APPENDIX G

Biodiversity Assessment

May 2016

ACWA POWER AFRICA HOLDINGS (PTY) LTD

Biodiversity (excluding bats and birds) Baseline and Impact Assessment: Proposed 75 MW Photovoltaic Solar Development (PV1) on the Remaining Extent of Farm Bokpoort 390, Northern Cape

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ACWA Power Africa Holdings (Pty) Ltd

REPORT

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Executive Summary

The proposed Bokpoort II development consists of a solar energy facility (Bokpoort II) on the north-eastern portion of the Remaining Extent (RE) of the Farm Bokpoort 390, which is 20 km northwest of the town of Groblershoop within the !Kheis Local Municipality in the ZF Mgcawu District Municipality, Northern Cape Province. The total Bokpoort II project area designated for the development is approximately 1 500 ha. The Orange River is located approximately 12 km south-west of the site; water for the proposed Bokpoort II project site will be pumped from the Orange River to the facility via an underground pipeline. The proposed Bokpoort II project site will also have a new water abstraction point. The abstraction point will be in close proximity to the existing Bokpoort I point. The new pipeline will run parallel to the existing Bokpoort I pipeline, within the existing pipeline servitude. The Study Area for this biodiversity impact assessment was defined as the area where the Bokpoort II project will be developed, as well as the route of the proposed pipeline to the water abstraction point, and the proposed new abstraction point.

The proposed Bokpoort II project will consist of three (3) applications for environmental authorisation, each having a Scoping Report and an Environmental Impact Assessment Report. ACWA Power is applying for environmental authorisation for two (2) 75 Mega Watt (MW) photovoltaic (PV) facilities and one (1) 150 MW Concentrated Solar Power (CSP) Tower facility. The combined power generation capacity of the entire Bokpoort II solar development will be 300 MW. Each of the solar technologies will have separate associated infrastructure that will not overlap in footprint.

This report will assess the potential biodiversity impacts associated with the proposed 75 MW PV1 solar facility (the Project).

The primary effect on biodiversity arising from the Project will be loss in extent of ecosystems due to site clearance and groundworks. These works are unlikely to be limited to the exact footprint of PV1 in isolation, therefore impacts are considered as occurring within the extent of the Bokpoort II boundary. The Study Area for this impact assessment was therefore defined as the area where the Bokpoort II project will be developed, as well as the route of the proposed pipeline to the water abstraction point (Figure 1).

The Study Area largely comprises arid grassland, with an area of rocky outcrop at the north-eastern extent of the boundary, whilst the proposed water pipeline will be laid in the existing pipeline servitude along the existing railway line and access road corridor; at this stage no additional natural vegetation clearance for the proposed pipeline is anticipated. As the pipeline approaches the Orange River, it diverts south along an existing access track, finally crossing approximately 200 m of agricultural cultivation and riparian fringe vegetation, to the proposed water abstraction point.

The development of PV1 will cause land cover changes through vegetation clearance, potential direct loss of species of conservation concern, and invasive species introductions, the effects of which will impact species of conservation concern, and the extent of ecosystems of conservation concern including Lower Gariep Alluvial vegetation. Increased presence of people and night-time lighting over the course of the operation of the Project will result in increased sensory disturbance to fauna, reducing the area of foraging habitat available to them.

Although several species of conservation concern have been recorded within the study area, no species that could trigger Critical Habitat as defined by IFC were recorded. The Lower Gariep Alluvial Vegetation mapped along the Orange River potentially qualifies as Critical Habitat, however the riparian area within the Study Area is already transformed by crop production and the existing abstraction point and no longer supports a natural alluvial vegetation community.

Appropriate surface and storm water management is essential for the prevention of serious pollution of aquatic ecosystems downstream of the project with contamination from surface water runoff from the Project footprint.

In particular, construction of the new abstraction point for the proposed water pipeline must be conducted in such a way that any clearance of riparian vegetation is at least minimised and preferably avoided, in order to avoid any loss of intact areas of the endangered ecosystem Lower Gariep Alluvial Vegetation that may be present downstream.

Provided that the recommended mitigation measures are incorporated into the Project environmental management plan, and are enacted and reported upon to the relevant authority throughout the lifetime of the project, the environmental significance of most impacts on biodiversity and ecosystem services can be reduced to environmentally acceptable levels. However, the Project may contribute to cumulative impacts on fauna in the locality through increased incidences of road kill as a result of increased vehicular traffic and the creation of a barrier to normal movement of medium-large mammals and reptiles. It is recommended that the mitigation measures be incorporated into a Biodiversity Management Plan for the Project to assist with biodiversity management throughout the lifetime of the Project and contribute to auditable environmental management systems.

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1.0 INTRODUCTION

ACWA Power Africa Holdings (Pty) Ltd. (the Client) intends to develop a solar energy facility (Bokpoort II) on the north-eastern portion of the Remaining Extent (RE) of the Farm Bokpoort 390, which is 20 km northwest of the town of Groblershoop within the !Kheis Local Municipality in the ZF Mgcawu District Municipality, Northern Cape Province. The total Bokpoort II project area designated for the development is approximately 1 500 ha. The Orange River is located approximately 12 km south-west of the site; water for the proposed Bokpoort II project site will be pumped from the Orange River to the facility via an underground pipeline. The proposed Bokpoort II project site will also have a new water abstraction point. The abstraction point will be in close proximity to the existing Bokpoort I point. The new pipeline will run parallel to the existing Bokpoort I pipeline, within the existing pipeline servitude.

The proposed Bokpoort II project will consist of three (3) applications for environmental authorisation, each having a Scoping Report and an Environmental Impact Assessment Report. ACWA Power is applying for environmental authorisation for two (2) 75 Mega Watt (MW) photovoltaic (PV) facilities and one (1) 150 MW Concentrated Solar Power (CSP) Tower facility. The combined power generation capacity of the entire Bokpoort II solar development will be 300 MW. Each of the solar technologies will have separate associated infrastructure.

This report presents an assessment of the potential impacts of the PV1 Project on terrestrial vegetation and flora, fauna (excluding birds and bats, which have been assessed separately), and aquatic ecosystems and sets out recommendations for their avoidance and reduction, where necessary. The impact assessment has been developed with reference to the baseline surveys initially completed for the Project in 2010 (BEC, 2010) and 2014 (RHDV, 2014a; RHDV, 2014b) . This report presents the results of the biological baseline studies, and uses the results to describe the overall biodiversity value of the Project area. It summarises the data from the baseline biodiversity studies in a way that is appropriate for impact assessment, and consistent with South Africa's national legislation and International Finance Corporation (IFC) requirements. This specialist study report includes the following sections:

- Section 2.0 describes the **terms of reference** for the report;
- Section 3.0 presents the **methods** used for the study that entail examining the study objectives, the approach employed and the limitations encountered;
- Section 4.0 sets out the **legislative background** applicable to the study;
- Section 5.0 summarises the **results** of the baseline studies;
- Section 6.0 assesses the **impacts** to biodiversity;
- Section 7.0 recommends **mitigation and management** measures; and
- Section 8.0 consists of a report **summary and recommendations** based on the results of the impact assessment.

Please note that separate baseline and impact assessment reports have been produced for birds (ARCUS, 2016) and bats (Golder Associates Africa, 2016a); therefore birds and bats are not addressed in this report.

1.1 The Project

The PV1 Project is a 75 Megawatt (MW) Photovoltaic (PV) Solar Development that will consist of the following infrastructure:

- Solar generator comprised of polycrystalline PV modules (JINKO Solar modules JKM 310Wp) that will be able to deliver up to 75 MW to the Eskom National Grid;
- Inverters that convert direct current (DC) generated by the PV modules into alternating current (AC) to be exported to the electrical grid. The inverter is a HSC2160S Solar Station manufactured by Helios Systems. The inverter is an 11.28 m high cube container which includes the DC distribution, the inverter, the medium voltage transformer and the medium voltage switchgear;

- A transformer that raises the system AC low voltage (LV) to medium voltage (MV). The transformer converts the voltage of the electricity generated by the PV panels to the correct voltage for delivery to Eskom;
- Transformer substation; and
- Instrumentation and Control consisting of hardware and software for remote plant monitoring and operation of the facility.

Associated infrastructure includes:

- Mounting structures for the solar panels will be either rammed steel piles or piles with pre-manufactured concrete footings to support the PV panels;
- Cabling between the structures, to be lain underground where practical;
- A new 132 kV overhead power line which will connect the facility to the national grid via Eskom's existing Garona Substation; The powerline will be approximately 5 km in length and will be located within a servitude spanning 50 m on both sides. The powerline towers will be 35 m high;
- Internal access roads (4 – 6 m wide roads will be constructed but existing roads will be used as far as possible) and fencing (approximately 3 m in height); and
- Associated buildings, including a workshop area for maintenance, storage (i.e. fuel tanks, etc.) and offices.

2.0 TERMS OF REFERENCE

The Terms of Reference for the biodiversity impact assessment, as reflected in the Scoping Report (Golder Associates 2015), include:

- Previous biodiversity studies on the Remaining Extent of the Farm Bokpoort 390 contain detailed information as to the ecological attributes of the site, as well as potential negative ecological impacts, as per the 2010 project description (Bokpoort I - 75 MW CSP Parabolic Troughs). The existing biodiversity baseline data for terrestrial and aquatic ecology will form the basis of the assessment and will be updated to reflect the latest ecological databases which have been updated since the initial baseline determination;
- A new biodiversity impact assessment, in the context of the current project description, with particular emphasis on cumulative impacts will be undertaken;
- Any specific identified sensitivities of the site related to the Project and its associated structures and infrastructures will be reported. This will include an identification of any areas to be avoided, including buffers;
- The location of the water abstraction point and the intrusion of the water pipeline into the riparian zone at the Orange River as well as the solar infrastructure footprint and overhead power line to be connected to the Garona Substation will be assessed and mitigation measures recommended;
- The biodiversity impact assessment will include an assessment of the impact of the proposed Project on avifauna, which will be done in accordance with the Guidelines to Minimise the Impact on Birds of Solar Facilities and Associated Infrastructure in South Africa released by BirdLife in 2014. ***Please note that this is provided as a separate study report (ARCUS, 2016)***;
- A professional opinion on the assessment of the impact and recommended mitigation measures on aquatic ecology will be included for the water pipeline abstraction point; and
- A Biodiversity Management Plan will be included in the Environmental and Social Management Systems; however if offsetting is required for predicted impacts on biodiversity, a Biodiversity Action Plan will be developed instead, as per International Finance Corporation (IFC) requirements.

2.1 Objectives

The aim of this biodiversity assessment was to collate baseline data of sufficient scope that could be used to characterise the baseline conditions of the area and assess how the Project could affect that biodiversity. This was undertaken in consideration of South Africa's national legislation and policy pertaining to biodiversity (ref. section 4.1) and with reference to the IFC Performance Standard 6 (ref. section 4.3), which seeks to protect biodiversity and ecosystem services from the adverse impacts of project activities, and support its conservation and sustainable use. Consequently, the objectives of the biodiversity impact were to:

- Characterise the ecological integrity of the terrestrial and aquatic ecosystems in the Project's area of influence;
- Identify sensitive or unique habitats and species (as protected under South African legislation and international obligations), which could suffer irreplaceable loss due to the Project;
- Identify species of concern that could trigger critical habitat (as defined by IFC PS6);
- Identify populations and trends of exotic and invasive species in the Project's area of influence;
- Identify and describe potential sources of risk and impact associated with the development that could affect biodiversity of the Project's area of influence;
- Identify the potential direct, indirect and cumulative effects on biodiversity associated with the Project;
- Recommend suitable mitigation measures where applicable;
- Develop a monitoring programme and management/action plan for the biodiversity affected by the Project's development; and
- Recommend measures for ongoing monitoring for biodiversity features affected by the Project's development.

2.2 Assumptions and Limitations

- This assessment is a desk-based study, informed by the data gathered as part of the biodiversity baseline assessments previously conducted for the Bokpoort development (RHDV, 2014a, 2014b; BEC 2010), and ground-truthing conducted during a site visit from 21/09/2015 – 23/09/2015; and
- No stakeholder engagement or consultation process regarding biodiversity issues was undertaken as part of this study.

3.0 APPROACH AND METHODS

This section presents the methods used in this study report to identify any important biodiversity within the Study Area.

The study comprised a desktop study of existing information that included previous baseline reports for the Study Area (DHV 2014a; DHV 2014b; BEC, 2010) and supplementary field studies conducted to address identified gaps in the baseline dataset for the Project. A review of national and international law, policies, agreements and standards pertaining to biodiversity in South Africa and the Northern Cape was also conducted. These included South African national law and policies, international conventions and treaties. The review of this documentation in section 4.0 highlights relevant legislative and policy requirements that must be met in order to satisfy biodiversity protection objectives, and achieve the desired biodiversity outcomes.

3.1 Study Area

The primary effect on biodiversity arising from the Project will be loss in extent of ecosystems due to site clearance and groundworks. These works are unlikely to be limited to the exact footprint of PV1 in isolation, therefore impacts are considered as occurring within the extent of the Bokpoort II boundary.

The proposed pipeline will be constructed within the existing cleared servitude for the Bokpoort I pipeline and will not result in any new areas of additional land-take, therefore no assessment of the current baseline environment or proposed impacts associated with the new pipeline was conducted. The proposed Bokpoort II project site will have a new water abstraction point, which will be constructed in close proximity to the existing Bokpoort I point, which is located at approximately S -28.805248°, E 21.884447°.

The local study area for this impact assessment was therefore defined as the area where the Bokpoort II project will be developed, as well as the location of the proposed water abstraction point in close proximity to the existing abstraction point (Figure 1).

