Loss of ecologically significant habitats associated with these species.	Avoidance of verified high and very high bat sensitivity areas. Particular attention in the bat assessments (where required) should be given to species of conservation importance as per Section 3.5. If development does take place in areas of verified Very High or High sensitivity, where required, based on the Decision-Making Tools (e.g. based on the recommendation of the general faunal ecologist), a bat specialist must be appointed to undertake site visits to recommend micro-siting measures, and advise on the least harmful time in terms of the breeding season of the relevant bats in the area.
Electrocution	During the operational phase. No reported cases in South Africa, however, large fruit bats further north in Africa and in Asia and Australia have been reported to be electrocuted by power lines.	Death	Avoidance of verified high and very high bat sensitivity areas. Particular attention in the bat assessments (where required) should be given to fruit bats and large insectivorous bats.
Electromagnetic interference	During the operational phase. No reported cases in bats, however, it is unknown as to whether electromagnetic radiation interferes with bat echolocation.	Disorientation	Avoidance of verified high and very high bat sensitivity areas. The bat assessments (where required) should conduct a desktop review on any possible new developments in this area of research.

6 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS

The only guidelines available in South Africa relating to the protection of bats in the context of development are those released by the South African Bat Assessment Association Panel (SABAAP) (Sowler *et al*, 2017; Aronson *et al*, 2014) in reference to wind energy development. However, IWS will contribute to the Decision-Making Tools that will be compiled for this specific SEA, in order to inform the site specific assessment requirements that are needed prior to commencement of the development.

6.1 Planning phase

- Ensure site specific Bat Assessments are conducted to inform planning and placement, where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist).

6.2 Construction, Operational Rehabilitation and Post Closure phases

- Site specific Bat Assessments to conduct impact assessments and provide mitigation and monitoring requirements for each phase of development, where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist). The principles of avoidance, minimization, mitigation and only if unavoidable offset/ compensation should apply.

6.3 Monitoring requirements

The EMPr should be audited bi-annually to ensure that any mitigation measures listed were and continue to be adhered to.

7 CONCLUSIONS AND FURTHER RECOMMENDATIONS

Bats, the second most diverse mammal group on the planet, warrant consideration and protection at the very least due to their economic value and the ecosystem services they provide, although tourism and biodiversity heritage value is also very important.

The potential impacts to bats by the EGI expansion during the construction phase could include roost disturbance and foraging habitat loss associated with clearing the right of way (which is expected to continue into the operational phase) and sensory disturbance due to increased levels of noise and dust associated with heavy vehicles and other machinery. During the operational phase, bats (particularly fruit bats) could potentially be negatively impacted by electrocution by power lines and to a lesser extent collision with them. Other potential impacts associated with the operational phase include electromagnetic radiation emitted by the power lines and its potential repellent effects, which may in turn lead to habitat fragmentation of certain species.

Measures to avoid and minimize impacts would include, in the planning phase, staying away from Very High and High sensitivity areas. Where required, based on the Decision-Making Tools (e.g. in areas of verified Very High or High sensitivity based on the recommendation of the general faunal ecologist), In these areas, detailed Bat Impact Assessments, including field work, must be performed to inform whether the project would have adverse effects on bats and whether it should proceed or not or to make informed mitigation recommendations. Such recommendations could be micro-siting to avoid key roosts or foraging habitat, avoiding construction in certain seasons, keeping the development footprint to a minimum, dust prevention and prevention of sedimentation runoff into water bodies, etc.

8 GAPS IN KNOWLEDGE

- Gaps in knowledge from a bat data perspective include:
- Lack of data on the impacts of power lines on bats in South Africa.
- 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 AoO vs EoO for species of conservation importance, but this level of detail was beyond the scope of this high level SEA. Commissioning such a detailed mapping exercise of the AoO for all species of conservation importance, both plants and animals, would be a worthwhile exercise for the DEA to consider for future conservation planning.

9 REFERENCES

Akasaka, T. Nakano, D. and Nakamura, F., 2009, Influence of prey variables, food supply, and river restoration on the foraging activity of Daubenton's bat (*Myotis daubentonii*) in the Shibetsu River, a large lowland river in Japan. *Biological Conservation142*:1302–1310.

Animalia fieldwork database. Obtained from Werner Marais in July 2013.

Arnett, E.B. and Baerwald, E.F. 2013. Impacts of Wind Energy Development on Bats: Implications for Conservation. In: Bat Evolution, Ecology, and Conservation (Adams, R.A. and Pedersen S.C., eds.) Springer, New York.

Aronson, J., Richardson, E., MacEwan, K., Jacobs, D., Marais, W., Aiken, S., Taylor, P., Sowler, S. and Hein, C. 2014. 1st edition South African Good Practise Guidelines for Operational Monitoring for Bats at Wind Energy Facilities. Unpublished guidelines.

Balona, J., Cohen, L., White, W., Jacobs, D., MacEwan, K., Monadjem, A., Richards, L.R., Schoeman, C., Sethusa, T., Taylor, P. 2016. A conservation assessment of *Cloeotis percivali*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Bats KZN fieldwork database. Obtained from Leigh Richards and Kate Richardson in July 2017.

Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D., Davies-Mostert, H.T., editors. 2016. The 2016 Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

David Jacobs fieldwork database. Obtained from David Jacobs in May 2018.

Fernsby, N., Cohen, L., Richards, L.R., Taylor, P.J., Child, M.F. 2016. A conservation assessment of *Scotophilus nigrita*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Fleming, T.H., Geiselman, C. and Kress, W.J. 2009. The evolution of bat pollination: a phylogenetic perspective. Annals of Botany 104:6: pp1017-1043.

Gonsalves, L., Law, B., Webb, C. and Monamy, V. 2013. Foraging ranges of insectivorous bats shift relative to changes in mosquito abundance. PLoS ONE 8:5 e64081.

Hagen, E.M. and J.L. Sabo J.L. 2012, Influence of river drying and insect availability on bat activity along the San Pedro River, Arizona (USA). The Journal of Arid Environments 84, 1-8

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.

IUCN. 2012. IUCN Red List Categories and Criteria: Version 3.1. Second edition. Gland, Switzerland and Cambridge, UK: IUCN. iv + 32pp

IUCN SSC (International Union for Conservation of Nature: Species Survival Commission). 2014. IUCN SSC Guidelines for Minimizing the Negative Impact to Bats and Other Cave Organisms from Guano Harvesting. Ver. 1.0. IUCN, Gland, Switzerland.

Jacobs D, Cohen L, Richards LR, Monadjem A, Schoeman C, MacEwan K, Sethusa T, Taylor P. 2016c. A conservation assessment of *Rhinolophus blasii*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs, D.S., MacEwan, K., Cohen, L., Monadjem, A., Richards, L.R., Schoeman, M.C., Sethusa, T. and Taylor PJ. 2016a. A conservation assessment of *Cistugo seabrae*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs D, Cohen L, MacEwan K, Monadjem A, Richards LR, Schoeman C, Sethusa T, Taylor PJ. 2016b. A conservation assessment of *Laephotis namibensis*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs D, Cohen L, Richards LR, Monadjem A, Schoeman C, MacEwan K, Sethusa T, Taylor P. 2016c. A conservation assessment of *Rhinolophus blasii*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jacobs, D.S., Schoeman M.C., Cohen, L., MacEwan, K., Monadjem, A., Richards, L.R., Sethusa, T. and Taylor, P. 2016d. A conservation assessment of *Rhinolophus swinnyi*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Jenkins, A.R., Smallie, J.J. and Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. Bird Conservation International, page 1 of 16. BirdLife International [2010] doi:10.1017/S0959270910000122

Kalka, M.B., Smith, A.R. and Kalko, E.K.V. 2008. Bats limit arthropods and herbivory in a tropical forest. Science 320: p 71.

Krystufek, B. 2009. On the Indian flying foxes (*Pteropus giganteus*) colony in Paradeniya Botanical gardens, Sri Lanka. Hystrix Italian Journal of Mammals 20:1: pp29-35

Kunz, T.H., Braun de Torez, E., Bauer, D., Lobova, T. and Fleming, T.H. 2011. Ecosystem services provided by bats. Annals of the New York Academy of Sciences 1223: 38pp.

Lisóon, F. and Calvo, J.F. 2014. Bat activity over small ponds in dry Mediterranean forests: Implications for conservation. Acta Chropterologica 16:1: pp 95-101.

MacEwan, K. 2016. Fruit Bats and Wind Turbine Fatalities in South Africa. African Bat Conservation News 42: p3-5.

Maine, J.J. and Boyles, J.G. 2015. Bats initiate vital agroecological interactions in corn. Proceedings of the National Academy of Sciences of the USA 112:40: doi: 10.1073/pnas.1505413112.

Markotter, W., MacEwan, K., White, W., Cohen, L., Jacobs, D., Monadjem, A., Richards, L.R., Schoeman, C., Sethusa, T., Taylor, P.J. 2016. A conservation assessment of *Rousettus aegyptiacus*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Martin, L. 2011. Is the fruit you eat flying-fox friendly? The effects of orchard electrocution grids on Australian flying-foxes (*Pteropus spp*., Megachiroptera). In: B. Law, P. Eby, D. Lunney and L. Lumsden, The Biology and Conservation of Australasian Bats. Joint Symposium on the Biology and Conservation of Australasian Bats, Sydney, NSW, Australia, (380-390). 12-14 April, 2007. doi:10.7882/FS.2011.039

Monadjem, A., Cohen, L., Jacobs, D.S., MacEwan, K., Richards, L.R., Schoeman, M.C., Sethusa, T. and Taylor PJ. 2016a. A conservation assessment of *Kerivoula argentata*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Monadjem, A., Taylor, P.J., Richards, L.R., White, W., Cohen, L., Jacobs, D., MacEwan, K., Schoeman, M.C. and Child, M.F. 2016b. A conservation assessment of *Neoromicia rendalli*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Monadjem, A., Taylor, P.J., Cotterill, F.P.D. and Schoeman M.C. 2010. Bats of southern and central Africa – A biogeographic and taxonomic synthesis. Wits University Press, Johannesburg.

Nicholls, B. and P. A. Racey. 2007. Bats Avoid Radar Installations: Could Electromagnetic Fields Deter Bats from Colliding with Wind Turbines? PloS one 2(3)

Nicholls, B. and Racey, P.A., 2009, The Aversive Effect of Electromagnetic Radiation on Foraging Bats—A Possible Means of Discouraging Bats from Approaching Wind Turbines. PLoS ONE 4(7): e6246. doi:10.1371/journal.pone.0006246.

Olson, D.M., Dinerstein, E., Wikramanayake, E.D., Burgess, N.D., Powell G.V.N., Underwood, E.C., D'amico, J.A., Itoua, I., Strand, H.E., Morrison, J.C., Loucks, C.J., Allnutt, T.F., Ricketts, T.H., Kura, Y., Lamoreux, J.F., Wettengel, W.W., Hedao, P. and Kassem, K.R. 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. BioScience 51(11):933-938.

Rajeshkumar, S., Raghunathan, C. and Krishnamoorthy, V. 2013. Observation on Electrocution of Flying Fox (*Pteropus giganteus*) In Andaman Islands and their conservation strategies. Journal of the Andaman Science Association 18(2): 213-215. Journal of the Andaman Science Association. 18. 213-215.

Rautenbach, I.L. 1982. Mammals of the Transvaal. No. 1, Ecoplan Monograph. Pretoria, South Africa.

Richards, L.R., MacEwan, K., White, W., Cohen, L., Jacobs, D.S., Monadjem, A., Schoeman, C. and Taylor, P.J. 2016a. A conservation assessment of *Miniopterus inflatus*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., Schoeman, C., Taylor, P.J., White, W., Cohen, L., Jacobs, D.S., MacEwan, K., Sethusa, T. and Monadjem, A. 2016b. A conservation assessment of *Otomops martiensseni*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., White, W., Cohen, L., Jacobs, D., MacEwan, K., Monadjem, M., Schoeman, C., Taylor, P.J. 2016c. A conservation assessment of *Scotoecus albofuscus*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Richards, L.R., Cohen, L., Jacobs, D.S., MacEwan, K., Monadjem, A., Schoeman, C., Sethusa, T. and Taylor, P.J. 2016d. A conservation assessment of *Taphozous perforatus*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Schoeman, C., White, W., Monadjem, A., Richards, L.R., Cohen, L., Jacobs, D., MacEwan, K., Sethusa, T., Taylor, P.J. 2016. A conservation assessment of *Epomophorus wahlbergi*. In Child, M.F., Roxburgh, L., Do Linh San, E., Raimondo, D. and Davies-Mostert, H.T., editors. 2017. The Red List of Mammals of South Africa, Swaziland and Lesotho. South African National Biodiversity Institute and Endangered Wildlife Trust, South Africa.

Serra-Cobo J., López-Roig M., Marquès-Lopez T. and Lahuerta, E. 2000. Rivers as possible landsmarks in the orientation flight of Miniopterus schreibersii. Acta Theriol. 45(3): 347-352.

Simmons, N. B. 2005. Order Chiroptera. In: Mammal Species of the World: A Taxonomic and Geographic Reference, D. E. Wilson and D. M. Reeder, eds., Smithsonian Institution Press, Washington, DC. Fossil Evidence and the Origin of Bats. Available from: https://www.researchgate.net/publication/30845735_Fossil_Evidence_and_the_Origin_of_Bats [accessed Jul 09 2018].

Sirami, C., Jacobs, D.S. and Cumming, G.S. 2013. Artificial wetlands and surrounding habitats provide important foraging habitat for bats in agricultural landscapes in the Western Cape, South Africa. Biological Conservation 164: pp 30–38.

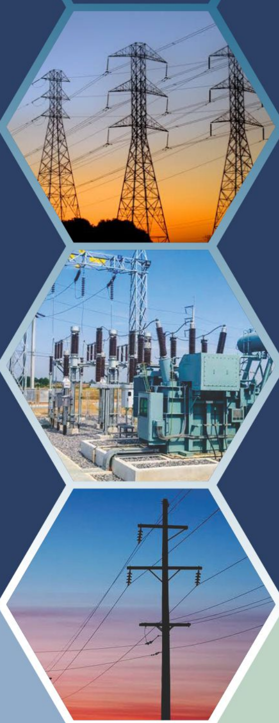
Sowler, S., Stoffberg, S., MacEwan, K., Aronson, J., Ramalho, R., Forssman, K. and Lotter, C. 2017. Edition 4.1: South African Good Practice Guidelines for Surveying Bats in Wind Energy Developments - Pre-construction. South African Bat Assessment Association.

Wingate, L. 1983. The population status of five species of Microchiroptera in Natal. M.Sc. Thesis, University of Natal.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.2

Visual Assessment Report



STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

VISUAL ASSESSMENT SPECIALIST REPORT

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Draft V1 – March 2018
Draft V2 – June 2018
Draft V3 – April 2019
Final Report – October 2019

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ABBREVIATIONS AND ACRONYMS

CAA	Civil Aviation Authority
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DEM	Digital Elevation Model
ECO	Environmental Control Officer
NEMA	National Environmental Management Act
NFEPA	National Freshwater Ecosystem Priority Areas
NGI	National Geospatial Information
NHRA	National Heritage Resources Act
OSM	Open Street Maps
PGWC	Provincial Government of the Western cape
PV	Photovoltaic
SANBI	South African National Biodiversity Institute
SAHRA	South African Heritage Resources Agency
SAPAD	South African Protected Areas Database
SDF	Spatial Development Framework
SEA	Strategic Environmental Assessment
SRTM	Shuttle Radar Topography Mission
VIA	Visual Impact Assessment

1 INTRODUCTION

1.1 Background to the Study

This Visual Assessment study is one of a series of specialist studies, which form part of a Strategic Environmental Assessment (SEA) to identify suitable routing corridors for the effective expansion of key strategic transmission infrastructure. The SEA, which has been commissioned by the Department of Environmental Affairs (DEA), is being conducted by the Council for Scientific and Industrial Research (CSIR), working in association with the South African National Biodiversity Institute (SANBI).

In the previous SEA study of 2016, a visual assessment of five national transmission infrastructure corridors was undertaken, and has recently been gazetted. The current visual study is for the expansion of the Western and Eastern Corridors (see Figure 2).

1.2 Scenic Value in the Context of Transmission Lines

Landscape qualities, particularly scenic resources, have important economic value in the form of tourism for most regions, including the Western and Eastern Expanded Electricity Grid Infrastructure (EGI) corridors currently being assessed.

Transmission lines and related infrastructure, such as substations, tend to have an industrial connotation and could potentially compromise the value of scenic resources, particularly in pristine or protected environments, while they tend to be less of an issue in industrial or mining landscapes.

Transmission lines could in addition detract from the amenity value of recreation or resort areas, and certainly affect property values in many cases, all of which could affect the economy of a region. On the other hand, transmission lines in the right location are necessary for the regional economy.

1.3 Perceptions relating to Transmission Lines

Although large sections of the population see transmission lines as a major visual detraction or eye-sore, there are others, mainly among the context of South Africa's working classes, who may regard them as a sign of progress and service delivery.

Habituation is another consideration, where transmission lines have been in place over a length of time and are hardly noticed or seen as a disturbance any longer. This appears to have been the case with communication masts, which initially caused visual concern, but to which people have grown accustomed.

The implications of these considerations are that the ‘context’ of both the landscape (the receiving environment) and the community (the receptor) is important in the siting of transmission infrastructure.

2 SCOPE OF THE VISUAL STRATEGIC ASSESSMENT

2.1 Definition of ‘Visual’

A visual assessment broadly includes visual, scenic, aesthetic and amenity values, which contribute to an area’s overall ‘sense of place’, and which encompass both natural and cultural landscape characteristics (Oberholzer, 2005).

2.2 The Basis of Visual Assessments

Sense of place is determined by the regional characteristics of the place including, but not restricted to, landscape features, geological structure, vegetation patterns, agricultural activities, settlement forms and vernacular architecture, as well as more intangible characteristics, such as traditions and beliefs. Seen as a whole, these qualities constitute the essential ‘genius loci’ or spirit of the place.

Often great value is attached to those landscapes where visual, scenic, cultural and heritage characteristics are intact, also described as the level of 'landscape integrity'. This concept is useful in providing a baseline for visual impact assessments.

A further consideration in establishing 'visual sensitivity', which involves a degree of interpretation, is where landscape features are pronounced, clustered or overlap within a defined area, adding to 'landscape complexity'.

No standardised scenic resource mapping exists for the country as a whole, nor the rating of scenic resources in terms of their value or sensitivity. This is seen as a major drawback in establishing a common baseline for visual impact assessments.

Finally, given that the study is strategic in nature, covering a fairly broad area, the level of information and mapping is necessarily regional in scale and does not, for example, include individual viewsheds, which only become significant at the local project scale.

3 APPROACH AND METHODOLOGY

3.1 Study Methodology

The visual assessment, together with accompanying maps, is based primarily on interpreting existing information, and uses recognised visual assessment criteria. The format and approach of the study follows that of the earlier 2016 Visual Assessment for purposes of consistency and continuity.

The methodology incorporates the terms of reference for the visual assessment including the following:

- Identify areas or features of visual or scenic value and sensitive receptors within each of the proposed corridors;
- Use this information to determine the overall sensitivity value within each corridor in the context of EGI;
- Describe additional information and assessment required in each sensitivity category before authorization should be considered; and
- Assess the corridor in terms of potential visual impacts and outline proposed management actions to enhance benefits and avoid, reduce or offset negative impacts.

The methodology for this visual assessment involved three basic steps, outlined below:

Step 1: Visual Resource Mapping (descriptive)
The first step involves a description and identification of visual and scenic features to provide a baseline for each of the corridors. It is a classification method in which following aspects are considered:

- Differentiation of the corridor into landscape types (see **Section 5** below);
- An inventory and mapping of visual / scenic features (see also **Appendix 1**);
- Identification of cultural landscapes and heritage sites, using available data.

Step 2: Visual Sensitivity Mapping (interpretive)
The second step involves interpretation, using criteria that influence the value of visual / scenic resources, and therefore their 'significance'. The criteria are spatialised by means of buffers, based on the scale of the EGI development, as well as the relative sensitivity of the feature or receptor. Four levels of visual sensitivity have been prescribed for the study, namely very high sensitivity, high sensitivity, medium sensitivity and low sensitivity. This step relies to a certain degree on judgement in which the following criteria are considered:

- Visually sensitive landforms, (e.g. ridgelines, cliffs, scarps, outcrops);
- Proclaimed or protected areas, (e.g. nature reserves);
- Visually sensitive receptors, (e.g. settlements, routes); and

- Heritage importance (e.g. national, provincial or local significance).

Step 3: Visual Resource Management (prescriptive)
The third step involves the design of strategies for the protection and management of visual / scenic resources to increase benefits and minimise impacts. This step involves prescription in which the following measures are considered:

- Additional information or assessment requirements;
- Permit requirements as part of authorization;
- Management actions to avoid, reduce or offset impacts; and
- Input into development protocol document.

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 2 of this report.

3.2 Data Sources

A list and description of data sources on which the visual assessment was based is given below (Table 1) and a detailed list for each feature is given in **Section 6.2.** The data sources form part of the descriptive or classification stage in Step 1 of the methodology above.

Table 1: Description of Data Sources used in the Visual Assessment

Data title	Source and date of publication	Data Description
1:2 000 000 Simplified Geological Map of South Africa, Lesotho and Swaziland	Council for Geoscience, 2008.	Geological stratigraphy and lithology.
1:500 000 and 1:250 000 topographical maps of South Africa	Surveys and Mapping (several sheets with various dates).	Topographical and cadastral information.
South African Protected Areas Database	DEA, Q4, 2017.	National Parks and Protected Areas.
Inventory of Heritage Sites for SA	SAHRA, Dec. 2017.	Heritage sites.
Map Studio	Road Atlas of South Africa	Scenic routes and mountain passes

3.3 Assumptions and Limitations

A list and description of study limitations and assumptions in the Visual Assessment report are given below (Table 2).

Table 2: Description of Assumptions and Limitations applicable to the Visual Assessment

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Level of mapping detail	1: 500 000 topographical maps, and 1:2 000 000 geological survey maps.	1:250 000 and 1:50 000 topographical maps.	1:500 000 mapping considered adequate for a regional scale study. 1:50 000 scale maps would be required for micro corridor selection.
Information on scenic resources	1:500 000 topographical maps and available shape files of water features and steep slopes.	Detailed survey of scenic features at a more detailed local scale.	Additional scenic resource mapping would be required on an individual project basis in the absence of a scenic resource data base.
Information on heritage sites	Information obtained from South African Heritage Resources Agency (SAHRA) / CSIR	Detailed analysis of local areas using historical airphotos or Google Earth imagery.	Additional heritage assessment would be required on an individual project basis in terms of the National Heritage Resources Act (NHRA).
Information on private reserves, game/ guest farms and resorts.	Information was included where these facilities were known.	Detailed survey of private reserves / game farms.	Detailed information would be needed on an individual project basis.
Viewsheds of National Parks and nature reserves		No viewsheds have been included for individual features.	Assumed that individual viewsheds would need to be prepared on an individual project basis.
Residual activities such as access roads, borrow pits etc. relating to transmission lines.	Some management actions are included in Section 8.	Visual criteria or buffers for access roads, borrow pits etc. not included in the study.	Consideration of access roads etc. would need to be given at the project scale, in terms of NHRA.

3.4 Relevant Regulatory Instruments

A list and description of relevant regulatory instruments associated with visual and scenic resources at international, national and provincial scale for each focus area, is given below (Table 3).

Table 3: Description of Relevant Regulatory Instruments

Instrument	Key objective	Application to Expanded Corridors
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.	Both expanded corridors have Ramsar sites, i.e. Orange River Mouth Wetland, St Lucia Wetland and Kosi Bay Wetland, which formed part of the sensitivity mapping.
National Instrument		
National Environmental Management: Protected Areas Act, 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).	There are a number of Protected Areas within the two expanded corridors, including national parks, nature reserves and mountain catchments. These, together with visual buffers, have been included in the sensitivity mapping.
Integrated Coastal Management Act (ICM Act) (Act 24 of 2008)	Protection of the coastal zone including land within 1 km of the High Water Mark (HWM) to 'protect the ecological integrity, natural character and the economic, social and aesthetic value of coastal public property'.	Both expanded corridors have coastlines and the legislated buffers for these have been included in the sensitivity mapping.
NHRA (Act 25 of 1999)	Includes protection of national and provincial heritage sites, as well as areas of environmental or cultural value, and proclaimed scenic routes.	Graded heritage sites occur in both expanded corridors and have been included in the sensitivity mapping.
Provincial and Municipal Instruments		
Spatial Development Frameworks (SDFs), zoning schemes and municipal by-laws.	Local authority zoning schemes can be used to protect natural and cultural heritage resources through 'Conservation Areas', 'Heritage Overlay Zones' and 'Scenic Overlay Zones' including scenic routes.	Provincial and municipal SDFs generally identify special or heritage protected areas within the expanded corridors.

4 IMPACT CHARACTERISATION

The potential footprint and visual implications of the proposed powerline grid have been partly derived from the previous EGI SEA (CSIR, 2016).

Eskom anticipates that a number of new transmission lines (≥ 400kV) and substations will be required within each of the expanded corridors. The precise number of lines will be dependent on which generation scenario unfolds in the future. Substations are considered as anchor points in the context of the SEA Process.

The design of the pylons could be a number of types, such as self-supporting lattice towers, guyed towers, or monopole structures, the selection of which could have fairly important implications at the local landscape or townscape scale, but not that pertinent for the current corridor alignment study.

However, the servitude and development envelope of the powerline, including the area of vegetation to be cleared could have some significance in terms of the visual footprint.

Using a worst case scenario of a large scale 765 kV powerline, the servitude width (project footprint) would need to be 80m and the development envelope 180m. Parallel 765 kV transmission lines need to be 80m apart, but less for smaller kV lines.

Typical activities relating to powerlines and substations that could have a visual effect on scenic resources are listed in the table below (Table 4).

Table 4: Typical activities relating to powerlines and substations that could have a visual effect on scenic resources

Activity	Footprint	Comments
Development envelope	180m wide	For 765 kV lines. Less for smaller lines.
Servitude	80m wide	For 765 kV lines. Less for smaller lines. About half of this is cleared of vegetation.
Access roads	4m wide	Required for construction and maintenance. Roads on steep or uneven slopes may require cut and fill resulting in more disturbance.
Pylons	Approximately 1000m²	1 ha disturbed area during construction, including assembly area.
Substations	Up to 70 ha	Would include communication masts, fencing etc. May also require access road.
Construction camps	Varies	Would include batching plants and temporary laydown areas.
Borrow pits	Varies	Could make use of existing borrow pits in the area, or require new borrow pits.

The potential visibility of a large scale pylon at a range of distances is given in Figure 1 below, pylons being particularly visible when seen on the skyline. The degree of visibility is one of the parameters used to determine buffers in the visual sensitivity mapping in Section 7.

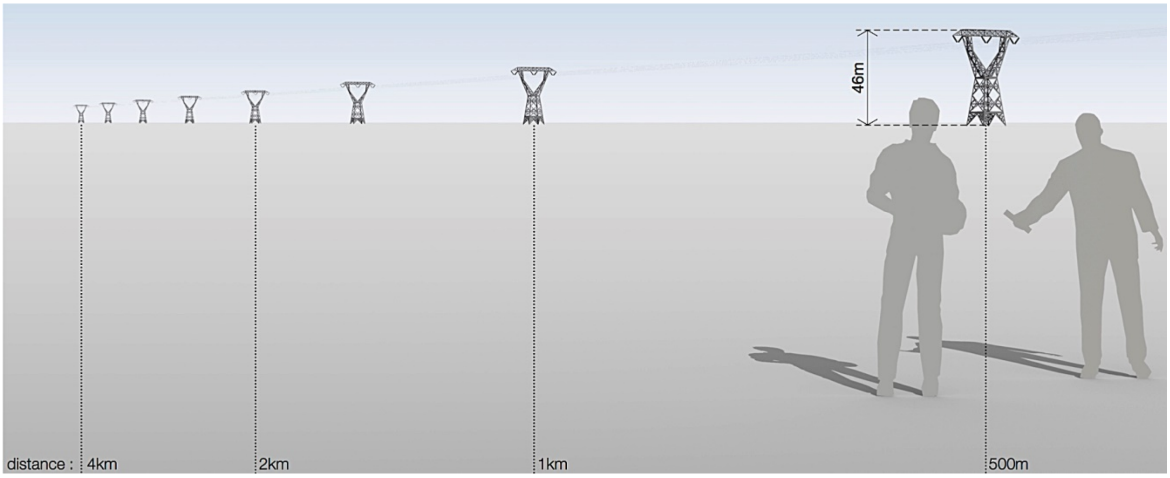


Figure 1: Degree of visibility of pylons at a range of distances from the viewer.

A location plan of the five previously assessed EGI corridors that have been gazetted as well as the two expanded corridors is given in Figure 2 below. Figure 2 also shows the proposed gas pipeline corridors that are being assessed separately as part of the SEA for the development of a Phased Gas Pipeline Network and Energy Corridors. The assessment of the gas pipeline corridors falls outside the scope of this Visual Assessment, as the pipelines will be underground and thus not expected to result in significant visual impacts during the operational phase.

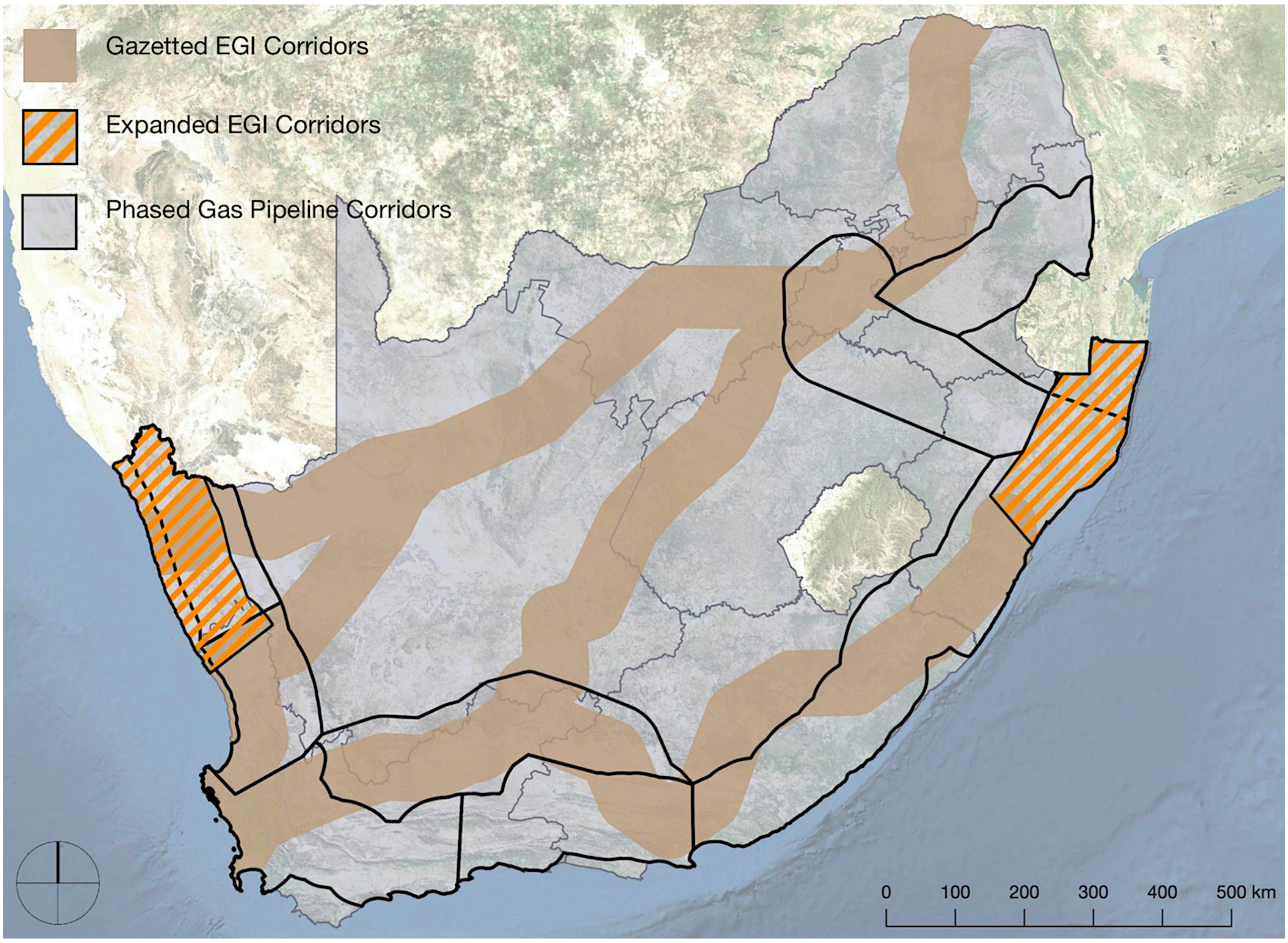


Figure 2: Expanded Western and Eastern EGI Corridors, and Gazetted EGI Corridors in relation to Gas Pipeline Corridors

5 CORRIDOR DESCRIPTION

Landscape characteristics for each of the expanded corridors were based on desktop studies, and the experience of the authors with previous visual assessment studies in those areas.

As landforms are the dominant landscape features at the regional scale, these play a major role in determining scenic resources. A description of the landforms was based on the geomorphology of the landscape. A useful publication in this regard was Norman and Whitfield (2006), where the correlation between geology and landscape or scenic features within the expanded corridors is explained, as illustrated in the transects.

Descriptions, with maps and transects, of the two expanded corridors are illustrated in the Figures that follow.

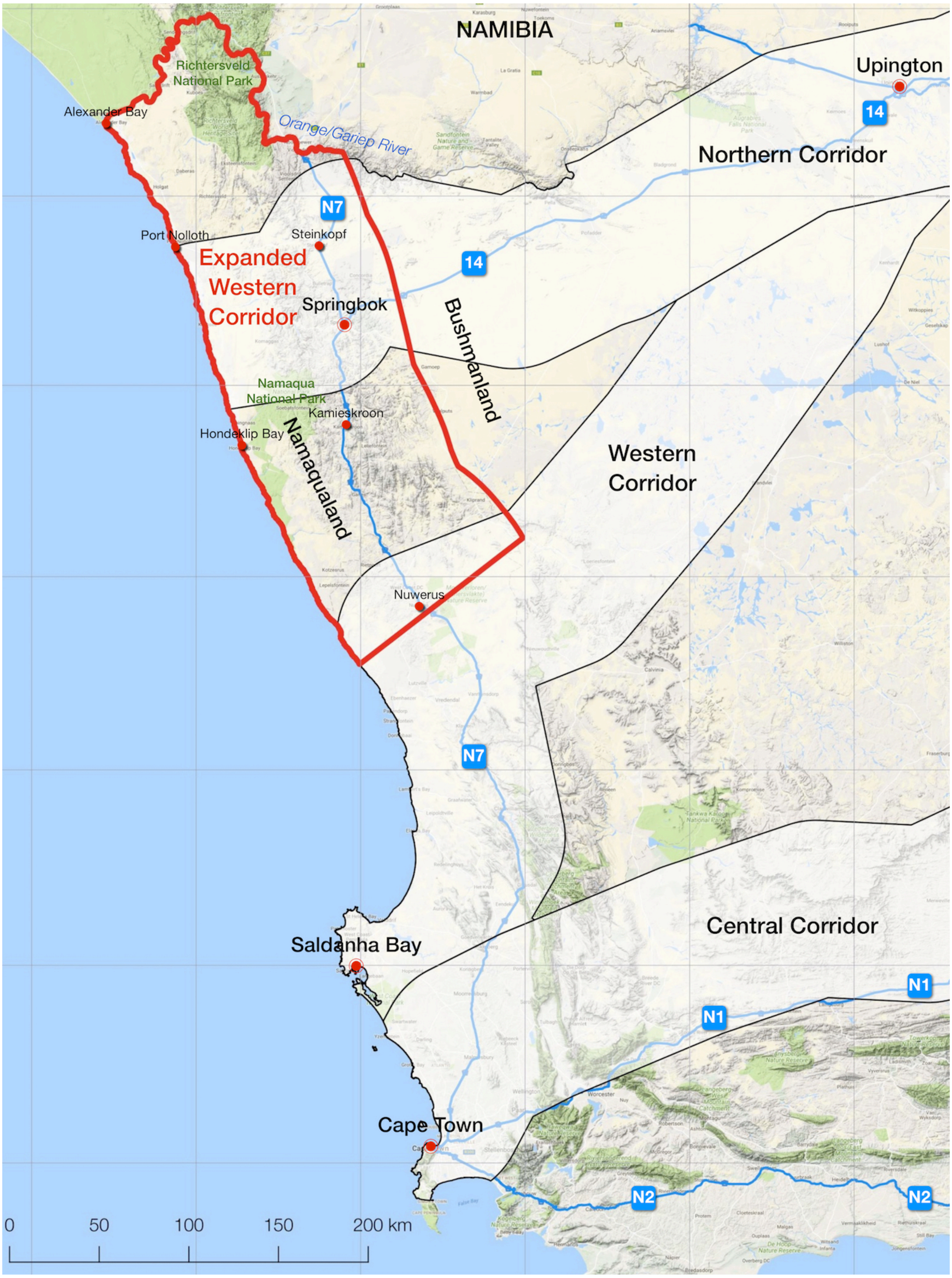
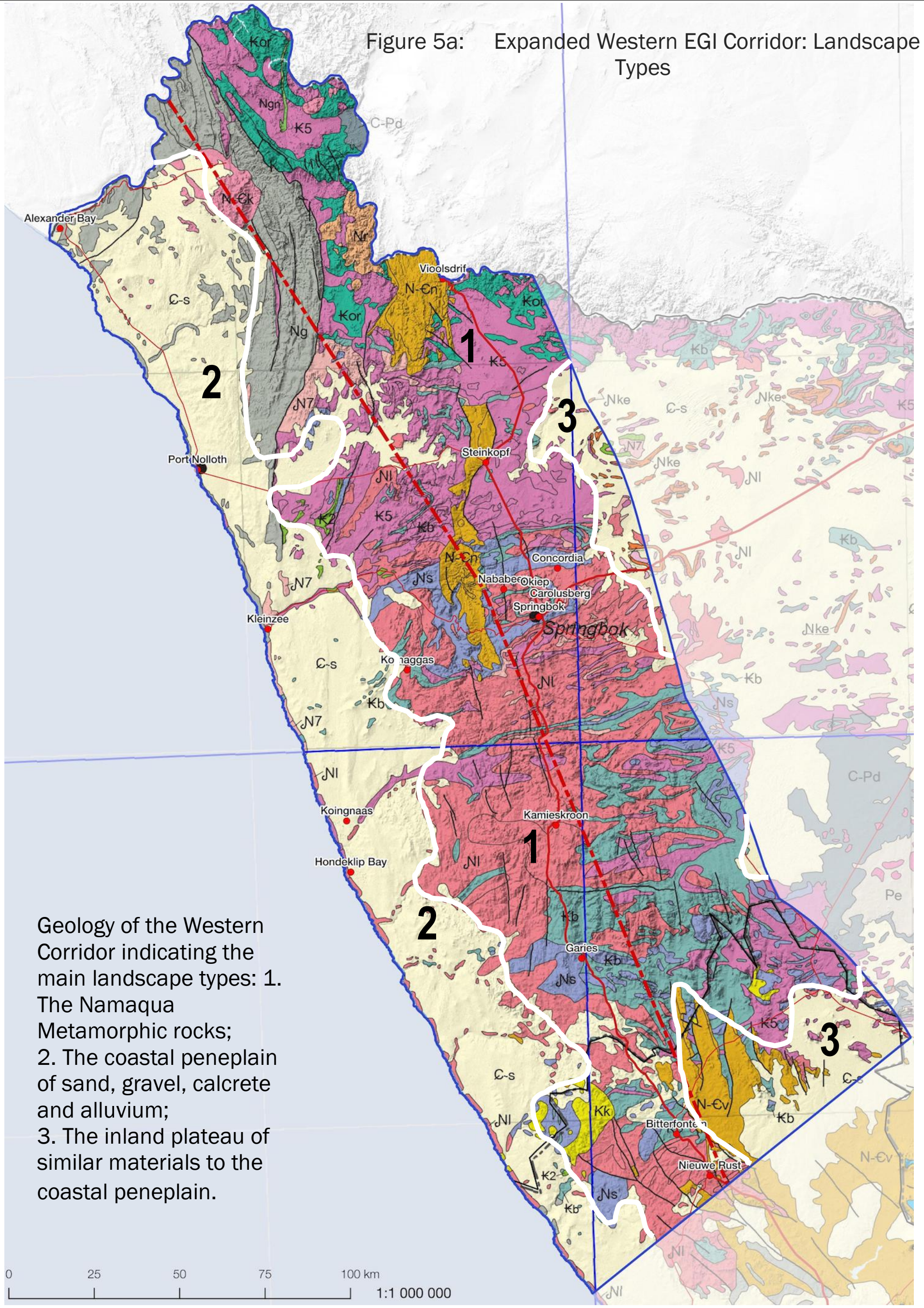


Figure 3: Expanded Western Corridor in relation to the gazetted EGI corridors

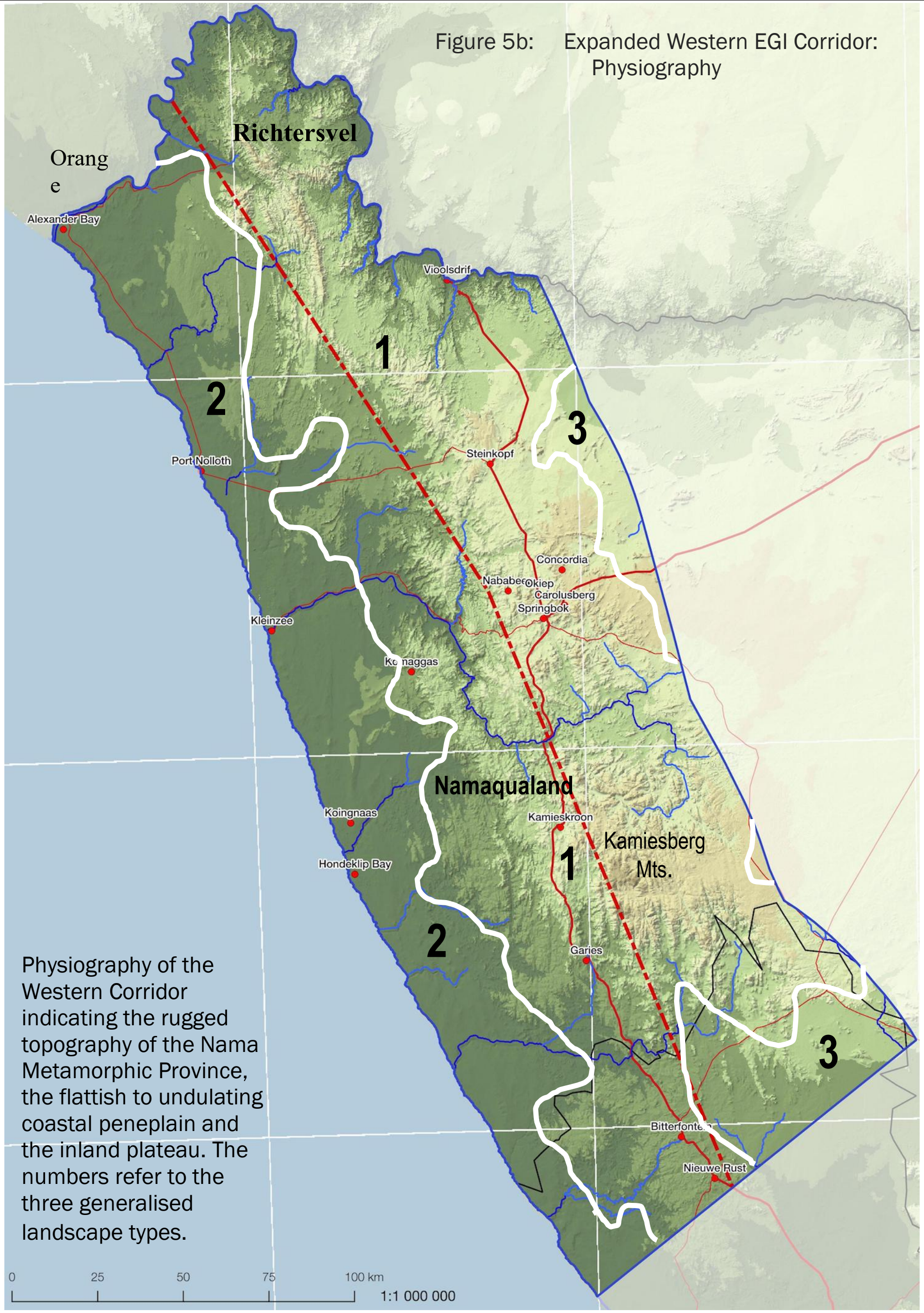
Figure 4: Expanded Eastern Corridor in relation to the gazetted EGI corridors

Figure 5a: Expanded Western EGI Corridor: Landscape Types



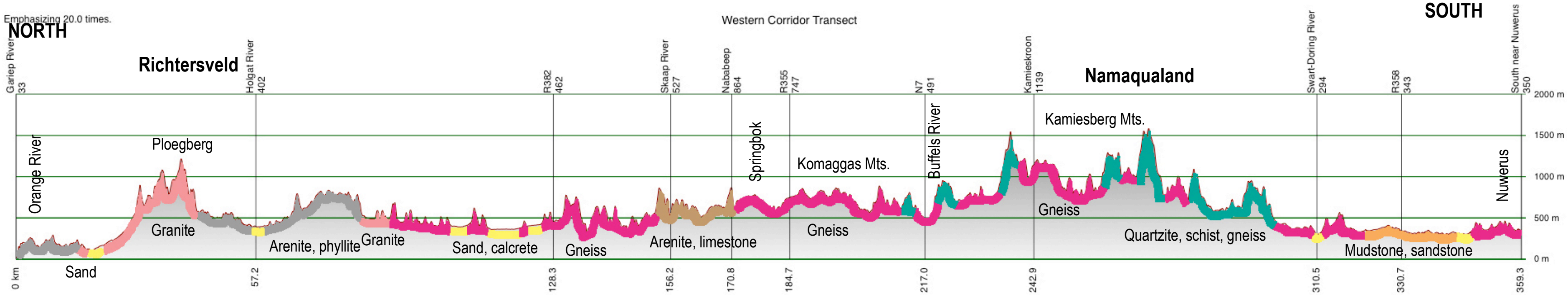
Geology of the Western Corridor indicating the main landscape types: 1. The Namaqua Metamorphic rocks;
2. The coastal peneplain of sand, gravel, calcrete and alluvium;
3. The inland plateau of similar materials to the coastal peneplain.

Figure 5b: Expanded Western EGI Corridor: Physiography



Physiography of the Western Corridor indicating the rugged topography of the Nama Metamorphic Province, the flattish to undulating coastal peneplain and the inland plateau. The numbers refer to the three generalised landscape types.

Figure 5c: Transect through the Expanded Western EGI Corridor



Regional context:
The expanded Western Corridor stretches from Nuwerus in the south to the Orange River (Gariep R.) in the north, and from the Namaqua coastline to about 120km inland. It forms part of the Namaqua Metamorphic Province, an arid, mountainous landscape, very different in character to the humid climate of the Natal Metamorphic Province of the expanded Eastern Corridor. Rivers are few and dry for most of the year. Except for the few towns clustered around the copper mining area, settlements tend to be small and scattered far apart. Nababeep, Okiep and Concordia, north of Springbok, are all historical mining towns. Most of the copper has been mined out and the mines abandoned. Diamond mining has taken place along the coastline, both offshore and onshore, although the latter has dwindled in recent years.

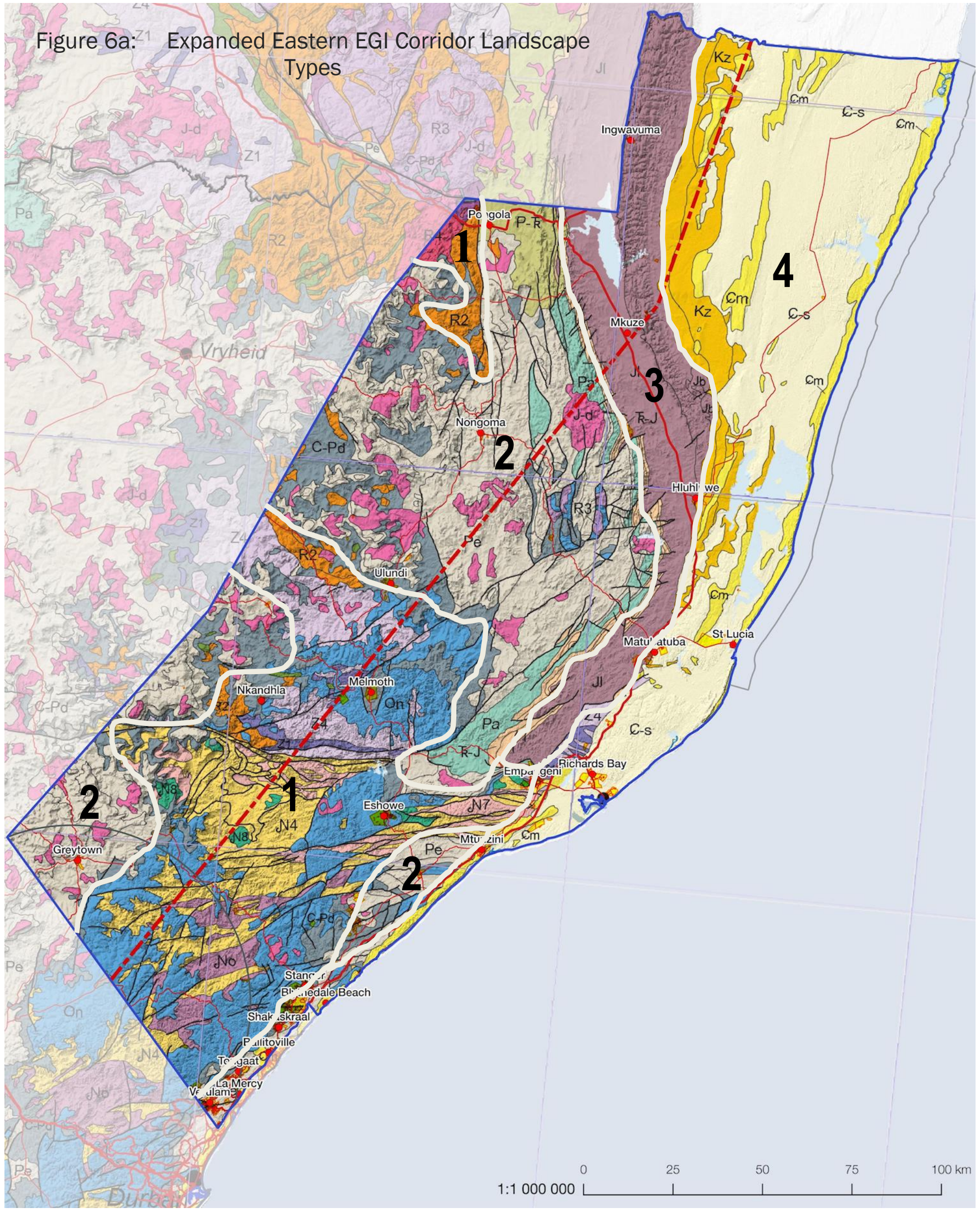
Geomorphology:
Within the three generalised landscape types shown in Figure 5a, the largest is the Namaqua metamorphic landscape, including gneiss, schist and quartzite. Gneiss and granite domes and outcrops are a feature of the area, particularly the weathered 'stacks' seen in the southern portion. Besides the general gneissic topography of the area, there are also arenites, a type of sandstone, of the Nama and Gariep Groups, to the north. The whole region has been faulted and incised by rivers, resulting in the rugged topography. The second landscape type is the coastal peneplain, consisting of sand, gravel, alluvium and calcrete, along with abandoned diamond diggings. To the east, a small section of the plateau is included in the Corridor, being about 1000m above sea level and consisting of similar sand and calcrete deposits as the coastal plain.

Landscape features:
In the south of the corridor, the Kamiesberg Mountains are particularly scenic, although much of the escarpment between the coastal plain and the inland plateau has scenic value, e.g. when viewed from the Spektakel Pass between Springbok and the coast. The Namaqua National Park, west of Kamieskroon, and the Goegap Nature Reserve near Springbok are known for their spring flowers. In the far north of the Corridor, the Richtersveld Transfrontier Park, part of which is a World Heritage Site (listed as the Richtersveld Cultural and Botanical Landscape). The Corridor is bounded in the north by the Orange River (Gariep R.), itself a major scenic and recreational attraction - a green corridor in a desert landscape.

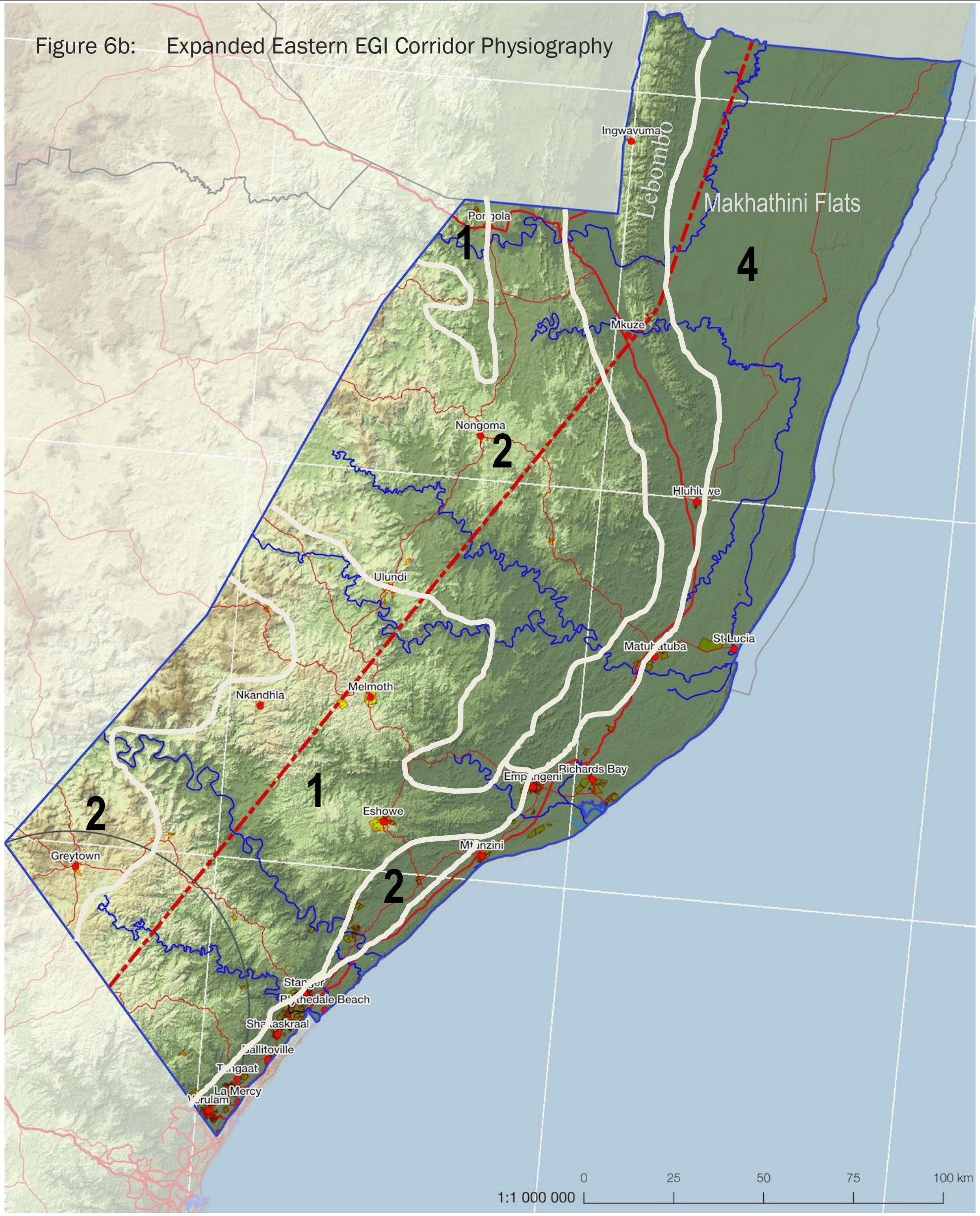
Landscape Type 1: Namaqua metamorphic landscape with typical gneiss rocky domes, such as those near Kamieskroon.

Landscape Type 2: Featureless coastal peneplain of sand, gravel and calcrete, with abandoned diamond diggings in places.

Landscape Type 3: Inland plateau landscape of flat sandy plains with granitic gneiss rock features

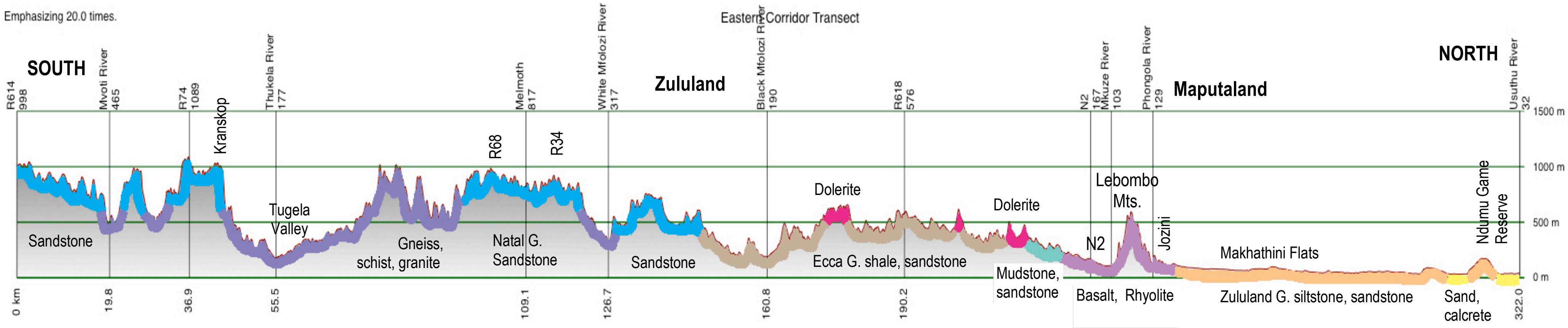


Geology of the Eastern Corridor indicating the main landscape types: 1. The Natal Metamorphic rocks overlaid by the Natal Sandstones (in blue); 2. The Karoo Ecca Group shales and sandstones intruded by dolerite (in pink); 3. The basalt band and rhyolite of the Lebombo Mountains; and 4. The wide coastal plain of sand, calcrete and limestone, becoming narrower to the south.



Physiography of the Eastern Corridor indicating the highly dissected landscape, where rivers and their tributaries have cut down to form steep sided valleys and remnant ridges in the interior. The low-lying coastal plain forms the broad Makhathini Flats in the north, becoming a narrower coastal belt in the south. The four main landscape types are indicated.

