STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT IN SOUTH AFRICA

Biodiversity and Ecological Impacts (Aquatic Ecosystems and Species) - Wetlands and Rivers

STRATEGIC ENVIRONMENTAL ASSESSMENT FOR GAS PIPELINE DEVELOPMENT

Draft v3 Specialist Assessment Report for Stakeholder Review

FRESHWATER ECOSYSTEMS

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ABBREVIATIONS AND ACRONYMS

ADU	Animal Demographic Unit
AOO	Area of Occupancy
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
EA	Environmental Authorisation
ECO	Environmental Control Officer
EI	Ecological Importance
EMPr	Environmental Management Programme
EN	Endangered
EOO	Extent of Occurrence
ES	Ecological Sensitivity
GBIF	Global Biodiversity Information Facility
GIS	Geographic Information System
GP	Gas Pipeline
HGM	Hydrogeomorphic
IAP	Invasive Alien Plant
IHI	Index of Habitat Integrity
IRP	Integrated Resource Plan
IUCN	International Union for Conservation of Nature
LC	Least Concern
m.a.s.l	Metres above sea level
NBA	National Biodiversity Assessment (2011)
NDP	National Development Plan
NFEPA	National Freshwater Ecosystem Priority Areas
PA	Protected Area - statutory
PES	Present Ecological State
QV	Quality Value
ROW	Right of way
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

In order to realise the potential of gas reserves in South Africa, and to contribute to the transition to a low carbon economy, the Operation Phakisa Offshore Oil and Gas Lab has set a target of achieving 30 exploration wells in the next ten years (from 2014). This sparked plans to accelerate gas to power development as recognised by the Government's Integrated Resource Plan (IRP), which included pre-planning for State Owned Entities to develop gas transmission servitudes across South Africa. As a result, initiatives were identified – development of a phased gas pipeline network being one of the identified initiatives. However, in order for gas pipeline development to go-ahead, Environmental Authorisation (EA) in terms of the Environmental Impact Assessment Regulations, 2014 (as amended in 2017) would be required. Strategic planning for gas servitudes also needs to be undertaken well in advance of final planning as a means to uphold Operation Phakisa, while preventing unnecessary delays through the EA process. The Council for Scientific and Industrial Research (CSIR) was commission by the National Department of Environmental Affairs (DEA) to undertake a Strategic Environmental Assessment (SEA) in order to identify and pre-assess environmental sensitivities within the identified gas pipeline corridors. GroundTruth was appointed by the CSIR to assess the corridors specifically in terms of freshwater ecosystems (i.e. wetland and river ecosystems) and fauna and flora associated with these systems.

The scope for the freshwater ecosystem/biodiversity study was provided by the CSIR to ensure that the approach and methodology followed was scientifically defendable and adequately defined within the context of the SEA. In particular, the approach was intended to be spatially explicit, drawing from available data depicting the distribution and extent, as well as importance and sensitivity of freshwater ecosystems and selected fauna and flora that inhabit these systems.

The study was based on a combination of desktop assessments building on strengths of mapping and geospatial analyses using geographical information systems (GIS), with input from meetings and discussions with relevant authorities and experts. This ensured a thorough interpretation of existing data incorporating defensible and rigorous methodologies. Data was sourced from various custodians, which was largely facilitated through the South African National Biodiversity Institute (SANBI) and their online data portal, BGIS (Biodiversity GIS). The data covered a range of spatial scales, from local (i.e. municipalities) to regional (i.e. provinces) to national. For wetlands, the spatial data was obtained as polygon features, while rivers were defined as lines and fauna/flora as points. Fauna and flora selected for the freshwater study included conservation important species (based on the latest available conservation assessments) that are dependent of wetland and river systems that include surrounding fringe habitats. In terms of fauna, the data collation and analysis focused on certain taxonomic groups, namely: aquatic macro-invertebrate (at the family level), dragonflies and damselflies (Family: Odonata), freshwater fish (Class: Actinopterygii), amphibians (Order: Anura), reptiles (Order: Reptilia) and mammals (Order: Mammalia). All data of freshwater ecosystem and selected key species was reviewed and refined to allow for integration to an appropriate scale/resolution. The sub-quaternary (SQ4) catchments for South Africa were used as the most appropriate scale for the spatial analyses and assessments of freshwater ecosystems within the SEA corridors. All spatial/GIS data was assessed firstly in terms of applicability/suitability, then merged/joined with other layers, then clipped according to the relevant gas pipeline corridors in order to assess the sensitivity-level of the corridors. Metrices were also used to calculate sensitivity using a four-tiered categorisation (i.e. low, medium, high and very high) as requested by the CSIR. A more detailed description of the data used and methods followed is presented in Section 4 of the freshwater specialist report, along with the relevant legislation/regulatory requirements and applicable assumptions and limitations for the study.

The results from the freshwater study are presented as a series of maps illustrating freshwater features and their current sensitivity (as per the four-tiered sensitivity classes) for each of the nine gas pipeline corridors as provided by the CSIR. Maps are arranged according to the respective corridors in Section 6 to provide an overview of river, wetland and freshwater biota sensitivity. In addition, a brief summary of the present state of freshwater ecosystems/biodiversity within each corridor is also provided in Section 5, which describes some of the key sensitivities, as well as drivers and pressures affecting freshwater ecosystems and biodiversity. Corridors found to be most sensitive (with high to very high sensitivity) are as follows:

- In terms of **river ecosystems** the Phase 3 Corridor is most sensitive, followed by Phase 8, then Phase 2.
- In terms of **wetland ecosystems** the Phase 2 Corridor is most sensitive, followed by Phase 1, then Phase 8.
- In terms of **freshwater biota (i.e. fauna and flora)** the Phase 1 Corridor is most sensitive, followed by Phase 8, then Phase 2.
- In terms of **overall sensitivity (i.e. combined river, wetland and biota)** the Phase 1 Corridor is most sensitive, followed closely by Phase 2 and Phase 8.

The primary purpose of the maps and spatial products are to assist the CSIR in integrating a number of key strategic issues such as (but not limited to) terrestrial biodiversity and socio-economics into the overall SEA, as well as to identify problem areas (or nick points) where special precautions and measures may be required to limit impacts from gas pipeline development. In terms of the freshwater study the spatial deliverables can assist planning and development of gas pipelines through a two-step process: firstly, to use the SQ4 catchments maps to identify areas where pipeline construction and operation will have the lowest impact on freshwater ecosystems, and secondly, to use the actual feature data to plan pipeline routing within the SQ4 catchments of each corridor.

Impacts that will potentially affect river and wetland ecosystems and associated fauna and flora have been identified to provide a generic evaluation of pipeline activities for various stages of development, from planning to construction to operation. Each activity is discussed in terms of the cause and effects that these will have on freshwater ecosystems. Appropriate, and again generic, mitigation measures are also provided as recommendations for preventing and/or minimising impacts to freshwater ecosystems/biodiversity. Part of the evaluation includes a risk assessment to rate the identified impacts with respect to the four-tiered sensitivity classes. The risk assessment also includes an evaluation of impacts both with and without mitigation. However, it is acknowledged that additional steps will be required once pipeline routes and alternatives have been established (i.e. desktop screening, ground-truthing and infield delineation and assessments).

In addition to the recommended mitigation measures, “best practice” (or “good practice”) guidelines and management actions are provided, and include practical, target-directed recommendations for monitoring of aspects, along with considerations on how to interpret and implement the four-tiered maps. Lastly, several gaps in knowledge are mentioned in terms of influencing this freshwater study and assessment.

2 INTRODUCTION

In 2012, the National Development Plan (NDP) was adopted to accelerate infrastructure development in order to address service delivery, backlogs and facilitate economic growth and job creation. This led to the launch of Operation Phakisa in July 2014 to fast-track service delivery, and to help implement the NDP.

The oil and gas sector within South Africa is in an early development phase, but nevertheless has the potential to create large value for the country in the long-term. Added to this are potential resources of oil and gas. In order to realise the potential of the gas reserves in the country, and to contribute to the transition to a low carbon economy, the Operation Phakisa Offshore Oil and Gas Lab has set a target of achieving 30 exploration wells in the next ten years (from 2014). In addition, the need to accelerate the planning for gas to power as part of the Government’s Integrated Resource Plan (IRP) and for State Owned Entities to pre-plan for the logical development of gas transmission servitudes within South Africa was recognised. Based on these needs, initiatives were identified with the development of a phased gas pipeline network being one of them.

The development and operation of infrastructure for the bulk transportation of dangerous goods (including gas using a pipeline exceeding 1000 m in length) is identified as activity 7 of Listing Notice 2 of 2014 as amended (GN R325, 2017) and therefore requires Environmental Authorisation (EA) in terms of the Environmental Impact Assessment Regulations, 2014 (as amended in 2017). Strategic planning for servitudes also needs to be undertaken well in advance of the final planning of a gas transmission pipeline system. To ensure that when required, obtaining an EA is not a cause for delay and to support the Operation Phakisa, the National Department of Environmental Affairs (DEA) in partnership with the National Department of Energy (DoE) and the National Department of Public Enterprises (DPE), representing iGas, Eskom and Transnet, has commissioned the Council for Scientific and Industrial Research (CSIR) in April 2017 to undertake a Strategic Environmental Assessment (SEA). The aim of this SEA is to identify and pre-assess environmental sensitivities within suitable gas routing corridors and, where required, expand the identified electricity power corridors (DEA, 2016: https://egi.csir.co.za), to facilitate a streamlined EA process for the development of energy infrastructure related to gas and electricity.

Upon gazetting of the energy corridors, it is envisaged that the EA process for gas pipeline and transmission infrastructure will be streamlined in specific areas identified through the SEA process as being less sensitive to the negative impacts associated with the development of these infrastructure. This should incentivise potential developers to plan and develop in the least sensitive areas. 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 EA process. The preliminary corridors were identified as part of the Operation Phakisa and will link specific supply and demand areas. This study is therefore intended to inform the SEA, specifically in terms of freshwater ecosystems and biota (fauna and flora) in relation to the preliminary corridors. This specialist report focuses on the impact of the proposed gas pipeline development on freshwater ecosystems.

Freshwater ecosystems, i.e. wetlands and rivers, are valuable ecosystems and it is well documented that they provide numerous ecological and hydrological functions (Cowan, 1995; Breen *et al.*, 1997; Mitchell, 2002). These functions include improving water quality (reductions in suspended sediments, excess plant nutrients and other pollutants), streamflow regulation (flood attenuation, water storage and sustaining streamflow), groundwater recharge, erosion control, and the maintenance of biodiversity for wetland-dependant fauna and flora (Kotze and Breen, 1994). Consequently, wetlands and rivers provide many important services to human society. At the same time, through continued negative perceptions by humanity, they remain ecologically sensitive and vulnerable systems (Turner *et al.*, 2003). Historically, freshwater ecosystems have been subjected to numerous pressures from surrounding developments and changing land use, to the extent that many wetlands and rivers have been severely degraded or completely lost (Kotze *et al.*, 1995). This has largely been as a result of human activities, either through direct disturbance, or indirectly from impacts upstream (Breen *et al.*, 1997). More than two decades ago, it was estimated that over half of South Africa's wetlands had been lost (Kotze *et al.*, 1995). The current situation is no doubt even greater, and of the remaining systems, 48% are classified as Critically Endangered (Nel and Driver, 2012). Thus, freshwater ecosystems need to be safeguarded as much as possible from on-going and future development in order to maintain, or even improve the status of existing wetland and river habitats.

3 SCOPE OF THIS STRATEGIC ISSUE

The primary objective of this study is to provide an assessment of freshwater ecosystems (i.e. rivers and wetlands) and associated biodiversity within pre-identified corridors (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 development of gas pipelines.

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 gas pipeline 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 gas pipeline corridors were identified as potential shortcomings needing to be addressed through further screening and ground-truthing assessments.

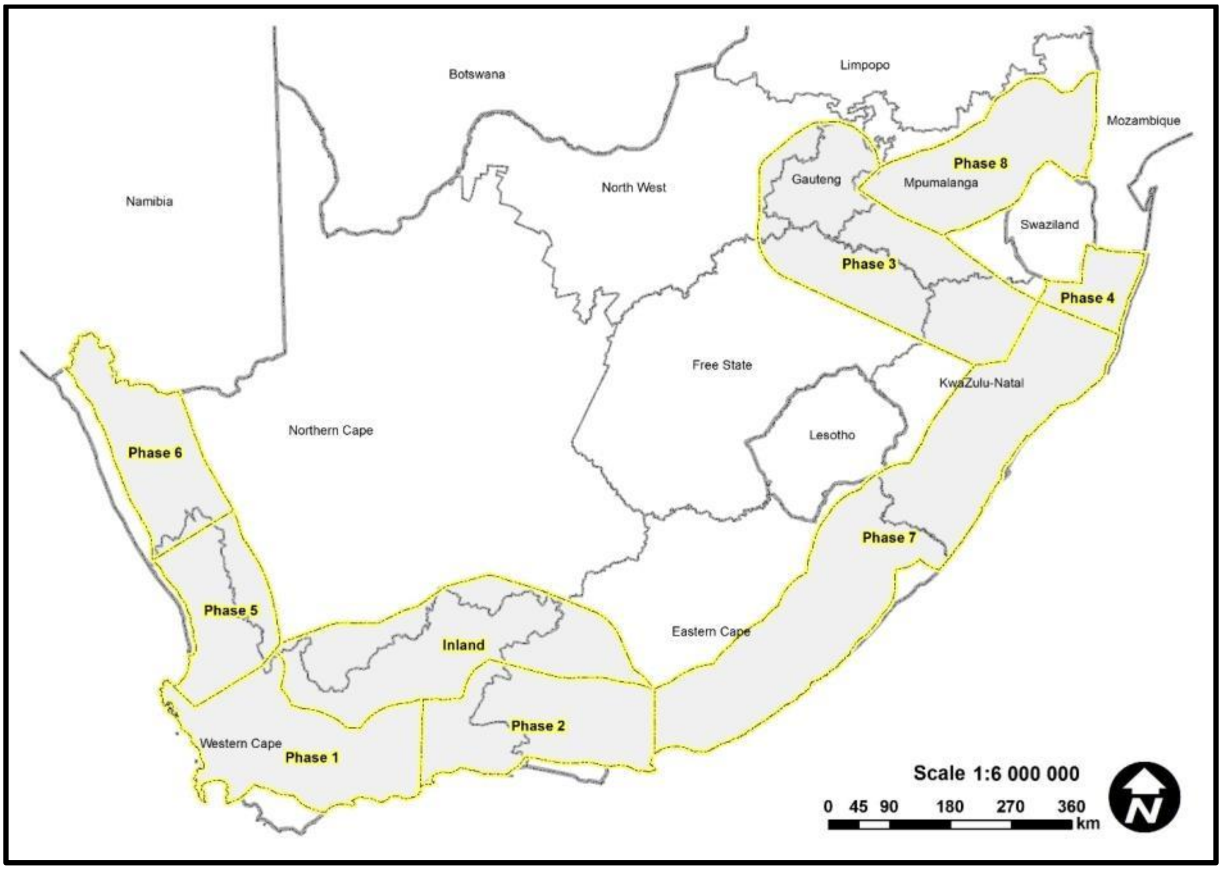


Figure 1: Overview of the proposed gas pipeline corridors

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 gas pipeline 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 gas pipelines, 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/Minimum Information Requirements, and Environmental Management Programme (EMPr) for the development of the gas pipelines.

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 gas pipeline 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 gas pipeline 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 a gas pipeline within the Gas 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 gas pipeline development 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 a gas pipelines;
  - 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 gas pipeline development (including inputs in the norms or standards/Minimum Information Requirements, 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.

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 gas pipeline 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 gas pipeline 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

4.1.5.1 River threat status and sensitivity:

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, Ecological Importance (EI) and Ecological Sensitivity (ES) data from the 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.

4.1.5.2 Wetlands threat status and sensitivity:

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 cumbersome, 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 above) 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.

4.1.5.3 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 gas pipeline 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.

4.1.5.4 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 141 species of plants (Appendix 1) that inhabit a range of freshwater habitats, broadly including wetlands, rivers and riparian areas. Point localities (approximately 4 129 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 3 202 (or 73%) are located within the gas pipeline corridors, 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 27 listed species (Appendix 2). Point localities (approximately 712 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). Forty nine species of conservation importance were selected for this study (Appendix 2). Point localities (approximately 1 194 records) for 28 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 21 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 29 listed species (Appendix 2). Point localities (approximately 11 444 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 six 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 4 452 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 11 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 3 072 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 seven, followed by amphibians (six), reptiles (five), mammals (four), fish (three), dragonflies and damselflies (two), and macro-invertebrates (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 gas pipeline 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 gas pipeline corridors include 4 843 SQ4 catchments ranging from 0.1 to 115 000 hectares. These catchment areas are used as the primary spatial unit for analysis in the freshwater component.
River Ecoregions (Level 1 and 2)	Kleynhans *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 25 Level 1 and 97 Level 2 River Ecoregions occur within the gas pipeline corridors.
River Present Ecological State (PES), Ecological Importance (EI) and Ecological Sensitivity (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.
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

Data title	Source and date of publication	Data Description
		allow for the development of the indicators and criteria used for identifying and delineating wetlands. This method of predicting wetlands in a landscape setting is more suitable for certain regions of the country than in others.
Mpumalanga Highveld Wetlands	SANBI (2014)	Wetland delineations for the Mpumalanga Highveld based on desktop mapping using Spot 5 imagery, supported by Google Earth, 1:50 000 contours, 1:50 000 rivers, exigent data, and NFEPA wetlands. This is an update of previous mapping through desktop digitising, ground-truthing and reviewing mapped data. Additional analysis was conducted to determine changes to ecosystem threat status, protection level and FEPAs.
Mpumalanga Biodiversity Sector Plan (BSP): Freshwater Assessment	Mpumalanga Tourism and Parks Agency (MTPA), CSIR and SANBI (2011)	Mapping of priority areas for freshwater biodiversity in Mpumalanga using FEPA layers to derive CBA rivers (i.e. FEPA rivers and free-flowing rivers), CBA wetlands (based on FEPA wetlands), CBA aquatic species (i.e. dragonflies/damselflies and crab taxa of conservation concern only), ESA wetland clusters (based on FEPA wetland clusters), and ESA wetlands (all non-FEPA wetlands). The MTPA land cover developed using SPOT 2010 imagery, together with high-resolution aerial imagery, was used to refine freshwater features mapping.
Gauteng Conservation Plan 3.3 prepared for the Gauteng Department of Agriculture and Rural Development - CBAs and EASs	Compaan (2011)	Represents priority areas for biodiversity conservation in Gauteng, primarily in the form of terrestrial features, but includes some areas supporting important aquatic features, principally wetland pans.
North West Biodiversity Sector Plan - Aquatic Critical Biodiversity Areas and Ecological Support Areas	North West Department of Rural, Environment and Agriculture Development (READ) (2015)	Layer showing all aquatic CBAs and ESAs for the North West province for use in CBA maps and general planning and distribution. The purpose and interpretation of the Aquatic CBA Map is described in the NW Biodiversity Sector Plan document and technical report.
KwaZulu-Natal Freshwater Systematic Conservation Plan	Ezemvelo KZN Wildlife (EKZNW) (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.

Data title	Source and date of publication	Data Description
Eastern Cape Draft 2017 Biodiversity Conservation Plan (BCP) Aquatic Critical Biodiversity Areas	ECBCP (2017)	Coverage of Aquatic Critical Biodiversity Areas as obtained from the Eastern Cape Biodiversity Conservation Plan (BCP), which is currently in a draft.
Eastern Cape Fine-scale Planning	South African National Parks (2012)	Identified CBAs and ESAs (including aquatic features) from fine-scale planning within the Eastern Cape, including areas within and adjacent to the Addo Elephant National Park (2012), Baviaanskloof Mega Reserve Area (2006), the Garden Route (2009), and the Nelson Mandela Bay Municipality (2009).
Western Cape Biodiversity Spatial Plans (fine-scale mapping)	Cape Nature (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.
Freshwater aquatic plants	Raimondo *et al.* (2009), with spatial data provided by SANBI (2018)	Point locations (from a total of 4 129 records) of conservation important plant species (141 species) that inhabit wetland, river and riparian habitats
Dragonflies and damselflies (Odonata)	IUCN (2017) and Samways and Simaika (2016), with spatial data provided by	Point locations of dragonflies and damselflies taken from a total of 712 records within South Africa. This data includes records of the conservation important Odonata selected for this

Data title	Source and date of publication	Data Description
	SANBI (2018)	assessment.
Aquatic macro-invertebrates	DWS (2015)	Point shapefiles of 94 aquatic macro-invertebrate families recorded from 3 202 monitoring sites on rivers within South Africa.
Freshwater fish	Coetzer (2017)	Point locations for freshwater fish for South Africa taken from a total of 1 194 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 21 of the selected fish species.
Amphibians	Minter *et al.* (2004), with spatial data provided by SANBI (2018)	Point localities (approximately 11 444 records) for these selected species were obtained from the SANBI TSP database (SANBI, 2018).
Reptiles	Bates *et al.* (2014), with spatial data provided by SANBI (2018)	Point locations of reptiles was taken from a total of 4 452 records.
Mammals	Child *et al.* (2016), with spatial data provided by SANBI (2018)	Point locations of mammals was taken from a total of 3 072 records.

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.
Protected Areas layers	No protected areas layer data were included	Protected Areas layers were not used in this study.	Aquatic ecosystems and features are inherently less sensitive given the levels of protection.

Limitation	Included in the scope of this study	Excluded from the scope of this study	Assumption
			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 (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

Instrument	Key objective	Feature
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: 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
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 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.	Relevant to rivers and wetlands during all phases
NEMA EIA 2014 Regulations, as amended April 2017 (Government Gazette 40772	These regulations provide listed activities that require EA 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 gas pipeline construction/ development in proximity to wetlands, rivers and critical biodiversity areas
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	Relevant to rivers and wetlands during all phases

Instrument	Key objective	Feature
	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.	
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).	Rivers and wetlands
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 phases of gas development projects, which may impact rivers and wetlands
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 the ecological character of such areas; and to promote participation of local communities in the management of protected areas, where appropriate.	Any protected areas - and related freshwater ecosystems affected by gas development

Instrument	Key objective	Feature
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 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 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	Water resource allocation to develop gas pipelines - during construction and operation phases. Relevant to water resources in the vicinity of gas pipelines.
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	Benchmark used for monitoring and evaluation of freshwater resources especially rivers in relation to the Reserve.

Instrument	Key objective	Feature
	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	
Water Research Act (Act 34 of 1971)	Promotes water related research	All water resources, and associated ecosystems
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
Eastern Cape		
Cape Local Authorities Gas Ordinance 7 of 1912	Regulates gas and control gas related water pollution	Gas pipeline development affecting rivers and wetlands
Divisional Councils Ordinance 18 of 1976	Provides for the regulation and control of effluents refuse and stormwater	Gas pipeline development affecting rivers and wetlands
Nature and Environmental Conservation	This ordinance is applicable in the Western Cape, Eastern Cape, Northern Cape and parts	Species diversity

Instrument	Key objective	Feature
Ordinance (Ordinance 19 of 1974; amended in 2000).	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.	
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
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

Instrument	Key objective	Feature
	Northern Cape Province	
Divisional Councils Ordinance 18 of 1976	Provides for the regulation and control of effluents refuse and storm water	Gas pipeline 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
	North West Province	
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 BASELINE DESCRIPTION OF THE PROPOSED GAS PIPELINE CORRIDORS

A description of the freshwater ecosystems within corridors that stand to be impacted by the phased development of the gas pipeline in South Africa is 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 Gas Pipeline corridors, including existing drivers and pressures.

Gas pipeline corridor	Description	Existing drivers and pressures
Phase 1 Corridor	**Rivers within the Phase 1 Corridor** are either perennial/permanently-flowing (approximately 55%) or ephemeral/non-perennial (approximately 45%), and are characteristic of the South Western Coastal Belt, Western Folded Mountains, Southern Folded Mountains and the Southern Coastal Belt ecoregions. Major river systems include the Berg, Bree, Gourits and Doring Rivers. Most (approximately 65%) of the river habitat in the corridor is currently Threatened (i.e. Critically Endangered, Endangered and Vulnerable). The upper reaches of the Doring River is a flagship/free-flowing river that drains the corridor. 30% of rivers in this corridor are in a natural/good condition, while 20% are in a fair condition, 44% are in a poor condition, and 6% are either very poor/critical condition. **Overall river sensitivity for the Phase 1 Corridor is as follows: very high (38%), high (30%), medium (27%), and low (5%).** **Wetland habitats within the Phase 1 Corridor** occupy a fair proportion of the corridor (~7%) comprising up to 221 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the East Coast Shale Renosterveld region. The corridor boasts five Ramsar wetlands, namely Langebaan, False Bay Nature Reserve, Bot-Kleinmond Estuarine System, De Mond (Heuningnes Estuary) and De Hoop Vlei. A moderate proportion (~18%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that 50% of the wetlands of the corridor are associated with the Critically Endangered wetland groups: East Coast Shale Renosterveld (20%), Rainshadow Valley Karoo (15%), West Coast Shale Renosterveld (9%) and Western Fynbos-Renosterveld Shale Renosterveld (6%). **Overall wetland sensitivity for the Phase 1 Corridor is as follows: very high (25%), high (60%), medium (13%), and low (2%).** **Threatened aquatic biota:** Three Endangered Odonata (*Proischnura polychromatica, Orthetrum rubens* and *Spesbona angusta*), as well as four Vulnerable and three Near Threatened species. *Orthetrum rubens* is a restricted species that is only known from the mountains of the Western Cape: since 2016 the only known extant population is in the Hottenstots-Holland Mountains, at	Approximately 67% of the Phase 1 Corridor comprises land that is largely natural with a small proportion (~1%) degraded. A significant proportion (20%) of the corridor is protected by over 100 different conservation areas (e.g. Koue Bokkeveld Mountain Catchment Area, Matroosberg Mountain Catchment Area, Langeberg Mountain Catchment Area). The remaining area is largely transformed by cultivation (~29%), but also urbanisation in and around Cape Town (2%) and plantations (1%). Impacts on freshwater ecosystems caused by land use activities vary across the corridor, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity. Key impacts include: • There has been rapid population growth within the Western Cape, and thus urbanization has increased, particularly since 2009. Informal settlements in particular have expanded and reactive spatial planning has led to poor or even absent basic service infrastructure. The result is unsustainable practices including increased illegal dumping and waste disposal in rivers, contributing to water pollution. The greatest instances of transformation are reported to be in Cape Town itself and other coastal nodes. • Very high (unacceptable) faecal contamination in the Berg, Bree, Diep, Gouritz and Kuils River systems. Inland water is generally considered not fit even for agricultural or industrial use. • Alien invasive species, which reduce both surface and ground water availability, increase fire risk and compete with indigenous species, which result in habitat loss and degradation. Alien invasive plants are a large problem, as are invasive fish species

Gas pipeline corridor	Description	Existing drivers and pressures
	Victoria Peak. *Spesbona angusta* is also restricted to a wetland at the base of Franschhoek pass, and thus careful conservation planning and improvement of wetland in terms of water depth and density of pools is required for this species (Veldtman *et al.*, 2017). *Proischnura polychromatica* has also only been recently recorded near Ceres, and also at the base of Franschhoek Pass, and are only known from sites where alien invasive trees have been removed (Veldtman *et al.*, 2017). The corridor supports an exceptionally high number of Red Listed fish (up to 22 species) of which four are Critically Endangered: *Pseudobarbus burchelli*, which is found in the Breede and Tradouw river systems, Pseudobarbus erubescens (endemic to the Twee River Catchment within Olifants system), *Pseudobarbus* sp. nov. 'doring' (Breekkrans and Driehoeks Tributaries of the Doring river, Olifants system), and *Pseudobarbus* sp. nov. 'heuningnes' (Heuningnes River System). In addition, 10 fish species are Endangered, three are Vulnerable, four are Near Threated and one is Data Deficient. The corridor also supports a high number of Red Listed amphibians (up to 16 species) of which five are Critically Endangered (*Arthroleptella rugosa, A. subvoce, Capensibufo rosei, Heleophryne rosei* and *Microbatrachella capensis*), two are Endangered, six are Near Threated and three are Data Deficient. *Arthroleptella rugosa* (Rough Moss frog) is a highly restricted species occurring only on the Klein Swartberg Mountain near Caledon, A. subvoce's status may be changed to a more threatened category (Turner and de Villiers, 2017); *Capensibufo rosei* is only found to occur on the Cape Peninsula, in two or three remaining populations; *Heleophryne rosei* is restricted to four streams on Table mountain area, and *Microbatrachella capensis* is a vital indicator of a unique and threatened ecosystem: coastal lowland blackwater wetlands. There is only one Red Listed reptile that occurs within the corridor, namely the Vulnerable *Bradypodion pumilum*. The Phase 1 Corridor supports known occurrences of the Critically Endangered Riverine Rabbit *Bunolagus monticularis*, which is restricted to the semi-arid Karoo, with an estimated Extent of Occurrence (EOO) of 54,227 km^2 and Area of Occupancy (AOO) 2,943 km^2 (2016 Mammal Red List *Bunolagus monticularis* CR). The Riverine Rabbit inhabits dense, discontinuous scrub vegetation along seasonal river beds and is dependent on soft, deep alluvial spoils along these river courses, for constructing burrows in order to breed. Other Red Listed mammals include the Vulnerable *Dasymys capensis*, as well as three species that are Near Threatened. This corridor supports the highest diversity of Red Listed plants with up to 75 species. Of this diversity, 16 are Critically Endangered, 23 are Endangered, 22 are Vulnerable, six are Near Threatened, four are Data Deficient and four are rare. **Overall species sensitivity for the Phase 1 Corridor is as follows: very high (50%), high (40%), medium (8%), and low (2%).**	within rivers – 17 in total. • Agriculture, also reported to be increasing in the Western Cape region, contributes to the pollution of freshwater resources, as a result of run-off of pesticides and fertilizers. In addition, over-abstraction of water for both agriculture and urban use forms a major problem in many areas. • Damage to river beds, wetlands and floodplains (channel modification) as a result of agricultural practices is also considered to be a major threat to freshwater ecosystems in this region. • Other pressures which impact on these systems include overgrazing and illegal harvesting of species • Further to this, within the Western Cape, water has been identified as a provincial risk, based on increased urbanization, climate change, failing infrastructure and consumer behaviour.