3.2 Desktop Review and Gap Analysis

A comprehensive literature review of available information on biodiversity features within the Study Area was conducted. The following tasks were undertaken:

- Review of available literature and GIS information on baseline biodiversity conditions within the Study Area, and ecosystem services supplied. Reviewed data included biodiversity baseline data gathered within the Study Area for aspects of the Bokpoort I development (RHDV, 2014a; RHDV, 2014b; BEC, 2010). Other information that was reviewed included IUCN Red Data lists for the Northern Cape, South Africa and any available information on nearby protected areas; and
- An assessment of available baseline data and information and in order to identify data gaps was conducted, highlighting the additional data required to be gathered as part of the baseline phase, in addition to those already identified in the previous studies.

Sensitive species and habitats and existing threats in the context of the biodiversity within the Study Area were identified through review of background biodiversity and environmental reports relating to the site, available published biodiversity literature, consideration of South Africa's national and Northern Cape's provincial biodiversity legislation and policies, Non-Governmental Organisation (NGO) opinion and guidance documentation, and through application of the expertise of the biodiversity impact assessment team. Refer to section 6.1.

3.3 Baseline Data Gathering

A site visit was conducted from 21/09/2015 – 23/09/2015 to ground-truth aspects of the previous assessment of vegetation communities conducted in 2010 and 2014, and assess the current extent of use of the Study Area by fauna. The following tasks were completed:

- Detailed field surveys have been conducted within the Study Area on several occasions (RHDV, 2014a; RHDV, 2014b; BEC, 2010), and little transformation of the area has taken place in the interim. Therefore, limited additional ground-truthing of vegetation communities was conducted during the 2015 site visit;
- Evaluation of the likelihood of presence of flora and fauna species of conservation concern within the Study Area that were preliminarily identified as potentially occurring, through habitat suitability assessment; and
- Bat monitoring of the Study Area was conducted by active monitoring of echolocation calls, using a driven transect method. Full survey results and bat impact assessment are provided in a separate report (Golder Associates Africa, 2016b).

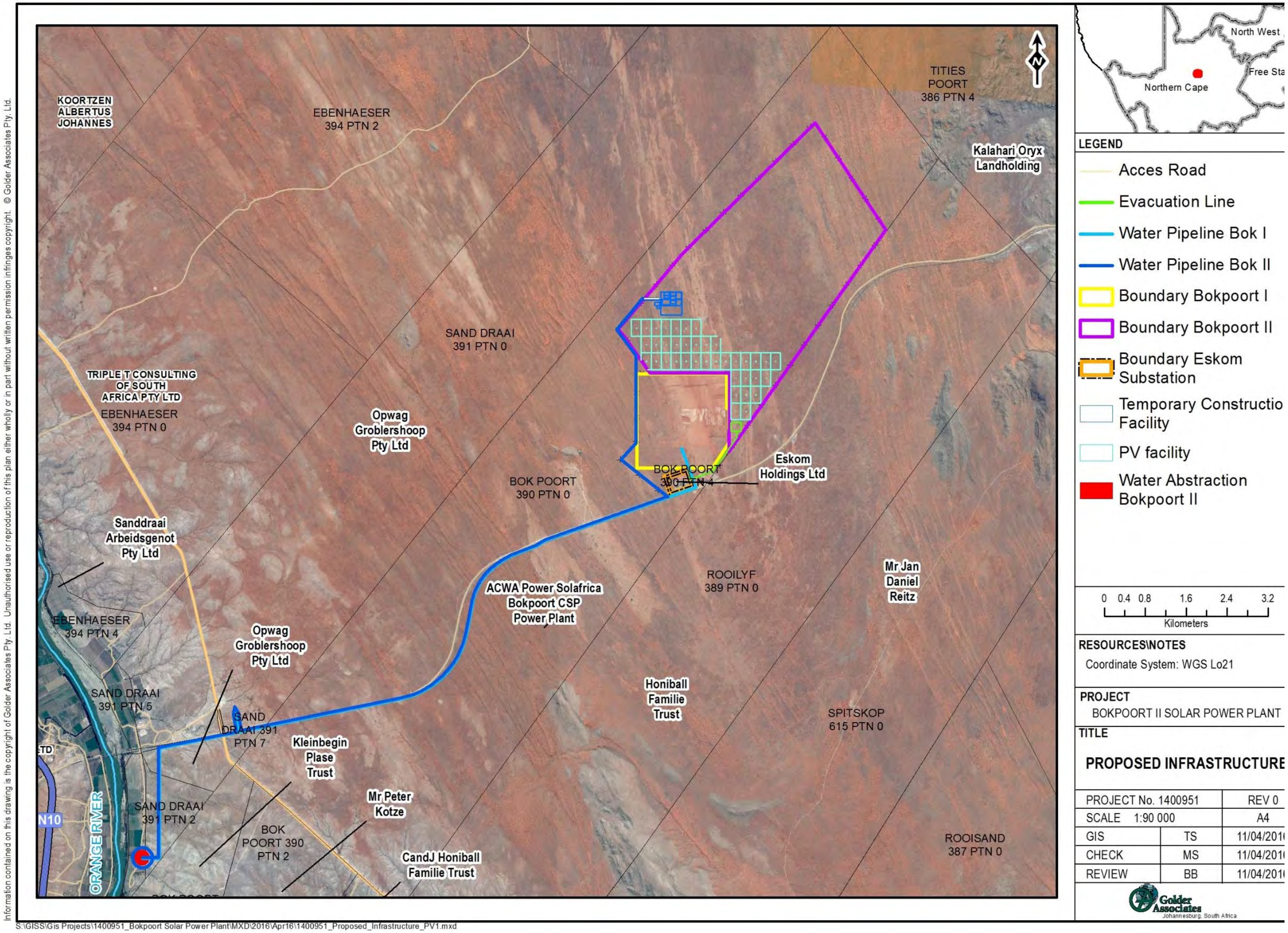

Figure 1: Study area

3.4 Assessment of Biodiversity Value

3.4.1 Ecosystems of Conservation Concern

Habitats were preliminarily defined as being either natural or modified, based on the International Finance Corporation (IFC) approach to assigning value to biodiversity (IFC PS6, 2012). For this impact assessment, natural habitats were defined as those habitats where the key processes, composition, and structure were largely intact, and modified habitats were defined as areas that have been altered by human activity and may contain large portions of non-native plants and animals (e.g. agricultural landscapes).

The ecological integrity of ecosystems and habitats was estimated (based on criteria including species diversity, habitat heterogeneity, presence of habitat linkages, representativeness and resilience) and assigned a subjective class: pristine, near-pristine, slightly-degraded, moderately-degraded, and heavily-degraded.

3.4.2 Species of Conservation Concern

Although all species occurring within an area of interest form a component of the overall biodiversity and ecological value, it is neither practicable, nor necessary, to assess potential effects of a project on every species that might be affected. Therefore, species of concern are defined as a plant or animal species that requires special conservation consideration based on certain characteristics, or one which may be particularly sensitive to project effects.

The following selection criteria were used to identify terrestrial species of concern for the assessment:

a) Threatened and restricted-range/endemic species;

b) Statutory species (protected by national/international legislation, agreements, conventions);

c) ‘Specially protected’ and ‘Protected’ species listed on Schedules I and II of the Northern Cape Nature Conservation Act 2009 (ref. section 4.1.2);

d) Species of economic and/or cultural importance;

e) Convention on the International Trade in Endangered Species (CITES)-listed species;

f) Evolutionarily distinct species;

g) Species that play a critical ecological role, represent guilds of species, or capture effects to other species with similar habitat requirements and sensitivities;

h) Vulnerable (VU) species where there is uncertainty regarding the IUCN listing, and the actual status of the species may be critically endangered (CR) or endangered (EN); and

i) Species new or little-known to science.

Predicted effects of the Project on species of conservation concern **confirmed** present and/or whose likelihood of presence is ‘**Probable’** are specifically addressed in the impact assessment.

3.4.3 Natural, Modified and Critical Habitat

Natural and modified habitats were mapped using the results of the previous vegetation assessments conducted for the Bokpoort development (BEC, 2010 & RDHV, 2014) to identify existing pressures on habitats within the study area, and assign natural and modified statuses. The determination of natural vs modified status is made based on the level of human-induced disturbance (e.g., presence of invasive species, level of pollution, extent of habitat fragmentation, viability of existing naturally-occurring species assemblages, resemblance of existing ecosystem functionality and structure to historical conditions, degree of other types of habitat degradation, etc.) and the biodiversity values of the site (e.g., threatened species and ecosystems, culturally important biodiversity features, ecological processes necessary for maintaining nearby critical habitats) (IFC 2012).

The potential presence of critical habitat as defined by IFC PS6 was screened through a comparison of the quantitative and qualitative IFC critical habitat determination criteria against the identified biodiversity values supported within the Study Area. This approach provides a high level determination of whether critical habitat exists, and if so, whether it could be impacted by the Project and its area of influence.

3.5 Impact Assessment

The significance of the identified impacts will be determined using the approach outlined below (terminology from the Department of Environmental Affairs and Tourism Guideline document on EIA Regulations, April 1998). This approach incorporates two aspects for assessing the potential significance of impacts, namely probability of occurrence and severity, which are further sub-divided as follows:

Occurrence		Severity	
Probability of occurrence	Duration of occurrence	Scale/extent of impact	Magnitude (severity) of impact

To assess each of these factors for each impact, the following four ranking scales are used:

Probability	Duration
5 - Definite/don't know	5 - Permanent
4 - Highly probable	4 - Long-term
3 - Medium probability	3 - Medium-term (8 - 15 years)
2 - Low probability	2 - Short-term (0 - 7 years) (impact ceases after the operational life of the activity)
1 - Improbable	1 – Immediate
0 - None	
Scale	**Magnitude**
5 - International	10 - Very high/don't know
4 - National	8 - High
3 - Regional	6 - Moderate
2 – Local	4 - Low
1 - Site only	2 - Minor
0 - None	

Once these factors are ranked for each impact, the significance of the two aspects, occurrence and severity, is assessed using the following formula:

- **SP (significance points) = (magnitude + duration + scale) x probability.**

The maximum value is 100 significance points (SP). The impact significance will then be rated as follows:

SP	Significance	Description
SP >75	Indicates high environmental significance	An impact which could influence the decision about whether or not to proceed with the project regardless of any possible mitigation.
SP 30 – 75	Indicates moderate environmental significance	An impact or benefit which is sufficiently important to require management and which could have an influence on the decision unless it is mitigated.
SP <30	Indicates low environmental significance	Impacts with little real effect and which should not have an influence on or require modification of the project design.
+	Positive impact	An impact that constitutes an improvement over pre-project conditions.

4.0 LEGISLATIVE AND POLICY CONTEXT

4.1 Applicable South African Legislation and Policy

This report is written in accordance with the terms of reference for specialist investigations to be conducted during the impact assessment phase, as set out in the NEMA EIA Regulations 2014. In addition, the biodiversity-related legislative instruments and policies discussed in the following sections are addressed in this report.

4.1.1 National Environmental Management Act: Biodiversity Act (2004)

The over-arching government policy on natural resource conservation in South Africa is provided for in the National Environmental Management Act: Biodiversity Act (Act No. 10 of 2004). The relevant constitutional provisions in the Act include the following:

- **Chapter 3 - Biodiversity Planning and Monitoring**: Provides for integrated and co-ordinated biodiversity planning, including the National Biodiversity Framework (see below); Bioregional plans, Biodiversity management plans and agreements, monitoring of the conservation status of various components of South Africa’s biodiversity, and promotion of research on biodiversity conservation including the sustainable use, protection and conservation of indigenous biological resources; and
- **Chapter 4 - Threatened or Protected Ecosystems and Species**: Provides for the protection of ecosystems and species that are threatened or in need of protection; gives effect to South Africa’s obligations under international agreements regulating trade in endangered species; and ensures that utilisation of biodiversity is managed in an ecologically sustainable way.

Project Relevance

The Project must demonstrate that it has taken appropriate measures to avoid/minimise any potential impacts on biodiversity within the Study Area, and where necessary, implement an invasive species management plan as part of the mitigation actions for potential effects on biodiversity within the Study Area. In addition, it should avoid significant effects on areas identified as Endangered within the Study Area, such as those linked to the riparian zone of the Orange River (Figure 2).

4.1.1.1 South Africa’s National Biodiversity Framework (2008)

South Africa’s National Biodiversity Framework (NBF) is a requirement of the National Environmental Management Act: Biodiversity Act, 2004 (ref. section 4.1.1). The NBF is informed by the National Biodiversity Strategy and Action Plan (NBSAP) (ref section 4.1.1.2) and the National Spatial Biodiversity Assessment (NSBA) (ref section 4.1.1.3), and provides a framework for implementation of the conservation and development objectives of the NBSAP and the NSBA.

Project Relevance

The NBF defines five major pressures on South Africa’s biodiversity, including loss and degradation of natural habitat, spread of invasive alien species, over-harvesting of species, over-abstraction of water and climate change.

Solar power is an industrial sector whose activities could contribute substantially to over-abstraction of water and invasive species introduction and spread through site clearance and earthworks prior to construction. The Project must therefore demonstrate that it has taken appropriate measures to avoid/minimise any potential impacts on baseline water quality and quantity in the Orange River, and where necessary, implement an invasive species management plan as part of the mitigation actions for potential effects on vegetation communities within the Study Area.

4.1.1.2 South Africa’s National Biodiversity Strategy and Action Plan (2005)

The NBSAP is a long-term (20 year) strategy for the conservation and sustainable use of South Africa’s biodiversity. The overall goal of the NBSAP is to conserve and manage terrestrial and aquatic biodiversity to ensure sustainable and equitable benefits to the people of South Africa.

It identifies five Strategic Objectives (SO) required to achieve that goal, of which SO1, SO3 and SO5 directly relate to biodiversity management and conservation:

- **SO1**: An enabling policy and legislative framework integrates biodiversity management objectives into the economy;
- **SO3**: Integrated terrestrial and aquatic management across the country minimises the impacts of threatening processes on biodiversity, enhances ecosystem services and improves social and economic security; and
- **SO5:** A network of conservation areas conserves a representative sample of biodiversity and maintains key ecological process across the landscape.