Figure 6c: Transect through Eastern Corridor



Regional context:

The expanded Eastern EGI Corridor stretches from north of Durban to the Mozambican border, and from the coastal belt to about 100km inland. The corridor is a geologically and topographically complex landscape. Interestingly, although the Eastern EGI corridor consists partly of rocks similar to those of the Namaqua Metamorphic Province in the Western EGI Corridor, the landscape is completely different owing to the humid, wet climate of Zululand. Here, instead of desert, the landscape is covered with grassy hills and densely forested valleys. Numerous rural settlements straddle the hillsides. The southern portion of the corridor is characterised by cattle farming, sugar cane, timber and wattle plantations. Further north is prime bird and wildlife country, with a large concentration of game reserves.

Geomorphology:

Within the four landscape types shown in the transect above, the southern section of the corridor consists mainly of Natal Group sandstones, underlain by metamorphic gneiss and schist, as well as granites. It is a deeply dissected landscape, where the rivers have cut down to the gneiss and granite basement rocks, combined with considerable faulting, resulting in numerous ridges and valleys, sometimes with steep cliffs. The meandering Thukela River (Tugela R.), one of the biggest in the area, has cut a deep and wide valley.

The central portion of the corridor consists of Ecca Group shales and sandstones, the softer rocks resulting in a more subdued topography. These are intruded in places by Karoo dolerites, (in pink on the transect above), which tend to form the peaks. Just north and east of this is a broad, flattish band of basalt, along which the N2 National Road has been located, avoiding the generally rugged landscape of the adjacent area. Alongside the band of basalt, the Lebombo Mountains, consisting of more durable rhyolite, ranges all the way to the Mozambique border and beyond.

Finally the eastern and northern parts of the corridor forms a flat coastal plain, more than 50km wide in the north. The plain consists mainly of sand, calcrete and limestone, with siltstone and sandstone further inland. The transect above illustrates how the various rock types dictate the topography and the character of the landscape. A good explanation of the geology, and its highlights, are given in Norman and Whitfield's book 'Geological Journeys' (2006).

Landscape features:

The area owes its scenery mainly to the sandstone table-lands and doleritic landforms. Scenically prominent features of the corridor include the mountainous terrain around Greytown, Kranskop and Nkandla, the deep, steep-sided river gorges, the high dunes with coastal forest, and the famous St Lucia wetlands, which have been declared a World Heritage Site. To the north, scenic features include the Lebombo Mountains, Pongolopoort Dam (Lake Jozini), Lake Sibaya, and Kosi Lake.

Landscape Type 1: Natal metamorphic landscape of gneiss, schist and granite, similar to the Namaqua metamorphic region, but with a humid climate.

Landscape Type 2: Ecca Group shales and sandstones, intruded in places by dolerite, and incised by rivers, such as the Mfolozi

Landscape Type 3: A basalt region viewed from the N2 National Road, with the Lebombo Range of rhyolite in the background.

Landscape Type 4: The flat, sandy coastal plain, with lakes, wetlands and coastal forest, such as that at St. Lucia.

6 FEATURE SENSITIVITY MAPPING

6.1 Feature sensitivity criteria

Criteria normally used for determining visual sensitivity, along with the reasoning for these, are listed in Table 5 below. The criteria are divided into inherent scenic resources of the expanded corridors, along with potential sensitive receptors.

Table 5: Criteria for Determining Visual Sensitivity

Scenic Resource	Contributing Factors
Topographic features	Landscape features in the area contribute to scenic and natural heritage value. These include features that provide visual interest or contrast in the landscape such as peaks, scarps, ridges, steep slopes and geological features. Intact wilderness or rural landscapes tend to have higher scenic value and therefore increased sensitivity.
Water Features	Water bodies, such as rivers, estuaries, large dams and wetlands, generally have aesthetic, scenic, recreational and amenity value. Coastal shorelines, particularly promontories, tend to be visually sensitive. Sensitivity generally relates to their national, regional or local significance.
Cultural landscapes	Cultural landscapes, often along fertile river valleys, tend to have rural scenic value and historical or cultural significance. These need to be correlated with heritage data.
Sensitive Receptors	**(includes residents, commuters, visitors and tourists)**
Protected Areas	These include national parks and nature reserves, which have wilderness and scenic attributes in addition to their biological conservation role, serving as important visitor / tourist destinations. Visual significance is increased by their protection status.
Game reserves / resorts	Private nature reserves, game farms, recreation resorts and tourist accommodation are important for the local economy, and tend to be sensitive to loss or degradation of scenic quality.
Human settlements	Towns, villages and farmsteads, particularly historical settlements, residential and resort areas, tend to be sensitive to visual intrusions, including an effect on property values and tourism.
Scenic routes and arterial roads	Scenic and arterial routes, such as national roads, mountain passes and *poorts*, tend to have historical, recreational and tourism importance, and are therefore visually sensitive.
Heritage sites	These form part of the heritage study, but could have visual implications.

A list of the key visual / scenic features considered during the visual assessment of the EGI corridors is given in Table 6 below. At the project scale, the viewshed, as well as viewing distances and visual absorption capacity of the landscape, would be additional criteria that are used to quantify potential visual impacts.

Table 6: Information sources for sensitive features and receptors in both corridors

Sensitivity Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
Topographic features	1: 500 000 topographic map series; Google Maps with terrain (2018); and steep slopes data.	Topographic maps for prominent elevations, ridgelines, scarps, ravines and geological features, particularly where these occur in combination with steep slopes to create complex landscapes.
Steep slopes	SRTM DEM v4.1, 2014.	Two categories of slopes used: steeper than 1:5 and 1:5 - 1:10. Areas with a high geographic density of steep slopes. Steep slopes have been combined with topographic features for mapping purposes.
Major rivers and water bodies	1: 500 000 topographic map series, and National Freshwater Ecosystem Priority Areas (NFEPA)	Mainly perennial rivers are included, except where a seasonal river is a major feature. Water bodies include lagoons, lakes, wetlands, pans and dams where these constitute a potential scenic resource.
Ramsar sites	DEA SAPAD Q4 2017.	Mapped as indicated in the database.
Coastal zone	1: 500 000 topographic map series, and NGI shapefiles.	A 1km strip of coastline is mapped.
National Parks	DEA SAPAD Q4 2017.	Mapped according to current boundaries, plus buffers as indicated.
Protected Areas	DEA SAPAD Q4 2017.	Includes proclaimed / protected nature reserves, game reserves and wilderness areas, plus buffers as indicated.
Private reserves and game farms	DEA SAPAD Q4 2017. Google Maps / Earth 2018.	Where known these include guest farms, resorts and tourism destinations.
Cultural landscapes	Google Earth 2018.	Includes historically or socially important agricultural areas.
Heritage sites	SAHRA heritage sites of SA, 2017.	Includes archaeological sites, battle sites, cemeteries, etc. where these have heritage significance.
Historical towns and villages	AfriGIS Towns, 2017 On Route in South Africa 3rd Edition, Sunbird Publishers	Lists of towns and villages for each corridor. General information and dates for listed towns and villages, (where available).
National Roads	National Geospatial Information (NGI) and Open Street Maps (OSM).	As marked on maps, plus buffers as indicated.
Provincial Roads	NGI and OSM	Includes main arterial routes. As marked on maps, plus buffers as indicated.
Scenic routes	1: 500 000 topographic map series; Google Maps with terrain (2018).	Includes mountain passes and poorts, and coastal routes with intact landscapes.
Passenger rail lines	NGI and OSM	Actively used passenger rail lines (Historic abandoned rail line in the case of the Expanded Western Corridor).
Airfields	Civil Aviation Authority (CAA) Google Earth 2018	CAA website. Relates to aircraft safety.

The criteria listed above are spatialised by means of buffers, based on the scale of the EGI development, as well as the relative sensitivity of the feature or receptor, (very high, high, moderate or low sensitivity) as indicated in Table 7 below and the sensitivity mapping in Section 7. The recommended buffers are consistent with those used in the Phase 1 EGI SEA (2016). The buffers could vary at the project scale depending on viewshed mapping and site conditions. The actual footprint and height of the proposed electrical facilities needs to be taken into account.

Table 7: Nominal buffer distances between EGI development and sensitive features / receptors for regional mapping purposes

Feature Type	Very high Sensitivity	High Sensitivity	Moderate Sensitivity	Low Sensitivity
Topographic features including steep slopes	250 m	500 m	1 km	-
Major rivers	500 m	1 km	2 km	-
Water bodies, dams, wetlands, pans	500 m	1 km	2 km	-
Ramsar Sites	1 km	2 km	3 km	-
Coastal zone	1 km	2 km	3 km	-
National Parks, World Heritage Sites	2 km	3 km *	4 km *	-
Protected Areas - Nature Reserves	1 km	2 km *	4 km *	-
Private reserves and game farms	n/a	1 km *	2 km *	-
Cultural landscapes	250 m	500 m *	1 km *	-
Heritage sites	250 m	500 m *	1 km *	-
Towns / villages / settlements	500 m	1 km	2 km	-
National roads	500 m	1 km *	2 km *	-
Provincial routes	250 m	500 m *	1 km *	-
Scenic routes	1 km	2 km *	3 km *	-
Passenger rail lines	250 m	500 m *	1 km *	-
Airfields	3 km	-	8 km	-

Note 1: * Viewsheds to be taken into account at the project scale. Buffers could be reduced if proposed transmission infrastructure is outside the viewshed or in a view shadow.

Note 2: Buffers are based on a 400kV transmission line 30 to 60m high, and substations of about 1 ha or more. Buffers could be reduced where towers are less than 20m high, or where substations are less than 1 000m^2.

Note 3: Buffers are in response to potential visibility of the proposed transmission infrastructure as indicated below based on field observations. Visibility would be increased by development on ridges or skylines:

High visibility:	Clearly noticeable within the observer's viewframe 0 to 0.5 km.
Moderate visibility:	Noticeable feature within observer's viewframe 0.5 to 1 km.
Marginal visibility:	Partially noticeable within observer's viewframe 1 to 2 km.
Low visibility:	Hardly visible unless pointed out to observer 2 to 4 km+.

Where sensitivities overlap no cumulative sensitivity has been allocated, the highest sensitivity value being the prevailing one. Visual sensitivity maps for each of the corridors are given in Section 7, and in Figures 9 and 10.

6.2 Feature Maps

6.2.1 Expanded Western EGI Corridor

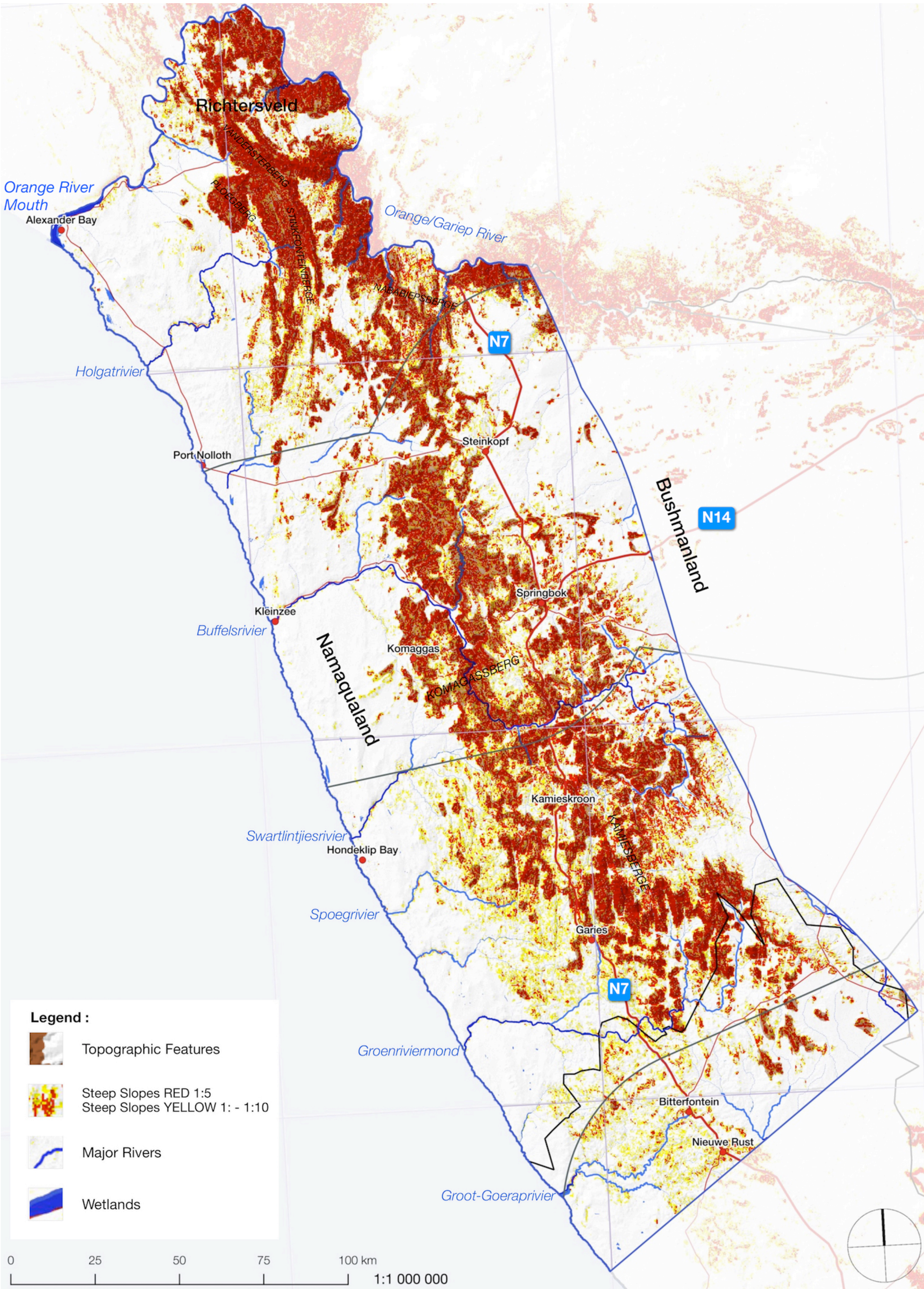


Figure 7a: Expanded Western Corridor: topographic and natural landscape features

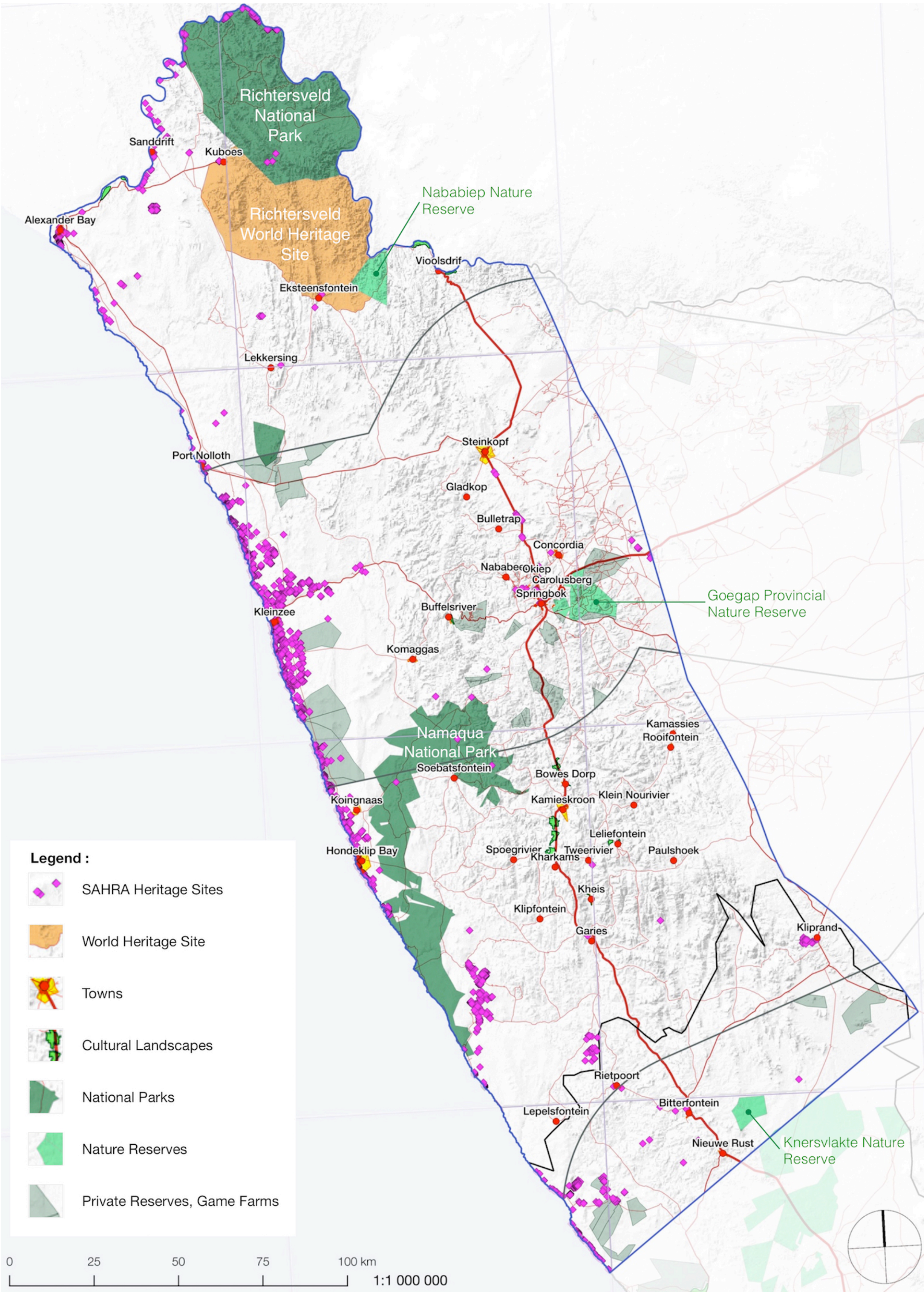


Figure 7b: Expanded Western Corridor: protected areas and heritage features

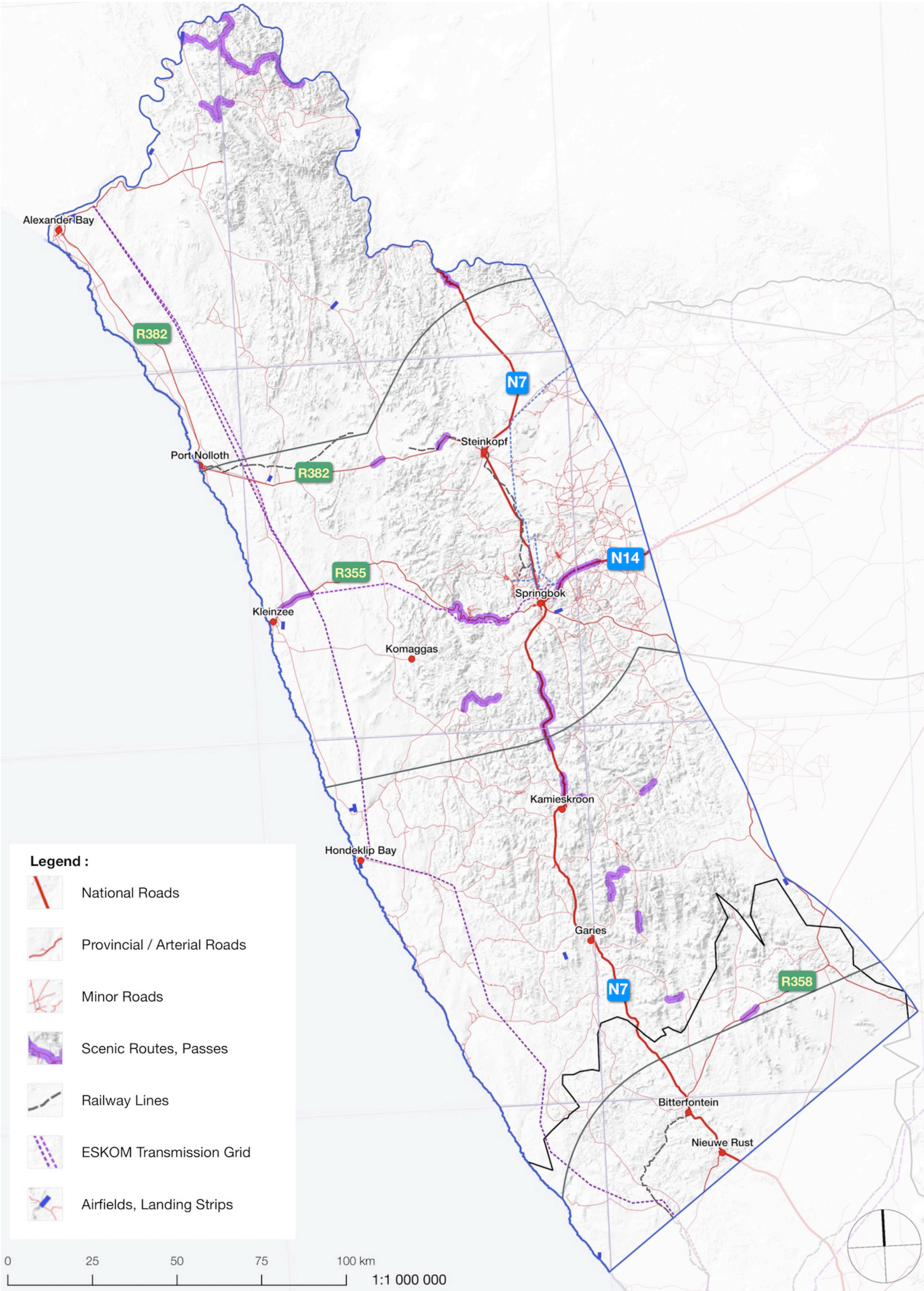


Figure 7c: Expanded Western Corridor: routes and transmission lines

6.2.2 Expanded Eastern Corridor

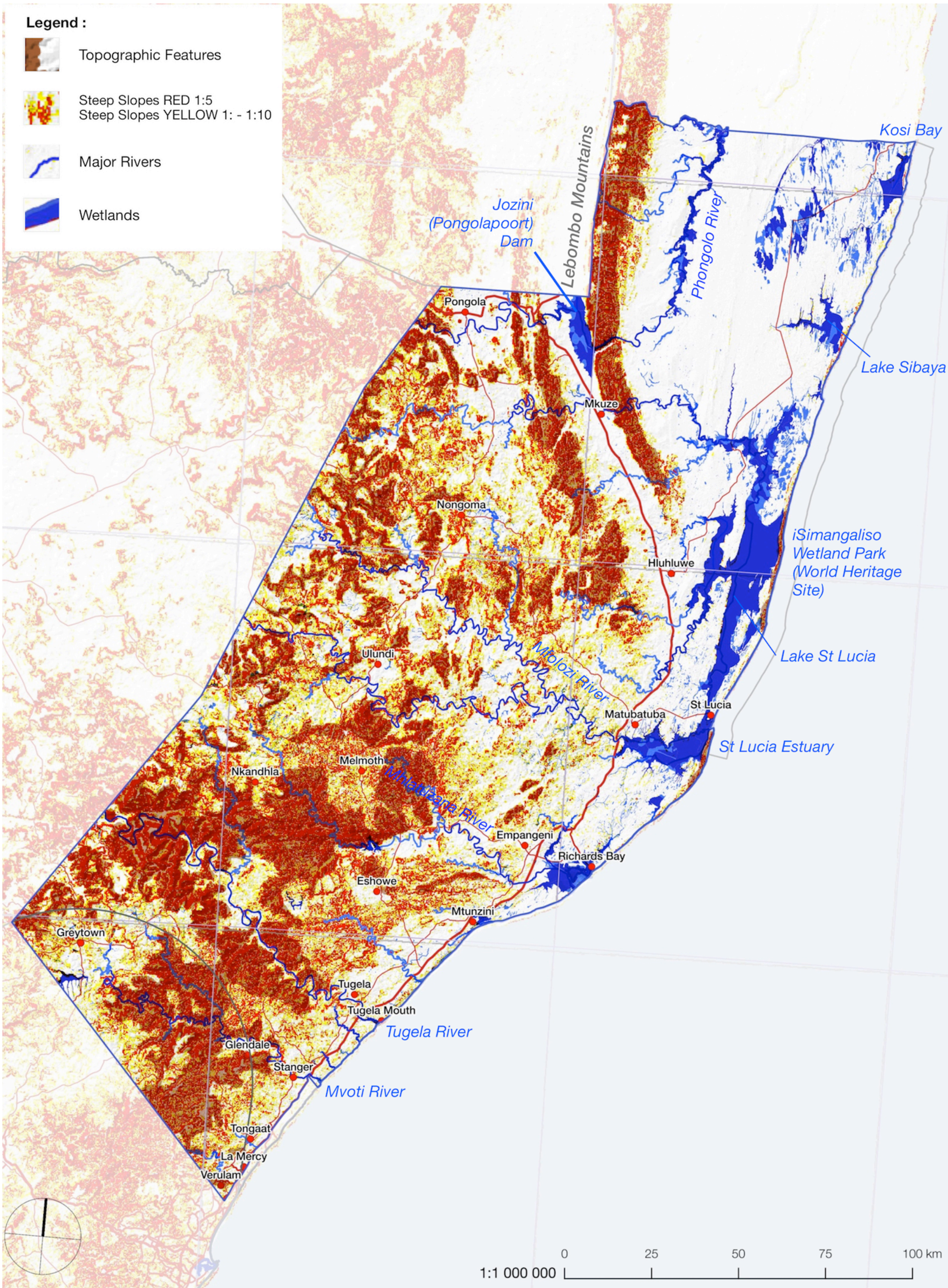


Figure 8a: Expanded Eastern Corridor: topographic and natural landscape features

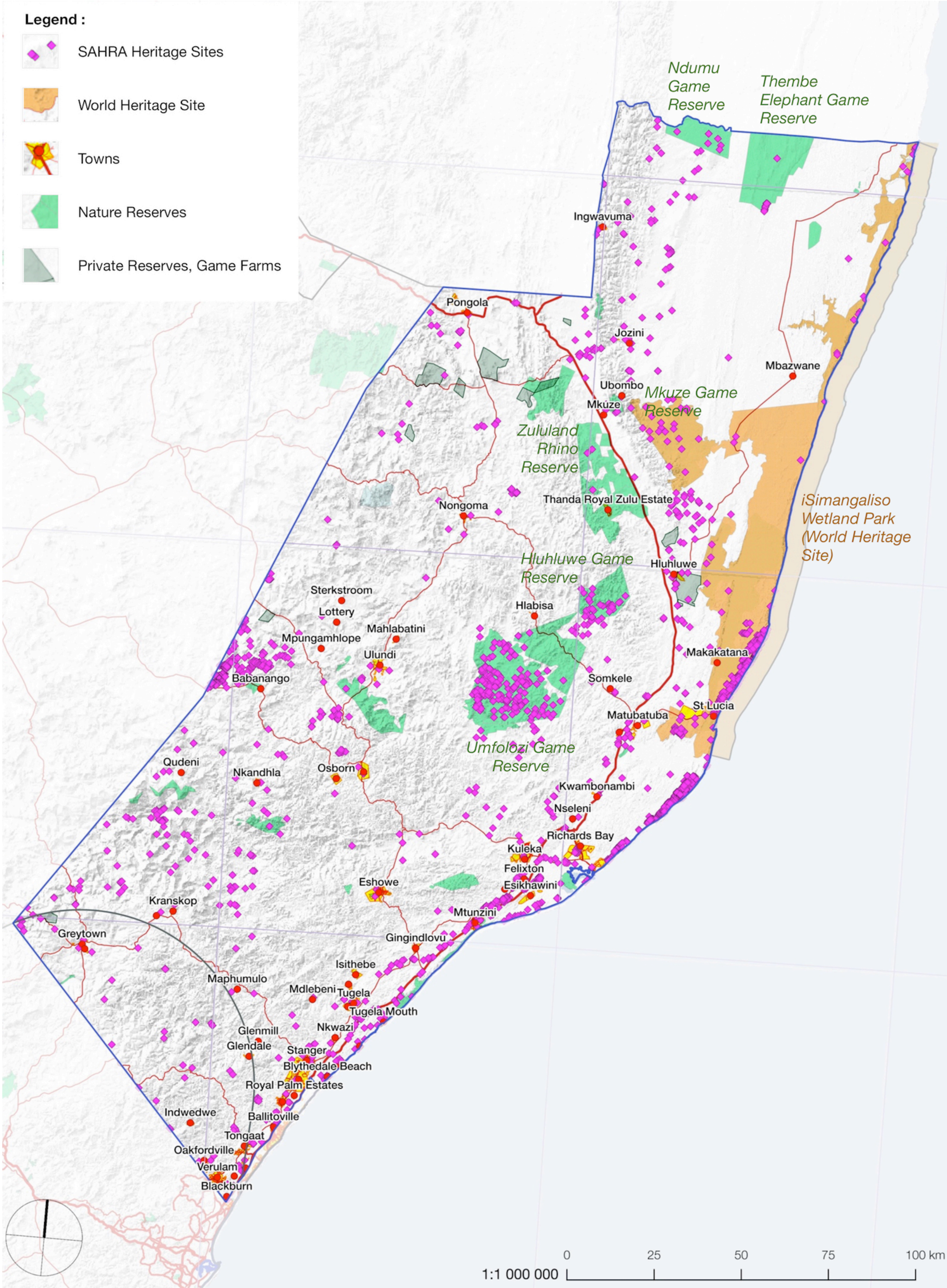


Figure 8b: Expanded Eastern Corridor: protected areas and heritage features

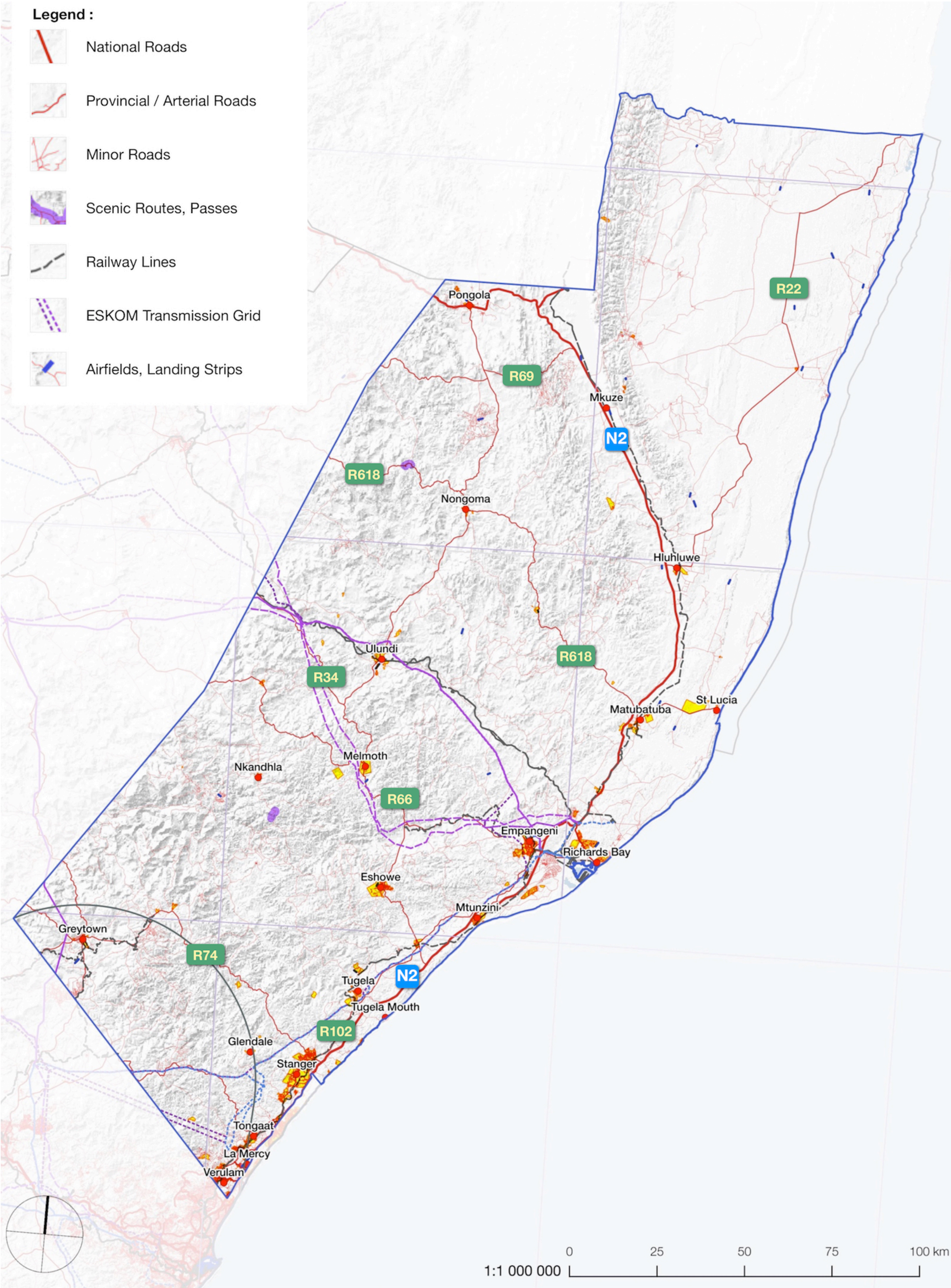


Figure 8c: Expanded Eastern Corridor: routes and transmission lines

7 FOUR- TIER SENSITIVITY MAPPING

7.1 Four Tier Sensitivity Maps

7.1.1 Expanded Western EGI Corridor

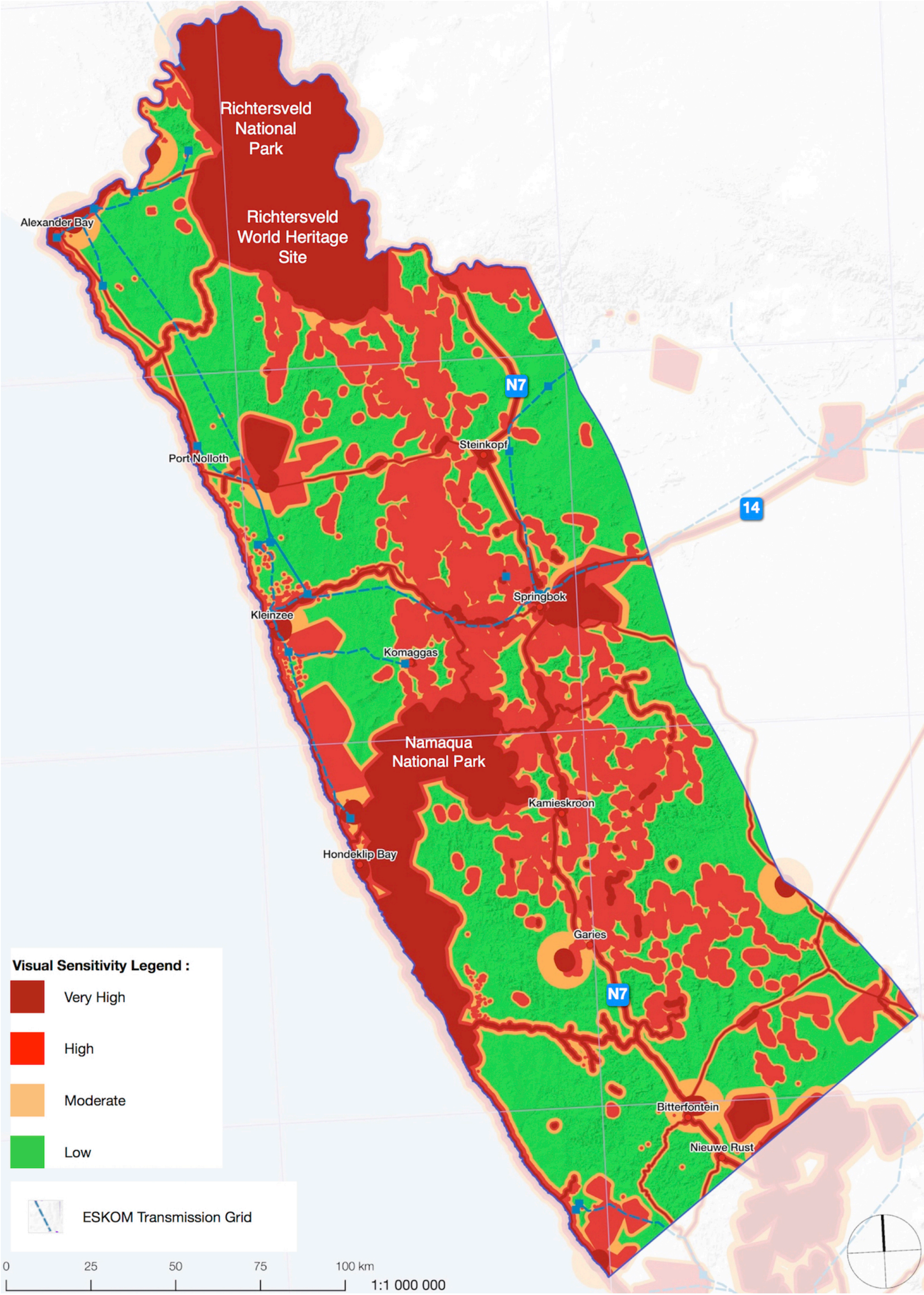


Figure 9: Expanded Western Corridor: visual sensitivity

7.1.2 Expanded Eastern EGI Corridor

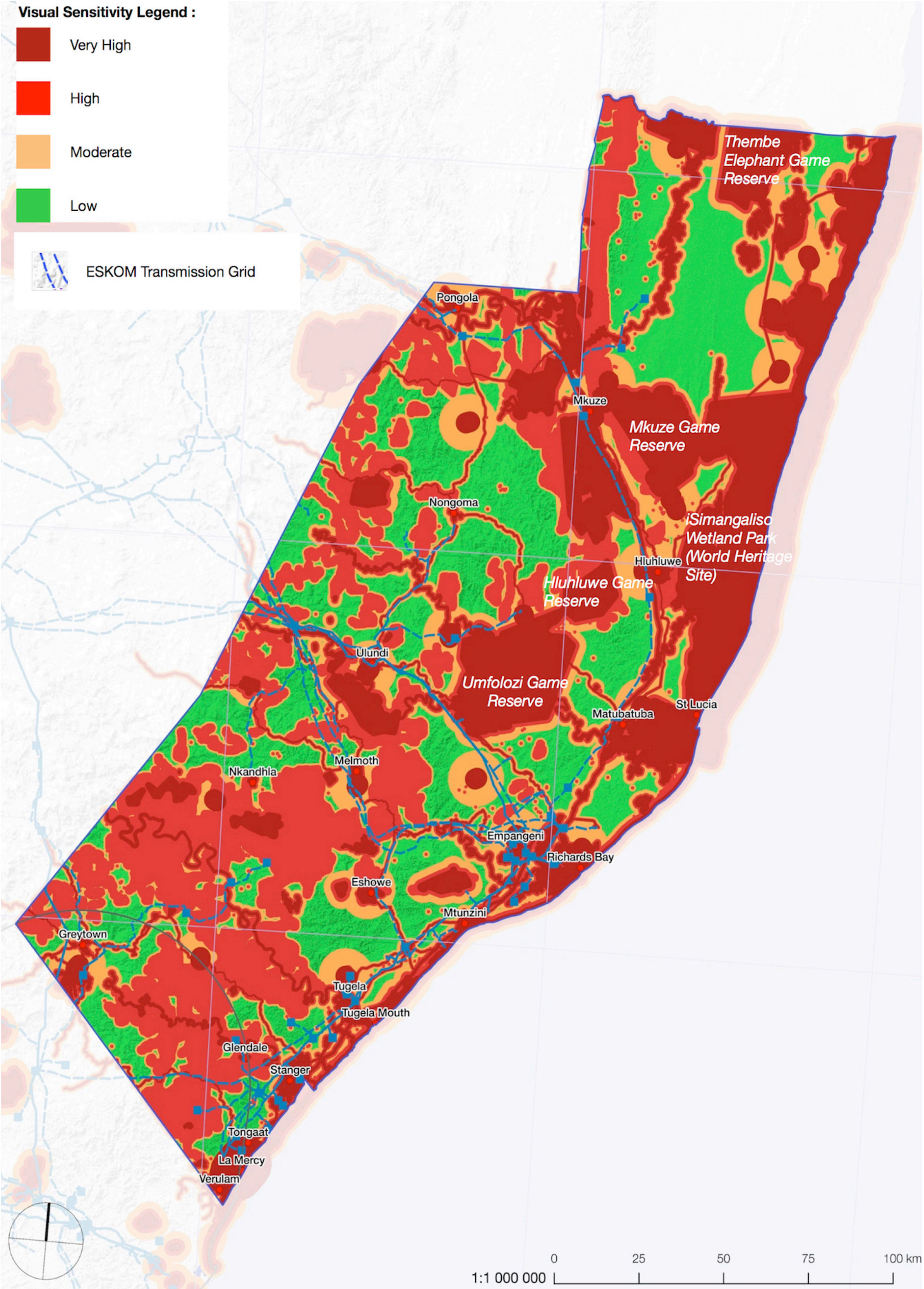


Figure 10: Expanded Eastern Corridor: visual sensitivity

8 KEY POTENTIAL VISUAL IMPACTS AND MANAGEMENT ACTIONS

The tables below for the Expanded Western and Eastern EGI Corridors provide avoidance mitigation measures to identify ideal routing of transmission lines at the regional corridor scale. Where avoidance is not feasible, a range of mitigation measures is given in **Section 9: Best Practice Visual Guidelines** at the local project scale.

Table 8: Key Impacts, Possible Effects and Management Actions for the Expanded Western EGI Corridor

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Management Actions
Expanded Western EGI Corridor	Potential visual intrusion on scenic mountain ranges, escarpment and granite outcrops.	Kamiesberg Mountains in the south, Komaggas Mountains, mountain peaks around Springbok and the rugged Richtersveld mountains.	Loss of mountain wilderness character, recreation amenity and tourism value.	Avoid development on visually sensitive mountain peaks, ridge skylines and steep slopes.
	Potential visual impact on national parks, nature reserves, and their related wilderness experience.	Namaqua National Park and related wild flower reserve, Richtersveld Transfrontier Park and World Heritage Site, Goegap Nature Reserve	Visual effect on conservation areas, pristine landscapes, recreation amenity and tourism economy.	Avoid development within viewshed of protected landscapes. Screen substations from view.
	Potential visual impact on private reserves, game farms and tourism facilities.	Private reserves, game farms and tourism facilities are indicated in the various maps included in Appendix 1.	Visual effect on wilderness / rural character, recreation amenity and tourism economy.	Avoid development where scenic resources or tourism facilities would be compromised.
	Potential visual impact on river corridors, which often form green oases in the arid landscape.	Orange River (Gariep R.), Holgat River, Buffels River, Spoeg River, Bitter River, Groen River.	Visual effect on green valleys which bring visual relief to the arid landscape and provide scenic / recreational amenity.	Although river crossings are inevitable, avoid scenic gorges or ravines.
	Potential visual impact on mission settlements, historical towns and other heritage sites.	Steinkopf, Rietpoort mission settlements, historical mining towns (Nababeep, Okiep, Concordia) and other historical settlements / sites.	Negative visual effect on historical settlements and sites of heritage value and their surrounding context.	Avoid powerlines and substations intruding on historical settlements and sites. Maintain recommended visual buffers.
	Potential visual impact on national / arterial and scenic routes / mountain passes. Also historical rail lines.	N7, particularly between Kamieskroon and Springbok, parts of the N14 east of Springbok, Spektakel Pass west of Springbok, and other smaller routes or passes.	Visual effect on major arterial routes, scenic routes and mountain passes which have scenic and tourism value.	Avoid powerlines crossing or running adjacent to scenic routes / passes. Locate substations away from routes and screen where necessary.

Table 9: Key Impacts, Possible Effects and Management Actions for the Expanded Eastern EGI Corridor

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Management Actions
Expanded Eastern EGI Corridor	Potential visual intrusion on scenic mountain ranges, ridgelines, scarp edges, dolerite koppies and high coastal dunes.	Lebombo and Ubombo Mountains in the north. Mountainous areas around Greytown, Nkandla and Ulundi. High dunes along the coast.	Visual intrusion on mountain scenery, loss of wilderness experience, recreation amenity and tourism value.	Avoid development on visually sensitive mountain ridge skylines, scarp edges, dolerite koppies, dunes and steep slopes.
	Potential visual impact on game reserves, nature reserves, wilderness areas and tourism facilities, including their wilderness experience.	Ndumi Game Reserve, Tembe Elephant Reserve and Mkuze Game Reserve in the north. Hluhluwe/ Umfolozi Game Reserves further south. St Lucia Game Reserve and World heritage Site at the coast.	Visual effect on conservation areas, pristine wilderness landscapes, recreation amenity and tourism economy.	Avoid development within viewshed of protected landscapes. Screen substations from view.
	Potential visual impact on river valleys, gorges, ravines, waterfalls, estuaries and wetlands.	Primarily the St Lucia wetland system. Lake Sibayi and Kosi Lake to the north. The large Jozini Dam (Pongolopoort Dam). The Tugela River Valley and tributaries.	Visual effect on the rural and scenic value of river valleys and ravines, and on recreation amenity and tourism economy.	Although river crossings are inevitable, avoid scenic ravines and estuaries.
	Potential visual impact on historic towns and settlements, and heritage sites including battle sites and gravesites.	Numerous traditional settlements. Towns, villages and heritage sites are indicated in the various maps included in Appendix 1.	Visual effect on historical towns and heritage sites, and their surrounding context.	Avoid powerlines intruding on historic settlements and battle sites. Maintain recommended visual buffers.
	Potential visual impact on national, arterial and scenic routes, and passenger rail lines.	The N2, particularly along the coast and across estuaries. The Pongola *poort* to Jozini. Numerous scenic routes and passes in rural areas.	Visual effect on scenic routes and passes, on their heritage value and tourism economy.	Avoid powerlines crossing or running adjacent to scenic routes / passes. Locate substations away from routes and screen where necessary.

8.1 Project Level Assessments

During the project specific stage, potential visual impacts are expected to be defined as follows:

Very high potential visual impact:
- Significant visual effect on wilderness / rural quality or scenic resources;
- Fundamental change in visual character of the area;
- Creates a major precedent for development in the area.

High potential visual impact:
- Intrusion on intact landscape or scenic resources;
- Noticeable change in visual character of the area;
- Creates a new precedent for development in the area.

Moderate potential visual impact:
- Some effect on intact landscape or scenic resources;
- Some change in visual character of the area;
- Adds to development in the area.

Minimal potential visual impact:
- Low level of intrusion on landscapes or scenic resources;
- Limited change in visual character of the area;
- Similar in nature or compatible with existing development.

The Guideline *for Involving Visual and Aesthetic Specialists in Environmental Impact Assessment Processes*. CSIR Report No. ENV-S-C 2005 053, (Oberholzer, B. 2005) indicates that Powerlines would fall under Type A assessments, being large in area extent and involving natural or rural landscapes. A visual specialist would preferably have qualifications in landscape architecture or environmental planning, or alternatively, recognised expertise and experience in the field of visual assessments.

As the SEA is concerned more with identifying suitable corridors at the regional scale, it is important that a basic visual assessment is carried out at the project stage, accompanied by more detailed mapping.

9 BEST PRACTICE VISUAL GUIDELINES AND MONITORING REQUIREMENTS

The visual effect of transmission lines, in particular the pylons, are difficult to screen or mitigate visually because of their construction and size, as well as the long distances of powerline routes. Numerous transmission lines, in parallel, potentially add to the cumulative visual impact, which together with substations, could result in an industrial landscape. A number of best-practice measures are indicated below.

9.1 Planning Phase

- At the macro scale transmission lines should be aligned with the grain, or flow, of the landscape, following longitudinal valleys rather than cutting across crests, ridges and scarps.
- In agricultural landscapes transmission lines should adhere to the rectilinear pattern of fields by following fence lines and hedgerows rather than awkwardly cutting across field patterns.
- Transmission lines should where possible be located in industrial or mining areas, where these occur, in preference to residential, recreation or resort areas.
- Transmission lines should be located in existing disturbed or degraded areas, as far as possible, in preference to pristine landscapes.
- Transmission lines could share corridors with other compatible linear routes or utilities, reducing the amount of servitudes required, and reducing the number of new corridors that fragment the landscape.

- Similarly, new transmission lines should be located near existing powerline corridors, except where the existing ones are in sensitive areas, or where the cumulative visual impact would be too high.
- Transmission lines should be located against a background of either topography or vegetation, such as treebelts, as much as possible. The objective is to avoid seeing powerlines in silhouette against the skyline if possible.
- The use of taller pylons at greater distances could help to reduce visual clutter in the landscape, but would depend on local context, as smaller pylons may need to be used where these are in close proximity to sensitive viewers.
- Where appropriate, direct connection of users to self generating energy sources could help to eliminate the need for transmission lines in certain instances.
- Substations should ideally be located in unobtrusive low-lying positions, rather than on hill crests, preferably away from roads and settlements. Where this is not possible, they must be screened by means of earth berms and/or tree planting.

9.2 Construction Phase

- In new development areas, consideration could be given to burying transmission lines underground, for example in tandem with new road construction. (Underground cables are usually only considered in urban areas and over short distances, where visual impacts would be significant).
- Strategically placed foreground planting can be used to screen views from sensitive viewpoints or receptors.
- Careful consideration should be given to the selection of pylon design, such as use of the more modern mono-pole and T-pylon, as used in Europe, which create less visual ‘clutter’ than lattice type towers.
- The use of different pylon types should be avoided, where possible, particularly where these are in visual proximity to each other.
- Buildings that form part of substations should be in keeping with their local context, and should be in sympathy with the regional or vernacular architecture.
- Maintenance roads required for transmission lines and substations should use existing access roads or farm roads as far as possible.
- Access roads should be sympathetically aligned with the grain of the topography and layout of agricultural fields. Roads should be diagonally aligned up slopes to minimise cut and fill.
- Areas disturbed by construction should be revegetated to match the surrounding flora or agricultural crops.
- Lighting related to substations should be fixed to walls or buildings and fitted with reflectors to avoid light spillage. Low-level bulkhead or bollard type lighting is preferred. High mast lighting should be avoided.
- Signage, if essential, should be discrete and confined to entrance gates. No corporate or advertising signage should be permitted.

9.3 Operations Phase

There are no special visual management actions that are applicable during the operational phase once the transmission infrastructure has been installed, except for the standard maintenance of revegetation work as part of an Environmental Management Programme (EMPr).

9.4 Rehabilitation and Post-closure

- All above-ground structures should be removed, safely disposed of or possibly recycled for use elsewhere.

- The affected area should be regraded to pre-development topographic conditions, unless the area is required for new specific uses.
- Compacted areas, including access or maintenance roads that are no longer required, should be scarified and exposed areas re-vegetated or re-seeded.
- Vegetation used for the restoration should match that of the surrounding veld, unless new uses are planned for the site.
- Re-vegetation should be according to an EMPr provided by a rehabilitation ecologist.

9.5 Monitoring Requirements

- Monitoring of the construction and rehabilitation phases should be carried out by an Environmental Management Team, including an Environmental Control Officer (ECO), who would be responsible for regular reporting during construction and rehabilitation.
- Visual monitoring by the ECO would include photographic records of the pre-construction and post-construction stages.

10 CONCLUSIONS AND FURTHER RECOMMENDATIONS

10.1 Expanded Western EGI Corridor

The visual sensitivity mapping for the Expanded Western Corridor (Figure 9) reveals that essentially two north-south development routes to the Namibian border are possible from a visual perspective.

The first follows the broad coastal plain, where a number of wind energy farms are at the proposal stage. The even topography lends itself to the construction of transmission lines, plus the fact that there are already a number of existing power lines in the area. Furthermore, the arid landscape is sparsely populated, and has been previously disturbed by diamond diggings along the coast. The main pinch-point is at the Namaqua National Park west of Kamieskroon, where the wild flower reserve is of national significance and a major tourist attraction.

The second possible development route is the inland plateau area along the eastern edge of the corridor, which also has relatively even topography and few visual constraints. The main pinch-point is at the Orange River in the north where rugged mountains, and the river itself, are important features of scenic value. In addition, picturesque granite and gneiss koppies, scattered across the plateau, have scenic value and need to be avoided. The arid plateau area, like the coastal plain, is sparsely populated. However, pylons would tend to be visible over long distances in the flat plateau landscape, particularly from the N7 and N14 National Routes.

If transmission lines on the inland plateau are considered, then the Expanded Western EGI Corridor study area may need to be marginally widened towards the east to provide more opportunity for powerline development.

The mountainous escarpment running down the centre of the Expanded Western EGI Corridor and ending in the Richtersveld Park / World Heritage Site, would be unsuitable for transmission line development because of the area's rugged topography and high scenic, botanical and cultural value.

10.2 Expanded Eastern EGI Corridor

The Expanded Eastern EGI Corridor is almost the converse of the Expanded Western EGI Corridor despite having similar metamorphic basement rocks. The difference is the humid, moist subtropical climate of the Eastern Corridor, resulting in a completely different landscape character of green hills, perennial rivers and densely forested ravines, compared to the arid landscape of the Western Corridor.

The visual sensitivity mapping for the Expanded Eastern Corridor (Figure 10) reveals a large number of pinch-points that would need to be negotiated by any proposed Transmission development routes.

The KwaZulu-Natal North Coast has a relatively narrow coastal belt with sensitive estuaries, which besides being densely populated, is a popular recreation and tourism destination. Further north, the coastal plain, with its even topography, widens in Maputaland, while the protected St Lucia wetland system and the large number of game reserves have immense wilderness, conservation and tourism value.

The inland areas of the Eastern Corridor have a complex topography, carved out by the many rivers with their steep-sided ravines, such as those of the Tugela Basin, resulting in visually sensitive landscapes. Added to this is the scatter of numerous rural settlements.

The wooded valleys, along with the Eucalyptus and wattle plantations would help to provide some visual screening for transmission lines, while sugar cane fields are not considered to be particularly visually sensitive.

Importantly, this inland area of Zululand is considered to have major cultural and historical importance, full of battle sites and memorials relating to South Africa's earlier history, and therefore called the 'Land of Rembrance'.

Given the relatively high frequency of visually and culturally sensitive features outlined above, consideration could be given to marginal widening of the Eastern Corridor towards the west, into the Natal coal belt, which is more industrial in character, and therefore less sensitive to the introduction of transmission lines.

10.3 General Conclusion

With regard to the existing corridors, the visual sensitivity mapping revealed that opportunities do exist in both of the expanded corridors for the alignment of transmission lines, although a number of pinch-points need to be negotiated. The recommended best practice visual guidelines could therefore play an important role at these pinch-points at the local project scale.

Existing Eskom transmission lines were not considered in the determination of the visual sensitivity maps, the intention being the identification of inherently suitable corridors for future transmission development, particularly as some of the existing transmission lines occur in sensitive zones. In areas that are not visually sensitive it may well be appropriate to locate future transmission lines in existing powerline corridors.

Given that the visual study has of necessity been carried out at a fairly coarse regional scale, more fine-scale mapping at the local scale, together with fieldwork, would help to identify both smaller scale features, as well as opportunities for powerline alignments, particularly where pinch-points occur.

The varied nature of the landscape in the two expanded EGI corridors, and widespread occurrence of scenic and heritage resources, will require that careful micro-siting of powerlines and substations at the project level will be essential, using the guidelines provided in this chapter.

A general finding of the visual study is that both the Expanded Western and Eastern EGI Corridors may need to be marginally widened in places, into less sensitive areas, to create more opportunities for transmission line routes.

11 REFERENCES

CSIR, 2016. Electricity Grid Infrastructure Strategic Environmental Assessment. Prepared for the Department of Environmental Affairs.

Erasmus, B.P.J. 1995. On Route in South Africa: Explore South Africa Region by Region. Jonathan Ball Publishers. Third Edition 2014, Sunbird Publishers.

Norman, N. and Whitfield, G. 2006. Geological Journeys: A Traveller's Guide to South Africa's Rocks and Landforms. Struik Publishers and De Beers.

Oberholzer, B. 2005. Guideline for involving visual and aesthetic specialists in EIA processes. CSIR Report No. ENV-S-C 2005 053. Provincial Government of the Western Cape, DEADP.

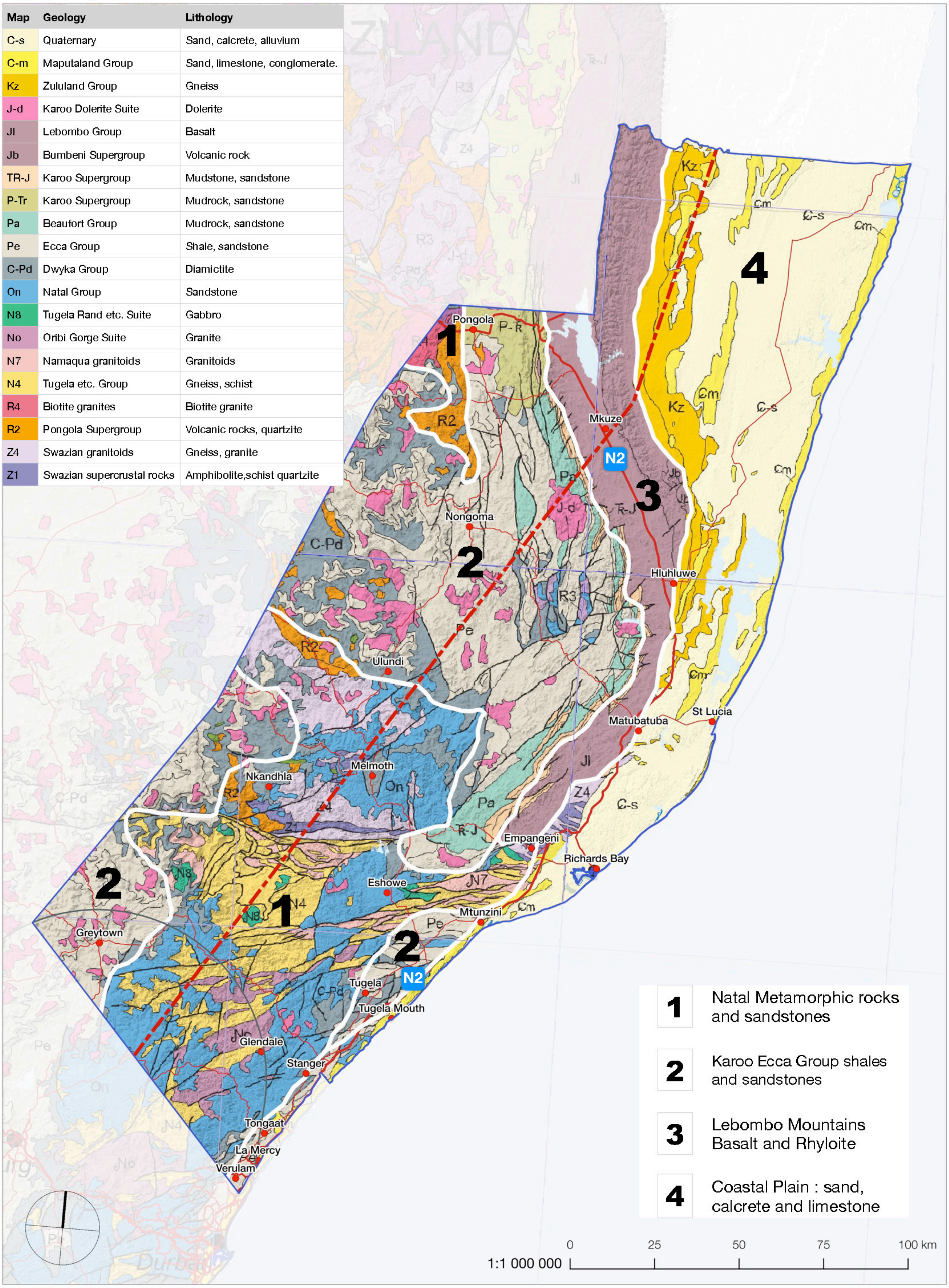
Appendix 1: Feature Maps and Sensitivity Maps

(See A3 folio of maps, and shape files provided under separate cover).