Gas pipeline corridor	Description	Existing drivers and pressures
Phase 2 Corridor	**Rivers within the Phase 2 Corridor** are either perennial/permanently-flowing (approximately 45%) or ephemeral/non-perennial (approximately 55%), and are largely characteristic of the Southern Folded Mountains ecoregion, as well as the Great Karoo and the Southern Eastern Coastal Belt ecoregions. Major river systems include the Olifants, Kouga, Doring Rivers and Sondags. A moderate proportion (approximately 41%) of the river habitat in the corridor is currently Threatened (i.e. Critically Endangered, Endangered and Vulnerable). The rivers are generally in either a natural/good (44 %) or fair (38%) condition, while 17% of the rivers are in either a poor, very poor or critical state. **Overall river sensitivity for the Phase 2 Corridor is as follows: very high (23%), high (50%), medium (25%), and low (2%).** **Wetland habitats within the Phase 2 Corridor** occupy a fair proportion of the corridor (~8%) comprising up to 133 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Albany Thicket and Eastern Fynbos-Renosterveld Sandstone Fynbos regions. The corridor contains one Ramsar wetland, the Wilderness Lakes, which cover 1 300 ha. A small proportion (~5%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that more than 60% of the wetlands of the corridor are associated with the Critically Endangered wetland groups: Albany Thicket Valley (34%), and Lower Nama Karoo (29%). **Overall wetland sensitivity for the Phase 2 Corridor is as follows: very high (58%), high (36%), medium (4%), and low (2%).** **Threatened aquatic biota:** One Endangered species of Odonata (i.e. *Metacnemis valida*) which occurs in the corridor (status threatened by habitat loss and now only known from two sites on the Kubusi River in the vicinity of Stutterheim) (IUCN, 2017) http://www.iucnredlist.org/details/42840/0); as well as two Vulnerable and two Near Threatened species. In addition, there are three vulnerable species, and two near-threatened species of Odonata supported in this corridor. The corridor also supports one Critically Endangered fish (i.e. *Pseudobarbus senticeps*: a narrow range endemic species which is restricted to the Krom River system (IUCN, 2017), along with three Endangered, one Vulnerable, one Near Threated and one Data Deficient species. The only Red Listed amphibians that occur within the corridor include the Endangered *Afrixalus knysnae* and *Heleophryne hewitti*. *Afrixalus knysnae*[1] is known from around five locations at low altitudes, on either side of the border between the Eastern Cape and Western Cape Provinces and its EOO is 816 km^2, and its AOO is	Majority (91%) of the Phase 2 Corridor comprises land that is largely natural, with a reasonable proportion (13%) of the corridor protected by a number of conservation areas (e.g. Addo Elephant National Park and Baviaanskloof Nature Reserve). The remaining area is largely transformed by cultivation (~6%), but also plantations (2%) and urbanisation (1%) particularly along the coastal areas George, Knysna and Port Elizabeth. Key impacts affecting freshwater ecosystems include: • Urbanization, particularly in towns and cities within the coastal zone, resulting in increased pressure on infrastructure and affecting water quality; • Flow alteration caused by impoundments (e.g. Kouga, Clanwilliam, Darlington), affect downstream aquatic systems (e.g. channel characteristics, riparian vegetation, and instream and floodplain habitats) as well as river continuity • Increased agriculture and cultivation in this area has caused increased pressure on aquatic ecosystem, through processes such as channel modification, over abstraction of water for irrigation, river bank alteration and contamination of groundwater and rivers through the run-off of fertilizers, pesticides and herbicides. The abstraction of water for the irrigation of crops such as potatoes, grapes, deciduous and citrus fruits within the Olifants catchment, has resulted in extreme pressure on the flow of this system; • Plantations of alien invasive species have also caused increased pressure on aquatic systems as a result of the decreased flow and lowering of the groundwater table. Kouga and Baviaanskloof form the source of many of the freshwater systems in the Eastern Cape, including a large proportion of the catchments of the Gamtoos, Krom and Seekoei rivers. Invasive alien Acacia, Hakea and Pinus trees pose a serious threat to the conservation

[1] http://www.iucnredlist.org/details/56065/0

Gas pipeline corridor	Description	Existing drivers and pressures
	27 km². (IUCN, 2017) The ghost frog occurring in the Kammanassie Mountains may be Hewitt's ghost frog (*Heleophryne hewitti*), but at this stage this still needs to be confirmed and thus the status updates (Turner and de Villiers, 2017). There are no Red Listed reptiles that are known to occur within the corridor. The corridor supports a reasonable diversity of Red Listed mammals, including the Critically Endangered Riverine Rabbit *Bunolagus monticularis* (see info on status above), as well as one Vulnerable and four Near Threatened species. This corridor supports a low diversity of (up to 7) Red Listed plants. Nevertheless, one is listed as Critically Endangered (i.e. *Cotula myriophylloides*) and another is Endangered (i.e. *Felicia westae*). The other species comprise of two Vulnerable, one Near Threatened, one Data Deficient, and one rare species. **Overall species sensitivity for the Phase 2 Corridor is as follows: very high (18%), high (54%), medium (2%), and low (26%).**	of water (the uptake of water of these species is high) and natural vegetation in these mountains; • Alien trees are also known to accelerate riverbank erosion and reduce in-stream flow. They are also responsible for changes in fire regime and alteration of plant community composition. This is particularly relevant in this region, which experiences high levels of water stress, drought and associated increased fire risk.
Phase 3 Corridor	**Rivers within the Phase 3 Corridor** are predominantly perennial/permanently-flowing (81%), and drain a number of ecoregions, notably the Highveld ecoregion. Major river systems include the Vaal, Klip and Buffels Rivers. A significant (approximately 71%) proportion of the rivers that drain the corridor are Critically Endangered. Less than 20% of the rivers are considered to be in a natural/good condition, while 50% are in a fair condition, 23% are in a poor condition and 10% are in either a very poor or critical condition. **Overall river sensitivity for the Phase 3 Corridor is as follows: very high (46%), high (34%), medium (19%), and low (<1%).** **Wetland habitats within the Phase 3 Corridor** occupy a significant proportion of the corridor (~17%) comprising up to 127 different wetland types, dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Mesic Highveld Grassland and Sub-escarpment Grassland regions. The corridor supports two Ramsar wetlands, namely Seekoeivlei Nature Reserve (4,754 ha) and the Blesbokspruit (1,858 ha). A small proportion (~8%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that more than 50% of the wetland habitats within the corridor are associated with the Critically Endangered Mesic Highveld Grasslands (Groups 2, 3 and 4). **Overall wetland sensitivity for the Phase 3 Corridor is as follows: very high (5%), high (64%), medium (23%), and low (8%).** **Threatened aquatic biota:** Only one notable species of Odonata, considered as vulnerable (i.e. *Lestes dissimulans*) occurs in the corridor. Of the 12 Red Listed fish species that occur within the corridor, one is Critically Endangered (i.e. *Pseudobarbus burchelli*), which is found in the Breede	Approximately 62% of the Phase 3 Corridor comprises land that is largely natural with a further 2% degraded. A very small proportion (2%) of the corridor is protected by a number of small conservation areas, but also larger ones such as the Cradle of Humankind World Heritage Site. A significant area has been transformed by cultivation (~29%), urbanisation in and around Johannesburg (5%), plantations (2%), as well as mining (1%). Key impacts affecting freshwater ecosystems include: • Very high (unacceptable) faecal pollution in rivers flowing through Gauteng (e.g. the Jukskei River), largely due to discharge of untreated or poorly treated effluent from malfunctioning/overloaded waste water treatment works, as well as surcharging manholes; • Unsustainable and rapid urbanisation has resulted in the pollution of most river systems within this region. Pollution of the Vaal itself reached crisis point in January 2018 as a result of the acid mine drainage effluent and raw or partially treated sewage being pumped into the system; • A high concentration of mining and industrial activity in this area

Gas pipeline corridor	Description	Existing drivers and pressures
	and Tradouw river systems, while two are Endangered, two are Vulnerable, five are Near Threatened and two are Data Deficient. The only Red Listed amphibian that occurs within the corridor includes the Near Threatened *Hemisus guttatus*. There are no Red Listed reptiles that are known to occur within the corridor. The corridor supports the highest number of Red Listed mammals (up to 9 species) of which four are Vulnerable and five are Near Threated. This corridor supports a low diversity of (up to 8) Red Listed plants, but which includes two Endangered species (i.e. *Disa zuluensis* and *Kniphofia flammula*). Other Red Listed species include three Vulnerable and three Near Threatened species. **Overall species sensitivity for the Phase 3 Corridor is as follows: very high (8%), high (9%), medium (35%), and low (48%).**	places enormous pressure on the aquatic systems and has caused contamination of these systems though chemical leaching; • Transformation and damage of wetlands e.g. Klip River wetland, through illegal dumping, high levels of urbanization, poor infrastructure and wastewater treatment works, and erosion through the high volumes of wastewater that flow through the wetland; • Over-abstraction of water, and various impoundments (construction of dams e.g. the Vaal in particular), place huge pressure on the flow of rivers in this region; • The effects of agriculture are evident and contribute to the pollution of freshwater resources as a result of run-off of pesticides and fertilizers.
Phase 4 Corridor	**Rivers within the Phase 4 Corridor** largely form part of the Lowveld and Natal Coastal Plain ecoregions, with a smaller number of rivers draining off from the Lebombo Uplands. The rivers are either perennial/permanently-flowing (approximately 62%) or ephemeral/non-perennial (approximately 38%). Major river systems include the Phongolo and Mkuze Rivers – the Mkuze River and one of its tributaries, the Msunduzi, are the only flagship/free-flowing rivers that drain the corridor. Less than 30% of the rivers are considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). Almost half of the rivers are in a natural/good condition, 36% are in a fair condition, while 16% are in a poor/very poor condition. **Overall river sensitivity for the Phase 4 Corridor is as follows: very high (15%), high (35%), medium (48%), and low (2%).** **Wetland habitats within the Phase 4 Corridor** occupy a small proportion of the corridor (~4%) comprising up to 47 different wetland types, dominated by floodplain wetlands, particularly within the Indian Ocean Coastal Belt region. The corridor boasts four Ramsar wetlands covering up to 185 000 ha, namely Ndumo Game Reserve, Kosi Bay, Lake Sibaya, and the St. Lucia System. A significant proportion (~51%) of the wetlands in the corridor are characterised as NFEPA wetlands. Most notable is that 65% of the wetland habitats within the corridor are associated with the Endangered Lowveld wetland vegetation (Group 10). **Overall wetland sensitivity for the Phase 4 Corridor is as follows: very high (20%), high (43%), medium (28%), and low (9%).**	Approximately 72% of the Phase 4 Corridor comprises land that is largely natural, with a significant proportion of the area protected by existing conservation areas (e.g. Isimangaliso Wetland Park, Tembe Elephant Park, Ndumo Game Reserve, Ithala Game Reserve). The remaining area has been largely degraded (~15%) or is transformed by cultivation, plantations, urbanisation and rural settlements. Impacts on freshwater ecosystems caused by land use activities vary across the corridor, however, combined effect has had a significant effect on freshwater ecosystem functioning and integrity. Key impacts affecting freshwater ecosystems 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

Gas pipeline corridor	Description	Existing drivers and pressures
	Threatened aquatic biota: The only Critically Endangered Odonata for South Africa occurs along the Phongolo River in the north-western corner of the Phase 4 Corridor, namely *Chlorocypha consueta*. The Endangered *Diplacodes pumila* also occurs in the corridor along with six species listed as Vulnerable and four species listed as Near Threatened. One Endangered fish, *Silhouettea sibayi*_occurs in coastal rivers that flow through the corridor. The corridor also supports two vulnerable species, three Near Threatened and two Data Deficient species of fish. The only Red Listed amphibians that occur within the corridor include the Endangered *Hyperolius pickersgilli* and the Near Threatened *Hemisus guttatus*. The corridor supports two Red Listed reptiles, namely the Hinged Terrapin *Pelusios rhodesianus*, (Vulnerable) which is known from a few water bodies along the coastal region – and *Macrelaps microlepidotus* (Near Threatened), which is found in forests and coastal bush. Up to eight Red Listed mammals occur within the Phase 4 Corridor, including five rodents/shrews, as well as Spotted-necked Otter *Hydrictis maculicollis* (Vulnerable) and Cape Otter *Aonyx capensis* (Near Threatened). This corridor supports a moderate diversity of (up to 24) Red Listed plants, including two that are Endangered (i.e. *Albizia suluensis* and *Mondia whitei*). The majority of the Red Listed plants occurring with the corridor are either Vulnerable (12 species) or Near Threatened (9 species), while one is considered rare. **Overall species sensitivity for the Phase 4 Corridor is as follows: very high (54%), high (12%), medium (31%), and low (3%).**	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 and other mining activities, particularly in the Richards Bay region; • Transformation and alteration of watercourses through canals, diversion structures, weirs, road crossings, flood control berms; • Abstraction of water for irrigation and extensive forestry, which is having a significant impact on groundwater and linked wetlands in the Maputaland region; • Erosion and degradation, especially linked to overgrazing, which is notable in the more rural areas; and • Excessive infestation of numerous IAPs, particularly along rivers and around wetlands, as well as instream (e.g. Water Hyacinth).
Phase 5 Corridor	**Rivers within the Phase 5 Corridor** are mostly ephemeral/non-perennial (approximately 61%), while around 39% are considered to be perennial/permanently-flowing. These rivers drain a number of ecoregions, such as the South Western Coastal Belt, Western Folded Mountains and the Great Karoo. Major river systems include the Doring, Olifant and Sout. Less than 25% of the rivers are considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). More than 60% of the rivers are in a natural/good condition, 8% are in a fair condition, while 30% are in a poor/very poor condition. **Overall river sensitivity for the Phase 5 Corridor is as follows: very high (27%), high (35%), medium (36%), and low (2%).** **Wetland habitats within the Phase 5 Corridor** occupy a small proportion of the corridor (~3%) comprising up to 90 different wetland types, dominated by channelled-valley bottom wetlands,	A large portion (81%) of the Phase 5 Corridor comprises land that is largely natural, with a fairly small proportion (8%) of the corridor protected by a number of conservation areas (e.g. Cederberg Wilderness Area, Moedverloren Nature Reserve and Tankwa Karoo National Park). The remaining area is mostly transformed by cultivation (~19%), with <1% attributed to plantations, urbanisation (e.g. Citrusdal and Vredendal) and mining. Key impacts affecting freshwater ecosystems include: • Pollution from application of fertilizers, herbicides and

Gas pipeline corridor	Description	Existing drivers and pressures
	particularly within the Northwest Sand Fynbos region. The corridor contains a single Ramsar wetland, namely Verlorenvlei, which is approximately 1,500 ha. A moderate proportion (~23%) of the wetlands in the corridor are characterised as NFEPA wetlands. Almost all of the wetland habitats within the corridor are associated with Least Threatened wetland vegetation groups (e.g. the Knersvlakte and Trans-Escarpment Succulent Karoo). **Overall wetland sensitivity for the Phase 5 Corridor is as follows: high (15%), medium (30%), and low (55%).** **Threatened aquatic biota:** Two species of Odonata that are listed as Vulnerable (i.e. *Syncordulia gracilis* and *S. legator*) occur in the corridor, along with two species that are Near Threated. Of the 14 Red Listed fish species that occur within the corridor, three are listed as Critically Endangered (i.e. *Pseudobarbus burchelli, P. erubescens* and *P.* sp. Nov. 'doring'), while six are considered Endangered, four are Near Threatened, and one is Data Deficient. The only Red Listed amphibian that occurs within the corridor includes the Near Threatened *Breviceps gibbosus*. There is also only one Red Listed reptile that occurs within the corridor, namely the Vulnerable *Bradypodion pumilum*. The Critically Endangered Riverine Rabbit *Bunolagus monticularis* occurs in a few, isolated localities within the corridor (see above for ecology and habitat). The only other Red Listed mammals include two that are Near Threatened. This corridor supports a moderate diversity of Red Listed plants of up to 25 species, including two that are Critically Endangered (i.e. *Pilularia bokkeveldensis* and *Senecio cadiscus*), while ten are Endangered, nine are Vulnerable and four are Near Threatened. **Overall species sensitivity for the Phase 5 Corridor is as follows: very high (34%), high (18%), medium (12%), and low (36%).**	pesticides, as well as point-source discharges from urban centres (e.g. Bitterfontein); • Grazing by livestock, particularly high/concentrated levels of along watercourses, causing overgrazing and trampling within and adjacent to river and wetland systems, which in turn leads to increased erosion and changes in vegetation structure (notably, the loss of riparian habitat); • Increases in woody vegetation along rivers, in particular by *Acacia karoo*, as well as infestations of invasive alien species (e.g. *Tamarix spp.* and *Prosopis glandulosa*). These deep-rooted species are able to readily consume groundwater. Heavily infested areas have a significant impact on the hydrology of catchments, as well as outcompeting indigenous species; • More localised, yet severe impacts, linked to sand mining and other mining activities (e.g. alluvial diamond mining at the mouth of the Gariep River and along the west coast); • Groundwater utilisation both for domestic and agricultural uses; • Construction of weirs and dams along river systems, which alters the natural hydrological flows, which is most notable for the Gariep River as a consequence of numerous, large dams/impoundments in the catchment; and • Road crossings, which cause concentration of surface runoff and localised sheet and gulley erosion in proximity to rivers and wetlands.
Phase 6 Corridor	**Rivers within the Phase 6 Corridor** are all non-perennial/ephemeral in character with exception of the Gariep River, which receives most of its flow from its headwaters in Lesotho and the Vaal River. Most of the river habitats fall within the Namaqua Highland Ecoregion, while a smaller number of systems occur within the Nama Karoo and the Orange River Gorge. Only 5% of the river habitat is considered to be Threatened (i.e. 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 30% of the rivers assessed to be in fair condition, while a very small proportion (1%) are in a poor state. **Overall river sensitivity for the Phase 6 Corridor is as follows: very high (1%), high (25%), medium (21%), and low (53%).**	Approximately 98% of the Phase 6 Corridor comprises land that is largely natural, thus only a very small proportion is transformed through urbanisation, agricultural and mining developments. A reasonable proportion (12%) of the corridor is protected by a number of conservation areas (e.g. Richtersveld National Park and Namaqua National Park). 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 invasive alien plants. The

Gas pipeline corridor	Description	Existing drivers and pressures
	Wetland habitats occupy a very low proportion of the corridor (<1%) owing to the xeric climatic conditions of the Succulent Karoo. Nevertheless, the area supports up to 44 wetland types, dominated by floodplain wetland habitat along the lower Gariep River and channelled-valley bottom wetlands within the Namaqualand Hardeveld region. One Ramsar wetland occurs within the corridor, and is located at the mouth of the Gariep River. A moderate proportion (17%) of the wetlands in the corridor are characterised as NFEPA wetlands, which predominantly include floodplain wetland along the Gariep River and seeps within the Namaqualand Hardeveld region. A small proportion (12%) of the wetland habitats are associated with the Endangered Gariep Desert wetland vegetation group. **Overall wetland sensitivity for the Phase 6 Corridor is as follows: very high (5%), high (23%), medium (57%), and low (15%)** **Threatened aquatic biota:** There are no known occurrences of Red Listed Odonata and fish from the Phase 6 Corridor. Three Red Listed amphibians are known to occur in the corridor, namely *Breviceps macrops* (Near Threatened), which inhabits sandy habitats along Namaqualand coast, *Capensibufo deceptus*[2] (Data Deficient) which occurs in shallow temporary pools with emergent sedge-like plants in Mountain Fynbos or Grassy Fynbos in the Fynbos Biome (IUCN, 2017) and *Breviceps branchi* (Data Deficient), which is only known from a single specimen collected near the Holgat River. One Critically Endangered reptile, *Pachydactylus rangei*, inhabits dry river beds and surrounding dunes/sanding environments in the north western corner of the corridor. One Red Listed mammal occurs within the corridor, namely the Near Threatened *Otomys auratus*. This corridor supports a low diversity of (up to 6) Red Listed plants. Of these, two are Vulnerable (i.e. *Isoetes eludens* and *Oxalis dines*), while four are Near Threatened. **Overall species sensitivity for the Phase 6 Corridor is as follows: very high (5%), high (0%), medium (32%), and low (63%).**	combined effect of anthropogenic pressures results in both localised and widespread impacts that affect functioning and integrity of freshwater ecosystems. Key impacts affecting freshwater ecosystems include: • Pollution from application of fertilizers, herbicides and pesticides, as well as point-source discharges from urban centres (e.g. Springbok and Vioolsdrif); • Grazing by livestock, particularly high/concentrated levels of along watercourses, causing overgrazing and trampling within and adjacent to river and wetland systems, which in turn leads to increased erosion and changes in vegetation structure (notably, the loss of riparian habitat); • Increases in woody vegetation along rivers, in particular by <u>*Acacia karoo*</u>, 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.

[2] http://www.iucnredlist.org/details/112716175/0

Gas pipeline corridor	Description	Existing drivers and pressures
Phase 7 Corridor	**Rivers within the Phase 7 Corridor** flow through a number of ecoregions, notably the South Eastern Uplands, but also the Norther Eastern Uplands, North Eastern Coastal Belt and Eastern Coastal Belt. The rivers are predominantly perennial/permanently-flowing (87%), and major river systems include the Groot-Kei, Mbhashe, Mzimvubu, Mzimkhulu, Mkomazi, uMngeni, Thukela, Mhlatuze and Mfolozi Rivers. Less than 30% of the rivers are considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). This corridor contains a significant number of the remaining flagship/free-flowing rivers in the country, namely: the Mfolozi and Thukela River systems in the northern parts of the corridor, and the Mzimkhulu, Mtamvuna, Mtentu, Ntakatye, Nqabarha, Kobonqaba River. More than 60% of the rivers are in a natural/good condition, 8% are in a fair condition, while 30% are in a poor/very poor condition. **Overall river sensitivity for the Phase 7 Corridor is as follows: very high (14%), high (44%), medium (40%), and low (2%).** **Wetland habitats within the Phase 7 Corridor** occupy a large proportion of the corridor (~12%) comprising up to 155 different wetland types dominated by channelled-valley bottom wetlands and floodplain wetlands, particularly within the Subescarpment Grassland region. The supports three Ramsar wetlands, including parts of the St. Lucia System, located in the north eastern corner of the corridor, as well as uMgeni Vlei Nature Reserve (958 ha) and Ntsikeni Nature Reserve (9,200 ha). A moderate proportion (~20%) of the wetlands in the corridor are characterised as NFEPA wetlands. A very small proportion (3%) of the wetland habitats are associated with the Endangered Lowveld wetland vegetation (Group 10), while 56% occur within the Vulnerable Lowveld wetland vegetation (Group 11). **Overall wetland sensitivity for the Phase 7 Corridor is as follows: high (10%), medium (52%), and low (38%).** **Threatened aquatic biota:** Of the ten species of Red Listed Odonata that are known to occur within the corridor, three are listed as Endangered (i.e. *Chlorolestes apricans, Diplacodes pumila* and *Metacnemis valida*), while five are considered Vulnerable and two near threatened. The corridor also supports up to 15 Red Listed fish, of which seven are Endangered and three are Vulnerable, two are near threatened and three are Date Deficient. Of the 9 Red Listed amphibians that occur within the corridor, one is Critically Endangered (i.e. *Vandijkophrynus amatolicus*), while five are Endangered, one is Vulnerable and two are Near Threatened. *Vandijkophrynus amatolicus*[3] has a severely fragmented population and is known only from the Winterberg and Amathole Mountains, centred on Hogsback. The species has a very narrow EOO is	Approximately 65% of the Phase 7 Corridor, which stretches across most of the Eastern Cape and KwaZulu-Natal, comprises land that is largely natural, with a fairly large area (6%) degraded by existing land management practices. A small proportion (4%) of the area is protected by a number of small conservation areas, but also larger ones (e.g. Addo Elephant National Park, Hluhluwe-Imfolozi Game Reserve and Isimangaliso Wetland Park). The remaining area is transformed by cultivation (19%), urbanisation and rural settlements (5%) and plantations (5%). Key impacts affecting freshwater ecosystems include: • Extensive urbanisation causing transformation and degradation of freshwater ecosystems, notably in the greater Durban area, which continues to expand down? along the coast, as well as Pietermaritzburg and a within numerous of coastal towns south of Durban; • Water quality impacts and pollution associated with urban areas (e.g. domestic and industrial effluents, failing water treatment infrastructure, etc.) and agriculture (e.g. pesticides, herbicides and fertiliser applications), all of which are contaminating receiving aquatic environments; • Very high (unacceptable) faecal contamination in the uMngeni, Mlazi and Mdloti Rivers, as well as numerous rivers draining the eThekwini Metropolitan and Pietermaritzburg; • Stormwater runoff from hardened surfaces and sewer reticulation in and around urban areas; • Altered flows and water quality caused by large impoundments (e.g. Midmar, Albert Falls, Inanda, Goedertrouw and Umtata Dams), inter-basin transfers, which severely affect downstream

[3] http://www.iucnredlist.org/details/3176/0

Gas pipeline corridor	Description	Existing drivers and pressures
	98 km^2, and there is ongoing decline in the extent and quality of habitat. (IUCN, 2017) This corridor supports the highest number of Red Listed reptiles, including two Vulnerable, one Near Threatened and one Data Deficient species. The corridor also supports a high diversity of Red Listed mammals (up to 8 species), including three that are Vulnerable and five that are Near Threatened. This corridor supports a high diversity of (up to 39) Red Listed plants. Of these, two are Critically Endangered (i.e. *Isoetes wormaldii* and *Kniphofia leucocephala*), while six are Endangered, 17 are Vulnerable, 11 are Near Threatened, two are Data Deficient and one is rare. **Overall species sensitivity for the Phase 7 Corridor is as follows: very high (26%), high (10%), medium (47%), and low (17%).**	aquatic systems (e.g. channel characteristics, riparian vegetation, thermal regimes, instream and floodplain habitats, etc.), as well as upstream/downstream river continuity; • Illegal sand mining, as well as and other mining activities, particularly along coastal areas; • Transformation and alteration of watercourses through canals, diversion structures, weirs, road crossings, flood control berms; • Cultivation of wetlands and floodplains (notably sugarcane), especially along the coastal region; • Abstraction of water for large-scale irrigation, as well as streamflow reduction associated with extensive plantations; • Erosion and degradation, especially linked to overgrazing, which is notable in the more rural areas; and • Excessive infestation of numerous IAPs, particularly along rivers and around wetlands, as well as instream (e.g. Water Hyacinth).
Phase 8 Corridor	**Rivers within the Phase 8 Corridor** are predominantly perennial/permanently-flowing (80%), and flow through ecoregions such as the Highveld, Northern Escarpment Mountains, North Eastern Highlands, and down through the Lowveld. Major river systems include the Olifants, Komati, Crocodile and Sabie Rivers. A significant proportion (approximately 71%) of the rivers are considered to be Threatened (i.e. Critically Endangered, Endangered and Vulnerable). The Elands River (tributary of the Olifants River) is the only flagship/free-flowing river within the corridor. Less than 25% of the rivers are in a natural/good condition, 47% are in a fair condition, 23% are in a poor condition, while 6% are in a poor condition. **Overall river sensitivity for the Phase 8 Corridor is as follows: very high (46%), high (32%), medium (21%), and low (<1%).** **Wetland habitats within the Phase 8 Corridor** occupy a large proportion of the corridor (~12%) comprising up to 93 different wetland types, dominated by channelled-valley bottom wetlands, and largely characteristic of the Mesic Highveld Grassland region. There are no Ramsar wetlands that occur within the corridor, and a small proportion (~8%) of the wetlands are classified as NFEPA wetlands, mostly in the form of channelled-valley bottoms, depressions and seeps. Nevertheless, a significant (75%) of the wetlands are associated with Critically Endangered wetland groups, notably the Mesic Highveld Grassland Group 4 (54%) and Group 3 (9%). **Overall wetland sensitivity for the Phase 8 Corridor is as follows: very high (12%), high (72%), medium**	Approximately 65% of the Phase 8 Corridor comprises land that is largely natural with a further 2% degraded. A fairly large proportion (16%) of the corridor is protected by conservation areas, including parts of Kruger National Park. The remaining area is mostly transformed by cultivation (~19%) and plantations (11%), and to a lesser extent by urbanisation (3%) and mining (1%). Key impacts affecting freshwater ecosystems include: • Plantations, concentrated in the central highlands, resulting in a number of impacts to freshwater ecosystems (e.g. streamflow reduction particularly dry-season baseflows, increased turbidity and sedimentation, removal of riparian vegetation and buffer zones, invasive alien plant infestation, loss of species diversity and abundance, etc.); • Mining related acitivities (notably for coal resources) resulting in pollution of surface waters caused predominantly by acidification (i.e. acid mine drainage) and other mining-related effluents;

Gas pipeline corridor	Description	Existing drivers and pressures
	(13%), and low (3%). **Threatened aquatic biota:** The corridor supports two species of Odonata that are listed as Endangered (i.e. *Ceriagrion suave* and *Diplacodes pumila*), along with three that are Near Threatened. There are also 13 Red Listed fish that are known to inhabit the corridor, including the Critically Endangered *Chiloglanis bifurcus* and *Enteromius treurensi. Chiloglanis bifurcus*[4] is an instream species, endemic to the Inkomati River System and within this system it is restricted to altitudes between 900 metres above sea level (m.a.s.l) to 1200 m.a.s.l. In addition there are also 3 endangered fish species, one Vulnerable, five Near Threatened, and two Data Deficient. There are no Red Listed amphibians that are known to occur within the corridor. Only one Red Listed reptile occurs within the corridor, namely the Near Threatened *Macrelaps microlepidotus*. The corridor supports a high diversity of Red Listed mammals (up to 7 species), including three that are Vulnerable and four that are Near Threatened. This corridor supports a moderate diversity of Red Listed plants, including one that is Critically Endangered (i.e. *Aloe simii*) and one that is Endangered (i.e. *Disa zuluensis*). The majority of the Red Listed plants occurring with the corridor are either Vulnerable (7 species) or Near Threatened (7 species), while one is Data Deficient and two are rare. **Overall species sensitivity for the Phase 8 Corridor is as follows: very high (41%), high (34%), medium (9%), and low (16%).**	• Run-of-river abstraction and small farm dams for irrigation, which is more pronounced in the western parts of the corridor; • Urbanisation in and around towns such as Emalahleni, Middleberg, Ermelo and Nelspruit placing increased pressure on water resources, largely due to increased stormwater runoff and decreased water quality from both point and non-point sources linked to residential and industrial areas); • Very high (unacceptable) faecal pollution in regions such as Witbank/Middleburg and Nelspruit, which is affecting river systems such as the Crocodile and Olifants; and • Extensive maize cultivation and livestock farming resulting in removal and/or degradation of freshwater habitat.
Inland Corridor	**Rivers within the Inland Corridor** are mostly ephemeral/non-perennial (95%), and are largely characteristic of the Great Karoo ecoregion, but also form part of the Nama Karoo and Drought Corridor ecoregions. Major river systems include the Dwyka, Kariega and Sondags Rivers. Less than 25% of the river habitat in the corridor is currently Threatened (i.e. Critically Endangered and Endangered). The rivers are mostly in a natural/good condition (60%), 34% of rivers are in a fair condition, while 6% are in a poor condition. **Overall river sensitivity for the Inland Corridor is as follows: very high (14%), high (50%), medium (31%), and low (5%).** **Wetland habitats within the Inland Corridor** occupy a fair proportion of the corridor (~7%), with up to 62 different wetland types dominated by channelled-valley bottom wetlands and depressions that are largely characteristic of the Nama Karoo. There are no Ramsar wetlands within the corridor, and a very small proportion (~1%) of wetlands are classified as NFEPA wetlands. Nevertheless, a significant portion (79%) of the wetlands are associated with Critically	Almost the entire (99%) area of the Inland Corridor comprises land that is largely natural, with only a very small proportion transformed by cultivation (1%) and urbanisation (<1%). A very small proportion (3%) of the corridor is protected by a few conservation areas (e.g. Karoo National Park and Tankwa Karoo National Park). Impacts on freshwater ecosystems from associated land use activities of the transformed landscape are thus relatively localised. More widespread impacts to freshwater systems tend to be linked to livestock farming practices and infestation of invasive alien plants. The combined effect of anthropogenic pressures results in both localised and widespread impacts that affect functioning and integrity of freshwater ecosystems.