The NBSAP is a useful policy guide for addressing South Africa's concerns in biodiversity conservation and the utilisation of its components, as well as for implementation of the requirements of the Convention on Biological Diversity (see section 4.2).

Project Relevance

The NBSAP promotes integrated terrestrial and aquatic management in order to minimise the impacts of threatening processes on biodiversity, enhance ecosystem services and improve social and economic security, sustainable use of biological resources, and maintenance of a network of conservation areas to conserve a representative sample of biodiversity and maintain key ecological process across the landscape. Through appropriate biodiversity survey, impact assessment and management, the Project can contribute to achieving the National biodiversity conservation aims outlined in the NBSAP.

4.1.1.3 National Spatial Biodiversity Assessment (2004)

The NSBA was the first comprehensive spatial assessment of biodiversity throughout South Africa, intended to inform policies and plans of both public and private-sector bodies with reference to biodiversity issues. It focusses on mainstreaming biodiversity priorities throughout the economy and making links between biodiversity and socio-economic development; with the intention of enabling these to reinforce each other so that conserving biodiversity strengthens the economy and contributes to social development.

Project Relevance

The spatial assessment generated several map products including terrestrial ecosystem status, priority conservation areas and protected areas. These maps will be viewed in the context of the Project to determine any potential impacts the Project may have on terrestrial and riparian ecosystems and ensuing effects on ecosystem service supply by those systems.

4.1.2 Northern Cape Nature Conservation Act (2009)

The Northern Cape Nature Conservation Act (NCNCA, 2009) provides for the sustainable utilisation of wild animals, aquatic biota and plants, and the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), to which South Africa is a signatory. Schedule 1 to the act lists '*specially protected animals*' and Schedule 2 lists '*protected animals'* for which certain activities are restricted. The main difference between '*specially protected*' and '*protected species*' is that '*protected*' species can be '*possessed*' without a specific permit, and hunting is allowed under certain conditions (permits, seasons, bag limits), whereas '*specially protected*' species cannot be possessed or hunted except under exceptional circumstances.

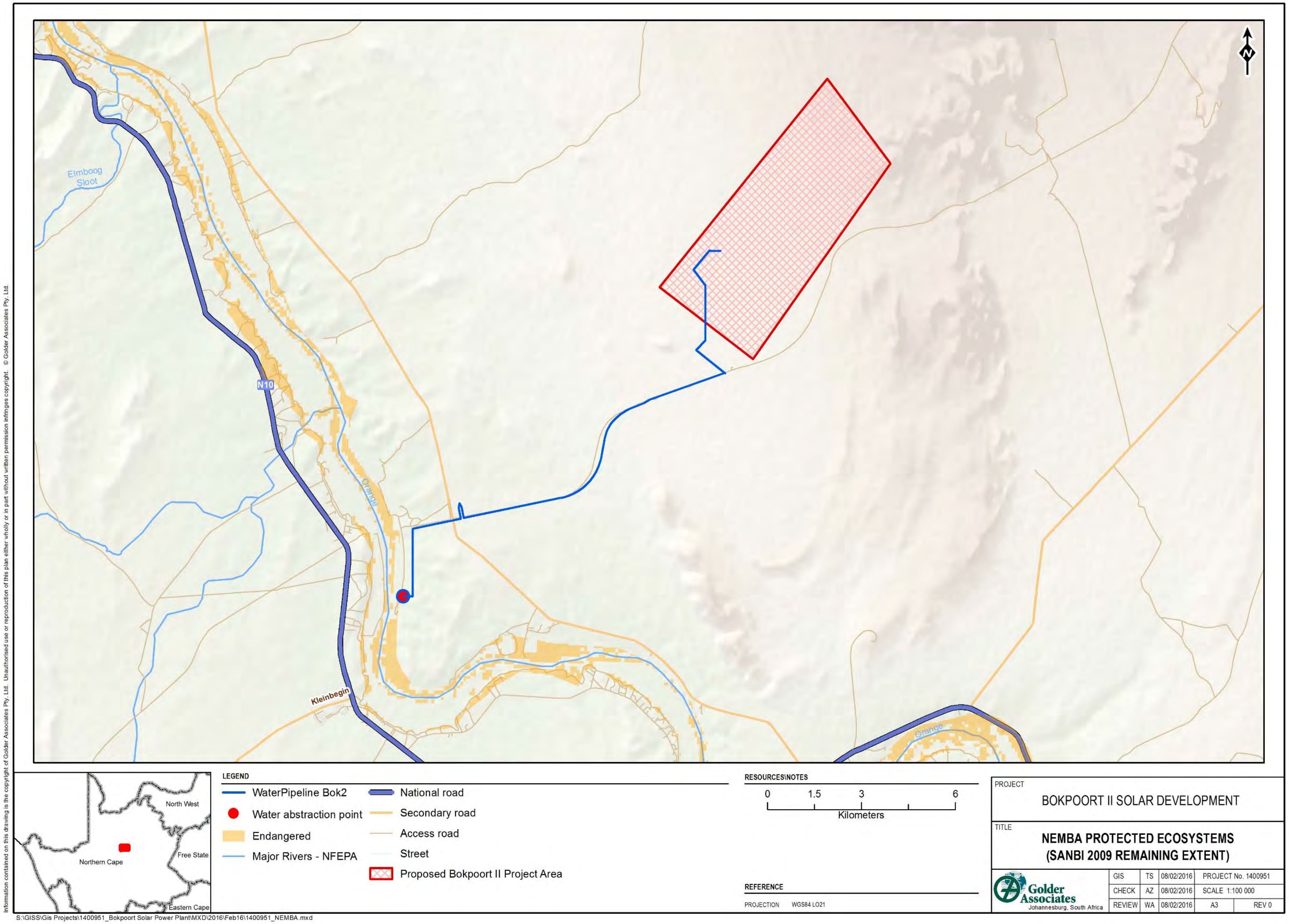

Figure 2: NEMBA-protected ecosystems

4.2 Conventions and International Agreements

South Africa is a signatory to the following international conventions and agreements:

- Convention on Biological Diversity: Under the convention, each contracting party is expected to develop national strategies, plans or programs for the conservation and sustainable use of Biological diversity (see NBSAP – section 4.1.1.2);
- Convention on International Trade in Endangered Species (CITES);
- Convention on the Conservation of Migratory Species of Wild Animals, (the Bonn Convention):
  - South Africa is a Contracting Party to the African-Eurasian Water-bird Agreement (AEWA).
- Convention on Wetlands of International Importance (the Ramsar Convention); and
- UNESCO World Heritage Commission.

Project Relevance

The Project will need to demonstrate alignment with the provisions of the conventions and agreements in order to satisfy Government obligations as a signatory to these. This can be achieved through identifying biodiversity value of the Study Area, and in particular restricting impacts on CITES-listed species, migratory species and wetlands by ensuring that internationally recognised practices for the protection, field-based study, and documentation of these biodiversity components are implemented throughout the ESIA and the lifetime of the Project.

4.3 IFC Performance Standards 2012

At the project financing level, the assessment and management of biodiversity is largely dealt with in Performance Standard 6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC, 2012); the PS is briefly summarised as follows.

PS 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources

Performance Standard 6 (PS6), and the associated Guidance Note (GN6) relates to:

- The protection and conservation of biodiversity;
- Maintenance of ecosystem services; and
- Sustainable management of living natural resources.

The requirements set out in PS6 have been guided by the Convention on Biological Diversity. PS6's main priority is that the Project should seek to avoid impacts on biodiversity and ecosystem services. When avoidance of impacts is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented.

However, when a project occurs in critical habitat supporting exceptional biodiversity value, a net gain in biodiversity value is required.

PS6 sets specific biodiversity protection and conservation standards relating to potential project impact. The specific requirements that may apply to this Project are summarised below according to the PS6 categories:

- **Modified Habitat**: Areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. PS6 relates to areas of modified habitat that have significant biodiversity value, and requires that impacts on such biodiversity must be minimised, and mitigation measures implemented as appropriate;

- **Natural Habitat**: Viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition. In such areas, the conservation outcome required by PS6 is no-net-loss of biodiversity **value** achieved using biodiversity offsets;
- **Critical Habitat**: Areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes. When a project occurs in critical habitat, a net gain in biodiversity value is required by PS6. This is achievable through appropriate biodiversity offsets;
- **Legally Protected Areas**: Such areas often have high biodiversity value; when this is the case these areas are likely to qualify as critical habitat and, as such, the conservation outcome required by PS6 is also a net gain in biodiversity value, as well as obtaining the relevant legal permits, following standard governmental regulatory procedures, and engagement of affected communities and other stakeholders;
- **Invasive Alien Species**: The development project should not intentionally introduce any new alien species (unless carried out within the appropriate regulatory permits) and should not deliberately introduce any alien species with a high risk of invasive behaviour under any circumstance. The project should *implement measures to avoid* the potential for accidental or unintended introductions; and
- **Management of Ecosystem Services**: where a project is likely to adversely impact ecosystem services, an *ecosystem service review to identify priority ecosystem services* is required. For a full assessment of ecosystem services within the Study Area, see Golder Associates (2016).

Project Relevance

In the case of its direct investments (including project and corporate finance provided through financial intermediaries), the IFC requires its clients to apply the Performance Standards to manage environmental and social risks and impacts so that development opportunities are enhanced. Together, the Performance Standards establish standards that the Project is to meet throughout the life of an investment by IFC. As stated above, Performance Standard 6 requires that Projects seek to avoid impacts on biodiversity and ecosystem services. When avoidance of impacts is not possible, measures to minimise impacts and restore biodiversity and ecosystem services should be implemented. Therefore, in order to secure Project funding from IFC or associated lending institutions, the Project must demonstrate that it is in compliance with the requirements of PS 6.

5.0 BASELINE BIODIVERSITY CHARACTERISATION

The Bokpoort II area largely comprises arid grassland, with an area of rocky outcrop at the north-eastern extent of the boundary, whilst the proposed water pipeline will be laid inside an existing pipeline servitude along the existing railway line and access road corridor; at this stage no additional natural vegetation clearance for the proposed pipeline is anticipated. As the pipeline approaches the Orange River, it diverts south along an existing access track, finally crossing approximately 200 m of agricultural cultivation and riparian fringe vegetation, to the proposed water abstraction point.

The following sections are based on the results of the desktop review, as well as the baseline studies previously conducted within the Study Area (RHD, 2014; BEC, 2010).

Additional data gathered during the 2015 survey relates particularly to bats and ecosystem services which are addressed in separate reports (Golder Associates Africa, 2016a; Golder Associates Africa, 2016b).

5.1 Vegetation and Flora - Regional Context

The Study Area is located in a transitional area that includes elements of both the Savanna Biome and the Nama Karoo Biome. The Savanna Biome is defined by the co-dominance of grasses and trees *(Sankaran et al.* 2005), and is the largest biome in South Africa, covering approximately 35% of the country's land surface (Scholes & Walker 1993).

Savannas are described as a patch-mosaic landscapes, comprising patches of grassland, scattered trees or closed woodlands, the relative proportions of which vary both spatially and temporally (Bond, 2008). Primary determinants of Savanna composition, structure and functioning include fire, a distinct seasonal climate, substrate type (soils), as well as browsing and grazing by large herbivores (Scholes & Walker 1993; Bond 2008). The Nama Karoo Biome, the second largest biome in Southern Africa, is characterised by plains of dwarf shrubs and grasses, dotted with characteristic 'koppies' (rocky outcrop). It is essentially a grassy, dwarf shrubland; the ratio of grasses to shrubs increases progressively until the Nama Karoo merges with the Savanna Biome (Mucina & Rutherford, 2006).

Two principal natural vegetation types are predicted for the Study Area (Mucina & Rutherford 2006); Kalahari Karroid Shrubland and Gordonia Duneveld - with Bushmanland Arid Grassland and Lower Gariep Alluvial Vegetation being traversed by the pipeline (Figure 3). The characteristics of the relevant vegetation types are discussed in the following sections.

The specialist studies conducted for the Bokpoort I project did not identify any wetlands within the study area. The presence of a seasonal pan within the Study Area was mentioned in passing in the EIA report and without reference. We are in agreement with the specialist that conducted the work for the Bokpoort I project, that no seasonal pan was identified during the site assessment. Therefore no wetland assessment is included in this biodiversity impact assessment.

5.1.1 Kalahari Karroid Shrubland

Kalahari Karroid Shrubland occurs in bands, alternating with Gordonia Duneveld to the north of Upington. Other patches occur around Kakamas and north of Groblershoop (Mucina & Rutherford 2006). Approximately 250 Ha of this vegetation type will be lost to the footprint of the PV1 development.

Vegetation and landscape features

- Low, karroid shrubland on flat, gravel plains (Mucina & Rutherford 2006).

Important plant taxa

Mucina & Rutherford (2006) note the following species as important taxa in the Kalahari Karroid Shrubland vegetation type:

- **Trees**: Acacia mellifera, Parkinsonia africana and Boscia foetida subsp. Foetida;
- **Shrubs**: *Rhigozum trichotomum, Tapinanthus oleifolius, Hermannia spinosa, Limeum aethiopicum, Phaeoptilum spinosum, Aizoon schellenbergii, Aptosimum albomarginatum, Aptosimum lineare Aptosimum marlothii, Aptosimum spinescens, Barleria rigida, Hermannia modesta, Indigofera heterotricha, Monechma genistifolium, Phyllanthus maderaspatensis, Polygala seminuda, Sericocoma avolans, Solanum capense and Tephrosia dregeana*;
- **Grasses**: *Aristida adscensionis, Aristida congesta, Enneapogon cenchroides, Enneapogon desvauxii, Enneapogon scaber, Eragrostis homomalla, Stipagrostis ciliata, Stipagrostis obtusa, Stipagrostis uniplumis, Eragrostis annulata, Eragrostis porosa and Tragus berteronianus*; and
- **Herbs**: *Dicoma capense, Chamaesyce inaequilatera, Amaranthus praetermissus, Barleria lichtensteiniana, Chamaesyce glanduligera, Chascanum garipense, Cleome angustifolia, Cucumis africanus, Geigeria ornativa, Hermannia abrotanoides, Indigastrum argyraeum, Indigofera alternans, Kohautia cynanchica, Limeum argute-carinatum, Mollugo cerviana, Monsonia umbellata Sesamum capense*.