Map E1 :	Expanded Eastern Corridor: Location indicating gazetted EGI corridors
Map E2 :	Expanded Eastern Corridor: Geology
Map E3 :	Expanded Eastern Corridor: Physiography
Map E4 :	Expanded Eastern Corridor: Topographic and Natural Features
Map E5 :	Expanded Eastern Corridor: Heritage and Protected Areas
Map E6 :	Expanded Eastern Corridor: Routes and Transmission Lines
Map E7 :	Expanded Eastern Corridor: Composite Feature Map
Map E8 :	Expanded Eastern Corridor: Visual Sensitivity
Map E9 :	Expanded Eastern Corridor: Visual Sensitivity (with existing Eskom grid)

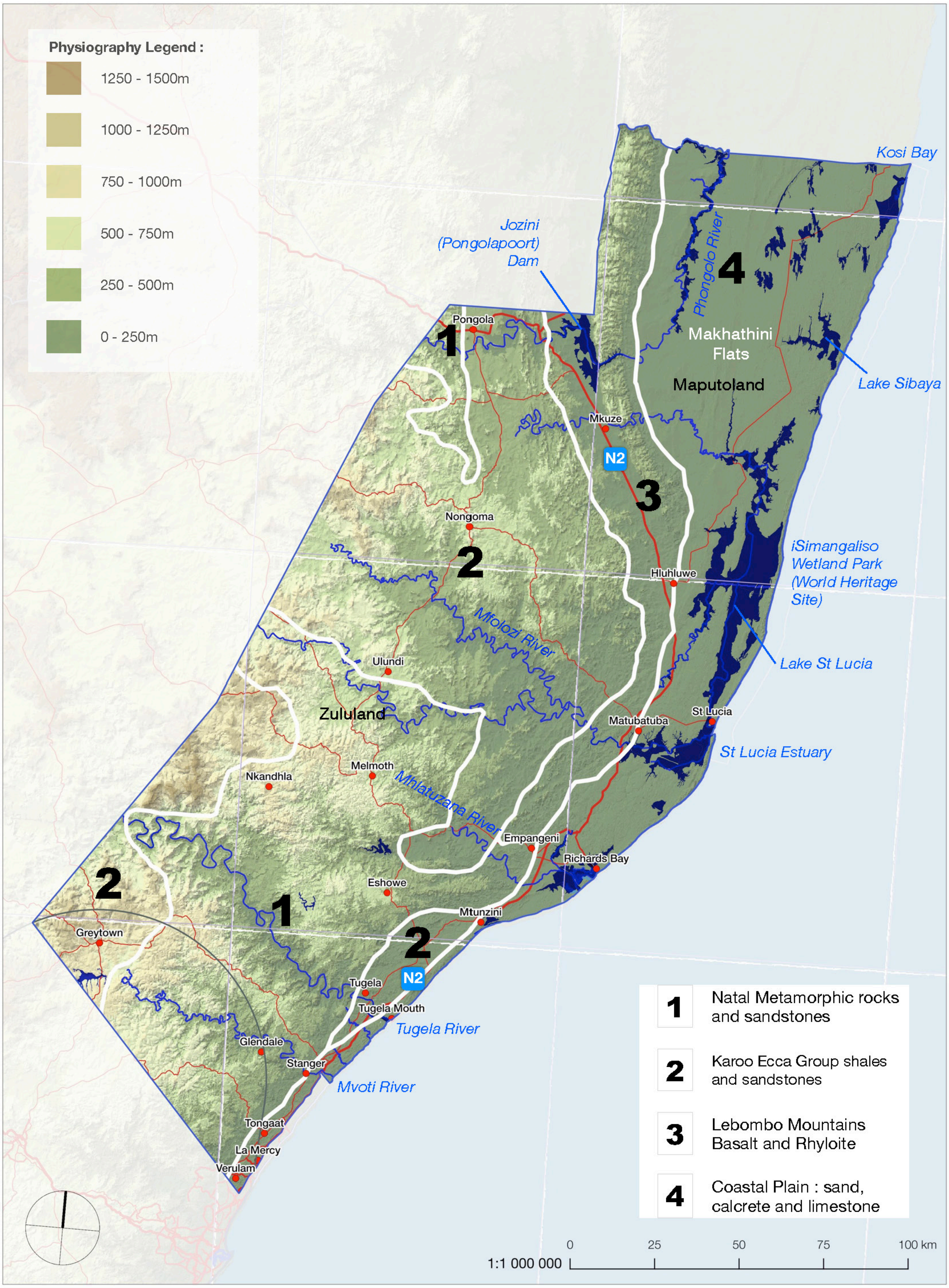
Map W1 :	Expanded Western Corridor: Location indicating gazetted EGI corridors
Map W2 :	Expanded Western Corridor: Geology
Map W3 :	Expanded Western Corridor: Physiography
Map W4 :	Expanded Western Corridor: Topographic and Natural Features
Map W5 :	Expanded Western Corridor: Heritage and Protected Areas
Map W6 :	Expanded Western Corridor: Routes and Transmission Lines
Map W7 :	Expanded Western Corridor: Composite Feature Map
Map W8 :	Expanded Western Corridor: Visual Sensitivity
Map W9 :	Expanded Western Corridor: Visual Sensitivity (with existing Eskom grid)

Map E1 • Expanded Eastern Corridor : **Location** indicating gazetted EGI corridors

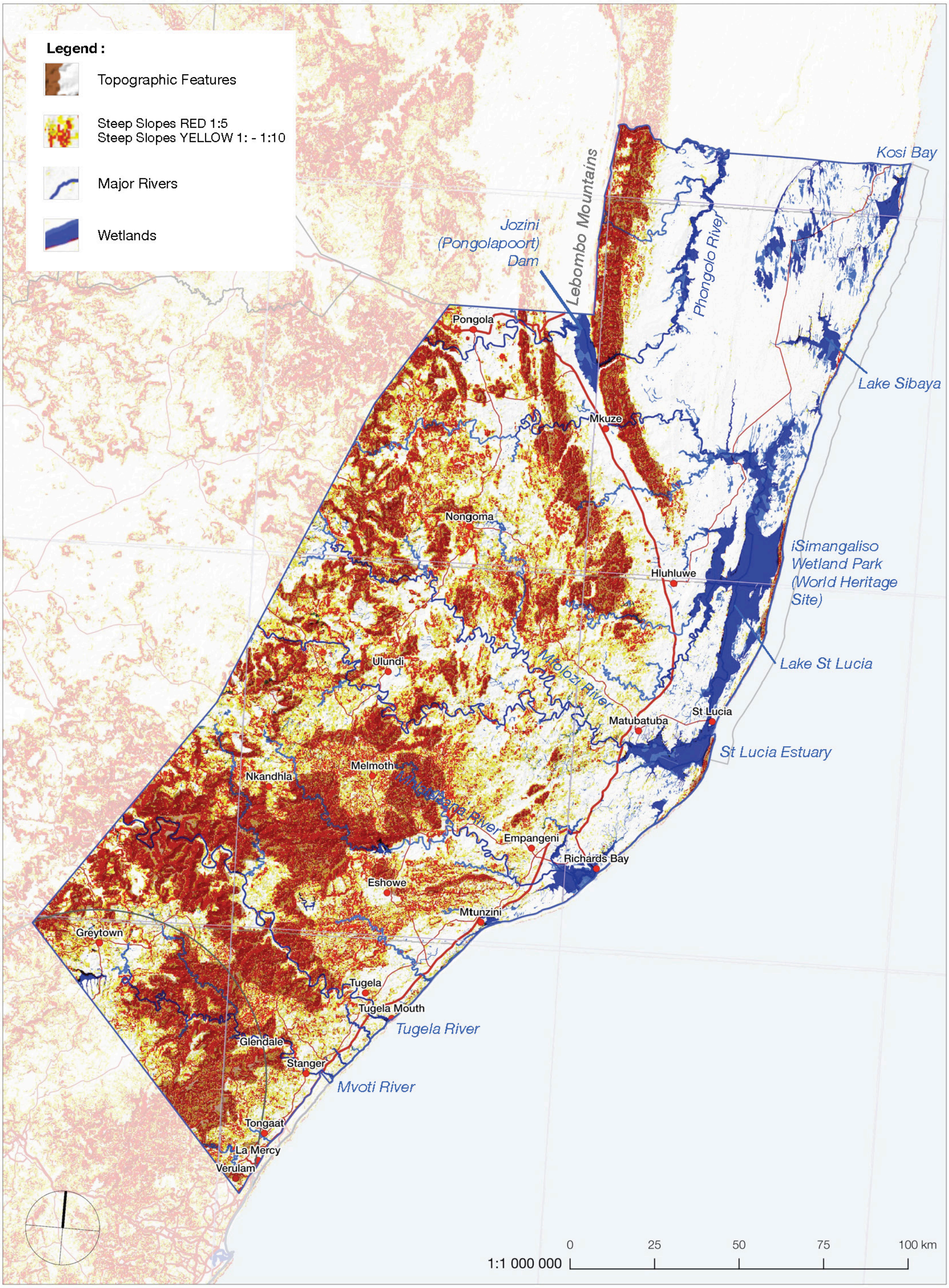


Map	Geology	Lithology
C-s	Quaternary	Sand, calcrete, alluvium
C-m	Maputaland Group	Sand, limestone, conglomerate.
Kz	Zululand Group	Gneiss
J-d	Karoo Dolerite Suite	Dolerite
Jl	Lebombo Group	Basalt
Jb	Bumbeni Supergroup	Volcanic rock
TR-J	Karoo Supergroup	Mudstone, sandstone
P-Tr	Karoo Supergroup	Mudrock, sandstone
Pa	Beaufort Group	Mudrock, sandstone
Pe	Ecca Group	Shale, sandstone
C-Pd	Dwyka Group	Diamictite
On	Natal Group	Sandstone
N8	Tugela Rand etc. Suite	Gabbro
No	Oribi Gorge Suite	Granite
N7	Namaqua granitoids	Granitoids
N4	Tugela etc. Group	Gneiss, schist
R4	Biotite granites	Biotite granite
R2	Pongola Supergroup	Volcanic rocks, quartzite
Z4	Swazian granitoids	Gneiss, granite
Z1	Swazian supercrustal rocks	Amphibolite,schist quartzite

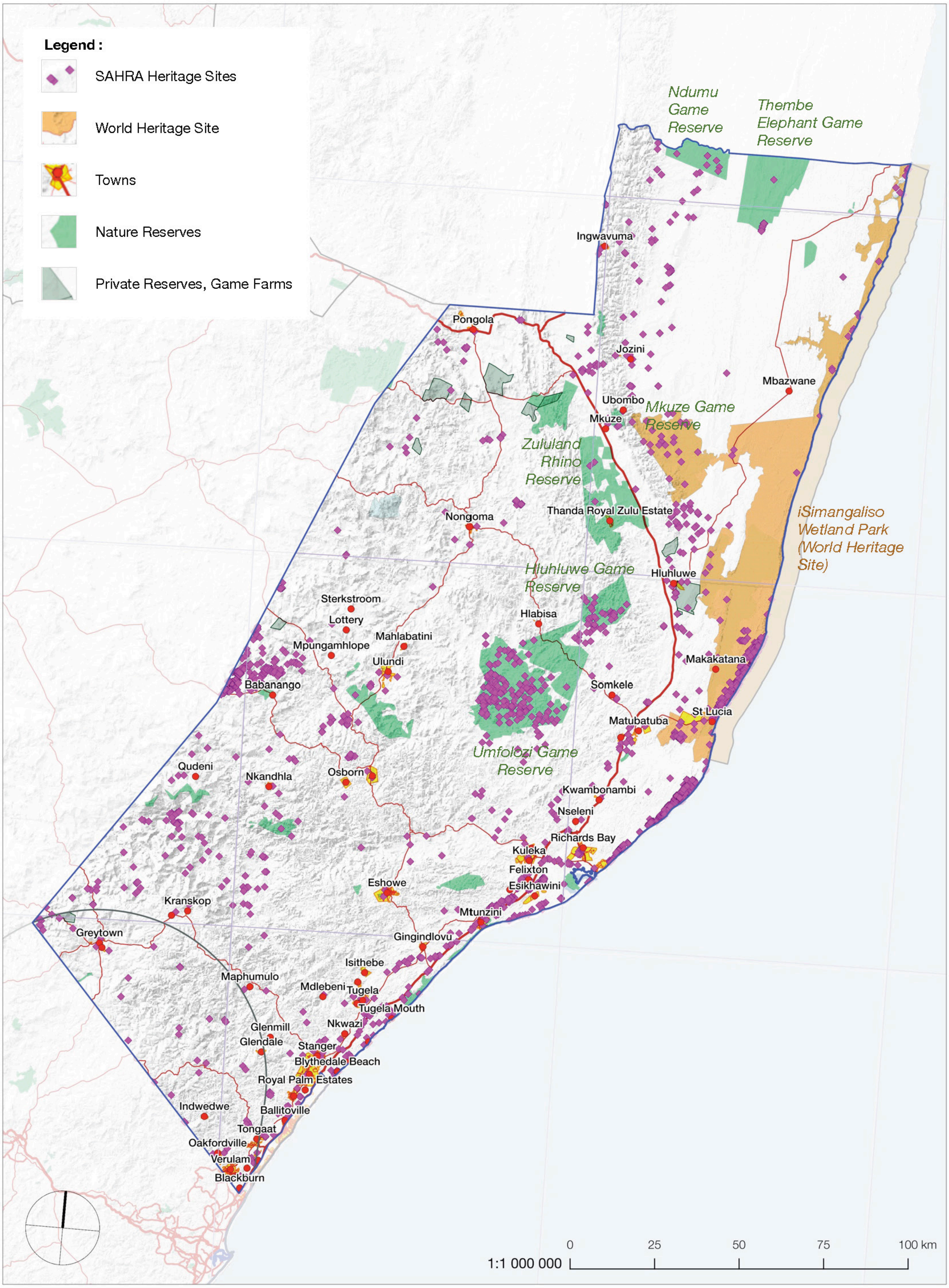
Map E2 • Expanded Eastern Corridor : **Geology and Landscape Types**



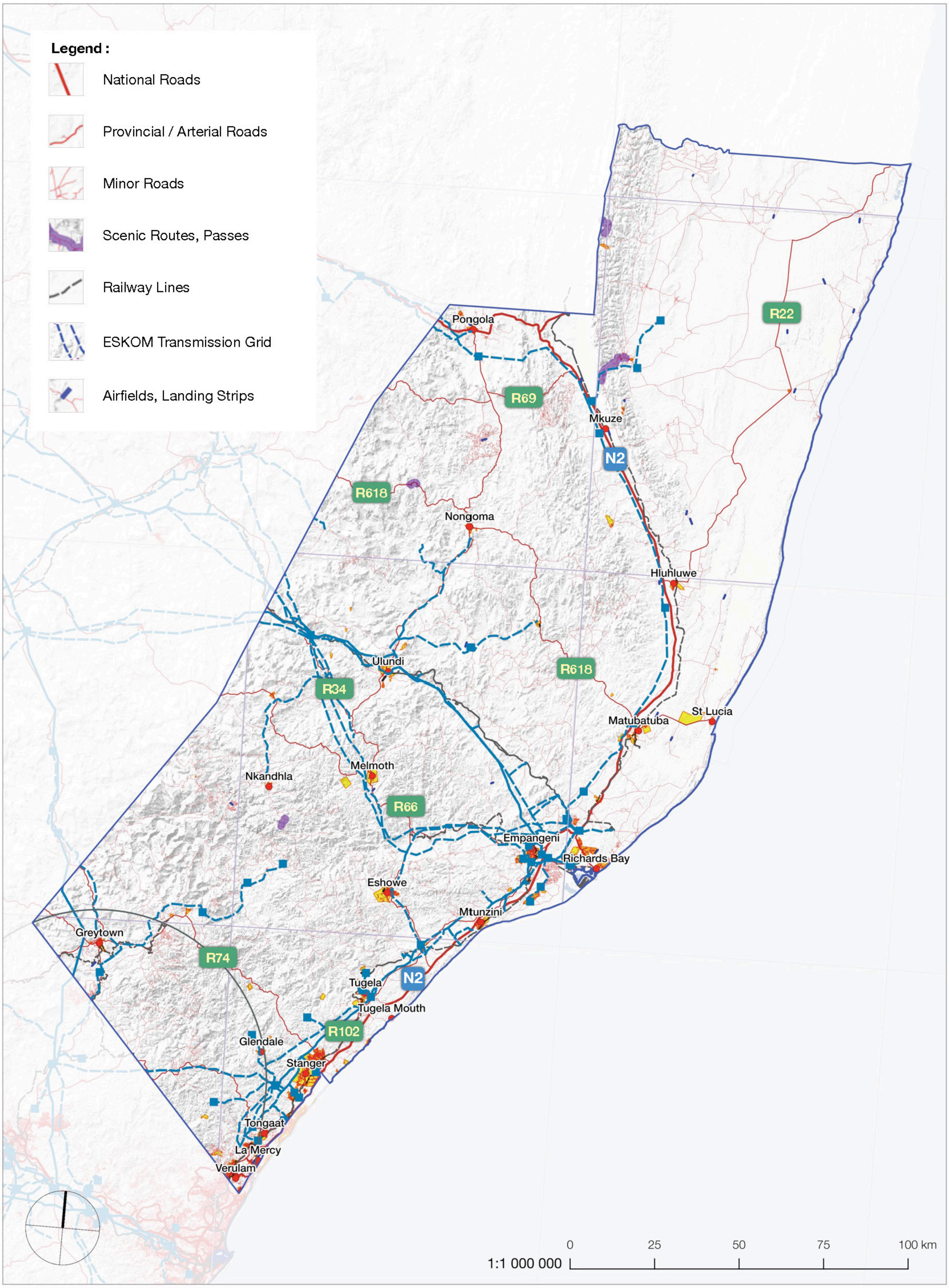
Map E3 • Eastern Corridor : **Physiography**



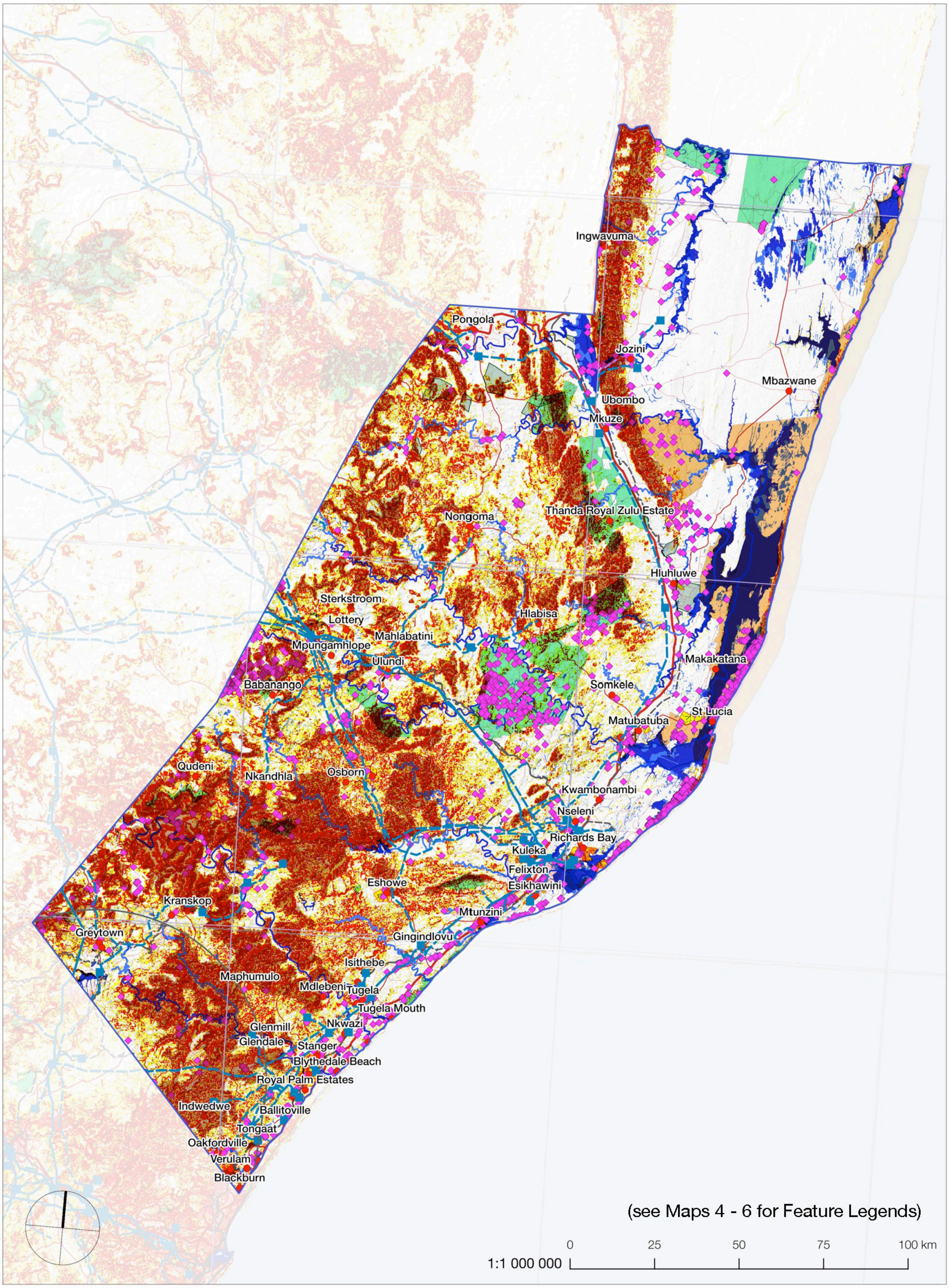
Map E4 • Expanded Eastern Corridor : **Topographic and Natural Features**



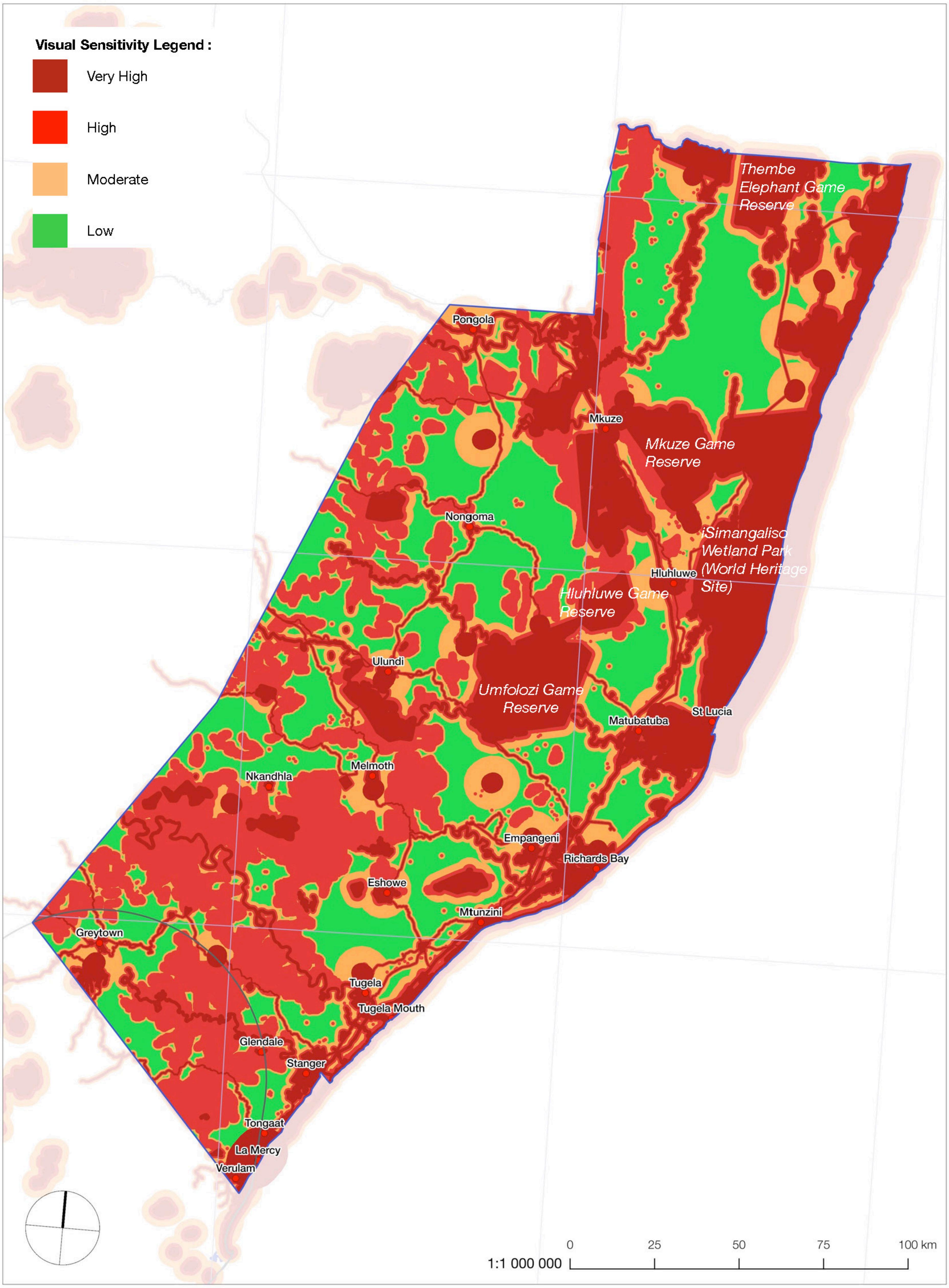
Map E5 • Expanded Eastern Corridor : **Heritage and Protected Areas**



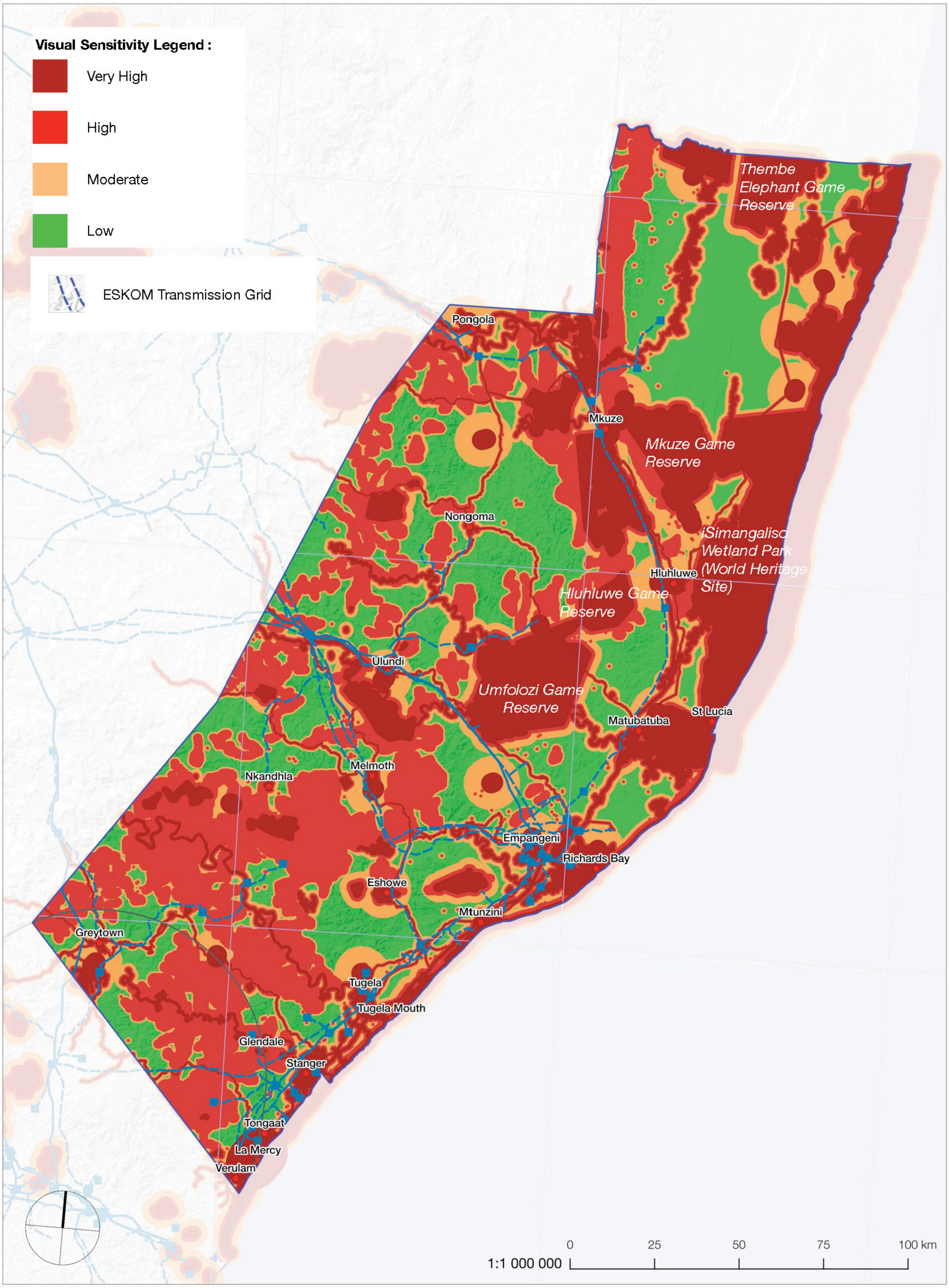
Map E6 • Expanded Eastern Corridor : **Routes and Transmission Lines**



Map E7 • Expanded Eastern Corridor : **Composite Feature Map**

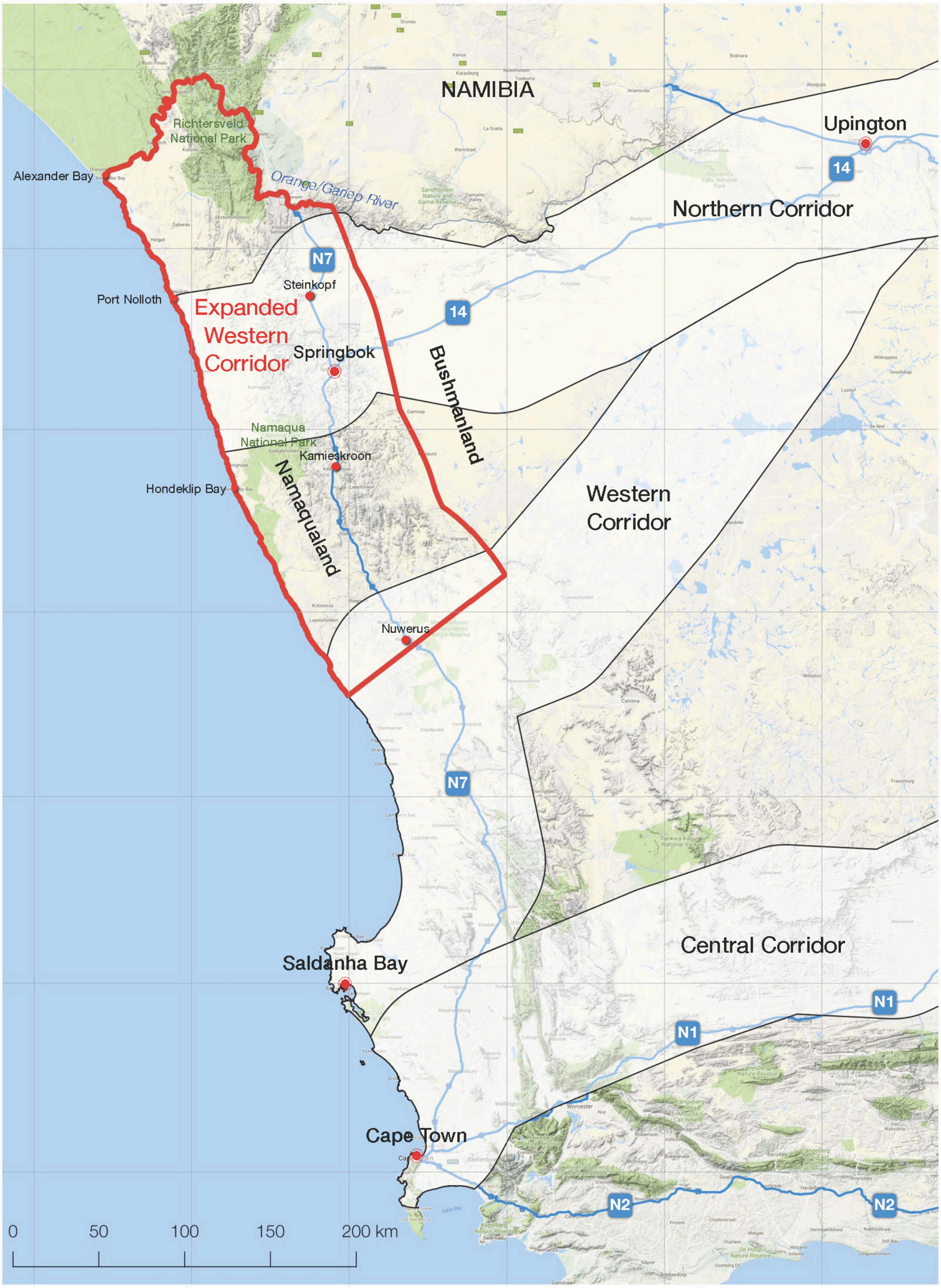


Map E8 • Expanded Eastern Corridor : **Visual Sensitivity**

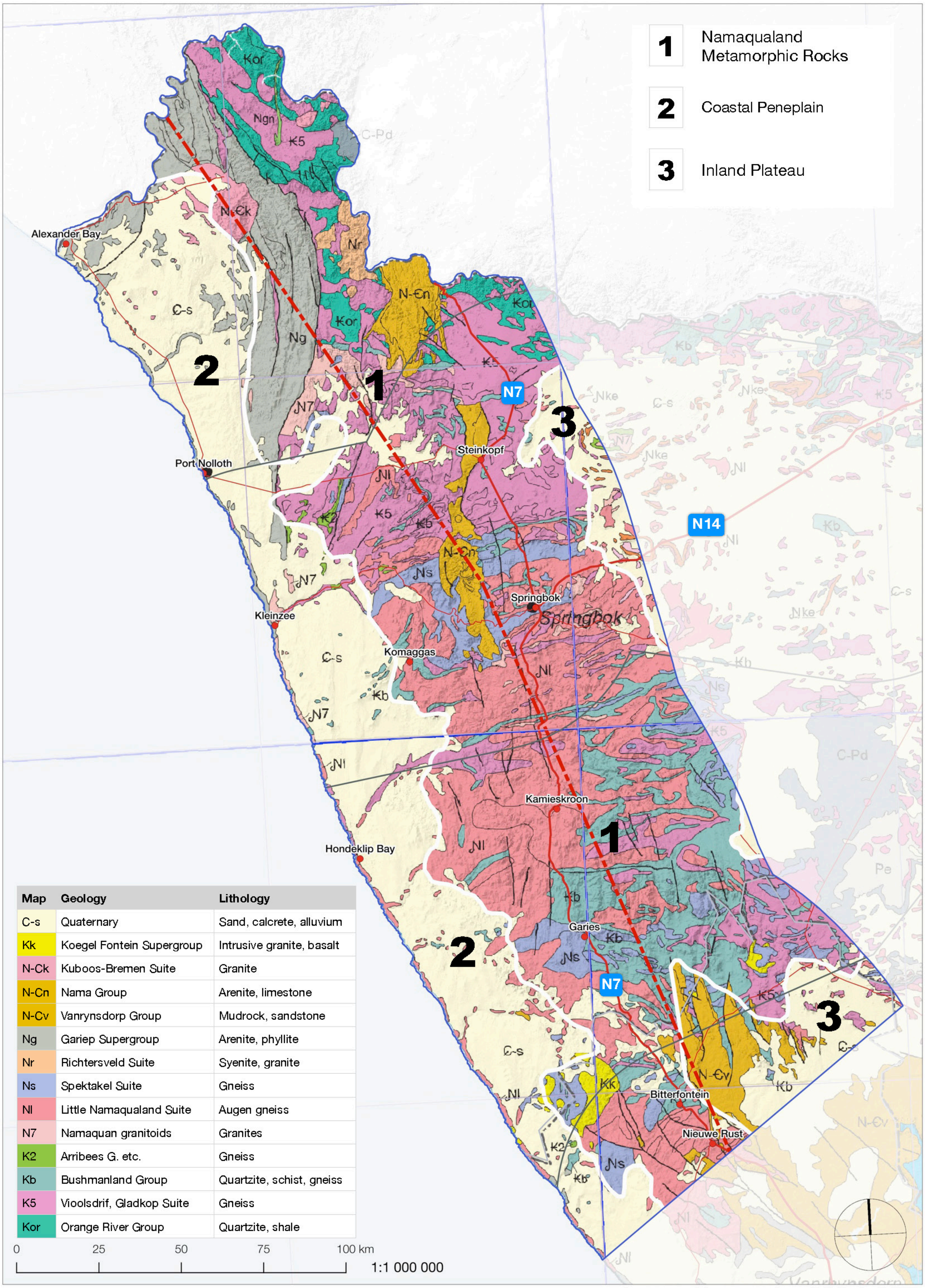


Source : CSIR / ESKOM TDP Substations and MTS Lines 2018

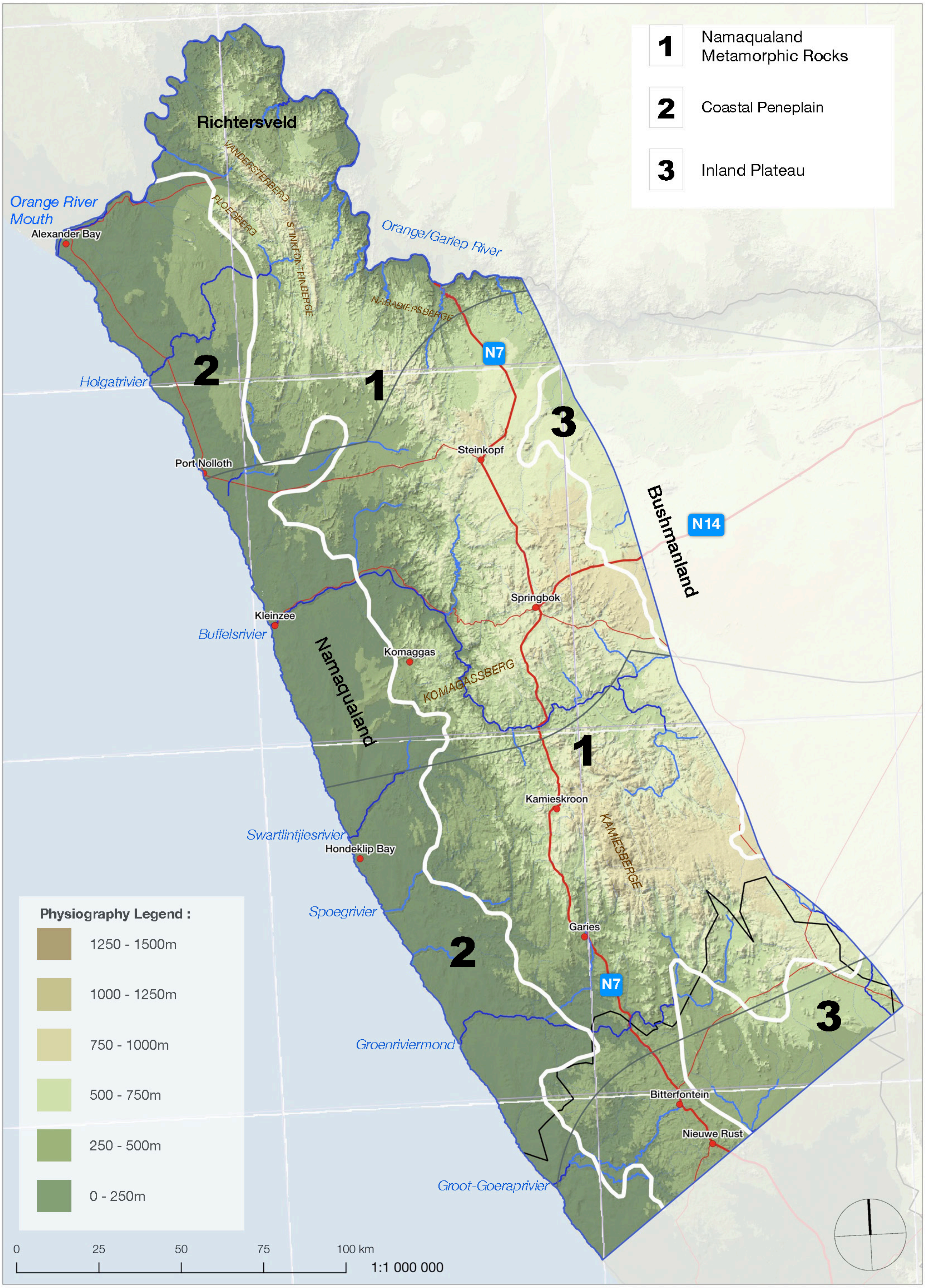
Map E9 • Expanded Eastern Corridor : **Visual Sensitivity** (showing existing ESKOM Grid 2018)



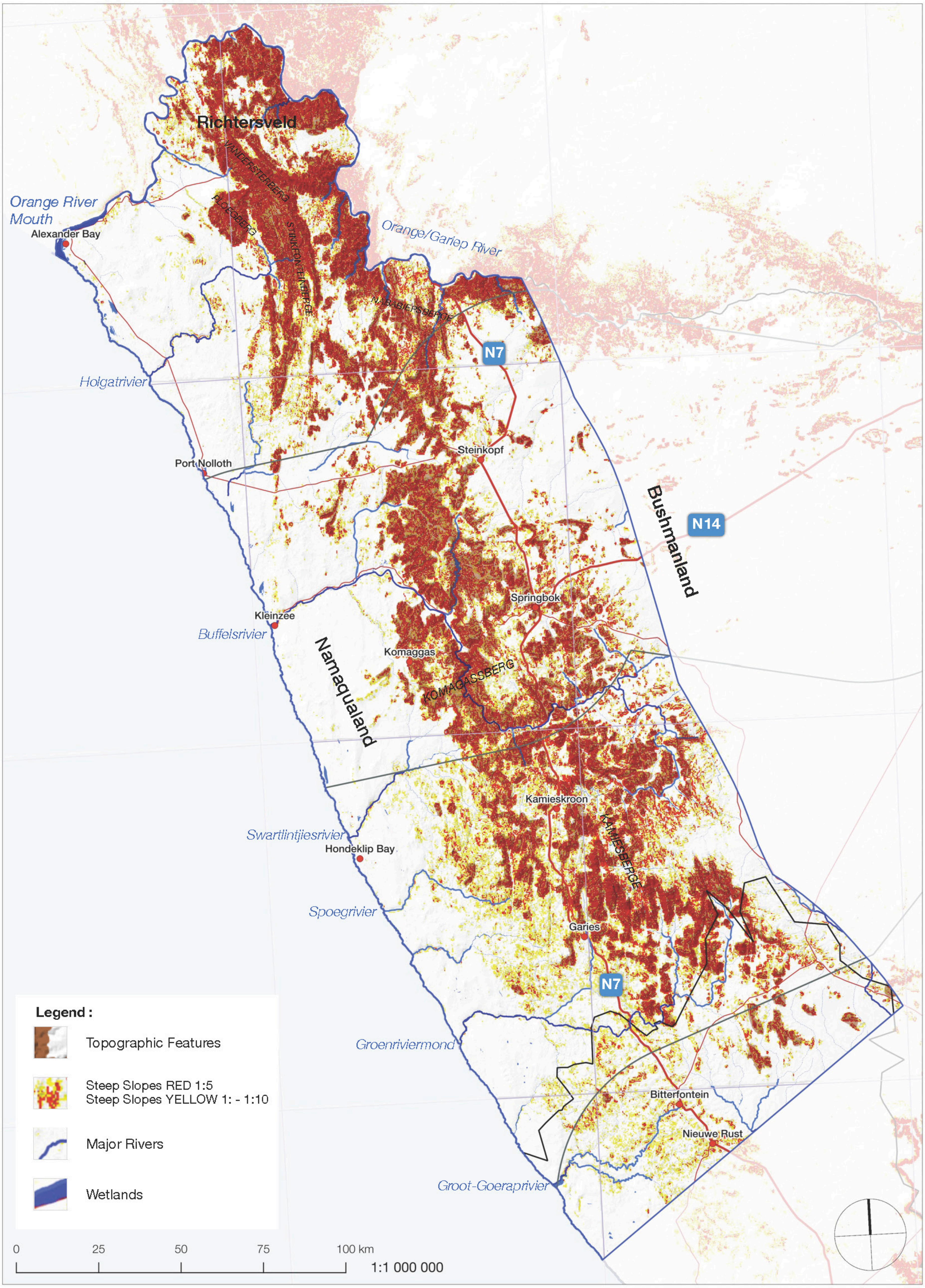
Map W1 • Expanded Western Corridor : **Location** indicating gazetted EGI corridors



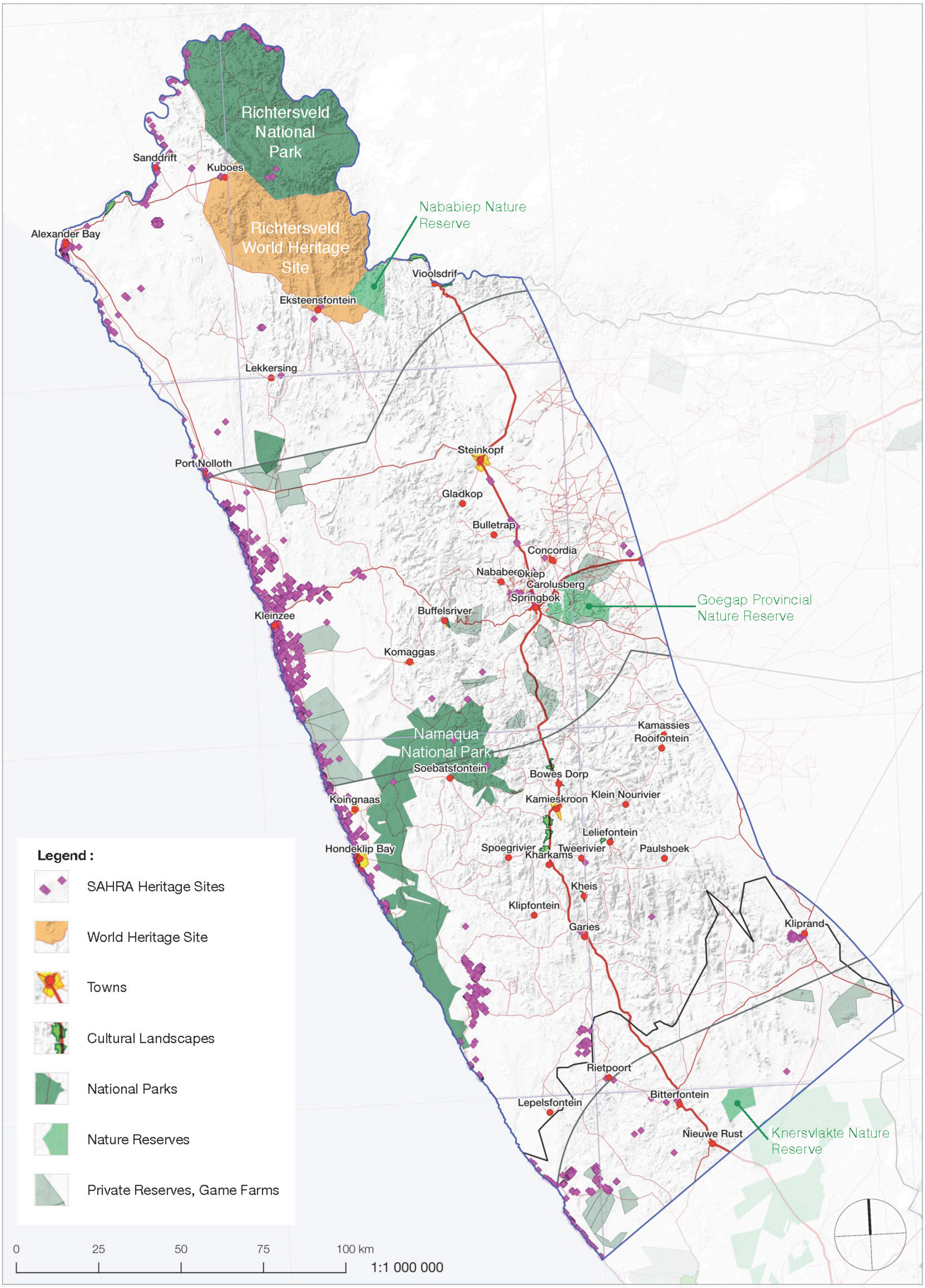
Map W2 • Expanded Western Corridor : **Geology and Landscape Types**



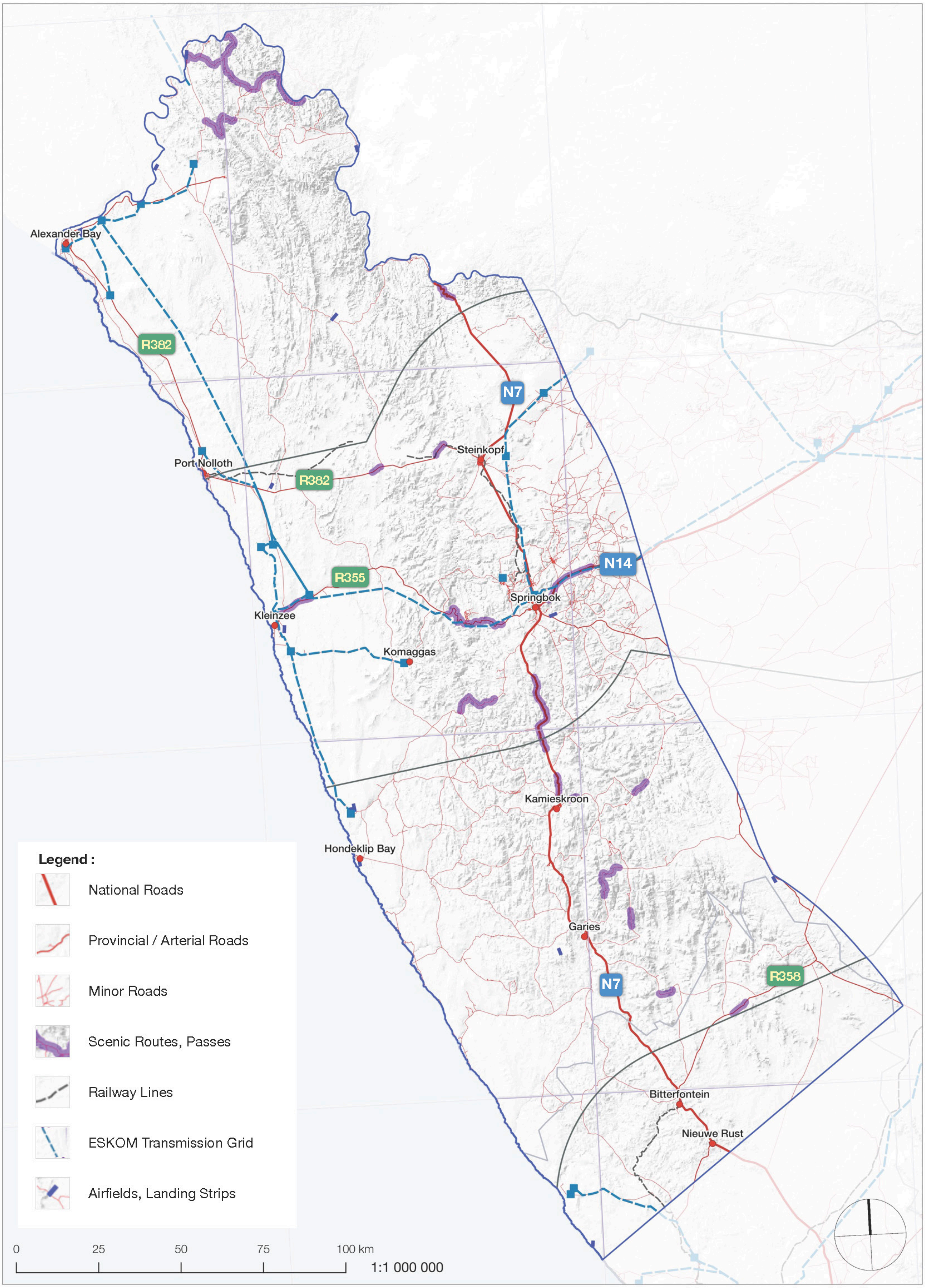
Map W3 • Expanded Western Corridor : **Physiography and Landscape Types**



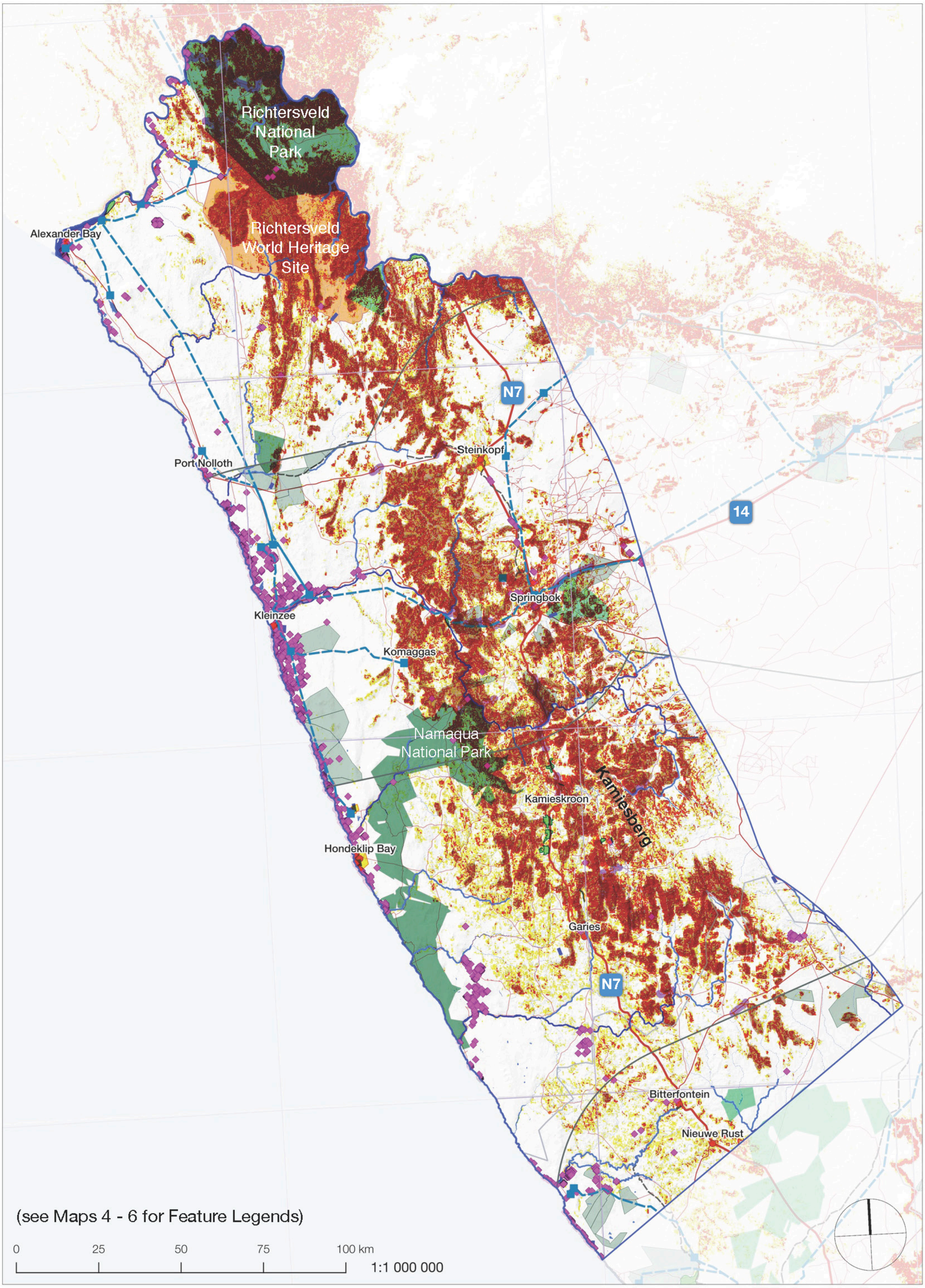
Map W4 • Expanded Western Corridor : **Topographic and Natural Features**