[4] http://www.iucnredlist.org/details/4632/0

Gas pipeline corridor	Description	Existing drivers and pressures
	Endangered wetland groups, notably the Lower Nama Karoo (60%) and the Rainshadow Valley Karoo (11%). **Overall wetland sensitivity for the Inland Corridor is as follows: very high (26%), high (56%), medium (4%), and low (14%).** **Threatened aquatic biota:** There are no Red Listed species of Odonata known to occur within the Inland Corridor. Only two Red Listed fish occur within the corridor, namely the Endangered *Pseudobarbus asper*, and the Data Deficient *Sandelia capensis*. There are no Red Listed amphibians and reptiles that are known to occur within the Inland Corridor. The corridor is most notable in terms of supporting significant populations of the Critically Endangered Riverine Rabbit *Bunolagus monticularis*, which is restricted to the semi-arid Karoo, with an estimated EOO of 54,227 km^2 and AOO of 2,943 km^2 (2016 Mammal Red List *Bunolagus monticularis* CR). The Riverine Rabbit inhabits dense, discontinuous scrub vegetation along seasonal river beds and is dependent on soft, deep alluvial spoils along these river courses, for constructing burrows in order to breed. Other Red Listed mammals include the Near Threatened *Serval Leptailurus* and the Near Threatened *Otomys auratus*. This corridor supports the lowest number of Red Listed plants, with only one Vulnerable plant (i.e. *Lachenalia longituba*) and one rare plant (i.e. *Pelargonium denticulatum*) occurring within the corridor. **Overall species sensitivity for the Inland Corridor is as follows: very high (11%), high (13%), medium (6%), and low (70%).**	Key impacts affecting freshwater ecosystems include: • Weirs and dams (including large water supply dams, e.g. De Hoop, Leeugamka, Vanrynevelspas), which affect instream and riparian habitat continuity, as well as regulate flows downstream; • Livestock grazing and trampling (including overgrazing, particularly in more rural areas), leading to increased erosion and sedimentation of systems; • Intensive cultivation immediately adjacent and along the banks of rivers; • Encroachment and infestation of woody vegetation, including invasive *Tamarix spp.*; and • Channel incision and headcut erosion, resulting in lowered groundwater table and drying of riparian and wetland habitats.

The following figures (Figure 2 to 5) show the distribution of freshwater features (i.e. rivers, wetlands, flora and fauna) associated with the various gas corridors as developed following the collation and compilation of available spatial datasets (see data sources in Section 4.2).

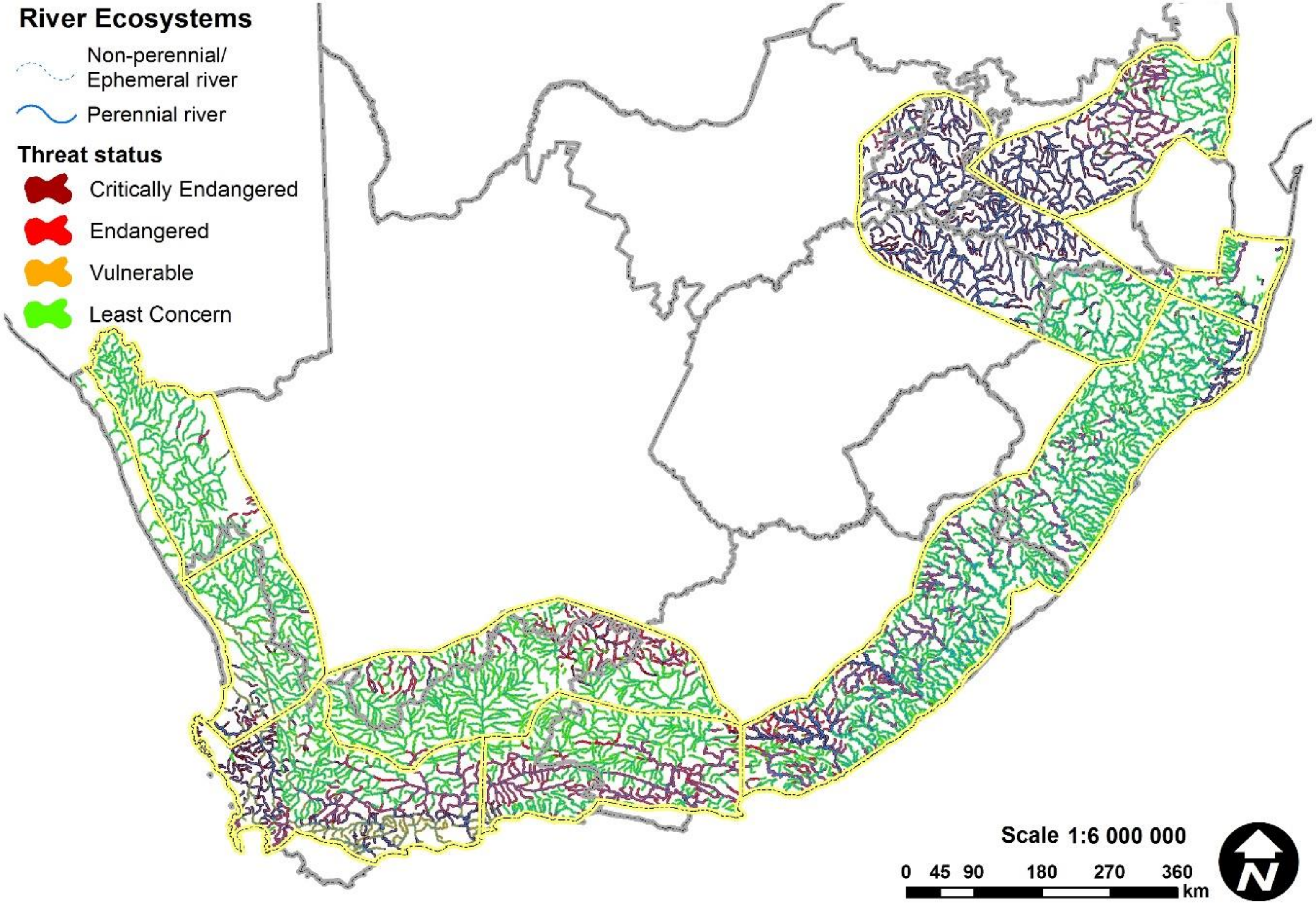


Figure 2: Flow (perennial and non-perennial) and threat status of rivers that flow through the gas pipeline corridors developed using the PES, EI and ES data from DWS (2014).

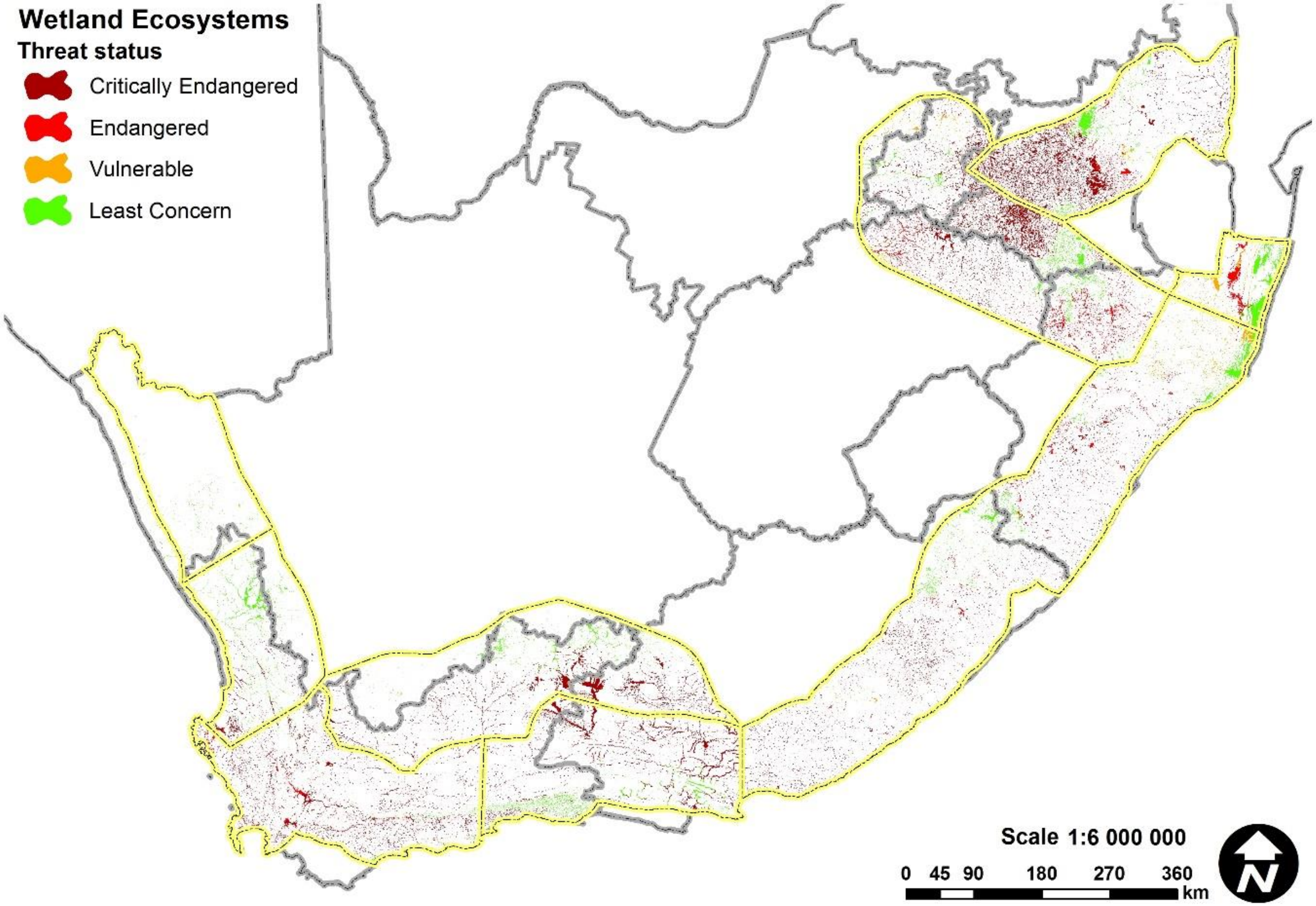


Figure 3: Wetland threat status based on the national wetland vegetation group regions of Nel and Driver (2012) applied to all wetlands of the collated wetland coverage developed for the gas pipeline corridors

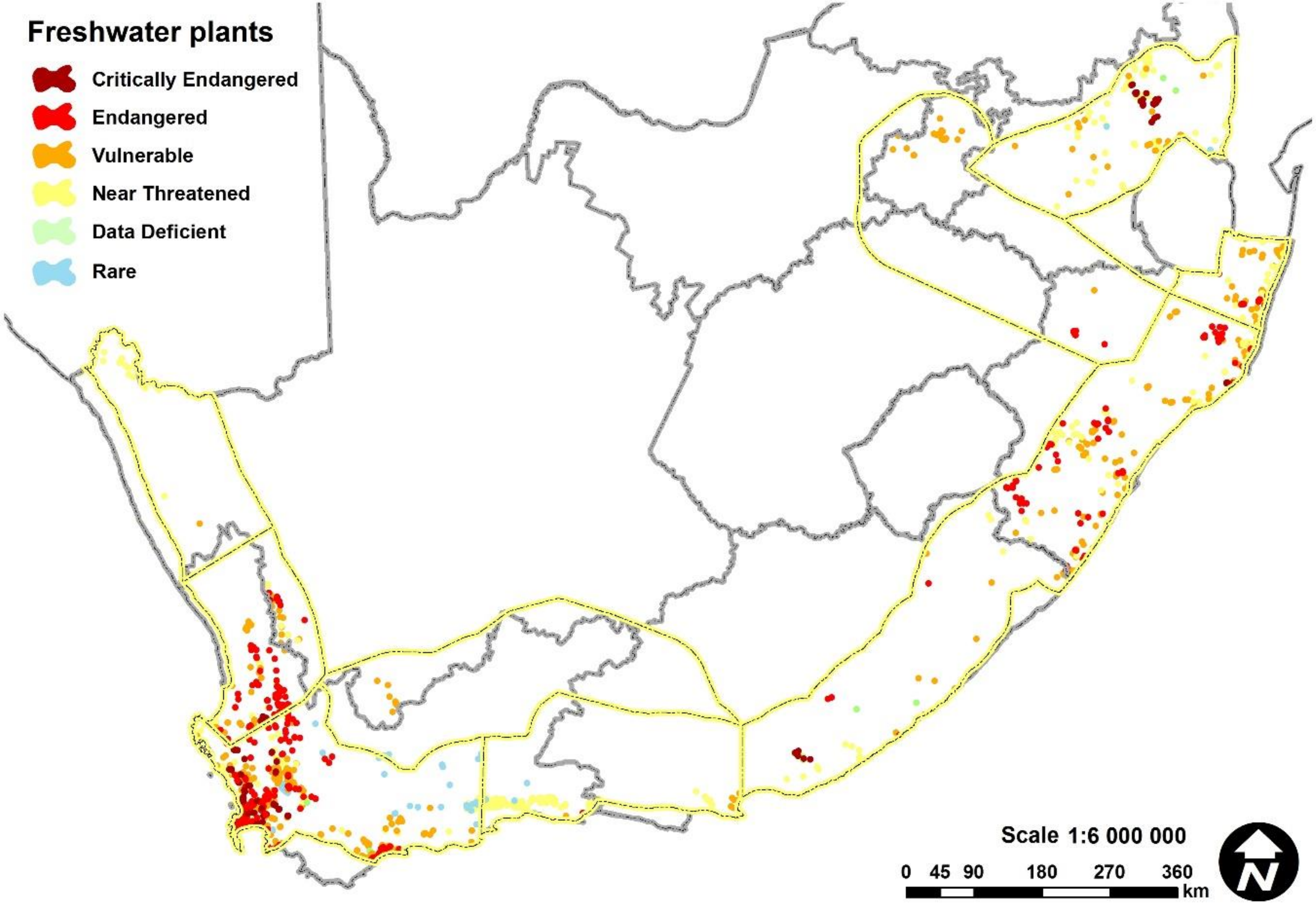
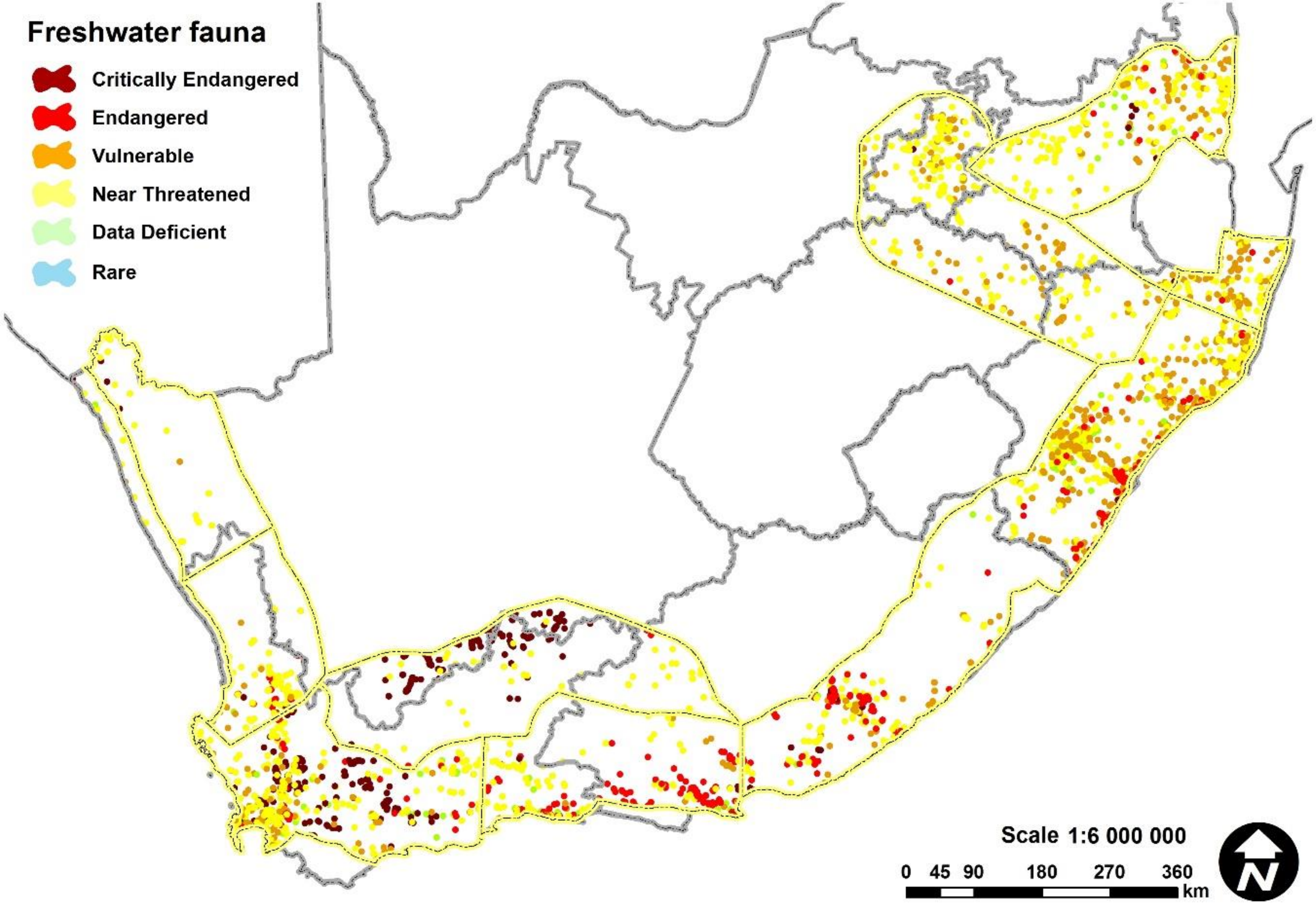


Figure 4: Point localities and corresponding threat status of freshwater plants based on known occurrence data within the gas pipeline corridors



1
2 Figure 5: Point localities and corresponding threat status of freshwater fauna based on known occurrence data within the gas pipeline corridors

6 SENSITIVITY MAPPING

6.1 Identification sensitivity criteria for features

Table 6 provides a list and description of the sensitivity criteria considered during this assessment of the proposed Gas Pipeline corridors.

Table 6: Data and criteria used to assign sensitivity to freshwater ecosystems within the proposed Gas Pipeline 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 from the SANBI Threatened Species Programme database (2018)	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 catchments were then classified into four sensitivity classes based on presence/ absence of selected
	Fauna: Aquatic macro-invertebrates	DWS Resource Quality Information Services (2015)	

Category	Feature Class	Data Source + Date of Publications	Data Description, Preparation and Processing
	Fauna: Odonata	IUCN (2017) and Samways and Simaika (2016), with spatial data provided from the SANBI Threatened Species Programme database (2018)	freshwater fauna and flora (i.e. low = no occurrence, medium = rare or NT, high = VU or EN, very high = CR or DD). 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.
	Fauna: Fish	Coetzer (2017), with spatial data provided from the SAIAB, and International Union for the Conservation of Nature (2017)	
	Fauna: Amphibians	Minter *et al.* (2004), with spatial data provided from the SANBI Threatened Species Programme database (2018)	
	Fauna: Reptiles (freshwater ecosystem obligate)	Bates *et al.* (2014), with spatial data provided from the SANBI Threatened Species Programme database (2018)	
	Fauna: Mammals (freshwater ecosystem obligate)	Child *et al.* (2016), with spatial data provided from the SANBI Threatened Species Programme database (2018)	

1

The feature types considered in the sensitivity analysis and the rating given to each feature and buffered area (Table 7).

Table 7: Sensitivity ratings assigned to freshwater ecosystem features in all of the proposed Gas Pipeline 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	

Figure 6 to Figure 41 depicts the sensitivity of freshwater ecosystems and associated features in the proposed Gas Pipeline corridors.

6.2 Phase 1 Corridor

6.2.1 Rivers

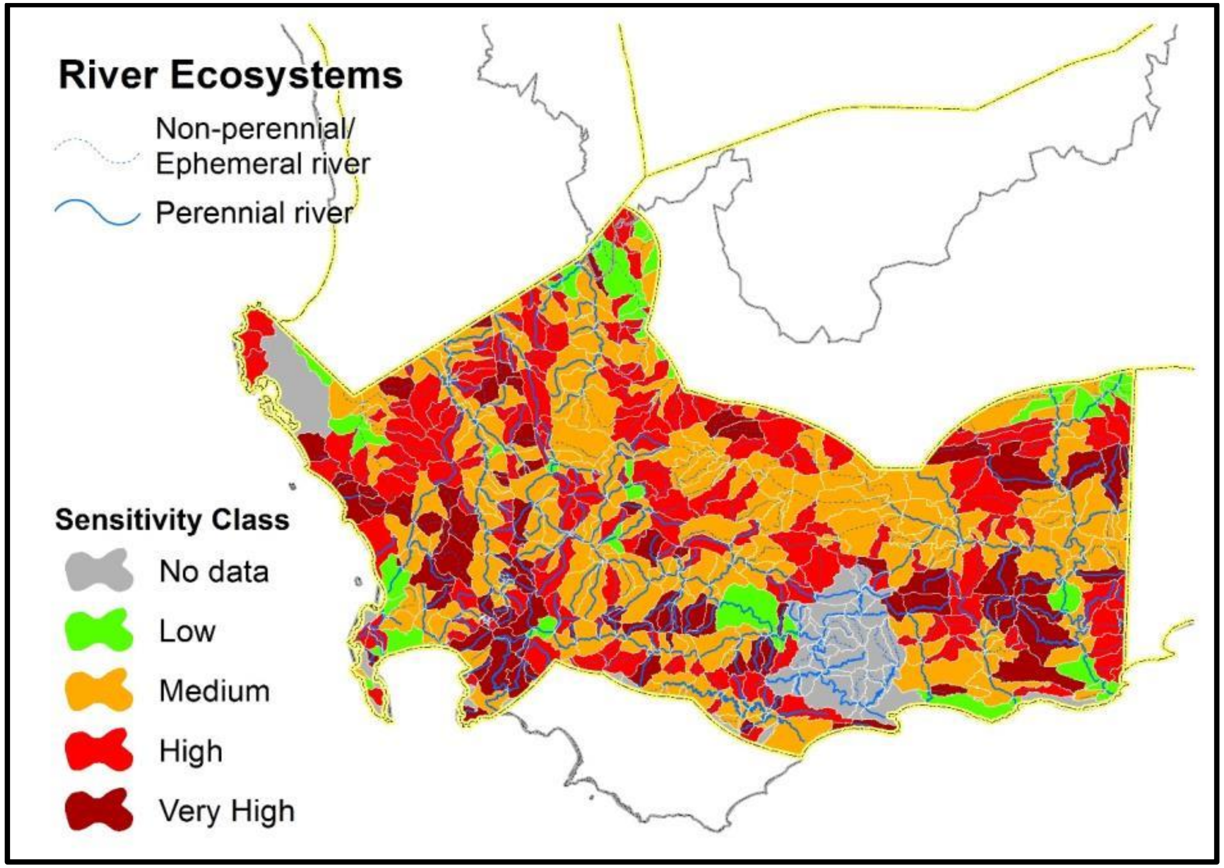


Figure 6: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 1 corridor using PES, EI and ES data from DWS (2014).

6.2.2 Wetlands

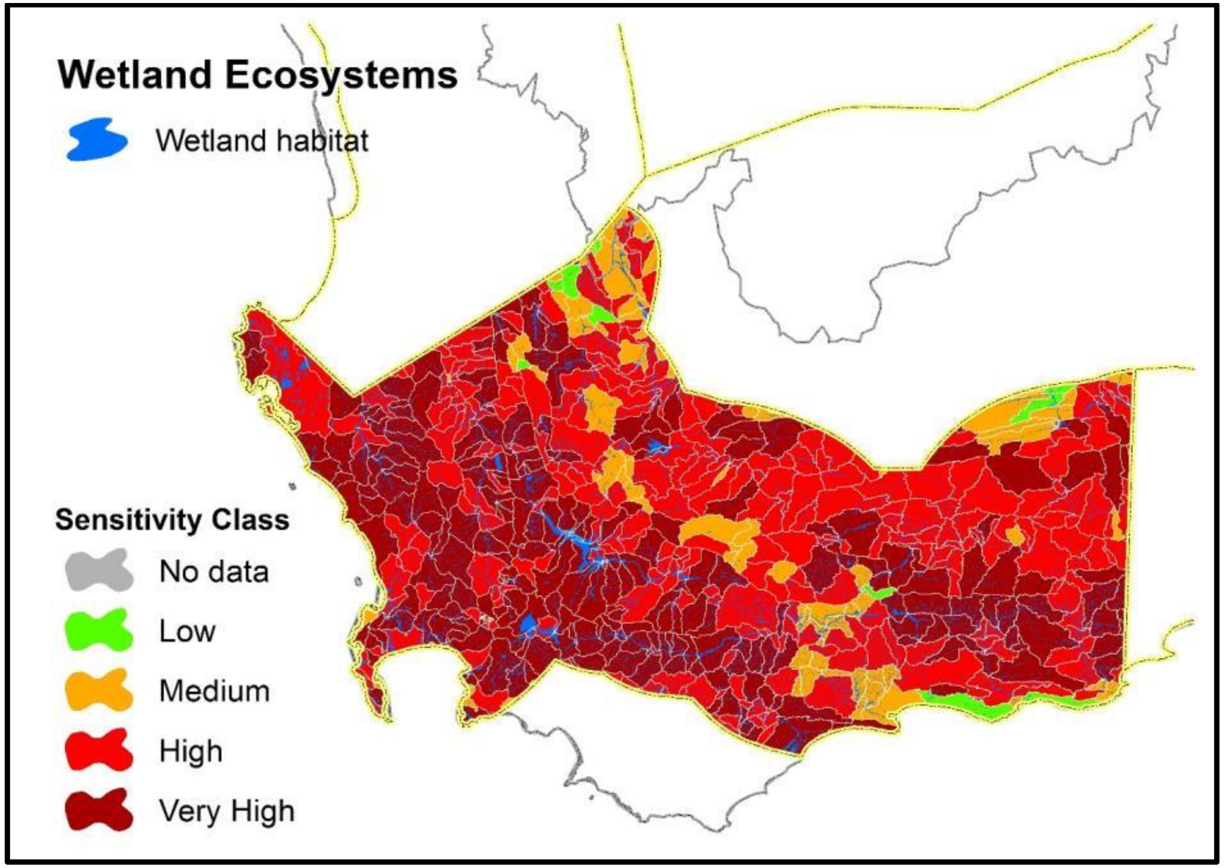


Figure 7: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 1 corridor.

6.2.3 Freshwater biota (fauna and flora)

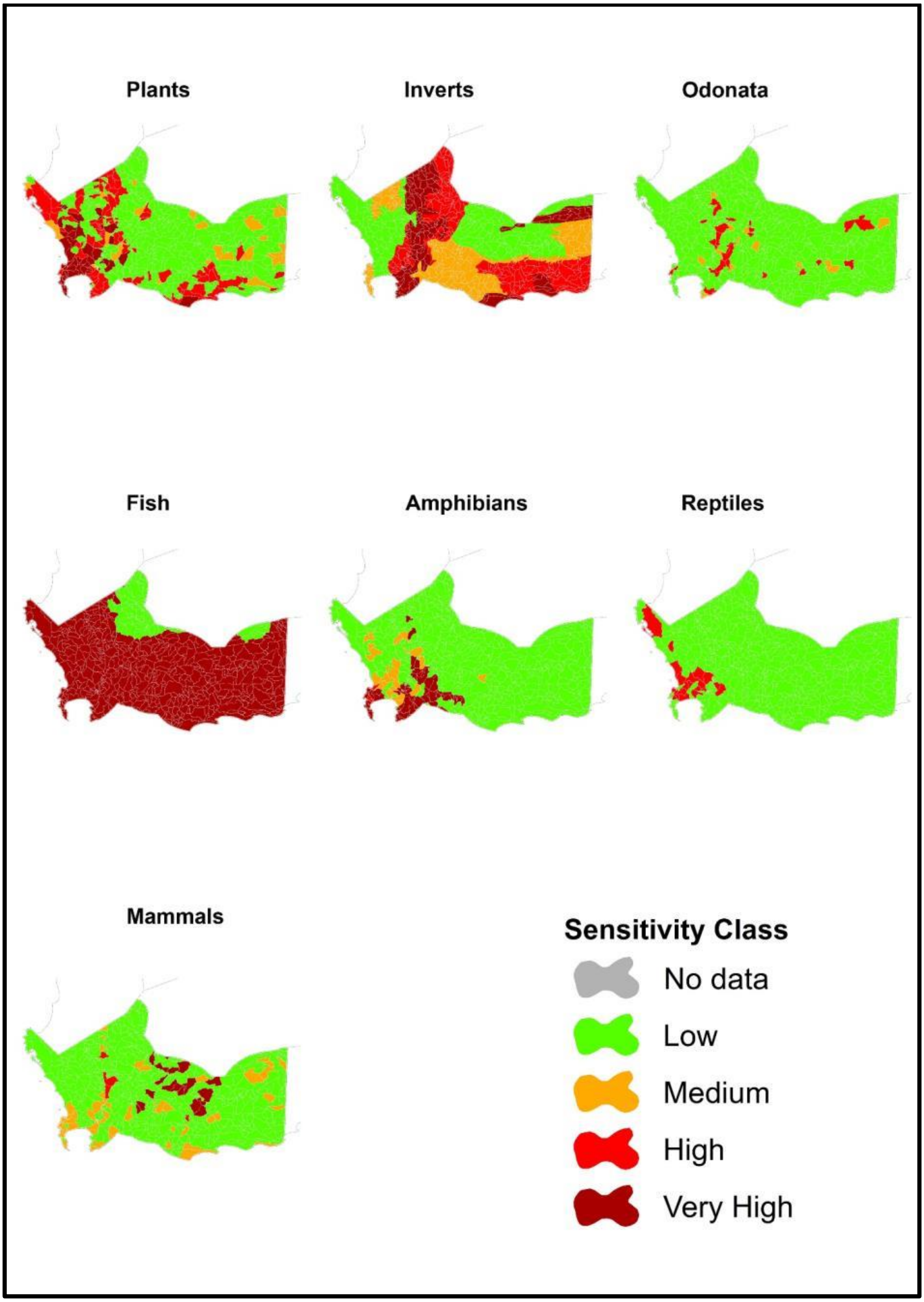


Figure 8: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 1 corridor in relation to sub-quaternary catchments.