5.1.2 Gordonia Duneveld

Gordonia Duneveld occurs in large dune fields around the Kgalagadi Transfrontier Park and into Botswana and in dune cordons south of the Orange River near Keimoes and between Upington and Putsonderwater (Mucina & Rutherford 2006).

Vegetation and landscape features

Parallel dunes characterised by open shrubland with ridges of grassland dominated by *Stipagrostis amabilis. Acacia haematoxylon* grows on dune slopes, with *Acacia mellifera* and *Rhigozum trichotomum* on lower slopes and interdune straaten (Mucina & Rutherford 2006).

Important plant taxa

Mucina & Rutherford (2006) note the following species as important taxa in the Gordonia Duneveld vegetation type:

- **Trees**: *Acacia mellifera*;
- **Shrubs**: *Grewia flava, Rhigozum trichotomum, Aptosimum albomarginatum, Monechma incanum, Requienia sphaerosperma, Lycium bosciifolium, Lycium pumilum, Talinum caffrum*;
- **Grasses**: *Schmidtia kalahariensis, Brachiaria glomerata, Bulbostylis hispidula, Centropodia glauca, Eragrostis lehmanniana, Stipagrostis ciliata, Stipagrostis obtusa, Stipagrostis uniplumis*; and
- **Herbs**: *Hermbstaedtia fleckii, Acanthosicyos naudinianus, Hermannia tomentosa, Limeum arenicolum, Limeum argute-carinatum, Oxygonum dregeanum, Sericorema remotiflora, Sesamum triphyllum and Tribulus zeyheri*.

5.1.3 Koranna-Langeberg Mountain Bushveld

The vegetation and landscape features of this unit include rugged mountains and steep slopes in parts of the Korannaberg but with few cliffs in the Langeberg to the south.

Generally supporting open shrubland with moderately open grass cover. *Croton gratissimus* is common in places, becoming particularly diminutive south of the Langeberg. The conservation status of this unit is regarded Least Threatened. None is conserved in statutory conservation areas, but is partly conserved in private reserves such as the Tswalu Kalahari Reserve. Virtually none of this unit is transformed. This unit forms the first, almost unbroken mountain barrier to the east of the Kalahari on the Gordonia plains.

Biogeographically important species include the low shrub *Justicia puberula* and the graminoid *Digitaria polyphylla.*

5.1.4 Bushmanland Arid Grassland

Bushmanland Arid Grassland extends from Aggeneys in the west to Prieska in the east. The southern border of the vegetation type is marked by the Bushmanland Basin, while the northern border is defined by the start of desert vegetation (i.e. Kalahari Karroid Shrubland and Gordonia Duneveld) (Mucina & Rutherford 2006).

Vegetation and landscape features

Topography is characterised large to irregular plains on a sloping plateau. Vegetation is dominated by open grassland dominated by *Stipagrostis* species, with occasional low *Sasola* shrubs (Mucina & Rutherford 2006).

Important plant taxa

Based on Mucina & Rutherford's (2006) vegetation classification, important plant taxa are those species that have a high abundance, a frequent occurrence (not being particularly abundant) or are prominent in the landscape within a particular vegetation type. They note the following species as some of the important taxa in the Bushman Arid Grassland vegetation type:

- **Trees**: *Acacia mellifera and Boscia foetida subsp. foetida*;
- **Shrubs**: *Lycium cinereum, Rhigozum trichotomum, Cadaba aphylla, Parkinsonia africana, Aptosimum elongatum, Aptosimum lineare, Aptosimum marlothii, Barleria rigida, Berkheya annectens, Blepharis mitrata, Eriocephalus ambiguus, Limeum aethiopicum, Monechma incanum, Pentzia pinnatisecta, Pteronia leucoclada, Pteronia mucronata, Pteronia sordida, Salsola tuberculata and Salsola glabrescens*;

- **Grasses**: *Aristida adscensionis, Aristida congesta, Enneapogon desvauxii, Enneapogon scaber, Eragrostis nindensis, Schmidtia brevifolia, Schmidtia kalahariensis, Stipagrostis ciliata, Stipagrostis obtusa, Stipagrostis uniplumis, Eragrostis annulata, Eragrostis porosa, Eragrostis procumbens, Panicum lanipes, Setaria verticillata and Tragus berteronianus*; and
- **Herbs**: *Acanthopsis hoffmannseggiana, Aizoon canariense, Amaranthus praetermissus, Barleria lichtensteiniana, Chamaesyce inaequilatera, Dicoma capensis, Indigastrum argyraeum, Lotononis platycarpa, Sesamum capense, Tribulus pterophorus, Tribulus terrestris and Vahlia capensis*.

5.1.5 Lower Gariep Alluvial Vegetation

Lower Gariep Alluvial Vegetation is a distinct vegetation class particularly associated with the riparian corridor of the Orange River. It consists of a complex of riparian thickets and reed beds with flooded grasslands and herb lands along sandbanks and terraces (Mucina & Rutherford, 2006). As discussed further below, it is important to note that this vegetation type is classified as an **Endangered** terrestrial ecosystem under NEMBA (ref. section 4.1.1, and Figure 2), largely due to transformation for agricultural cultivation (vegetables and grapes) and alluvial diamond mining; in addition, the invasive species *Prosopis* spp., *Nicotiana glauca* and *Argemone ochroleuca* occur in many areas (Mucina & Rutherford, 2006). A small area within this vegetation classification will be traversed by the proposed pipeline, adjacent to the abstraction point.

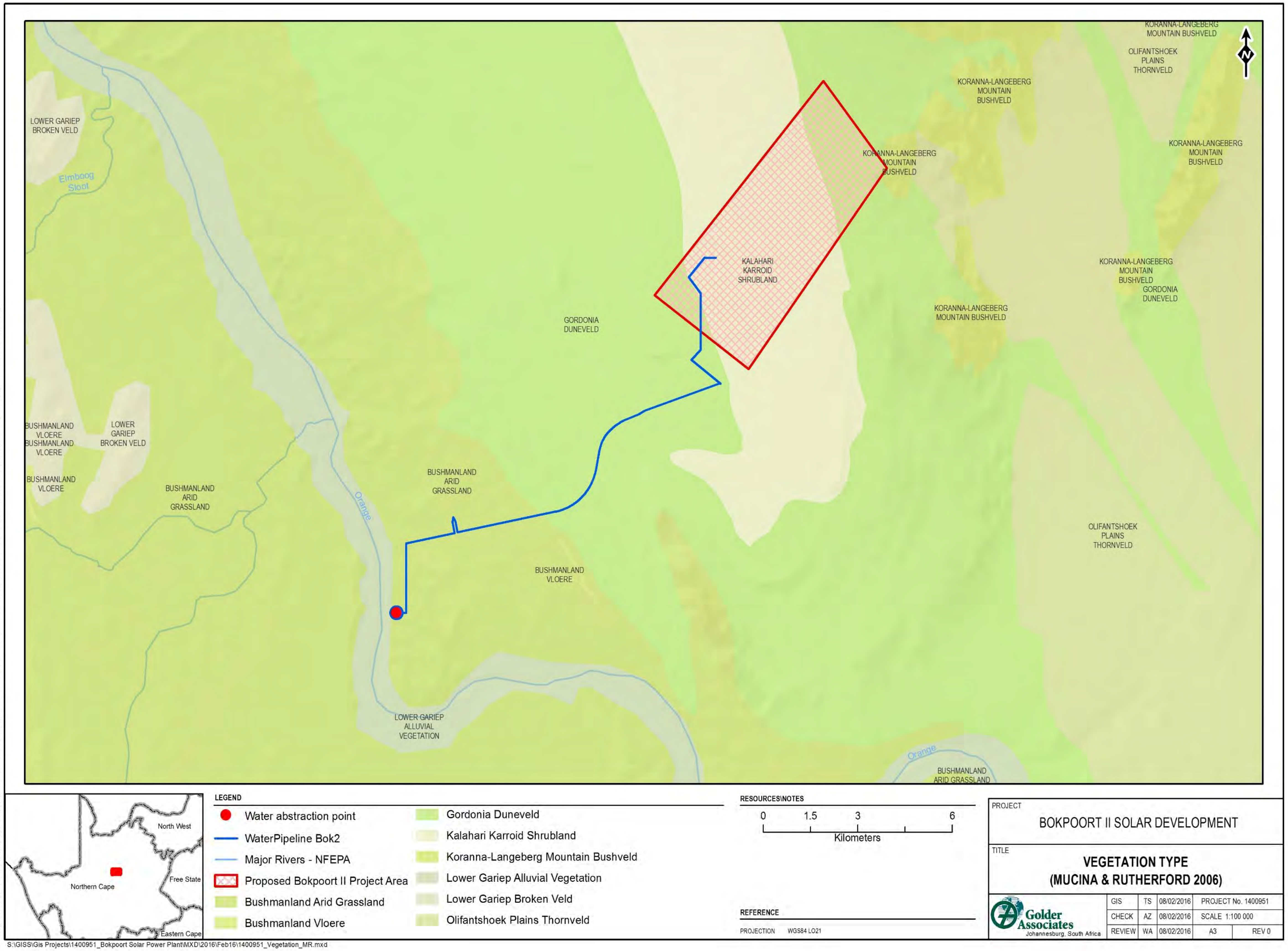

Figure 3: Vegetation classification (Mucina & Rutherford, 2006)

5.2 Vegetation and Flora Assessment of Study Area

5.2.1 Infrastructure Footprint

The Study Area is largely untransformed, consisting of natural 'Low Shrubland' land cover interspersed with patches of Grassland and Thicket/Dense Bush (Figure 8). The northern part of the Study Area is characterised by undulating dune hills which support the Gordonia Duneveld vegetation type, while the southern area adjacent to the existing facility consists of flat plains characterised by Kalahari Karroid Shrubland. The Study Area is currently (September 2015) grazed by sheep and goats; some areas of over-grazing was evident, most likely as a result of dry end-of-winter conditions experienced during the September 2015 field trip.

The vegetation communities of the Study Area were described in detail in the previous baseline biodiversity studies (RHDV, 2014; BEC, 2010). These descriptions are summarised in the following paragraphs, and the vegetation communities are illustrated on Figure 9.

Calcareous Low Shrub Plains

The topography of these areas are characterised by relative flat or slightly undulating plains (Figure 4). The underlying soils consist of whitish calcareous and compact sandy soils that are grey-brown in colour. The vegetation is characterised by low shrubs and grasses; tall shrubs and trees are generally absent from this unit, or occur infrequently. Prominent species include the grasses *Enneapogon desvauxii, Eragrostis obtusa, Eragrostis truncata, Fingerhuthia africana, Stipagrostis ciliata,* the shrub *Salsola etoshensis* and the forbs *Pentzia calcarea, Eriocephalus spinescens, Monechma genistifolium subsp. australe, Geigeria* sp. The shrubs *Rhigozum trichotomum* and *Lycium horridum* were observed in this unit.

Figure 4: Calcareous low shrub plains

The status of these areas appears to be relatively degraded due to grazing pressure from sheep and other livestock; a moderate ecological integrity status is therefore ascribed.

Open Shrub Plains

Open shrub plains occupy the majority of the Study Area. Biophysical attributes include open plains (flat or slightly undulating) with high shrubs and scattered trees on deep sandy, red soils or gravel plains and a well-developed herbaceous layer (Figure 5).

Figure 5: Open shrub plains, with duneveld visible in the background

The species diversity is relatively low; only 24 species were observed during the 2010 survey (BEC, 2010). Prominent tall woody species in this undulating landscape are *Acacia erioloba, A. mellifera, Parkinsonia africana*, *Grewia flava* and *Boscia albitrunca.* Low shrubs include *Lebeckia linearifolia, Lycium bosciifolium, Rhigozum trichotomum* and *Salsola etoshensis.* Conspicuous grass species include *Schmidtia kalahariensis, Eragrostis lehmanniana* and *Stipagrostis ciliata*. Prominent forb species include *Monechma genistifolium subsp. genistifolium* and *Indigofera* spp.

This habitat type is representative of the regional vegetation type Kalahari Karroid Shrubland (Mucina & Rutherford, 2006; Figure 3), which typically forms bands alternating with bands of Gordonia Duneveld. Due to similar grazing pressures in this vegetation community, a moderate floristic status is ascribed to this unit.

Open Shrub Duneveld

This vegetation unit is characterised by the presence of low dunes with crests, slopes and streets, with a vegetation composition that largely conforms to an open tree savanna (Figure 6). Dominant species include the tree *Acacia mellifera* and the grass *Schmidtia kalahariensis*. Other prominent woody species are *Acacia haematoxylon, Parkinsonia africana, Rhigozum trichotomum, Boscia albitrunca* and *Acacia erioloba* and occasionally *Lycium bosciifolium*. Besides *Schmidtia kalahariensis*, the grass layer is characterised by *Eragrostis lehmanniana, Centropodia glauca, Stipagrostis amabilis, Brachiaria glomerata Stipagrostis obtusa* and *S. ciliata.* Herbs that are found in this unit include *Hermannia tomentosa, Hermbstaedtia fleckii, Requienia sphaerosperma, Dicoma capensis, Momordica balsamina* and the climber *Pergularia daemia*.