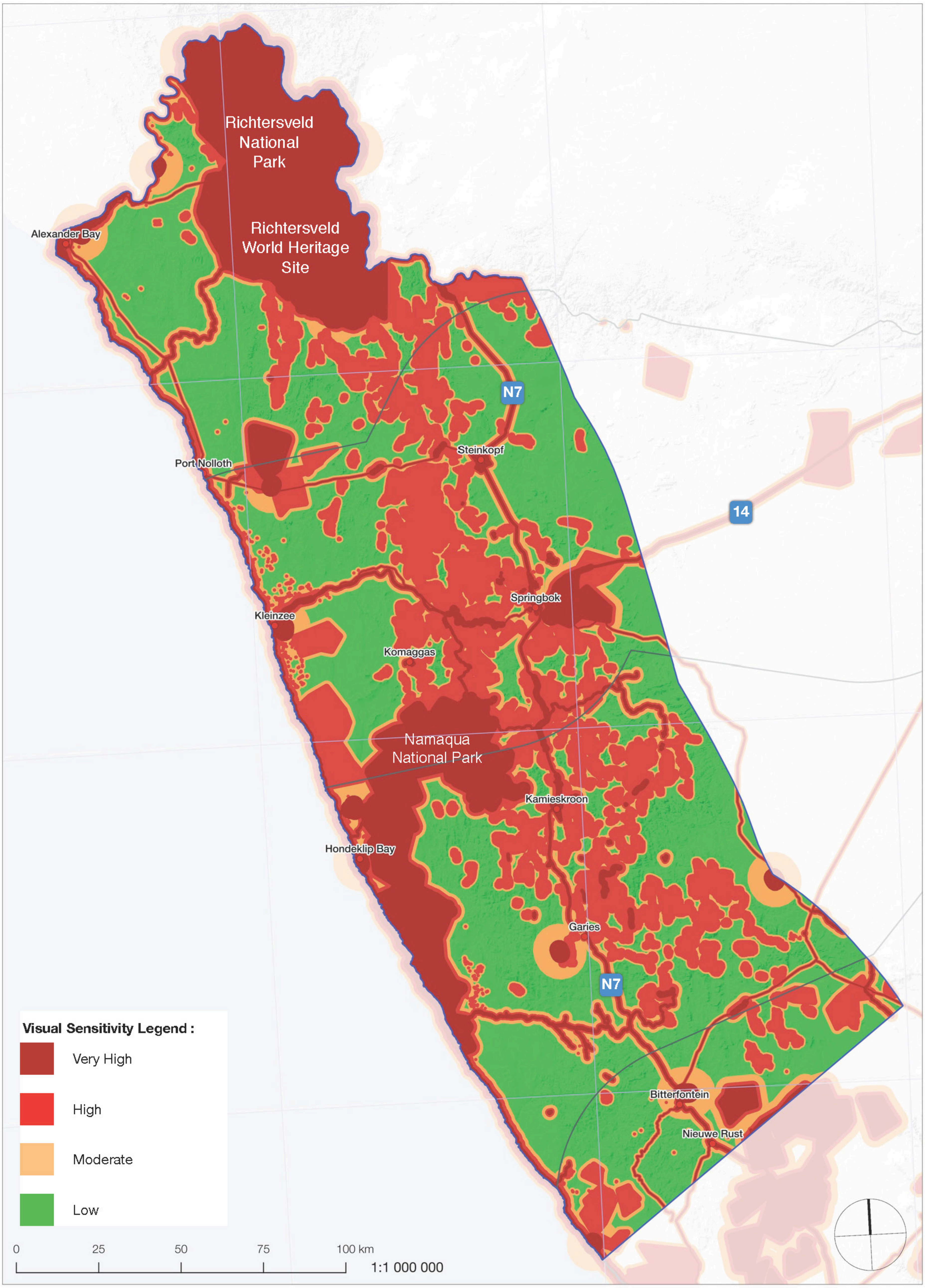
Map W5 • Expanded Western Corridor : **Heritage and Protected Areas**



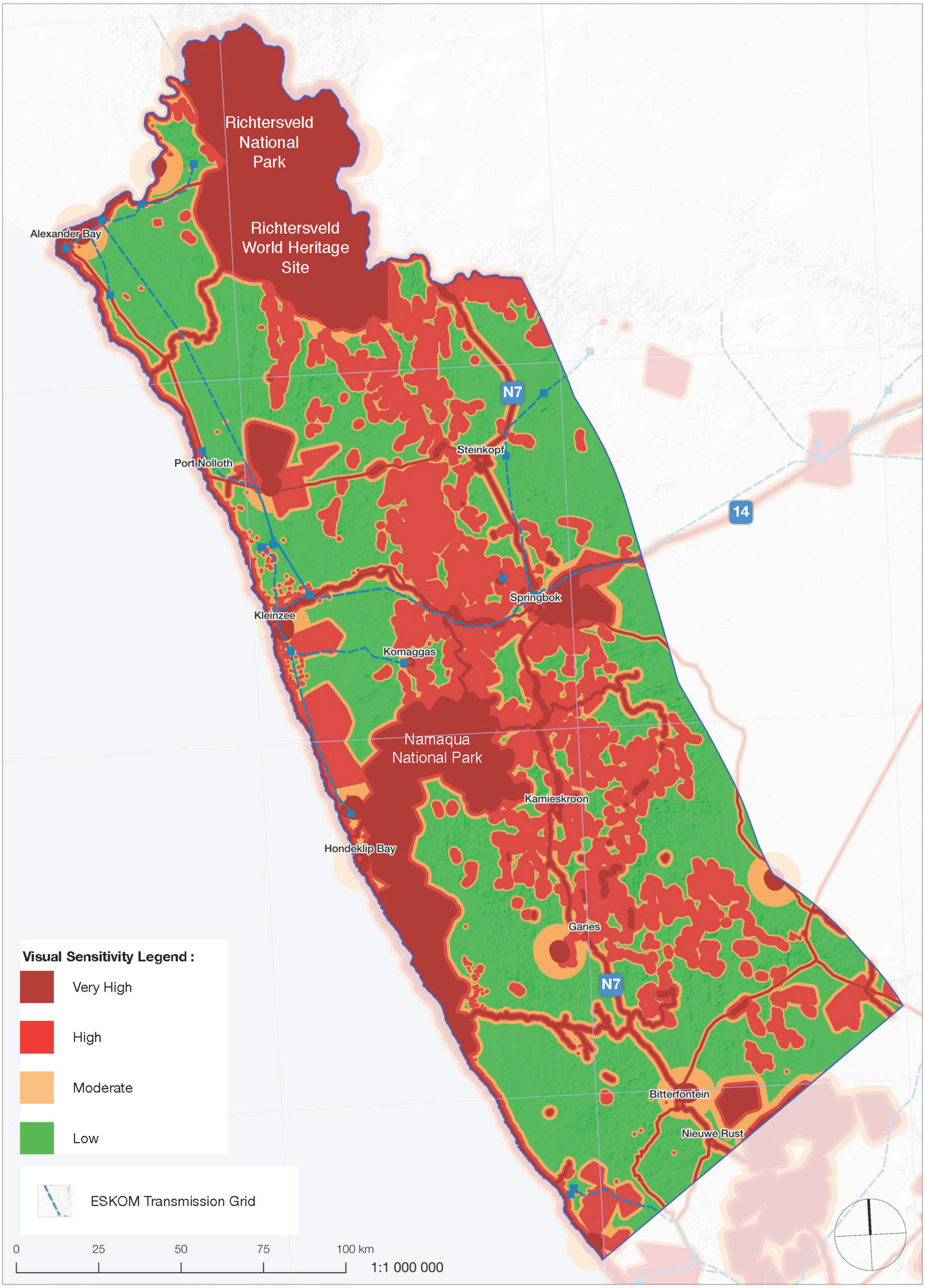
Map W6 • Expanded Western Corridor : **Routes and Transmission Lines**



Map W7 • Expanded Western Corridor : **Composite Feature Map**



Map W8 • Expanded Western Corridor : **Visual Sensitivity**



Source : CSIR / ESKOM TDP Substations and MTS Lines 2018

Map W9 • Expanded Western Corridor : **Visual Sensitivity** (showing existing ESKOM Grid 2018)

Appendix 2: Peer Review and Specialist Response Sheet

Peer Reviewer: Scott Mason, SRK Consulting (South Africa) (Pty) Ltd

EXPERT REVIEW AND SPECIALIST RESPONSES: Visual - EGI Expansion					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**	**Specialist Response**
Scott Masson	2	4		Visual Impact Assessment	Amended.
Scott Masson	3	14		The visual assessment should also be dependent on the type of infrastructure. For example, in some instances, a mono-pole has a very different visual impact compared to a lattice structure. This is especially the case when there is a mountainous (grey) backdrop to the lattice structure.	The issue of pylon types is not the focus of an SEA conducted at a regional scale, where the emphasis is on identifying optimal routing of powerlines. Pylon types can be visually important, but are normally dealt with in an EIA of a particular project. The wording in the report is being updated to make the distinction more clear.
Scott Masson	3	16		Does the worst case scenario assume mono-pole or lattice structure or are mono-pole structures not possible for the largest kV transmission lines? I note the comment on pg 10 and that the pylon type can have fairly important implications at the local landscape or townscape scale.	See response above. Correct, the pylon type has important implications at the local project or townscape scale.
Scott Masson	3	21		Emphasis is on geomorphology, but I would argue that land use is equally important in informing visual sensitivity. This is an initial comment without having reviewed the methodology.	In the experience of the visual specialists, landforms play a more significant role at the regional scale of the study. Land use and vegetation cover tend to only have visual significance at the local scale.
Scott Masson	4	10		Eastern Corridor	Amended.
Scott Masson	4	15		In the comment for the expanded Western Corridor, is the identification of the Medium and High sensitivity areas a function of distance from the proposed EGI only?	Both 'distance' and the nature of the feature or receptor are taken into account in the visual sensitivity mapping.
Scott Masson	4	15		"Very high visual sensitivity areas are those **visual resources** (?) and **sensitive** (?) receptors..."	Wording added to provide clarification.
Scott Masson	6	29 -32		I would think it would be very difficult to determine the sense of place for a project of this scale. Is the author not referring to "Visual Character" or "Visual Quality" as these aspects are determined by the regional characteristics of a place? The sense of place is determined by how a person / community identifies to those characteristics / qualities. And for this project, there will be many different types of communities to consider.	The concept of 'Sense of place' is merely being described here, and could apply at a range of scales, e.g. the Cape Winelands. 'Genius Loci' by C. Norberg-Schulz is a classic reference.
Scott Masson	7	18		Step 2?	Corrected. It is supposed to be 'Section 6'.
Scott Masson	7	18-20		What about land use? It has been mentioned earlier in the report that visual sensitivity will be very different if the corridor is across a mining area	As mentioned above, land use only becomes significant at the local scale. The SEA is a regional-scale desktop study based on

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Expert Reviewer Name	**Page Range**	**Line/s**	**Table/ Figure**	**Expert Reviewer Comments**	**Specialist Response**
				compared to a pristine area.	available information and shape files. Urban areas and protected environments have however been included.
Scott Masson	8	32		Heading to next page	Final draft will be formatted by CSIR.
Scott Masson	9	5		For NEM:ICMA: I would remove reference to 1 km because it would depend on if the coastal zone is in urban or non-urban areas and also if coastal setback lines have been determined.	It makes sense to use the 1 km at the regional scale, as per the legislation, as the mapping does not deal with any urban areas, nor with local area mapping determination.
Scott Masson	9	5		NEM:PAA: This "provincial" instrument has already been discussed as a "national" instrument. Also check PAA acronym for first time use.	Wording has been amended.
Scott Masson	10	2		"The potential footprint and visual implications of the proposed powerline grid **have** been…"	Amended.
Scott Masson	10	8-11		From field observations, in my opinion, a monopole structure can be significantly more (visually) intrusive than a lattice structure, but I acknowledge that it would be difficult to consider at the scale of this study.	A range of pylon types are available for different uses and local conditions. These were not considered for a regional-scale SEA.
Scott Masson	10	12 -13		Depends on vegetation type and I think pylon structure could have equal value, for certain landscapes, in determining the visual sensitivity.	Typical footprints are merely indicated here, but do not have a meaningful bearing on the sensitivity mapping at the regional scale.
Scott Masson	10	19		Is 70 ha correct? 700 000 m^2?	These figures were provided to the specialists. On checking, the large substation at e.g. De Aar is nearly 70 ha.
Scott Masson	16 / 18		5c / 6c	West - east transect would be also useful to show the elevation change from the coast inland.	This would be of academic value as the national powerlines would generally run the length of the corridor.
Scott Masson	16 / 18		5c / 6c	Can you include photographs of the types of landscape features? If the reader hasn't been to these areas before or does not have a good handle of geology, then the reader will not be able to picture the different types of geomorphological areas or landscape features.	Agreed. The a few photos have been included. The specialists are a bit limited by the fact that the SEA is a desktop study with no fieldwork.
Scott Masson	19		7.1	Game reserves / resorts	Amended.
Scott Masson	20		7.2	Refer to previous comment about coastal zone. The mapped 1 km then already has an inherent buffer zone.	Refer to previous response. The 1 km is being used by CSIR and SANBI.
Scott Masson	21		7.3	For topographic features, cultural landscapes and heritage sites, there should be some form of buffer for "Very high sensitivity" because, for example, a pylon within 250 m of a heritage site would have a significant impact on that feature similar to a provincial route.	Agreed. 250m has been added for those features. However, it should be noted that these are regional mapping buffers. Actual setbacks need to be determined based on local conditions.
Scott Masson	24 / 27		7c / 8c	It is unclear why transmission lines have been included in this figure. I agree that the lines should be considered as aligning the proposed transmission lines along / near existing lines may increase compatibility and landscape integrity (although cumulative impact becomes a problem) but the transmission lines are not features.	Figures 7c and 8c are information maps and not related to sensitivity. The existing transmission lines are merely included as useful information.

EXPERT REVIEW AND SPECIALIST RESPONSES: Visual - EGI Expansion					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**	**Specialist Response**
Scott Masson	33	11		May have to reword because in mitigation table, it states that powerlines should not run along river valleys. Perhaps lines should not run along **narrow** valleys?	Wording in mitigation table amended.
Scott Masson	33	16-18		A simplified map showing degraded areas (e.g. industrial / mining areas) may also be useful rather than a land use map. Existing transmission lines could be shown on this map.	Agreed that this information would be useful, but is far too detailed and not available as shape files. The SEA does also not involve any field work.
Scott Masson	33	22 - 24			
Scott Masson	34	8-10		In my opinion, the monopole is more visually intrusive than lattice structures.	See previous responses above. Those considerations were not part of the regional mapping study.
Scott Masson	36	7-8		Perhaps then the alignment should be on landscape unit 2 or 3 but close to the interface with landscape unit 1 so that a backdrop is provided on at least on side? This obviously depends on proximity to other sensitive features and receptors.	Agreed. This accounted for in the Guidelines of Section 10.1.
Scott Masson	37	1-3		The plantations and sugar cane fields could be presented on a "land use" map as mentioned in the comment on page 33.	As in the case of industrial/mining areas, sugar cane fields would be too detailed to map at the regional scale without shape files.

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.3

Seismicity Assessment Report

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE CORRIDORS IN SOUTH AFRICA

SEISMICITY SPECIALIST REPORT

Impacts of Earthquakes, Seismicity and Faults

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Draft V1 – March 2018
Draft V2 – October 2018
Draft V3 – April 2019
Final Report – October 2019

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ABBREVIATIONS AND ACRONYMS

CGS	Council for Geoscience
DEA	Department of Environmental Affairs
DRR	Disaster Risk Reduction
EGI	Electricity Grid Infrastructure
GMPE	Ground motion prediction equation
M	Earthquake Magnitude
M_L	Local Magnitude
M_{max}	Magnitude of the largest credible earthquake
M_w	Moment Magnitude
MMI	Modified Mercalli Intensity
MASW	Multi-channel analysis of surface waves
PGA	Peak Ground Acceleration
PGPN	Phased Gas Pipeline Network
PPV	Peak Particle Velocity
PSA	Peak Spectral Acceleration
PSHA	Probabilistic Seismic Hazard Assessment
SANSN	South African National Seismograph Network
SANS	South African National Standard
SEA	Strategic Environmental Assessment

1 INTRODUCTION

The Department of Environmental Affairs (DEA) commissioned a Strategic Environmental Assessment (SEA) for a phased gas pipeline network (PGPN) and electricity grid infrastructure (EGI) expansion in South Africa. The geographic extent of the "energy corridors" covered by the SEA is shown in Figure 1. The expanded EGI corridors shown in diagonal lines in Figure 1 are part of this assessment. They are extensions to the gazetted Western and Eastern EGI corridors (as identified in the 2016 EGI SEA).

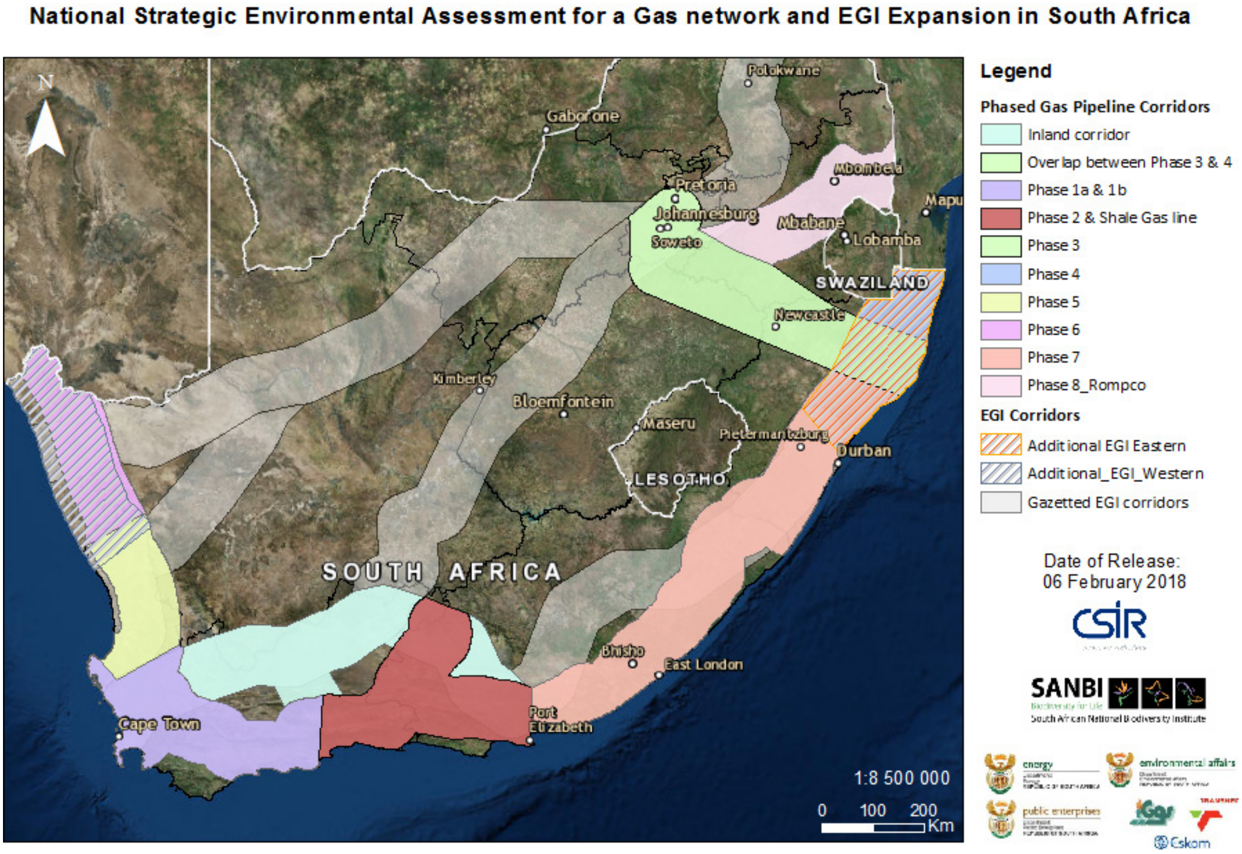

Figure 1: The PGPN and additional EGI Corridors for Specialist Assessment

This Specialist Assessment Report addresses the risks posed by earthquakes and associated phenomena such as landslides, liquefaction and tsunamis on the expanded EGI corridors.

The high level conclusions and recommendations are contained in the body of the report. The evidence on which these conclusions are based is contained in three appendices:

A. Earthquake monitoring, hazard and risk assessment in South Africa;
B. OpenQuake PSHA computation for South Africa and the energy corridors; and
C. Vulnerability of EGI.

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 D of this report.

2 SCOPE OF WORK

2.1 Terms of Reference

EGI are "lifelines", a term used by the Disaster Risk Reduction (DRR) community to describe *"man-made structures [that are] important or critical for a community to function, such as roadways, pipelines, power lines, sewers, communications, and port facilities"* (Aki & Lee 2003: 1821). Lifelines are vulnerable to damage caused by the shaking of the ground during an earthquake, as well as associated phenomena such as the displacement of the ground across a fault, landslides, liquefaction of soils and tsunamis. Not only will damage to EGI and pipelines disrupt the supply of electricity and gas, but it could also trigger a cascade of other hazardous situations, such as fires, explosions, asphyxiation and electrocution.

Earthquakes are driven either by geological forces (e.g. motion of tectonic plates, isostatic response to erosion, volcanism) or certain human activities (e.g. mining, impoundment of reservoirs, fluid injection or extraction). EGI do not affect seismicity in any known way. The following issues are assessed in this study:

- What damage could earthquake-related phenomena (e.g. strong ground motion, surface displacement as the result of fault rupture, landslides triggered by strong ground motion, liquefaction of soils induced by ground shaking, tsunami) cause to EGI?
- What impact would the damage to EGI have on the environment and people?

This assessment focuses primarily on the interpretation of existing data and is based on defensible and standardised and recognised methodologies. It discusses direct, indirect and cumulative impacts, and identifies any gaps in information linked to earthquakes and seismicity with respect to EGI.

2.2 Methodology

The following methodology was used to assess the impact of earthquakes on EGI, and the consequent impact of any damage on the environment or people, as well as measures to mitigate the impact:

1. Review of available seismic and geological data, previous hazard and risk assessments and relevant research work (Appendix A).
2. Computation of the Probabilistic Seismic Hazard Assessment (PSHA) for the energy corridors considering recurrence periods, Peak Ground Acceleration (PGA) and spectral accelerations (Appendix B).
3. Assessment of the vulnerability of the proposed energy infrastructure (e.g. pylons, transformers, substations, etc.) to ground vibrations (Appendix C).
4. Assessment of the impact of earthquakes on the proposed energy infrastructure and the consequent impact of any damage on the environment or people.
5. Recommendations for site specific seismic hazard assessment studies or any supplementary monitoring that may need to be done for the proposed and actual EGI infrastructure routes within the corridor.

2.3 Data Sources

The primary sources of information used in this study are listed in Table 1 below.

Table 1: Data Sources

Data title	Source and date of publication	Data Description
Landslide geohazard for South Africa	Singh et al. 2011	Detailed study on landslides in South Africa
CGS Geohazard Atlas	http://197.96.144.125/jsviewer/Geohazards/index.html#	Collapsing and swelling soils
Earthquake seismology	Durrheim 2015	Comprehensive review of earthquake monitoring, hazard and risk assessment in South Africa.
The history of mining seismology	Durrheim & Riemer 2015	Comprehensive review of mining-induced earthquake monitoring, hazard and risk assessment in South Africa.
Compiling a homogeneous earthquake catalogue for Southern Africa	Mulabisana 2016 (MSc dissertation)	Earthquake catalogue for South Africa
Seismic sources, seismotectonics and earthquake recurrence for the KZN coastal regions.	Singh 2016 (PhD thesis)	Active faults in the KZN coastal region
Seismotectonics of South Africa	Manzunzu et al. 2019	Seismotectonic model for South Africa, which includes active faults and earthquake source mechanisms.
The Probabilistic Seismic Hazard Assessment (PSHA) of South Africa.	Midzi et al. 2018 (in review)	PSHA for South Africa
Development of a South African Minimum Standard on ground vibration, noise, air-blast and flyrock near surface structures to be protected	Milev et al. 2016	Blasting-induced ground vibrations
Global catalogues of earthquakes in stable continental regions	Johnston et al. 1994	Global catalogues of earthquakes in stable continental regions

Relevant information from the primary sources listed in Table 1 above and many secondary sources are reviewed in the appendices.

2.4 Assumptions and Limitations

The limitations and assumptions applicable in this study are listed in Table 2 below.

Table 2: Assumptions and Limitations

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Completeness of the earthquake catalogue	Earthquake catalogue published by the SANSN.	Data recorded by local mine and research networks.	Catalogue sufficiently complete to provide a reasonable estimate of recurrence times and M_{max}; values from similar tectonic domains elsewhere in the world provide reasonable constraints (see Johnston et al. 1994; Vanneste et al. 2016).
Ground motion prediction equations (GMPEs)	GMPEs from similar tectonic domains elsewhere in the world.	Measurement of local GMPEs.	GMPEs from similar tectonic domains elsewhere in the world are adequate.
Site effects	Descriptions of site effects in published papers and reports.	Measurement of site effects.	Reasonable estimates of local site amplification can be made from geological knowledge.
Site Specific PSHA	Review of published regional PSHA studies.	PSHA calculations that include local site effects.	PSHA for regional studies is for bedrock.

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Analysis of liquefaction potential	Reports on occurrence of liquefaction in KwaZulu-Natal.	Measurement of liquefaction susceptibility.	Knowledge of liquefaction potential is poor.
Active faults	Traces of active faults described in published papers and reports.	Mapping and monitoring of active and capable faults.	Knowledge of active and capable faults is poor.
Vulnerability of EGI structures	Published papers and reports.	Measurement or calculation of seismic response.	Local EGI structures meet international standards.

2.5 Relevant Regulatory Instruments

Table 3 below provides feedback on the relevant regulatory instruments.

Table 3: Relevant Regulatory Instruments

Instrument	Key objective
International Instruments	
Eurocode 8	In the Eurocode series of European standards (EN) related to construction, Eurocode 8: Design of structures for earthquake resistance (abbreviated EN 1998 or, informally, EC 8) describes how to design structures in a seismic zone, using the limit state design philosophy. http://eurocodes.jrc.ec.europa.eu/
ISO4866	ISO4866 provide guidelines for the measurement of vibrations and evaluation of their effects on fixed structures, not safe limits of vibration for structures. Section 12.4 of the ISO4866 guideline refers users to safe limits published by authorities in France, Germany and Norway, noting that these limit values take building category, vibration category, and frequency range into account.
National Instruments	
South African Constitution	Section 24 states: "Everyone has the right – a) To an environment that is not harmful to their health and well-being, and b) To have the environment protected, for the benefit of the present and future generations, through reasonable legislative and other measures that – i. Prevent pollution and environmental degradation; ii. Promote conservation; and iii. Secure ecologically sustainable development and use of natural resource while promoting justifiable economic and social development."
Disaster Management Act (Act 57 of 2002; amended in Act 16 of 2015)	Each metropolitan and district municipality is required to develop such a disaster management strategy.
Geoscience Act (Act 100 of 1993; amended in Act 16 of 2010)	The Act mandates the Council for Geoscience to be the custodians of geotechnical information, to be a national advisory authority in respect of geohazards related to infrastructure and development, and to undertake reconnaissance operations, prospecting research and other related activities in the mineral sector; and to provide for matters connected therewith.
South African National Standard (SANS) SANS4866	The South African Bureau of Standards adopted standard ISO4866 of the International Organization for Standardization (ISO). The first ISO edition was published in 1990 and a second edition in 2010. SANS4866:1990 = ISO4866:1990 SANS4866:2011 = ISO4866:2010
SANS 10160-4-2017	South African National Standard (2017). Basis of Structural Design and Actions for Buildings and Industrial Structures. Part 4: Seismic Actions and General Requirements for Buildings. Pretoria: South African Bureau of Standards. ISBN 978-0-626-30384-6.
Provincial Instruments	
Local Government Municipal Systems Act (No. 32 of 2000)	In terms of the Local Government Municipal Systems Act (No. 32 of 2000) all municipalities are required to complete Spatial Development Frameworks (SDFs) as a core component of Integrated development Plans (IDPs). The Department of Rural Development and Land Reform has developed guidelines to assist with the process. http://www.ruraldevelopment.gov.za/phocadownload/spatial_Planning_Information/SDF-Guidelines/A5.pdf

3 KEY SEISMIC-RELATED ATTRIBUTES AND SENSITIVITIES OF THE STUDY AREAS

3.1 Terminology

Magnitude (M) is a measure of the energy released by the earthquake and the amount of slip on the fault. Seismograms recorded by many widely-spread seismograph stations are used to assign a single magnitude to an event. The SANSN uses either the local magnitude scale (M_L) or the moment magnitude scale (M_w), which are essentially equivalent for M<6.5. The M_L scale uses the maximum amplitude of ground motion recorded at the various local stations, is quick and easy to measure, but saturates above M6.5. The M_w scale takes the entire seismogram into account and is derived from an assessment of the mass of rock moved (or work done, hence the subscript 'w') by the earthquake. M_w does not saturate and can be estimated from local, regional or global stations. It has been calibrated to match M_L for M<6.5. Earthquakes are generally divided into the following categories: micro M<3, small 3<M<5, moderate 5<M<7 and major M>7. Natural earthquakes are generally only felt when M>3 and only cause significant damage when M>6. However, people unaccustomed to earthquakes may be frightened by the shaking that is produced by a M5 event, even though the amplitude of ground motion is only 1/10 that of a M6 event. It should be noted that earthquakes induced by mining or fluid injection may cause damage if 5<M<6 because they generally occur at much shallower depths than natural events.

Intensity (I) describes the shaking experienced on the surface of the earth. Intensity generally decreases with distance from the epicentre (the point on the earth's surface above the earthquake source), but is also affected by near-surface geology. Shaking is generally amplified where there is a thick layer of alluvium. Reports by many widespread observers are collated to derive Intensity Data Points (IDPs) and compile an isoseismal map. The SANSN uses the **Modified Mercalli Intensity (MMI) scale**.

The levels of the intensity scale can be roughly related to the **Peak Ground Acceleration (PGA)**, a quantity that is used by engineers to design structures. It is expressed either in terms of gals (cm/s^2) or the acceleration of gravity (g, 9.8 m/s^2). To give some examples: an MMI of III (0.001 – 0.002 g) indicates ground motion that is perceptible to people, especially on the upper floors of buildings; VI (0.02 – 0.05 g) is felt by all, many people are frightened and run out of doors, and a few buildings may be slightly damaged; VIII (0.1 – 0.2 g) causes slight damage to earthquake-resistant structures, considerable damage to solid buildings, and great damage to poorly-built buildings; while XII (> 2 g) indicates total destruction, with objects thrown into the air. The resonant frequency of structures depends on their height and footprint. Thus engineers make use of estimates of the **Peak Spectral Acceleration (PSA)**, a measure of ground motion at particular frequencies, to determine if structures will respond to an earthquake.

3.2 Background

Southern Africa is, by global standards, a seismically quiet region as it is far from the boundaries of tectonic plates and active continental rifts (Johnson & Kanter 1990). Seismicity in South Africa arises from both natural sources (e.g. plate tectonic forces, buoyant uplift of the continent after erosion) and human-induced sources (e.g. rock failure caused by mining-induced stresses, slip on faults causes by changes in load and pore fluid pressure during the filling of reservoirs, and vibrations produced by blasting for open pit mining, civil excavation and the disposal of expired munitions). Most earthquakes are induced by deep-level mining for gold and platinum, and thus restricted to the mining districts (Figure 2). However, natural earthquakes do take place from time to time. They are driven by various tectonic forces, such as the spreading of the sea floor along the mid-Atlantic and mid-Indian ocean ridges, the propagation of the East African Rift System, and the response of the crust to erosion and uplift (Calais et al. 2016).

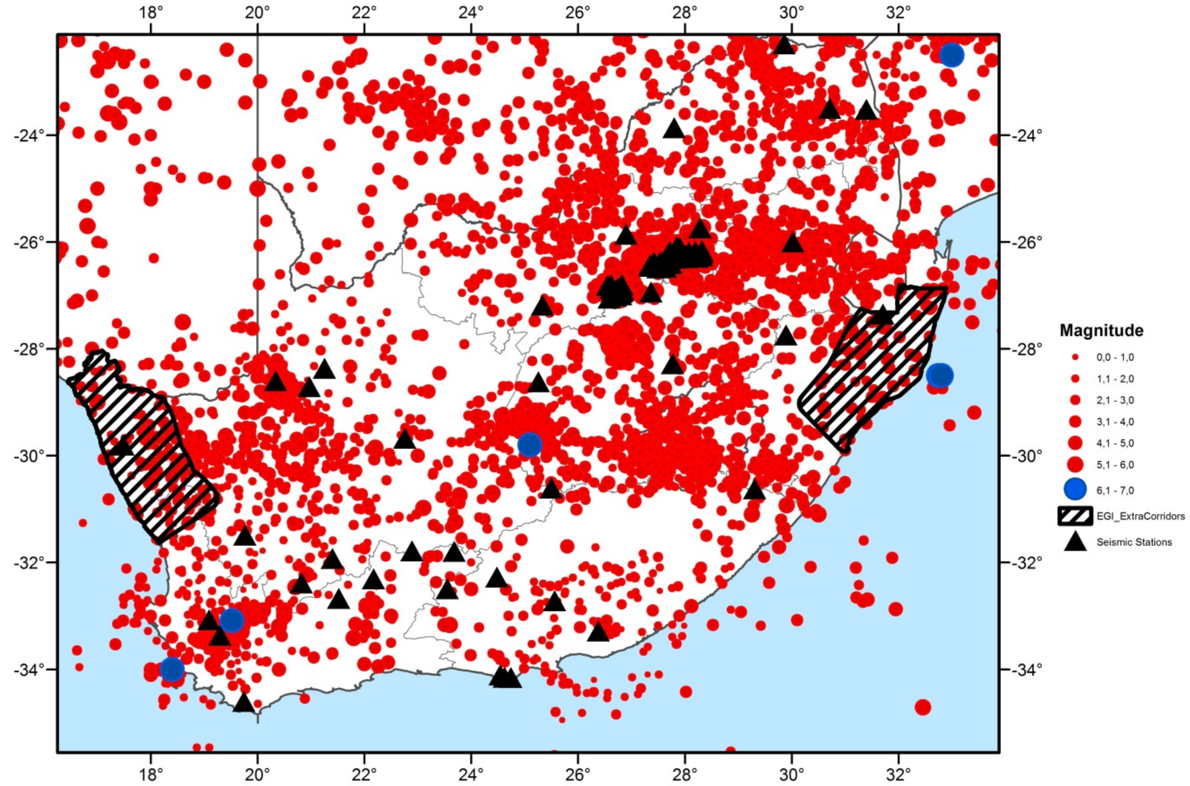

Figure 2: Location of recorded earthquakes in Southern Africa from 1811-2014 in relation to the Expanded EGI corridors which are shown by diagonal lines.

Note: Triangles mark the position of the stations that comprise the South African National Seismograph Network (SANSN).

South Africa has the infrastructure and capability to monitor seismicity and assess seismic hazard and risk. Mulabisana (2016) indicates that the homogenized earthquake catalogue is complete above M2.5 since 1965, but this is thought to be somewhat optimistic as all M>3 earthquakes were only reliably recorded after the establishment of the South African National Seismograph Network in 1971. The bedrock geology has been mapped in fair detail, while geotechnical mapping is largely confined to built-up areas. Studies of earthquake hazard and risk have recently been published by Durrheim (2015), Durrheim & Riemer (2015), Singh (2016), Goedhart (2017), Midzi et al. (2018), and Manzunzu et al. (2019). An assessment of the risk posed by open pit blasting has been published by Milev et al. (2016), while ground vibrations produced by the disposal of expired munitions has been investigated by Grobbelaar (2017).

Ground vibrations may also be produced by blasting in open pit mines and for civil excavations (e.g. road cuttings), and the disposal of expired military explosives. The effect of these blasts is local. Guidelines are available to design rock blasts so that the ground vibration levels are controlled (Milev et al., 2016). Intensities strong enough to cause damage to sensitive structures are usually limited to distances of tens to hundreds of meters, or at most a kilometre or two from the source. Expired munitions are usually detonated on the surface, so relatively little energy is transmitted into the earth and little damage done. However, the shock wave travelling through the air may cause alarm, discomfort, and in some cases damage.

The Council for Geoscience has made measurements of the ground motion produced by military explosives detonated on surface and their effects on buildings (B Manzunzu, pers. Comm., 2018). The measured peak particle velocity (PPV) and dominant frequency of the ground motion was compared with the US Code of Federal Regulations (CFR) that deals with the control of adverse effects caused by explosives. Ground motions were recorded at distances ranging from 5.25 to 29.07 km in a sandy terrain. The biggest charge detonated had a mass of 25000 kg and the highest PPV recorded was 0.0095 cm/s, which is only 0.5% of the CFR limit. The highest PPV was recorded at another range where the geology is hard rock and the equipment was installed within 100 m of the explosion caused by a missile fired from an aircraft. The reading obtained was equivalent to 15% of the CFR limit.

It is important to note that a low rate of seismicity does not mean that there cannot be large earthquakes; just that earthquakes are less frequent. The history of earthquake occurrences and seismological observations and research in South Africa is reviewed in **Appendix A.** Three M>6 tectonic earthquakes have occurred in the last 120 years within the borders of South Africa: in the Western Cape (M6.3, 1969), northern KwaZulu-Natal (M6.3, 1932), and the southern Free State (M6.2, 1912). The 1932 M6.3 St Lucia event is the only M>5 event recorded in either of the EGI corridors considered in this study. A moderately-sized earthquake could prove disastrous should it occur close to vulnerable buildings and lifelines, especially if the structures are not designed to be earthquake-resistant, the terrain is steep and prone to landslides, or the soil is thick and prone to local site amplification or liquefaction.

A recent example of a serious damage produced by a 'moderate' earthquake is the M6.0 event that struck Christchurch, New Zealand, on 13 June 2011, claiming nearly 200 lives and causing substantial damage due to soil liquefaction.

Manzunzu et al. (2019; see Figure 1 in Appendix B) compiled a map of faults in southern Africa that were potentially active during the Quaternary (2.588 ± 0.005 million years ago to the present). This is an update of the seismotectonic map of Africa produced by Meghraoui et al. (2016). It should be noted that the 2.588 Ma time period is considerably longer than that commonly used in the definition of an "active fault". For example, the glossary in the International Handbook of Earthquake and Engineering Seismology (Aki and Lee, 2003) define an active fault as "a fault that has moved in historic (e.g., past 10,000 years) or recent geological time (e.g., past 500,000 years)". Only two of these faults (Kango and Bosbokpoort) have palaeoseismological evidence of large earthquakes of magnitude exceeding M7 that caused surface ruptures. It is not clear whether the fissure created by the 1809 Cape Town earthquake (ML6.1) is a surface expression of the fault rupture or the result of near-surface mass movement caused by the shaking. A literature search yielded descriptions of several other faults that have been active during the Quaternary. For example, a thrust fault exposed in an open pit platinum mine near Brits that displaced strata with a maximum age of 175,000 by about 4 m; and a fault near the KwaZulu-Natal – Mozambique border that displaced the 75,000 year-old Port Durnford Formation by 30 m. For further details see the sections headed 'Neotectonics' and "Paleoseismology" in **Appendix A**.

In summary, a lot is known about the risk that earthquakes pose to EGI from work done both locally and internationally, although further work (e.g. sensitive seismic monitoring, detailed geological and geotechnical mapping) would be beneficial to improve understanding of site specific hazards.

3.3 Key sensitivities within the proposed corridors

Earthquake-related hazards are divided into two categories: (i) primary hazards viz. ground shaking and displacement, and (ii) secondary hazards viz. landslides, soil liquefaction. Parts of the Expanded EGI corridors that are sensitive to earthquake hazards lie within the following regions.

- Regions with **elevated seismic hazard**. An earthquake may cause the ground and EGI to shake to such an extent that damage occurs; or the earthquake rupture causes a displacement between opposite sides of the fault that is large enough to damage structures or break cables that straddle it. Aftershocks may exacerbate the damage caused by the main shock. [Generally the largest aftershock is about 1.2 magnitude units smaller than the main shock (Båth, 1965).] There are numerous examples of damage to EGI as a result of earthquakes in tectonically-active regions (e.g. Fujisaki et al. 2014). Moderate dynamic loading may occur throughout South Africa however while large dynamic loading is possible; the probability of it occurring is estimated to be very low within decadal timescales. EGI built according to international standards should be resilient to this (see **Appendix C**).
- Regions **prone to landslides** and/or characterised by **problem soils** (i.e. soils that are prone to collapse, swelling or liquefaction). Earthquake shaking may trigger landslides and rockfalls and cause soils to liquefy. All these phenomena may lead to damage and loss.

These earthquake-related phenomena could cause damage to EGI that might disrupt the supply of electricity. In worst cases, the damage could trigger a cascade of secondary impacts, e.g. damage to nearby infrastructure and associated impacts/releases.

Of course, there are other many other natural and anthropogenic hazards that may have an impact on these structures, such as storms, floods, wildfires, aircraft crashes and terrorist attacks, and thus the mitigation of the risk posed by earthquakes should not be considered in isolation, but as part of an integrated DRR strategy. The Disaster Management Act (Act 57 of 2002; amended in Act 16 of 2015) makes it obligatory for each metropolitan and district municipality to develop such a strategy.

3.3.1 Probabilistic Seismic Hazard Assessment

The latest and most complete assessment of seismic hazard (PSHA) in South Africa was performed by the Council of Geoscience (Midzi et al. 2018) using an up-to-date homogenised earthquake catalogue. Here we extend the CGS assessment to focus on the energy corridors (Appendix B). The main results for the PGA calculations are shown in Figure 3.

It is important to realise that these are probabilistic estimates made on a relatively coarse grid (0.5° x 0.5°) and at a few key localities. There is no quick and easy way to increase spatial resolution or reduce uncertainty in the PSHA calculations. This can only be done through decades or centuries of monitoring. Identification and mapping of palaeoseismic faults will require extensive field work.

The PGA (10% probability of exceedance in 50 years) in the Eastern and Western extension corridors reach values of about 0.04 g and 0.07 g, respectively. These values are typical of MMI VI, where the shaking is strong enough to cause alarm but only cause minor damage to buildings and well below the damage thresholds of modern EGI (Appendix C). Larger events are possible, but have recurrence times of centuries.

Regions where the risk is relatively high (but still low) are the Klerksdorp and Welkom mining districts in the North West and Free State Provinces, where gold mining at depths approaching 4 km had induced three shallow earthquakes with M>5 that caused damage to surface structures (M5.2, Welkom,1976; M5.3, Stilfontein, 2005; M5.5, Orkney, 2014). Here the PGA (10% probability of exceedance in 50 years) reaches values of about 0.2 g, which is typical of MMI values of about VIII where the shaking is strong enough to cause slight damage to earthquake-resistant structures, considerable damage to solid buildings, and great damage to poorly-built buildings. These regions are far removed from the EGI corridors considered here.

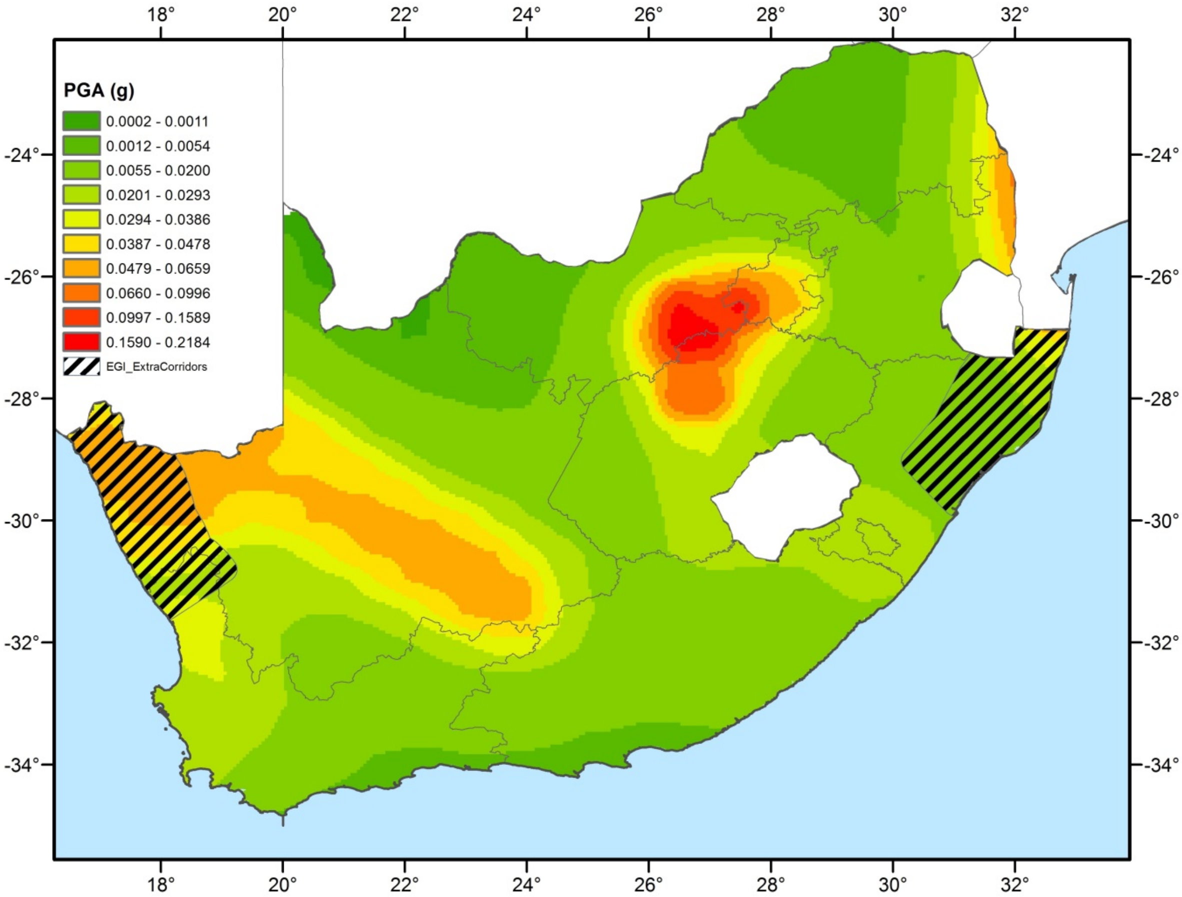

Figure 3: PGA (g) with 10% probability of exceedance in 50 years

The South African National Standard seismic hazard map and hazard zones (SANS, 2017) is shown in Figure 4 and is computed for 10% probability of exceedance in 50 years (return period of 475 years) with the nominal peak ground acceleration expressed in g (9,98 m/s^2). The parametric-historic procedure (Kijko & Graham 1998; 1999) used to produce the seismic hazard map is described in the Council for Geoscience report, *Probabilistic Seismic-Hazard Maps for South Africa*, Version 1, 2003, Pretoria (Kijko et al. 2003). The parametric-historic procedure was developed to combine the best features of the "deductive" and "historic" procedures. Two zones are identified, namely: Zone I Natural seismic activity only, and Zone II Regions of mining-induced and natural seismic activity. Buildings were classified into four "importance classes": I Buildings of minor importance for public safety, e.g. agricultural buildings, etc.; II Ordinary buildings, not belonging to the other categories; III Buildings for which seismic resistance is of importance in view of the consequences associated with a collapse, e.g. schools, assembly halls, cultural institutions, etc.; and IV Buildings for which integrity during earthquakes is of vital importance for protection, e.g. hospitals, fire stations, power plants, etc. Depending on the seismic zone and importance classes, building were required to comply with certain construction standards.

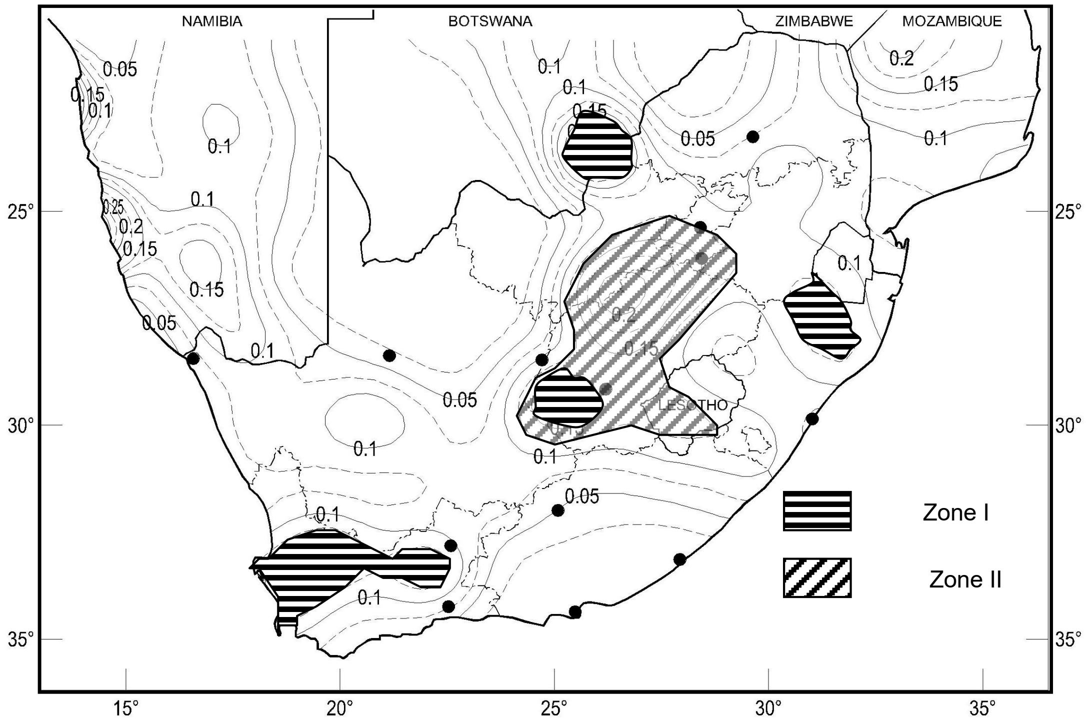

Figure 4: South African National Standard Seismic Hazard Map and Hazard Zones (SANS, 2017)

There are significant differences between the seismic hazard maps produced using Probabilistic Seismic Hazard Assessment (PSHA) method (Figure 3) by Midzi et al (2018) and the parametric-historic method (Figure 4) by Kijko & Graham (1998, 1999), most significantly in the distribution of areas with relatively high PGAs. Both methods agree that PGAs >0.1g have a 10% or greater chance of exceedance in 50 years in the gold mining districts. However, there are large differences with regard to the assessment of the hazard posed by tectonic seismicity. The parametric-historic method gives greater weight to the regions where the large earthquakes have been recorded in the last century (e.g. southern Free State, Western Cape, northern KwaZulu-Natal), while the PSHA method places greater weight on regions with generally elevated seismicity (e.g. Northern Cape). It is beyond the scope of this study to evaluate the methods, apart from noting that the PSHA method places great emphasis on the definition of seismic source zones using both seismic and non-seismic data, while the parametric-historic method relies on seismic data alone. Of course, the ultimate test lies in the accuracy of their predictions. Unfortunately this will take decades or even centuries as large events are rare and the predictions are long term. They may be considered to provide an example of the challenges of earthquake hazard assessment

3.3.2 Landslide Hazards

Comprehensive surveys of the **landslide hazards** in KwaZulu-Natal and South Africa have been conducted by Singh et al. (2008, 2011). The landslide susceptibility map is shown in Figure 5. [Note that the predominant trigger of landslides is intense rainfall, not earthquakes.] Landslide susceptibility is low for the western EGI corridor, but is significant in parts of the eastern corridor.

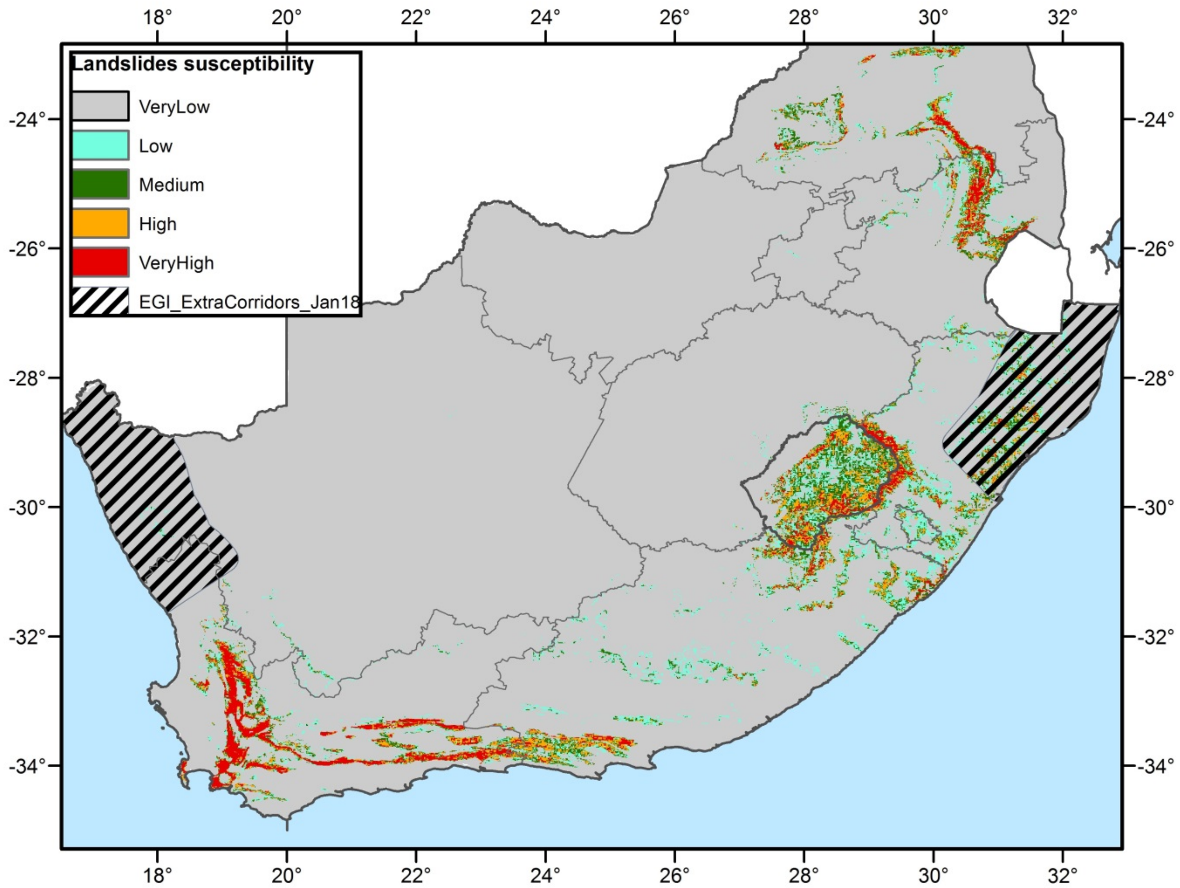

Figure 5: Landslide susceptibility map. This page of the CGS Geohazard Atlas can be viewed online at http://197.96.144.125/jsviewer/Geohazards/index.html. (Singh et al. 2011)

3.3.3 "Problem-Soil" Hazards

The EGI will require excavation for the power line pylons. Thus the upper few meters of the earth should be mapped at the proposed pylon locations to establish the optimum trenching method (e.g. what type of mechanical excavator is required, or if blasting is necessary). Some soils may liquefy during an earthquake. These zones should be identified so that they can be taken into account when choosing EGI routes or deciding on remedial measures. However, it is important to note that some soils can create problems even in the absence of earthquakes. The severity of the problem along proposed EGI routes should be assessed by geotechnical engineers as it is affected by a host of factors (e.g. soil properties and thickness, weight and 'footprint' of structures) that affect the cost of remedial measures (e.g. re-routing of EGI, re-siting of infrastructure, re-design of foundations). Problem soils are divided into two main categories.

i. **Collapsible soils** (Figure 6), also known as metastable soils, are unsaturated soils that undergo a large volume change upon saturation. The sudden and usually large volume change could cause considerable structural damage. The most common types are aeolian soils, typically wind-deposited sands and or silts, such as loess, aeolic beaches, and volcanic dust deposits characterized by showing in-situ high void ratios and low unit weights; and residual soils, which are a product of the in-situ weathering of local parent rocks that leaches out soluble and colloidal materials producing soils with a large range of particle size distribution and large void ratios. Collapsible residual granite sand is found in parts of the Expanded Eastern EGI Corridor; and collapsible transported sands are found in parts of both the Expanded Eastern and Western EGI Corridors.

ii. **Swelling soils** (Figure 7), also known as expansive clay soils, are prone to large volume changes (swelling and shrinking) that are directly related to changes in water content. Soils with a high content of expansive minerals can form deep cracks in drier seasons or years, e.g. the 'black turf', a product of the weathering of the mafic rocks of the Bushveld Complex (not located within the Expanded EGI corridors). The occurrence of swelling soils in the Expanded Eastern EGI Corridor ranges from "very low" to "moderate to high" (in some small sections). The occurrence of swelling soils in the Expanded Western EGI Corridor is "very low".