6.2.4 Freshwater ecosystems and biota (combined)

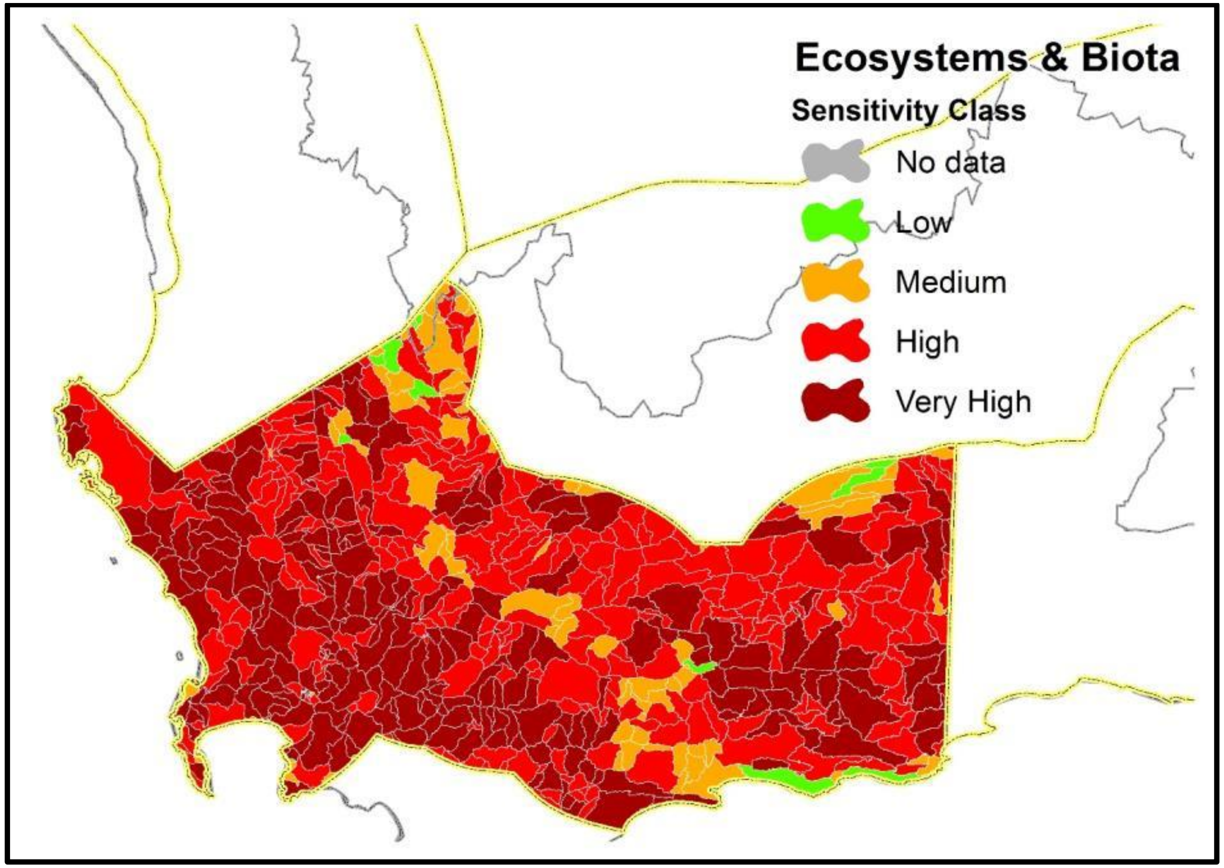


Figure 9: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 1 corridor.

6.3 Phase 2 Corridor

6.3.1 Rivers

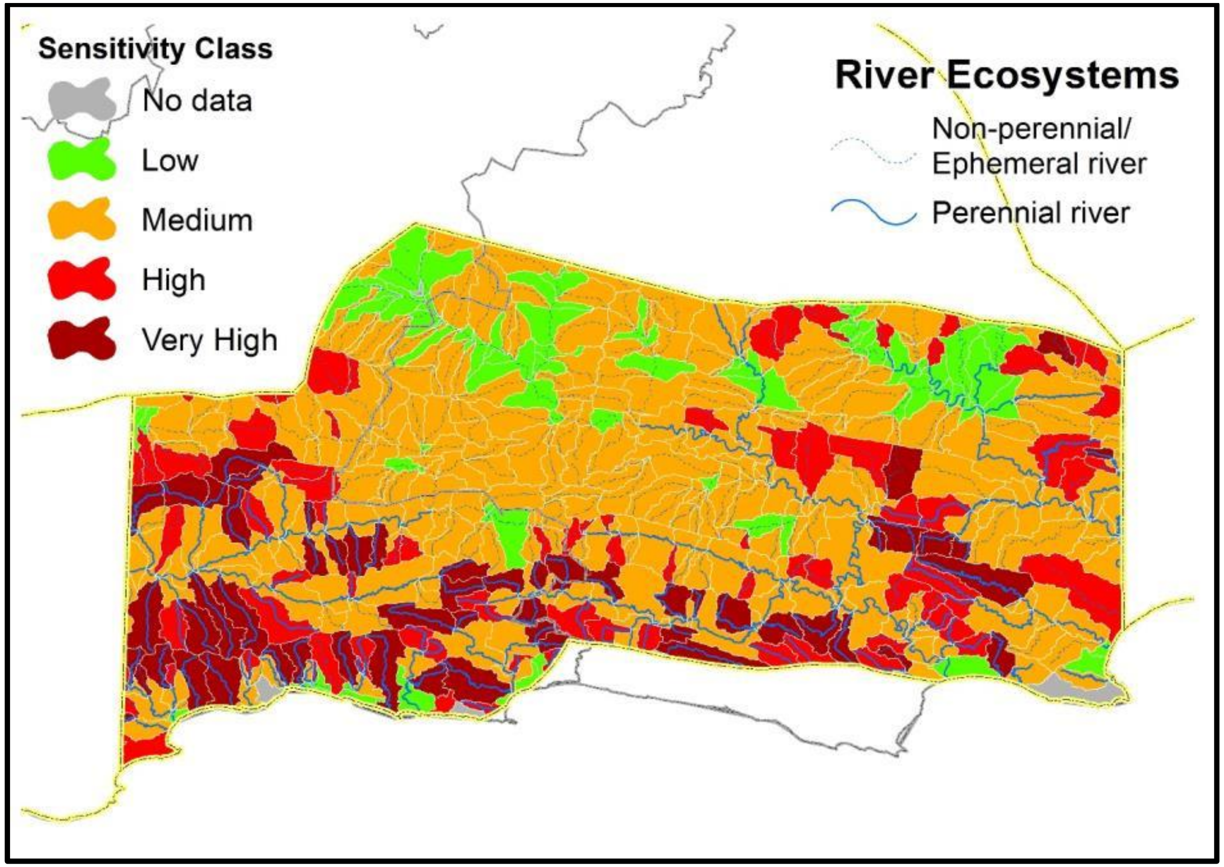


Figure 10: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 2 corridor using PES, EI and ES data from DWS (2014).

6.3.2 Wetlands

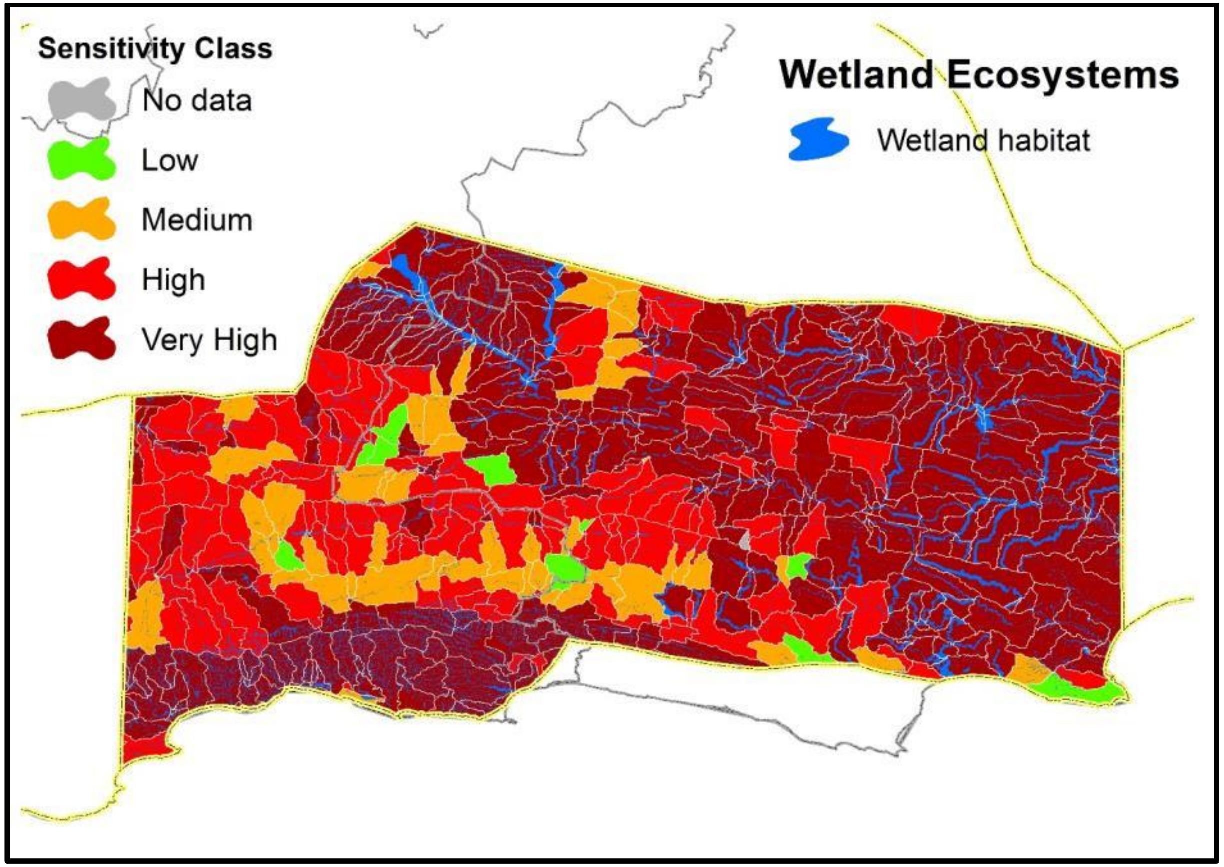


Figure 11: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 2 corridor.

6.3.3 Freshwater biota (fauna and flora)

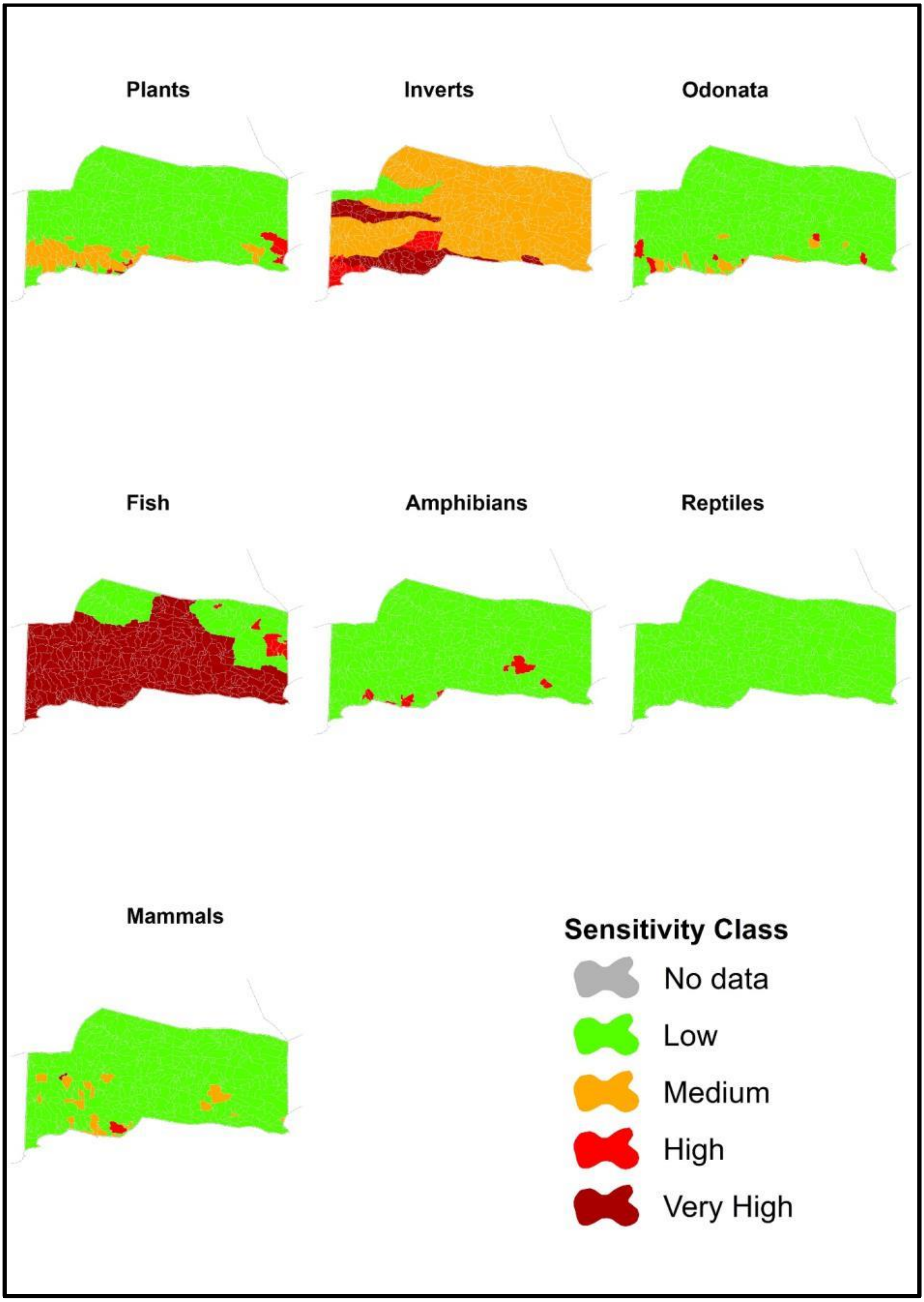


Figure 12: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 2 corridor in relation to sub-quaternary catchments

6.3.4 Freshwater ecosystems and biota (combined)

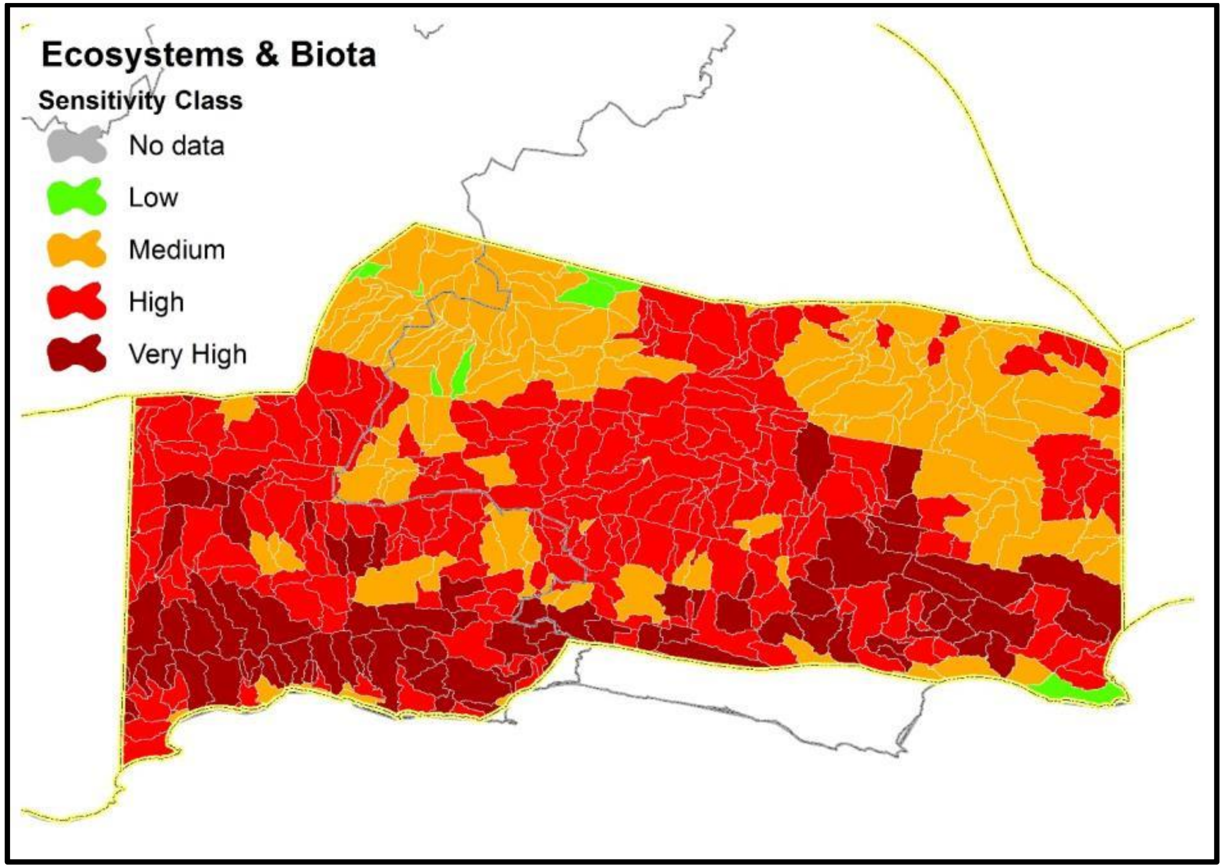


Figure 13: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 2 corridor.

6.4 Phase 3 Corridor

6.4.1 Rivers

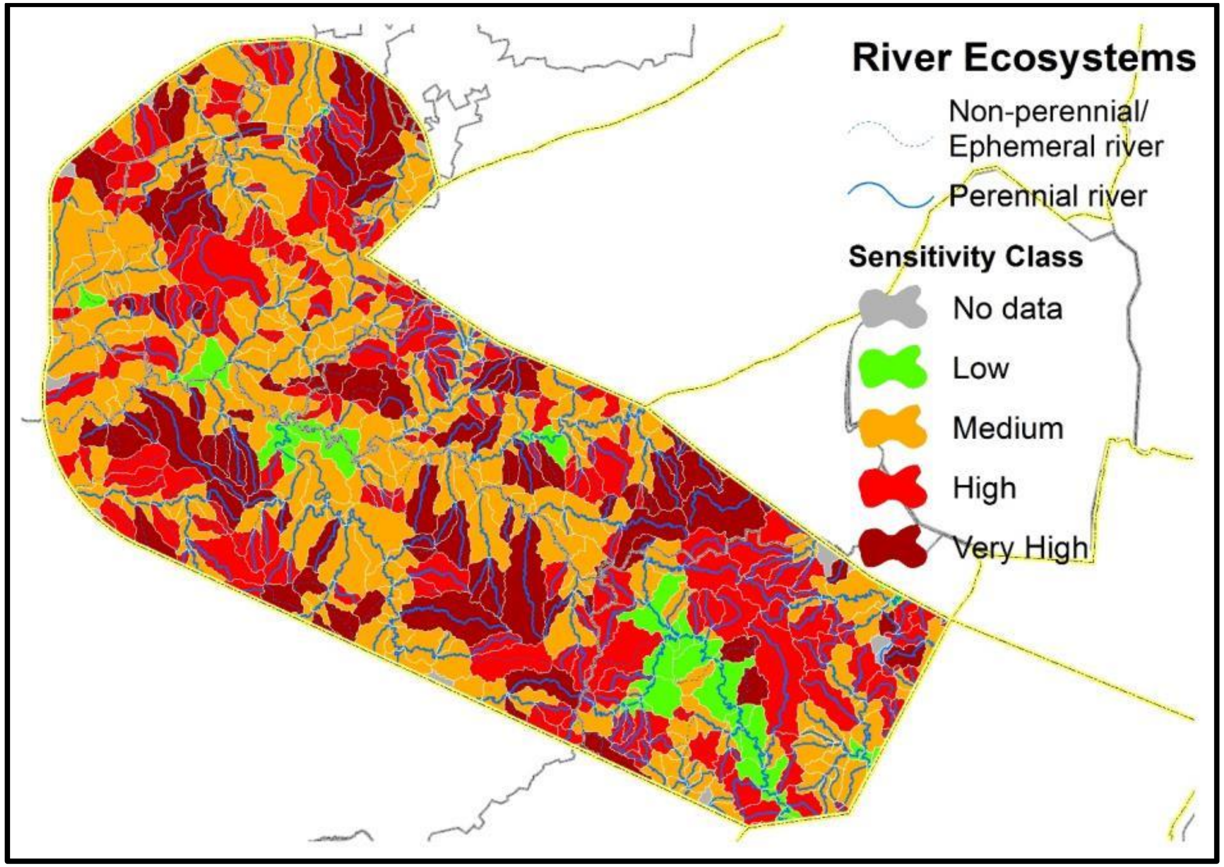


Figure 14: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 3 corridor using PES, EI and ES data from DWS (2014).

6.4.2 Wetlands

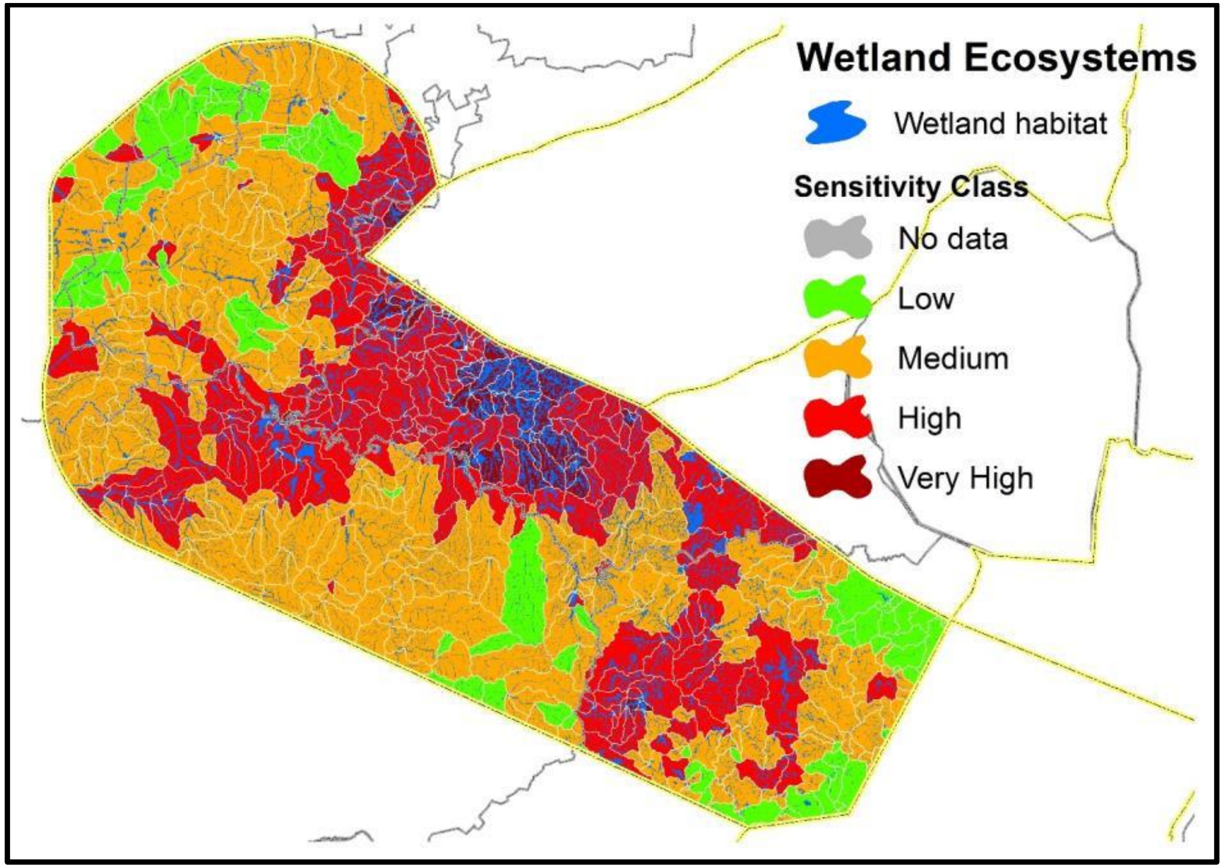


Figure 15: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 3 corridor.

6.4.3 Freshwater biota (fauna and flora)

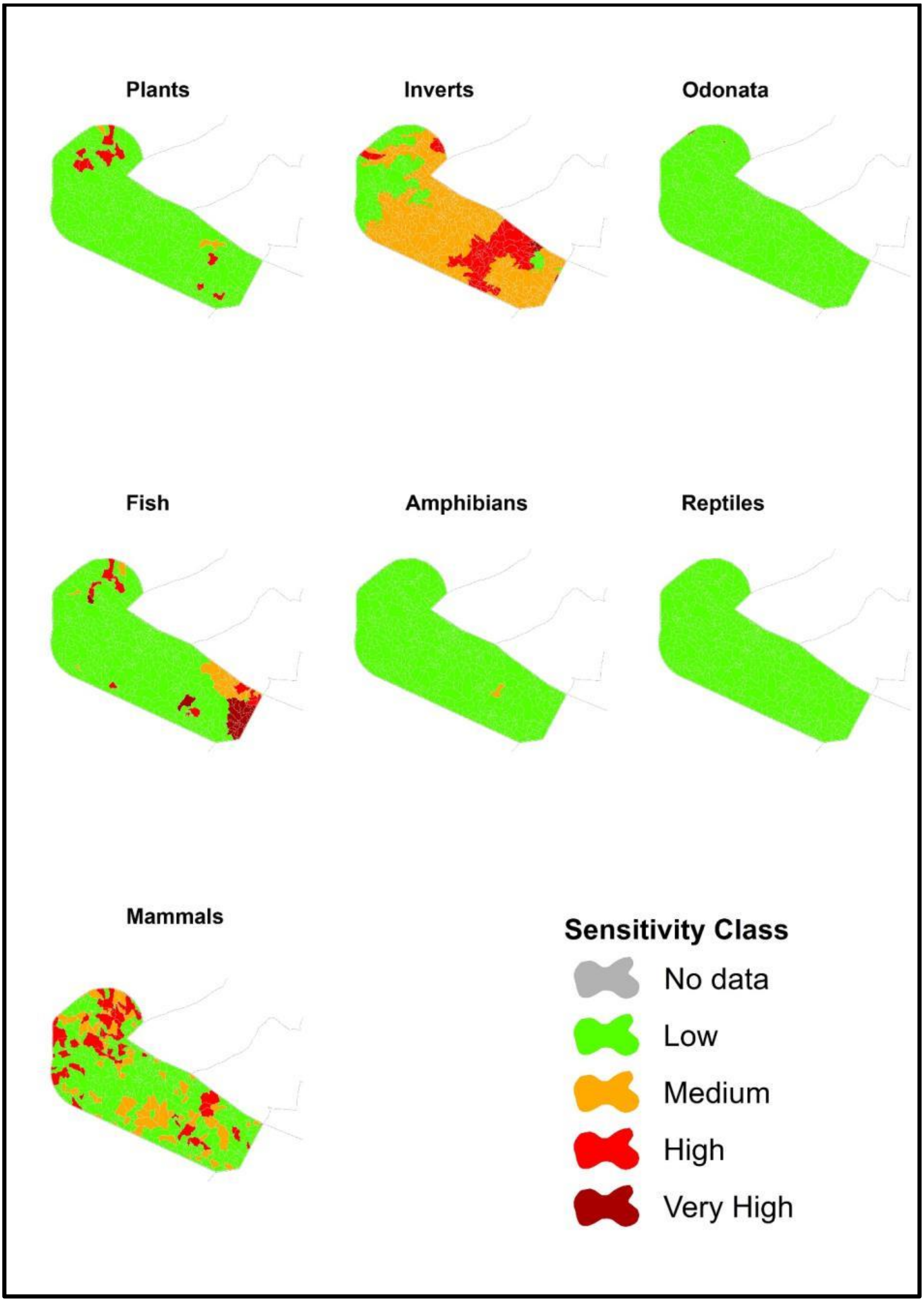


Figure 16: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 3 corridor in relation to sub-quaternary catchments

6.4.4 Freshwater ecosystems and biota (combined)

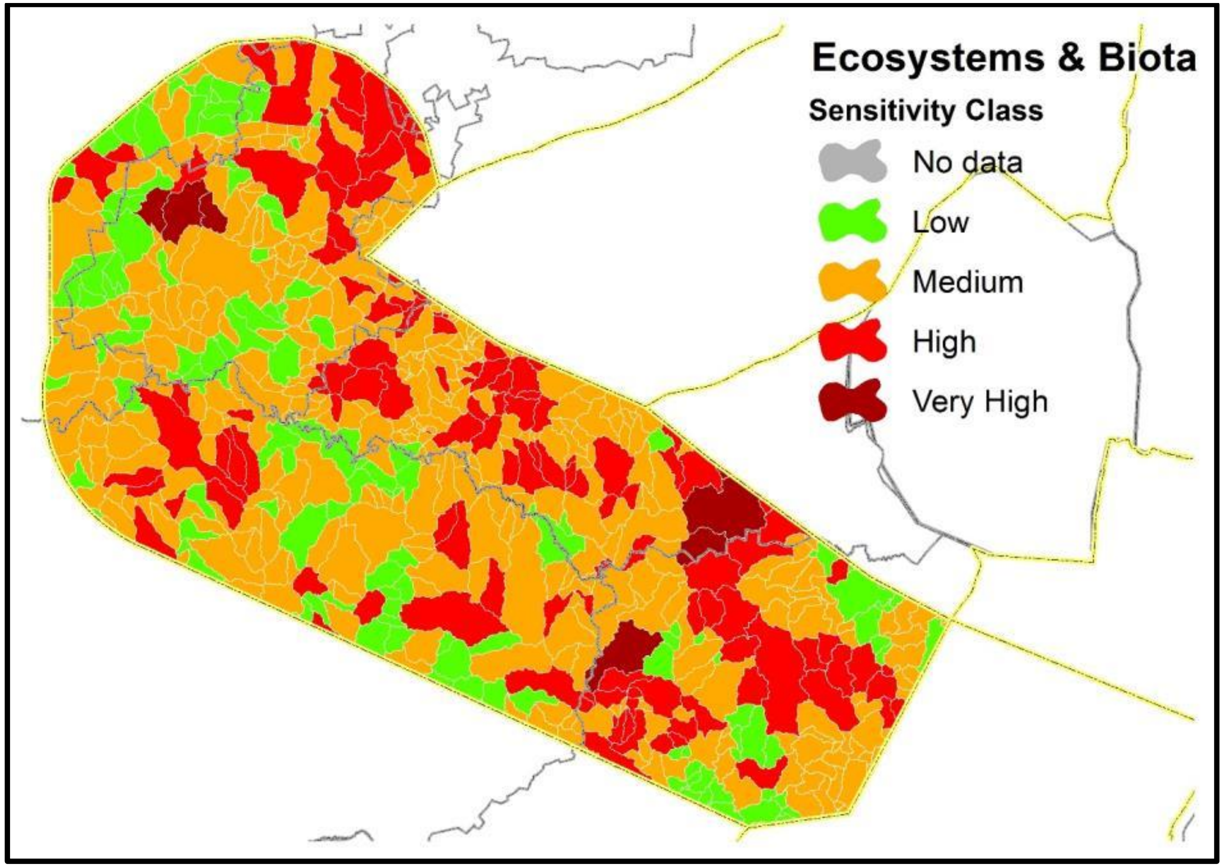


Figure 17: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 3 corridor.