Figure 6: Duneveld vegetation in the northern region of the Study Area

The presence of the grass species *Schmidtia kalihariensis* is generally accepted as an indicator of high utilisation pressure. This habitat type is representative of the Gordonia Duneveld vegetation type (Mucina & Rutherford, 2006) and was found to be in a relatively good condition in 2010 (BEC, 2010); however it appeared to be degraded as a result of livestock grazing pressure during the 2015 site visit (Figure 7). A moderate ecological integrity status and moderate-high sensitivity was ascribed to this unit due to the association with dune habitat.

Figure 7: Livestock grazing pressure in duneveld vegetation, 2015

Rocky Outcrops/Foothills

Part of the Korannaberg foothills is located in the northern corner of the study area, characterised by boulders, high slopes and mountainous topography. Soils in this unit are characteristically shallow and poor in nutrients.

The species composition compares well to the Koranna-Langeberg Mountain Bushveld described by Mucina and Rutherford (2006). The vegetation consists of an open tall shrubveld; a prominent herbaceous layer with interspersed tall shrubs, bushes and low trees.

A moderate species diversity (27 species) was noted with a relatively equal distribution of herbs, grasses and shrubs. The shrubs *Croton gratissimus* and *Searsia burchelli* are characteristic of vegetation in this unit. Prominent grasses include *Cymbopogon pospischilii*, *Aristida* species, *Digitaria eriantha*, *Enneapogon scoparius, Cenchrus ciliaris* and *Stipagrostis ciliata*.

This area was found to be in pristine condition and, due to the association with high slopes, is generally regarded as sensitive.

Transformed Areas

A large area within the southern part of the Bokpoort II boundary is already transformed through vegetation clearance and construction activity associated with the existing Bokpoort I facility.

5.2.2 Abstraction Point

As mentioned previously, at this stage no additional natural vegetation clearance for the proposed pipeline is anticipated. The servitude cleared for the existing pipeline will be used for the proposed additional pipeline. The focus of the baseline is therefore on riparian vegetation which may be cleared at the new abstraction point, particularly since this vegetation type aligns with the Endangered (NEMBA) Lower Gariep Alluvial Vegetation type.

Riparian Vegetation

A detailed investigation of the drainage lines being intercepted by the proposed pipeline, and the riparian vegetation and bank condition of the Orange River at the proposed water abstraction point was conducted by Royal HaskoningDHV (RHDV, 2014a) for the existing pipeline. They found that riparian vegetation adjacent to the abstraction point consists of dense thickets of trees and shrubs with a dense understorey (*Vachellia (Acacia) karroo, Ziziphus mucronata, Rhus lancea, Diospyros ramulosa* and *Lycium cinereum*), as well as stands of reeds *Phragmites australis* at the edge of the Orange River. The invasive species *Prosopis glandulosa* was recorded throughout the *Phragmites* reed bed.

5.2.3 Invasive Species

Three invasive plant species have been recorded in the Study Area (BEC, 2010); no additional invasive plant species were observed during the September 2015 site visit.

Table 1: Declared invasive, exotic flora species recorded in the Study Area

Species	Family	Threat Status	Location
Prosopis glandulosa	Fabaceae	Category 2 Invader	Riparian vegetation
Rhigozum trichotomum	Bignoniaceae	Declared indicator of encroachment	Disturbed areas
Acacia mellifera	Fabaceae	Declared indicator of encroachment	Disturbed areas

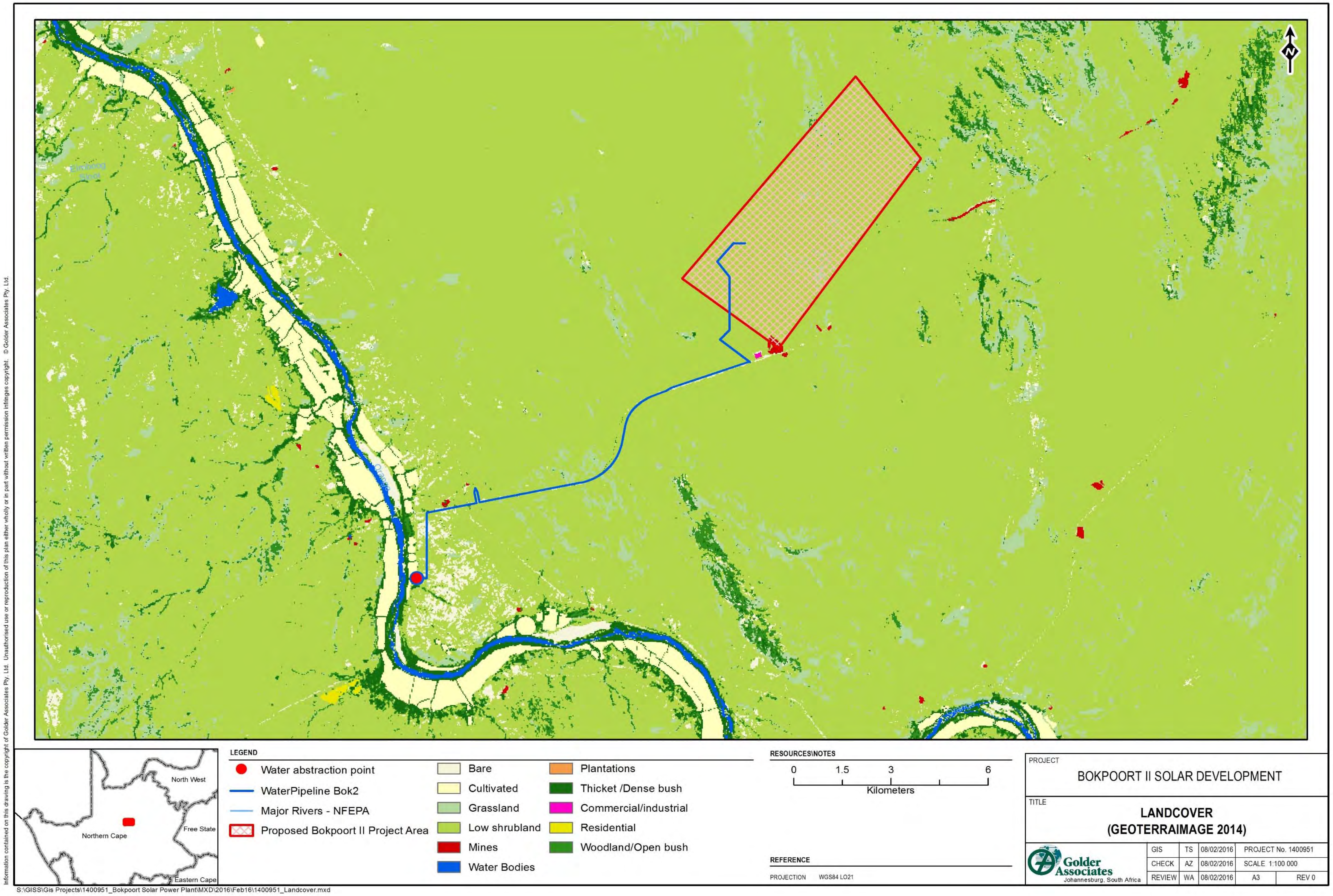

Figure 8: Land cover classification of the Study Area

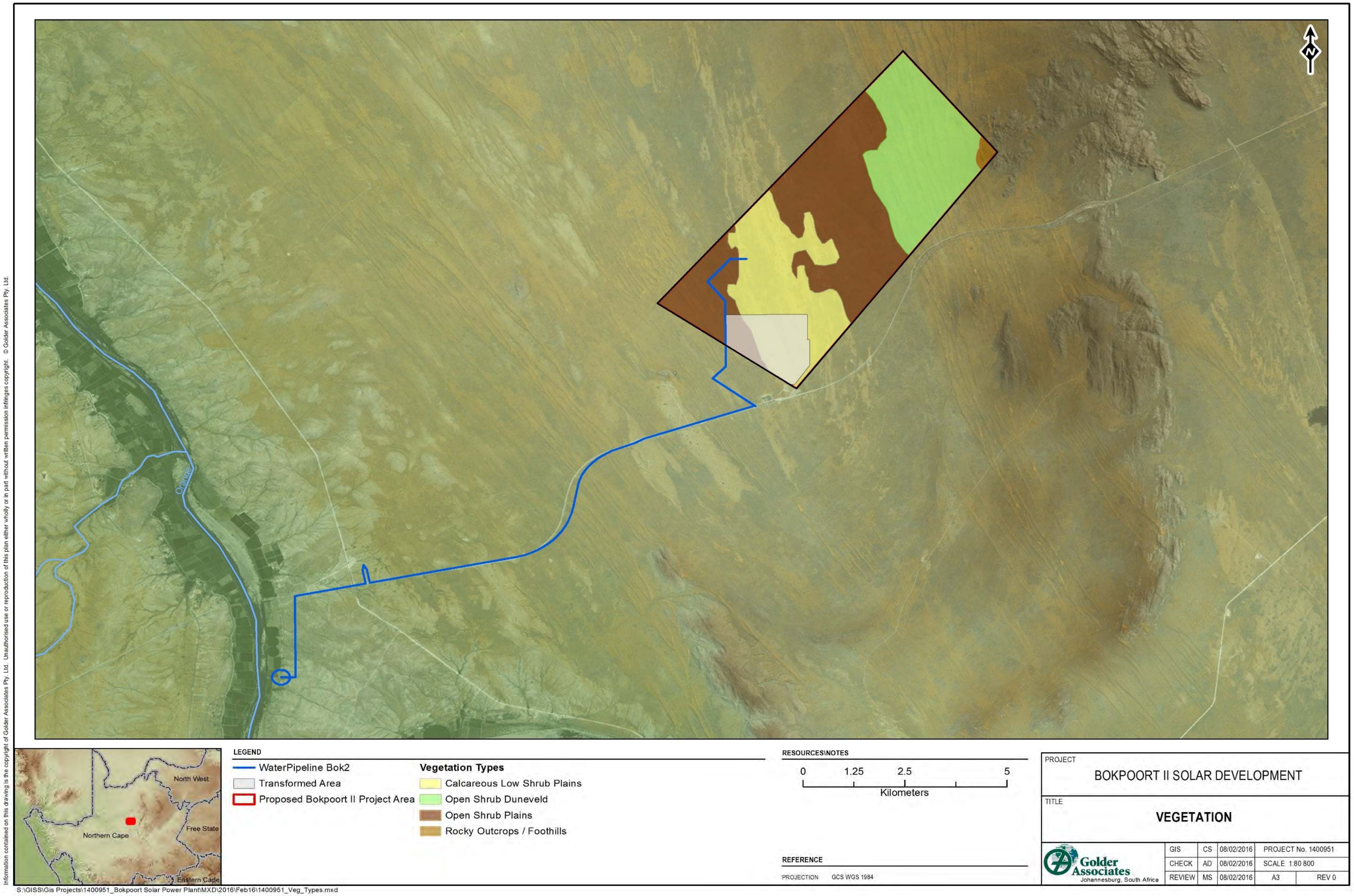

Figure 9: Vegetation communities recorded within the Study Area

5.3 Fauna

A summary of the baseline of the fauna species of the Study Area is presented in the following sections, based on the findings of the desktop study and the field investigations. The detailed baseline studies are provided in APPENDIX B.

Please note that birds are addressed in a separate specialist study report (ARCUS, 2016).

5.3.1 Invertebrates

Invertebrate species previously recorded within the Study Area (BEC, 2010) were restricted to butterflies only (Table 2). All species are common and ubiquitous species of the region, nevertheless the butterfly species richness is likely a factor of the largely untransformed and non-fragmented nature of the Study Area.

Table 2: Butterfly species observed within the Study Area (BEC, 2010)

Species name	Common Name	Conservation Status (IUCN)
Belenois aurota	Brown-veined	Least threatened
Catopsilla florella	African Migrant	Least threatened
Cigaritis phanes	Silvery Bar	Least threatened
Colotis eris	Banded Gold Tip	Least threatened
Colotis lais	Kalahari Orange Tip	Least threatened
Danaus chryssipus	African Monarch	Least threatened
Junonia hierta	Yellow Pansy	Least threatened
Pinacopteryx eriphia	Zebra White	Least threatened
Spialia diomus	Common Sandman	Least threatened
Zintha hintza	Hintza Blue	Least threatened
Zizeeria knysna	Sooty Blue	Least threatened
Zizula hylax	Gaika Blue	Least threatened

Two invertebrate species of conservation concern (that have not yet been observed) could potentially occur within the Study Area, these and their likelihood of presence based on habitat suitability are summarised in Table 3.

Table 3: Invertebrate species of concern with distribution in Study Area and likelihood of occurrence

Species name	Common Name	Conservation Status (IUCN)	Likelihood of presence
Alfredectes browni	Brown's Shieldback	DD	**Possible** – This katydid species is understudied, being known only from three specimens, but occurs in a wide range of habitats from grasses along highly disturbed roadsides, to low trees, to high elevation fynbos vegetation so could occur within the Study Area (Bazelet & Naskrecki, 2014).
Lepidochrysops penningtoni	Pennington's Blue	DD	**Unlikely** – Considerable uncertainty exists around this species' taxonomy and distribution and it is likely that the species will fall into the category of Least Concern with further information as it occupies remote habitats and does not face any major threats. Its strongly seasonal appearance has probably led to it being under-recorded (Larsen, 2011).

Species name	Common Name	Conservation Status (IUCN)	Likelihood of presence
			It is thought to be endemic to the Northern Cape; however it prefers vegetation consisting of mesembryanthemums and other low shrubs (succulent Karoo) (Pringle *et al.,* 1994), which has not been recorded within the Study Area.

5.3.2 Herpetofauna – Amphibians and Reptiles

Amphibians

No amphibian species have been recorded within the Study Area to date; however some frog species are expected to occur in the vicinity of the abstraction point in the Orange River (Table 4).