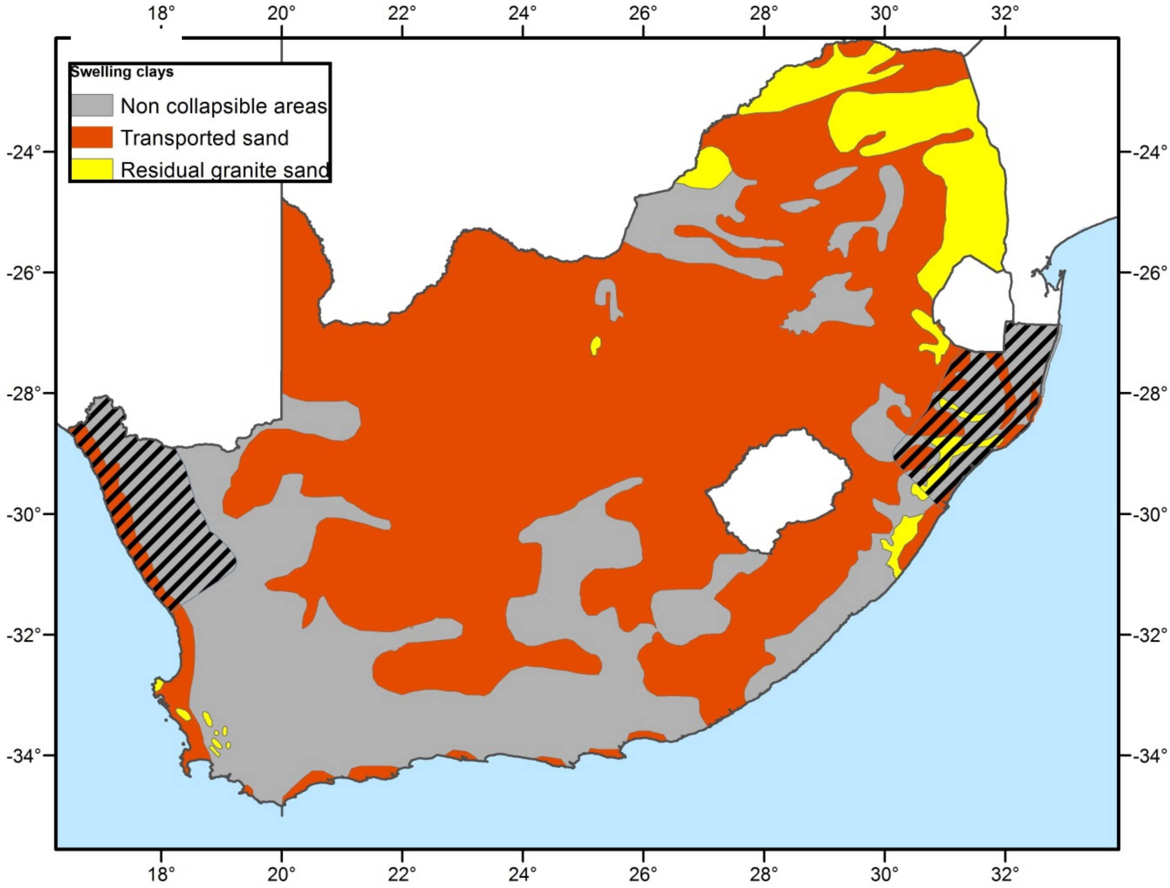

Figure 6: Collapsible soils. This page of the CGS Geohazard Atlas can be viewed online viewed at http://197.96.144.125/jsviewer/Geohazards/index.html

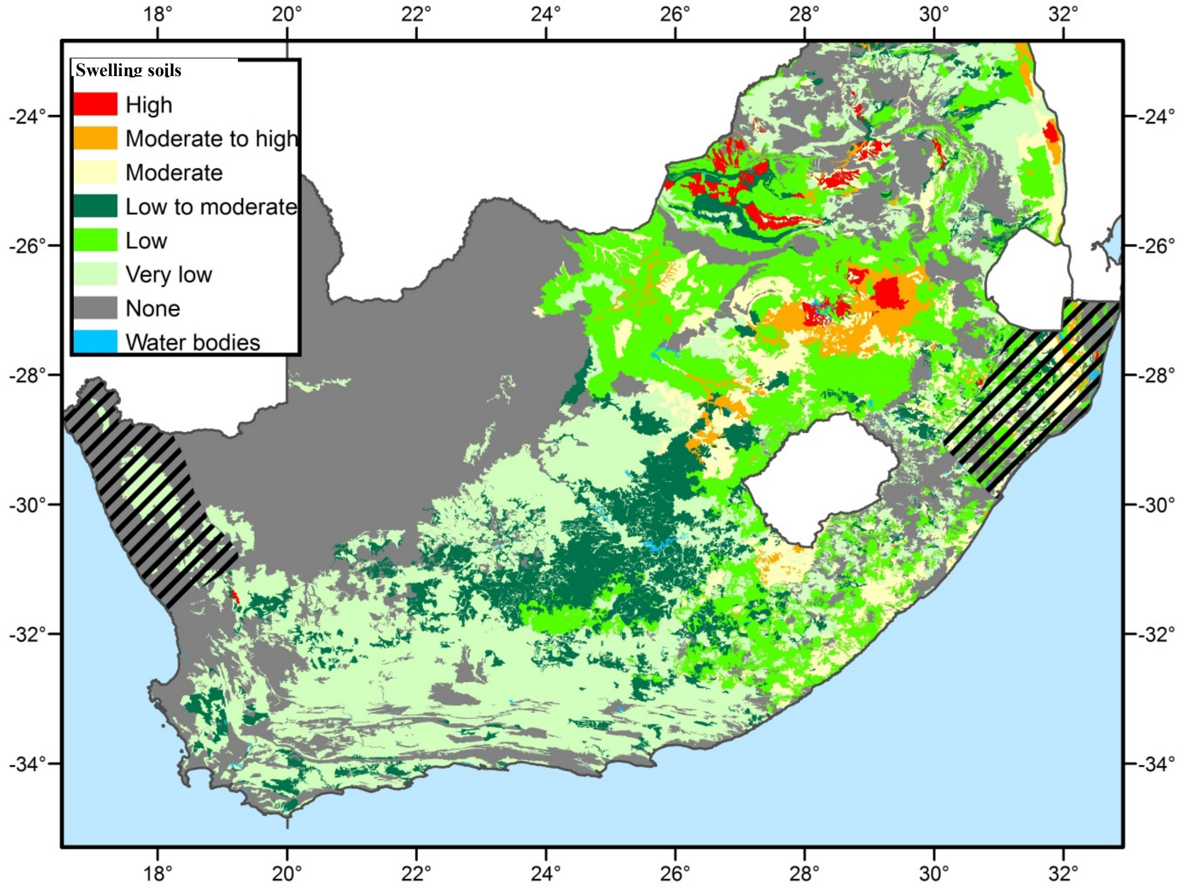

Figure 7: Swelling soils. This page of the CGS Geohazard Atlas can be viewed online viewed at http://197.96.144.125/jsviewer/Geohazards/index.html

3.4 Key sensitivities criteria

The following criteria are proposed to identify regions where EGI may be sensitive to the effects of earthquakes:

1. Elevated seismic hazard, *viz.* regions that have:
    a. Historical or instrumental records of M>5 earthquakes,
    b. Paleoseismic evidence of M>6 earthquakes (age <100,000 years, indicated by mapped and dated fault scarps),
    c. PGA>0.05 g (475 years recurrence, equivalent to 10% probability of exceedance in 50 years), or
    d. Active faults (indicated by present-day seismic activity).
2. Elevated vulnerability, *viz.* sub-regions that have:
    a. Steep topography prone to seismically-triggered landslides,
    b. Thick near-surface low-seismic-velocity layers prone to site amplification, or
    c. Saturated soils and sands prone to liquefaction when shaken.

The pertinent results of the PSHA (Midzi et al. 2018, Appendix B), landslide susceptibility and problem soil cover for the EGI corridors are summarised in Table 4 below. A value of 7.5 has been used for M_{max}. In their global study of M_{max} in stable continental regions, Vanneste et al. (2016) found that M_{max}7.9, and suggested that the recurrence rate for an event this size in an area of 10^6 km^2, roughly the size of South Africa, was about 70,000 years.

Table 4: Corridor Sensitivities

<table>
<tr><th>Site</th><th>Brief description
PGA (peak ground acceleration) and PSA (peak spectral acceleration) for a return period of 475 years (10% probability of exceedance in 50 years); M_{max} is the size of the largest credible earthquake.</th></tr>
<tr><td>Expanded Eastern EGI Corridor</td><td>
East coast from Mozambique border to beyond eThekwini Metropolitan.
The Tugela Fault has been mapped as “potentially active” by Manzunzu et al. (2019); and a fault near the KwaZulu-Natal – Mozambique border that displaced the 75,000 year-old Port Durnford Formation by 30 m is described by Kruger and Meyer (1988).
Areas of rugged topography are prone to landslides. These are generally triggered by high rainfall, which may occur from time to time.
Collapsible residual granite soils and collapsible transported sands are found in limited areas.
Swelling soils occur in some areas
M_w>6 tectonic earthquake occurred near St Lucia (1932, with liquefaction).
M_w>6 events could recur one or twice per century
M_{max}<7.5
PGA<0.03 g except for extreme northern KZN.
Estimates of PGA and PSA on bed rock for Richards Bay
<table>
<tr><th>PGA</th><th>PSA= 0.1s</th><th>PSA = 0.5s</th><th>PSA = 1.0s</th></tr>
<tr><td>2.74E-02</td><td>6.14E-03</td><td>3.24E-04</td><td>8.46E-05</td></tr>
</table>
</td></tr>
<tr><td>Expanded Western EGI Corridor</td><td>
Namibian border towards Abrahamvilliersbaai
Several faults have been mapped as “potentially active” by Manzunzu et al. (2019).
Areas of rugged topography are prone to landslides. These are generally triggered by high rainfall, which is rare.
Collapsible transported sands are found along the coast line
Swelling soils do not occur
No recorded M>6 earthquakes
M_w>6 events could recur one or twice per century
M_{max}<7.5
Estimates of PGA and PSA on bed rock for the Namaqua National Park (NNP) and Loeriesfontein (LF)
<table>
<tr><th></th><th>PGA</th><th>PSA= 0.1s</th><th>PSA = 0.5s</th><th>PSA = 1.0s</th></tr>
<tr><td>NNP</td><td>4.41E-02</td><td>2.91E-02</td><td>9.12E-04</td><td>6.90E-05</td></tr>
<tr><td>LF</td><td>3.38E-02</td><td>9.25E-03</td><td>2.17E-04</td><td>2.30E-05</td></tr>
</table>
</td></tr>
</table>

Sensitivity maps have not been produced because of the poor resolution of probabilistic seismic hazard assessments, large uncertainties, and the lack of detailed information regarding currently active faults and near-surface geology. Note also that no active faults have been mapped because the accuracy of earthquake locations is too poor to definitively associate them with a particular fault plane, and no historical earthquakes have caused surface ruptures. The fissure created by the 1809 Cape Town earthquake is considered more likely to be due to near-surface slip or spreading caused by the shaking than to be the surface expression of the fault rupture itself.

4 ASSESSMENT OF THE IMPACT OF EARTHQUAKES AND MANAGEMENT ACTIONS

In this desktop study we review what is known about earthquake hazard and risk in South Africa along the EGI corridors, as well as international standards and best practice for the mitigation of the risk posed by earthquakes to EGI.

As noted above, shaking may directly damage EGI; and also cause damage indirectly by triggering landslides and rockfalls, causing soils to liquefy, or even dams to fail. All these phenomena may lead to damage and loss. Consequently, a cascade of effects needs to be considered involving large uncertainties. Earthquake-related phenomena could cause damage to EGI that might disrupt the supply of electricity. In worst cases, the damage to EGI could trigger a cascade of other hazardous phenomena (secondary impacts) such as fires, explosions, asphyxiation, electrocution, release of toxic and radioactive substances, etc.

Two hazard scenarios are considered:

1. **Direct impact** i.e. ground displacement across the earthquake fault that is large enough and/or ground motion that that is strong enough to damage EGI. A significant surface rupture would likely require an earthquake with M>7, producing a surface rupture with a length of 20-80 km and a displacement exceeding 0.5 m. The likelihood of such an earthquake occurring in South Africa is considered to be of the order of 1/1000 per annum. The likelihood of a randomly located active fault being close enough to an EGI element (substation or pylon) to damage it is perhaps 1/10, and thus the combined probability of an M>7 occurring and damaging EGI is perhaps 1/10,000 per annum. Shaking strong enough to cause damage to nearby EGI would likely require a tectonic earthquake with M>6 or a shallow mining-related earthquake with M>5.
2. **Indirect impact** i.e. ground displacement such as landslides, liquefaction and lateral spreading triggered by the earthquake shaking causes damage to EGI.

While considered unlikely, such events are certainly possible. In the last 120 years, three M>6 earthquakes have occurred, giving an average recurrence time of, say, 40 years. However, none of these events caused a surface rupture. A M7.4 event that occurred about 10,000 years ago in the Cape Fold Belt had a rupture length of about 80 km and a throw of up to 2 m. The M7.0 earthquake that occurred in the Machaze district of Mozambique in 2006 had a rupture length of the order of 40 km and a maximum displacement 1.0-1.5 m. The Hebron fault in Namibia is another example of a southern African fault with clear surface offsets, although the number and magnitude of the events that formed this scarp remain debatable (White et al. 2009). Tectonic earthquakes could occur anywhere in South Africa. Three M>5 mining-related earthquake have occurred in the last 50 years, and caused strong shaking due to their shallow origin. None of these events caused a surface rupture, although the tectonic earthquakes triggered some sort of ground displacement, notably a few landslides or areas of liquefaction. The mining-related earthquakes did not cause any landslides or liquefaction, probably because there were no susceptible conditions nearby. However, the risk of a tailings dam liquefying cannot be overlooked. On the night of 22 February 1994 a tailings dam failed due to operational shortcomings and flooded the suburb of Merriespruit in Virginia in the Free State. Eighty houses were destroyed, 200 houses were severely damaged, and 17 people were killed. The frequency of earthquakes capable of triggering indirect impacts is considered to be of the order of 1/20 per annum. The maximum distance from the epicentre in which significant mass movements (e.g. landslides) could be triggered is about 50 km for 5<M<6.5 earthquakes.

Table 5 below indicates the potential impacts, effects and mitigation.

Table 5: Potential Impacts, effects and mitigations

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
Expanded Eastern Corridor	Earthquakes cause direct and indirect damage to EGI. Direct Impact M>7 earthquake causes fault displacement over 20-80 km that damages EGI Indirect Impact Landslides, liquefaction or lateral spreading that damages EGI triggered by a M>6 tectonic earthquake or M>5 shallow mining-related earthquake	The Durban area is subject to local amplification and shaking. Distant moderate events have caused alarm. Liquefaction was observed following the 1932 St Lucia earthquake Areas with rugged topography in KZN are prone to landslides. These are generally triggered by high rainfall.	Disruption of electricity supply. In worst cases, the damage could trigger a cascade of other hazardous phenomena that may cause harm to the environment and people (secondary impacts). For example, fires, explosions, asphyxiation, electrocution, release of toxic and radioactive substances.	Avoid sites prone to landslides, lateral spreading and liquefaction, or the infrastructure will be strengthened or made more flexible, or the ground will be improved, or some combination of these measures will be implemented
Expanded Western Corridor		The 1969 Ceres-Tulbagh earthquake damaged buildings and triggered rockfalls. The 1809 Cape Town earthquake caused surface fissures.		

The risk posed by earthquakes to EGI in South Africa is considered to be generally low, provided local ground motion amplification, liquefaction and land slide phenomena are taken into account. For example: liquefaction was observed following the 1932 St Lucia earthquake; the Durban area seems to be subject to local amplification, and shaking due to distant moderate events has occasionally caused alarm; and soils in the Milnerton area of Cape Town could be prone to amplification and even liquefaction if subjected to shaking similar to that produced by the earthquakes that struck the region in 1809 and 1811.

Lastly, it should be noted that there are very few 'no go' areas for earthquake engineers. They have the option of either: (i) avoiding sites that are susceptible to earthquake damage; (ii) stabilising the sites e.g. driving piles, using raft foundations, dewatering potential landslides, anchoring critically-balanced rocks; or (iii) reinforcing or protecting the EGI. The decision is based on numerous factors, including environmental impacts, risk and cost.

5 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS FOR EARTHQUAKES

5.1 Planning phase

Map the regions within the EGI corridors that have:

- (i) Historical or instrumental records of M>5 earthquakes,
- (ii) Palaeoseismic evidence of M>6 earthquakes (age<100,000 years), or
- (iii) Seismically-active faults.

Within the corridors, map sub-regions that have either:

- (i) Steep topography prone to seismically-triggered landslides,
- (ii) Thick near-surface low-seismic-velocity layers that could cause site amplification, or
- (iii) Saturated soils and sands that could liquefy when shaken.

These regions should be designated as "sensitive".

Current knowledge, as summarised in Appendix A, is inadequate to map these regions accurately. It must be remembered that the duration of the earthquake catalogue is short compared to the likely recurrence time of M>5 events. The current national network is simply not dense or sensitive enough in these regions to relate earthquake hypocentres to any particular fault. Geological maps frequently show numerous faults, but it is important to realise that these faults are the result of tectonic forces and earthquakes that might have been active tens, hundreds or even thousands of millions of years ago. The mapping of currently active faults involves arduous palaeoseismic studies and detailed and sensitive seismic mapping.

Site effects are an important consideration (see e.g. Tamaro et al. 2013). The account of site effect (at least its first approximation) can be done by the account of average S velocity (Vs30) of the top 30 meters. Vs30 can be calculated from the topographic slope (Allen and Wald, 2007) and its implementation is easy (e.g. Atkinson and Boore, 2006). Geological and geophysical investigations should be conducted in “sensitive” regions to quantify the hazard of landslides, strong ground motion or liquefaction. Should these surveys indicate that there is a significant probability that EGI damage thresholds will be exceeded, the EGI should either be relocated, reinforced or protected (e.g. landslide mitigation measures).

The Vaalputs nuclear waste disposal site and the Thyspunt nuclear build site are examples of sites in South Africa where such studies have been conducted. For example, sensitive and dense local seismic networks have been deployed, historical records have been scoured for evidence of earthquakes, geotechnical surveys of the near surface have been conducted, and trenches have been dug for palaeoseismic studies. Similarly the detailed mapping of areas that may be prone to local site effects such as amplification, liquefaction and landslides requires detailed geological, geotechnical and geophysical mapping. This activity is known as ‘microzonation’. Such studies have been carried out at nuclear power station sites and nuclear waste disposal sites. The Council for Geoscience recently commenced seismic microzonation studies in the Johannesburg and Cape Town areas.

Some of the world’s most technologically-advanced countries are exposed to seismic hazard, for example, Italy, Japan and the USA. Standard methodologies have been developed to assess seismic hazard; numerous studies have been conducted to assess the risk posed by earthquakes to lifelines; and engineering specifications for EGI have been published. It must be emphasised that risk posed by earthquakes is generally not viewed in isolation, but as part of a multi-hazard strategy. For example:

- *Earthquake Resistant Construction of Electrical Transmission and Telecommunication Facilities Serving the Federal Government,* published by the US Federal Emergency Management Agency (FEMA, 1990)
- *Plan for Developing and Adopting Seismic Design Guidelines and Standards for Lifelines,* published by the US Federal Emergency Management Agency (FEMA, 1995)
- *Protecting Electricity Networks from Natural Hazards*, published by the Organization for Security and Co-operation in Europe (OSCE, 2016).
- *Power Grid Recovery after Natural Hazard Impact,* published by the Joint Research Centre of the European Commission (Karagiannis et al. 2017)

5.2 Construction phase

Install sensors and monitor both weak and strong ground motion in “sensitive” regions to improve hazard assessments.

5.3 Operations phase

Monitor both weak and strong ground motion in “sensitive” regions to improve hazard assessments. If necessary, increase the sensitivity and/or density of the sensors. Relocate, reinforce or protect the EGI if a significant increase in hazard or risk is indicated.

5.4 Rehabilitation and post closure

Not applicable.

5.5 Monitoring requirements

Statutory requirements for instruments to monitor ground motion are listed in Appendix C. In summary, the South African National Standard (SANS 4866:2011, based on ISO 4866:2010) specifies measuring ranges for various vibration sources, including earthquakes and blasts. These standards should be applied when carrying out surveys related to EGI.

The standard prescribes that instruments used to monitor ground-borne blast vibrations must be capable of measuring ground motions over the range 0.2 mm/s to 100 mm/s in the frequency range of 1 Hz to 300 Hz; while instruments used to monitor earthquakes must be capable of measuring ground motions over the range 0.2 mm/s to 400 mm/s in the frequency range of 0.1 Hz to 30 Hz.

6 GAPS IN KNOWLEDGE

A great deal is known about the impact of earthquakes and faults on EGI from work done in regions that are both highly-developed and tectonically-active, such as Italy, Japan and the western USA.

South Africa has a seismic monitoring network and a homogenized earthquake catalogue, although further work is required to reduce the uncertainties in hazard assessment along particular corridors and at specific sites. In particular, this would involve:

- Sensitive seismic monitoring to detect active faults.
- Strong motion monitoring to determine local ground motion prediction equations (GMPEs). However, it could take decades or even centuries to produce useful results as large earthquakes are rare.
- Determination of local site effects by geological, geotechnical and geophysical surveys.
- Analysis of ground response through amplification studies e.g. multi-channel analysis of surface waves (MASW) to determine the average shear wave velocity in the uppermost 30 metres (V_s30) and spectral ratio surveys.
- Detailed paleoseismological and geological mapping to map the length and throw of prehistoric fault ruptures, and geochronological studies to date the events.
- Detailed site-specific PSHA.
- Liquefaction potential analysis.
- Landslide susceptibility studies.
- Detailed assessment of the vulnerability of EGI.

In general, there is however sufficient information available to guide decisions on EGI development in South Africa. South Africa is regarded as a stable continental region. Earthquakes are far less frequent than in tectonically active regions such as Italy, Japan and the western USA. This does not mean that strong earthquakes cannot occur; but that the return periods are centuries or millennia. Experience in developed tectonically-active countries has shown that EGI is generally resilient to high intensities of ground motion. It is recommended that focused studies of earthquakes risk be conducted at critical EGI sites such as power stations and sub-stations situated in areas deemed to be exposed to a higher risk of damage (see Table 4).

7 CONCLUSIONS AND FURTHER RECOMMENDATIONS

Based on the findings above and provided that appropriate management actions are implemented when planning and constructing EGI, both the expanded Eastern and Western EGI corridors are deemed suitable for power line infrastructure development. Attention should be given to local conditions that increase the earthquake hazard. For example:

- Steep slopes that are prone to landslides; and
- Thick soils and alluvium that may amplify ground motions and/or liquefy when shaken.

These sites should be avoided, or the EGI reinforced or protected appropriately.

Site specific assessments include:

- Mapping of the regions within the EGI corridors that have (i) historical or instrumental records of M>5 earthquakes, (ii) palaeoseismic evidence of M>6 earthquakes (age <100,000 years), or (iii) seismically-active faults.
- Within these regions, mapping of sub-regions that have either (i) steep topography prone to seismically-triggered landslides, (ii) thick near-surface low-seismic-velocity layers that could cause site amplification, or (iii) saturated soils and sands that could liquefy when shaken. These regions should be designated as "sensitive".
- Geological and geophysical investigations in "sensitive" regions to quantify the hazard of landslides, strong ground motion or liquefaction.
- Installation of sensors to monitor both weak and strong ground motion in "sensitive" regions to improve hazard assessments.

8 REFERENCES

Aki, K and Lee, WHK, 2003. Glossary of interest to earthquake and engineering seismologists, In: WHK Lee, H Kanamori, PC Jennings & C Kisslinger (Eds). *International Handbook of Earthquake and Engineering Seismology*. Part B. Amsterdam: Academic Press. 1793-1856.

Allen TI & Wald DJ. 2007. *Topographic slope as a proxy for seismic site-conditions (VS30) and amplification around the globe*. Open-File Report 2007-1357. U.S. Department of the Interior, U.S. Geological Survey.

Atkinson G & Boore D, 2006. Ground motion prediction equations for earthquakes in eastern North America, *Bulletin of the Seismological Society of America,* 96:2181–2205

Båth, M. 1965. Lateral inhomogeneities of the upper mantle. *Tectonophysics*, *2:*483-514.

Calais, E., Camelbeeck, T., Stein, S., Liu, M. and Craig, T.J., 2016. A new paradigm for large earthquakes in stable continental plate interiors. *Geophysical Research Letters*, 43, doi:10.1002/2016GL070815.

Durrheim, RJ, 2015. Earthquake seismology, In: J.H. de Beer (ed.), *The History of Geophysics in Southern Africa*, SUN MeDIA, Stellenbosch, pp. 22-52, ISBN 978-1-920689-80-3.

Durrheim, R.J. and Riemer, K.L., 2015. The history of mining seismology, In: J.H. de Beer (ed.), *The History of Geophysics in Southern Africa*, SUN MeDIA, Stellenbosch, pp. 85-110. ISBN 978-1-920689-80-3.

Durrheim, R., Doucouré, M. and Midzi, V., 2016. Earthquakes: In Scholes, R., Lochner, P., Schreiner, G., Snyman-Van der Walt, L. and De Jager, M. (eds). 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/

Eskom 1998. Paleoseismic investigations undertaken in the vicinity of the Tshipise and Bosbokpoort faults, and their implications for slope stability under operating conditions within the upper dam basin of the Mutale pumped storage scheme. Unpublished Report.

Eurocode http://eurocodes.jrc.ec.europa.eu/

FEMA, 1990. *Earthquake Resistant Construction of Electrical Transmission and Telecommunication Facilities Serving the Federal Government*, Report FEMA 202 September 1990, US Federal Emergency Management Agency.

FEMA, 1995. *Plan for Developing and Adopting Seismic Design Guidelines and Standards for Lifelines*, Report FEMA 271 5/96, US Federal Emergency Management Agency.

Fujisaki, E., Takhirov, S., Xie, Q. and Mosalam, K.M., 2014. Seismic vulnerability of power supply: lessons learned from recent earthquakes and future horizons of research. In *Proceedings of 9th International Conference on Structural Dynamics* (EURODYN 2014). European Association for Structural Dynamics, Porto, Portugal (pp. 345-350).

Goedhart, ML. 2017. *A paleoseismic investigation of Late Quaternary reactivation of the Kango Faults and its relevance to the siting of critical structures in the southern Cape Fold Belt, South Africa*. PhD thesis, Nelson Mandela Metropolitan University (in examination).

Grobbelaar, M, 2017. Using empirical relationships to predict PPV for surface explosions. Abstract S02-2-05, IASPEI Assembly, Kobe JAPAN 2017. https://confit.atlas.jp/guide/event/iagiaspei2017/subject/S02-2-05/advanced

Grünthal G, Bosse C, Sellami S, Mayer-Rosa D & Giardini D. 1999. Compilation of the GSHAP regional seismic hazard for Europe, Africa and the Middle East. *Annali di Geofisica*, 42:1215-1223.

GSHAP 2013. *Global Seismic Hazard Assessment Program*. Retrieved from http://www.gfz-potsdam.de/portal/gfz/Struktur/Departments/Department+2/sec26/projects/01_seismic_hazard_assessment/GSHAP (accessed 14 April 2013).

Johnson AC & Kanter LR. 1990. Earthquakes in stable continental crust. *Scientific American*, 262:68-75.

Johnston AC, Kanter LR, Coppersmith KJ & Cornell CA. 1994. *The earthquakes of stable continental regions*. Volume 1, Assessment of large earthquake potential, Final report (No. EPRI-TR-102261-V1). Electric Power Research Inst., Palo Alto USA

Karagiannis GM, Chodrogiannis, S, Krausmann, E & Turksezer ZI. 2017. *Power Grid Recovery after Natural Hazard Impact,* EUR 28844 EN, doi:10.2760/87402, European Commission, Luxembourg.

Kijko A & Graham G. 1998. 'Parametric-Historic' procedure for probabilistic seismic hazard analysis. part I: assessment of maximum regional magnitude mmax. *Pure and Applied Geophysics*, 152:413-442.

Kijko A & Graham G. 1999. 'Parametric-Historic' procedure for probabilistic seismic hazard analysis. part II: assessment of seismic hazard at specified site. *Pure and Applied Geophysics*, 154:1-22.

Kruger GP & Meyer R. 1988. A sedimentological model for the northern Zululand coastal plain. *Proceedings of the 22nd Earth Science Congress of the Geological Society of South Africa*, pp.423-426.

Kijko A, Graham G, Bejaichund M, Roblin D & Brandt MCB. 2003. Probabilistic Seismic-Hazard Maps for South Africa, Version 1, Council for Geoscience, Pretoria.

Manzunzu B. 2018. Personal Communication.

Manzunzu, B, Midzi, V, Mulabisana, TF, Zulu, B, Pule, T, Myendeki, S and Rathod, GW. 2019. Seismotectonics of South Africa. *Journal of African Earth Sciences*, 149:271-279.

Meghraoui, M, Amponsah, P, Ayadi, A, Ayele, A, Ateba, B, Bensuleman, A, Delvaux, D, El Gabry, M, Fernandes, R, Midzi, V and Roos, M. 2016. The seismotectonic map of Africa. *Episodes*, 10:9-18.

Midzi V, Manzunzu B, Mulabisana TF, Zulu BS, Pule T, Myendeki S & Rathod, G. 2018. The Probabilistic Seismic Hazard Assessment of South Africa. *Journal of African Earth Sciences* (in review).

Milev, A, Durrheim, R, Brovko, F, Kgarume, T, Singh, N, Lumbwe, T, Wekesa, B, Pandelany, T and Mwila, M, 2016, *Development of a South African minimum standard on ground vibration, noise, air-blast and flyrock near surface structures to be protected*, Final Report, Project SIM14-09-01, South African Mine Health and Safety Council Report.

Mulabisana, T, 2016. *Compiling a homogeneous earthquake catalogue for Southern Africa.* MSc dissertation (unpublished), University of the Witwatersrand Johannesburg.

New Scientist 2012. *Last year costliest on record for natural disasters.* Retrieved from http://www.newscientist.com/article/mg21328474.200-last-year-costliest-on-record-for-natural-disasters.html (accessed 20 October 2012).

OSCE, 2016. *Protecting Electricity Networks from Natural Hazards*, Organization for Security and Co-operation in Europe.

Pule T, Fourie CJ, Kijko A & Midzi V. 2015. Comparison and quantitative study of vulnerability/damage curves in South Africa. *South African Journal of Geology*. 118:335-354.

SABS 1990. *Code of practice for the general procedures and loadings to be adopted for the design of buildings*. SABS 0160-1989. Pretoria: South African Bureau of Standards.

SANS (South African National Standard) 2017. SANS 10160-4-2017. Basis of Structural Design and Actions for Buildings and Industrial Structures. Part 4: Seismic Actions and General Requirements for Buildings. Pretoria: South African Bureau of Standards. ISBN 978-0-626-30384-6.

Saunders I, Brandt M, Steyn J, Roblin D & Kijko A. 2008. The South African Seismograph Network. *Seismological Research Letters*, 79:203-210.

Singh, M. 2016. *Seismic Sources, Seismotectonics and Earthquake Recurrence for the KZN Coastal Regions*. PhD thesis (unpublished), University of KwaZulu-Natal.

Singh RG, Botha GA, Richards NP & McCarthy TS. 2008. Holocene landslides in KwaZulu-Natal, South Africa. *South African Journal of Geology*, 111:39-52.

Singh, RG, Forbes, C, Chiliza, G, Diop S, Musekiwa C & Claasen D. 2011. *Landslide Geohazards in South Africa.* Report No. 2011-0016, Council for Geoscience.

Tamaro A, Grimaz S, Santulin M & Slejko D. 2013. Characterization of the expected seismic damage for a critical infrastructure: the case of the oil pipeline in Friuli Venezia Giulia (NE Italy). *Bulletin of Earthquake Engineering*, 13: 1425-1445.

UNISDR, 2017, Terminology. United Nations Office for Disaster Risk Reduction, http://www.unisdr.org/we/inform/terminology [accessed 3 January 2018].

Vanneste K, Vleminckx B, Stein S & Camelbeeck T. 2016. Could Mmax be the same for all stable continental regions? Seismological Research Letters, 87: 1214-1223.

Van Wyk W. L. and Kent L. E. (Eds), 1974, The earthquake of 29 September 1969 in the southwestern Cape Province, South Africa: Seismologic Series 4, Geological Survey of South Africa, South Africa.

Wells DL & Coppersmith KJ. 1994. New empirical relationship among magnitude, rupture length, rupture width, rupture area, and surface displacement. Bulletin of the Seismological Society of America, 84:974–1002.

White S, Stollhofen H, Stanistreet IG, & Lorenz V. 2009. Pleistocene to Recent rejuvenation of the Hebron Fault SW Namibia. *Geological Society of London*, Special Publications, 316: 293-317.

Appendix A: Seismic Hazard in South Africa

Primary reference: Durrheim, RJ, 2015. Earthquake seismology, In: J.H. de Beer (ed.), *The History of Geophysics in Southern Africa*, SUN MeDIA, Stellenbosch, pp. 22-52, ISBN 978-1-920689-80-3.

Summary

Earthquakes were responsible for some of the most devastating disasters to occur in the early years of the 21st century. On 26 December 2004 an M_w9.1 earthquake occurred off the coast of Sumatra, triggering a tsunami that swept across the Indian Ocean, killing some 228 000 people (USGS 2012). The M_w9.0 Great Eastern Japanese earthquake and tsunami of 11 March 2011 was the costliest disaster of all time, with losses amounting to USD210 billion, not including the cost of the incident at Fukushima nuclear power station (New Scientist 2012). Fortunately, large earthquakes are relatively rare in South Africa, the most deadly earthquake on record being the M_L6.3 event that struck the Ceres-Tulbagh region on 29 September 1969, claiming the lives of nine people (Van Wyk & Kent 1974). Nevertheless, South Africans cannot afford to be complacent. A moderate-sized earthquake with a shallow focus occurring close to a town can be devastating, especially if the buildings are not designed to be earthquake-resistant, the terrain is steep and prone to landslides, or the soil is thick and prone to amplification and liquefaction.

EARLY SCIENTIFIC INVESTIGATIONS (circa 1600 to 1900)

Historical catalogues

In 1858 an Irish civil engineer named Robert Mallet (1810-1881), sometimes referred to as 'the father of seismology', published a global map of earthquake epicentres based entirely on reports of felt earthquakes (Agnew 2002). It was obvious that most earthquakes occurred in distinct zones, particularly around the Pacific Ocean and near high mountain ranges such as the Alps and Himalayas. The region surrounding the Cape of Good Hope was shaded orange, indicating that earthquakes had been felt and reported. The historical seismological catalogue for southern Africa (Brandt et al 2005, which superseded Fernández & Guzmán 1979a) lists forty-five earthquakes prior to the 20th century: four in the 17th century, three in the 18th century, and the balance in the 19th century. The catalogue is largely based on the work of Finsen (1950), Theron (1974) and De Klerk and Read (1988), who searched for reports of earthquakes in historical documents such as local newspapers and journals kept by explorers and travellers. The earliest event in the South African catalogue is dated at 1620. However, a recent re-examination of historical records by Master (2012) concluded that the event, recorded by the captain of a ship anchored in Table Bay, was most likely a thunderclap and not an earthquake. Consequently the oldest event is now dated at 1690. Discoveries of 'old' earthquakes continue to be made. For example, Master (2008) discovered a report in the *Cape Monthly Magazine* (Bright 1874) of an intensity III earthquake that was felt by many people in Maseru in February 1873, a recent study by Albini et al (2014) reviewed reports of seismic events that occurred in the Eastern Cape region between 1820 and 1936, while Singh et al (2015) were able to assign intensity values to reports of ground shaking produced by seven events felt in KwaZulu-Natal between 1927 and 1981 that were not listed in the historical database.

The most damaging event to occur in the pre-instrumental era struck the Cape Town district on 4 December 1809. Three strong quakes were felt, and many buildings suffered numerous cracks. Von Buchenröder (1830) provided an eyewitness account of the event: *In the evening, a little after ten o'clock, three shocks, each accompanied by a tremendous noise, were felt, within the space of a minute or two. .... While we were standing in the street, the second shock took place, which was felt much stronger; was accompanied by a louder, and very tremendous noise, that continued longer than the first ... The second shock roused all the inhabitants, who came running into the streets in great consternation, many of them undressed from having being in bed.* The next day Von Buchenröder undertook an inspection of the town and noted that chimneys, parapets and figurines on gables had been damaged. On 9 December he undertook an expedition to Blaauweberg's Valley (near present-day Milnerton), where he made quantitative observations of a scientific type: *[N]ear the Kraal I found rents and fissures in the ground, one of which I followed for about the extent of a mile.* The deduced intensity (on the Modified Mercalli scale) and magnitude were VII-VIII and M_L6.1, respectively (Brandt et al 2005).

The renowned explorer William Burchell provides an equally vivid account of an earthquake that struck Cape Town on 2 June 1811 in his *Travels in the Interior of Southern Africa* (Burchell 1822). He was staying in the Lutheran parsonage in Cape Town at the time: *I hastened out of doors to ascertain what had happened;[...] I came into the street and beheld all the inhabitants rushing out of doors in wild disorder and fright; [...] when I beheld this, I instantly guessed that an earthquake had happened.* Burchell goes on to describe the structural damage: *Walking afterwards about the town [...] I was told that many houses* *were exceedingly rent, and some more materially damaged; but none were actually thrown down [...] Many of the ornamental urns which had escaped the earthquake of 1809, were now tumbled from the parapets down into the street [...] and the wall of my bedroom was in the same instant divided by a crack which extended from the top of the house to the bottom.* The deduced intensity (on the Modified Mercalli scale) and magnitude were VII and M_L5.7, respectively (Brandt et al 2005).

INSTRUMENTAL SEISMOLOGY (circa 1900 – 1970)

The first seismometer installed in South Africa was a Milne-type horizontal pendulum instrument installed at the Royal Observatory in Cape Town in 1899 (Schweitzer & Lee 2003). It was deployed as part of a campaign to establish a worldwide seismograph network. Seismometers were installed in Johannesburg in 1910 to monitor earth tremors associated with mining, one in the Union Observatory and another near Ophirton. While most events were related to mining activity, some natural regional events were also recorded (Wood 1913). Over the next fifty years, seismometers were installed in Cape Town, Johannesburg, Grahamstown, Pietermaritzburg, Kimberley and Pretoria. Details of these early installations are provided by Wright and Fernández (2003).

A network of five seismographs was deployed on the northern rim of the Witwatersrand Basin in 1939 by researchers at the newly established Bernard Price Institute for Geophysics (BPI) at the University of the Witwatersrand. Data were transmitted by radio to a central point, where continuous 24-hour registration, coupled with an ingenious device that triggered distant seismographs, allowed all the larger mining-related events to be located accurately in space and time (Gane et al. 1949; 1946). This was the first use of a telemetered network anywhere, and is the only South African achievement included in the 'History of Seismology' chapter in the *International Handbook of Earthquake and Engineering Seismology*, published by the International Association for Seismology and the Physics of the Earth's Interior (IASPEI) (Agnew 2002).

It is important to note that instrumental recording does not guarantee correct location, especially in the early period. For example, the International Seismological Summary (ISS), the most comprehensive global earthquake catalogue for the time period between 1918 and 1963, lists a M6.5 earthquake on 31 October 1919 with its epicentre in Swaziland based on phase readings from 22 stations distributed around the globe. The absence of any local reports of shaking or damage led Manzunzu and Midzi (2015) to investigate its authenticity. They concluded that the event did not occur in Swaziland and should be removed from the local catalogue. The mis-location was either due to the wrong association of phases by ISS, or the simultaneous recording of phases from multiple events.

THE SOUTH AFRICAN NATIONAL SEISMOGRAPH NETWORK (1971 to the present)

The history of the South African National Seismograph Network (SANSN) is comprehensively reviewed by Saunders et al., (2008), so only a few highlights will be mentioned here. The first seven short-period (1 sec) vertical component seismic stations of the SANSN were deployed in 1971, shortly after the Ceres-Tulbagh event. Since then the SANSN has provided the essential infrastructure for the assessment of seismic hazard in South Africa. By 1997 the network had expanded to twenty-seven stations. In 1991 several digital seismographs were installed, first with dial-up landlines and later with dial-up GSM (Global System for Mobile Communications) modems.

The network was rejuvenated and modernized in 2003, partly motivated by a seismic hazard assessment programme in support of the South African government's plan to build nuclear power stations. Seven Geotech KS-2000 broadband seismometers (100 s) were installed across the network, and Guralp CMG-40T three-component extended short-period (30 s) seismometers at the other stations. There is also one very broadband Streckeisen STS-2 (120 s) seismometer at Silverton. Delays in transferring the waveforms of the Stilfontein event of 9 March 2005 triggered further upgrades to the SANSN to enable near-real-time data transmission. In 2006 seismic stations were installed in the Far West Rand (KLOF) and Central Rand (ERPM) gold fields. The KLOF station also recorded triggered data at 750 Hz, compared to the SANSN continuous recording standard of 100 Hz.

The velocity model is one of the most important factors affecting the accuracy of earthquake locations. Midzi et al. (2010) reviewed the model used by the SANSN and derived a new 1-D model by inverting P-wave travel times recorded by the SANSN. Moment tensors provide important information for seismotectonic and hazard studies. However, earthquakes with M_w<4.5 are too weak to be analysed using global moment tensor techniques. Prior to 2010, moment tensors had only been calculated for six South African earthquakes. Brandt & Saunders (2011) supplemented seismograms recorded by the SANSN with data recorded between 1996-1999 by the Southern African Seismic Experiment (SASE), conducted by the Wits University, MIT and the Carnegie Institute of Washington. The data were used to compute regional moment tensors (RMTs) for three near-regional M_w~4.0 earthquakes, two of which were mining-related events in the Far West Rand gold field, while the third was a tectonic event from the Koffiefontein cluster. The M_L scale for South Africa was recalibrated using 263 tectonic earthquakes recorded by the SANSN from 2006 to 2009 at epicentral distances of 10-1000 km, and station corrections determined for twenty-six stations (Saunders et al 2013). The anelastic term derived in this study indicated that the ground motion attenuation is significantly different from that of Southern California (which had been used previously), but comparable with other stable continental regions.

The Council for Geoscience (CGS) also operates seismographs stations and/or delivers data as a service to other organizations.

US Geological Survey National Earthquake Information Centre (NEIC) and the International Seismological Centre (ISC): The CGS releases digital seismological data, including phase readings and located epicentres, to the NEIC and ISC, where the phase readings are incorporated in international bulletins and released.

Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO): South Africa ratified the Comprehensive Nuclear Test Ban Treaty (CTBT) in 2003, and the CGS is responsible for the operation and maintenance of two stations of the International Monitoring System (IMS): a primary seismograph and infrasound station at Boshof (BOSA), and an auxiliary seismograph station at Sutherland (SUR). The stations are equipped with both short-period (1 s) and very broadband (120 s) sensors. The BOSA station is also part of the Global Telemetered Seismological Network (GTSN) of the US Air Force, while the SUR station is part of the Global Seismological Network (GSN) operated by the Incorporated Research Institutions for Seismology (IRIS).

Indian Ocean Tsunami Warning System (IOTWS): The devastating Indian Ocean tsunami of 26 December 2004 led to an initiative to establish the IOTWS by the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO). In June 2005, during the 23rd session of the IOC, the Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWS) was formally established. Five SANSN stations were equipped with broadband equipment and were linked to the IOTWS. In 2018 the group had 28 member states, including South Africa. Many countries participate through national tsunami warning centres. However, three Regional Tsunami Service Providers (Australia, India and Indonesia) are the primary source of tsunami advisories for the Indian Ocean (http://iotic.ioc-unesco.org/indian-ocean-tsunami-warning-system/tsunami-early-warning-centres/57/regional-tsunami-service-providers; last access 30 April 2018).

AfricaArray (2005-present): The Council for Geoscience was a founding member of the AfricaArray programme, established in 2005 (Nyblade et al 2008; Nyblade et al 2011). CGS contributes data from eleven broadband stations to the programme. The data is archived at the IRIS facility in the US.

Water Ingress Project (2008 – present): A 12-station-strong ground motion array was deployed in the Central Rand in 2008 to monitor seismicity associated with the flooding of mines.

Mine Health and Safety Council (2010-present): A 25-station-strong ground motion array was established in the Klerksdorp region to monitor mining-related seismicity in 2010. The array proved its worth when it recorded the M_L5.5 event that occurred on 5 August 2014 and its numerous aftershocks.

Observational Study in South African Mines to Mitigate Seismic Risks (2010-present): A 10-station array was deployed in 2011/12 in the Far West Rand mining district to monitor mining-related seismicity as part of a Science and Technology Research Partnership for Sustainable Development (SATREPS) project. SATREPS is a Japanese-South African collaboration funded by the Japan Science and Technology Agency (JST), Japan International Cooperation Agency (JICA), the Department of Science and Technology (DST), the Council for Geoscience, and the CSIR (Durrheim et al 2012; Durrheim et al 2010).

MEASUREMENTS OF STRESS AND STRAIN IN THE EARTH'S CRUST

Earthquakes are driven by stresses in the Earth's crust that are indirectly quantifiable by measuring strains in the rock. Crustal deformation is often extremely difficult to measure, as rates of strain and tilt are generally extremely small, especially in 'stable' continental regions.

Stress measurements in southern Africa

In the early 1970s Nick Gay of the BPI compiled in situ stress measurements made at fifteen localities in South Africa, Rhodesia (now Zimbabwe) and Zambia (Gay 1975). At that time, the most commonly used strain cell was the CSIR doorstopper developed by Leeman (1964, 1969). Measurement depths ranged from 20-2500 m. At shallow depths the horizontal stresses are generally greater than the vertical stresses, but at greater depths the vertical stresses are about double those acting horizontally. Gay subsequently published two important global reviews (McGarr & Gay 1978; Gay 1980). Stress measurements in the mining districts were compiled by Stacey & Wesseloo (1998).

Neotectonic studies

There are several concepts related to the assessment of earthquake hazard that are often used loosely, and hence we recommend using definitions contained in the glossary in International Handbook of Earthquake & Engineering Seismology (Aki & Lee 2002).

Active fault: A fault that has moved in historic (e.g. past 10,000 years) or recent geological time (e.g. past 500,000 years). It should be noted that all faults that move in earthquakes today are active, but not all active faults generate earthquakes – some are capable of moving aseismically.

Neotectonics: The study of post-Miocene structures and structural history of the Earth's crust (the Miocene ended about 5 million years ago).
Paleoseismology: The study of ancient earthquakes decades, centuries or millennia after their occurrence, made possible by evidence of surface faulting, displacements in young sediments, or other near-surface phenomena such as liquefaction.

Meghraoui et al (2016) published the Seismotectonic Map of Africa, showing faults considered to have been active since the Quaternary (2,588 Ma to present) and during the last 150 ka. Manzunzu et al (2019) published a study of the seismotectonics of South Africa, in which they update Meghraoui et al's (2016) map, highlighting the fault segments that have strongest evidence for activity during the past 150 ka.

The assessment of seismic hazard at potential sites for the disposal of radioactive and toxic waste requires a detailed knowledge of any geological structures that may be active. Marco Andreoli of the Nuclear Energy Corporation of South Africa (Necsa) and his co-workers compiled observations of neotectonic faults, Landsat, SEASAT and GEOSAT imagery, aerial photography, hot springs, earthquake focal mechanisms, and detailed field mapping, amongst others (Andreoli et al., 1996). They deduced that neotectonic activity is taking place in the south-western Cape and Namaqualand, as well as in a broad region extending from the Free State to the Limpopo and Kwazulu-Natal, and also defined a broad region of NW-SE trending maximum horizontal compressive stress, which they named the Wegener Stress Anomaly.

There are several other faults that have been active during the last 5 million years. For example, Steenekamp et al (2018) describe a thrust fault exposed in an open pit platinum mine near Brits that displaced strata with a maximum age of 175,000 by about 4 m, and Kruger & Meyer (1988) describe a fault near the KwaZulu-Natal – Mozambique border that displaced the Port Durnford Formation by 30 m more recently than 75,000 years ago. However, without knowledge of the strike of the faults and the date, size and rate of individual slip events, it is impossible to estimate the magnitude and recurrence times of earthquakes along these structures. Hobday & Jackson (1979) and Jackson & Hobday (1980) attribute faults and overturned folds in coastal exposures of the Port Durnford Formation in Zululand to a combination of gravity gliding and clay diapirism, which may have been triggered by seismicity or rapid loading of lagoonal sediments by transgressive barrier sands.

Global and regional stress and strain models

Peter Bird of the University of California, Berkeley and his co-workers (including Marco Andreoli of Necsa) used a thin-shell finite element technique constrained by realistic heat flow and rheology to investigate the propagation of the East African Rift and compute the state of stress in the southern African crust (Bird et al., 2006). One objective of the study was to investigate the origins of the Wegener Stress Anomaly, first identified by Andreoli et al (1996). The boundary conditions of the Bird model are provided by the rates of spreading at the Mid-Atlantic and Indian Ocean Ridges, as well as various stress measurements compiled in the World Stress Map database (Reinecker et al 2004). It was concluded that the Wegener Stress Anomaly is caused primarily by resistance to the relative rotation between the Somalia and Africa plates. While the model of Bird et al (2006) certainly provides interesting results, the continental fracture that describes the East African Rift System is shown to continue along a line that joins the clusters of mining-related earthquakes in the Central and Far West Rand, Klerksdorp and Free State, before tracking through Lesotho and heading into the Indian Ocean. This plate boundary model is perpetuated in the series of earthquake posters published by the National Earthquake Information Centre at the US Geological Survey (see, for example, the poster for the M_w7.0 Machaze earthquake of 22 February 2006 (NEIC 2006)).

An analysis of the evolution of the regional stress field over the past 500 Ma was carried out by Viola et al (2012). Only one stress tensor was assigned to the Cenozoic tectonic evolution of the area, obtained from a "weathered" fault set and tentatively attributed to the Pliocene-Early Pleistocene NW-SE oriented extensional tectonic phase reported in the Kalahari basin, related to the propagation of the East African Rift System into southern Africa and formation of local fault-bounded depressions.

InSAR

Interferometric synthetic aperture radar (InSAR) is a satellite-based method that is used to detect ground deformations associated with geophysical phenomena such as the inflation of volcanoes and earthquakes. Its application to earthquake studies in South Africa has been limited. Doyle et al. (2001) used it to assess the surface deformation associated with a M_L4.5 tremor that occurred in the Free State Gold Fields on 23 April 1999. A 5-km-long elliptical depression centred on the Eland shaft of Matjhabeng Mine was mapped, with a maximum depth at its centre of 9 cm. InSAR has also been used to assess movement along the Kango-Baviaanskloof Fault (Engelbrecht & Goedhart 2009; Goedhart & Booth 2009).

Trignet CGPS network

Starting in 2001, the National Geo-Spatial Information (NGI) Directorate deployed a network of about sixty-five continuously observing global positioning system (CGPS) stations covering South Africa. Richard Wonnacott (NGI Directorate) was the leader of this programme. The average distance between stations is 200 km, with local densifications (70 km) around Cape Town, Durban and Johannesburg. Data are freely available from the Trignet web page (www.trignet.co.za). The first findings were published by Malservisi et al. (2013) using the stations with at least a thousand days of recording by June 2011. The results show that the South African region behaves rigidly, with deformation in the order of one nanostrain/year or less. The Trignet data were compared with data for the Nubian plate, and it was found that the South African block is rotating in a clockwise direction with respect to the African continent, which is consistent with the propagation of the East African Rift along the Okavango region.

SIGNIFICANT SOUTH AFRICAN EARTHQUAKES SINCE 1900

Earthquake size is expressed in terms of the intensity of shaking, which diminishes with distance from the epicentre; and magnitude, which is proportional to the deformation caused by the earthquake rupture or the seismic energy that is radiated by the source. In South Africa, the Modified Mercalli Intensity (MMI scale) and local magnitude scale (M_L, a local implementation of the Richter scale) are commonly used, though other scales, such as surface wave (M_s) and moment magntidue (M_w) are sometime used.

At the end of 1905 the Transvaal Meteorological Department acceded to a request from the Kaiserliche Hauptstation für Erdbebenforschung to collect information on earthquakes, and postcards with printed questions were sent to meteorological observers. Wood (1913) reported that there had not been a single earthquake of great importance during seven years of observation, and only three shocks that had been widely felt.

M_L5.0 earthquake in the Zoutpansberg, 5 August 1909: The M_L5.0 earthquake in the northern Zoutpansberg was felt as far away as Bulawayo and Johannesburg. It was the first event for which macroseismic data was systematically collected over a large area, enabling an isoseismal map to be drawn. Wood (1913) provides an account given by Mr Forbes Mackenzie, a superintendent at the Seta diamond mines, not far from the epicentre. The earthquake was assigned a peak MMI of VI (Brandt et al 2005).

Earthquakes near Philipstown (M_L5.0, 21 October 1910) and Koffiefontein (M_L6.2, 20 February 1912): The Philipstown and Koffiefontein earthquakes near the border between the Cape and the Free State were amongst the first natural events to be recorded by the Wiechert seismometers installed in Johannesburg in 1910. Many farm buildings south of Koffiefontein were destroyed and buildings in Kimberley were cracked. Wood (1913) provides isoseismal maps for both these events. The MMI scale intensities of the Philipstown and Koffiefontein events were V-VI and VIII, respectively (Brandt et al 2005).

M_L6.3 earthquake off Cape St Lucia, 31 December 1932

The M_L6.3 Cape St Lucia event of 31 December 1932 occurred off the Zululand coast and was felt as far away as Port Shepstone and Johannesburg, some 500 km away (Krige & Venter 1933). The nearest point on land to the epicentre was Cape St Lucia, where a MMI of IX was assigned on the evidence of sand boils and cracks in the surface. In the severely shaken areas, poor-quality houses (built of unburned or half-burnt bricks, or other low-quality materials) were severely damaged, while cracks were occasionally seen in well-built houses. As this region falls within the extension to the Eastern EGI corridor, the description of the more intense phenomena is repeated verbatim.

The shocks reached the intensity 7 in a small area in Zululand, including Palm Ridge, Mtubatuba, St. Lucia, Estuary Lots, St. Lucia Lighthouse, Umfolosi, Eteza, Empangeni, Felixton and Mtunzini. At these centres the earthquake had the following effects:

Everybody was frightened and all ran outside.
Movement of ground caused persons standing to stagger.
The shocks appeared to come from the south-east at St. Lucia Lighthouse, from the east at Eteza, and Mtubatuba, from the south at Palm Ridge.
Buildings rattled as if about to collapse.
Plaster fell from ceilings.
Many chimneys and walls were cracked, also cement pavements and steps at St. Lucia Lighthouse and at St. Lucia Estuary Lots.
A few houses were so badly damaged that they were abandoned.
One house collapsed.
Crockery, bottles and glasses were smashed.
Water splashed over sides of large railway tanks and out of some smaller tanks.
Corrugated-iron tanks sprang leaks, burst or were dislodged.
Trees and shrubs moved like waves caused by a mighty hurricane, the movement lasting three minutes. One large tree was uprooted.
Water in Nyalazi River, near Palm Ridge, appeared as if boiling.

Fissures up to four inches or more wide, and often several hundred yards long, formed in the sand hills near St. Lucia Lighthouse and in the damp ground near rivers and streams. One fissure was over two miles long and affected a railway embankment, which it crossed ten miles north of Matubatuba, to such an extent that a train was derailed.

At Mr. Shire's sugar mill, near the Umfolosi River, south-east of Mtubatuba, some of the fissures opened to a width of about two feet during the earthquake, and then closed up again partly, sending columns of water resembling geysers into the air for 10 feet or so. They left deposits of white sand on the black soil on both sides of the fissure. One of the fissures, which was parallel to the river, was followed for over a mile, but extended further in both directions. As Mr. Shire's house also suffered considerable damage, it seems that intensity 8 was reached at this locality.

At St. Lucia Lighthouse, which is built on the sand hills near the shore, 370 feet above sea level, the 30-foot iron lighthouse-tower was violently shaken for two minutes. The gas cylinders weighing between 300 and 400 lbs. were moved about. The lamp and lenses were thrown out of position. The lighthouse-keeper's wife was flung from a sofa on to the floor.

The shocks attained or exceeded intensity 8 on the rocky shore from Cape St. Lucia, to the mouth of the "Estuary" and perhaps also along the banks of the Umfolosi River during the last few miles of its course. Near the mouth of the Estuary "a low rumbling noise like underground thunder" accompanied the tremor, which was "quite violent for about 15 seconds". It appeared to be moving from S.W. to N.E. Close to the observer six or eight fountains were seen to gush up from the surface of the water to heights of 2½ or 3 feet. They spouted black, muddy water, containing lumps of black clay. Numerous cracks were also formed in the sand on the banks, some of them a foot wide. As this area is very sparsely inhabited, it seems probable that similar phenomena occurred, without being observed or reported, along the banks of the Umfolosi River as far up as Mr. Shire's sugar mill, mentioned above.

The effects of the earthquake were conspicuously displayed on the sea-shore below the St. Lucia Lighthouse, where numerous cracks had formed in the calcareous sandstone. These were generally a quarter to half an inch wide, but occasionally an inch or more. They ran in different directions, being for the most part approximately vertical, although some followed the bedding which is nearly horizontal. The cracks were seen over a distance of about a mile. It is possible that they extend somewhat further, as the rocks were not well exposed at the time of our visit, which coincided with neap tide and a strong sea breeze. The rock sometimes contains a few pebbles, and where these were in the way of a crack they were occasionally shot out of their sockets. Two or three large loose fragments were seen that had been broken off from the fixed rock along perfectly fresh fractures. The intensity of the shocks here must have reached the 9th degree.

The interpreted link between geology and the intensity of shaking is also repeated verbatim.

The isoseismal of the 8th degree runs close to the shore from Cape St. Lucia northwards, and then projects inland along the Umfolosi River. The reason for its nearness to the shore is the great thickness of sand in the costal dunes, which acted as a protective cover and reduced the intensity of the shocks. In this region, near the epicentre, the severity of the earthquake effects was seen to depend to a large extent upon the nature of the surface materials. The calcareous sandstone on the beach was cracked to a considerable extent, and it seems likely that any ordinary house built upon this rock would have collapsed entirely. And yet the lighthouse-keeper's wooden-frame residence and its brick kitchen-chimney, situated less than half a mile from the shore, suffered hardly any damage. This building stands on the sand hills at an altitude of over 350 feet. The thick cover of sand acted as a buffer and protected the house from destruction. At the St. Lucia Lots the two hotels and the other houses are all built upon sand, which is about 100 feet or more thick. They did not suffer any more than the buildings at Mtubatuba, which is about 13 miles further from the epicentre, and they also were protected by the sand.

In the moist alluvial soil along the banks of the Umfolosi River, on the other hand, the intensity of the earthquake shocks was greatly increased.

These effects are in agreement, with the common experience that a thin cover of unconsolidated material above bedrock, especially if it is wet alluvial soil, increases the destructive effects of earthquakes, while a thick cover of sand or other loose material greatly diminishes them.

M_L6.3 earthquake in the Ceres-Tulbagh region, 29 September 1969

The most destructive earthquake that has occurred in South African recorded history was a M_L6.3 event that occurred at 10:03 pm (local time) on 29 September 1969 in the Ceres-Tulbagh region of the Western Cape, killing nine people. Modern concrete-frame buildings sustained relatively minor damage, but some well-constructed brick houses were badly damaged, and many adobe-type buildings were completely destroyed. Many historical buildings, such as the Drostdy in Tulbagh, were severely damaged. Rockslides started a large number of fires on the surrounding mountains. The earthquake was felt as far as Durban, 1175 km away. No surface rupture was found. The maximum intensity was VIII on the MMI scale (Van Wyk & Kent 1974).

An array of seven continuous-recording seismographs was deployed to monitor the aftershocks (Green 1973). The first two stations (at Paarl and Tulbagh) were deployed within two days of the main shock, and the remaining five stations a week later (Green & Bloch 1971). Over 2000 events were recorded during the five weeks of operation. Aftershock activity had virtually ceased when an M_L5.7 event occurred on 14 April 1970, causing further damage in the towns of Ceres and Wolseley. A bulletin issued by the Geological Survey (Van Wyk & Kent 1974) covers many topics, including a record of disaster relief efforts; an assessment of the focal mechanisms determined by Fairhead & Girdler (1969), Green & Bloch (1971), and Green & McGarr (1972); an assessment of earthquake risk; and recommendations for the construction of earthquake-resistant buildings. A microseismic study of the area was conducted in 2012 (Smit et al 2015): 172 events with M_L<0.5 were recorded in a three month period, delineating a 5-km-wide and 15-km-deep sub-vertical zone subparallel to the 1969 aftershock zone.

The Ceres-Tulbagh earthquake had some positive results. It jolted South Africa out of complacency regarding the risks posed by earthquakes, and the National Seismograph Network was established shortly thereafter. Strong shaking was felt in Cape Town, and earthquake-resistant measures adopted in the construction of the Koeberg nuclear power plant. The buildings lining historic Church Street in Tulbagh were restored to their original splendour and a small Earthquake Museum was established.

M_L5.2 earthquake near Welkom, 8 December 1976

The M_L5.2 Welkom earthquake was the first seismic event in a mining district to cause serious damage to buildings on the surface, most dramatically the collapse of Tempest Hof, a six-storey apartment block (Fernández & Labuschagne 1979). Fortunately, it was possible to evacuate the building before it collapsed. An array of seismographs was deployed to monitor the aftershocks and investigate the origin of the event (Arnott 1981).

M_L5.3 earthquake near Stilfontein, 9 March 2005

An M_L5.3 earthquake occurred at 12:15 pm on 9 March 2005 at Durban Roodepoort Deep’s (DRD) Northwest operations (Durrheim et al 2006). The event and its aftershocks shook the nearby town of Stilfontein, causing serious damage to some buildings. Shattered glass and falling masonry caused minor injuries to fifty-eight people. The underground workings were severely damaged: two mine workers died, and 3 200 were evacuated under difficult circumstances. The mine went into liquidation soon afterwards and some 6 500 mine workers lost their jobs. Some R500 million was claimed from insurers for damage to mine infrastructure and loss of production.