6.5 Phase 4 Corridor

6.5.1 Rivers

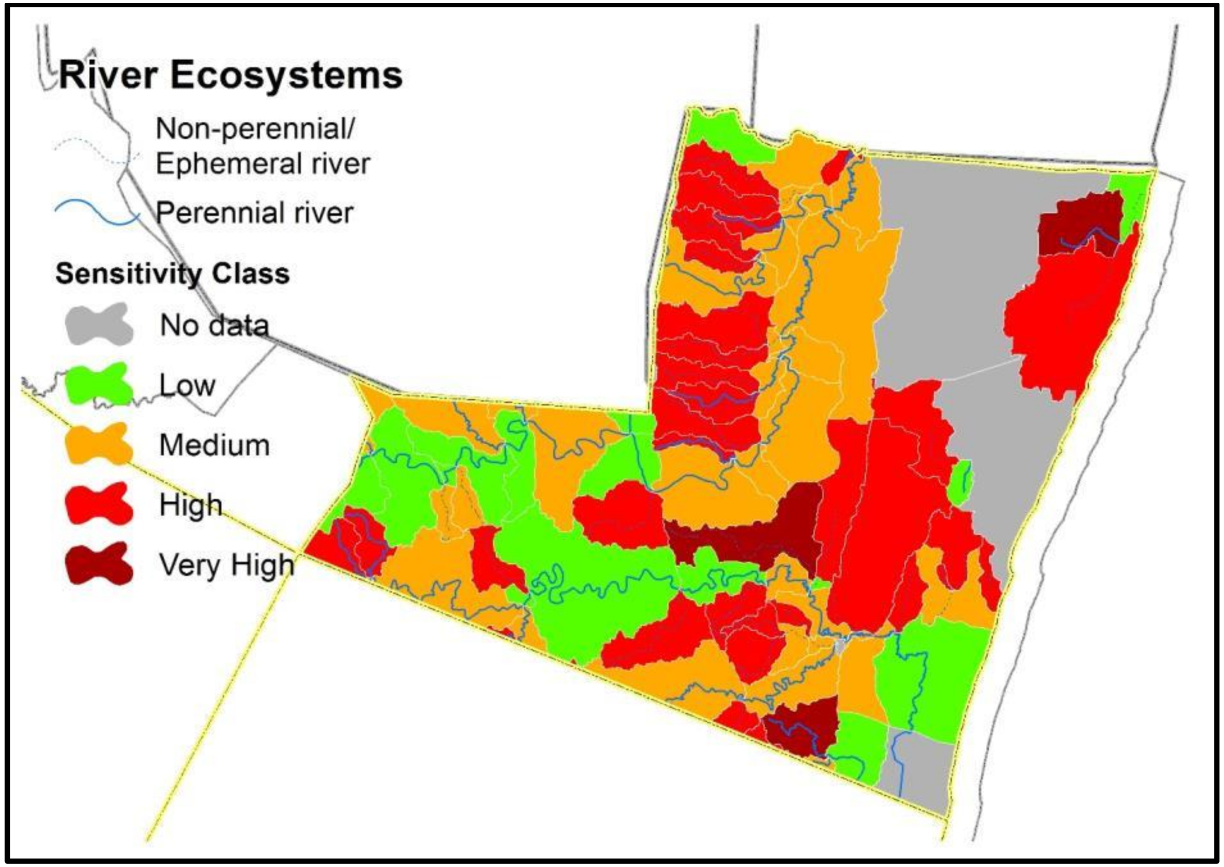


Figure 18: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 4 corridor using PES, EI and ES data from DWS (2014).

6.5.2 Wetlands

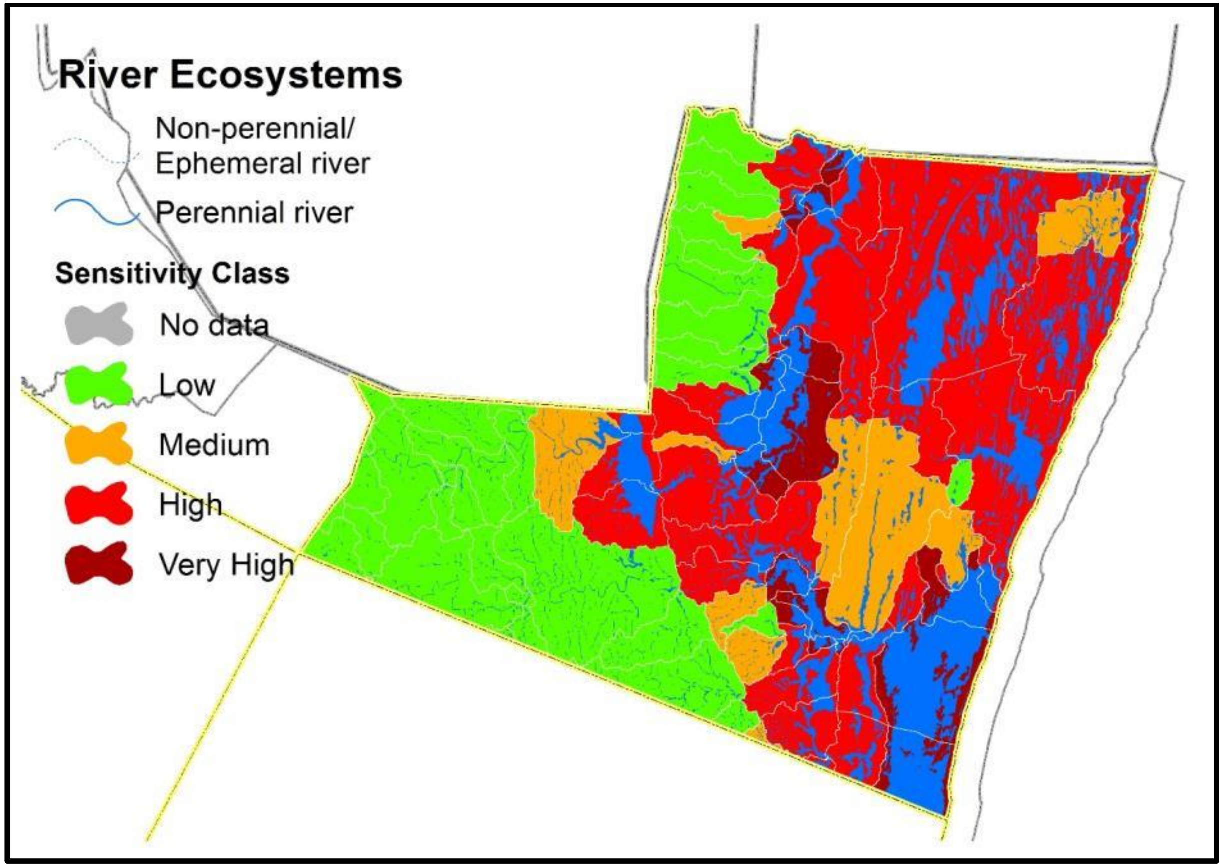


Figure 19: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 4 corridor.

6.5.3 Freshwater biota (fauna and flora)

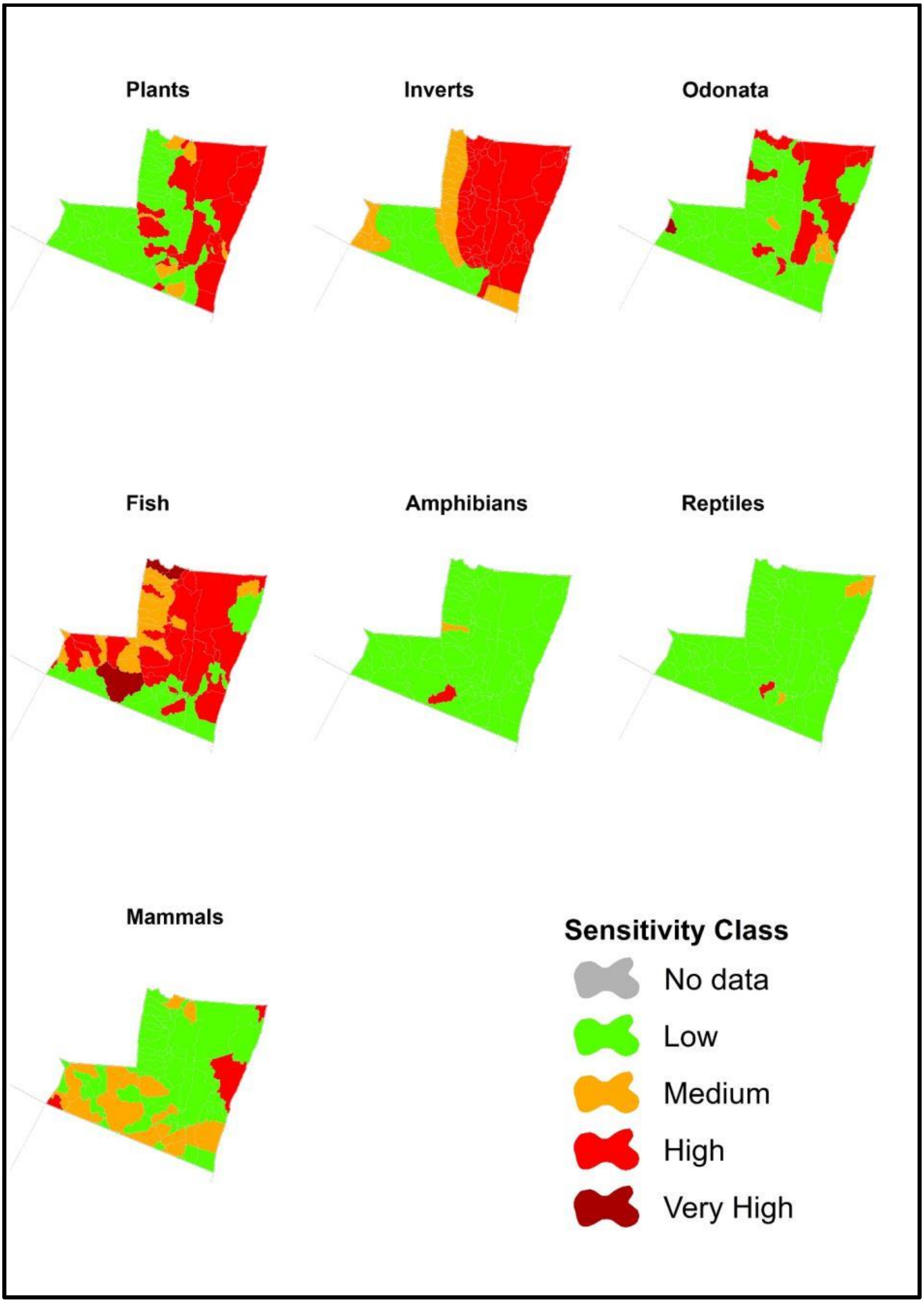


Figure 20: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 4 corridor in relation to sub-quaternary catchments

6.5.4 Freshwater ecosystems and biota (combined)

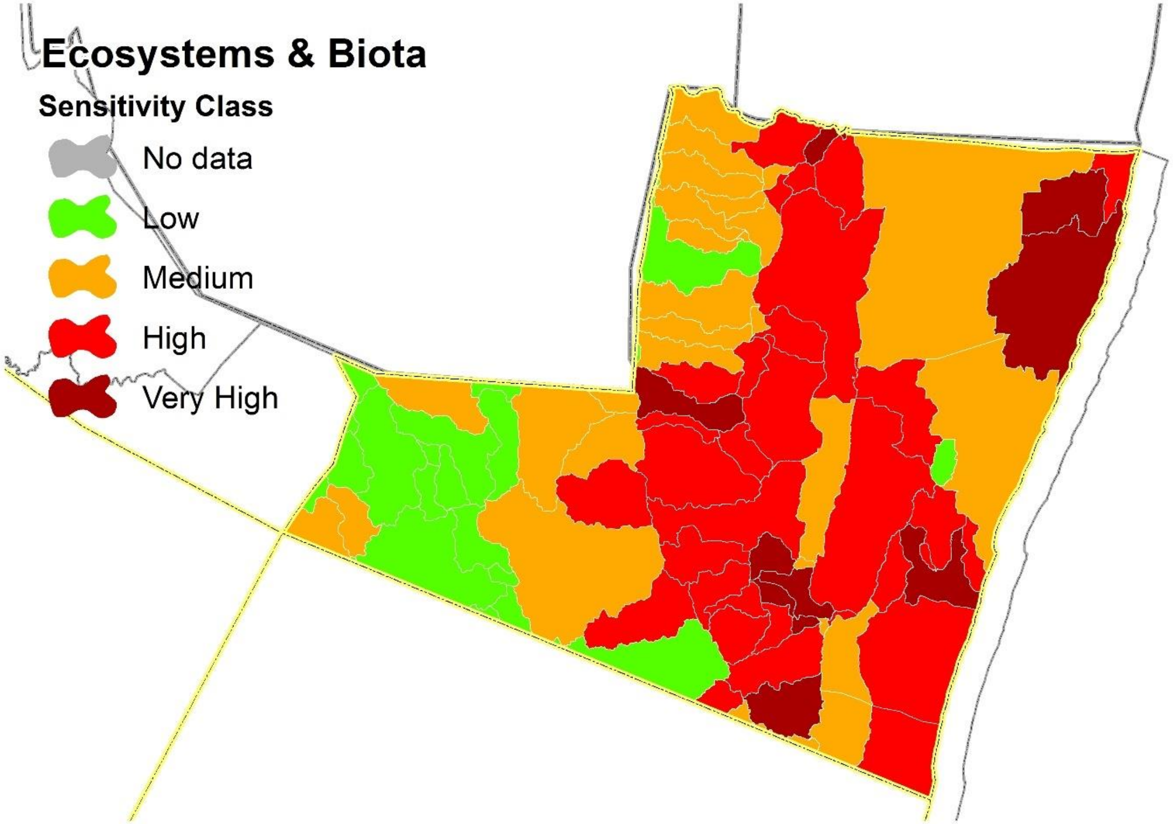


Figure 21: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 4 corridor.

6.6 Phase 5 Corridor

6.6.1 Rivers

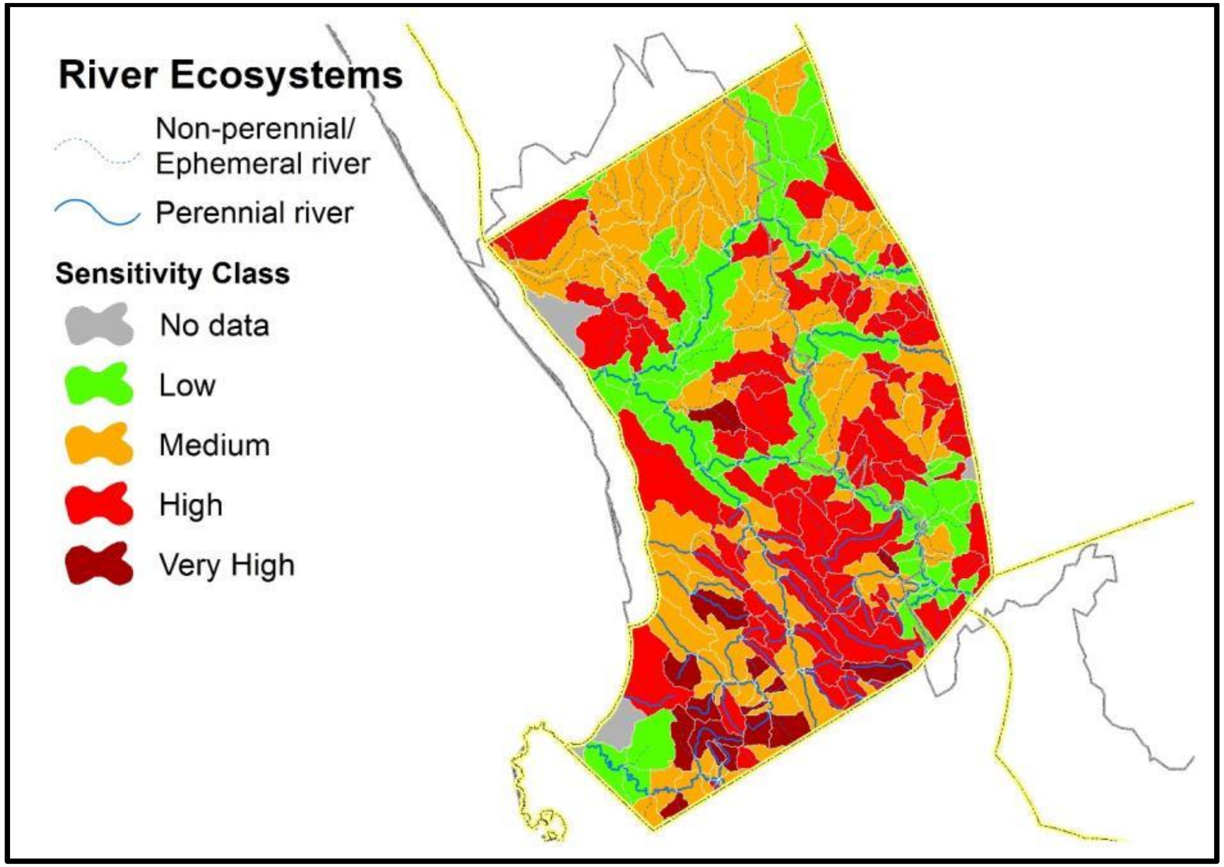


Figure 22: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 5 corridor using PES, EI and ES data from DWS (2014).

6.6.2 Wetlands

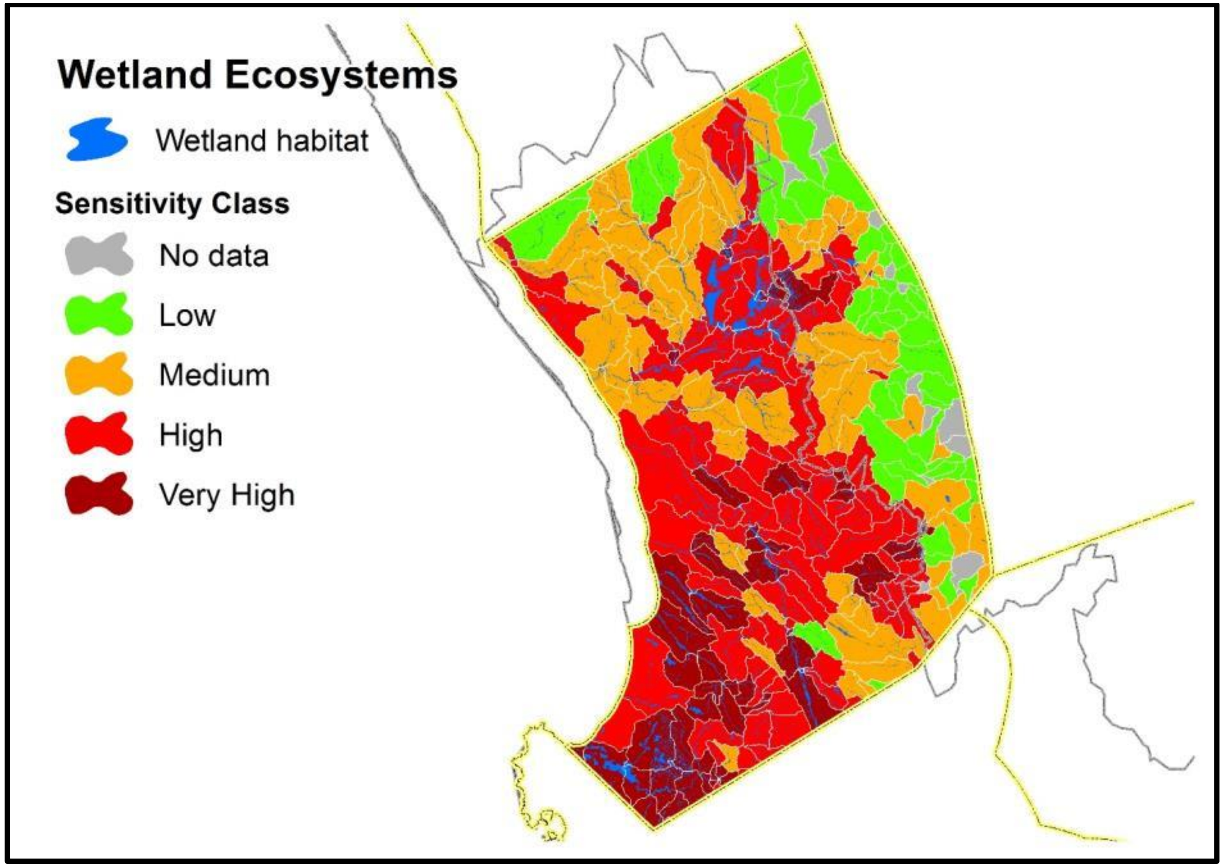


Figure 23: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 5 corridor.

6.6.3 Freshwater biota (fauna and flora)

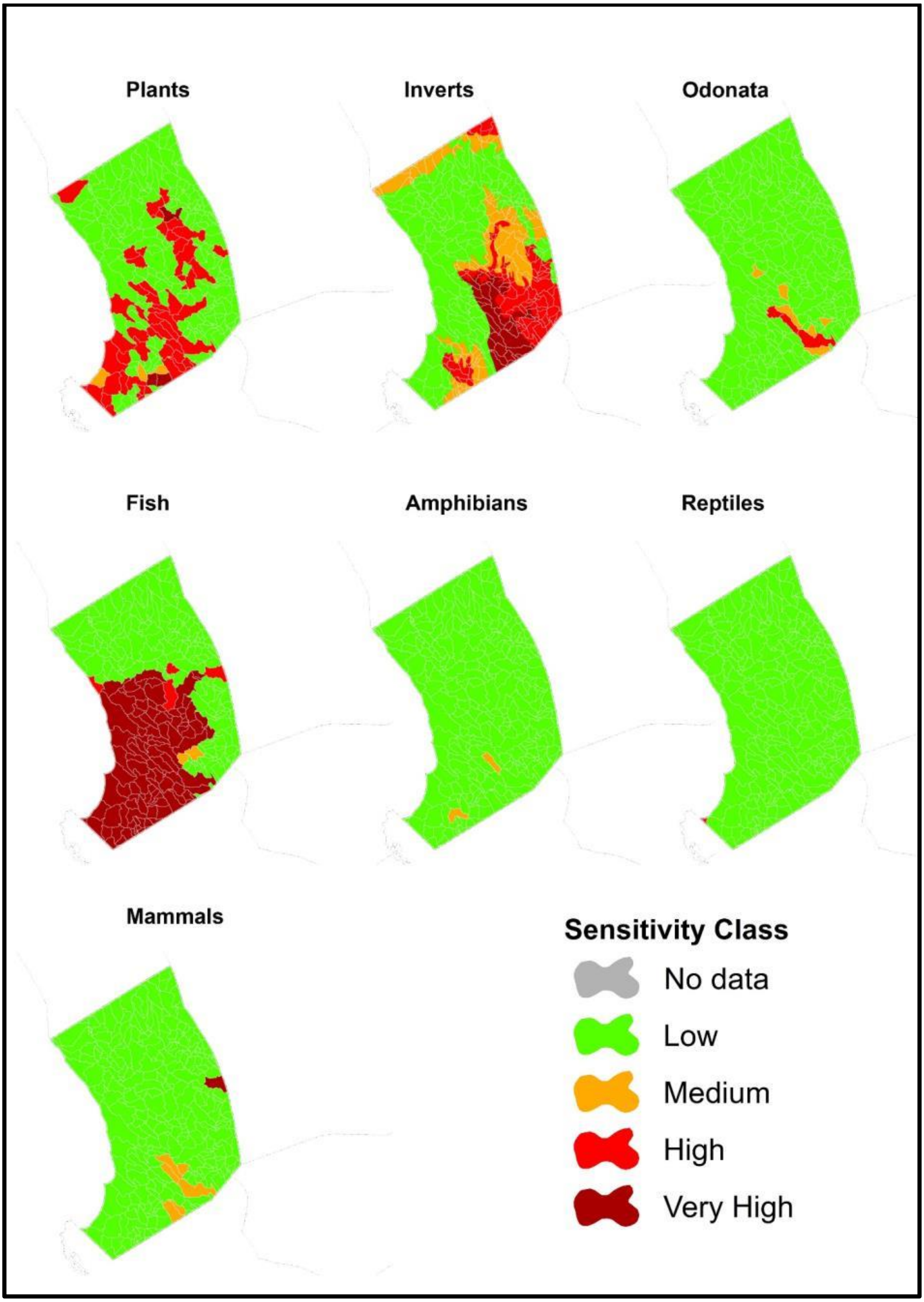


Figure 24: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 5 corridor in relation to sub-quaternary catchments

6.6.4 Freshwater ecosystems and biota (combined)

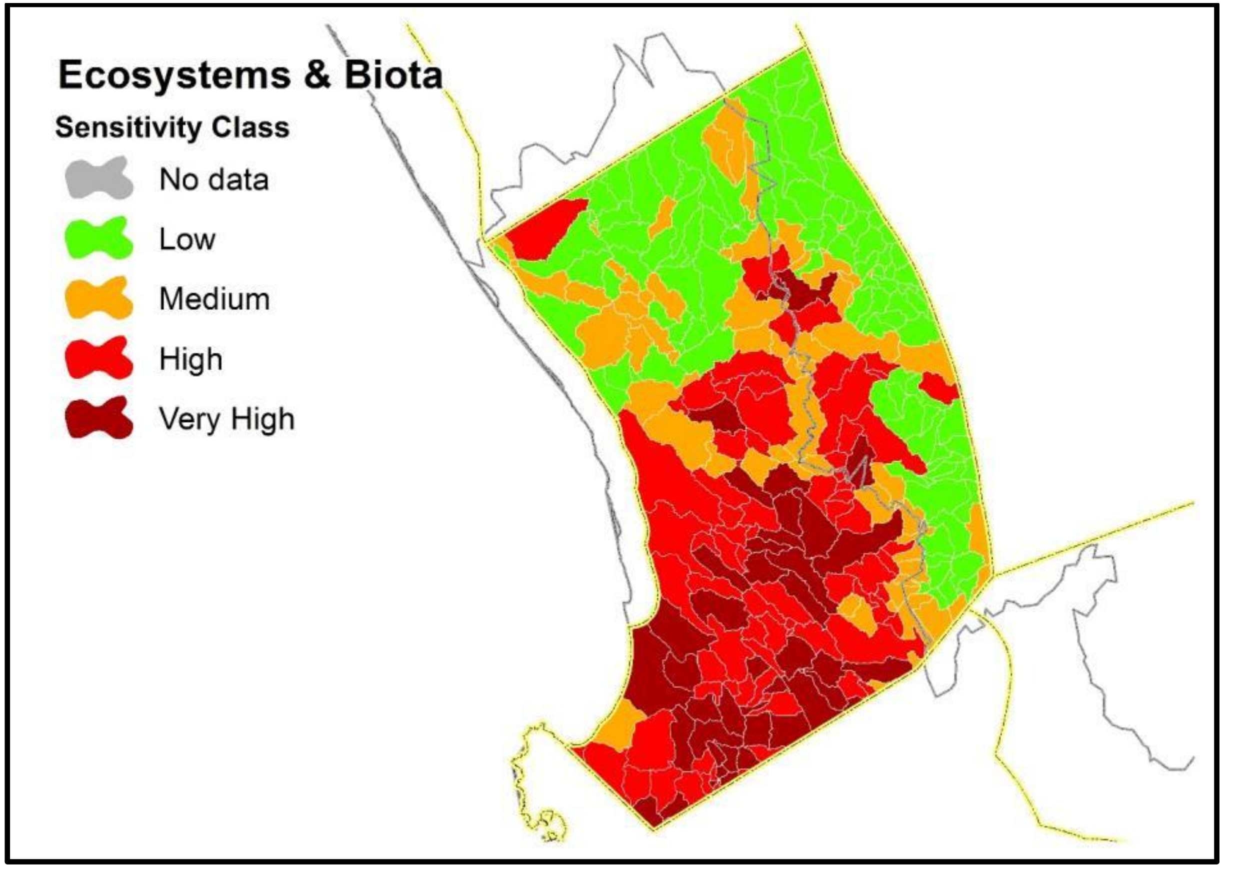


Figure 25: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 5 corridor.