Table 4: Amphibian species likely to occur in the vicinity of the abstraction point on the Orange River

Scientific Name	Common Name	Conservation Status		
		IUCN – Regional Status (2004)	NEMBA TOPS List (2013)	Northern Cape - Protected Species (2009)
Amietophrynus gutturalis	Guttural Toad	-	-	Protected
Amietophrynus rangeri	Raucous Toad	-	-	Protected
Amietophrynus poweri	Western Olive Toad	-	-	Protected
Vandijkophrynus gariepensis	Karoo Toad	-	-	Protected
Xenopus laevis	Common Platanna	-	-	Protected
Amietia angolensis	Common River Frog	-	-	Protected
Cacosternum boettgeri	Common Caco	-	-	Protected
Pyxicephalus adspersus	Giant Bullfrog	Near threatened	-	Specially Protected
Tomopterna cryptotis	Tremolo Sand Frog	-	-	Protected
Tomopterna tandyi	Tandy's Sand Frog	-	-	Protected

Source: Distributions = du Preez & Carruthers (2009); Conservation Status = Minter et al. (2004), NEMBA ToPS List (2013) & (Northern Cape Nature Conservation Act 2009)

Reptiles

Eight reptile species were observed during the previous baseline fieldwork (BEC, 2010); **confirmed species** (shown in bold) as well as other species whose distributions overlap with the Study Area and therefore could potentially occur are listed in Table 5.

Table 5: Reptile species recorded/likely to occur within the Study Area, and conservation status

Scientific Name	Common Name	Conservation Status		
		NEMBA TOPS List (2013)	Northern Cape-Protected Species (2009)	Endemic Status
Agama aculeata aculeata	Western Ground Agama	-	-	-
Agama anchietae	Anchieta's Agama	-	-	-
Agama atra	**Southern Rock Agama**	**-**	**-**	**Near Endemic**

Scientific Name	Common Name	Conservation Status		
		NEMBA TOPS List (2013)	Northern Cape-Protected Species (2009)	Endemic Status
Monopeltis infuscata	Dusky Worm Lizard	-	-	-
Monopeltis mauricei	Maurice's Worm Lizard	-	-	-
Dasypeltis scabra	Rhombic Egg-eater	-	Protected	-
Telescopus beetzii	Beetz's Tiger Snake	-	-	-
Karusasaurus polyzonus	Southern Karusa Lizard	-	Specially Protected	Near Endemic
Aspidelaps lubricus lubricus	Coral Shield Cobra	-	-	-
Naja nigricincta woodi	Black Spitting Cobra	-	-	-
Naja nivea	**Cape Cobra**	**-**	**-**	**-**
Chondrodactylus angulifer angulifer	Common Giant Gecko	-	-	-
Chondrodactylus bibronii	Bibron's Gecko	-	-	-
Chondrodactylus turneri	Turner's Gecko	-	-	-
Colopus wahlbergii furcifer	Striped Ground Gecko	-	-	-
Lygodactylus bradfieldi	Bradfield's Dwarf Gecko	-	-	-
Pachydactylus capensis	Cape Gecko	Protected	-	-
Pachydactylus latirostris	Quartz Gecko	Protected	-	-
Pachydactylus montanus	Namaqua Mountain Gecko	Protected	-	-
Pachydactylus punctatus	Speckled Gecko	Protected	-	-
Pachydactylus purcelli	Purcell's Gecko	Protected	-	-
Pachydactylus rugosus	Common Rough Gecko	Protected	-	-
Ptenopus garrulus garrulus	**Common Barking Gecko**	**-**	**-**	**-**
Ptenopus garrulus maculatus	Spotted Barking Gecko	-	-	
Cordylosaurus subtessellatus	Dwarf Plated Lizard	-	-	-
Heliobolus lugubris	Bushveld Lizard	-	Protected	-
Meroles suborbitalis	Spotted Desert Lizard	-	Protected	-

Scientific Name	Common Name	Conservation Status		
		NEMBA TOPS List (2013)	Northern Cape-Protected Species (2009)	Endemic Status
Nucras tessellata	Western Sandveld Lizard	-	Protected	-
Pedioplanis inornata	Plain Sand Lizard	-	Protected	-
Pedioplanis laticeps	Karoo Sand Lizard	-	Protected	Endemic
Pedioplanis lineoocellata	**Spotted Sand Lizard**	**-**	**Protected**	**-**
Pedioplanis namaquensis	Namaqua Sand Lizard	-	Protected	-
Boaedon capensis	Common House Snake	-	-	-
Dipsina multimaculata	Dwarf Beaked Snake	-	-	-
Lycophidion capense	Cape Wolf Snake	-	Protected	-
Prosymna bivittata	Two-striped Shovel-snout	-	Protected	-
Prosymna frontalis	Southwestern Shovel-snout	-	Protected	-
Psammophis notostictus	Karoo Sand Snake	-	-	-
Psammophis trinasalis	Four-marked Sand Snake	-	-	-
Pseudaspis cana	Mole Snake	-	Protected	-
Xenocalamus bicolor bicolor	Bicoloured Quill-snouted Snake	-	-	-
Acontias kgalagadi kgalagadi	Kgalagadi Legless Skink	-	-	-
Acontias lineatus lineatus	Striped Dwarf Legless Skink	-	-	-
Trachylepis sparsa	Karasburg Tree Skink	-	-	-
Trachylepis spilogaster	Kalahari Trees Skink	-	-	-
Trachylepis striata	**Striped Skink**			
Trachylepis sulcata	Western Rock Skink	-	-	-
Trachylepis variegata	Variegated Skink	-	-	-
Psammobates oculifer	**Serrated tent Tortoise**		**Protected**	**-**
Psammobates tentorius	Tent Tortoise	-	Protected	-
Stigmochelys pardalis	Leopard Tortoise	-	Protected	-
Rhinotyphlops lalandei	Delalande’s Beaked Blind Snake	-	-	-

Scientific Name	Common Name	Conservation Status		
		NEMBA TOPS List (2013)	Northern Cape-Protected Species (2009)	Endemic Status
Rhinotyphlops schinzi	Schinz's Beaked Blind Snake	-	-	-
Varanus albigularis albigularis	**Rock Monitor**	**-**	**Protected**	**-**
Varanus niloticus	Water Monitor	-	Protected	-
Bitis arietans arietans	**Puff Adder**	**-**	**-**	**-**
Bitis caudalis	Horned Adder	Protected	-	-

5.3.3 Mammals (Excluding Bats)

Fifty-one mammal species (excluding bats) potentially occur in the Study Area. Fourteen (14) of these have been confirmed during field studies (RHV, 2014; BEC, 2010).

These and details of their conservation status/ level of protection afforded to them are listed on Table 6; species that have been confirmed present during fieldwork are highlighted in **bold** text.

Table 6: Mammal species recorded/likely to occur within the Study Area

Scientific Name	Common Name	Conservation Status			Likelihood of presence
		IUCN – regional Status	NEMBA TOPS List	Northern Cape NCA	
Antidorcas marsupialis	Springbok	-	-	Protected	Unlikely – largely restricted to private reserves and protected areas (IUCN SSC Antelope Specialist Group. 2008).
Oreotragus oreotragus	Klipspringer	-	Protected	Protected	Unlikely – no suitable rocky/ mountainous terrain is present within the study area.
Raphicerus campestris	Steenbok	-	-	Protected	Probable - occur widely in drier savannas, grasslands and scrublands and show a particular preference for heavily grazed areas (IUCN SSC Antelope Specialist Group. 2008b).
Sylvicapra grimmia	Common Duiker	-	-	Protected	Probable – widespread and common.
Tragelaphus strepsiceros	Kudu	-	-	Protected	Unlikely due to limited scrub/woodland cover available within the study area.
Canis mesomelas	**Black-backed Jackal**	**-**	**-**	**-**	**Confirmed (BEC, 2010)**

Scientific Name	Common Name	Conservation Status			Likelihood of presence
		IUCN – regional Status	NEMBA TOPS List	Northern Cape NCA	
Otocyon megalotis	**Bat-eared Fox**	**-**	**Protected**	**Specially protected**	**Confirmed (BEC, 2010)**
Vulpes chama	Cape Fox	-	Protected	Specially protected	Probable - associate with open country, including grassland, grassland with scattered thickets, and lightly wooded areas, particularly in the dry Karoo regions, the Kalahari and the fringes of the Namib Desert (Hoffman, 2014).
Papio ursinus	Chacma Baboon	-	-	-	Possible – although Chacma Baboon are common and widespread, few foraging/ watering opportunities are available within the Study Area.
Cercopithecus pygerythrus	Vervet Monkey	-	-	-	Possible – although Vervet Monkey are common and widespread, few foraging/ watering opportunities are available within the Study Area.
Caracal caracal	**Caracal**	**-**	**-**	**-**	**Confirmed (BEC, 2010)**
Felis nigripes	Black-footed Cat	-	Protected	Specially protected	Possible – it is a specialist of open, short grass areas with an abundance of small rodents and ground-roosting birds. It inhabits dry, open savanna, grasslands and Karoo semi-desert with sparse shrub and tree cover (Sliwa, 2008), which are a feature of the Study Area.
Felis sylvestris	African wild Cat	-	-	Specially protected	Possible – wide habitat tolerance (Stuart & Stuart, 2007).
Atilax paludinosus	**Water Mongoose**	**-**	**-**	**Protected**	**Confirmed (DHV, 2014).**
Cynictis penicillata	**Yellow Mongoose**	**-**	**-**	**Protected**	**Confirmed (BEC, 2010).**
Galerella sanguinea	**Slender Mongoose**	**-**	**-**	**Protected**	**Confirmed (BEC, 2010).**
Galerella pulverulenta	Small Grey Mongoose	-	-	Protected	Probable – very wide habitat tolerance includes open scrub (Stuart & Stuart, 2007).
Suricata suricatta	Suricate	-	-	Protected	Probable – its preferred habitat is arid, open country, characterised by short grasses and sparse woody growth,

Scientific Name	Common Name	Conservation Status			Likelihood of presence
		IUCN – regional Status	NEMBA TOPS List	Northern Cape NCA	
					which characterises the Study Area.
Parahyaena brunnea	Brown Hyena	Near threatened	Protected	Specially protected	Probable – inhabits dry areas, generally with annual rainfall less than 100 mm, particularly along the coast, in semi-desert, open scrub and open woodland savanna.
Hystrix africaeaustralis	**Porcupine**	**-**	**-**	**-**	**Confirmed (BEC, 2010).**
Lepus capensis	**Cape Hare**	**-**	**-**	**Protected**	**Confirmed (DHV, 2014).**
Lepus saxatilis	**Scrub Hare**	**-**	**-**	**Protected**	**Confirmed (BEC, 2010).**
Macroscelides proboscideus	Karoo Round-eared Sengi	-	-	Protected	Probable – a habitat specialist, which occupies gravel plains (Rathbun & Smit-Robinson, 2015a) such as those present within the Study Area associated with the Kalahari Karroid Shrubland vegetation type.
Elephantulus rupestris	Western Rock Sengi	-	-	Protected	Possible – occupies arid habitats including dry savanna and shrubland, and is typically associated with rocky ridges, outcrops or koppies (Rathbun & Smit-Robinson, 2015b).
Elephantulus intufi	Bushveld Sengi	Data deficient	-	Protected	Unlikely – prefers very arid terrain and semi-desert (Rathbun, 2015).
Manis temminckii	Ground Pangolin	Vulnerable	Vulnerable	Specially protected	Unlikely - inhabits mainly savanna woodland in low-lying regions with moderate to dense scrub, and is not present in arid areas or deserts (Pietersen *et al.*, 2014).
Aethomys chrysophilus	Red Rock Rat	-	-	Protected	Unlikely – typically a savanna species (Agwanda *et al.*, 2008).
Desmodillus auricularis	Cape Short-tailed Gerbil	-	-	Protected	Probable - inhabits arid gravel plains and areas of hardened sand (Coetzee, 2008).

Scientific Name	Common Name	Conservation Status			Likelihood of presence
		IUCN – regional Status	NEMBA TOPS List	Northern Cape NCA	
Gerbillurus paeba	Hairy-footed Gerbil	-	-	Protected	Probable – found in sandy ground or sandy alluvium with a grass, scrub or light woodland cover (Coetzee & Griffin, 2008a).
Malacothrix typica	Large-eared Mouse	-	-	Protected	Possible - inhabits a wide range of habitats including dry savanna (Coetzee & Griffin, 2008b).
Myomyscus verreauxii	Verreaux's White-footed Rat			Protected	Unlikely – found in fynbos vegetation (van der Straeten, 2008).
Aethomys namaquensis	Namaqua Rock Rat	-	-	Protected	Probable – present in most habitat types.
Mus musculus	House Mouse	-	-	-	Unlikely – no inhabited areas within the Study Area.
Parotomys brantsii	Brant's Whistling Rat	-	-	Protected	Possible – restricted to consolidated sands in semi-desert (Coetzee, 2008b).
Parotomys littledalei	Littledale's Whistling Rat	Near threatened	-	Protected	Possible – occurs in shrubland (Coetzee & Griffin, 2008c).
Rhabdomys pumilio	Striped Mouse	-	-	Protected	Unlikely – prefers agricultural lands and houses (Coetzee & van der Straeten, 2008).
Saccostomus campestris	Pouched Mouse	-	-	-	Unlikely – associated with savanna woodland (Corti *et al.*, 2008).
Tatera brantsii	Highveld Gerbil	-	-	Protected	Probable - associated with open areas, or plains, in subtropical and wooded grasslands on consolidated sands (Griffin & Coetzee, 2008).
Tatera leucogaster	Bushveld Gerbil	Data deficient	-	Protected	Unlikely – more typically associated with bushland and grasslands (Coetzee, 2008c).
Aonyx capensis	**Cape Clawless Otter**	**-**	**Protected**	**Protected**	**Confirmed (DHV, 2014).**
Ictonyx striatus	**Striped Polecat**	**Data deficient**	**-**	**Specially protected**	**Confirmed (BEC, 2010).**
Mellivora capensis	**Honey Badger**	**Near threatened**	**-**	**Specially protected**	**Confirmed (BEC, 2010).**
Graphiurus ocularis	Spectacled Dormouse	-	-	-	Unlikely - associated with the sandstone formations of the Cape (Coetzee *et al.*, 2008).