Shortly thereafter, the Chief Inspector of Mines initiated an 'Investigation into the risks to miners, mines and the public associated with large seismic events in gold mining districts' (Durrheim et al 2006). The terms of reference listed nine specific issues that were to be addressed, top of the list being whether the events of 9 March 2005 could be attributed to mining activity. The team considered both statistical and mechanistic evidence. Andrzej Kijko (Council for Geoscience) presented evidence that the number of events with M>3 in the Klerksdorp mining district exceeded the average for the rest of South Africa by a factor of 700. Analysis of seismic records for the main event and its aftershocks showed that the source was close to the Number 5 Shaft fault and the reef horizon. Art McGarr (United States Geological Survey) showed that the dewatering of the rock mass during mining operations will tend to stabilize natural faults that might be close to failure. The team found that: *The magnitude 5.3 event and its aftershocks can be ascribed to past mining. The event was caused by rejuvenated slippage on an existing major fault, with extensive mining activities in the region contributing most of the strain energy. The chance of the events being solely due to natural forces is considered to be extremely small.*

M_w7.0 earthquake, Machaze district, Mozambique, 23 February 2006

The M_w7.0 earthquake struck Mozambique just after midnight, local time (Saunders et al., 2010). The shaking was sufficiently strong to cause many residents of Maputo and Beira to flee into the streets, and was felt in South Africa (Durban, Johannesburg and Pretoria), Zambia and Zimbabwe. The epicentral region is sparsely populated, but four people were killed and thirty-six injured, and at least 288 houses, six schools and two small bridges were destroyed (UNOCHA 2006). Fenton & Bommer (2006) surveyed three segments of the fault rupture with a combined length of some 15 km (the total rupture length is expected to be in the order of 30-40 km). The surface rupture, although visible in the field, could not be followed along its entire length due to the danger posed by buried land mines. They observed average vertical displacements of 1.0-1.5 m, and in one segment left-lateral offsets of 0.7 m. They also observed spectacular liquefaction features, such as sand blows with diameters of 5-8 m, and a 318-m-long liquefaction fissure. Fenton & Bommer (2006) were unable to decide if the earthquake was on an 'old, slow fault', similar to those found in intraplate regions, or a new structure related to the southward propagation of the East African Rift (NEIC 2006). Satellite radar interferometry allowed both the co-seismic and post-seismic displacement along the entire surface rupture to be measured (Raucoules et al., 2010).

M_L5.5 earthquake near Orkney, 5 August 2014

The M_L5.5 earthquake, with its epicentre near Orkney in the North West Province, occurred at 12:22 local time (Midzi et al 2015b). The earthquake shaking was felt as far away as Cape Town. More than 600 houses were damaged and one person was killed. Many people completed an online questionnaire administered by the Council for Geoscience (CGS), whilst others reported the event and its effects on social networks and in newspapers (Midzi et al 2015b). The CGS also sent out a team of scientists to further assess the effects of the event by interviewing members of the public and completing additional questionnaires. A total of 866 observations were collected. Analysis of the macroseismic data produced 170 intensity data points which showed a maximum MMI of VII in the epicentral area (Midzi et al 2015b).

This earthquake, being the largest recorded to date around the mining regions of South Africa, is mysterious for several reasons (Ogasawara 2015; Moyer et al., 2017). The mechanism was a left-lateral strike-slip on a NNW-SSE striking and nearly vertically dipping plane. This differs significantly from typical mining-induced earthquakes in the region, which usually exhibit dip-slip on NE-SW striking normal faults close to the mining horizon. The geological structures mapped on the mining horizon in the Orkney district are characterized by a horst and graben structure trending NE-SW, intruded by multiple dykes trending NNW-SSE. So, the strike-slip might be on a dyke. However, the hypocenter was significantly deeper than the mining horizon (at least 1-2 km deeper), and no dyke or seismic fault rupture was reported on the mining horizon. The maximum principal stress measured in situ at 3.0 km depth and several km from the hypocenter was almost vertical, while the intermediate principal stress was horizontal, trending NNW-SSE almost parallel to the M5.5 fault plane.

In order to assess the seismic hazard posed by such earthquakes as this, it is very important to understand stress field and loading mechanism (or tectonics) to address the above mysteries, because such dykes may prevail elsewhere. A proposal was submitted to the International Continental scientific Drilling Programme (ICDP) by a South African – Japanese team to investigate the source zone directly by drilling (Ogaswara et al. 2015). The ICDP granted funds to hold a workshop to form an international consortium and prepare a full proposal. The proposal was approved, and drilling commenced in 2017.

M_w6.5 earthquake in Botswana, 3 April 2017

The M_w6.5 earthquake occurred on the evening of 3 April 2017 in Central Botswana, southern Africa (Midzi et al 2018a). Its effects were felt widely in southern Africa and were especially pronounced for residents of Gauteng and the North West Province in South Africa. In total 181 questionnaires were obtained by the Council for Geoscience through interviews and 151 online from South Africa, Zimbabwe and Namibia in collaboration with the Meteorological Services Department, Zimbabwe and the Geological Survey of Namibia. All data were analysed to produce 79 intensity data points located all over the region, with maximum MMI values of VI observed near the epicentre. These are quite low values of intensity for such a large event, but are to be expected given that the epicentral region is in a national park which is sparsely populated. The CGS and Botswana Geoscience Institute deployed a network of aftershock recorders. More than 450 aftershock events of magnitude M_L> 0.5 were recorded and analysed for this period. All the events are located at the eastern edge of the Central Kgalagadi Park near the location of the main event in two clear clusters. The observed clusters imply that a segmented fault is the source of these earthquakes and is oriented in a NW-SE direction, similar to the direction inferred from the fault plane solution of the main event.

Reservoir-induced earthquakes

The impoundment of large reservoirs may trigger local earthquakes as a result of increases in the surface load and the pore fluid pressure, and seismic hazard should be taken into account when designing any large dam, regardless of whether the seismic loading is due to natural tectonic earthquakes or reservoir-induced seismicity (World Commission on Dams 2000).

Kariba Dam, Zimbabwe: The filling of Lake Kariba on the Zambezi River and subsequent fluctuations in water level has been accompanied by seismicity. The Kariba Dam was built from 1955 to 1959, and is one of the world's largest dams. The wall of the Kariba Dam is 128 m high, and the reservoir is 280 km long and has a storage capacity of 180 km^3. Seismic loading was not taken into account during the design of the dam, even though the reservoir is located in a tectonically active branch of the East African Rift system and an M_s6.0 earthquake had occurred in the region in 1910. (M_s denotes the surface wave magnitude, which is similar to other magnitudes.) No local measurements of seismicity were carried out prior to the impoundment, but many studies were carried out after 1959 (World Commission on Dams 2000). Geophysical work in Rhodesia (now Zimbabwe) did not begin in earnest until 1958 when seismograph stations were deployed around the Zambezi Valley to monitor seismic activity as Lake Kariba filled behind the Kariba Dam. Substantial seismic activity was recorded, increasing as the dam filled and peaking in 1963 (Gough & Gough 1970a; 1970b). The larger earthquakes (M>5) occurred in the vicinity of the dam wall. The largest event (M_L6.1, which occurred in 1963) caused damage to the dam structure and some property in nearby settlements, but no casualties were reported. Since 1963 there has been a general decline in seismic activity. It was initially thought that the loading of the water filling the dam on the crust was the cause of the seismic events. Consensus later swung towards the increase in hydrostatic pressure in faults as the likely cause of the seismicity.

Gariep Dam, South Africa: The 61-m-high and 600-m-long Gariep Dam (previously known as the HF Verwoerd Dam) on the Orange River was impounded in 1970. Seismicity was monitored by Milner (1973). A seismometer array comprising one three-component and six vertical component stations was deployed prior to impoundment. Seismicity was first recorded in February 1971, six months after impoundment, when the water level reached 40 m. During the next ten months 93 events were recorded, the largest of which being an M2.1 event. Seismicity declined after December 1971.

Katse Dam, Lesotho: Seismicity was also associated with the filling of the 185-m-high Katse Dam on the Malibamat'so River in Lesotho, which was completed in 1996 (Brandt 2000, 2001). Seismicity was monitored from 1995 to 1999. The first recorded event occurred when the water level in the reservoir had risen by 45 m. The largest event had a magnitude of M_L3.0, when fresh fissures opened along a shear zone adjacent to the dam; dwellings in the village of Mapeleng suffered minor damage. The ground motion expected by a hypothetical M5 reservoir-induced seismic event was modelled by Brandt (2004). It was concluded that such an event does not pose any risk to the dam wall. Although it may pose a risk to the villages built on the steep slopes surrounding the dam.

SEISMIC HAZARD ASSESSMENT

The African continent is largely a tectonically stable intraplate region and has been surrounded by spreading ridges since the break-up of Gondwana, about 120 million years ago. The only parts of Africa that do not display the characteristics of an intra-plate region are the Africa-Eurasia collision zone, the Cameroon Volcanic Line, and the East African Rift System and its continuations into Botswana and

Mozambique. The rest of Africa and South Africa (apart from the mining regions) is characterised by a relatively low level of seismic activity, with earthquakes randomly distributed in space and time. However, it is important to note that global observations have shown that intraplate earthquakes, while rare, can occur even without significant precursory seismic activity; moreover, they may have large magnitudes and cause considerable damage.

Hazard assessment is the process of determining the likelihood that a given event will take place. Probabilistic seismic hazard assessment (PSHA) is generally expressed in terms of the ground motion (for example, peak ground acceleration (PGA)) that has a certain likelihood of exceedance (say 10%) in a given period (say fifty years). There are many PSHA schemes, but all require a catalogue of earthquakes (size, time, location); the characterisation of seismically active faults and areas (usually in terms of the maximum credible magnitude and recurrence periods); and a prediction of variation in ground motion with distance from the epicentre. The longer the duration of the catalogue, the smaller the magnitude of completeness, and the better the zonation, the more reliable is the PSHA.

Palaeoseismology

In order to assess the risk posed by earthquakes, it is important to have a record of past earthquake activity. These parameters are best known if earthquakes are recorded by seismographs. However, the global instrumental catalogue does not go back much further than a century, and, in many parts of the world, the recurrence times of the largest plausible earthquake is much longer than this. Thus historical records of earthquakes, while less accurate and complete, are a vital supplement to instrumental catalogues. However, the historical record often only covers a few centuries and is inevitably incomplete. Thus palaeoseismologists seek to extend the catalogue back in time by discovering and deciphering clues left by prehistoric earthquakes (say events occurring during the last 100 000 years). For example, geomorphological features such as fault scarps and knick points in rivers can be used to deduce the length and displacement of the rupture caused by a particular earthquake, while geochronological techniques can be used to determine the age of sediments deposited along fault scarps, and hence the minimum age of the earthquake.

Soutpansberg M8.0 event: A project was commissioned by Eskom (1998) to investigate palaeo-seismic movement of Tshipise and Bosbokpoort faults, this was then used to investigate as part of a study of the slope stability within Mutale upper dam basin. Evidence for the recent reactivation of the faults was first reported in 1977 by Tim Partridge (Eskom 1998). Different fault zones were mapped, and the length, throw and age of the palaeoseismic fault ruptures estimated. The biggest event, based on rupture length and throw, was estimated to have been an M8.0 earthquake that occurred about 100 000 years ago.

Kango fault M7.4 event: Palaeoseismic studies have been carried out as part of an investigation into the Quaternary tectonic history of the south-eastern continental margin, in support of the assessment of seismic hazard at proposed sites for nuclear power stations (Engelbrecht & Goedhart 2009; Goedhart & Booth 2009; Midzi & Goedhart 2009; Goedhart & Booth 2016a, 2016b). There is little seismic information for this region, and the record is too short to include the long recurrence intervals typical of large, surface-rupturing earthquakes in intraplate regions. Goedhart & Booth (2016a) interpreted a scarp running parallel to the Kango fault in the Cape Fold Belt to be the surface expression of an 84-km-long extensional surface rupture (Figure 1). An 80-m-long, 6-m-deep and 2.5-m-wide trench was dug across the fault, exposing twenty-one lithological units, six soil horizons, and nineteen faults strands. Vertical displacement indicated a fault throw of about 2 m. Optically stimulated luminescence dating indicated that the fault was active between 12 200 and 8 800 years ago, and most probably around 10 600 years ago. Goedhart and Booth (2016b) used published relations between surface rupture length, displacement and magnitude to estimate the magnitude of the event at M_w7.4.

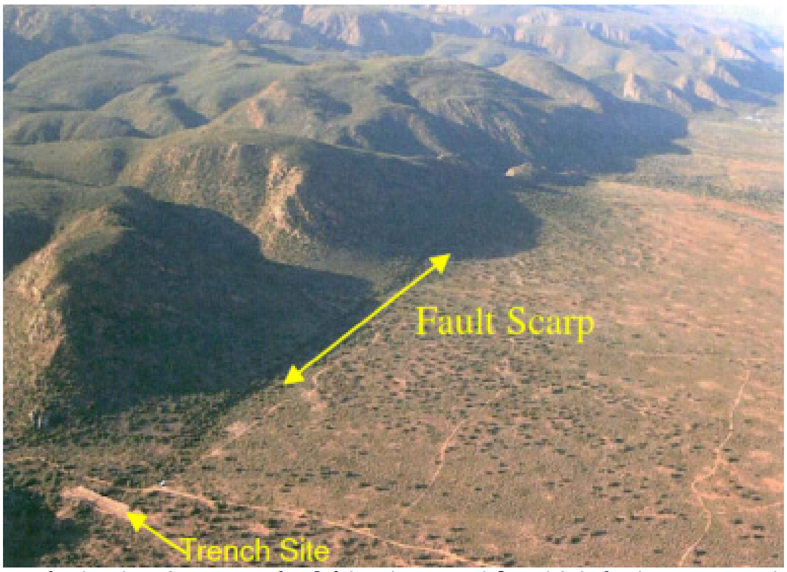

Figure 1: The Kango fault, showing part of a 84-km-long and 2-m-high fault scarp produced by an M_w7.4 event about 10 600 years ago (Source: Midzi & Goedhart 2009)

Early efforts to quantify seismic hazard

The 1969 M_L6.3 Ceres-Tulbagh earthquake gave impetus to the establishment of the Southern African Seismograph Network. The number of stations increased from five in 1969 to 11 in 1973, and in 1992 consisted of 25 stations in South Africa and five in neighbouring countries (Fernández & Du Plessis 1992). Monthly bulletins and annual catalogues were published from 1971 onwards, and in 1979 a bulletin was published containing several maps depicting earthquake hazard levels in South Africa based on the distribution of annual extreme values (Fernández & Guzmán 1979b).

The *Seismic Hazard Maps for Southern Africa* poster was published in 1992 (Fernández & Du Plessis 1992). The poster features explanatory notes and three maps: a plot of the maximum reported Modified Mercalli scale intensities from 1620-1988; a contour plot of the Modified Mercalli scale intensity with a 10% probability of being exceeded at least once in fifty years; and a contour plot of the PGA with a 10% probability of being exceeded at least once in 50 years. The areas exposed to the greatest natural hazard (where PGAs were considered to have a 10% probability of exceeding 100 cm/sec^2 (0.1 g) at least once in fifty years) are the south-western Cape, the southern Free State and Lesotho, and Swaziland. In 1990 the South African Bureau of Standards (SABS) issued the *Code of practice for the general procedures and loadings to be adopted for the design of buildings* (SABS 1990). The Code designated two zones: Zone 1, corresponding to the three areas noted above; and Zone 2, regions exposed to mining-related seismicity.

In 1996, Luiz Fernández, head of the Seismology Unit at the Geological Survey, summarized the state of the art with regard to seismic hazard evaluation in a report entitled *The seismic climate of Southern Africa: Peak ground accelerations to be expected from tectonic and mining seismicity* (Fernández 1996). Standard methods (for example, McGuire 1993; Cornell 1968; Kijko 2011) of assessing seismic hazard required a priori knowledge of the seismogenic regions, including a clear demarcation of their borders and their activity rates. In regions that have low seismic activity rates, such as the interior of the global plates, this knowledge is rudimentary, especially when the time window of data is very short. This is the case for South Africa.

One of the first attempts to estimate the maximum credible magnitudes of earthquakes in South Africa was made by Shapira et al. (1989). It was concluded that the catalogue of earthquakes was complete for $M_L \geq 4.6$ events since 1950; for $M_L \geq 4.9$ events since 1910; and for $M_L \geq 5.3$ events since 1906, and that the maximum credible magnitudes of tectonic and mining-related earthquakes were M7.5 and M5.5, respectively. Shapira and Fernández (1989) also estimated the probability that a defined horizontal PGA will be exceeded at fourteen cities in southern Africa.

Ideally, the historical and instrumental catalogue used to assess seismic hazard should be complete; that is, there should be no data gaps or changes in the threshold of completeness. However, this ideal is often not met, particularly in the developing world. A 'parametric-historic method' that compensates for these difficulties was developed by Professor Kijko, previously at the Council for Geoscience and now at the University of Pretoria (Kijko & Graham 1998; 1999; Kijko & Sellevol 1989; 1992; Kijko et al 2016) and is used in many countries. Kijko also applied his formidable statistical skills to the related important problem of estimating the maximum credible earthquake magnitude m_{max} (Kijko 2004, 2012; Kijko & Singh 2011; Kijko & Smit 2012). In 2003 the Council for Geoscience published seismic hazard maps showing the 10% probability of exceeding the calculated PGA at least once in fifty years at 1, 3, 5 and 10 Hz, frequencies that are important for the fragility of buildings (Kijko et al 2003; Kijko 2008). The parametric-historic procedure of Kijko and Graham (1998; 1999) was used.

Recent efforts to quantify seismic hazard
During the 1990s the Global Seismic Hazard Assessment Programme (GSHAP 2013) compiled and published a seismic hazard map of the world (Giardini et al 1999). The GSHAP map for Africa (Grünthal et al 1999; Midzi et al 1999) is currently being updated under the auspices of the Global Earthquake Model initiative (GEM-SSA 2013, Pagani et al 2018).

The first step in assessing the seismic hazard and risk for any site is to develop a seismotectonic model. The area under investigation is divided into smaller zones or regions that have a similar tectonic setting and similar seismic potential. These zones are then used in a seismic hazard assessment model to determine the return periods of certain levels of ground motion at a given site in the area in question. Mayshree Singh (née Bejaichund) of the Seismology Unit of the Council for Geoscience developed a first-order seismotectonic model for South Africa. The outputs of the project were first reported in an unpublished MSc dissertation (Bejaichund 2010) and published in a series of three papers (Singh et al 2009; Singh & Hattingh 2009; Singh et al 2011). The inputs to the seismotectonic model include the historical and instrumental earthquake catalogue for South Africa, maps of geological and geophysical terrains, evidence of Quaternary fault activity, thermal springs, and so forth (Singh et al 2009). Isoseismal maps are extremely useful for assessing seismic hazard, in particular for determining parameters such as crustal attenuation and identifying local site effects. If possible, surveys of macroseismic effects (damage to buildings, surface ruptures, liquefaction, and so forth) are conducted immediately after an earthquake, but historical documents can also be used. Singh and Hattingh (2009) compiled thirty-two isoseismal maps for South Africa, the earliest being for the 1932 earthquake with its epicentre offshore from St Lucia (M_L6.3, intensity VIII). Eighteen seismotectonic zones were defined. Finally, the frequency-magnitude relations were analysed using ten different procedures. Estimates of the earthquake recurrence parameters and maximum possible earthquake magnitudes m_{max} were obtained for each seismotectonic zone (Singh et al 2011). This work has been extended with a more detailed study of KwaZulu-Natal (Singh et al., 2015; Singh 2016).

As part of CGS's effort to improve hazard assessment in South Africa, a database of the intensity of earthquakes occurring between 1912 and 2011 was compiled (Midzi et al., 2013), as well as intensity surveys of two moderate-sized earthquakes that occurred in 2013 (Midzi et al 2015a). The CGS made use of GEM products and tools (notably the OpenQuake software package), coupled with a new zonation model for South Africa, to compute the seismic hazard (Midzi et al 2018b). Seismotectonic data was compiled and interpreted by Manzunzu et al (2019). The outputs of these studies are used for this assessment (see Appendix B of this report).

SEISMIC RISK ASSESSMENT
A risk assessment is an attempt to quantify the losses that could be caused by a particular hazard. It is calculated as follows:

Risk = likelihood of the hazard occurring X seriousness of consequences

The consequences of an earthquake depend on four main factors: the vulnerability of structures (e.g. EGI infrastructure or gas pipelines) to damage, the exposure of persons and other assets to harm, the cost of reconstruction, and the cost of lost economic production. Risk assessments are useful for raising awareness of possible disasters and motivating policies and actions to mitigate losses and avoid disasters. For example, vulnerable structures may be reinforced, building codes enforced and insurance taken out to cover possible losses. An important input into the assessment of consequences is the vulnerability of structures subjected to shaking. The vulnerability curves for typical South African buildings have been published by Pule et al (2015).

Insuring against earthquake risk: In 2001 a global reinsurance company, Hannover Re, published a report assessing the risk posed by seismicity to the South African insurance industry (Hannover Re 2001). The seismic research was performed by Andrzej Kijko and Paul Retief of the CGS, while the application to the insurance industry was carried out by Nicholas Davies of Hannover Re. The main findings of these studies were translated into the language of the insurance industry and published in the *South African Actuarial Journal* (Davies & Kijko 2003).

Quantifying earthquake risk in the Tulbagh region: A comprehensive study of seismic hazard and risk in the Tulbagh area was conducted by Kijko et al 2002, 2003). The worst case scenario is an event that produces shaking with a PGA of 0.3 g.

FIFA 2010 Soccer World Cup stadia: In 2010 South Africa hosted the FIFA Soccer World Cup. To coincide with this event, the global reinsurance company, Aon Benfield, issued its report *South Africa Spotlight on Earthquake* in conjunction with the Aon Benfield Natural Hazard Centre Africa (Aon Benfield 2010). According to the report, earthquake is "regarded as the natural hazard most likely to trigger the country's largest financial loss" (Aon Benfield 2010). The objective of the report was to enable insurers to obtain a more accurate estimate of their exposure and in turn purchase appropriate reinsurance cover. Earthquake risk was assessed in Cape Town and Durban, two cities where major new stadia had been built and which had experienced the largest seismic events recorded in South African history, and hence where risk would most likely be greatest. The losses associated with a scenario earthquake similar to the M_L6.1 1809 Cape Town earthquake were considered. The worst case scenario, a M6.9 earthquake on the Milnerton Fault, would produce a MMI of about IX, which would be "ruinous" (Aon Benfield 2010) to the Cape Town CBD and Cape Town Stadium, only 10 km away. Fortunately, the probability of such an event is low, in the order of one in 1000 years. While a M6.3 earthquake occurred near St Lucia, 220 km north of Durban, on New Year's Eve 1932, Durban is not regarded as being exposed to high seismic risk as no active faults are known to exist close to the city. The report concluded that M5.0 and M6.0 events would only cause structural damage if their epicentres were closer than 45 and 90 km, respectively. The return periods of such events was estimated to be 735 and 5000 years, respectively.

Risk posed by tsunamis: Numerical tsunami simulations have been conducted to investigate the realistic and worst-case scenarios that could be generated by the nearest (but distant) subduction zones, *viz.* Makran, South Sandwich Islands, Sumatra and Andaman (Okal & Hartnady, 2009; Okal et al., 2009; Kijko et al. 2018). The simulated tsunami amplitudes and run-up heights calculated for the coastal cities of Cape Town, Durban, and Port Elizabeth are relatively small and therefore pose no real risk to the South African coast.

Nuclear power stations: The damage to the Fukushima nuclear power station caused by the M_w9.0 Great Eastern Japanese earthquake and tsunami of 11 March 2011 naturally raised concerns about the safety of the Koeberg nuclear power station, situated on the Atlantic seaboard 30 km north-west of Cape Town. The managing director of Eskom's operations and planning division, Kannan Lakmeeharam, promptly assured parliament and the public that Koeberg was designed to withstand both earthquakes and tsunamis (News24, 2011). The construction of the 1800-megawatt power station began in 1976. The pressurized water reactors are housed within a containment building mounted on a base-isolated raft. It is designed to withstand an M_L7 earthquake without any risk of rupture.

In 2006 the South African government announced plans to build several more nuclear power stations, and a programme to identify suitable sites was launched. Five potential sites were identified, two on the Indian Ocean coastline (Thyspunt near Jeffrey's Bay, and Bantamsklip near Gansbaai) and three on the Atlantic coastline (Duynefontein (Koeberg), and two sites in Namaqualand). Environmental Impact Assessments (EIAs) were commissioned and published on the internet (http://www.eskom.co.za/c/article/1719/nuclear-1-eia-documentation/). The EIAs addressed a wide range of issues, including geology, seismology, hydrology and geotechnics (addressing issues such as liquefaction potential). Neotectonic and palaeoseismic investigations were undertaken and field measurements of Vs30 were made (Park 2013). The earthquake catalogue for each site was updated, the maximum ground velocity determined deterministically for each site, and the expected PGA determined probabilistically for each site. Site-specific SHAs were previously undertaken for the three sites by the Council for Geoscience (CGS), employing a methodology called the Parametric-Historic SHA. Using this methodology, median PGA values of 0.16 g, 0.23 g and 0.30 g were calculated for the Thyspunt, Bantamsklip and Duynefontein sites, respectively (CGS 2011). In order to enhance the probability that the assessment of the hazard associated with vibratory ground motion (due to natural earthquakes) will be accepted by the National Nuclear Regulator, methodologies with considerable precedence and recognition by the US Nuclear Regulatory Commission (USNRC) and regulators from other countries were used, in particular a process that was drafted by the USNRC Senior Seismic Hazard Committee (SSHAC). The SSHAC process is documented by Budnitz et al (1997) and Hanks et al (2009), and the application to Thyspunt by Strasser & Mangongolo (2012), Bommer et al (2013) and Bommer et al (2015).

Nuclear waste disposal facilities: The Namaqualand-Bushmanland region has numerous features that make it attractive for the storage of radioactive waste. In the late 1970s a programme was launched to find a suitable site for low- and intermediate-level waste. The Vaalputs facility, approximately 100 km south of Springbok, was opened in 1986. Seismicity is one of several key factors that are monitored as part of the ongoing operations. A two-station network of short-period seismometers was installed in 1989 and replaced in 2012 with a three-station network comprising one broadband and two short-period seismometers (Malephane, Durrheim & Andreoli 2013). Data from these networks, the South African National Seismological Network, and the International Seismological Centre has been used to compile a catalogue of the general seismicity of the region.

Large dams: A seismic risk classification was performed for 101 large (wall height >30 m) state-owned dams (Singh et al 2011). The risk is strongly dependent on the method used to construct the dam wall, with gravity and earth-fill dams being the most vulnerable to ground shaking.

Fracking: The risk posed by fracking-induced earthquakes in the Karoo basin was assessed as part of a Strategic Environmental Assessment commissioned by the Department of Environmental Affairs (Durrheim et al 2016).

Open-pit mine blasting: The risk posed by open pit blasting was assessed in a study commissioned by the Mine Health and Safety Council (Milev et al 2016).

CONCLUSIONS

South Africa is fortunate to be situated far from a plate boundary. Large, damaging tectonic earthquakes (6.5<M<7.5) are rare and losses due to earthquakes have been small. However, it should be noted that a damaging earthquake (5.0<M<6.5) could occur anywhere in South Africa. Mining-related earthquakes are restricted to the regions where deep and extensive gold mining has taken place, notably the Welkom and Klerksdorp districts. Earthquakes have been identified as the natural hazard with the potential to cause the greatest financial losses. A low rate of seismicity does not mean that the maximum size of an earthquake will be small, just that earthquakes are less frequent. A moderate-sized earthquake (such as those that occurred near Cape Town in 1809 and Ceres in 1969) can prove disastrous if it occurs beneath a town with many vulnerable buildings.

REFERENCES

Aki, K and Lee, WHK, 2003. Glossary of interest to earthquake and engineering seismologists, In: WHK Lee, H Kanamori, PC Jennings & C Kisslinger (Eds). *International Handbook of Earthquake and Engineering Seismology*. Part B. Amsterdam: Academic Press. 1793-1856.

Agnew DC. 2002. History of Seismology. In: WHK Lee, H Kanamori, PC Jennings & C Kisslinger (Eds). *International Handbook of Earthquake and Engineering Seismology*. Part A. Amsterdam: Academic Press. 3-12.

Albini P, Strasser FO & Flint NS. 2014. Earthquakes from 1820 to 1936 in Grahamstown and surroundings (Eastern Cape Province, South Africa). *Bulletin of Earthquake Engineering.* 12:45-78.

Andreoli MAG, Doucouré M, Van Bever Donker J, Brandt D & Andersen NJB. 1996. Neotectonics of southern Africa – a review. *African Geoscience Review*, 3:1-16.

Aon Benfield. 2010. *South Africa Spotlight on Earthquake*. Retrieved from www.aon.com/attachments/reinsurance/201006_mega_eq_report.pdf (accessed 27 June 2015).

Arnott FW. 1981. *Seismicity in the Welkom area, OFS (with special reference to the origin of the 1976-12-8 event).* Unpublished MSc thesis. Johannesburg: University of the Witwatersrand.

Bejaichund M. 2010. Seismotectonic models, earthquake recurrence, and maximum possible earthquake magnitudes for South Africa. Unpublished MSc thesis. Johannesburg: University of the Witwatersrand.

Bird P, Ben-Avraham Z, Schubert G, Andreoli M & Viola G. 2005. Patterns of stress and strain rate in southern Africa. *Journal of Geophysical Research*, 111:1-14.

Bommer JJ, Coppersmith KJ, Coppersmith RT, Hanson KL, Mangongolo A, Neveling J, Rathje EM, Rodriguez-Marek A, Scherbaum F, Shelembe R & Stafford PJ. 2015. A SSHAC Level 3 probabilistic seismic hazard analysis for a new-build nuclear site in South Africa. *Earthquake Spectra*, 31:661-98.

Bommer JJ, Coppersmith KJ, Hattingh E & Nel AP. 2013. An application of the SSHAC level 3 process to the probabilistic seismic hazard assessment for the Thyspunt nuclear site in South Africa. *Proceedings of the Twenty-second International Conference on Structural Mechanics in Reactor Technology (SMiRT22)*, 18-24 August, San Fransisco, California, United States.

Brandt, M. B. C., 2000. A review of the reservoir induced seismicity at the Katse Dam, Kingdom of Lesotho, November 1995 to March 1999. MSc dissertation, University of Bergen, Norway.

Brandt MCB. 2001. A review of the reservoir-induced seismicity at the Katse dam, Kingdom of Lesotho – November 1995 to March 1999. In: G van Aswegen, RJ Durrheim & WD Ortlepp (Eds). *Proceedings of the Fifth International Symposium on Rockbursts and Seismicity in Mines (RaSiM5)*. Symposium Series S27. Johannesburg: Southern African Institute of Mining and Metallurgy. 119-132.

Brandt MBC. 2004. Ground motions for a moderate earthquake for the Katse reservoir, Kingdom of Lesotho. *Africa Geoscience Review.* 11:31-64.

Brandt MBC, Bejaichund M, Kgaswane EM, Hattingh E & Roblin DL. 2005. Seismic history of southern Africa. *Seismological Series 37*. Pretoria: Council for Geoscience.

Brandt MBC & Saunders I. 2011. New regional moment tensors in South Africa. *Seismological Research Letters*, 82:69-80.

Bright HER. 1874. The geology of Basutoland. *Cape Monthly Magazine*, October 1874, 9(2):223-227.

Budnitz RJ, Apostolakis G, Boore DM, Cluff LS, Coppersmith KJ, Cornell CA & Morris PA. 1997. *Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on the Uncertainty and Use of Experts.* NUREG/CR-6372. Two volumes. Senior Seismic Hazard Committee, US Nuclear Regulatory Commission, Washington, DC.

Burchell WJ. 1822. *Travels in the Interior of Southern Africa. Volume 1.* London: The Batchworth Press.

CGS 2011. *Environmental Impact Assessment for the proposed nuclear power station ('Nuclear-1') and associated infrastructure. Seismic hazard Environmental Impact Report.* Council for Geoscience. CGS-EIA-0005. Retrieved from http://projects.gibb.co.za/portals/3/projects/201104_N1_DEIR/27._APP_E2_to_E30_Specialist_Reports/Rev_DEIR_0APP_E4_Seismic_Risk_Assessment.pdf (accessed 27 June 2015).

Cornell C. 1968. Engineering seismic risk analysis. *Bulletin of the Seismological Society of America*, 58:1583-1606.

Davies N & Kijko A. 2003. Seismic Risk Assessment: with an application to the South African insurance industry. *South African Actuarial Journal*, 3:1-28.

De Klerk WJ & Read J Du S. 1988. *An account of historical seismic activity in southern Africa, with emphasis on the southern and eastern Cape coastal belts*. Grahamstown: Albany Museum.

Doyle GS, Stow RJ & Inggs MR. 2001. Satellite radar interferometry reveals mining-induced seismic deformation in South Africa. In: *Proceedings of the Geoscience and Remote Sensing Symposium (IGARSS)*, 9-13 July 2001, Sydney, New South Wales, Australia. 2037-2039.

Durrheim RJ, Anderson RL, Cichowicz A, Ebrahim-Trollope R, Hubert G, Kijko A, McGarr A, Ortlepp WD & Van der Merwe N. 2006. *Investigation into the risks to miners, mines, and the public associated with large seismic events in gold mining districts.* Pretoria: Department of Minerals and Energy.

Durrheim, R., Doucouré, M. & Midzi, V. 2016. Earthquakes. In Scholes, R., Lochner, P., Schreiner, G., Snyman-Van der Walt, L. and de Jager, M. (eds). *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/.

Durrheim RJ, Ogasawara H, Nakatani M, Yabe Y, Kawakata H, Naoi M, Ward AK, Murphy SK, Wienand J, Lenegan P, Milev AM, Murakami O, Yoshimitsu N, Kgarume T, Cichowicz A & the SATREPS Research Group. 2012. Establishment of SATREPS experimental sites in South African gold mines to monitor phenomena associated with earthquake nucleation and rupture. In: Y Potvin (Ed). *Proceedings of the Sixth International Seminar on Deep and High Stress Mining*. Perth: Australian Centre for Geomechanics. 173-187.

Durrheim RJ, Ogasawara H, Nakatani M, Yabe Y, Milev A, Cichowicz A, Kawakata H, Moriya H & the JST-JICA SA Research Group. 2010. Observational study to mitigate seismic risks in mines: A new Japanese-South African collaborative project. In: M Van Sint Jan & Y Potvin (Eds). *Proceedings of the Fifth International Seminar on Deep and High Stress Mining*. Perth: Australian Centre for Geomechanics. 215-225.

Engelbrecht J & Goedhart ML. 2009. Advanced differential interferometry for detection of crustal warping and potential movement along the Baviaanskloof Fault – towards earthquake hazard assessment. Abstract and poster. General Assembly of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), 12 to 16 January 2009, Cape Town, South Africa.

Eskom 1998. *Paleoseismic investigations undertaken in the vicinity of the Tshipise and Bosbokpoort faults, and their implications for slope stability under operating conditions within the upper dam basin of the Mutale pumped storage scheme.* Unpublished Report.

Fairhead JD & Girdler RW. 1969. How far does the Rift System extend through Africa? *Nature*, 221:1018-1020.

Fenton CH & Bommer JJ. 2006. The M_w7 Machaze, Mozambique, earthquake of 23 February 2006. *Seismological Research Letters*, 77:426-439.

Fernández LM. 1996. *The seismic climate of Southern Africa: Peak ground accelerations to be expected from tectonic and mining seismicity.* Geological Survey of South Africa Report No 1996-0036. Pretoria: Council for Geoscience.

Fernández LM & Du Plessis A. 1992. *Seismic Hazard Maps for Southern Africa*. Pretoria: Government Printer.

Fernández LM & Guzmán JA. 1979a. *Seismic history of Southern Africa*. Seismologic Series 9. Pretoria: Geological Survey of South Africa.

Fernández LM & Guzmán JA. 1979b. *Earthquake hazard in Southern Africa*. Seismologic Series 10. Pretoria: Geological Survey of South Africa.

Fernández LM & Labuschagne PGA. 1979. *Catalogue of earthquakes in southern Africa and surrounding oceans for 1976*. Seismologic Series 8. Pretoria: Geological Survey of South Africa.

Finsen WS. 1950. *The geographical distribution of some South African earthquakes*. Johannesburg: Circular Union Observatory.

Gane PG, Hales AL & Oliver HA. 1946. A seismic investigation of the Witwatersrand earth tremors. *Bulletin of the Seismological Society of America*, 36:49-80.

Gane PG, Logie HJ & Stephen JH. 1949. Triggered recording seismic equipment. *Bulletin of the Seismological Society of America*, 39:117-143.

Gay NC. 1975. In-situ stress measurements in Southern Africa. *Tectonophysics*, 29:447-459.

Gay NC. 1980. The state of stress in the plates. In: AW Bally, PL Bender, TR McGetchin & RI Walcott (Eds). *Dynamics of Plate Interiors*. Geodynamics Series 1. Washington, DC: American Geophysical Union. 145-153.

GEM-SSA. 2013. *GEM Sub-Saharan Africa*. Retrieved from http://www.nexus.globalquakemodel.org/gem-sub-saharan-africa (accessed 13 April 2013).

Giardini D, Grünthal G, Shedlock K & Zhang P. 1999. The GSHAP Global Seismic Hazard Map. *Annali di Geofisica*, 42:1225-1230.

Goedhart ML & PWK Booth. 2009. Early Holocene extensional tectonics in the South-eastern Cape Fold Belt, South Africa. Short paper. In: *Proceedings of the 11th Technical Meeting of the South African Geophysical Association*, 16 to 18 September 2009, Ezulwini, Swaziland. 510-513.

Goedhart ML & PWK Booth. 2016a. A palaeoseismic trench investigation of early Holocene neotectonic faulting along the Kango Fault, southern Cape Fold Belt, South Africa–Part I: stratigraphic and structural features. *South African Journal of Geology*, 119:545-568.

Goedhart ML & PWK Booth. 2016b. A palaeoseismic trench investigation of early Holocene neotectonic faulting along the Kango Fault, southern Cape Fold Belt, South Africa–Part II: earthquake parameters. *South African Journal of Geology*, 119:569-582.

Gough DI & Gough WI. 1970a. Stress and deflection in the lithosphere near Lake Kariba. *Geophysical Journal of the Royal Astronomical Society*, 21:65-78.

Gough DI & Gough WI. 1970b. Load-induced earthquakes at Lake Kariba. *Geophysical Journal of the Royal Astronomical Society*, 21:79-101.

Green R 1973. A portable multi-channel seismic recorder and a data processing system. *Bulletin of the Seismological Society of America*, 63:423-431.

Green RWE & Bloch S. 1971. The Ceres, South Africa, earthquake of September 29th, 1969. Report on some aftershocks. *Bulletin of the Seismological Society of America*, 61:851-859.

Green RWE & McGarr A. 1972. A comparison of the focal mechanism and aftershock distribution of the Ceres, South Africa, earthquake of September 29, 1969. *Bulletin of the Seismological Society of America*, 62:869-871.

Grünthal G, Bosse C, Sellami S, Mayer-Rosa D & Giardini D. 1999. Compilation of the GSHAP regional seismic hazard for Europe, Africa and the Middle East. *Annali di Geofisica*, 42:1215-1223.

GSHAP 2013. *Global Seismic Hazard Assessment Program*. Retrieved from http://www.gfz-potsdam.de/portal/gfz/Struktur/Departments/Department+2/sec26/projects/01_seismic_hazard_assessment/GSHAP (accessed 14 April 2013).

Hanks TC, Abrahamson NA, Boore DM, Coppersmith KJ & Knepprath NE. 2009. *Implementation of the SSHAC Guidelines for level 3 and 4 PSHAs – experience gained from actual applications.* US Geological Survey Open File Report.

Hannover Re. 2001. *Seismic risk in South Africa: a study of the potential risk faced by the SA insurance industry as a result of seismic activity.* Johannesburg: Hannover Re.

Hobday DK & Jackson MPA. 1979. Transgressive shore zone sedimentation and syndepositional deformation in the Pleistocene of Zululand, South Africa. *Journal of Sedimentary Research,* 49:145-158.

James DE. 2003. Imaging crust and upper mantle beneath southern Africa: The southern Africa broadband seismic experiment. *The Leading Edge*, 22:238-249.

Jackson MP, Hobday DK. 1980. Gravity gliding and clay diapirism in a Pleistocene shoreline sequence in Zululand, South Africa. *American Journal of Science*, 280:333-362.

Kijko A. 2004. Estimation of the Maximum Earthquake Magnitude m_{max}. *Pure and Applied Geophysics*, 161:1-27.

Kijko, A. 2008. Data driven probabilistic seismic hazard assessment procedure for regions with uncertain seismogenic zones. In: ES Husbye (Ed). *Earthquake Monitoring and Seismic Hazard Mitigation in Balkan Countries*. New York City: Springer. 235-249.

Kijko A. 2011. Introduction to Probabilistic Seismic Hazard Analysis. In: HK Gupta (Ed). *Encyclopedia of Solid Earth Geophysics*. Dordrecht: Springer Netherlands.

Kijko A. 2012. On Bayesian procedure for maximum earthquake magnitude estimation. *Research in Geophysics*, 2(1):46-51.

Kijko A & Graham G. 1998. 'Parametric-Historic' Procedure for Probabilistic Seismic Hazard Analysis. Part I: Assessment of Maximum Regional Magnitude m_{max}. *Pure and Applied Geophysics*, 152:413-442.

Kijko A & Graham G. 1999. 'Parametric-Historic' Procedure for Probabilistic Seismic Hazard Analysis. Part II: Assessment of Seismic Hazard at Specified Site. *Pure and Applied Geophysics*, 154:1-22.

Kijko A, Graham G, Bejaichund M, Roblin D & Brandt MCB. 2003. *Probabilistic peak ground acceleration and spectral seismic hazard maps for South Africa*. Report No 2003-0053. Pretoria: Council for Geoscience.

Kijko A, Retief SPJ & Graham G. 2002. Seismic hazard and risk assessment for Tulbagh, South Africa: Part I – assessment of seismic hazard. *Natural Hazards*, 26:175-201.

Kijko A, Retief SPJ & Graham G. 2003. Seismic hazard and risk assessment for Tulbagh, South Africa: Part II – assessment of seismic risk. *Natural Hazards*, 30:25-41.

Kijko A & Sellevoll MA. 1989. Estimation of Earthquake Hazard Parameters from Incomplete Data Files. Part I: Utilization of Extreme and Complete Catalogues with Different Threshold Magnitudes. *Bulletin of the Seismological Society of America*, 79:645-654.

Kijko A & Sellevoll MA. 1992. Estimation of Earthquake Hazard Parameters from Incomplete Data Files. Part II: Incorporation of Magnitude Heterogeneity. *Bulletin of the Seismological Society of America*, 82:120-134.

Kijko A & Singh M. 2011. Statistical tools for Maximum Possible Earthquake Magnitude Estimation. *Acta Geophysica*, 59:674-700.

Kijko A & Smit A. 2012. Extension of the Aki-Utsu *b*-value estimator for incomplete catalogs. *Bulletin of the Seismological Society of America*, 102:1283-1287.

Kijko A, Smit A, Papadopoulos, GA & Novikova T. 2018. Tsunami hazard assessment of coastal South Africa based on mega-earthquakes of remote subduction zones, *Pure and Applied Geophysics*, 175: 1287–1304.

Kijko A, Smit A & Sellevoll MA. 2016. Estimation of Earthquake Hazard Parameters from Incomplete Data Files. Part III: Incorporation of uncertainty of earthquake-occurrence model. *Bulletin of the Seismological Society of America*, 106: 1210-1222.

Krige LJ & Venter FA. 1933. The Zululand earthquake of the 31st December 1932. *Transactions of the Geological Society of South Africa*, 36:101-112.

Kruger GP & Meyer R. 1988. A sedimentological model for the northern Zululand coastal plain. Extended Abstract, *Proceedings of the 22nd Earth Science Congress of the Geological Society of South Africa*, pp.423-426.

Leeman ER. 1964. The measurement of stress in rock: Parts I, II and III. *Journal of the South African Institute of Mining and Metallurgy*, 65:45-114, 254-284.

Leeman ER. 1969. The 'doorstopper' and triaxial rock stress measuring instruments developed by the CSIR. *Journal of the South African Institute of Mining and Metallurgy*, 69:305-339.

Malephane H, Durrheim RJ & Andreoli MAG. 2013. Seismic monitoring in the Namaqualand-Bushmanland region. *Proceedings SAGA-AEM Joint Conference and Exhibition*, 6-11 October 2013, Kruger Park, South Africa.

Malservisi R, Hugentobler U, Wonnacott R & Hackl M. 2013. How rigid is a rigid plate? Geodetic constraint from the Trignet CGPS network, South Africa. *Geophysical Journal International*, 192:918-928.

Manzunzu B & Midzi V. 2015. The curious case of the 1919 Swaziland earthquake. *Seismological Research Letters*, 86:803-9.

Manzunzu, B., Midzi, V., Mangongolo, A. and Essrich, F., 2017. The aftershock sequence of the 5 August 2014 Orkney earthquake (ML 5.5), South Africa. *Journal of Seismology*, 21:1323-1334.

Manzunzu B, Midzi V, Mulabisana TF, Zulu BS, Pule T, Myendeki S & Rathod, G. 2019. Seismotectonics of South Africa. *Journal of Africa Earth Sciences,* 149:271-279.

Master S. 2008. Henry Richard Bright: a forgotten pioneer of the geological and palaeontological exploration of Lesotho in the 1870s. *Archives of Natural History*, 35:191-202.

Master S. 2012. Oldest 'earthquake' in South Africa (Robben Island, 07 April 1620) discredited. *South African Journal of Science*, 108:1-3.

McGarr A & Gay NC. 1978. State of stress in the Earth's crust. *Annual Review of Earth and Planetary Science*, 6:405-436.

McGuire RK (Ed). 1993. *The Practice of Earthquake Hazard Assessment.* International Association of Seismology and Physics of the Earth's Interior and European Seismological Commission.

Meghraoui, M, Amponsah, P, Ayadi, A, Ayele, A, Ateba, B, Bensuleman, A, Delvaux, D, El Gabry, M, Fernandes, R, Midzi, V & Roos, M. 2016. The seismotectonic map of Africa. Episodes, 10:9-18.

Midzi V, Hlatywayo DJ, Chapola LS, Kebede F Atakan, K Lombe DK, Turyomurugyendo G & Tugume FA. 1999. Seismic hazard assessment in eastern and southern Africa. *Annali di Geofisica*, 42:1067-1083.

Midzi V & Goedhart ML. 2009. *Paleoseismic investigation along the Kango Fault, South Africa: determination of associated uncertainty*. Abstract and poster. 30th General Assembly of the International Association of Seismology and Physics of the Earth's Interior (IASPEI), 10 to 16 January 2009, Cape Town, South Africa.

Midzi V, Bommer JJ, Strasser FO, Albini P, Zulu BS, Prasad K & Flint NS. 2013. An intensity database for earthquakes in South Africa from 1912 to 2011. *Journal of Seismology*. 17:1183-1205.

Midzi V, Manzunzu B, Zulu BS, Mulabisana T, Myendeki S & Mangongolo A. 2015a. Impact of recent moderately sized earthquakes in South Africa: macroseismic investigations of the 18 November and 2 December 2013 earthquakes. *South African Journal of Geology*. 118:373-388.

Midzi V, Zulu B, Manzunzu B, Mulabisana T, Pule T, Myendeki S & Gubela W. 2015b. Macroseismic survey of the M_L5. 5, 2014 Orkney earthquake. *Journal of Seismology*. 19:741-751.

Midzi, V., Saunders, I., Manzunzu, B., Kwadiba, M.T., Jele, V., Mantsha, R., Marimira, K.T., Mulabisana, T.F., Ntibinyane, O., Pule, T. & Rathod, G.W., 2018a. The 03 April 2017 Botswana M6.5 Earthquake: Preliminary Results. *Journal of African Earth Sciences*, 143:187-194.

Midzi V, Manzunzu B, Mulabisana TF, Zulu BS, Pule T, Myendeki S & Rathod, G. 2018b. The Probabilistic Seismic Hazard Assessment of South Africa. *Journal of African Earth Sciences* (in review).

Milev, A, Durrheim, R, Brovko, F, Kgarume, T, Singh, N, Lumbwe, T, Wekesa, B, Pandelany, T & Mwila, M, 2016. *Development of a South African Minimum Standard on Ground Vibration, Noise, Air-blast and Flyrock near Surface Structures to be Protected*, Final Report, Project SIM14-09-01, South African Mine Health and Safety Council Report.

Milner B. 1973. A geophysical investigation of the loading of the Hendrik Verwoerd dam. Unpublished MSc thesis. Johannesburg: University of the Witwatersrand.

Moyer PA, Boettcher MS, Ellsworth WL, Ogasawara H, Cichowicz A, Birch D & Van Aswegen G. 2017. Call for models—a test case for the source inversion validation: the 2014 M_L 5.5 Orkney, South Africa, earthquake. *Seismological Research Letters*. 88: 1333-1338

NEIC 2006. *M_W7.0 Machaze earthquake of 22 February 2006*. Poster. Washington, DC: US Geological Survey, National Earthquake Information Centre.

News24, 2011. *Koeberg can withstand quake, tsunami*. Retrieved from http://www.news24.com/SouthAfrica/News/Koeberg-can-withstand-quake-tsunami-20110315, (accessed 27 June 2015).

New Scientist 2012. *Last year costliest on record for natural disasters.* Retrieved from http://www.newscientist.com/article/mg21328474.200-last-year-costliest-on-record-for-natural-disasters.html (accessed 20 October 2012).

Nyblade A, Dirks P, Durrheim RJ, Webb S, Jones M, Cooper G & Graham G. 2008. AfricaArray: developing a geosciences workforce for Africa's natural resource sector. *The Leading Edge*, 27(10):260-263.

Nyblade A, Durrheim RJ, Dirks P, Graham G, Gibson R & Webb S. 2011. Geoscience initiative develops sustainable science in Africa. *EOS Transactions AGU*, 92:161-162.

Okal EA & Hartnady CJ. 2009. The South Sandwich Islands earthquake of 27 June 1929: seismological study and inference on tsunami risk for the South Atlantic. *South African Journal of Geology* 112: 359-370.

Okal, EA, Fritz, H.M. and Sladen, A., 2009. 2004 Sumatra-Andaman tsunami surveys in the Comoro Islands and Tanzania and regional tsunami hazard from future Sumatra events. *South African Journal of Geology*, 112:343-358.

Ogasawara H. 2015. Stress and strength at seismic event hypocenters in deep South African gold mines and the M5.5 Orkney earthquake. *Proceedings of the 10th Annual AfricaArray Workshop*, 18-26 January 2015. 24.

Ogaswara H, Yabe Y, Ito T, Van Aswegen G, Cichowicz A & Durrheim, R. 2015. Drilling into seismogenic zones of M2.0 - M5.5 earthquakes in deep South African gold mines (DSeis). *Proceedings of the Japan Geosciences Union Meeting*, 24-28 May 2015, Chiba Japan. Abstract MIS32-14.

Pagani, M, Garcia-Pelaez, J, Gee, R, Johnson, K, Poggi, V, Styron, R, Weatherill, G, Simionato, M, Viganò, D, Danciu, L, Monelli, D. (2018). Global Earthquake Model (GEM) Seismic Hazard Map (version 2018.1 - December 2018), DOI: 10.13117/GEM-GLOBAL-SEISMIC-HAZARD-MAP-2018.1 https://www.globalquakemodel.org/africa-model-release

Park C. 2013. MASW for geotechnical site investigations. *The Leading Edge*, 32:656-662.

Pule T, Fourie CJ, Kijko A & Midzi V. 2015. Comparison and quantitative study of vulnerability/damage curves in South Africa. *South African Journal of Geology*. 118:335-354.

Raucoules D, Ristori B, De Michele M, Briole P. 2010. Surface displacement of the Mw 7 Machaze earthquake (Mozambique): Complementary use of multiband InSAR and radar amplitude image correlation with elastic modelling. *Remote Sensing of Environment*, 114:2211-2218.

Reinecker J, Heidbach O, Tingay M, Connolly P & Müller B. 2004. *The 2004 release of the World Stress Map*. World Stress Map Project. Retrieved from www.world-stress-map.org.

SABS 1990. *Code of practice for the general procedures and loadings to be adopted for the design of buildings*. SABS 0160-1989. Pretoria: South African Bureau of Standards.

Saunders I, Brandt M, Molea T, Akromah L & Sutherland B. 2010. Seismicity of southern Africa during 2006 with special reference to the Mw 7 Machaze earthquake. *South African Journal of Geology*. 113:369-380.

Saunders I, Brandt M, Steyn J, Roblin D & Kijko A. 2008. The South African Seismograph Network. *Seismological Research Letters*, 79:203-210.

Saunders I, Ottemőller L, Brandt MCB & Fourie CJS. 2013. Calibration of an M_L scale for South Africa using tectonic earthquake data recorded by the South African national seismograph network, 2006-2009. *Journal of Seismology*, 17:437–451.

Schweitzer J & Lee WHK. 2003. Old seismic bulletins to 1920: a collective heritage from early seismologists. In: W Lee, P Jennings, C Kisslinger & H Kanamori (Eds). International Handbook of Earthquake & Engineering Seismology, Part B, Academic Press, 1665-1723.

Shapira A & Fernández LM. 1989. Probabilities of exceedance for prescribed peak ground accelerations (PGA at selected South African locations). *Tectonophysics*, 167:253-260.

Shapira A, Fernández LM & Du Plessis A. 1989. Frequency-magnitude relationships of South African seismicity. *Tectonophysics*, 167:261-271.

Singh, M., 2016. Seismic sources, seismotectonics and earthquake recurrence for the KZN coastal regions. Doctor of Philosophy in Engineering, University of KwaZulu-Natal.

Singh, M, Akombelwa, M & Maud, R. 2015. Analysis of possible sources of some unregistered historical earthquake tremors that affected the KwaZulu-Natal coastal regions of South Africa for seismo-tectonic investigations. *Natural Hazards*, 75:2279-2289.

Singh M & Hattingh E. 2009. Short communication: collection of isoseismal maps for South Africa. *Natural Hazards*, 50:403-408.

Singh M, Kijko A & Durrheim RJ. 2009. Seismotectonic models for South Africa: synthesis of geoscientific information, problems, and the way forward. *Seismological Research Letters*, 80:71-80.

Singh M, Kijko A & Durrheim RJ. 2011. First-order regional seismotectonic model for South Africa. *Natural Hazards*, 59:383-400.

Singh M, Kijko A & Van den Bergh L. 2011. Seismic risk ranking for large dams in South Africa. *Acta Geophysica*, 59:72-90.

Smit L, Fagereng Å, Braeuer B & Stankiewicz J. 2015. Microseismic activity and basement controls on an active intraplate strike-slip fault, Ceres–Tulbagh, South Africa. *Bulletin of the Seismological Society of America*. 105:1540-1547.

Stacey TR & Wesseloo J. 1998. In situ stresses in mining areas in South Africa. *Journal of the Southern African Institute of Mining and Metallurgy*. 98:365-368.

Steenekamp JMA, Van der Westhuizen, WA, Bateman MD, Jacobsen, L & Nel L. 2018. A Pleistocen thrust fault in anorthosite of the Rustenburg Layered Site near Mooinooi, Norht West Province, South Africa: neotectonic implications. *South African Journal of Geology. 121:421-430.*

Strasser FO & Mangongolo A. 2013. TNSP Earthquake Catalogue. 2012 - 0166. Available: http://www.eskom.co.za/Whatweredoing/SSHAC_ProjectResults/Documents/21TNSP_EarthquakeCatalogue.pdf [Accessed 19 January 2018].

Theron JN. 1974. The seismic history of the south-western Cape Province. In: WL van Wyk & LE Kent (Eds). *The Earthquake of 29 September 1969 in the southwestern Cape Province, South Africa*. Seismologic Series 4. Pretoria: Geological Survey of South Africa.

UNOCHA 2006. *Mozambique Earthquake OCHA Situation Report No 2.* UN Office for the Coordination of Humanitarian Affairs. Retrieved from http://reliefweb.int/report/mozambique/mozambique-earthquake-ocha-situation-report-no-2

USGS 2012. *Earthquakes with 50,000 or more deaths.* Retrieved from http://earthquake.usgs.gov/earthquakes/world/most_destructive.php [accessed 7 October 2012).

Van Wyk WL & Kent LE (Eds). 1974. *The Earthquake of 29 September 1969 in the southwestern Cape Province, South Africa*. Seismologic Series 4. Pretoria: Geological Survey of South Africa.

Viola G, Kounov A, Andreoli MA, Mattila J. 2012. Brittle tectonic evolution along the western margin of South Africa: more than 500 Myr of continued reactivation. *Tectonophysics.* 514:93-114Von Buchenröder WL. 1830. An account of earthquakes which occurred at the Cape of Good Hope during the month of

December 1809, etc. *South African Quarterly Journal*, Cape Town, 1 October 1829 to September 1830. 18-25.

Wood HE. 1913. On the occurrence of earthquakes in South Africa. *Bulletin of the Seismological Society of America*, 3:113-120.

Wood HE. 1914. Witwatersrand earth tremors. *Journal of the Chemical, Metallurgical and Mining Society of South Africa*, 14:423-426.

World Commission on Dams. 2000. *Kariba Dam, Zambia and Zimbabwe – Final Report: November 2000*. WCD Case Study. Prepared for the World Commission on Dams (WCD) by Soils Incorporated (Pvt) Ltd, Harare, Zimbabwe in association with Chalo Environmental & Sustainable Development Consultants, Lusaka, Zambia. Cape Town: Secretariat of the World Commission on Dams.

Wright C & Fernández LM. 2003. Earthquakes, seismic hazard and earth structure in South Africa. In: W Lee, P Jennings, C Kisslinger & H Kanamori (Eds). *International Handbook of Earthquake and Engineering Seismology. Part B*. Elsevier Academic Press. 1-35.

Appendix B: OpenQuake PSHA computation for South Africa and the energy corridors

Primary references:

Midzi V, Manzunzu B, Mulabisana TF, Zulu BS, Pule T, Myendeki S & Rathod, G. in press. The Probabilistic Seismic Hazard Assessment of South Africa. *Journal of African Earth Sciences*.

Manzunzu B, Midzi V, Mulabisana TF, Zulu BS, Pule T, Myendeki S & Rathod, G. 2019. Seismotectonics of South Africa. *Journal of Africa Earth Sciences,* 149:271-279.

Meghraoui, M, Amponsah, P, Ayadi, A, Ayele, A, Ateba, B, Bensuleman, A, Delvaux, D, El Gabry, M, Fernandes, R, Midzi, V & Roos, M. 2016. The seismotectonic map of Africa. Episodes, 10:9-18.

Summary:

More than 20 years has passed since previous national seismic hazard maps were prepared for South Africa. In those maps, zone-less techniques were applied. The availability of more reliable seismicity and geological data has made it possible to update those maps using state of the art probabilistic seismic hazard assessment methodologies that take into consideration all available data. The papers by Manzunzu et al (2019) and Midzi et al (in press) present a summary of the work conducted to produce the latest seismic hazard maps for South Africa. This involved the systematic compilation and homogenisation of an earthquake catalogue, which comprised both historical and instrumental events. The catalogue played a prominent role in the preparation and characterisation of the seismic source model. Two ground motion prediction equations were identified from available international models for regions that are tectonically similar to South Africa. These two models were then implemented in the hazard calculations, which were done using the OPENQUAKE software. Uncertainties associated with input parameters in both the seismic source and ground motion models were taken into account and implemented using the logic tree technique. Maps showing the distribution of acceleration at three periods (0.0s, 0.15s and 2.0s) computed for 10% probability of exceedance in 50 years were produced. These maps constitute a valuable product of this study that can be useful in updating South African building codes.