6.7 Phase 6 Corridor

6.7.1 Rivers

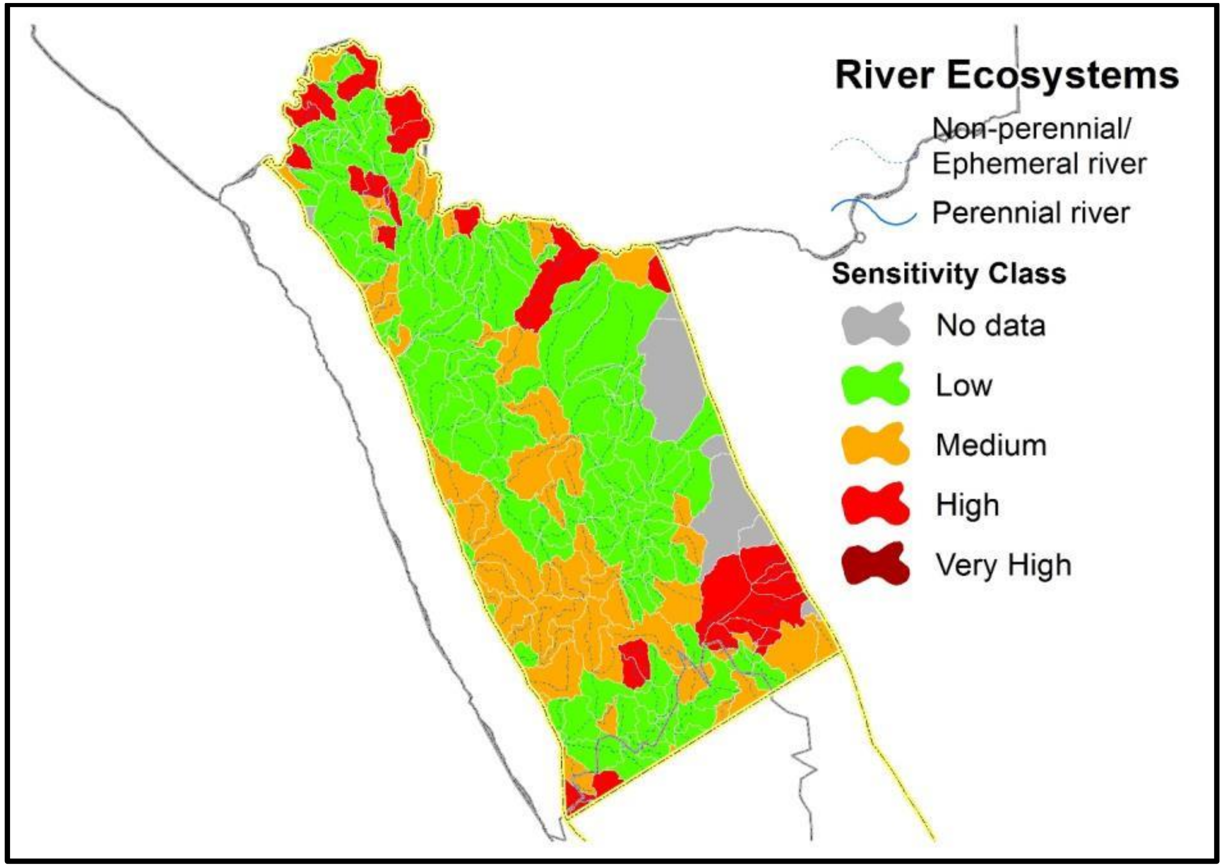


Figure 26: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 6 corridor using PES, EI and ES data from DWS (2014).

6.7.2 Wetlands

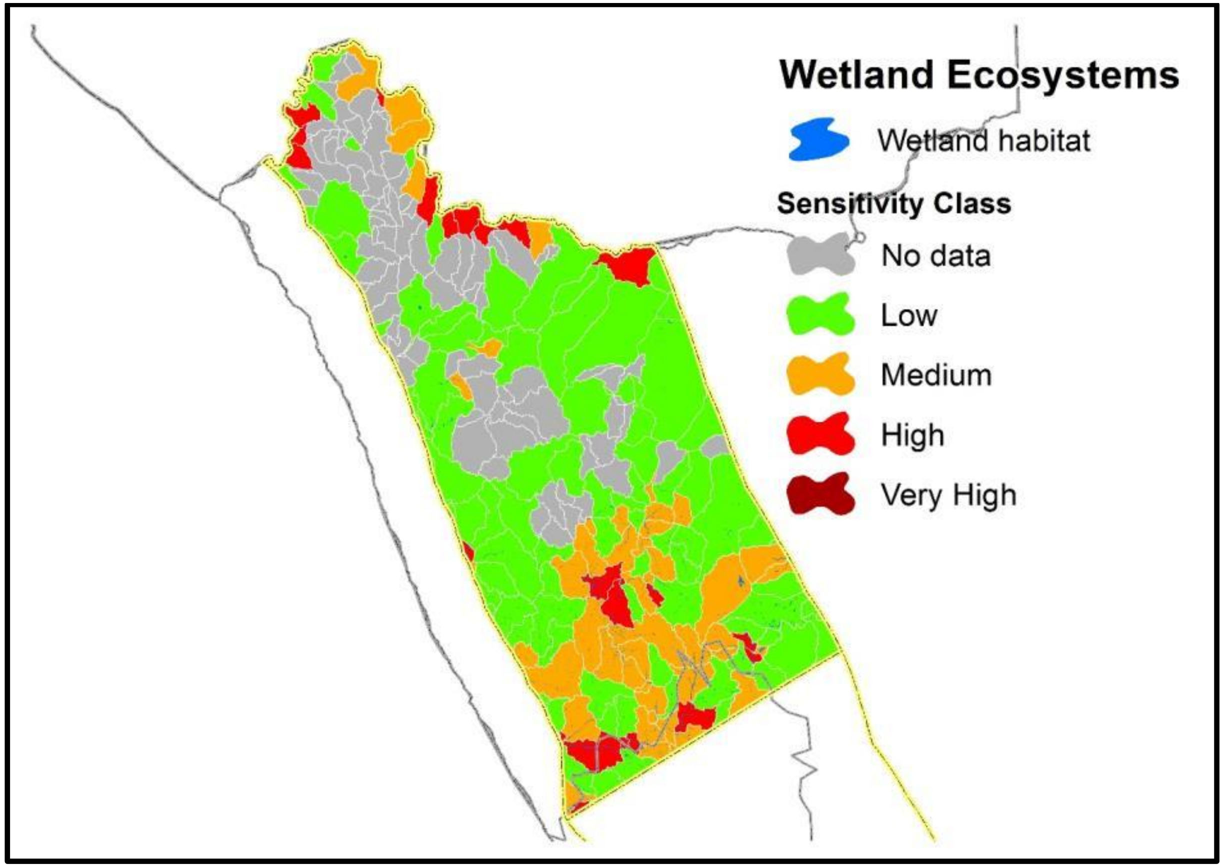


Figure 27: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 6 corridor.

6.7.3 Freshwater biota (fauna and flora)

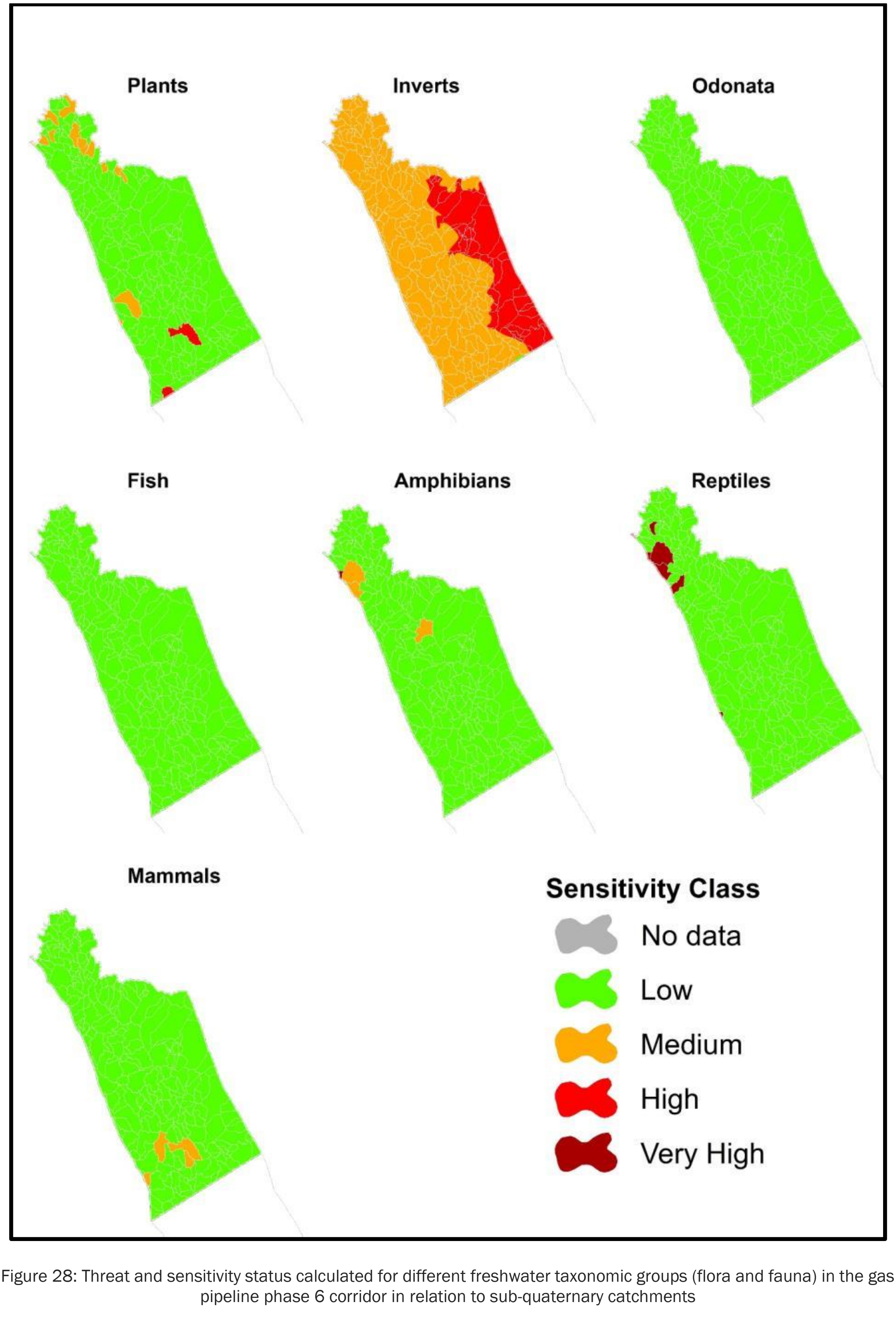


Figure 28: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 6 corridor in relation to sub-quaternary catchments

6.7.4 Freshwater ecosystems and biota (combined)

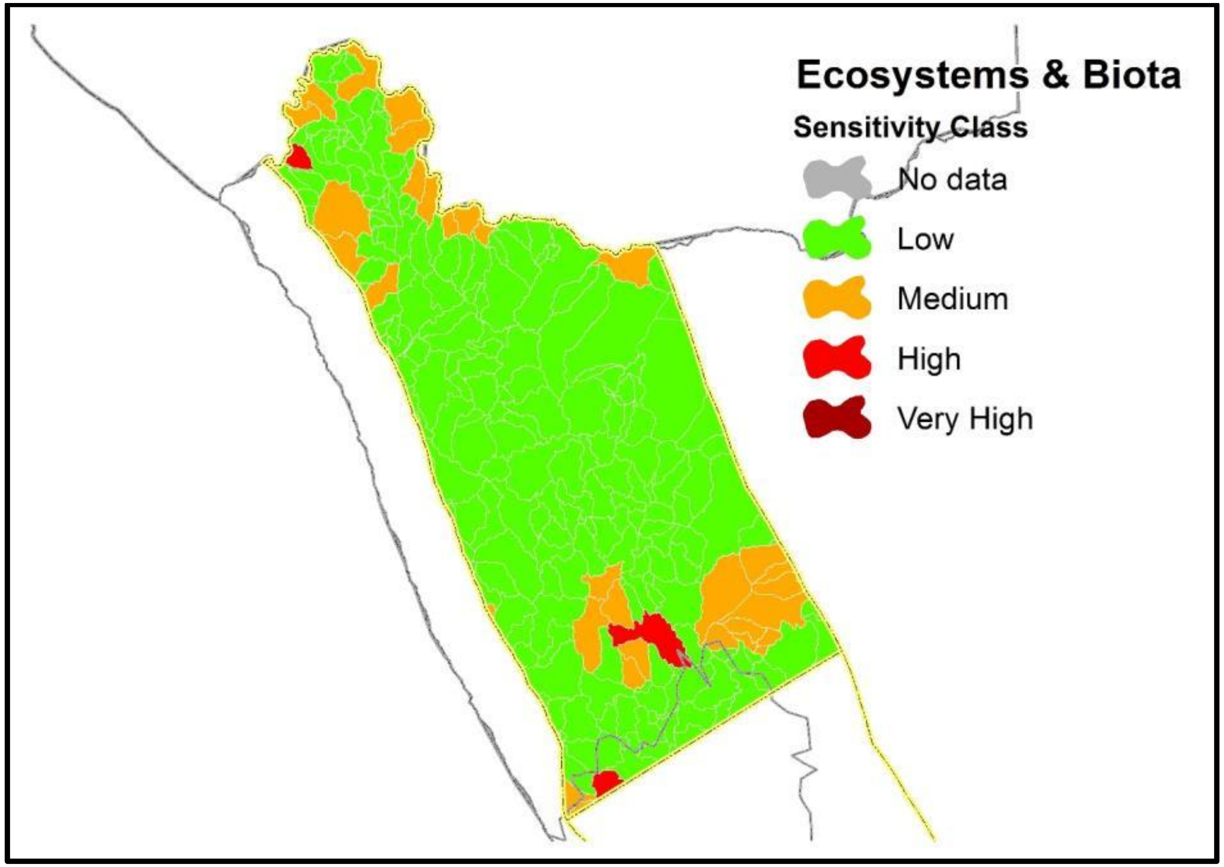


Figure 29: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 6 corridor.

6.8 Phase 7 Corridor

6.8.1 Rivers

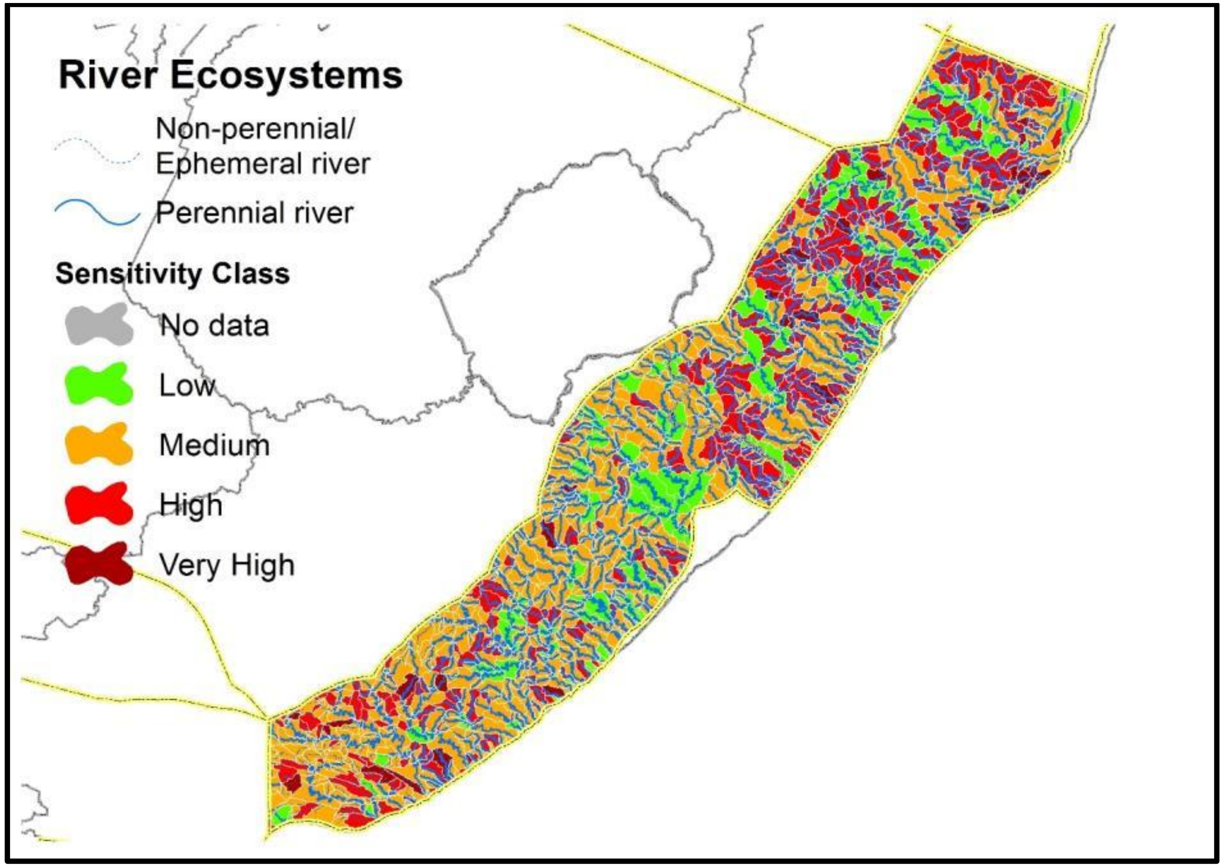


Figure 30: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 7 corridor using PES, EI and ES data from DWS (2014).

6.8.2 Wetlands

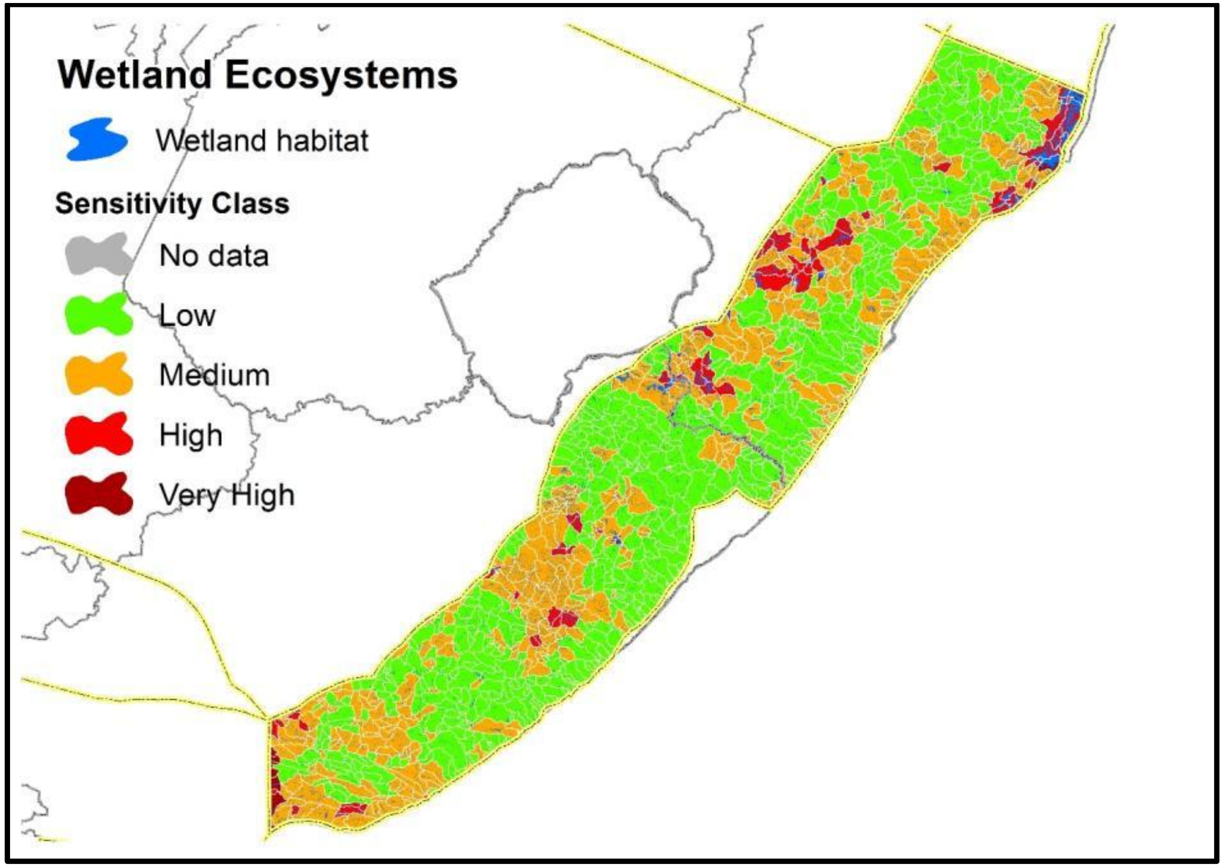


Figure 31: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 7 corridor.

6.8.3 Freshwater biota (fauna and flora)

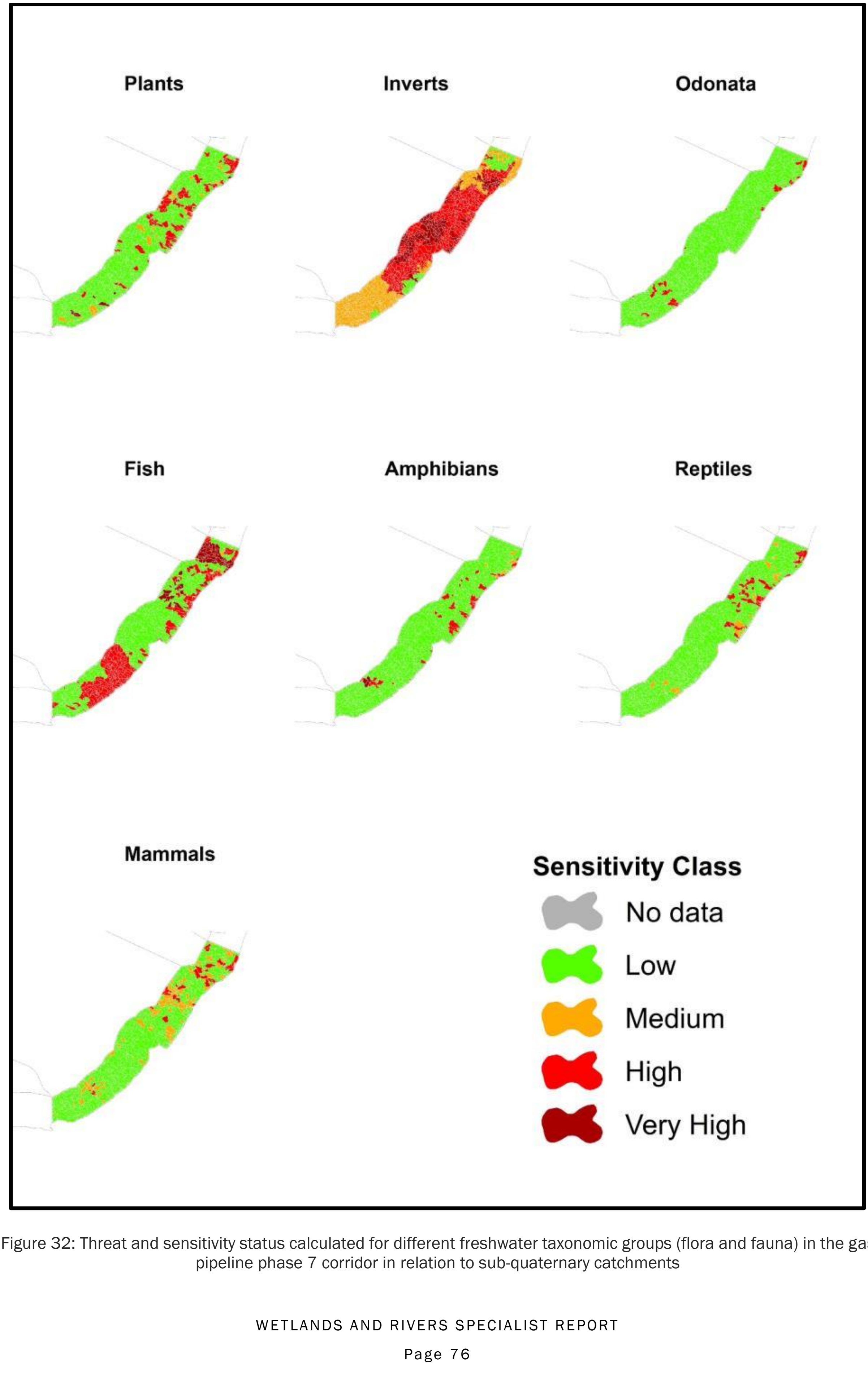


Figure 32: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 7 corridor in relation to sub-quaternary catchments

6.8.4 Freshwater ecosystems and biota (combined)

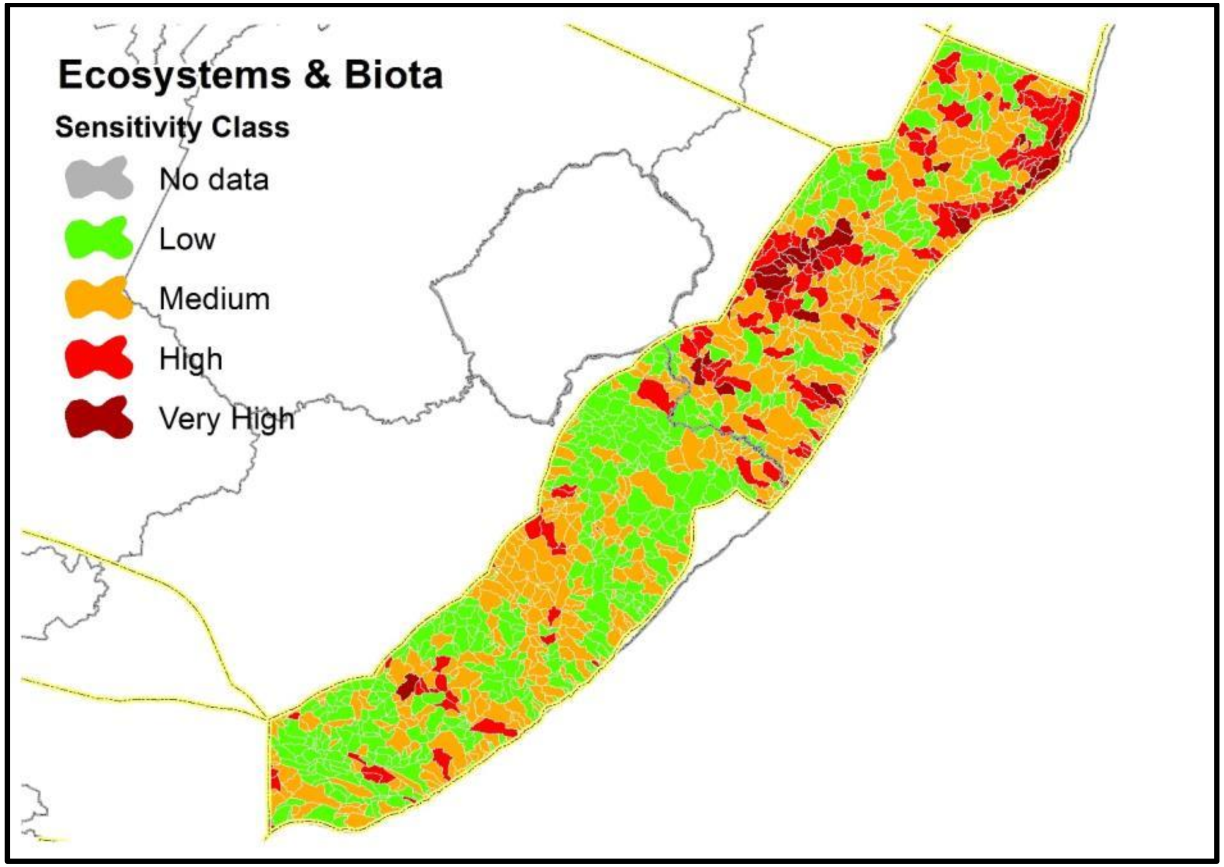


Figure 33: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 7 corridor.

6.9 Phase 8 Corridor

6.9.1 Rivers

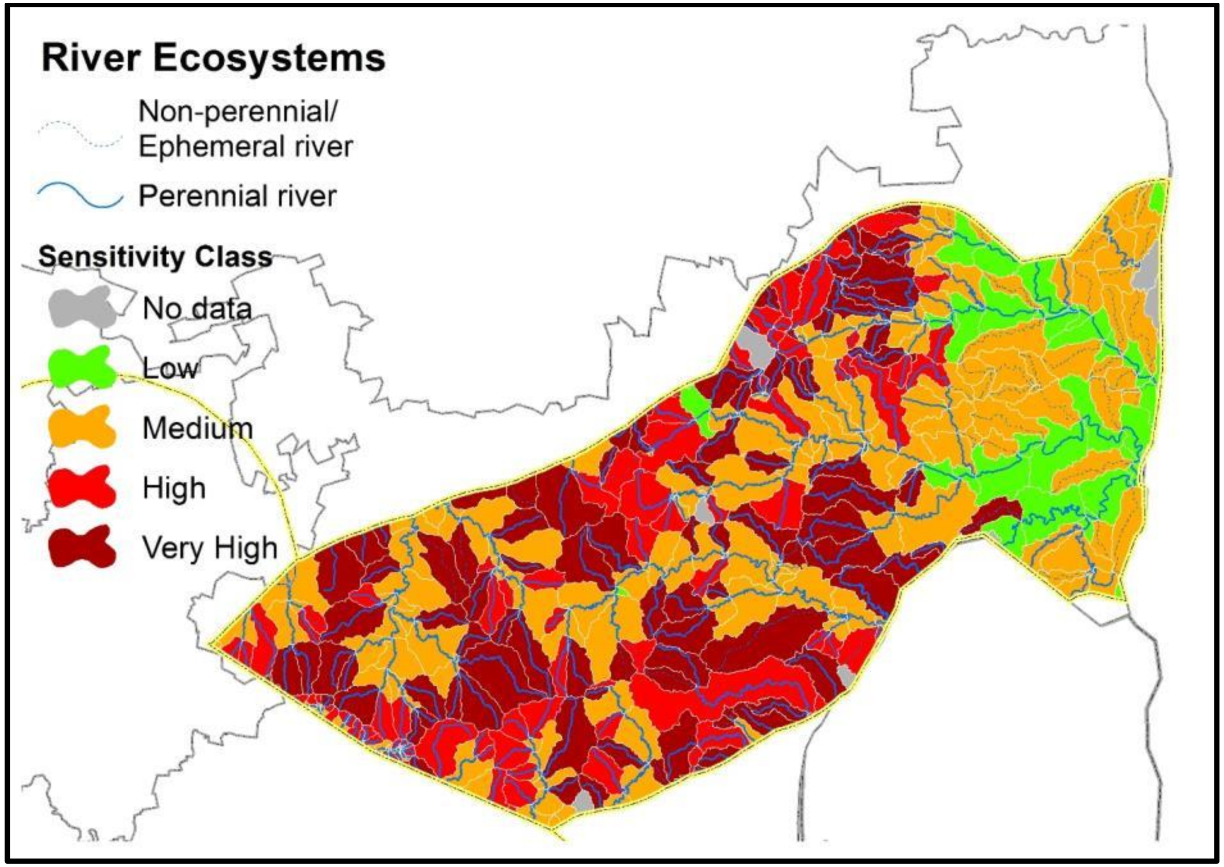


Figure 34: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline phase 8 corridor using PES, EI and ES data from DWS (2014).