Scientific Name	Common Name	Conservation Status			Likelihood of presence
		IUCN – regional Status	NEMBA TOPS List	Northern Cape NCA	
Orycteropus afer	**Aardvark**	**-**	**Protected**	**Specially protected**	**Confirmed (BEC, 2010).**
Pedetes capensis	**Springhare**	**-**	**-**	**-**	**Confirmed (BEC, 2010)**
Procavia capensis	Rock Hyrax	-	-	Protected	Unlikely - typically associated with rocky outcrops, cliffs or boulders which are not a feature of Study Area.
Proteles cristatus	Aardwolf	-	-	Specially protected	Probable - prime habitat is open, grassy plains, being entirely absent from forests or pure desert (Green, 2015).
Xerus inauris	Ground Squirrel	-	-	-	Probable – occurs widely throughout arid parts of Southern Africa.
Crocidura cyanea	Reddish-grey Musk Shrew	Data deficient	-	Protected	Unlikey – occurs in montane grasslands and temperate-sub-tropical forests (Baxter *et al.*, 2008).
Genetta genetta	Small-spotted Genet	-	-	-	Unlikely – prefers wooded habitat.

Source: Distributions = Stuart & Stuart (2007);Conservation Status = Friedmann & Daly (2004), NEMBA ToPS List (2013) & (Northern Cape Nature Conservation Act 2009)

5.4 Aquatic Ecosystems

The proposed 75 MW PV solar facility includes the abstraction of 25 000 m^3 water per annum from the Orange River. The abstraction point is located in the Orange River approximately 17 km downstream of Groblershoop.

5.4.1 Biophysical Aquatic Environment

The proposed project area is situated within the Lower Orange Water Management Area (WMA14), Quaternary Drainage Region D73D. The Orange River reach within the study area was classified with a Present Ecological State (PES) Class C, indicative of a moderately modified river system (DWS, 2013) (Figure 10).

The primary aquatic ecosystem within the study area is the Orange River. All other watercourses are ephemeral or episodic, a term used when these systems only flow following high rainfall events (Da Cruz, 2014). The Orange River has been prioritised as a National Freshwater Ecosystem Priority Area (NFEPA) (Nel, *et al.*, 2011). A floodplain wetland has been associated with this system within the Study Area; however examination of the aerial imagery suggests the majority of this has been transformed for agricultural cultivation. As the PES of the river is already considered moderately modified, further development on this reach should be avoided or adequately mitigated.

Since the proposed pipeline will be constructed within the existing servitude for the Bokpoort I pipeline, the baseline description of aquatic ecosystems focusses on the Orange River where the abstraction point for this Project will be located.

5.4.2 *In Situ* Water Quality

Both the flow regime and water quality along the entire Orange River system has been severely impacted upon by extensive upstream infrastructural developments and agricultural practices within the Orange River catchment (ORASECOM, 2009, DWA, 2004).

Salinity levels/electrical conductivity (EC) have increased downstream of the confluence of the Vaal and Orange Rivers, as well as from Prieska to Vioolsdrift along the Lower Orange River.

This is owing to the transfer of water out of the Orange River, as part of the transfer scheme, high nutrient input and irrigation return flows as a result of the agricultural activities along the banks of the river (DWA, 2004; DWA, 2009, ORASECOM, 2009), poor water quality from the Vaal River return flows (DWA, 2004) and evaporation losses along the river (ORASECOM, 2009). Eutrophic conditions are evident along the Lower Orange River, whereby intermittent blooms of toxic algae have been reported in the Upington area (Scherman, 2012).

Regarding the state of the water quality, following a study conducted by LORMS, 2005, the Present Ecological State (PES) for the river reach between Upington to Vioolsdrif, was marginally to moderately modified (B/C category) and subsequently the ecosystem functions were still predominantly unchanged. Conversely during an Orange-Senqu River Commission (ORASECOM) study conducted in 2010, water quality was recorded at an upstream site called ERF02 (Boegoeberg) (Scherman 2010).

Table 7 overleaf details the results from that study which further provides the categories per water quality parameter, where the integrated water quality category was identified through the use of the model 'Physico-chemical habitat Assessment Index' (PAI). The category identified was a Class C, moderately modified indicating a deterioration in water quality since the 2005 study (Scherman, 2010). Additionally, the water quality at sites EFR03 (Augrabies) and EFR04 (Vioolsdrif), were classed as moderately modified (Class C) and moderate to largely modified (Class C/D) respectively (Scherman, 2010).

Table 7: Water quality data for site EFR02 (Boegoeberg) (Scherman, 2010)

Water Quality parameter		RC Value	PES Value	Category
Salt ions (mg/L)	Ca	37.40	34.06	-
	Cl	20.36	46.28	
	K	3.70	3.99	
	Mg	15.10	18.00	
	Na	23.70	35.36	
	SO_4	48.10	63.99	
Nutrients (mg/L)	SRT	0.014	0.022	A
	TIN	0.14	0.22	A
Physical-Variables	pH	7.05 + 7.91	7.71 + 8.60	A/B
	Temperature	-	-	No category as site is downstream from numerous dams, with significant changes expected from natural conditions.
	Dissolved oxygen	-	-	
	Turbidity	-	Average: 7.92	A/B
			95th percentile: 30.67	A/B
	Electrical conductivity	35.68	50.80	A/B
Toxics	Fluoride (mg/L)	0.452	0.260	A

Water Quality parameter		RC Value	PES Value	Category
	Ammonia (mg/L)	0.002	0.011	A
	Aluminium *mg/L)	0.02	0.166 (n = 2; 2008) (Koekemoer, 2010)	D
	Iron (mg/L)	-	0.110 (n = 2; 2008) (Koekemoer, 2010)	No guideline + insufficient data
	Arsenic (mg/L)	0.02	297 (n = 2; 2008) (Koekemoer, 2010)	E
	Cadmium (mg/L)	0.0003	0.005 (n = 2; 2008) (Koekemoer, 2010)	E
	Lead (mg/L)	0.002	0.011 (n = 2; 2008) (Koekemoer, 2010)	E

5.4.3 Aquatic Macroinvertebrates

Systems which have a large diversity of habitat availability, good water quality and varying flow velocities often support a great diversity and abundance of aquatic macroinvertebrates. However, the lower Orange River is characterised by low numbers of aquatic macroinvertebrate species, which is in part attributed to its biogeographic isolation and vulnerability to change (Palmer, 2010). The macroinvertebrate communities recorded by Palmer (2010) were dominated by filter-feeders, highlighting the importance of fine particulate material (bacteria, phytoplankton and detritus) in the ecology of the river. In accordance to the study conducted by Palmer (2010) whereby a sample was retrieved at site EFR02 (Boegoeberg), the South African Scoring System Version 5 (SASS5) was calculated to be 116 (recommended condition (RC: 165) and the average score per taxon (ASPT) of 5.8 (RC: 6.6) resulting in a moderately modified state (Class C) (Palmer, 2010).

Furthermore, a baseline aquatic assessment previously conducted (EnviRoss, 2010) at the abstraction point for this project, the Integrated Habitat Assessment System (IHAS) as proposed by McMillan (1998), indicated good habitat availability near to the proposed abstraction point of this project. This was likely owing to a diversity of habitat biotopes for macroinvertebrates, namely Stones-In-Current (SIC), Vegetation (Veg) and sand, gravel and mud (GSM) available at the proposed site. Based on these findings and further from the results from the SASS5 survey, the aquatic macroinvertebrate community structures were representative of natural conditions (EnviRoss, 2010).

5.4.4 Fish

Based on the desktop review of available literature, an expected species list was compiled for the proposed project site (Kleynhans *et al.,* 2007, IUCN, 2016). A total of 13 indigenous fish species are expected to occur within the study area, which includes the Near Threatened *Labeobarbus kimberleyensis* (Vaal-Orange Largemouth Yellowfish) (IUCN, 2016) (Table 8). Total population size of this species has not been determined, but the species is known to be widespread and reasonably common in the main-stream Lower Orange River. General concerns about reducing densities across its range suggest that this species could be listed in a threatened category in the future. *Barbus hospes* (Namaqua barb), *L. kimberleyensis*, *L. aneus* (Smallmouth Yellowfish), *Labeo capensis* (Orange River Labeo) and *Austroglanis sclateri* (Rock catfish) are endemic to, and widely distributed in the Orange River System (Kleynhans *et al.,* 2007, IUCN, 2016). The endemic *B. hospes* only occurs below the Augrabies Falls, as does an isolated population of the *M. brevianalis* (River sardine) (Scherman Colloty & Associates, 2012). However, fish experts believe that *B. hospes* and *Austroglanis sclateri* (Rock catlet) may be threatened in the Lower Orange River owing to the deterioration of their habitat(LORMS, 2005) and thus it has been recommended that further studies be established to identify their true conservation status in this region (Scherman, 2012).

It is important to note that the greatest impacts on the fish abundance and diversity of species recorded within the Orange River are the numerous migratory barriers namely, weirs, which are constructed for water abstraction points. River flows, velocities and poor water quality are further being compromised due to significant infrastructural developments along the river banks, namely abstraction points and hydro-electrical plants, affecting the spawning habitats of these riverine fish (Scherman, 2012).

Table 8: Expected Fish List, IUCN status, habitat preferences and intolerances (Skelton, 2001, Kleynhans, 2007, IUCN (2016)) (*Invasive fish species)

Abbreviation	Species Name	Common Name	IUCN Status	Habitat Preference		Tolerance Rating	Intolerance Description
ASCL	*Austroglanis sclateri*	Rock-catfish	Least Concern	FS	Rocky habitats in flowing water, favouring rapids	2.7	Moderately modified
BANO	*Barbus anoplus*	Chubbyhead barb	Least Concern	SS	Wide variety of habitats	2.6	Moderately modified
BHOS	*Barbus hospes*	Namaqua barb	Least Concern	SS, SD	Open waters in mainstreams and backwaters	0	Tolerant
BPAU	*Barbus paludinosus*	Straightfin barb	Least Concern	SD/SS	Wide variety of habitats	1.8	Tolerant
BTRI	*Barbus trimaculatus*	Threespot barb	Least Concern	SD/SS	Wide variety of habitats	2.2	Moderately modified
BAEN	*Barbus aeneus*	Smallmouth yellowfish	Least Concern	FS	Rocky habitats in flowing water, favouring rapids	2.5	Moderately modified
BKIM	*Barbus kimberleyensis*	Largemouth yellowfish	Near threatened	FS	Rocky habitats in flowing water, favouring rapids	3.6	Moderately intolerant
*CCAR	*Cyprinus carpio*	Carp (ex)	Exotic	SD	Deep, slow-flowing and still waters	1.4	Tolerant
CGAR	*Clarias gariepinus*	Sharptooth catfish	Least Concern	SD	Wide variety of habitats	1.2	Tolerant
LCAP	*Labeo capensis*	Orange River labeo	Least Concern	SD	Wide variety of habitats	3.2	Moderately intolerant
LUMB	*Labeo umbratus*	Moggel	Least Concern	SD	Standing waters, shallow dams and muddy shallow areas	2.3	Moderately modified
*MSAL	*Micropterus salmoides*	Largemouth bass	Exotic	SD	Clear standing or slow flowing water	2.2	Tolerant
MBRE	*Mesobola brevianalis*	River sardine	Least Concern	FS, FD	Well-aerated and open waters	2.3	Tolerant
PPHI	*Pseudocrenilabrus philander*	Southern mouthbrooder	Unlisted	SS	Wide variety of habitats	1.3	Tolerant
TSPA	*Tilapia sparmanii*	Banded tilapia	Least Concern	SS	Wide variety of habitats	1.3	Tolerant