The map of 'major' and 'active faults' produced by Manzunzu et al. (2019), shown in Figure 1, is an update of the faults identified as 'active (<150 ka)' by Meghraoui et al. (2016), shown in Figure 2.

Manzunzu et al's 'major' faults are identical to Meghraoui et al's 'active faults (<150 ka)'. Manzunzu et al's 'active faults' (coloured yellow in Figure 1) are segments of faults where additional evidence of seismic activity has been found, mainly published geological information (cited in Manzunzu et al., 2019), or through association with seismicity (Manzunzu, personal communication, 15 August 2019).

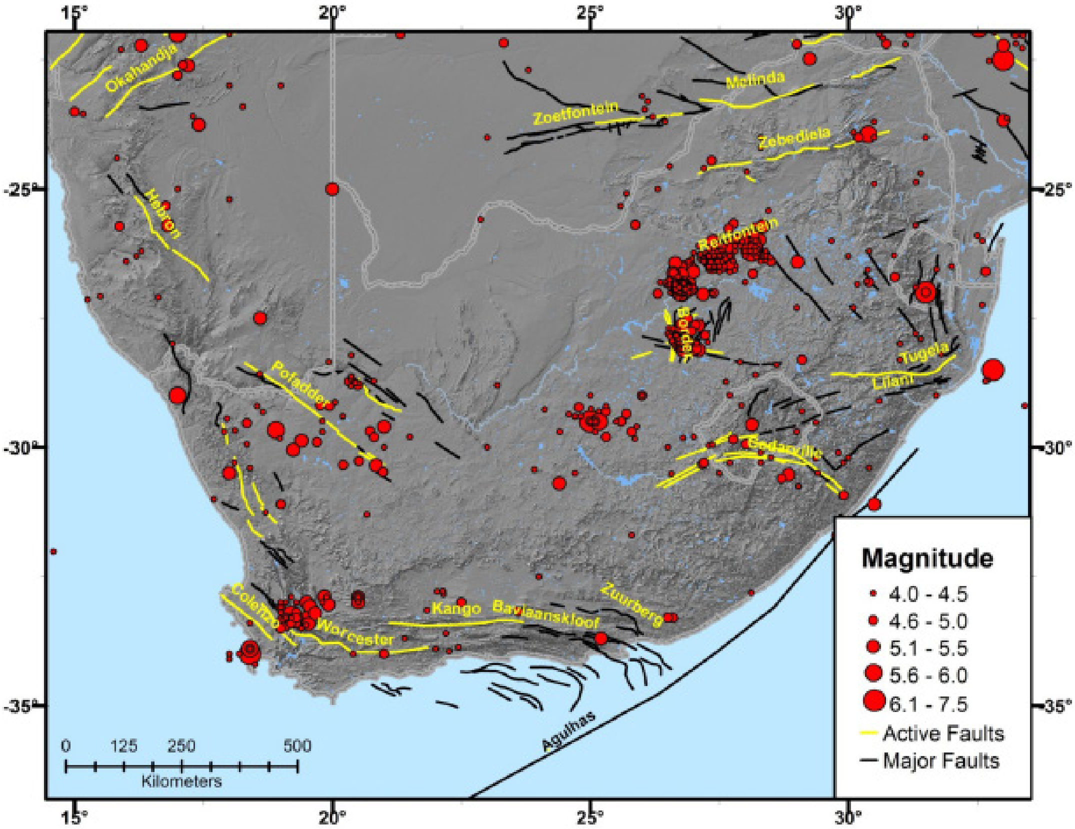

Figure 1: Neotectonic faults of southern Africa (from Manzunzu et al., 2019). Red circles are southern African earthquakes of magnitude greater than or equal to 4.0.

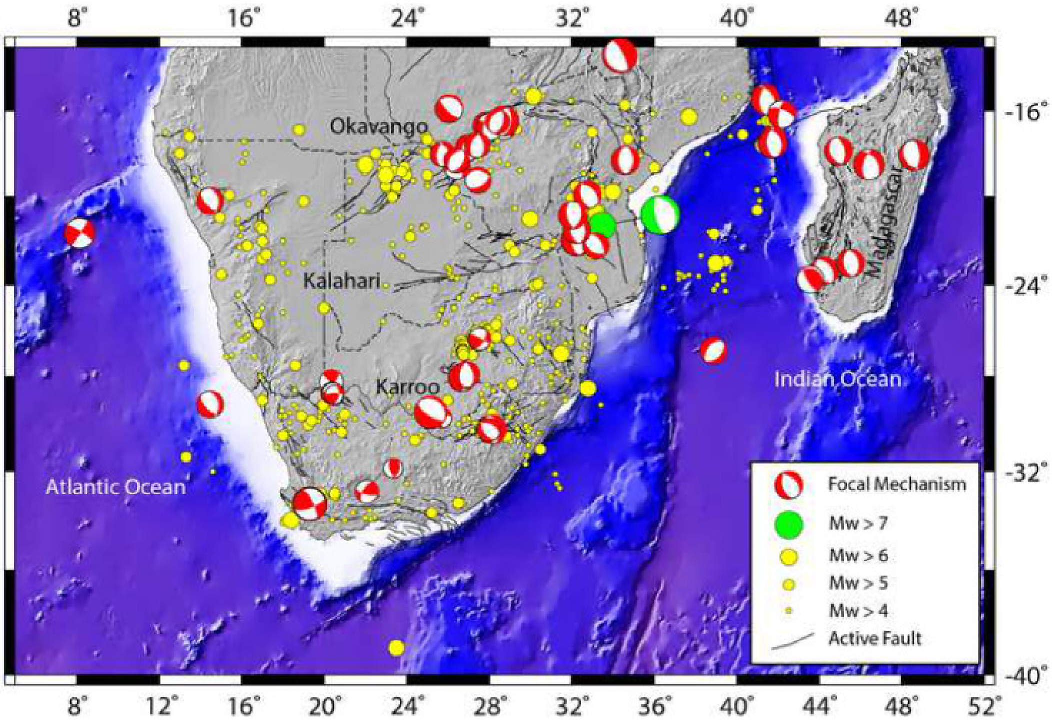

Figure 2: A seismotectonic map of southern Africa combining available information used in the identification of seismic sources (from Meghraoui et al., 2016)

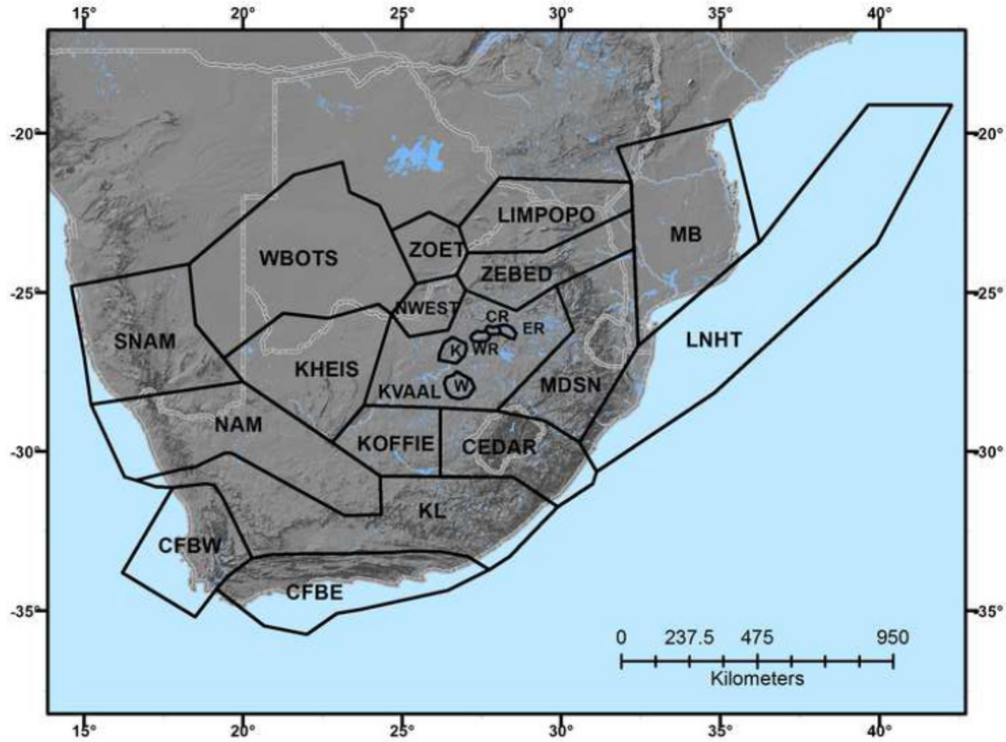

Figure 3: Illustration of the individual area source zones used in this study. ER- ERAND, WR – WRAND, CR – CRAND, K – KOSH and W – Welkom (from Midzi et al., in press)

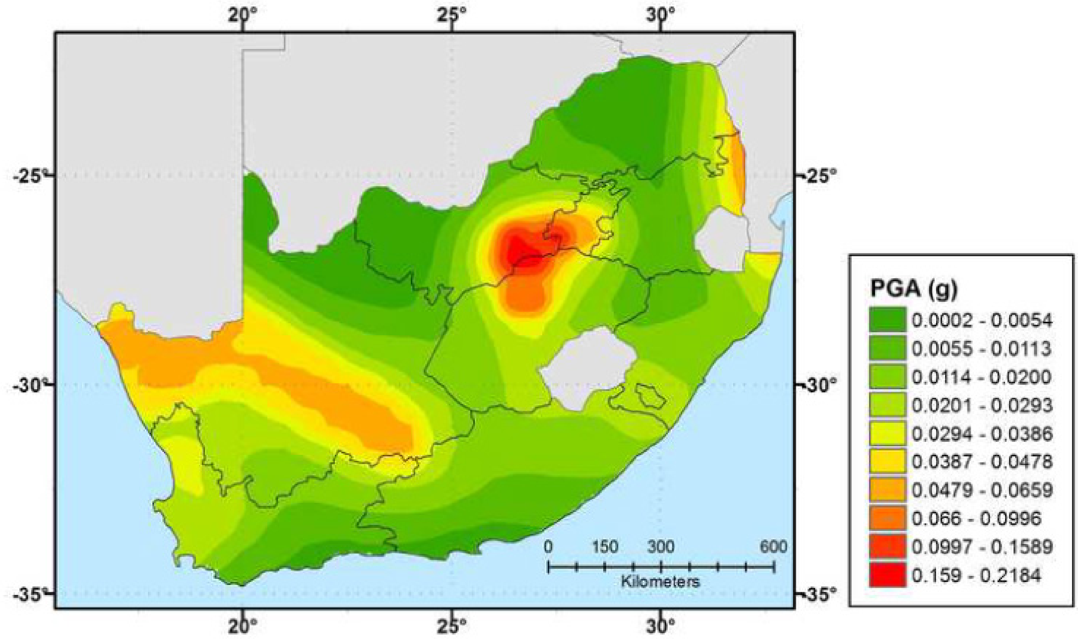

Figure 4. Distribution of mean PGA values in South Africa computed for 10% probability of exceedance in 50 years (return period of 475 years) (from Midzi et al., in press)

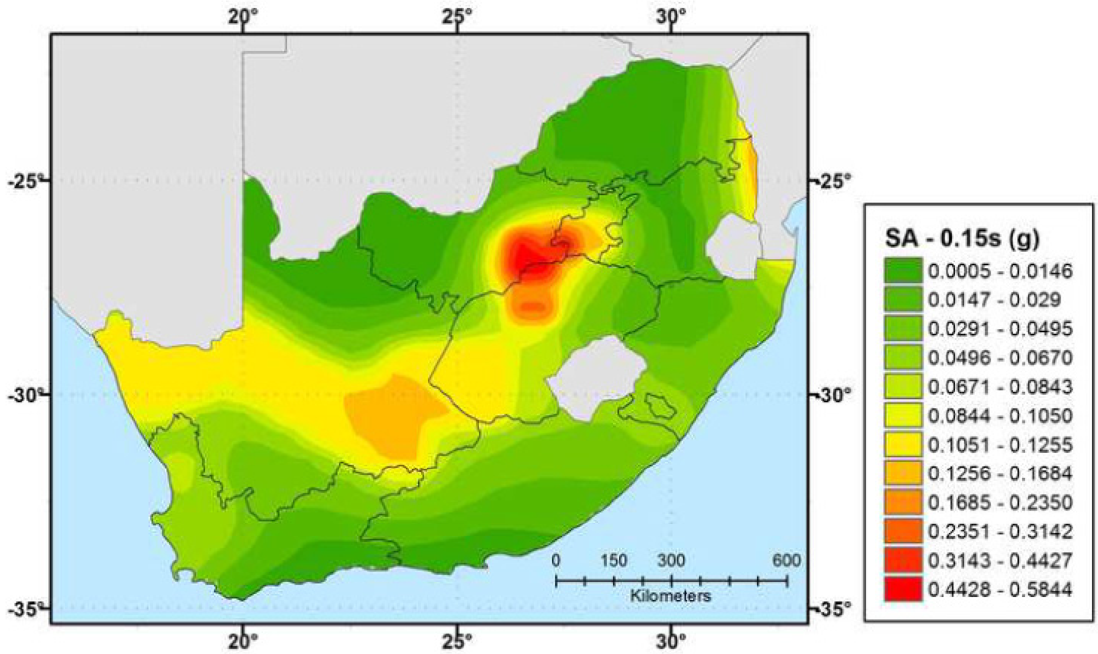

Figure 5. Distribution of spectral acceleration (period of 0.15s) values in South Africa computed for 10% probability of exceedance in 50 years (return period of 475 years) (from Midzi et al., in press)

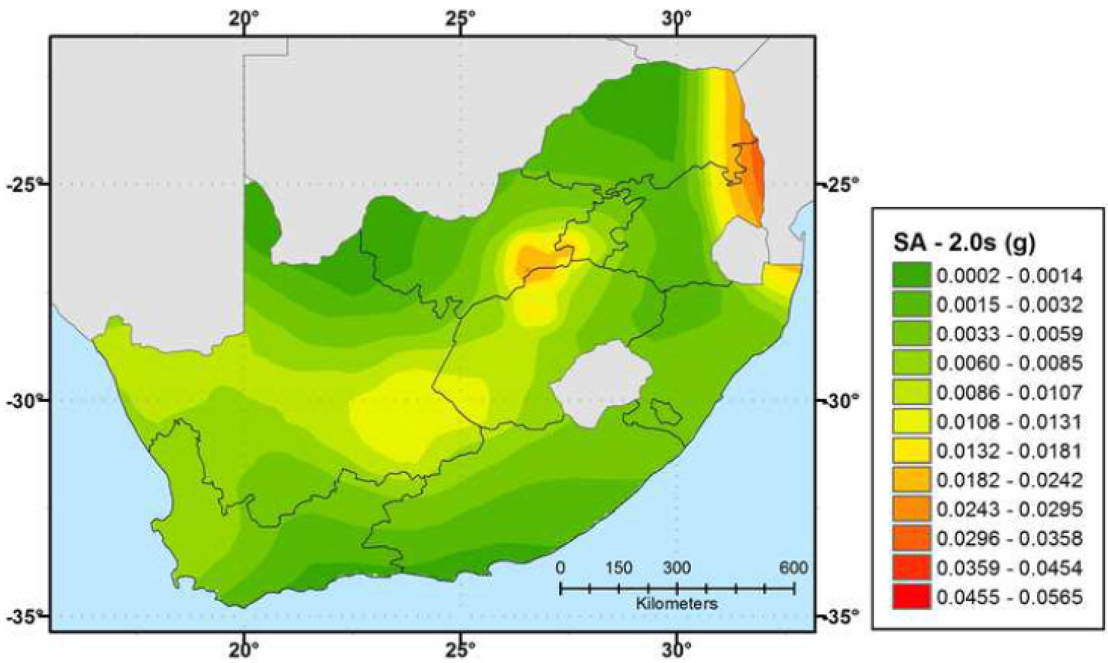

Figure 6. Distribution of spectral acceleration (period of 2.0s) values in South Africa computed for 10% probability of exceedance in 50 years (return period of 475 years) (from Midzi et al., in press)

Appendix C: Vulnerability of EGI and Monitoring

Primary reference: Milev, A, Durrheim, R, Brovko, F, Kgarume, T, Singh, N, Lumbwe, T, Wekesa, B, Pandelany, T & Mwila, M, 2016. *Development of a South African Minimum Standard on Ground Vibration, Noise, Air-blast and Flyrock near Surface Structures to be Protected.* Final Report, Project SIM14-09-01, South African Mine Health and Safety Council Report.

GROUND SHAKING

Ground vibrations are the inevitable results of earthquakes. The rock close to the fault zone may be crushed or fractured, but a proportion of the energy is radiated as elastic energy in the form of compressional (P) and shear (S) waves. The class of seismic waves that distort the Earth's surface most severely are known as 'surface waves', and are formed by the 'trapping' of P- and S-wave energy in near-surface layers. Surface waves have both compressional (and dilatational) components and vertical and horizontal components of shear. Their effect on buildings and other structures depends on the wavelength of the waves and the footprint and height of the structures. The seismic wavelength, in turn, depends on:

i. the size of the earthquake, and
ii. the seismic velocity of the rock, weathered material, alluvium or soil that comprises the near-surface layer of the Earth (say the uppermost 10-30 m).

Surface wave velocities (c) for near surface materials typically range from 200 m/s (alluvium) to 2000 m/s (slightly weathered granite); while the frequencies (f) produced by a typical blast in an open cast mine range from 5-200 Hz. The wavelength ($\lambda = c/f$) thus ranges from 1 m to 400 m. The potential to cause damage to buildings is greatest when the wavelength is of the same order as the footprint of the building (Figure 1).

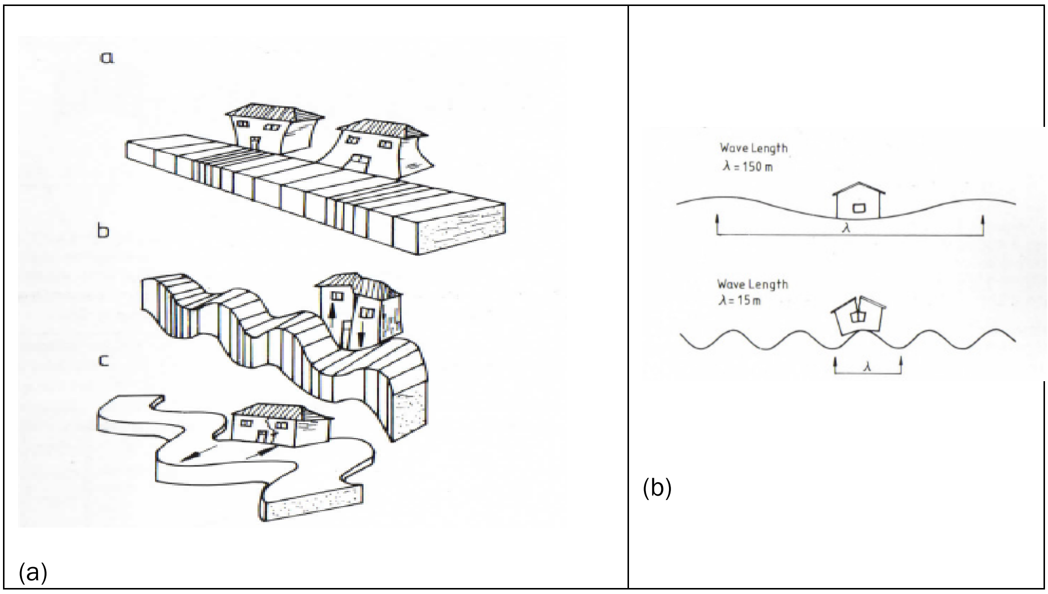

Figure 1: (a) How seismic waves distort structures; (b) The effect of wavelength
(Source: Tamrock, 1984, p. 166-167)

Earthquake-induced ground vibration can be measured using three different parameters: ground displacement (u), particle velocity (V) or acceleration (a). These parameters are related by the frequency (f) and π:

$$V = 2\pi f u$$
$$a = 2\pi f V = 4\pi^2 f^2 u$$

- **Acceleration (a)** is a measure of how quickly the point of interest changes velocity over a set period of time. This is usually expressed in millimetres per second per second (mm/s^2) or as a multiple of gravitational acceleration ($9.8\ m/s^2$, or "g"). Acceleration on its own does not necessarily cause damage, but differential acceleration between objects or structures can create dynamic stresses and strains, causing damage.

- **Velocity (V)** is a measure of how far the point of interest moves in a set period of time. It is usually expressed in millimetres per second (mm/s). Like acceleration, velocity on its own does not cause damage. A house, car or person can sustain high speeds without damage; we see this every time we fly in a passenger jet.
- **Displacement (u)** is the distance that the point of interest moves from a certain reference point. This is usually expressed in millimetres (mm). Displacement alone does not cause damage; a house on the back of truck can be moved kilometres without being damaged. It is differential displacement (strain) that ultimately causes damage.

The potential to cause damage to buildings is most closely correlated with the Peak Particle Velocity (PPV). People can detect ground motions with PPVs as low as 0.8 mm/s; buildings may experience cosmetic damage at PPVs of 10 mm/s at frequencies of 10 Hz; while severe structural damage may occur when PPVs exceed 200 mm/s.

The methods used to record and analyse vibrations produced by earthquakes and mine blasts are similar, but there are important differences (Table 1). This means that the relationships and conclusions that are valid in earthquake engineering do not necessarily apply to mine blasting (JKMRC, 1996, p. 270).

Table 1: Comparison of blast-induced and earthquake ground vibrations

	Typical opencast blast	**Damaging Earthquake (M>6)**
Frequency (Hz)	5 - 200	0.1 – 5
Duration (sec)	0.5 - 5	10s of seconds to minutes
Displacement (mm)	0.001 - 2	100s of mm
Peak velocity (mm/s)	0.1 - 1000	Up to 1000
Peak acceleration (m/s^2)	0.01 - 100	Seldom > 10

SAFE LIMITS OF GROUND VIBRATION FOR EGI AND OTHER ENGINEERED STRUCTURES

Vibration limits have been published in the literature for different types of equipment and structures. Although these may differ slightly from application to application, the guidelines by Bauer and Calder (1977) are based on empirical information (Table 2).

Table 2: Vibration amplitudes for structures and equipment other than buildings
(Rorke, 2011; citing Bauer and Calder, 1977)

Type of Structure	**Type of Damage**	**PPV at which Damage starts (mm/s)**
Rigidly mounted mercury switches	Trip-out	12.7
Concrete blocks (e.g. floor slabs)	Hairline cracks in concrete	203
Cased drill holes	Horizontal offset	381
Mechanical equipment (e.g. pumps and compressors)	Shaft misalignment	1016
Prefabricated metal buildings on concrete pads	Cracked floor, building twisted and distorted	1524

The Australian Coal Association Research Programme (ACARP) project C14057 investigated methodologies for the assessment of the strength of infrastructure types and established limits for installations such as conveyors, power transmission towers, wooden power poles, electrical substations, pipelines, bridges, public access roads and underground working (Richards and Moore, 2007 and 2008). Some of the conclusions are listed below:

- **Power transmission towers:** Transgrid had commonly specified a limit of 50 mm/s. The study showed that this was conservative and a higher limit of 100 mm/s was validated, subject to effective measurement and control.
- **Wooden power poles:** Investigations showed that vibrations up to 240 mm/s did not adversely affect the poles.

- **Electrical substations:** The vibration limit is determined by the sensitivity of the trip switches in the substations, and the sensitivity of the switches varies considerably.
- **Conveyor structures:** Tests were limited to 25 mm/s. It was found that no significant additional stresses were imparted to the structure. Based on conservative assumptions, it is predicted that the conveyor will remain within serviceability limits at ground vibrations of 50 mm/s.

Vibration limits for civil and engineering structures such as power lines, roads, pipelines and conveyors are provided by Rorke (2011):

- **Eskom Power Lines:** Eskom places a limit of 75 mm/s at its pylons. This is a conservative limit as the steel structure of each pylon and the concrete foundation blocks can both withstand significantly higher vibrations.
- **Public Roads:** For public roads, such as the regional and national roads (e.g. R545, N4), the risk of disaggregation of the road material will start to appear at vibration amplitudes of the vertical component above 150 mm/s. Thus vibration levels at these structures need to be kept below 150 mm/s.
- **Telkom Relay Tower:** Structurally, towers will be able to withstand relatively high vibration at frequencies above 5 Hz. However, the electronic circuitry will be more sensitive, and a ground vibration limit of 10 mm/s is applicable.
- **Pipelines (Water and Transnet):** The limit at which pipelines will start to become damaged is high. Blasting near pressurized steel pipelines has taken place safely at PPV's in excess of 50 mm/s in South Africa. Unless the pipelines are in very poor condition or made of old concrete/asbestos, a level of 50 mm/s is considered to be safe. Transnet prescribed a limit of 25 mm/s on their pipeline that runs close to blasting operations along the N12 highway. (The purpose of the pipeline is not specified).
- **Conveyors:** A steel conveyor structure will withstand very high vibrations and the concrete plinths will remain undamaged by ground vibration up to 200 mm/s.

A similar compilation of vibration limits for civil and engineering structures such as power lines, roads, pipelines and conveyors is given in Table 3.

Table 3: Vibration limits for civil infrastructure used in South Africa
(Source: Blast Management & Consulting, 2015):

Structure Description	Ground Vibration Limit (mm/s)
National Roads/Tar Roads	150
Electrical Lines (Pylons)	75
Railway	150
Transformers	25
Water Wells	50
Telecoms Tower	50
General Houses of proper construction	USBM Criteria or 25 mm/s
Houses of lesser proper construction	12.5
Rural building – Mud houses	6

MONITORING OF VIBRATIONS

The South African National Standard (SANS 4866:2011, based on ISO 4866:2010) specifies measuring ranges for various vibration sources, including earthquakes and blasts (Table 4). These standards should be applied when carrying out surveys related to EGI.

The standard prescribes that instruments used to monitor ground-borne blast vibrations must be capable of measuring ground motions over the range 0.2 mm/s to 100 mm/s in the frequency range of 1 Hz to 300 Hz; while instruments used to monitor earthquakes must be capable of measuring ground motions over the range 0.2 mm/s to 400 mm/s in the frequency range of 0.1 Hz to 30 Hz.

Table 4: South African standards for measuring mechanical vibrations
(South African National Standard (SANS) 4866:2011)

Vibration source	Frequency range[a] Hz	Amplitude range µm	Particle velocity range mm/s	Particle acceleration range m/s^2	Time characteristic
Traffic road, rail, ground-borne	1 to 100	1 to 200	0,2 to 50	0,02 to 1	C[b]/T[c]
Blasting vibration ground-borne	1 to 300	100 to 2 500	0,2 to 100	0,02 to 50	T
Air over pressure	1 to 40	1 to 30	0,2 to 3	0,02 to 0,5	T
Pile driving ground-borne	1 to 100	10 to 50	0,2 to 100	0,02 to 2	T
Machinery outside ground-borne	1 to 100	10 to 1 000	0,2 to 100	0,02 to 1	C/T
Machinery inside	1 to 300	1 to 100	0,2 to 30	0,02 to 1	C/T
Human activities inside	0,1 to 30	5 to 500	0,2 to 20	0,02 to 0,2	T
Earthquakes	0,1 to 30	10 to 10^5	0,2 to 400	0,02 to 20	T
Wind	0,1 to 10	10 to 10^5	—	—	T
Acoustic (inside)	5 to 500	—	—	—	C/T

NOTE 1 The ranges quoted are extreme, but they still indicate the values which may be experienced and which may have to be measured (see also Note 2). Extreme ranges of displacement amplitudes and frequencies have not been used to derive particle velocities and accelerations. Values lower than 0,2 mm/s can also be considered. For building security and human annoyance, these values may be insignificant, but for sensitive equipments they are significant.

NOTE 2 Vibration values within the given ranges may cause concern. There are no standards which cover all varieties of structures, conditions and durations of exposure, but many national codes associate the threshold of visible (or otherwise noticeable) effects with peak particle velocities at the foundation of a structure of more than a few millimetres per second. A significant damage is linked to peak particle velocities of several hundred millimetres per second. Vibration levels below the threshold of human perception may be of concern in delicate and industrial processes.

[a] Ranges quoted refer to the response of structures and structural elements to a particular type of excitation and are indicative only.

[b] Continuous.

[c] Transient.

The guideline *Noise and Vibration from Blasting* issued by the Queensland Department of Environment and Heritage Protection (EM2402, version 3.00, approved 22 January 2016) differs slightly from SANS 4866:2011, recommending that ground vibration instrumentation used for compliance monitoring must be capable of measurement over the range 0.1 mm/s to 300 mm/s with an accuracy of not less than 5% and have a flat frequency response to within 5% over the frequency range of 4.5 Hz to 250 Hz.

Field Practice Guidelines for Blasting Seismographs, published by the International Society of Explosives Engineers (ISEE, 2015), is the industry standard for the correct monitoring of blast vibrations. It can be downloaded at https://www.isee.org/digital-downloads/290-isee-field-practice-guidelines-for-blasting-seismographs-2015. It notes that the following issues require special attention:

- **Coupling of vibration sensors:** If transducers are placed on the ground alongside the building being monitored, the recorded vibrations can be significantly affected by surface or near-surface features which may have a very localised affect. At high levels of vibration which occur at certain frequencies, it is also possible for transducers to leave the ground. In principle, this can be addressed by driving a stiff steel rod into the ground through the loose surface layer and attaching the transducer to it, but good coupling is often difficult to achieve. Alternatively, the transducer can be fixed to a rigid surface plate such as a well-bedded paving slab. Some equipment manufacturers suggest placing the transducer on a hard surface with a small sandbag on top of it. However, even if good coupling is achieved, the nature of the ground under the hard surface is unknown, and it might be very broken and affect the vibrations. Better coupling can be achieved if the transducers are buried in a density-matching box, but this is only practicable for permanent monitoring stations.
- **Calibration of vibration sensors:** The detectors commonly used to measure ground vibrations are either geophones (velocity transducers) or accelerometers. The vibrations produced by mining operations generally occur over the frequency range of 2-200 Hz and thus the detectors should be capable of

accurately monitoring vibrations across this range. Geophones require regular re-calibration over a period of time and if shaken violently. Geophones should be calibrated annually at least.

- Orientation of vibration sensors:
  - Some sensors are sensitive to orientation; a vertical 2 Hz geophone cannot be used as a horizontal sensor and vice-versa.
  - In a permanent array, sensors are usually orientated with respect to geographic north; while for a temporary measurement, the radial component is pointed towards the blast.
  - The three axes (directions) of measurement, the longitudinal (or "radial", the vector connecting the seismograph transducer and source of vibration), transverse (the vector in the same plane as, but perpendicular to, the longitudinal) and vertical (up and down) vectors, are always measured and reported separately. One reason for this is that they have different degrees of importance in causing damage. Structures are built to withstand vertical forces. For that reason, vibrations along the vertical vector are usually of lesser importance in causing damage, though not always benign. Vibrations in both the longitudinal and transverse directions have the potential for causing shear in the structure, which is a major contributor to damage effects. When in shear, various parts of the house move at different speeds or even in different directions, which can cause cosmetic cracking or even structural damage.
  - Vibration standards generally do not take these differences in damage potential between vibration direction components into account, but simply specify a single limit that applies to all three axes of measurement.
- Parameter(s) to measure
  - PPV is a "vector" quantity (i.e. it has both a value and an associated direction).
  - The Peak Vector Sum (PVS) is usually also quoted; it is simply the square root of the sum of the squares of the PPV values in all three vector directions measured by the geophones. PVS is a "scalar" quantity, i.e. one with only a value, which is always larger than the individual PPV vector values.
  - Scientific studies have shown that the PPV, of all the tested characterizations of ground movement (e.g. acceleration, displacement, or strain), correlates best with damage potential.
  - All the standards are quoted in PPV values, not PVS or other measures of movement, although the "acceptable" values of PPV differ with the standard applied and with the frequency of the vibration components.

It is important that ground and structure vibrations should be measured properly to ensure the receipt of correct records. A contemporary transducer for velocity measurement is a tri-axial pack of geophones with the frequency response from 1-300 Hz.

REFERENCES

Bauer, A. and Calder, P.N., 1977. *Pit Slope Manual*, Chapter 7. *Canmet Report*, pp.77-14.

Dowding, C.H., 1985. *Blast Vibration Monitoring and Control*, Prentice Hall, Englewood Cliffs.

GDAEC, 2008. *Mining and Environmental Impact Guide.* Gauteng Department of Agriculture, Environment and Conservation, 1119 pp.

ISEE, *Blasters' Handbook*, 17th edition. International Society of Explosives Engineers, Cleveland, USA, 742 pp.

ISEE, 2015. *Field Guide for Blasting Seismographs.* International Society of Explosives Engineers, Cleveland, USA, 11 pp.

ISO, 1990. *International Standard: Mechanical vibration and shock — Vibration of fixed structures — Guidelines for the measurement of vibrations and evaluation of their effects on structures*, International Organization for Standardization, ISO 4866:1990.

ISO, 2010. *International Standard: Mechanical vibration and shock — Vibration of fixed structures — Guidelines for the measurement of vibrations and evaluation of their effects on structures*, 2nd edition, International Organization for Standardization, ISO 4866:2010.

ISO, 1997. *International Standard: Mechanical vibration and shock – Evaluation of human exposure to whole body vibration*. ISO 2631-1, Second edition May 1997,

JKMRC 1996. *Open Pit Blast Design: analysis and optimisation.* A. Scott (editor), Julius Kruttschnitt Mineral Research Centre, Brisbane, Australia, 338 pp.

Nicholls, H. R., Johnson, C. F., & Duvall, W. I. 1971. *Blasting vibrations and their effects on structures*, US Government Printers.

QDEHP, 2016. *Guideline: noise and vibration from blasting*, Queensland Department of Environment and Heritage Protection, EM2402, version 3.00, approved 22 January 2016.

Richards A.B. and A.J. Moore, 2007. Effect of blasting on infrastructure, In *Proceedings of EXPLO2007, Blasting Techniques and Technology*,3-4 September 2007, Wollongong, Australasian Institute of Mining and Metallurgy, 45-50.

Richards A.B. and A.J. Moore, 2008. Effect of blasting on infrastructure, Australian Coal Association Research Program (ACARP), Project C140570.

Rorke, A.J., 2011, *Blasting Impact Assessment for the proposed New Largo Colliery based on New Largo Mine Plan 6. Available at: https:www.* zitholele.co.za.2015/11/16

Siskind, M., Stagg S., Kopp J.W. and C. H. Dowding 1989. *Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting.* United States Bureau of Mines Standard (USBM) RI 8507, U.S. Department of the Interior.

Siskind, D.E., 2000, *Vibrations from Blasting.* International Society of Explosives Engineers.

SANS, 2011. *Mechanical vibration and shock — Vibration of fixed structures — Guidelines for the measurement of vibrations and evaluation of their effects on structures.* South African National Standard, SANS 4866:2011.

Tamrock, 1984. *Handbook on Surface Drilling and Blasting.* 310 pp.

Appendix D: Peer Review and Specialist Response Sheet

Peer Reviewer: Dr Alistair Sloan; University of Cape Town

EXPERT REVIEW AND SPECIALIST RESPONSES: Seismicity – EGI Expansion					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 the Specialist**
A Sloan	2	all		Good summary of major points. Neither overplays nor underplays the hazard, acknowledges uncertainty, and emphasises the importance of considering local site conditions and secondary hazards. This report is very similar in scope to the one I previously reviewed and I see most of my comments were addressed. I therefore have few additional substantive remarks here.	Noted
A Sloan	8	n/a	1	I believe Midzi et al. 2018a is now accepted/online with a publication date of 2019.	Yes, the paper has been published with "Manzunzu" as the first author. The full reference has been inserted in the reference list i.e. Manzunzu, B, Midzi, V, Mulabisana, TF, Zulu, B, Pule, T, Myendeki, S and Rathod, GW. 2019. Seismotectonics of South Africa. Journal of African Earth Sciences, 149:271-279. Therefore Midzi et al 2018a has been amended to Manzunzu et al 2019; and Midzi et al 2018b has been amended to Midzi et al 2018 in the main report. In addition, Midzi et al 2018b has been amended to Manzunzu et al 2019; and Midzi et al 2018c has been amended to Midzi et al 2018b in Appendix A.
A Sloan	13	49-50		Perhaps better to actually quote and cite Bath's Law (difference in M of 1.2). Bath, 1965 Lateral inhomogeneities of the upper mantle, Tectonophysics could be used as a citation.	Noted. This has been included in the section and cited in the reference list for the EGI and Gas Seismicity Reports.
A Sloan	14	1-3		Perhaps could be phrased better. Moderate dynamic loading may occur throughout South Africa however while large dynamic loading is possible, the probability of it occurring is estimated to be very low within decadal timescales.	Noted. This has been re-phrased in both the EGI and Gas Seismicity Reports.
A Sloan	16	27-28		There is significant landslide susceptibility in the eastern area as acknowledged later in the document.	Noted. This has been re-phrased.

EXPERT REVIEW AND SPECIALIST RESPONSES: Seismicity – EGI Expansion					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 the Specialist**
A Sloan	20		4	As in the previous document there are active faults mapped in both areas (Appendix B, Fig. 1). Are these not documented here because that data source is considered unreliable, or because a different criteria of 'active fault is used'?	Descriptions have been included in Table 4. In addition, additional information has been added in Appendix B, and Figure 1 in Appendix B has been replaced with a map that cites fault names.
A Sloan	22	12-13		Typo? Would this not be better as "has occasionally caused alarm"?	Noted, this has been corrected in the report
A Sloan	23	40		Typo: evidence of earthquakes.	Noted, this has been corrected in the report

Strategic Environmental Assessment for the Expansion of Electricity Grid Infrastructure Corridors in South Africa

Appendix C.4

Socio-Economic Assessment

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR THE EXPANSION OF ELECTRICITY GRID INFRASTRUCTURE IN SOUTH AFRICA

SOCIO-ECONOMIC ASSESSMENT SPECIALIST REPORT

Integrating Author	Surina Laurie[1]
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Draft V1 – March 2018
Draft V2 – September 2018
Draft V3 – April 2019
Final Report – October 2019

CONTENTS

TABLES

FIGURES

ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
BA	Basic Assessment
DEA	Department of Environmental Affairs
DoE	Department of Energy
DFID	Department for International Development
DPE	Department of Public Enterprises
DTI	Department of Trade and Industry
CSIR	Council for Scientific and Industrial Research
EA	Environmental Authorisation
EGI	Electricity Grid Infrastructure
EMF	Electro-magnetic Field
EMPr	Environmental Management Programme
ERG	Expert Reference Group
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IDZ	Industrial Development Zone
IEEE	Institute of Electrical and Electronics Engineers
I&APs	Interested and Affected Parties
IIASA	International Institute for Applied Systems Analysis
IFC	International Finance Corporation
IPP	Independent Power Producers
MF	Monitoring Forum
NEMA	National Environmental Management Act
PPP	Public Participation Process
PS	Performance Standards
PSC	Project Steering Committee
RAP	Resettlement Action Plan
REDZ	Renewable Energy Development Zones
SEA	Strategic Environmental Assessment
SEZ	Special Economic Zone
SIP	Strategic Integrated Project
SANBI	South African National Biodiversity Institute
SPLUMA	Spatial Planning and Land Use Management Act
TDP	Transmission Development Plan
WHO	World Health Organisation

1 INTRODUCTION

The National Department of Environmental Affairs (DEA) has embarked on a process of identifying ways streamline the Environmental Authorisation (EA) process for major infrastructure build programmes in South Africa. In particular, the DEA is looking to facilitate the efficient roll out of Strategic Integrated Projects (SIPs) lead by the Presidential Infrastructure Coordinating Committee and detailed in the National Infrastructure Plan and National Development Plan (2011).

As part of this initiative, in 2014 the DEA, in collaboration with Eskom, commissioned the Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI) to undertake a Strategic Environmental Assessment (SEA) linked to SIP 10: Electricity Transmission and Distribution for all. The SEA was entitled “National Department of Environmental Affairs Electricity Grid Infrastructure (EGI) Strategic Environmental Assessment” and aimed to identify suitable routing corridors to enable the efficient and effective expansion of key strategic transmission infrastructure designed to satisfy national transmission requirements up to 2040. This SEA concluded in 2016 with the identification of five 100 km wide corridors, namely (Figure 1) (DEA, 2016):

- Central Corridor;
- Northern Corridor;
- International Corridor;
- Eastern Corridor, and;
- Western Corridor.

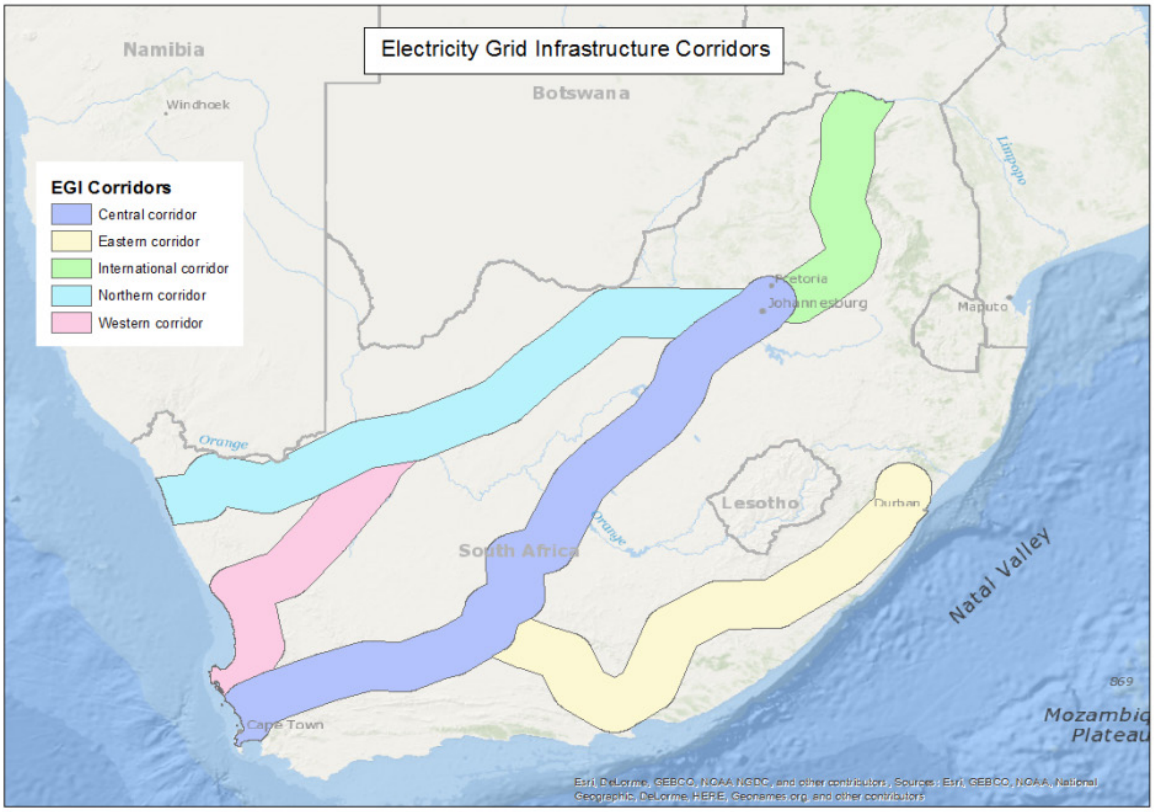

Figure 1: The five EGI corridors identified as part of the 2016 SEA (DEA, 2016)

The outcome of the 2016 EGI SEA (i.e. a streamlined EA process within the gazetted corridors) incentivises Eskom and other potential transmission and distribution infrastructure developers to plan and develop in less sensitive areas. The streamlined process consists of undertaking of a Basic Assessment (BA) instead of an Environmental Impact Assessment (EIA) and allowing a pre-negotiated route to be brought forward to the DEA. The benefits of the development of an EGI network in South Africa is supported by Eskom's Transmission Development Plan (TDP) that notes that the development of new transmission lines and associated electrical infrastructure forms part of the strategy to support regional power corridors. These corridors will therefore provide connectivity between different load centres (DEA, 2016). Several other benefits between socio-economic upliftment and electricity development are noted within literature and includes but are not limited to the Department for International Development (DFID) (2002) synopsis that states that access to energy services is positively linked to a reduced infant mortality and illiteracy and an increased life expectancy. As noted in the International Institute for Applied Systems Analysis (IIASA) (2013), electricity provision can also assist in alleviating poverty through economic growth, employment opportunities and the promotion of sustainable human development. The access to energy also shows to have a positive impact on employment opportunities. The case study by Dinkelman (2010) in rural KwaZulu-Natal found that electrification was linked to an increase of 9.5% in female employment (over a five year period) that can mostly be attributed to releasing women from household work.

The outcomes of the 2016 EGI SEA (i.e. final five EGI corridors) were gazetted in Government Notice No. 113 entitled "Notice of the identification in terms of Section 24(5)(a) and (b) of the National Environmental Management Act, 1998 (NEMA), of the procedure to be followed in applying for EA for large scale electricity transmission and distribution development activities identified in terms of Section 24(2)(a) of the NEMA when occurring in geographical areas of strategic importance", dated 16 February 2018.

The CSIR has now been commissioned by the DEA in partnership with the Department of Energy (DoE), Department of Public Enterprises (DPE), iGas, Eskom and Transnet to undertake a SEA for the identification of energy corridors as well as the assessment and management measures for the development of a gas pipeline network for South Africa (considered as part of a separate SEA Report). As part of this appointment, the expansion of the gazetted Western and Eastern EGI corridors also needs to be considered. This assessment refers to this component of the scope of work. The terms of reference specific to this assessment is outlined below:

- Assessment of the expanded EGI network; and
- Make any amendments to the generic Environmental Management Programme (EMPr) for the development of EGI based on the additional assessment undertaken.

2 SCOPE OF THIS STRATEGIC ISSUE

The proposed two expanded EGI corridors and the existing EGI corridors are shown in the figure below (Figure 2).

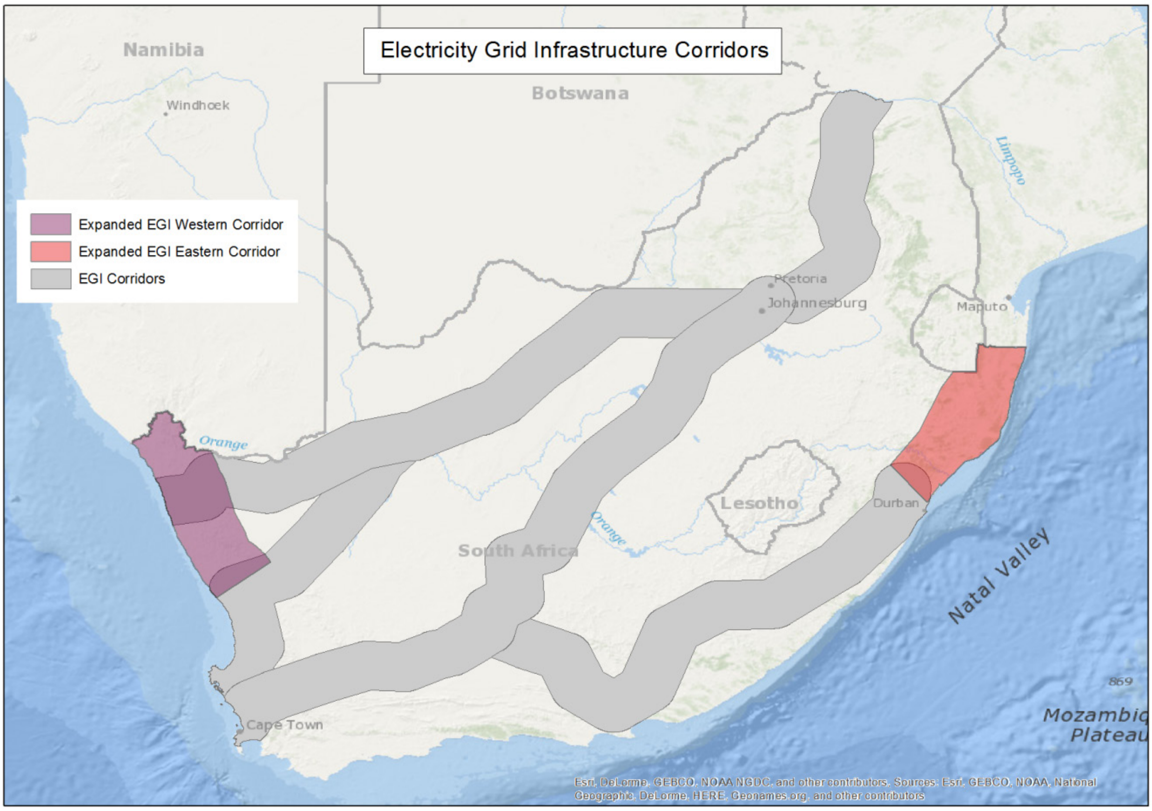

Figure 2. The two proposed expanded EGI corridors and the five existing and gazetted EGI corridors identified as part of the 2016 EGI SEA

A socio-economic assessment (dated 2015) was undertaken by Dr Hugo van Zyl and Tony Barbour as part of the 2016 EGI SEA to provide an understanding of the socio-economic impacts that were likely to arise as a result of the declaration of transmission corridors and the associated EGI elements (DEA, 2016). This assessment (i.e. for the expanded EGI corridors) will be based on the methodology undertaken by Dr Hugo van Zyl and Tony Barbour to ensure that there is an alignment of the scope of work, continuity and to allow for a comparative analysis of the assessments (if necessary). The Socio-Economic Scoping Assessment Specialist Report (2015) should therefore be used as a baseline and be read in conjunction with this assessment (DEA, 2016). This report is an addendum to the 2015 Socio-Economic Scoping Assessment Specialist Report (DEA, 2016). A copy of the EGI SEA Report (DEA, 2016) and the 2015 Socio-Economic Scoping Assessment Specialist Report (DEA, 2016) is available on the following website: https://egi.csir.co.za/?page_id=1375.

3 APPROACH AND METHODOLOGY

3.1 Study Methodology

As noted within Section 2, because this assessment only considers the expansion of the EGI corridors previously assessed as part of the 2016 EGI SEA, this assessment relies heavily on the content presented in the 2015 Socio-Economic Scoping Assessment Specialist Report and included in the 2016 EGI SEA Report. The methodology undertaken within the 2015 Socio-Economic Scoping Assessment Report was used to inform the findings of this assessment.

This assessment includes basic socio-economic conditions, land uses and key towns within each of the two proposed expanded EGI corridors. The following socio-economic indicators from the 2001 and 2011 Census data have been used, as per the previous assessment:

- Population numbers;
- Population growth (2001 to 2011);
- Population density;
- Unemployment levels;
- Percentage of households with electricity; and
- Key towns and tourism location.

The findings of the socio-economic conditions of the expanded EGI corridors will then be integrated with the findings of the 2015 socio-economic assessment and additional recommendations made, if necessary.

3.2 Data Sources

Table 1. Data sources

Data title	Source and date of publication	Data Description
Census data	2001 and 2011 Census Data, provided by Statistics South Africa	The census data provided information on the total population, unemployment rates and main towns that fall within the two expanded EGI corridors. The data was used to provide an overview of the socio-economic environment of the corridors.

In order to conduct nationally comparable town and settlement specific analyses in the EGI Expansion SEA, the CSIR Open Settlement Footprint framework was used. Due to the fine grained nature, it enables a much better spatial accuracy in the analyses than using municipal level data. This framework has been developed by the CSIR based on spatially disaggregated Statistics South Africa data and a range of other spatial specific data set. The CSIR Open Settlement Footprint Layer is only available for 2011, as it requires the most extensive census data set for spatial accuracy.

3.3 Assumptions and Limitations

The assumptions and limitations applicable to this assessment have been sourced from the 2015 socio-economic assessment (DEA, 2016). These are detailed in Table 2 below.

Table 2. Assumptions and limitations of the study

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
Lack of detailed assessments of impacts	High level information available based on census data, desktop literature available and information sharing meetings with	Detailed interviews with residents, site visits to the key towns within the corridors, finer scale assessments based on	Where required, additional site specific management actions will be recommended once the final EGI route has been determined

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
	various stakeholders (authorities and public)	the receiving socio-economic environment of a specific area	
Shortcomings of literature reviewed	Available literature on specific topics	Addressing the short comings in gaps in knowledge highlighted in the literature reviewed	Conclusions reached based on the literature reviewed are adequate to inform the SEA

3.4 Relevant Regulatory Instruments

The relevant regulatory instruments that guide this assessment are detailed in Table 3.

Table 3. Regulatory instruments that guide the socio-economic assessment

Instrument	Key objective
International Instrument	
World Bank Operational Policy (4.12) on Involuntary Resettlement (Revised in 2011)	Involuntary resettlement may cause severe long-term hardship, impoverishment, and environmental damage unless appropriate measures are carefully planned and carried out. For these reasons, the overall objectives of the Bank's policy on involuntary resettlement are the following: (a) Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs. (b) Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs. (c) Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.
International Finance Corporation (IFC) Performance Standards (PS) on Environmental and Social Sustainability (Revised in 2012), specifically PS 5: Land Acquisition and Involuntary Resettlement, specifically PS 5: Land Acquisition and Involuntary Resettlement	PS 5 recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. The key objectives are: • To avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs. • To avoid forced eviction. • To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by (i) providing compensation for loss of assets at replacement cost and (ii) ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected. • To improve, or restore, the livelihoods and standards of living of displaced persons. • To improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.
IFC PS 7: Indigenous People (2012)	PS7 seeks to ensure that business activities minimize negative impacts, foster respect for human rights, dignity and culture of indigenous populations, and promote development benefits in culturally appropriate ways. Informed consultation and participation with Indigenous People throughout the project process is a core requirement and may include Free, Prior and Informed Consent under certain circumstances. The key objectives are: • To ensure that the development process fosters full respect for the human rights, dignity, aspirations, culture, and natural resource-based livelihoods of

Instrument	Key objective
	Indigenous Peoples. • To anticipate and avoid adverse impacts of projects on communities of Indigenous Peoples, or when avoidance is not possible, to minimize and/or compensate for such impacts. • To promote sustainable development benefits and opportunities for Indigenous Peoples in a culturally appropriate manner. • To establish and maintain an ongoing relationship based on Informed Consultation and Participation with the Indigenous Peoples affected by a project throughout the project's life-cycle. • To ensure the Free, Prior, and Informed Consent of the Affected Communities of Indigenous Peoples when the circumstances described in this Performance Standard are present. • To respect and preserve the culture, knowledge, and practices of Indigenous Peoples.
IFC's Handbook for Preparing a Resettlement Action Plan (2002)	The purpose of this handbook is to provide guidance in the planning and execution of involuntary resettlement associated with IFC investment projects. IFC's policy on involuntary resettlement applies to any project that may result in the loss of assets, the impairment of livelihood, or the physical relocation of an individual, household, or community. The audience for this handbook includes: IFC clients; host government agencies that support private investment in development projects; nongovernmental organizations; and the people whose lives and livelihoods will be affected by projects financed by IFC.
African Development Bank's (AfDB) Policy on Involuntary Resettlement (2003)	The policy has the following key objectives: • To avoid involuntary resettlement where feasible, or minimize resettlement impacts where population displacement is unavoidable, exploring all viable project designs. Particular attention must be given to socio-cultural considerations, such as cultural or religious significance of land, the vulnerability of the affected population, or the availability of in-kind replacement for assets, especially when they have important intangible implications. When a large number of people or a significant portion of the affected population would be subject to relocation or would suffer from impacts that are difficult to quantify and to compensate, the alternative of not going ahead with the project should be given a serious consideration; • To ensure that displaced people receive resettlement assistance, preferably under the project, so that their standards of living, income earning capacity, and production levels are improved; • To provide explicit guidance to Bank staff and to the borrowers on the conditions that need to be met regarding involuntary resettlement issues in Bank operations in order to mitigate the negative impacts of displacement and resettlement and establish sustainable economy and society; and • To set up a mechanism for monitoring the performance of involuntary resettlement programs in Bank operations and remedying problems as they arise so as to safeguard against ill-prepared and poorly implemented resettlement plans.
National Instrument	
The Constitution of the Republic of South Africa (Act 108 of 1996)	Places a legal obligation on the government of South Africa to ensure the health (Personal and Environmental) and safety of its citizens. In terms of section 41 (1) (b) of the Constitution, all spheres of government are required to "*secure the wellbeing of the people of the Republic*". Section 152 (1) (d) also requires local government *"to promote a safe and healthy environment"*.
National Environmental Management Act (Act 107 of 1998)	The NEMA sets out a number of principles (Chapter 1, Section 2) to give guidance to developers, private land owners, members of public and authorities. The proclamation of the NEMA gives expression to an overarching environmental law. Various mechanisms, such as cooperative environmental governance, compliance and non-compliance, enforcement, and regulating government and business impacts on the environment, underpin NEMA. NEMA also outlines the Public Participation Process to be undertaken when requiring an Environmental Authorisation for certain development applications.
Prevention of Illegal Eviction from and Unlawful Occupation of Land Act	This Act came into effect in 1998 and set out to prevent the arbitrary eviction of occupiers of a site. The Act supports the Constitution which states that "No one may be evicted from their home, or have their home demolished, without an order of court made after considering all the relevant circumstances. No legislation may permit arbitrary evictions.

Instrument	Key objective
	This Act sets out the procedure to be followed in the case of such evictions.
National Housing Code (2009) Policy developed in terms of the Housing Act (1997)	Chapter 4 of the Housing Code (2009) includes the provision of the National Housing Programme for Housing Assistance in Emergency Housing Circumstances. The programme's objective is to provide for temporary relief to people in urban and rural areas who find themselves in emergencies. National Housing Programme: Upgrading of Informal Settlements deals with the process and procedure for the in situ upgrading of informal settlements as it relates to the provision of grants to a municipality to carry out the upgrading of informal settlements within its jurisdiction in a structured manner. The grant funding provided will assist the municipality in fast tracking the provision of security of tenure, basic municipal services, social and economic amenities and the empowerment of residents in informal settlements to take control of housing development directly applicable to them. The Programme includes, as a last resort, in exceptional circumstances, the possible relocation and resettlement of people on a voluntary and co-operative basis as a result of the implementation of upgrading projects.
Occupational Health and Safety Act (Act 85 of 1993)	Aims to provide and regulate health and safety at the workplace for all workers.

4 CORRIDORS DESCRIPTION

For each corridor, the data and information listed in Section 3.1 is provided, focusing on the local municipal scale and drawing primarily on the 2011 Census.