6.9.2 Wetlands

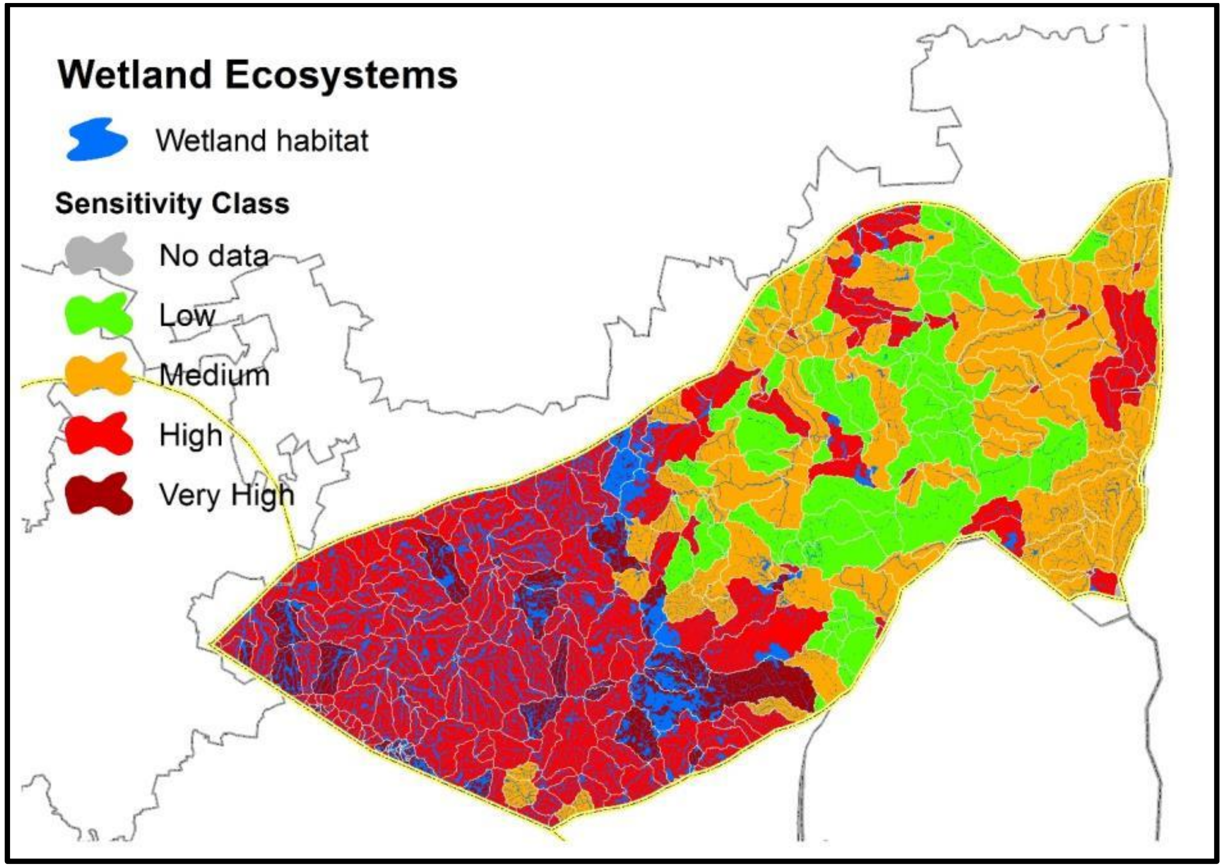


Figure 35: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline phase 8 corridor.

6.9.3 Freshwater biota (fauna and flora)

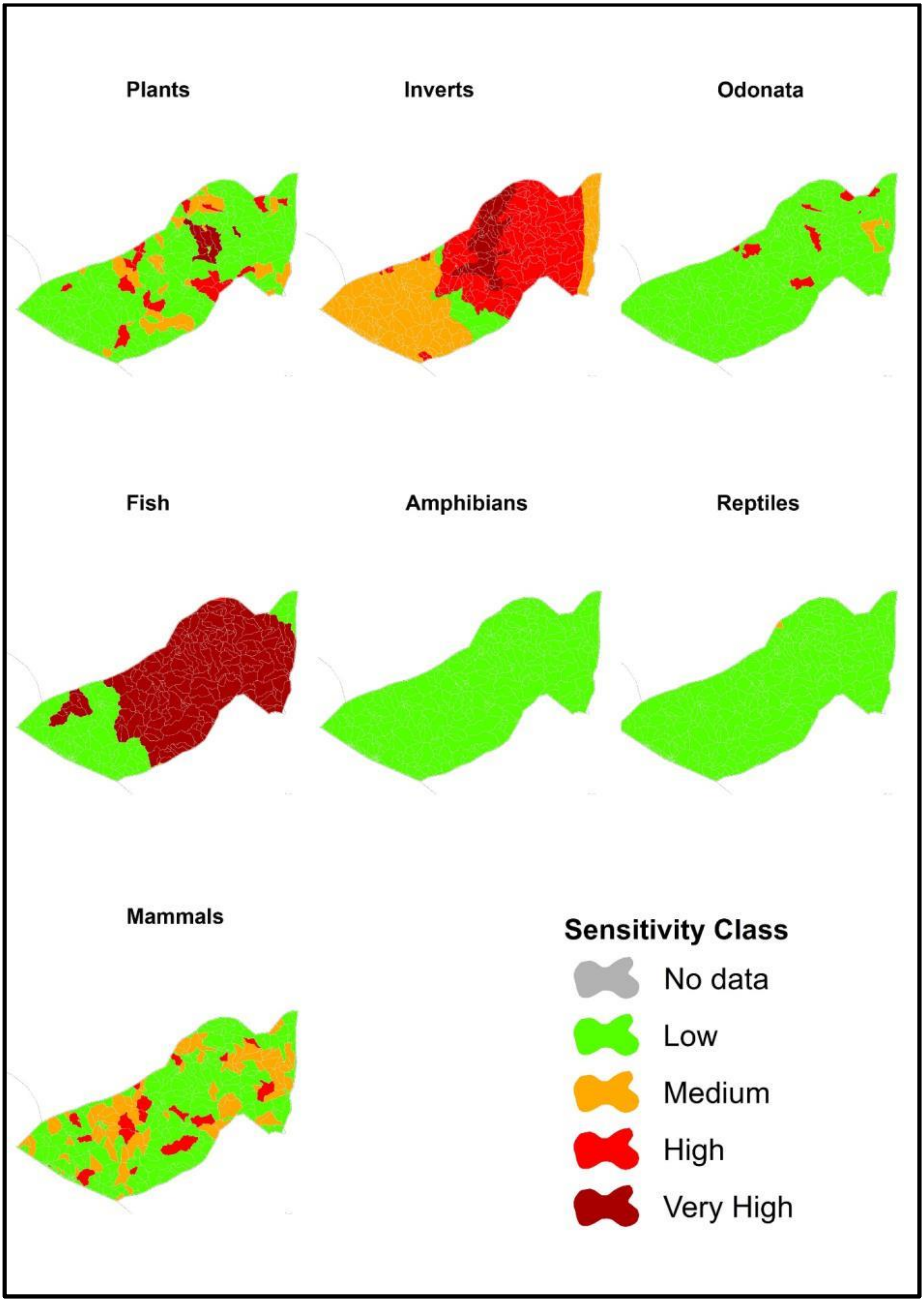


Figure 36: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline phase 8 corridor in relation to sub-quaternary catchments

6.9.4 Freshwater ecosystems and biota (combined)

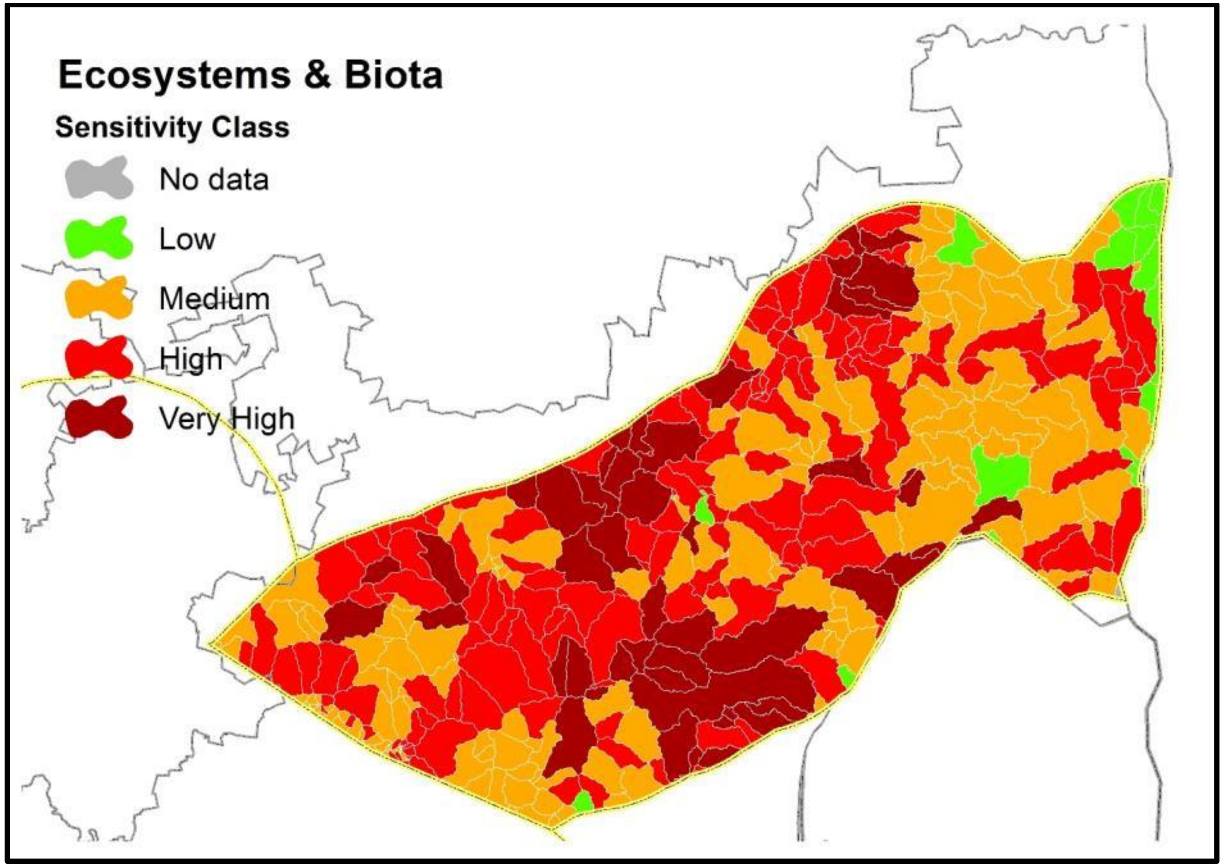


Figure 37: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline phase 8 corridor.

6.10 Inland Corridor

6.10.1 Rivers

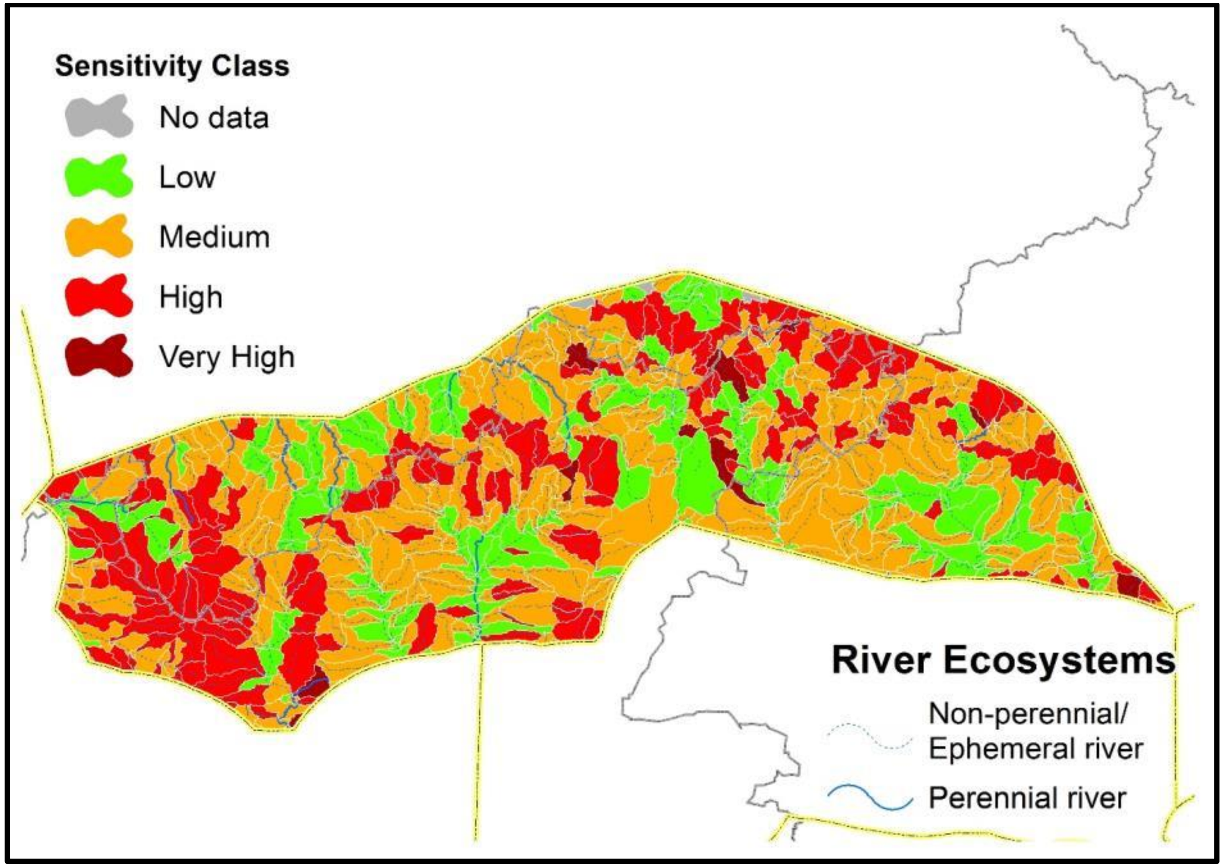


Figure 38: River threat status and sensitivity calculated for sub-quaternary catchments in the gas pipeline inland corridor using PES, EI and ES data from DWS (2014).

6.10.2 Wetlands

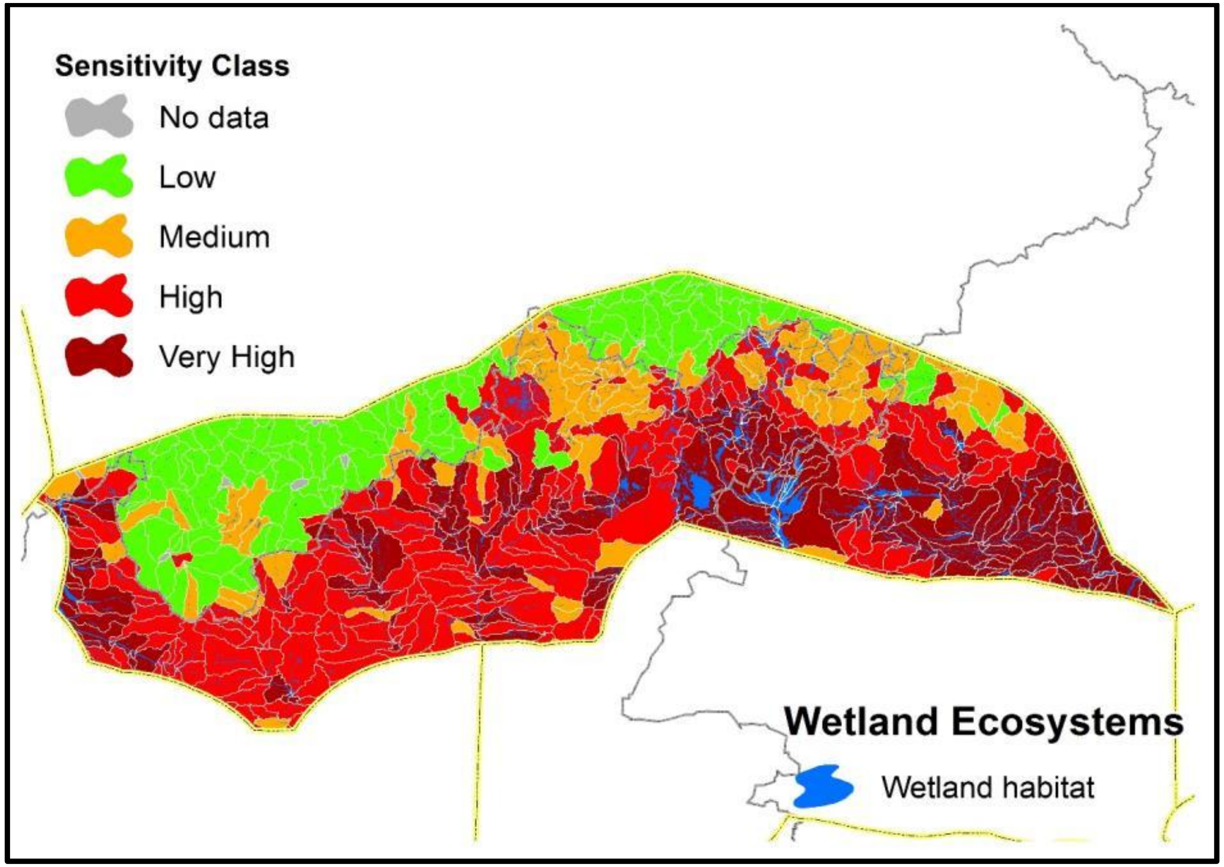


Figure 39: Wetland threat status and sensitivity calculated in relation to areas of sub-quaternary catchments in the gas pipeline inland corridor

6.10.3 Freshwater biota (fauna and flora)

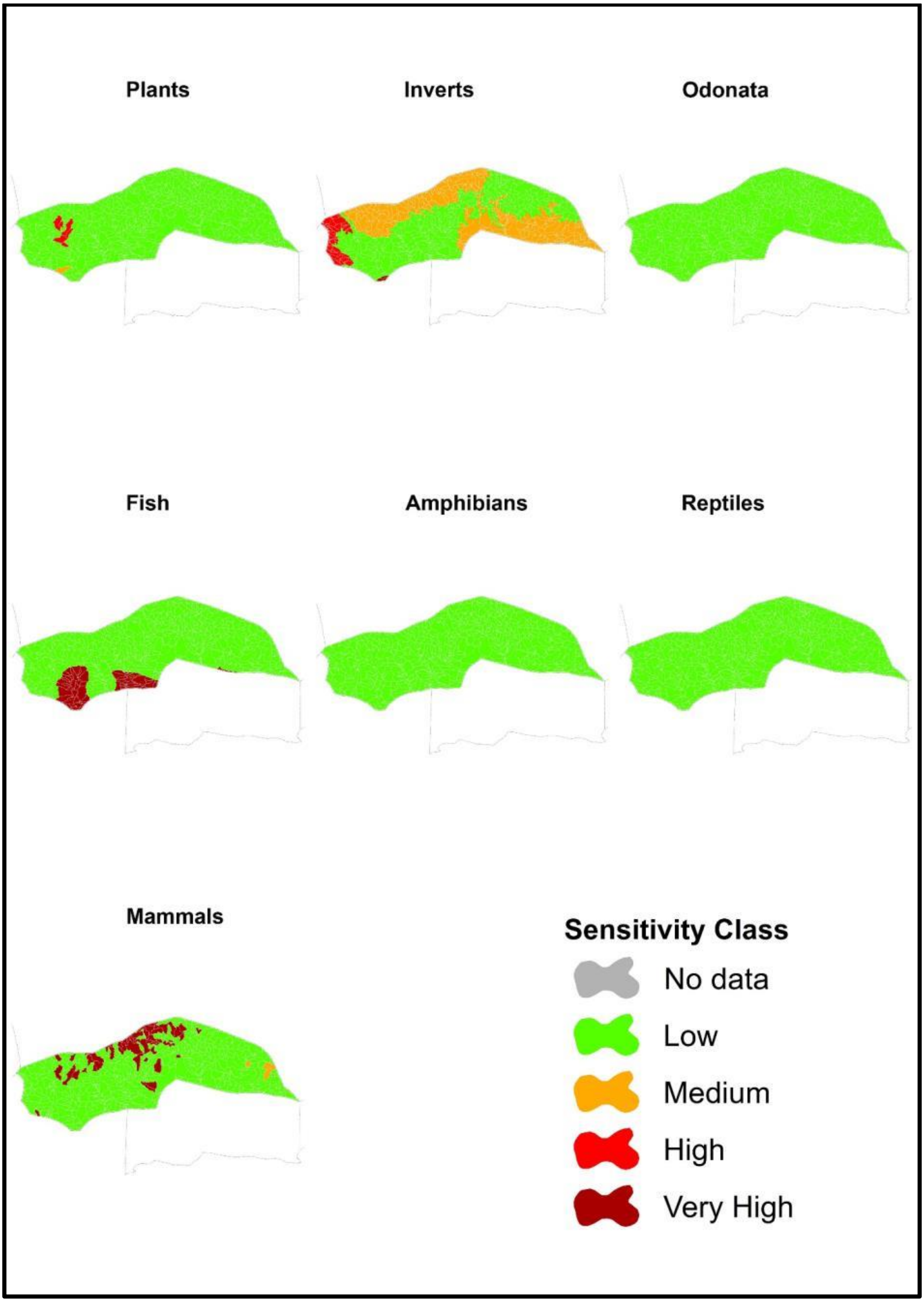


Figure 40: Threat and sensitivity status calculated for different freshwater taxonomic groups (flora and fauna) in the gas pipeline inland corridor in relation to sub-quaternary catchments

6.10.4 Freshwater ecosystems and biota (combined)

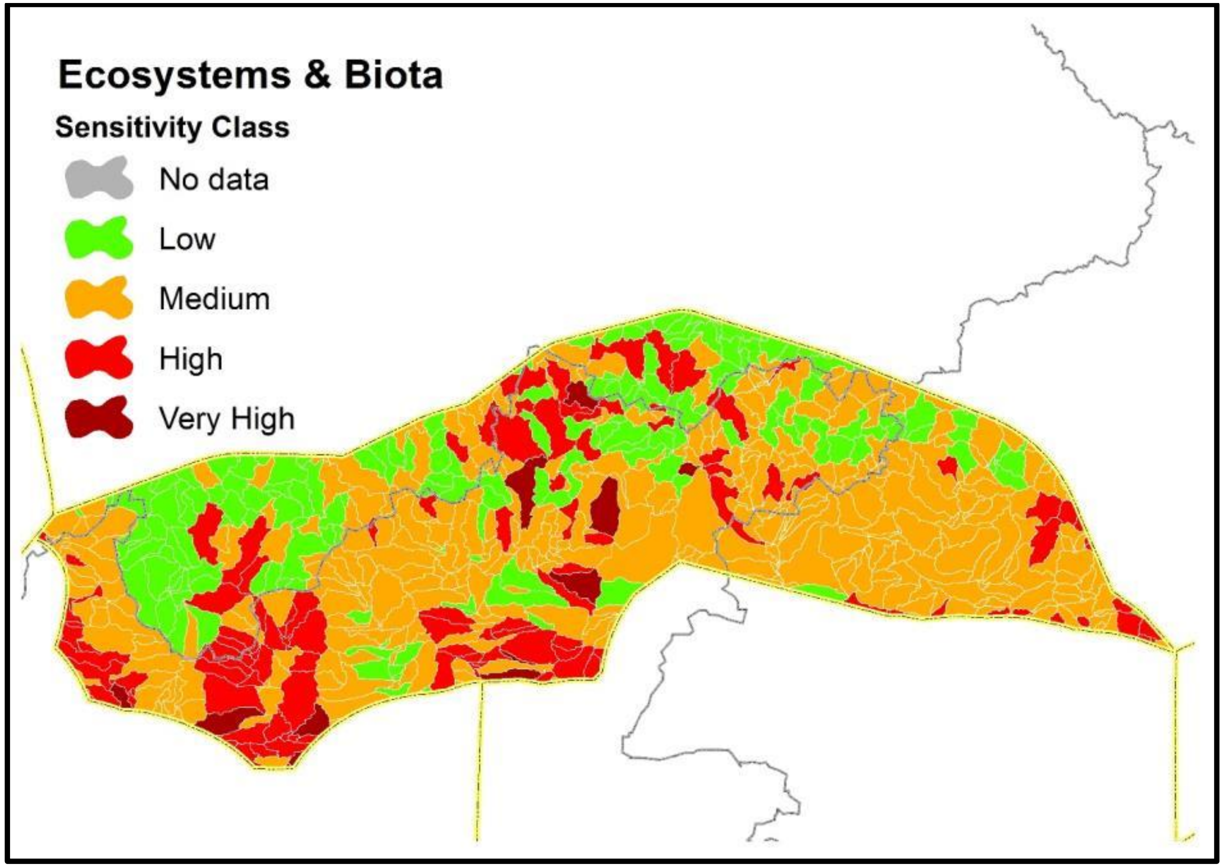


Figure 41: Integrated sensitivity and threat status map for freshwater ecosystems and biota in the gas pipeline inland corridor.

7 KEY POTENTIAL IMPACTS AND MITIGATION

The impacts associated with gas pipeline development range from those that are direct (e.g. excavation of trenches for pipelines and maintenance of vegetation within pipeline servitudes) to those that are more subtle (indirect) and which occur over longer timeframes (e.g. vegetation compositional changes from continued servitude maintenance, habitat fragmentation, and alien plant infestation). 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.

- **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:
    - 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 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 (i.e. fatality) 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.
- **Vegetation clearing and grading** – The stripping/removal of vegetation and topsoil to prepare the right of way (ROW) for pipeline construction will result in similar impacts to the development of access roads (as above), but will differ in terms of extent, duration and intensity. Typical ROWs are between 30 to 50 metres wide, translating to roughly one hectare for every 200 to 300 metres of pipeline constructed. Thus, the total area of wetland and riparian vegetation that is removed will be based on the total length of pipeline that passes through these freshwater ecosystems and their associated buffer habitats.
- **Trenching and excavation** – Trenches to bury pipelines will also need to be excavated during the pipeline construction process. This will also include excavations for pigging stations, which will be positioned every 250 to 500 km (based on new technology). Trenching and excavations have the potential to cause direct mortality of fauna that inhabit freshwater and fringe habitats, in particular fossorial fauna (i.e. animals adapted to living underground), but also small fauna that are moving across the excavation path that then fall into trenches or excavation where they become trapped and eventually die.
- **Rehabilitation and maintenance** – Gas pipeline servitudes for accessing the pipeline and pigging stations will require ongoing vegetation management and clearing to maintain a strip of grass/herbaceous vegetation, with trees/shrubs removed in most cases.

In addition to the main activities and key impacts resulting from gas pipeline 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 gas pipelines, and the associated servitudes for ongoing maintenance, is the fragmentation of freshwater habitat and associated buffers, especially where areas are permanently impacted (e.g. through roads and pigging stations). This presents a potential serious issue particularly to freshwater 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 an area are likely to invade newly disturbed areas, by gradual (or even rapid) encroachment into disturbed areas (e.g. ROWs, temporary construction camps, borrow pits, vehicle parking, pipeline stockpiles, etc.), transitional habitats, as well as areas 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 (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* 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. In addition there is the risk of fauna falling into and getting trapped within trenches and excavations, which may lead to further mortality cases. Lastly, 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, vibrations, dust and/or artificial lighting. Artificial lighting in and around construction camps and pipeline stockpiles 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.
- **Water quality impacts** – One of the main impacts that result from construction activities within and/or adjacent to rivers and wetlands is the increase in suspended solids and deposition of sediments causing habitat destruction due to sediment ‘smothering’, which in turn affects composition, feeding, reproduction, and wellbeing of aquatic biota. Other impacts that may also occur include accidental spills and vehicle leakages (e.g. fuels, oils, cement, etc.) that result in contamination of aquatic environments.

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 pipeline 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 gas pipelines within the proposed 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.

Table 8 provides detail in terms of key impacts and possible effects on freshwater ecosystems and associated fauna and flora that are linked to gas pipeline phases and development activities. Mitigation measures are included to ensure that impacts are avoided where necessary and/or minimised in terms of mitigation hierarchy.

1 Table 8: Key potential impacts to freshwater ecosystems and associated fauna and flora by gas pipeline development, and their mitigation.