4.1 Expansion of the Western Corridor

The expanded Western Corridor is predominantly located in the Northern Cape Province and extends from Alexander Bay in the north along the West Coast into the Western Cape Province (Figure 3). The corridor contains areas that are sparsely populated and have declining population numbers due to urbanisation. The expanded corridor mostly consists of small towns surrounded by arid and semi-arid areas. Some of the small towns, including Nababeep, Okiep and Concordia all fall within the corridor and are historical mining towns. While mines on which these towns relied have been abandoned, there are still extensive diamond diggings along the coast and some mineral sands mines. The key towns within the corridor, from north to south are Alexander Bay, Port Nolloth, Springbok, and Hondeklipbaai which all fall within the Namaqualand tourism region. The expanded Western Corridor contains the Namaqua National Park, the Goegap Nature Reserve and the Richtersveld Transfrontier Park (a World Heritage Site). The corridor is also bound in the North by the Orange River that is a key recreational attraction. The corridor contains the N7 that runs to Namibia and the N14 that is routed to Pofadder in the east.

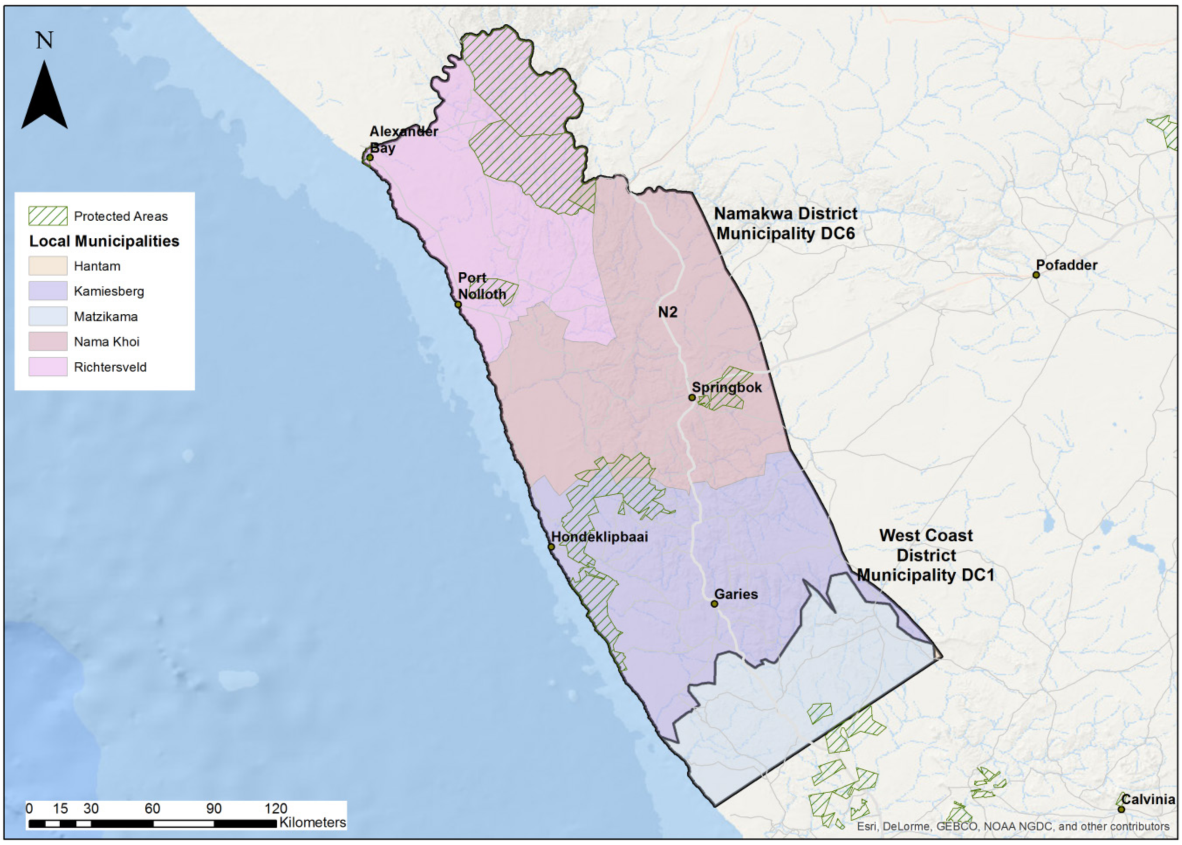

Figure 3: District and Local Municipalities as well as key roads and formal protected areas falling within the expanded Western Corridor.

The key economic sector within the corridor is government dominated. The portion of the corridor that falls within Northern Cape is increasingly being associated with the development of renewable energy (solar and wind). The Hantam and Matzikama local municipalities have the highest percentages, 16.42 % and 10.49%, respectively, of households that are without electricity (Table 4). The establishment of an EGI network in the area may therefore potentially benefit these municipalities.

Table 4 contains a summary socio-economic data and a list of key towns/cities in the expanded Western Corridor. It is important to note that unemployment rate noted in Tables 4 and 5 below is a percentage of the total population of the province/local municipality, and not a percentage of the total employable population of the province/local municipality.

Table 4. Socio-economic data and key towns - Expanded Western Corridor

Province/ Local Municipality	Total Population (2011)	Annual Population Growth Rate (2001 to 2011)	Population Density 2011 (people/km²)	Unemployment Rate - 2011	Percentage of households without electricity (2011)	Main Towns	Tourism Region
Northern Cape	**1 145 433.25**	**1.34**	**3.06**	**12.80**	**13.31**	**Kimberley, Upington**	
Richtersveld	11 981.00	1.50	1.25	8.86	3.70	Port Nolloth	Namaqualand
Nama Khoi	47 034.66	0.46	2.61	7.79	5.43	Springbok	Namaqualand
Kamiesberg	10 171.30	(0.53)	0.72	9.64	8.17	Garies	Namaqualand
Hantam	21 960.32	0.74	0.56	3.85	16.42	Calvinia	Kalahari and Diamond Fields
Khâi-Ma	12 434.27	0.58	0.79	10.48	8.12	Pofadder	Kalahari and Diamond Fields
Western Cape	**5 822 511.31**	**2.32**	**44.81**	**11.60**	**6.12**	**Cape Town**	
Matzikama	67 156.00	1.92	5.17	5.79	10.49	Vredendal	Namaqualand

4.2 Expansion of the Eastern Corridor

The expanded Eastern Corridor contains the KwaZulu-Natal North Coast, from the northern outskirts of eThekwini to the Mozambican border, which is densely populated and a popular tourism and recreation destination (Figure 4). The key economic sectors include agriculture, tourism, industry, forestry, government and services. The northern section of the corridor contains the St Lucia wetland system (isiMangaliso Wetland Park, a World Heritage Site), scenically prominent features including Greytown, Kranskop and the Lebombo Mountains, Lake Jozini, Lake Sibaya and Kosi Lake and a large number of game reserves, all adding to its tourism value. The corridor also contains the Umfolozi and Mkhuze Game Reservesand the Zululand Rhino Reserve. The key tourism regions within this corridor are the Midlands and Battlefields as well as the Zululand and Maputaland. Zululand, especially, is also considered to have cultural and historical significance. Richards Bay, including its port centred around coal exports through the Richards Bay Coal Terminal, is the prominent industrial hub in the region. The Dube TradePort Special Economic Zone (SEZ), international airport and surrounds are also a major growth node with significant scope for further expansion along with nearby coastal areas.

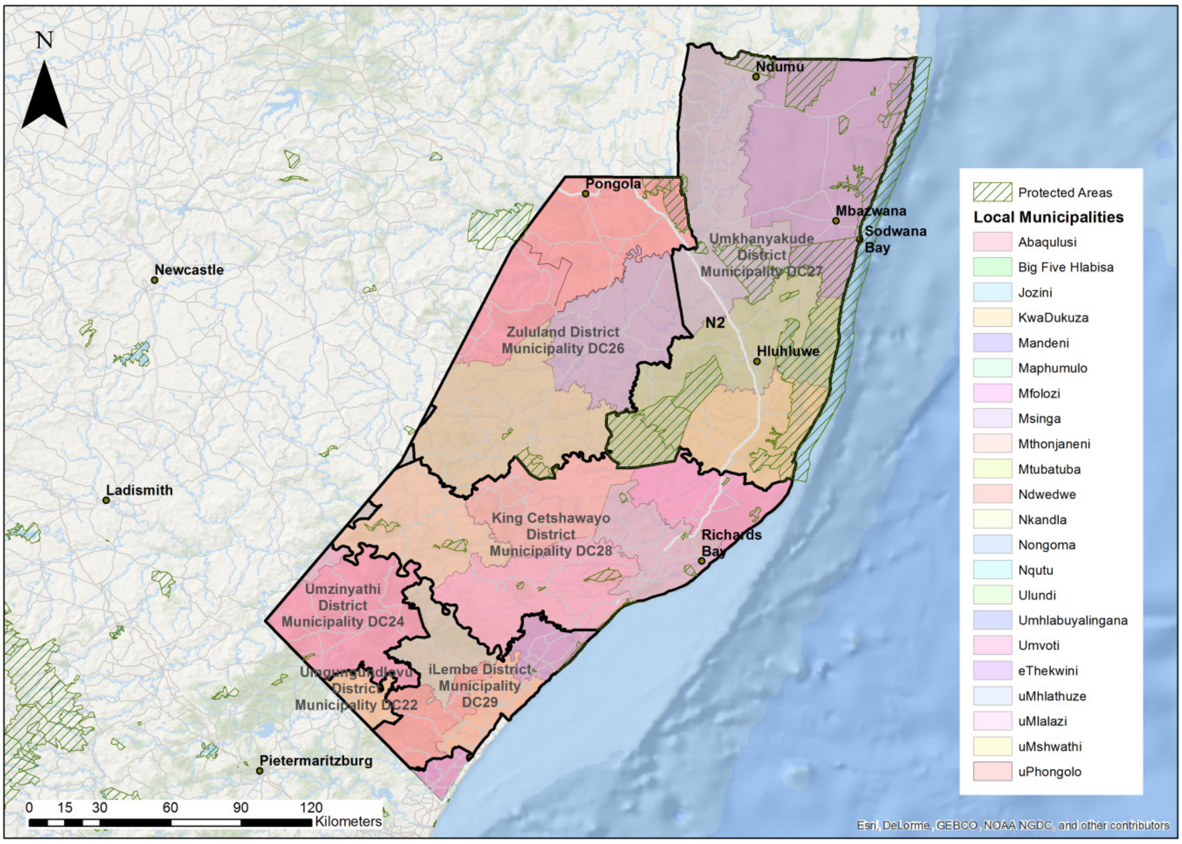

Figure 4: District and Local Municipalities as well as key roads and formal protected areas falling within the expanded Eastern Corridor

Table 5 contains a summary of socio-economic data and a list of key towns/cities in the expanded Eastern Corridor. In terms of unemployment levels, this corridor contains generally areas of high unemployment and percentage of households without electricity that could potentially benefit from an EGI network in the area.

Table 5. Socio-economic data and key towns - Expanded Eastern Corridor

Province/Local Municipality	Total Population (2011)	Annual Population Growth Rate (2001 to 2011)	Population Density 2011 (people/km^2)	Unemployment Rate - 2011	Percentage of households without electricity (2011)	Main Towns	Tourism Region
KwaZulu-Natal	10 269 876.11	1.43	108.84	14.65	21.25	Durban	
eThekwini	3 473 508.78	1.01	1 359.01	12.49	9.85	Durban	Midlands and Battlefields
uMhlathuze	367 350.58	1.28	297.84	11.46	6.46	Richards Bay	Zululand and Maputaland
KwaDukuza	231 455.73	2.74	314.92	9.83	9.36	Stanger	Midlands and Battlefields
Abaqulusi	214 820.15	0.95	49.80	7.11	27.82	Vryheid	Midlands and Battlefields
uMlalazi	213 472.00	(0.35)	96.42	6.31	40.81	Eshowe	Midlands and Battlefields
Inkosi Langalibalele	196 202.42	0.83	57.73	9.11	27.98	Estcourt	Midlands and Battlefields
Nongoma	194 483.00	(0.18)	89.13	6.41	35.21	Nongoma	Zululand and Maputaland
Ulundi	188 144.00	(0.02)	57.89	7.87	25.58	Ulundi	Midlands and Battlefields
Jozini	186 439.00	0.16	54.16	6.74	66.61	Mkuze	Zululand and Maputaland
Mtubatuba	175 375.38	1.71	89.03	7.38	33.25	Mtubatuba	Zululand and Maputaland
Msinga	170 227.58	0.67	71.67	4.87	70.61	Pomeroy	Midlands and Battlefields
Nqutu	165 164.16	(0.26)	84.17	4.81	46.45	Nqutu	Midlands and Battlefields
Umhlabuyalingana	156 649.00	0.88	31.47	6.83	80.78	Emangusi	Zululand and Maputaland
Ndwedwe	140 448.27	(0.34)	128.51	7.66	61.55	Ndwedwe	Midlands and Battlefields
Mandeni	138 045.00	0.78	253.07	8.59	16.74	Mandeni	Zululand and Maputaland
Mfolozi	129 604.71	1.09	99.71	10.11	15.22	KwaMbonambi	Zululand and Maputaland
uPhongolo	123 379.69	0.55	39.67	8.02	25.39	Pongola	Zululand and Maputaland

Province/Local Municipality	Total Population (2011)	Annual Population Growth Rate (2001 to 2011)	Population Density 2011 (people/km²)	Unemployment Rate - 2011	Percentage of households without electricity (2011)	Main Towns	Tourism Region
Nkandla	114 227.00	(1.69)	62.50	4.72	54.66	Nkandla	Midlands and Battlefields
Umvoti	113 315.75	0.81	41.90	6.70	41.69	Greytown	Midlands and Battlefields
Big Five Hlabisa	107 129.62	0.57	30.91	7.39	45.93	Hluhluwe	Zululand and Maputaland
uMshwathi	106 994.67	(0.20)	57.35	6.63	26.60	Wartburg	Midlands and Battlefields
Maphumulo	96 626.00	(2.40)	107.85	5.44	61.95	Maphumulo	Midlands and Battlefields
Mthonjaneni	84 389.54	(1.63)	51.50	5.73	43.15	Melmoth	Zululand and Maputaland
eDumbe	82 016.00	(0.02)	42.22	7.09	36.54	Paulpietersburg	Midlands and Battlefields
Mkhambathini	57 056.58	0.93	65.70	7.97	29.84	Camperdown	Midlands and Battlefields
Mpofana	35 487.54	0.22	20.20	8.74	23.28	Mooirivier	Midlands and Battlefields
Alfred Duma	339 636.75	0.04	90.22	8.93	23.35	Ladysmith	Midlands and Battlefields
Endumeni	64 860.00	2.12	40.28	8.43	20.33	Dundee	Midlands and Battlefields
Emadlangeni	34 427.00	0.62	9.73	10.19	49.90	Utrecht	Midlands and Battlefields
The Msunduzi	621 556.92	1.05	827.54	12.24	7.68	Pietermaritzburg	Midlands and Battlefields
uMngeni	92 695.63	1.98	61.00	10.48	13.97	Howick	Midlands and Battlefields
Mpumalanga	4 039 691.46	1.68	52.81	14.80	13.07	Nelspruit (Mbombela)	
Mkhondo	171 987.00	1.69	35.23	9.96	32.43	Piet Retief	Midlands and Battlefields

5 KEY POTENTIAL IMPACTS AND MITIGATION

New transmission lines and associated infrastructure are required to connect generation pools to one another and to the major load/demand centres in the country. EGI is thus essential for the transmission or transport of electricity from locations where it is generated to its end users. It therefore forms an integral part of the system that allows for the provision of electricity to consumers and its strategic socio-economic benefits are essentially inseparable from the overall strategic benefits of electricity provision. These are highly significant, diverse and relatively self-evident. Adequate electricity supply is a pre-requisite for reduction in poverty and for the establishment and continued growth of a modern economy. However, proposed EGI projects are generally perceived in a negative manner and subjected to drawn out servitude negotiation processes. It is recognised and understood that in general impacts on surrounding communities and the acceptability of proposed projects are often linked to the way in which the public participation processes are managed.

Various methods of stakeholder engagement have been adopted during the SEA:

- Two Public Outreach Programmes have been held at key towns across the country in November 2017 and October 2018.
- A number of sector specific and focus group meetings were undertaken throughout the SEA.
- A Project Steering Committee (PSC) and Expert Reference Group (ERG) were set up during the inception phase of the SEA and consists of representatives from relevant authorities, experts, NGOs etc.
- Public and stakeholder commenting will also be undertaken during the gazetting process to ensure that all Interested and Affected Parties (I&APs) have the opportunity to comment on the decision support outputs generated as part of the SEA (such as the final corridors, EMPr, Protocols and Standards/Minimum Information Requirements), before they are gazetted.

Additional information on the public outreach programme undertaken during this SEA Process is included in Appendix A of the EGI Expansion SEA Report. Detailed requirements in terms of further public outreach at project specific level will also be included, where applicable, as part of the proposed decision support outputs (e.g. Standard/Minimum Information Requirements, protocol, EMPr), to ensure that adequate consultation is undertaken once a route has been identified and planned to be constructed.

The streamlining of the environmental authorisation process that would be associated with the EGI development inside the declared corridors would have significant economic advantages due to reduction of the timeframes and pre-negotiation of servitudes. The declaration of the corridors will also provide greater certainty to electricity generators and large users and would demonstrate a commitment to prioritising grid expansion and facilitate/accommodate investment. Refer to Section 7.1 of the 2015 Socio-Economic Assessment (DEA, 2016) for further details on the strategic benefits of electricity provision and corridors declaration.

The following potential socio-economic impacts associated with the expansion of the EGI corridors have been identified and assessed:

Positive Impacts (Benefits)

1. Impacts on key economic sectors including[1]:
    a. Impacts on electricity generators
    b. Impacts on energy intensive users

Negative Impacts

    c. Impacts on tourism (including eco-tourism)
2. Impacts on property values
3. Impacts on surrounding communities due to visual intrusion
4. Resettlement and relocation/displacement impacts
5. Impacts associated with project workers/workforce
6. Health impacts focused on electro-magnetic fields (EMFs)

[1] Note that impacts on agriculture are dealt with in Part 4.2.5 of the EGI Expansion SEA Report.

Generic impacts linked to the development of EGI were assessed in the 2015 Socio-Economic Assessment undertaken as part of the EGI SEA (DEA, 2016) and have not been repeated in this report. The reader is referred to Section 7 of the 2015 Socio-Economic Assessment (DEA, 2016) undertaken by Dr Hugo van Zyl and Tony Barbour for a detailed description of those impacts. Where required, relevant section of the 2015 Socio-Economic Assessment has been cross-referenced and provided in this report for ease of reference.

5.1 Impacts on electricity generators

The development of EGI will enhance grid access to electricity generators so that the energy they generate can reach users and it will therefore constitute a positive impact on electricity generators. This includes generation plants of all types and sizes. It also encompasses independent power producers (IPPs) which have rapidly become a key source of demand for grid access particularly for renewable energy projects. Note that the rapid development of renewable energy generation over the last few years lead to mis-matches between where developers wanted to establish generation projects and grid access opportunities.

The latest Eskom TDP (2019-2028) notes that the establishment of large-scale renewable energy developments is becoming the key driver of network development in the three Cape provinces (apart from the Cape Corridor project and the base metals mining area in the Northern Cape and established load centres) (Eskom, 2015; 2019). The Northern Cape is the greatest beneficiary of the programme thus far with 59 projects awarded preferred bidder status (IPP Office, 2017). This represents 53% of the total capacity for Renewable Energy IPP up to the fourth window (including the small scale renewable energy bidding windows 1 and 2) followed by the Eastern Cape with 15% and the Western Cape with 13% of total capacity (IPP Office, 2017). It is beneficial that the proposed expanded corridors overlap, where possible, with the gazetted Renewable Energy Development Zones (REDZs) (published in Government Notice 114 in Government Gazette 41445 on 16 February 2018) as this is where future grid access will be required; and with the preferred IPPs where current grid access is required. The expanded western corridor covers a small section of REDZ 8 not previously included within the original EGI corridors and the eastern corridor includes a preferred IPP (Figure 5). It is important to re-iterate that the two expanded EGI corridors were conceptualised in order to support potential business and economic activity extending to Mozambique and Namibia, as well as to facilitate potential export and import of power to and from these regions.

The current SEA Process also launched an energy generation mapping exercise to gather information on where EGI expansion needs to be prioritised (in the context of the EGI expansion corridors) to support the evacuation of electricity from future energy generation activities (e.g. Renewable projects and Gas to power plants). Where suitable motivation is provided, based on this mapping exercise, the positioning of the corridors are to be refined to overlap with areas of aggregated common development interest amongst generators and to accommodate these plans. Additional information on the demand mapping process is provided in the Parts 3 and 5 of the EGI Expansion SEA Report.

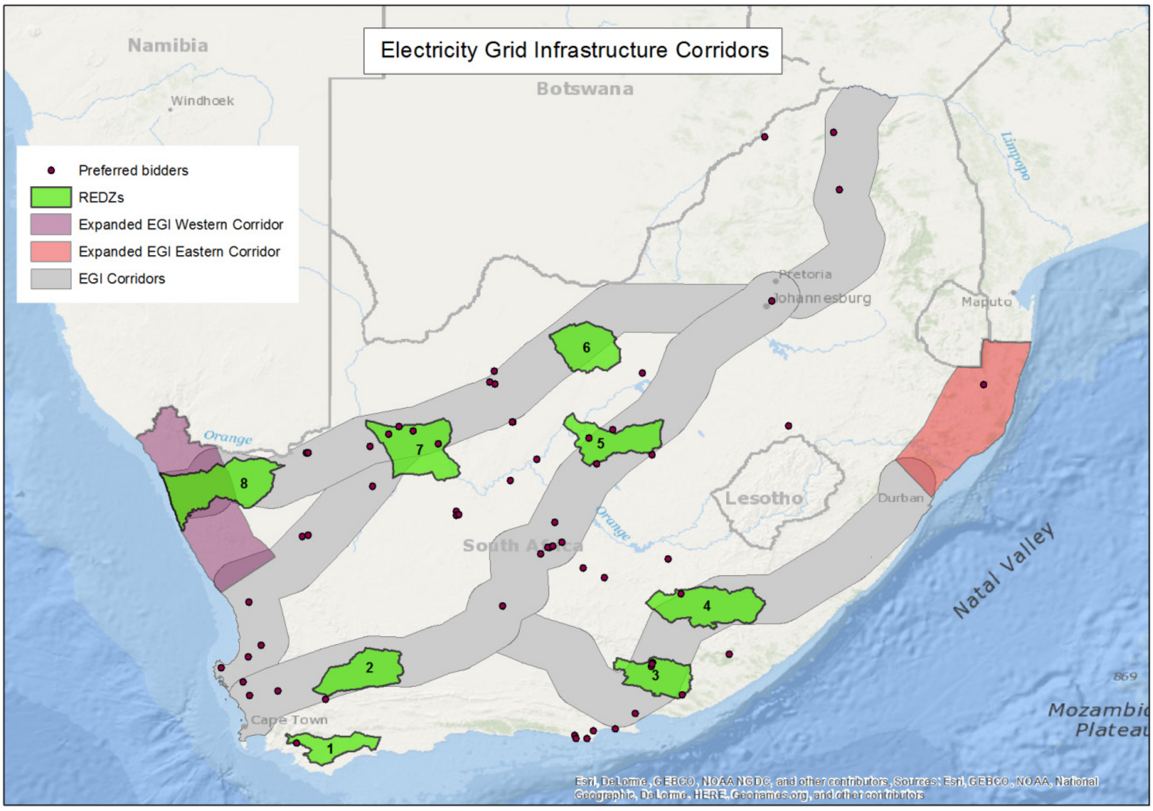

Figure 5: Expanded EGI corridors, existing and gazetted EGI corridors overlapped with the identified and gazetted REDZs and preferred IPPs (in terms of Bidding Windows 1 to 4).

In addition, as noted above, the declaration of these corridors will lead to significant benefits for electricity generators as it will provide them with the option to self-build connections to the Eskom EGI network infrastructure under an exempted EA Process via the adoption of Standards or a streamlined EA process via compliance with Minimum Information Requirements.

It will also facilitate in the planning process associated with rolling out and location of future projects and provide better investment certainty. The declaration of the EGI corridors will also enable Eskom to provide feedback in a more-timely manner in terms of future grid availability.

Refer to Section 7.2 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on the impacts of EGI development and corridor declaration on electricity generators.

5.1.1 Management and mitigation

The key need of IPPs will be access to timely and accurate information about intended development within the corridors. Eskom should engage with the relevant representative bodies with a view to drawing up an appropriate and clearly understandable information package and dissemination plan in this regard. Refer to Section 7.2.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for a description of the recommended mitigation measures for this impact.

5.2 Impacts on energy intensive users (industry and mining)

The development of EGI will facilitate the supply of power to what are often large, energy intensive users such as industry and mining. Linked to industry, the SEZs are spread throughout the country and occur within most provinces. The eight SEZs and their locations are listed below (Department of Trade and Industry (dti), 2016):

1. Coega Industrial Development Zone (IDZ) (Eastern Cape)
2. Richards Bay IDZ (KwaZulu-Natal)
3. East London IDZ (Eastern Cape)
4. Saldanha Bay IDZ (Western Cape)
5. Dube TradePort SEZ (KwaZulu-Natal)
6. Maluti-A-Phofung SEZ (Free State)
7. OR Tambo SEZ (Gauteng)
8. Musina/Makhado SEZ (Limpopo)

The Richards Bay IDZ and Dube TradePort SEZ fall within the additional Eastern EGI corridor.

In addition, there are two proposed SEZs noted by the dti (2016), namely: Nkomazi SEZ in Mpumalanga; and Bojanala SEZ in the North-West. Research indicates that in late 2018, a decision was made by the dti to designate the Nkomazi SEZ and to accordingly grant an SEZ licence to the Mpumalanga Department of Economic Development and Tourism (Creamer Media, 2018). Based on feedback from authorities during meetings held during the SEA, an SEZ is also proposed in Upington. In addition, based on feedback received during the review process, it is understood that the Atlantis SEZ in the Western Cape was promulgated in June 2018. These additional SEZs do not fall within the proposed EGI corridors, however could still benefit from the two expanded EGI corridors.

Similarly to the energy generation mapping exercise undertaken as part of this SEA, an energy demand mapping exercise was also carried out to identify areas designated for future energy intensive usage activities, such as industrial development (industrial expansion, IDZ, SEZ) or potential mining operations which could be represented spatially. The outputs of this mapping exercise also informed the corridor refinement process to ensure that the corridors overlap with areas planned for intensive energy activities. Additional information on the demand mapping process is provided in Part 3 and 5 of the EGI ExpansioSEA Report.

In addition, the establishment of the two expanded corridors will facilitate energy trading and commerce among the interconnected entities which will have a positive impact on the overall energy mix. As noted above, the expanded Western Corridor will enable a connection between Namibia and South Africa to support gas power generation and transmission as well as renewable energy generation integration. The expanded Eastern Corridor will enable a connection to Mozambique.

The positive impacts associated with the declaration of the Eastern and Western EGI corridors on the industry and mining sectors would be similar to the benefits to electricity generators, as outlined in Section 5.1 of this report. These include providing investment certainty to these sectors and enable Eskom and other developers to provide informed responses to electricity supply requests. In addition, these corridors will also facilitate planning through Spatial Planning and Land Use Management Act (SPLUMA) which requires provinces, districts and local municipalities to make provision for the development of infrastructure including that which may be linked to EGI (DEA, 2016). Once gazetted, the outcome of the EGI Expansion SEA process will mean that bulk generators and bulk users of electricity will benefit from the accelerated authorisation or absence thereof for the construction of transmission level infrastructure in the gazetted corridors.

Refer to Section 7.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on this impact.

5.2.1 Management and mitigation

The key need of mining and industry will be access to timely and accurate information about intended development within the corridors. Eskom should engage with the relevant representative bodies with a view to drawing up an appropriate and clearly understandable information package and dissemination plan in this regard. Refer to Section 7.3.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for a description of the recommended mitigation measures for this impact.

5.3 Impacts on tourism

Landscape qualities, particularly scenic resources, have important economic value in the form of tourism for most regions, including the Western and Eastern expanded Electricity Grid Infrastructure (EGI) corridors currently being assessed. Transmission lines and related infrastructure, such as substations, tend to have an industrial connotation and have been found to entail risks for tourism where visual quality and natural landscapes with minimal signs of man-made structures (e.g. pristine or protected environments) are a key attraction. This tends to be the case in relatively unspoilt areas and particularly those containing land uses such as protected areas and game farms. Such areas can be found in all of the two expanded EGI corridors. There are, however, certain areas where tourism is relatively more prominent and potentially sensitive. Such areas are broadly identified in Table 6 below for each corridor. These features have all been considered within the Visual Impact Assessment undertaken as part of this SEA and were allocated an appropriate sensitivity level.

Table 6: Areas of particular tourism sensitivity per corridor

Corridors	Areas of relatively higher tourism value and sensitivity
Expanded Western Corridor	Namaqua National Park, the Goegap Nature Reserve and the Richtersveld Transfrontier Park (a World Heritage Site). The corridor is also bound in the North by the Orange River that is a key recreational attraction. The key towns within the corridor, from north to south are Alexander Bay, Port Nolloth, Springbok, Kamieskroon which all fall within the Namaqualand tourism region.
Expanded Eastern Corridor	Scenically prominent features that would be a drawcard to tourists include Greytown, Kranskop and the Lebombo Mountains, and Lake Jozini, Lake Sibaya and Kosi Lake. A key tourism attraction is also the St. Lucia Wetlands (Isimangaliso Wetland Park, a World Heritage Site). Key tourism regions include Midlands and Battlefields as well as the Zululand and Maputaland.

The declaration of the expanded corridors will have a positive impact to the tourism sector due to the enhanced planning information available and would provide the following (DEA, 2016):

- An increased level of certainty to the tourism sector regarding the broad areas (i.e. 100 km corridors) where future major transmission lines and other EGI are likely to be constructed;
- Guidance regarding particularly sensitive areas within the corridors which are likely to be avoided by future EGI projects making them potentially more suitable for tourism on balance;
- Understanding of risks posed by the introduction of transmission lines to tourism establishments located inside the corridors wishing to expand;
- New tourism ventures and providing a fuller set of information in terms of location options.

On a local level the declaration of the corridors may pose a risk to new tourism investment and/or expansion through the avoidance of the corridors. However, the establishment of a 100 km wide corridor will in all likelihood limit the risk (DEA, 2016).

The risk to especially eco-tourism would be in areas where the sensitivity mapping undertaken for these corridors would leave limited areas available for EGI development. This would mean that the likelihood of the EGI going through narrow areas would increase, which could in turn deter investment in the area (DEA, 2016).

Sensitivity mapping within the EGI corridors introduced layers for the following types of land uses or areas:

- Protected areas (including buffers and expansion areas), game farms and private nature reserves.
- Visually sensitive areas including scenic routes.
- Areas of high heritage and ecological value.

The avoidance of these areas will assist with limiting tourism risks at a broad level. A more detailed strategy or study, including ground truthing, at project specific level is recommended. Such assessment would need to:

- Identify, briefly describe and map key tourism assets and establishments (e.g. lodges, guest houses).
- Assess their likely sensitivity to impacts taking into consideration their tourism offering and key target markets. For example, high-end ecotourism or hunting lodges are likely to be particularly sensitive given their clientele.
- Assess potential socio-economic impacts on them, informed by visual impacts along with how these could be mitigated (DEA, 2016).

Refer to Section 7.4 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on this impact.

5.3.1 Management and mitigation

A comprehensive list of mitigation measures that can essentially be applied to all transmission line projects is provided by Milburn (2013). As one would expect, the majority of these measures focus on limiting visual and ecological impacts of echoing the findings of visual and ecological specialist studies.

Refer to Section 7.4.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for a description of the recommended management actions for this impact.

5.4 Impacts on property values

EGI has the potential to impact negatively on property values primarily through the visual impacts that are often associated with substations and transmission lines in particular. Health concerns and disruption of activities such as farming or recreation can also play a role. Risks have been found to be highly case specific and variable and tend to be higher in residential areas and in rural areas where visual quality and natural landscapes with minimal signs of man-made structures are a key attraction (e.g. protected areas and game farms). They can be found in both expanded EGI corridors.

In terms of impact on property values, the expanded Western Corridor contains large pieces of land (used for farming or owned by mining companies), making the impact to property value low, while the expanded Eastern Corridor contains areas of high property value, due to the tourism potential especially along the coast. These areas would need to be avoided to manage the impact to property values within this corridor.

The declaration of the corridors are likely to have a positive impact on the property market by providing a fuller picture of where an EGI network is likely to occur and contribute to improved property market functioning. Without the declaration of the corridors property purchase decisions will be based on incomplete information.

However, while there may be a positive impact to property functioning, the declaration of the corridors may pose a risk to existing property owners. This would especially be the case where prospective buyers looking for eco-tourism and/or leisure or lifestyle potential properties are deterred from the corridors if they are seeking properties with a high (current and future) aesthetic value. In terms of agriculture, buyers may avoid these areas due to the potential disruption to agricultural activities.

Having established that there may be risks, it is extremely difficult to come to an overall conclusion regarding the actual level of risk (DEA, 2016). The 100 km width of the corridors should, however, ensure that risks are kept low. The risk of the impact occurring may be higher in areas were the outcome of the sensitivity mapping reduces the developable area for EGI development. This would increase the likelihood of the EGI network going through these areas and buyers are then likely to be particularly careful when considering such areas.

As noted in Section 7.5.2 of the 2015 socio-economic report, the potential for speculative buying to drive up demand for these areas cannot be entirely ruled out (i.e. people buying with the sole purpose of extracting a higher price from the Developer given their weaker bargaining position). However, such a strategy would entail significant risks with potentially limited rewards which most speculators should be aware of. In particular they are unlikely to be encouraged by the limited likelihood of the Developer paying high prices for servitudes as discussed in the next section. Increased powers of land expropriation for strategically important projects as envisaged by the Land Expropriation Bill are also likely to discourage speculation.

The avoidance of these areas will assist with limiting risks to property values at a broad level. In addition, as per Section 5.3 of this report, it has been recommended that key tourism areas are avoided and a more detailed assessment be undertaken for individual EGI projects within corridors. This should limit impacts on those property values that are linked to tourism.

Refer to Section 7.5 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on this impact.

5.4.1 Management and mitigation

As in the case of tourism impacts, mitigating property value impacts should focus on the limitation of visual and ecological impacts along with other potentially relevant impacts such as those of a social or heritage nature which may play a role in affecting property values. The relevant specialist inputs (i.e. the visual and terrestrial ecology studies) provide more details in this regard which are not repeated here.

Refer to Section 7.5.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for a description of the recommended mitigation measures for this impact.

5.5 Visual impacts and intrusion on surrounding communities

Although large sections of the population see transmission lines as a major visual detraction or eye-sore, there are others, mainly among the context of South Africa's working classes, who may regard them as a sign of progress and service delivery. Habituation is another consideration, where transmission lines have been in place over a length of time and are hardly noticed or seen as a disturbance any longer. This appears to have been the case with communication masts, which initially caused visual concern, but to which people have grown accustomed (Lawson & Oberholzer, 2018).

The implications of these considerations are that the 'context' of both the landscape (the receiving environment) and the community (the receptor) is important in the siting of transmission infrastructure.

Visually sensitive receptors, (e.g. settlements, routes); towns, villages and farmsteads, particularly historical settlements, residential and resort areas, tend to be sensitive to visual intrusions, including an effect on property values and tourism. Refer to the Visual Impact Assessment for further details on this impact and recommended management actions.

5.6 Resettlement and relocation/displacement impacts

The establishment of EGI has the potential to result in involuntary resettlement or relocation. If the resettlement is not properly planned or managed is can impact on people's lives and result in long-term hardships. Resettlement in rural areas and small villages is usually as a result of the loss houses and farmland. The loss of access to farmland and other resources, such as rivers, springs and forests, can also impact on communities that rely on these resources for their livelihoods. One of the key challenges facing resettlement in rural areas is linked to the restoration of livelihoods based on land and access to resources (DEA, 2016).

Although transmission lines qualify as large infrastructure projects, the physical footprint and associated land take is relatively small and usually limited to the foundations associated with the powerline pylons. Impacts associated with the development of a substation may be more important given that substations have a large footprint; however, few substations are required to connect several kilometres of powerline. This means that not many substations will be developed within a corridor and can be located in areas that would have the least possibility of requiring resettlement/relocation. Given the width of the EGI expanded corridors (100km), it is likely that a suitable route and placement of substation can be identified that avoids and or minimises the impacts associated with involuntary resettlement. The need to relocate entire villages or communities is therefore highly unlikely.

In the event of involuntary resettlement occurring, there are two types of displacement that need to be considered when developing a Resettlement Action Plan (RAP). These are physical and economic displacement.

Expanded Western Corridor

As noted above, the majority of the expanded Western Corridor passes through sparsely populated rural farm land and areas owned by mining companies in the Northern Cape Province. The land uses along this route are linked to commercial farming activities, mostly livestock (plus areas disturbed by mining, specifically diamond mining along the coast). The corridor is associated with declining population numbers due to urbanisation. The potential for involuntary resettlement related impacts (physical and economic) along this route are considered to be very low.

Expanded Eastern Corridor

On the other hand, the eastern section of the expanded Eastern corridor passes through dense urban areas, including Durban and Richards Bay. These cities have large mixed economies and coupled with this, large population numbers. This will increase the potential for involuntary resettlement related impacts (physical and economic) along this section of the expanded Eastern Corridor. Care will need to be taken to avoid impacting on built up areas. The use of existing servitudes and road reserves would also reduce the potential impacts.

The western section of the expanded Eastern corridor has relatively lower population numbers. However, the trend is towards gradually increasing populations and economies which are likely to increase the risk of involuntary resettlement related impacts (physical and economic). However, with well-placed transmission lines, the potential for involuntary resettlement related impacts (physical and economic) along this section will be low.

Refer to Section 7.6 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on this impact.

5.6.1 Management and mitigation

Accepted international best practice requires that involuntary resettlement be avoided where possible. If this is not possible the number of people affected should be minimised.

Refer to Section 7.6.3 of the 2015 Socio-Economic Assessment (DEA, 2016) for a description of the recommended mitigation measures for this impact.

5.7 Impacts associated with project workers/workforce

While some temporary local employment of unskilled labour is likely to be provided during the construction phase, long term employment opportunities are limited to repairs and maintenance and will be considered at a project specific level. Benefits associated with job opportunities during both the construction and operational phase are therefore anticipated to be limited.

Given the linear nature of the work associated with the establishment of transmission lines, the construction activities will not be confined to a single area. The development of substations, on the other hand, will require that the workforce remain in a single location for a longer period. In both cases, however, the size of the workforce is likely to be relatively small compared to large civil or construction projects. The attraction potential for job seekers and the associated social impacts during both the construction and operational phase are therefore not anticipated to be significant.

The potential social impacts associated with the presence of construction workers are also likely to be limited and can be managed through the implementation of effective management and mitigation measures as listed below. This applies to both the expanded corridors. This also applies to workers involved with the repair and maintenance of the powerlines/substations once they are operational.

The two expanded corridors are discussed below.

Expanded Western Corridor

The potential impacts associated with construction workers and maintenance crews along this corridor are likely to be of low significance due to the low population numbers.

Expanded Eastern Corridor

The population numbers in this corridor are higher in the eastern section compared to the western section but growth trends show that the population in the western section is increasing. This has the potential to increase the risks associated with the activities of construction and maintenance crews. Additional care will need to be taken in managing construction workers and maintenance crews along this section of the corridor.

Refer to Section 7.7 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional details on this impact.

5.7.1 Management and mitigation

The recommended mitigation measures apply to construction and maintenance related activities and are included in Section 7.7.3 of the 2015 Socio-Economic Assessment (DEA, 2016).

5.8 Health impacts focused on EMFs

Findings in this section are largely based on a World Health Organisation (WHO) study on EMF (http://www.who.int/peh-emf/about/WhatisEMF/en/index3.html) which found no evidence of health consequences associated with exposure to low level of EMFs. However, the study did find that some gaps in knowledge about biological effects exist and need further research. This finding is also confirmed in the IFCs, Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution (2007).

The WHO study found that the exposure of people living in the vicinity of high voltage power lines differs very little from the average exposure in the population. The potential health related risks associated with the establishment of high voltage transmission lines is therefore not regarded as a key social issue. Despite this, efforts should be made to ensure that transmission lines are not located within close proximity to dwellings and settlements (DEA, 2016).

Given the width of the EGI corridors (100km) it is likely that a suitable sub-corridor (5 km wide) can be identified that enables adequate buffer zones to be established between the servitude and potentially affected dwellings and settlements. The buffer distances should be informed by internationally accepted guidelines for buffers (DEA, 2016).

Since the expanded Western Corridor contains rural areas with low population numbers, this would especially be the case for the expanded Eastern Corridor. Each corridor is discussed below.

Expanded Western Corridor

This risk of health impacts due to EMF levels are considered to be low for this corridor since the siting of transmission pylons to ensure adequate distances between dwellings and transmission lines is considered to be easily implemented.

Expanded Eastern Corridor

Care will need to be taken in siting transmission pylons in order to maximise the distances between dwellings and the overhead transmission lines.

The overall anticipated health impacts are considered to be low. Refer to Section 7.8 of the 2015 Socio-Economic Assessment (DEA, 2016) for additional information on this impact.

5.8.1 Management and mitigation

Given the 100 km width of the EGI corridors it is likely that a suitable sub-corridor (5 km wide) can be identified that enables adequate buffer zones to be established between the servitude and potentially affected dwellings and settlements. The buffer distances should be informed by internationally accepted guidelines for buffers.

While the IFCs, Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution (2007), indicates that while the evidence of adverse health risks is weak, it is still sufficient to warrant limited concern. The recommendations applicable to the management of EMF exposures and to address the health and safety of electricity utility workers exposed to EMF are included in Section 7.8.3 of the 2015 Socio-Economic Assessment (DEA, 2016).

5.9 Summary of the Key Potential Impacts and Mitigation

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
Expanded Western Corridor	Impacts on electricity generators	The corridor does cover a section of REDZ 8 not previously included within the original EGI corridors	The corridor provides access to the National Grid which will support renewable energy developments. The key benefits from corridor declaration would be exemption or streamlining the authorisation process; and the provision of greater certainty or clarity regarding the future roll-out of EGI.	See Section 5.1.1 of this report. Note that mitigation measures are also described in Section 6 of this report.
	Impacts on industry and mining	No SEZs are currently identified within this corridor though there are extensive diamond diggings and some mineral sands mines along the coast.	The corridor provides access to the National Grid which will support mining and industrial developments. The positive impacts associated with the declaration of the EGI corridors to the industry and mining sectors would be similar to the benefits to electricity generators, as outlined in Section 5.1.1 of this report.	See Section 5.2.1 of this report.
	Impacts on tourism	The corridor contains that Namaqua National Park, the Goegap Nature Reserve and the Richtersveld Transfrontier Park (a World Heritage Site). The corridor is also bound in the North by the Orange River that is a key recreational attraction. The key towns within the corridor, from north to south are Alexander Bay, Port Nolloth, Springbok, Kamieskroon which all fall within the Namaqualand tourism region.	The declaration of the corridors will have a positive impact to tourism sector due to the enhanced planning information available. The development of EGI within the corridor may negatively impact on tourism due to its effect on sense of place (visual) and ecology.	See Section 5.3.1 of this report.
	Impacts on property values	Contains areas that are sparsely populated and have declining population numbers due to urbanisation.	EGI can have a positive impact on property values by contributing to socio-economic development and social well-being. However, the presence of EGI on a property may negatively influence the value of the property due to its impact on the visual quality of the property, health concerns and disturbing the current land-use of the property. The impact is however likely to be low. The declaration of the corridors are likely to have a positive impact on the property market by providing a comprehensive picture of where an EGI network is likely to occur and contribute to improved	See Section 5.4.1 of this report.

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
			property functioning. However, the declaration of the corridors may also pose a risk to existing property owners (e.g. prospective buyers looking for eco-tourism and/or leisure or lifestyle potential properties are deterred from the corridors if they are seeking properties with a high (current and future) aesthetic value). The potential for speculative buying to drive up demand for these areas also cannot be entirely ruled out.	
	Resettlement and relocation/ displacement impacts	May contain communities that need to be resettled, depending on the final routing of the EGI.	The establishment of transmission lines has the potential to result in involuntary resettlement or relocation. If the resettlement is not properly planned or managed it can have an impact on the livelihoods of the said community. The potential for involuntary resettlement related impacts (physical and economic) in this corridor are considered to be low based on the low population numbers.	See Section 5.6.1 of this report.
	Impacts associated with project workers/ workforce	The presence of workers and job seekers may have an impact on local social networks and family structures.	The potential impacts associated with the presence of project workers apply to both the construction and operational phase of the transmission lines. Although, given the remote location of the EGI corridors and the linear nature of the EGI corridors, the anticipated social impact associated the development of transmission lines within the EGI corridors are considered to be low. The potential social impacts can be managed through the implementation of effective management and mitigation measures. Due to the low population sizes, he potential impacts associated with construction workers and maintenance crews along this corridor are likely to be low.	See Section 5.7.1 of this report.
	Health impacts focused on EMFs	Urban and rural areas are located within the corridors which means that communities may be exposed to EMF	EMFs are always created, in varying levels, with the generation and use of electricity and at the frequency of the electrical power system and may have an impact on human health. This risk of health impacts due to EMF levels are considered to be low for this corridor.	See Section 5.8.1 of this report.
Expanded Eastern Corridor	Impacts on electricity generators	The corridor currently includes one preferred IPP	The corridor provides access to the National Grid which will support renewable energy developments. The key benefits from corridor declaration would be exemption or streamlining the authorisation process; and the provision of greater certainty or clarity regarding the future roll-out of EGI.	See Section 5.1.1 of this report.

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
	Impacts on industry and mining	The Richards Bay IDZ and Dube Tradeport SEZ are located in the corridor	The corridor provides access to the National Grid which will support mining and industrial developments. The positive impacts associated with the declaration of the EGI corridors to the industry and mining sectors would be similar to the benefits to electricity generators, as outlined in Section 5.1.1 of this report.	See Section 5.2.1 of this report.
	Impacts on tourism	Contains scenic prominent features that would be a drawcard to tourists. These include Greytown, Kranskop and Nkandla and the Lebombo Mountains, and Lake Jozini, Lake Sibaya and Kosi Lake. A key tourism attraction is also the St Lucia Wetlands. The key tourism regions within this corridor are the Midlands and Battlefields as well as the Zululand and Maputaland. Zululand, especially, is also considered to have cultural and historical significance.	The declaration of the corridors will assist the tourism sector due to the enhanced planning information available. The development of EGI within the corridor may negatively impact on tourism due to its effect on sense of place (visual) and ecology.	See Section 5.3.1 of this report.
	Impacts on property values	Contains the Kwa-Zulu Natal North Coast which is densely populated and a popular tourism and recreation destination. The northern section of the corridor contains that St Lucia wetland system and a large number of game reserves, all adding to its tourism value.	EGI can have a positive impact on property values by contributing to socio-economic development and social well-being. However, the presence of EGI on a property may negatively influence the value of the property due to its impact on the visual quality of the property, health concerns and disturbing the current land-use of the property. The declaration of the corridors are likely to have a positive impact on the property market by providing a comprehensive picture of where an EGI network is likely to occur and contribute to improved property market functioning. However, the declaration of the corridors may also pose a risk to existing property owners (e.g. prospective buyers looking for eco-tourism and/or leisure or lifestyle potential properties are deterred from the corridors if they are seeking properties with a high (current and future) aesthetic value). The potential for speculative buying to drive up demand for these areas also cannot be entirely ruled out.	See Section 5.4.1 of this report.
	Resettlement and relocation/	May contain communities that need to be resettled, depending on the	The establishment of transmission lines has the potential to result in involuntary resettlement or relocation. If the resettlement is not	See Section 5.6.1 of this report.

Corridor	Key Impacts	Site Specific Descriptions	Possible Effect	Mitigations
	displacement impacts	final routing of the EGI	properly planned or managed it can have an impact on the livelihoods of the said community. The dense urban areas, including Durban and Richards Bay, which have large mixed economies and large population numbers, will increase the potential for involuntary resettlement related impacts (physical and economic) along the Eastern section of this corridor. On the other hand, the Western section of this corridor has lower population numbers but these are on an increasing trend, which means that in the near future the risk of involuntary resettlement related impacts (physical and economic) would increase.	
	Impacts associated with project workers/ workforce	The presence of workers and job seekers may have an impact on local social networks and family structures	The potential impacts associated with the presence of project workers apply to both the construction and operational phase of the transmission lines. Although, given the remote location of the EGI corridors and the linear nature of the EGI corridors, the anticipated social impact associated the development of transmission lines within the EGI corridors are considered to be low. The population numbers in this corridor is higher in the eastern section compared to the western section but growth trends show that the western section is increasing in population numbers. This has the potential to increase the risks associated with the activities of construction and maintenance crews.	See Section 5.7.1 of this report.
	Health impacts focused on EMFs	Urban and rural areas are located within the corridors which means that communities may be exposed to EMF	EMFs are always created, in varying levels, with the generation and use of electricity and at the frequency of the electrical power system and may have an impact on human health. Based on the higher population numbers in this corridor, mainly towards the eastern section, care will need to be taken in siting transmission pylons in order to maximise the distances between dwellings and the overhead transmission lines.	See Section 5.8.1 of this report.

6 BEST PRACTICE GUIDELINES AND MONITORING REQUIREMENTS FOR THE MANAGEMENT OF THE SOCIO-ECONOMIC ENVIRONMENT

6.1 Planning phase

- The key need of the IPPs, mining, industry and tourism sectors will be access to timely and accurate information about intended development within the corridors. The Developer should engage with the relevant representative bodies with a view to drawing up an appropriate and clearly understandable information package and dissemination plan in this regard.
- Limit the extent of visual and ecological impacts as well as impacts of a social or heritage nature, which may play a role in affecting property values by adhering to the provisions made within the relevant supporting assessments undertaken for this SEA (i.e. Visual, Biodiversity (Terrestrial and Aquatic), and Socio-Economic Assessments).
- Anticipation of low payments can contribute to property value risks. Better servitude payments for EGI are therefore a potential mitigation if the goal is to reduce value losses specifically for property owners of EGI sites.
- Accepted international best practice requires that involuntary resettlement be avoided where possible. If this is not possible the number of people affected should be minimised.
- Where involuntary resettlement cannot be avoided, the relocation of affected households and/or compensation for economic displacement should be guided by international best practice and a Resettlement Action Plan (RAP) should be developed to manage the impact of resettlement.
- Given the width of the EGI corridors it is likely that a suitable sub-corridor (5 km wide) can be identified that enables adequate buffer zones to be established between the servitude and potentially affected dwellings and settlements. The buffer distances should be informed by internationally accepted guidelines for buffers.
- Installing transmission lines or other high voltage equipment above or adjacent to residential properties or other locations intended for highly frequent human occupancy, (e.g. schools or offices), should be avoided.
- It is recommended that further public outreach be undertaken at project specific level.

6.2 Construction phase

- The Developer should make it a requirement for contractors to implement a ‘locals first’ policy for construction jobs.
- The Developer should consider the need to establish a Monitoring Forum (MF) in order to monitor the implementation of the recommended mitigation measures.
- The Developer and the appointed contractor(s) should, in consultation with representatives from the MF, develop a Code of Conduct for the construction phase.
- The Developer should be liable for compensating farmers in full for any stock losses and/or damage to farm infrastructure that can be linked to construction workers.
- The EMPr should outline procedures for managing and storing waste on site, specifically plastic waste that poses a threat to livestock if ingested.
- The EMPr should also address risks posed by veld fires.
- The Developer s and the appointed contractor(s) should implement an HIV/AIDS awareness programme for all construction workers at the outset of the construction phase.
- Disturbed areas should be rehabilitated at end of construction phase. EMPr should outline procedures for rehabilitating disturbed areas;
- The Developer and or the appointed contractor should provide transport to and from the site on a daily basis for construction workers.
- Where feasible, no workers, with the exception of security personnel, should be permitted to stay over-night on the site. This would reduce the risk to local farmers.
- Identify potential EMF exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities.
- Train workers in the identification of occupational EMF levels and hazards.

- Establish and identify safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers.
- Implement action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the IEEE (Institute of Electrical and Electronics Engineers).
- Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent).
- Action plans should be developed to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

6.3 Operations phase

- The Developer should make it a requirement for contractors to implement a 'locals first' policy for maintenance jobs.
- The Developer should consider the need to establishing a MF in order to monitor the implementation of the recommended mitigation measures.
- The Developer and the appointed contractor(s) should, in consultation with representatives from the MF, develop a Code of Conduct for the operations (maintenance) phase.
- The Developer should be liable for compensating farmers in full for any stock losses and/or damage to farm infrastructure that can be linked to /maintenance workers.
- The Developer and the appointed contractor(s) should implement an HIV/AIDS awareness programme for all maintenance workers at the outset of the operations phase.
- The Developer and or the appointed contractor should provide transport to and from the site on a daily basis for maintenance workers.
- Where feasible, no maintenance workers, with the exception of security personnel, should be permitted to stay over-night on the site. This would reduce the risk to local farmers.
- Identify potential EMF exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities.
- Train workers in the identification of occupational EMF levels and hazards.
- Need to have a section that covers impacts associated with spills, leaks and explosions.
- Establish and identify safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure, limiting access to properly trained workers.
- Implement action plans to address potential or confirmed exposure levels that exceed reference occupational exposure levels developed by international organizations such as the ICNIRP and the IEEE.
- Personal exposure monitoring equipment should be set to warn of exposure levels that are below occupational exposure reference levels (e.g. 50 percent).
- Action plans should be developed to address occupational exposure may include limiting exposure time through work rotation, increasing the distance between the source and the worker, when feasible, or the use of shielding materials.

6.4 Monitoring requirements

- Evaluate potential exposure to the public against the reference levels developed by the ICNIRP. Average and peak exposure levels should remain below the ICNIRP recommendation for General Public Exposure. Consider siting new facilities so as to avoid or minimize exposure to the public.
- If EMF levels are confirmed or expected to be above the recommended exposure limits, application of engineering techniques should be considered to reduce the EMF produced by power lines, substations, or transformers. Examples of these techniques include:
  - Shielding with specific metal alloys;

- Burying transmission lines;
- Increasing height of transmission towers;
- Modifications to size, spacing, and configuration of conductors.

7 CONCLUSIONS AND RECOMMENDATIONS

The majority of the expanded Western Corridor passes through sparsely populated rural farm land near the coastline in the Northern Cape Province. The primary land uses along this route are linked to commercial farming activities, mostly livestock, along with tourism and mining (existing and abandoned) uses. Large parts of the corridor are associated with declining population numbers due to urbanisation.

The expanded Eastern Corridor would be within KwaZulu-Natal Province extending from the northern outskirts of eThekwini to the Mozambican border. The western section of this corridor passes through dense urban areas, including Durban and Richards Bay. These cities have large mixed economies and coupled with this, large population numbers. The eastern section of the corridor has lower population numbers but trends are showing that these areas are increasing in population and economy sizes. The eastern section also passes through a number of conservation areas.

Based on the findings of this study, given its critical importance to socio-economic development, it makes sense to plan ahead for the installation of EGI and ensure that it can be delivered within a reasonable and predictable timeframe. The main benefactors of the improved planning of the roll-out of the EGI network are **electricity generators** and the **industry and mining sectors**.

The presence of an EGI network (which includes powerlines and substations) may also have an impact on the **tourism sector** and on **values** of properties that are located within or adjacent to the final routing of the future major transmission lines. However, given the 100 km width of the corridors it is likely that the majority of the potential negative impacts on tourism and property can be effectively mitigated with careful route selection.

In terms of **relocation and involuntary resettlement** given the low population numbers and rural character of the expanded Western Corridor, the potential for involuntary resettlement related impacts (physical and economic) along this route are considered to be low. Inversely, the expanded western and eastern sections of the Eastern Corridor contain large population numbers which will increase the potential for involuntary resettlement related impacts (physical and economic).

In terms of potential impacts associated with the **presence of project workers**, this depends on the size of the workforce, the duration of the construction or operational activity and the location of the site. The potential risks can however be effectively mitigated.

With regards to **EMFs**, based on a comprehensive WHO study and other sources, no health consequences associated with the exposure to EMFs from transmission lines have been found.

8 REFERENCES

Creamer Media (2018). Progress made with establishing Nkomazi SEZ. Published online in Engineering News. Accessed 29 January 2019: http://www.engineeringnews.co.za/article/progress-made-with-establishing-nkomazi-sez-2018-12-06

Department of Environmental Affairs (DEA). 2015. Strategic Environmental Assessment for Wind and Solar Photovoltaic Energy in South Africa. CSIR Report Number: CSIR/CAS/EMS/ER/2015/0001/B. Stellenbosch.

DEA. 2016. Strategic Environmental Assessment for Electricity Grid Infrastructure in South Africa. CSIR Report Number: CSIR/02100/EMS/ER/2016/0006/B. Stellenbosch.

Department for International Development (DFID) UK. 2002. Access to energy in developing countries. UK Parliamentary Office of Science and Technology Postnote nr 191, London.

Department of Trade and Industry (dti), 2016. South African Special Economic And Industrial Development Zones. Accessed: 18 June 2018
http://www.thedti.gov.za/industrial_development/docs/SEZ_brochure.pdf

Dinkelman, T. 2010. The Effects of Rural Electrification on Employment: New Evidence from South Africa. Princeton University.

Eskom. 2015. Transmission Development Plan 2016 – 2025. Eskom, Midrand.

Eskom. 2019 Transmission Development Plan 2019 – 2028. Eskom, Midrand.

Fahey, J. 2010. Why Landowners Fight Wind And Solar Transmission Lines. Forbes Magazine Online. Available at: http://www.forbes.com/sites/jonathanfahey/2010/08/12/why-landowners-fight-wind-and-solar-transmission-lines/2/.

Independent Power Producers Office, Department of Energy, Department of National Treasury, Development Bank of Southern Africa (2017). Independent Power Producers Procurement Programme (IPPPP): An Overview: As at 30 June 2017. https://ipp-projects.co.za/Publications. Accessed 28 June 2018.

International Finance Corporation (IFC). 2007. Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution. IFC, Washington.

International Institute for Applied Systems Analysis (IIASA). 2013. Global Energy Assessment – Toward a Sustainable Future: Ch 2 on Energy, Poverty, and Development. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Lawson Q. and Oberholzer B. 2018. Strategic environmental assessment for the expansion of electricity grid infrastructure in South Africa - Visual specialist report.

Milburn, D. 2013. EIA of the proposed Perseus-Gamma 765kv transmission powerline and substations upgrade, Northern Cape and Free State provinces: ecotourism impact assessment. Report prepared by Integrated Ecotourism Solutions for Mokgope Consulting.

Pretorius, P.H. 2006. Electric and Magnetic Fields from Overhead Power Lines: A Summary of Technical and Biological Aspects. Report prepared for Eskom, Midrand.

United Nations Development Programme (UNDP). 2012. Guidelines for Integrating HIV and Gender-related Issues into Environmental Assessment in Eastern and Southern Africa. Prepared for UNDP Regional Centre for Eastern and Southern Africa by the Southern African Institute for Environmental Assessment.