Project Phase	Activity	Key Impact	Possible Effect	Mitigation
Design phase	Placement of gas pipelines and pigging stations within ROWs, as well as construction camps, pipeline stockpiles, and access roads within or close to wetlands or rivers (including associated buffer habitat)	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.	Gas pipeline routing to avoid catchments with a very high sensitivity as far as possible, and try to avoid catchments with a medium to high sensitivity. However, where this is unavoidable, placement of pipeline infrastructure within these catchments (as well as catchments with a low sensitivity) should avoid freshwater ecosystems and associated buffers, which should be determined during route screening, validation and walk-throughs.
		Fragmentation of aquatic 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)	As far as possible, existing road networks should be used. Where this is not possible, avoid and/or minimise road crossings through wetlands and rivers as far as possible. Where this is not possible, ensure that crossings are designed to minimise impacts, as well as to ensure connectivity and avoid fragmentation of ecosystems, especially where systems are linked to a river channel. Designs to consider use of riprap, gabion mattresses, with pipe crossings or culverts. 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.	As far as possible, existing road networks should be used. Where this is not possible, avoid and/or minimise road crossings through wetlands and rivers as far as possible. 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.
		Erosion caused by loss of vegetation cover through site clearing and consequent	Alterations in moisture availability and soil structure can promote the invasion of	Avoid clearing of sensitive indigenous vegetation as far as possible. Bank stabilisation measures (gabions, eco logs, geofabric, sediment fences) are required when wetland or

Project Phase	Activity	Key Impact	Possible Effect	Mitigation
		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).	weedy and/or alien species at the expense of more natural vegetation and thus a loss of habitat integrity and/or biodiversity. Loss of vegetation altogether can lead to erosion and increased sedimentation and therefore loss or degradation of riverine/wetland habitats	watercourse banks steeper than 1:5 are denuded during construction. Appropriate rehabilitation procedures/measures should be planned.
Construction phase	Establishment of ROWs and construction of gas pipelines and pigging stations (including trenching/ excavations), as well as camps, pipeline stockpiles, and access roads within or close to wetlands or rivers (including associated buffer habitat)	Physical destruction or damage of freshwater ecosystems and adjacent fringe habitats 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 ecosystem services provided by these habitats, as well as mortality of fauna and flora directly through clearing and trenching/ excavation, as well as indirectly through poaching/hunting.	All wetlands and watercourses should generally be treated as “no-go” areas (as far as possible) and appropriately demarcated as such. No vehicles, machinery, personnel, construction materials, cement, fuel, oil or waste should be allowed into these areas without the express permission of and supervision by an on-site Environmental Control Officer (ECO). Construction camps, toilets, temporary laydown areas should be located outside of the recommended buffer areas around wetlands and watercourses and should be rehabilitated following construction. Ensure that a 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 No. 36 of 1998). Trenches/excavations should be backfilled and rehabilitated immediately after the pipes/pigging stations have been installed, and should be done concurrently as the pipeline construction process progresses along the ROW. Trenches/excavations that are open should be inspected daily by an ECO and plans put in place to rescue any vertebrate fauna that have become trapped within a trench/excavation. Low fences that will prevent fauna from entering the ROW

Project Phase	Activity	Key Impact	Possible Effect	Mitigation
				should be used especially in situations where trenches/excavations remain open for longer periods of time (i.e. a few weeks to several months). All construction activities (including establishment of construction camps, temporary lay-down areas, construction of haul roads and operation of heavy machinery, should ideally take place during the dry season to reduce potential impacts to freshwater ecosystems that are linked to rainfall-runoff.
	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	Construction activities associated with the establishment of access roads through wetlands or watercourses (if unavoidable) should be restricted to a working area of ten metres in width either side of the road, and these working areas should be clearly demarcated. No vehicles, machinery, personnel, construction material, cement, fuel, oil or waste should be allowed outside of the demarcated working areas. Vehicles and machinery should not be washed within 30 metres of the edge of any wetland or watercourse.
	Construction of haul roads for movement of machinery and materials	Reduction in habitat quality through erosion and sedimentation of 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 watercourses.		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) should be used to minimise the transport of wind-blown dust. Any roads/crossings not needed after the construction process should be decommissioned and rehabilitated in accordance with detailed rehabilitation plans.
	Excavation of borrow pits for road construction	Excavation of borrow pits can act as pitfall traps for amphibians and other		Borrow pits should be located outside of the recommended buffer areas around wetlands and watercourses and should be rehabilitated following construction in accordance with detailed

Project Phase	Activity	Key Impact	Possible Effect	Mitigation
		terrestrial species leading to unnecessary death of species.		rehabilitation plans. Borrow pits should also be checked regularly by the on-site ECO to rescue any trapped vertebrate fauna.
	Operation of heavy machinery within or in close proximity to wetlands or other watercourses	Disturbance to and fatality of aquatic and semi-aquatic fauna, as a result of the noise and vibration from and movement of construction teams and their machinery working within or in close proximity to wetlands and rivers. Damage to vegetation from operating heavy machinery		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. 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. 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 rainfall), this water should be pumped into an appropriate settlement area, and not allowed to flow straight into any 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.

Project Phase	Activity	Key Impact	Possible Effect	Mitigation
				Workers should be made aware of the importance of not destroying or damaging the vegetation along watercourses and in wetland areas, of not undertaking activities that could result in the pollution of drainage lines or wetlands, and of not killing or harming any animals that they encounter. This awareness should be promoted throughout the construction phase and can be assisted through erecting appropriate signage Fixed point photography to monitor vegetation changes and potential site impacts occurring during construction phase
Operational Phase	Clearing or trimming of natural wetland or riparian vegetation to maintain the ROW, and access thereof.	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	Fixed point photography could be used to monitor long-term vegetation changes and potential site impacts. Avoid clearing vegetation (especially indigenous vegetation from high and very highly sensitive areas. Active removal of alien vegetation/spraying to be guided by an invasive alien plant control programme with long term monitoring.
	Application of herbicides	Pollution (water quality deterioration) of freshwater ecosystems and potential contamination of groundwater/subsurface drainage, which could also lead to bioaccumulation or poisoning of fauna and flora.		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.

8 RISK ASSESSMENT

The following risk assessment (as presented in Table 9 below) was carried out for all of the identified impacts described in Section 7. For each impact the consequence (ranging from slight to extreme) of the impact affecting freshwater systems and/or biota was defined as a combination of three factors, namely: impact severity, spatial scale and duration. The probability is based on the likelihood of an impact occurring from extremely unlikely to very likely. The overall risk of a particular impact is based on the combined consequence of the impact and the probability/likelihood that the impact will occur, with each impact evaluated according to the four-tiered rating scale as used in the sensitivity mapping.

Table 9: Assessment of risk associated with impacts to freshwater ecosystems resulting from gas pipeline development with respect to the four-tiered sensitivity classes for freshwater attributes.

Direct Impact	Combined Sensitivity level	Without Mitigation			With Mitigation		
		Consequence	Probability	Risk	Consequence	Probability	Risk
Loss of freshwater habitat through clearing/ infilling of wetlands and rivers and associated buffer habitat, potentially including threatened/ sensitive ecosystems	Low	Moderate	Very likely	Low	Slight	Not likely	Very Low
	Medium	Substantial	Very likely	Moderate	Slight	Not likely	Very Low
	High	Severe	Very likely	High	Moderate	Not likely	Low
	Very High	Extreme	Very likely	Very High	Substantial	Not likely	Moderate
Fragmentation of aquatic habitat (mostly as a result of road construction)	Low	Slight	Likely	Very Low	Slight	Not likely	Very Low
	Medium	Moderate	Likely	Low	Slight	Not likely	Very Low
	High	Substantial	Likely	Moderate	Slight	Not likely	Very Low
	Very High	Severe	Likely	High	Moderate	Not likely	Low
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	Low	Slight	Likely	Very Low	Slight	Not likely	Very Low
	Medium	Moderate	Likely	Low	Slight	Not likely	Very Low
	High	Substantial	Likely	Moderate	Moderate	Not likely	Low
	Very High	Substantial	Likely	Moderate	Substantial	Not likely	Moderate
Erosion caused by loss of vegetation cover through site clearing and consequent sedimentation of aquatic ecosystems	Low	Moderate	Very Likely	Low	Slight	Likely	Very Low
	Medium	Moderate	Very Likely	Low	Moderate	Likely	Low
	High	Substantial	Very Likely	Moderate	Substantial	Likely	Moderate
	Very High	Severe	Very Likely	High	Substantial	Likely	Moderate
Physical destruction or damage of freshwater ecosystems and adjacent fringe habitats by workers and machinery operating within or in close proximity to wetlands or drainage lines, and through the establishment of construction camps or	Low	Substantial	Very Likely	Moderate	Moderate	Likely	Low
	Medium	Substantial	Very Likely	Moderate	Substantial	Likely	Moderate
	High	Severe	Very Likely	High	Substantial	Likely	Moderate
	Very High	Extreme	Very Likely	Very High	Severe	Likely	High

Direct Impact	Combined Sensitivity level	Without Mitigation			With Mitigation		
		Consequence	Probability	Risk	Consequence	Probability	Risk
temporary laydown areas							
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	Low	Moderate	Likely	Low	Slight	Likely	Very Low
	Medium	Substantial	Likely	Moderate	Slight	Likely	Very Low
	High	Severe	Likely	High	Moderate	Likely	Low
	Very High	Extreme	Likely	High	Substantial	Likely	Moderate
Clearing or trimming of natural wetland or riparian vegetation leading to loss and/or reduction in habitat quality	Low	Moderate	Likely	Low	Slight	Likely	Very Low
	Medium	Moderate	Likely	Low	Slight	Likely	Very Low
	High	Substantial	Likely	Moderate	Moderate	Likely	Low
	Very High	Substantial	Likely	Moderate	Moderate	Likely	Low
Reduction in habitat quality through erosion and sedimentation of wetlands and rivers	Low	Moderate	Very Likely	Low	Slight	Likely	Very Low
	Medium	Moderate	Very Likely	Low	Slight	Likely	Very Low
	High	Substantial	Very Likely	Moderate	Moderate	Likely	Low
	Very High	Substantial	Very Likely	Moderate	Moderate	Likely	Low
Excessive dust generation from road construction and vehicle traffic/haulage leading to impact on surrounding vegetation health and suspended solids/sediment entering nearby watercourses	Low	Slight	Very Likely	Very low	Slight	Likely	Very Low
	Medium	Slight	Very Likely	Very Low	Slight	Likely	Very Low
	High	Moderate	Very Likely	Low	Moderate	Likely	Low
	Very High	Substantial	Very Likely	Moderate	Moderate	Likely	Low
Excavation of borrow pits for road construction acting as pitfall traps for amphibians and other terrestrial species leading to unnecessary death of species.	Low	Slight	Very Likely	Very Low	Slight	Likely	Very Low
	Medium	Substantial	Very Likely	Moderate	Slight	Likely	Very Low
	High	Severe	Very Likely	High	Moderate	Likely	Low
	Very High	Severe	Very Likely	High	Substantial	Likely	Moderate
Disturbance to and fatality of aquatic and semi-aquatic fauna, as a result	Low	Slight	Likely	Very Low	Slight	Not likely	Very Low
	Medium	Slight	Very Likely	Very Low	Slight	Not likely	Very Low

Direct Impact	Combined Sensitivity level	Without Mitigation			With Mitigation		
		Consequence	Probability	Risk	Consequence	Probability	Risk
of the noise and vibration from and movement of construction teams and their machinery working within or in close proximity to wetlands and rivers.	High	Moderate	Very Likely	Low	Slight	Not likely	Very Low
	Very High	Moderate	Very Likely	Low	Slight	Not likely	Very Low
Clearing, disturbance or trimming of natural wetland or riparian vegetation leading to stimulation of alien vegetation/invasive species	Low	Moderate	Likely	Low	Slight	Likely	Very Low
	Medium	Substantial	Very Likely	Moderate	Slight	Likely	Very Low
	High	Severe	Very Likely	High	Moderate	Likely	Low
	Very High	Extreme	Very Likely	Very High	Substantial	Likely	Moderate
Pollution (water quality deterioration) of freshwater ecosystems and potential contamination of groundwater/ subsurface drainage, which could also lead to bioaccumulation or poisoning of fauna and flora.	Low	Moderate	Likely	Low	Moderate	Not likely	Low
	Medium	Moderate	Very Likely	Low	Moderate	Not likely	Low
	High	Substantial	Very Likely	Moderate	Substantial	Not likely	Moderate
	Very High	Severe	Very Likely	High	Severe	Not likely	Moderate

9 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 0.

9.1 Planning phase

The planning phase for gas pipeline development through firstly establishing preferred pipeline routings and alignments, 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, then sub-quaternary catchments classified with a very high or high sensitivity should be avoided. Where these areas cannot be avoided, then a detailed desktop investigation should be followed to determine whether the gas pipeline alignment and development footprint can avoid the actual freshwater ecosystems (i.e. wetland and river habitats) and associated buffers (see Section 6.1). 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, then 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 of gas pipelines 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 gas pipeline development must be subject to a project level assessment.

9.2 Construction phase

This phase may include the establishment of ROWs and construction of pipelines and pigging stations, 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 0, 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 9.5 below.

9.3 Operations phase

This phase will predominantly include activities typical of routine maintenance, such as clearing/trimming of natural wetland or riparian vegetation (to maintain pipeline servitudes), as well as IAP control and application of herbicides. Specific measures to be considered are provided in in Section 9.1.

9.4 Rehabilitation and post closure

Rehabilitation and post-closure measures would be mostly required for ROWs within or in proximity to freshwater ecosystems, as well as for areas degraded by access routes, operation of vehicles/heavy machinery, and infestation of servitudes by IAPs. In general, the following processes/procedures as recommended by James and King (2010):

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

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.).

9.5 Monitoring requirements

Sites/areas where freshwater ecosystems are likely to be affected by gas pipeline development, according to the various phases of development (including rehabilitation), appropriate measures of monitoring should be considered, including:

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

10 GAPS IN KNOWLEDGE

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

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

11 CONCLUSIONS AND FURTHER RECOMMENDATIONS

Biodiversity impacts, unfortunately, are unavoidable when developing large-scale projects such as a national-scale network of gas pipelines. 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 gas pipeline development footprints, including servitude negotiations and potential land acquisitions, such that environmental impacts to freshwater ecosystems are minimised. The maps also indicate those areas where development is likely to be able to proceed with minimal risk and needs for EA.

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 gas pipeline development and are not generally applicable to other types of development.

Pipeline 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 pipeline route through the identified corridor/s based on more detailed desktop and infield assessments. Ultimately, pipeline alignment 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.

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APPENDICES

Appendix 1: Selected flora used in the assessment of freshwater biota

Family	Species	Conservation status
Rutaceae	*Agathosma sedifolia*	EN
Fabaceae	*Albizia suluensis*	EN
Apiaceae	*Alepidea attenuata*	NT
Asphodelaceae	*Aloe simii*	CR
Aponogetonaceae	*Aponogeton angustifolius*	NT
Aponogetonaceae	*Aponogeton fugax*	EN
Asteraceae	*Arctotheca forbesiana*	VU
Apocynaceae	*Asclepias gordon-grayae*	EN
Apocynaceae	*Aspidonepsis cognata*	NT
Asteraceae	*Athanasia capitata*	EN
Salviniaceae	*Azolla pinnata subsp. africana*	NT
Plantaginaceae	*Bacopa monnieri*	NT
Plantaginaceae	*Callitriche bolusii*	DD
Cyperaceae	*Carex subinflata*	VU
Rhizophoraceae	*Cassipourea gummiflua var. verticillata*	VU
Cyperaceae	*Catabrosa drakensbergense*	VU
Rosaceae	*Cliffortia ericifolia*	EN
Rhamnaceae	*Colubrina nicholsonii*	VU
Asteraceae	*Cotula eckloniana*	VU
Asteraceae	*Cotula filifolia*	NT
Asteraceae	*Cotula myriophylloides*	CR
Asteraceae	*Cotula paludosa*	VU
Asteraceae	*Cotula pusilla*	VU
Crassulaceae	*Crassula tuberella*	NT
Amaryllidaceae	*Crinum campanulatum*	NT
Amaryllidaceae	*Crinum moorei*	VU
Tecophilaeaceae	*Cyanella aquatica*	EN
Cyperaceae	*Cyathocoma bachmannii*	VU
Cyperaceae	*Cyperus sensilis*	NT
Amaryllidaceae	*Cyrtanthus eucallus*	VU
Acanthaceae	*Dicliptera magaliesbergensis*	VU
Orchidaceae	*Disa cernua*	VU
Orchidaceae	*Disa extinctoria*	NT
Orchidaceae	*Disa flexuosa*	NT
Orchidaceae	*Disa scullyi*	EN
Orchidaceae	*Disa zuluensis*	EN
Aizoaceae	*Disphyma dunsdonii*	VU
Asteraceae	*Dymondia margaretae*	EN
Apocynaceae	*Ectadium virgatum*	NT
Restionaceae	*Elegia verreauxii*	VU
Cyperaceae	*Eleocharis schlechteri*	DD
Aizoaceae	*Erepsia brevipetala*	EN
Ericaceae	*Erica alexandri subsp. alexandri*	CR
Ericaceae	*Erica bakeri*	CR
Ericaceae	*Erica chrysocodon*	CR
Ericaceae	*Erica hansfordii*	CR
Ericaceae	*Erica heleogena*	CR
Ericaceae	*Erica margaritacea*	CR
Ericaceae	*Erica melanacme*	EN
Ericaceae	*Erica purgatoriensis*	VU

Family	Species	Conservation status
Ericaceae	*Erica riparia*	EN
Eriocaulaceae	*Eriocaulon mutatum var. angustisepalum*	VU
Eriocaulaceae	*Eriocaulon transvaalicum subsp. tofieldifolium*	VU
Hyacinthaceae	*Eucomis pallidiflora subsp. pole-evansii*	NT
Zygophyllaceae	*Fagonia rangei*	NT
Asteraceae	*Felicia westae*	EN
Cyperaceae	*Ficinia elatior*	VU
Cyperaceae	*Fimbristylis aphylla*	VU
Iridaceae	*Geissorhiza brehmii*	VU
Iridaceae	*Geissorhiza geminata*	EN
Geraniaceae	*Geranium ornithopodioides*	EN
Iridaceae	*Gladiolus paludosus*	VU
Thymelaeaceae	*Gnidia ornata*	VU
Amaryllidaceae	*Haemanthus nortieri*	EN
Hydrostachyaceae	*Hydrostachys polymorpha*	VU
Isoetaceae	*Isoetes capensis*	VU
Isoetaceae	*Isoetes eludens*	VU
Isoetaceae	*Isoetes stellenbossiensis*	NT
Isoetaceae	*Isoetes stephanseniae*	CR
Isoetaceae	*Isoetes wormaldii*	CR
Cyperaceae	*Isolepis venustula*	VU
Asphodelaceae	*Kniphofia flammula*	EN
Asphodelaceae	*Kniphofia latifolia*	EN
Asphodelaceae	*Kniphofia leucocephala*	CR
Hyacinthaceae	*Lachenalia bachmannii*	EN
Hyacinthaceae	*Lachenalia longituba*	VU
Hyacinthaceae	*Lachenalia salteri*	EN
Hydrocharitaceae	*Lagarosiphon cordofanus*	VU
Proteaceae	*Leucadendron conicum*	NT
Proteaceae	*Leucadendron corymbosum*	VU
Proteaceae	*Leucadendron floridum*	CR
Proteaceae	*Leucadendron laxum*	EN
Proteaceae	*Leucadendron levisanus*	CR
Proteaceae	*Leucadendron linifolium*	VU
Proteaceae	*Leucadendron macowanii*	CR
Proteaceae	*Leucadendron modestum*	EN
Proteaceae	*Leucospermum catherinae*	EN
Alismataceae	*Limnophyton obtusifolium*	NT
Plumbaginaceae	*Limonium anthericoides*	EN
Scrophulariaceae	*Lindernia monroi*	DD
Fabaceae	*Liparia angustifolia*	EN
Lobeliaceae	*Lobelia quadrisepala*	DD
Onagraceae	*Ludwigia leptocarpa*	NT
Asteracea	*Marasmodes sp. nov.*	CR
Marsileaceae	*Marsilea apposita*	DD
Marsileaceae	*Marsilea farinosa subsp. arrecta*	VU
Marsileaceae	*Marsilea fenestrata*	NT
Celastraceae	*Maytenus abbottii*	EN
Proteaceae	*Mimetes hirtus*	VU
Apocynaceae	*Mondia whitei*	EN
Iridaceae	*Moraea stagnalis*	VU
Najadaceae	*Najas setacea*	VU
Amaryllidaceae	*Nerine pancratioides*	NT
Lythraceae	*Nesaea crassicaulis*	NT
Lythraceae	*Nesaea wardii*	VU
Menyanthaceae	*Nymphoides forbesiana*	DD

Family	Species	Conservation status
Lamiaceae	*Ocimum reclinatum*	VU
Hydrocharitaceae	*Ottelia exserta*	NT
Hydrocharitaceae	*Ottelia ulvifolia*	NT
Oxalidaceae	*Oxalis davyana*	VU
Oxalidaceae	*Oxalis dines*	VU
Oxalidaceae	*Oxalis disticha*	NT
Oxalidaceae	*Oxalis natans*	CR
Oxalidaceae	*Oxalis uliginosa*	EN
Thymelaeaceae	*Passerina paludosa*	EN
Marsileaceae	*Pilularia bokkeveldensis*	CR
Marsileaceae	*Pilularia dracomontana*	Rare
Asteraceae	*Poecilolepis maritima*	VU
Potamogetonaceae	*Pseudalthenia aschersoniana*	CR
Fabaceae	*Psoralea alata*	VU
Fabaceae	*Psoralea angustifolia*	VU
Fabaceae	*Psoralea sp. nov.*	EN
Orchidaceae	*Pterygodium cruciferum*	EN
Orchidaceae	*Pterygodium microglossum*	EN
Arecaceae	*Raphia australis*	VU
Restionaceae	*Restio femineus*	EN
Restionaceae	*Restio paludosus*	VU
Restionaceae	*Restio sabulosus*	EN
Restionaceae	*Restio zuluensis*	VU
Iridaceae	*Romulea aquatica*	EN
Iridaceae	*Romulea multisulcata*	VU
Asteraceae	*Senecio cadiscus*	CR
Santalaceae	*Thesium polygaloides*	VU
Scrophulariaceae	*Torenia thouarsii*	VU
Lentibulariaceae	*Utricularia benjaminiana*	NT
Lentibulariaceae	*Utricularia cymbantha*	VU
Lentibulariaceae	*Utricularia foliosa*	VU
Menyanthaceae	*Villarsia goldblattiana*	VU
Campanulaceae	*Wahlenbergia pyrophila*	CR
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
Gomphidae	*Ceratogomphus triceraticus*	Cape Thorntail	NT
Coenagrionidae	*Ceriagrion suave*	Sauve Citril	EN
Chlorocyphidae	*Chlorocypha consueta*	Ruby Jewel	CR
Synlestidae	*Chlorolestes apricans*	Amatola Malachite	EN
Libellulidae	*Diplacodes pumila*	Dwarf Percher	EN
Synlestidae	*Ecchlorolestes nylephtha*	Queen Malachite	NT
Synlestidae	*Ecchlorolestes peringueyi*	Rock Malachite	NT
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
Platycnemididae	*Metacnemis valida*	Blue Streamjack	EN
Libellulidae	*Olpogastra lugubris*	Bottletail	NT
Libellulidae	*Orthetrum robustum*	Robust Skimmer	NT
Libellulidae	*Orthetrum rubens*	Elusive Skimmer	EN
Libellulidae	*Parazyxomma flavicans*	Banded Duskdarter	VU
Corduliidae	*Phyllomacromia monoceros*	Sable Cruiser	NT
Coenagrionidae	*Proischnura polychromatica*	Mauve Bluet	EN
Platycnemididae	*Spesbona angusta*	Spesbona	EN
Corduliidae	*Syncordulia gracilis*	Yellow Presba	VU
Corduliidae	*Syncordulia legator*	Gilded Presba	VU
Corduliidae	*Syncordulia serendipator*	Rustic Presba	VU
Corduliidae	*Syncordulia venator*	Mahogany Presba	VU
Libellulidae	*Trithemis werneri*	Elegant Dropwing	NT
Fish			
Amphiliidae	*Amphilius natalensis*	*Natal Mountain Catfish*	DD
Poeciliidae	*Aplocheilichthys myaposae*	*Natal Topminnow*	NT
Austroglanididae	*Austroglanis barnardi*	*Barnard's Rock-catfish*	EN
Austroglanididae	*Austroglanis gilli*	*Clanwilliam Rock Catfish*	NT
Cyprinidae	*Barbus amatolicus*	*Amatola Barb*	VU
Cyprinidae	*Barbus eutaenia*	*Orangefin Barb*	DD
Cyprinidae	*Barbus sp. nov. 'Keiskamma'*		EN
Cyprinidae	*Barbus sp. nov. 'South Africa'*		NT
Cyprinidae	*Barbus sp. nov. 'Waterberg'*	*Waterberg Shortfin Barb*	NT
Cichlidae	*Chetia brevis*	*Orange-fringed River Bream*	EN
Mochokidae	*Chiloglanis bifurcus*	*Incomati Suckermouth*	CR
Cyprinidae	*Engraulicypris gariepenus*		NT
Cyprinidae	*Enteromius brevipinnis*	*Shortfin Barb*	NT
Cyprinidae	*Enteromius motebensis*	*Marico Barb*	NT
Cyprinidae	*Enteromius treurensis*	*Treur River Barb*	CR
Cyprinidae	*Enteromius trevelyani*	*Border Barb*	EN
Galaxiidae	*Galaxias sp. nov. 'Breede'*		EN
Galaxiidae	*Galaxias sp. Nov. 'Goukou'*		VU
Galaxiidae	*Galaxias sp. Nov. 'Heuningnes'*		EN
Galaxiidae	*Galaxias sp. nov. 'Riviersonderend'*		VU
Galaxiidae	*Galaxias sp. nov. 'Verlorenvlei'*		EN
Kneriidae	*Kneria sp. nov. 'South Africa'*	*Southern Kneria 'South Africa'*	EN

Family	Species name	Common name	Conservation status
Cyprinidae	*Labeo rubromaculatus*	*Tugela Labeo*	VU
Cyprinidae	*Labeo seeberi*	Clanwilliam Sandfish	EN
Cyprinidae	*Labeobarbus kimberleyensis*	*Largemouth Yellowfish*	NT
Cyprinidae	*Labeobarbus nelspruitensis*	*Incomati Chiselmouth*	NT
Cyprinidae	*Labeobarbus seeberi*	*Clanwilliam Yellowfish*	NT
Mormyridae	*Marcusenius caudisquamatus*		EN
Cichlidae	*Oreochromis mossambicus*	Mozambique Tilapia	VU
Cyprinidae	*Pseudobarbus afer*	Eastern Cape Redfin	EN
Cyprinidae	*Pseudobarbus asper*	Smallscale Redfin	EN
Cyprinidae	*Pseudobarbus burchelli*	Barrydale Redfin	CR
Cyprinidae	*Pseudobarbus burgi*		EN
Cyprinidae	*Pseudobarbus calidus*	Clanwilliam Redfin	NT
Cyprinidae	*Pseudobarbus capensis*	Berg-Breede River Whitefish	EN
Cyprinidae	*Pseudobarbus erubescens*	Twee River Redfin	CR
Cyprinidae	*Pseudobarbus phlegethon*	*Fiery Redfin*	EN
Cyprinidae	*Pseudobarbus senticeps*		CR
Cyprinidae	*Pseudobarbus serra*	*Clanwilliam Sawfi*	NT
Cyprinidae	*Pseudobarbus skeltoni*	*Giant Redfin*	EN
Cyprinidae	*Pseudobarbus sp. nov. 'doring'*	*Doring Fiery Redfin*	CR
Cyprinidae	*Pseudobarbus sp. nov. 'heuningnes'*		CR
Cyprinidae	*Pseudobarbus swartzi*	*Gamtoos River Redfin*	EN
Cyprinidae	*Pseudobarbus tenuis*	*Slender Redfin*	NT
Cyprinidae	*Pseudobarbus verloreni*		EN
Anabantidae	*Sandelia bainsii*	*Eastern Cape Rocky*	EN
Anabantidae	*Sandelia capensis*	*Cape Kurper*	DD
Cichlidae	*Serranochromis meridianus*	*Lowveld Largemouth*	EN
Gobiidae	*Silhouettea sibayi*	*Sibayi Goby*	EN
Amphibians			
Hyperoliidae	*Afrixalus knysnae*	Knysna Leaf-folding Frog	EN
Pyxicephalidae	*Anhydrophryne ngongoniensis*	Mistbelt Chirping Frog	EN
Pyxicephalidae	*Anhydrophryne rattrayi*	Hogsback Chirping Frog	VU
Pyxicephalidae	*Arthroleptella landdrosia*	Landdros Moss Frog	NT
Pyxicephalidae	*Arthroleptella lightfooti*	Lightfoot’s Moss Frog	NT
Pyxicephalidae	*Arthroleptella rugosa*	Rough Moss Frog	CR
Pyxicephalidae	*Arthroleptella subvoce*	Northern Moss Frog	CR
Brevicipitidae	*Breviceps bagginsi*	Bilbo's Rain Frog	NT
Brevicipitidae	*Breviceps branchi*	Branch's Rain Frog	DD
Brevicipitidae	*Breviceps gibbosus*	Cape Rain Frog	NT
Brevicipitidae	*Breviceps macrops*	Desert Rain Frog	NT
Pyxicephalidae	*Cacosternum capense*	Cape Dainty Frog	NT
Pyxicephalidae	*Cacosternum platys*	Smooth Dainty Frog	NT
Pyxicephalidae	*Cacosternum thorini*	Hogsback Caco	EN
Bufonidae	*Capensibufo deceptus*	Deception Peak Mountain Toadlet	DD
Bufonidae	*Capensibufo magistratus*	Landdroskop Mountain Toadlet	DD
Bufonidae	*Capensibufo rosei*	Rose’s Mountain Toadlet	CR
Bufonidae	*Capensibufo selenophos*	Moonlight Mountain Toadlet	DD
Heleophrynidae	*Heleophryne hewitti*	Hewitt’s Ghost Frog	EN
Heleophrynidae	*Heleophryne rosei*	Table Mountain Ghost Frog	CR
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	*Microbatrachella capensis*	Micro Frog	CR
Pyxicephalidae	*Natalobatrachus bonebergi*	Kloof Frog	EN
Pyxicephalidae	*Poyntonia paludicola*	Montane Marsh Frog	NT
Bufonidae	*Sclerophrys pantherina*	Western Leopard Toad	EN
Bufonidae	*Vandijkophrynus amatolicus*	Amathole Toad	CR

Family	Species name	Common name	Conservation status
Pipidae	*Xenopus gilli*	Cape Platanna	EN
Reptiles (freshwater obligates)			
Chamaeleondidae	*Bradypodion melanocephalum*	KwaZulu Dwarf Chamaeleon	VU
Chamaeleondidae	*Bradypodion pumilum*	Cape Dwarf Chamaeleon	VU
Lamprophiidae	*Macrelaps microlepidotus*	KwaZulu-Natal Black Snake	NT
Lamprophiidae	*Montaspis gilvomaculata*	Cream-spotted Mountain Snake	DD
Gekkonidae	*Pachydactylus rangei*	Namib Web-footed Gecko	CR
Pelomedusidae	*Pelusios rhodesianus*	Variable Hinged Terrapin	VU
Mammals (freshwater obligates)			
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
Lagomorpha	*Bunolagus monticularis*	Riverine Rabbit	CR
Rodentia	*Dasymys capensis*	Cape Marsh Rat	VU
Rodentia	*Dasymys incomtus*		NT
Rodentia	*Dasymys robertsii*		VU
Rodentia	*Otomys auratus*	Vlei Rat	NT
Rodentia	*Otomys laminatus*	Laminate Vlei Rat	NT