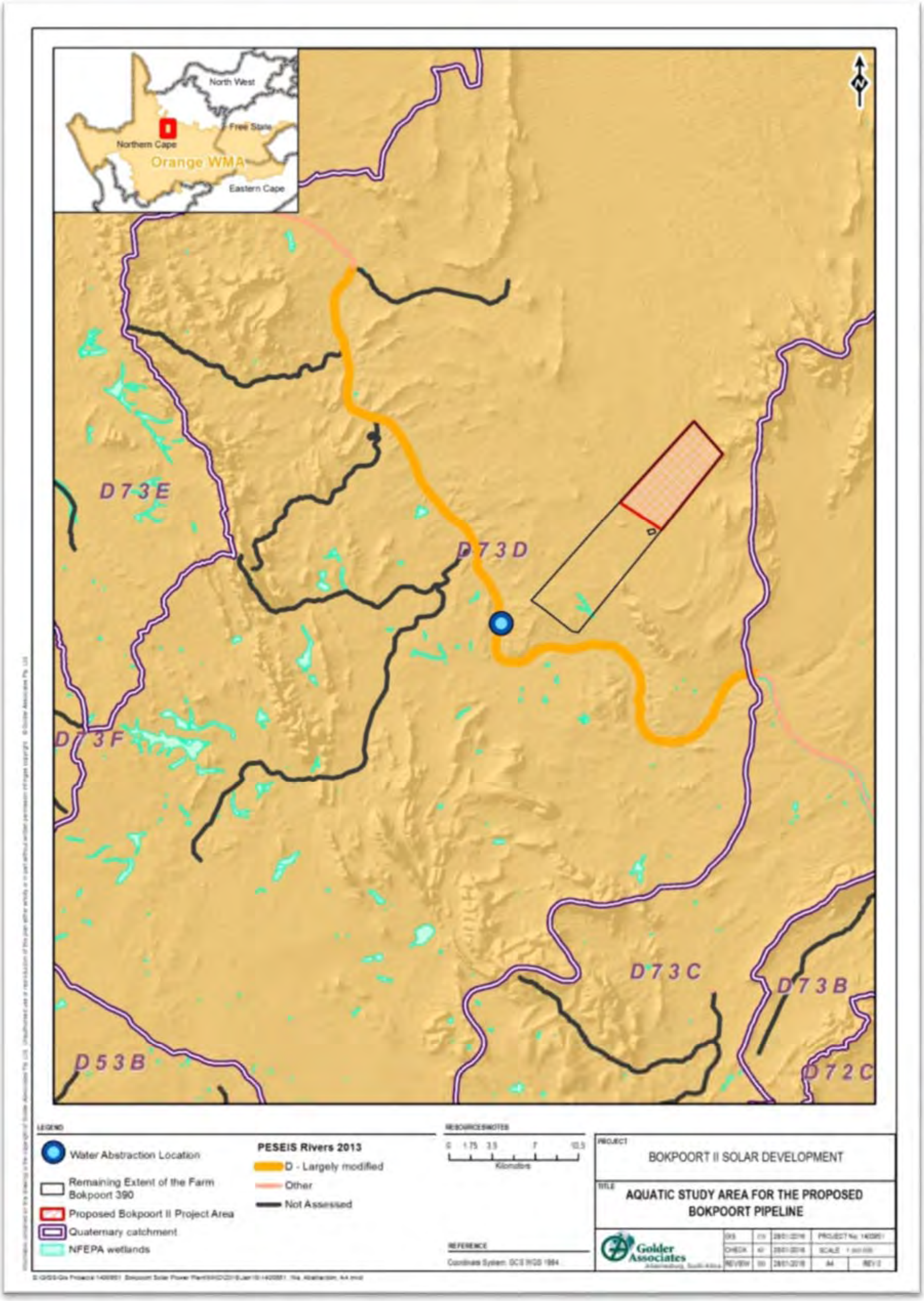

Figure 10: Study area illustrating the aquatic ecosystem and associated Present Ecological State of the rivers

5.5 Protected Areas

The Witsand Nature Reserve is located approximately 40 km to the east of the proposed Bokpoort II site (Figure 11), and as such is unlikely to be affected by the Project. No other protected areas are known to occur in the vicinity of the Project.

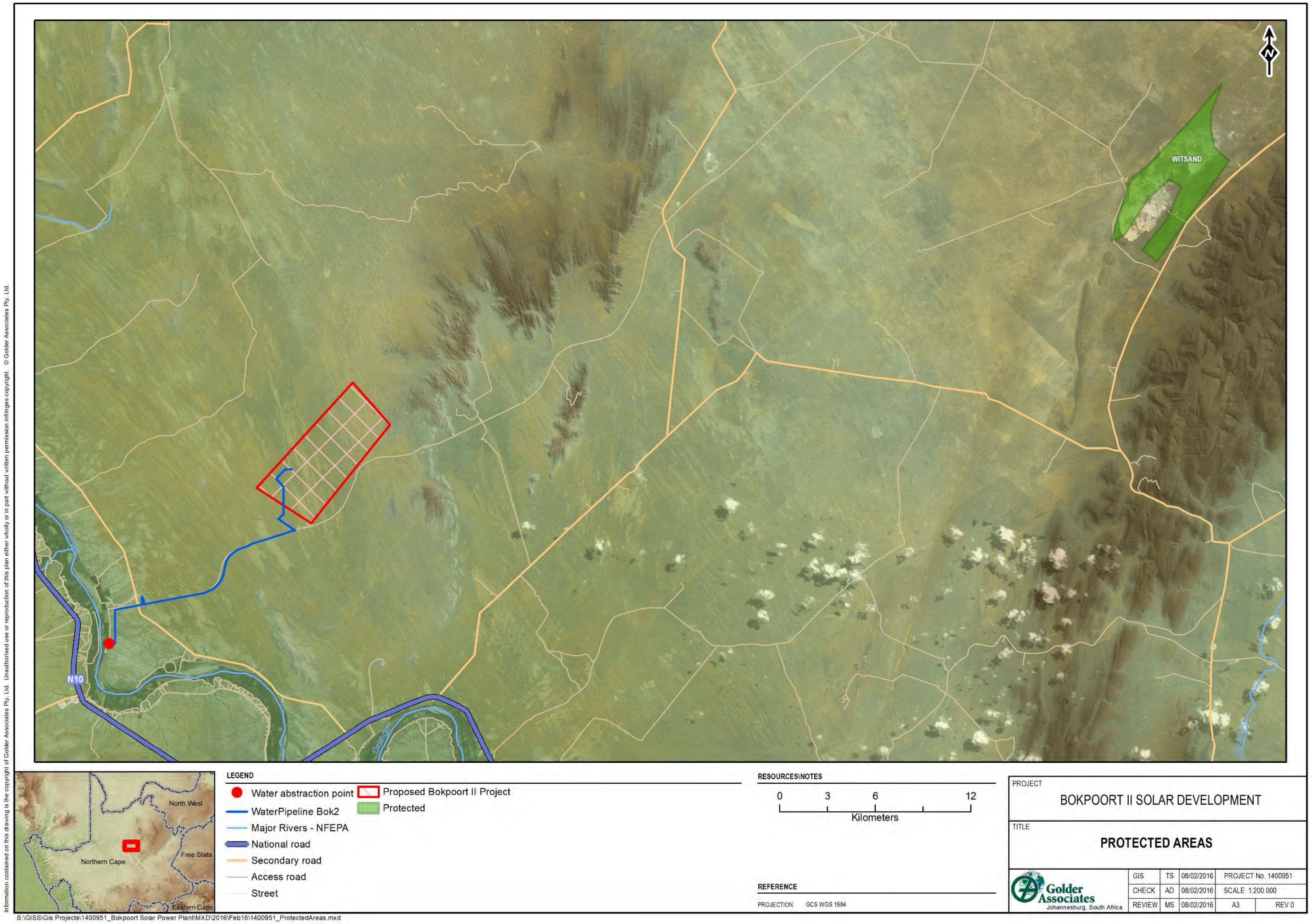

Figure 11: Protected Areas in the context of the Study Area

5.6 Assessment of Biodiversity Value

Species and ecosystems of concern identified as key issues for impact assessment are summarised in the sections that follow.

5.6.1 Species of Conservation Concern

Species of conservation concern (ref. section 3.4.2) that have been confirmed present or considered likely (possible-probable) to be present within the Study Area, and for which potential project impacts will be assessed, are summarised in Table 9 and Table 10 below.

Flora

Flora species of conservation concern that have been **recorded** within the Study Area or are expected to occur within the Study Area (BEC, 2010) are listed in Table 9.

Table 9: Flora species of conservation concern recorded*/expected in the Study Area

Species	Family	Conservation Status
Acacia erioloba	**Fabaceae**	**Protected Tree (National Forest Act, 1998)**
Acacia haematoxylon	**Fabaceae**	**Kalahari endemic**
Anthephora argentea	Poaceae	Regionally important (VEGMAP)
Boscia albitrunca	**Capparaceae**	**Protected Tree (National Forest Act, 1998)**
Helichrysum arenicola	Asteraceae	Regionally Important (VEGMAP)
Megaloprotrachne albescens	Poaceae	Regionally important (VEGMAP)
Neuradopsis austro-africana	Neuradaceae	Regionally important (VEGMAP)
Stipagrostis amabilis	**Poaceae**	**Kalahari endemic**

Fauna

Fauna species of concern that have been **recorded** during field surveys or are considered likely to be present based on habitat association and known distribution are summarised in Table 10.

Table 10: Fauna Species of Conservation Concern recorded*/expected in the Study Area

Species name	Common Name	Conservation Status	Habitat Association in Study Area
Invertebrates			
Alfredectes browni	Brown's Shieldback	IUCN - Data deficient	Disturbed roadsides, open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Herpetofauna			
Amietophrynus gutturalis	Guttural Toad	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Amietophrynus rangeri	Raucous Toad	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Amietophrynus poweri	Western Olive Toad	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Vandijkophrynus gariepensis	Karoo Toad	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.

Species name	Common Name	Conservation Status	Habitat Association in Study Area
Xenopus laevis	Common Platanna	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Amietia angolensis	Common River Frog	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Cacosternum boettgeri	Common Caco	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Pyxicephalus adspersus	Giant Bullfrog	IUCN – Regionally Near Threatened; NCNCA 2009 - Specially Protected	Riparian habitat at water abstraction point.
Tomopterna cryptotis	Tremolo Sand Frog	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Tomopterna tandyi	Tandy's Sand Frog	NCNCA 2009 - Protected	Riparian habitat at water abstraction point.
Pedioplanis lineoocellata lineoocellata	Spotted Sand Lizard	NCNCA 2009 - Protected	Commonly associated with open ground and scattered rock fragments, such as the calcareous low shrub plains in the Study Area (Figure 9).
Psammobates oculifer	Serrated tent Tortoise	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Varanus albigularis	Rock Monitor	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint; riparian vegetation at water abstraction point.
Fish			
Barbus kimberleyensis	Largemouth yellowfish	Near threatened	Orange River.
Pseudocrenilabrus philander	Southern mouthbrooder	Not listed*	Orange River.
Mammals			
Raphicerus campestris	Steenbok	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains.
Sylvicapra grimmia	Common Duiker	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, riparian vegetation.
Otocyon megalotis	**Bat-eared Fox**	**NCNCA 2009 – Specially Protected**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**

Species name	Common Name	Conservation Status	Habitat Association in Study Area
Vulpes chama	Cape Fox	NCNCA 2009 – Specially Protected, NEMBA	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Felis nigripes	Black-footed Cat	NCNCA 2009 – Specially Protected, NEMBA	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
****Atilax paludinosus***	**Water Mongoose**	**NCNCA 2009 - Protected**	**Riparian habitat at water abstraction point.**
****Cynictis penicillata***	**Yellow Mongoose**	**NCNCA 2009 - Protected**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**
****Galerella sanguinea***	**Slender Mongoose**	**NCNCA 2009 - Protected**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**
Galerella pulverulenta	Small Grey Mongoose	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint; riparian vegetation at water abstraction point.
Suricata suricatta	Suricate	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
****Lepus capensis***	**Cape Hare**	**NCNCA 2009 - Protected**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**
****Lepus saxatilis***	**Scrub Hare**	**NCNCA 2009 - Protected**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**
Macroscelides proboscideus	Karoo Round-eared Sengi	NCNCA 2009 - Protected	A habitat specialist, which occupies gravel plains such as those present within the Study Area associated with the Kalahari Karroid Shrubland vegetation type; this coincides with the open shrub plains, calcareous low shrub

Species name	Common Name	Conservation Status	Habitat Association in Study Area
			plains throughout Bokpoort II footprint.
Desmodillus auricularis	Cape Short-tailed Gerbil	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Gerbillurus paeba	Hairy-footed Gerbil	NCNCA 2009 - Protected	Riparian vegetation particularly areas of Lower Gariep Alluvial vegetation at abstraction point.

Species name	Common Name	Conservation Status	Habitat Association in Study Area
Aethomys namaquensis	Namaqua Rock Rat	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Tatera brantsii	Highveld Gerbil	NCNCA 2009 - Protected	Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.
Aonyx capensis	**Cape Clawless Otter**	**NCNCA 2009 – Protected, NEMBA**	**Riparian habitat at water abstraction point.**
Ictonyx striatus	**Striped Polecat**	**NCNCA 2009 – Specially Protected; Data Deficient**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint; riparian vegetation at water abstraction point.**
Mellivora capensis	**Honey Badger**	**NCNCA 2009 – Specially Protected; Near Threatened**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint; riparian vegetation at water abstraction point.**
Orycteropus afer	**Aardvark**	**NCNCA 2009 – Specially Protected, NEMBA**	**Open shrub duneveld, open shrub plains, calcareous low shrub plains throughout Bokpoort II footprint.**
Proteles cristatus	Aardwolf	NCNCA 2009 – Protected	Open shrub duneveld, open shrub plains in northern region of Bokpoort II footprint.

5.6.2 Ecosystems of Conservation Concern

The ecosystems of priority conservation concern include those identified by NEMBA as endangered, those considered to be of pristine ecological integrity, and those considered important for their support of species of conservation concern.

Therefore, the ecosystems of priority conservation concern for impact assessment include the following:

- The **rocky outcrop** in the northern corner of the Study Area associated with the Koranna-Langeberg Mountain Bushveld Vegetation type – as well as having an intact ecological integrity in terms of vegetation community composition (section 5.2.1), it is an important area in terms of its support of roosting bat species (Golder Associates Africa, 2016b); and
- The **riparian habitat** associated with the Orange River – this area supports the endangered vegetation type Lower Gariep Alluvial Vegetation, and has importance as an ecological corridor through the landscape. In addition it is an important support area for foraging faunal species, including bats.

5.6.3 Natural and Modified Habitats

Natural and modified habitat was mapped using the baseline data provided in the previously conducted vegetation assessments (BEC, 2010; EnviRoss 2014) (Figure 9).

The vegetation types and associated IFC habitat categories are outlined on Table 11 and illustrated on Figure 12.

Table 11: Natural and modified habitats

Vegetation type	IFC Natural/ Modified	Comment
Calcareous low shrub plains	Modified	Considered relatively degraded due to livestock grazing pressure.
Open shrub plains	Modified	Considered relatively degraded due to livestock grazing pressure.
Open shrub duneveld	Modified	Found to be degraded due to livestock grazing during 2015 site visit (Figure 7)
Rocky outcrop/foothills	Natural	Assessed as being in pristine condition.
Transformed areas	Modified	Areas already transformed through vegetation clearance and construction activity are considered modified.

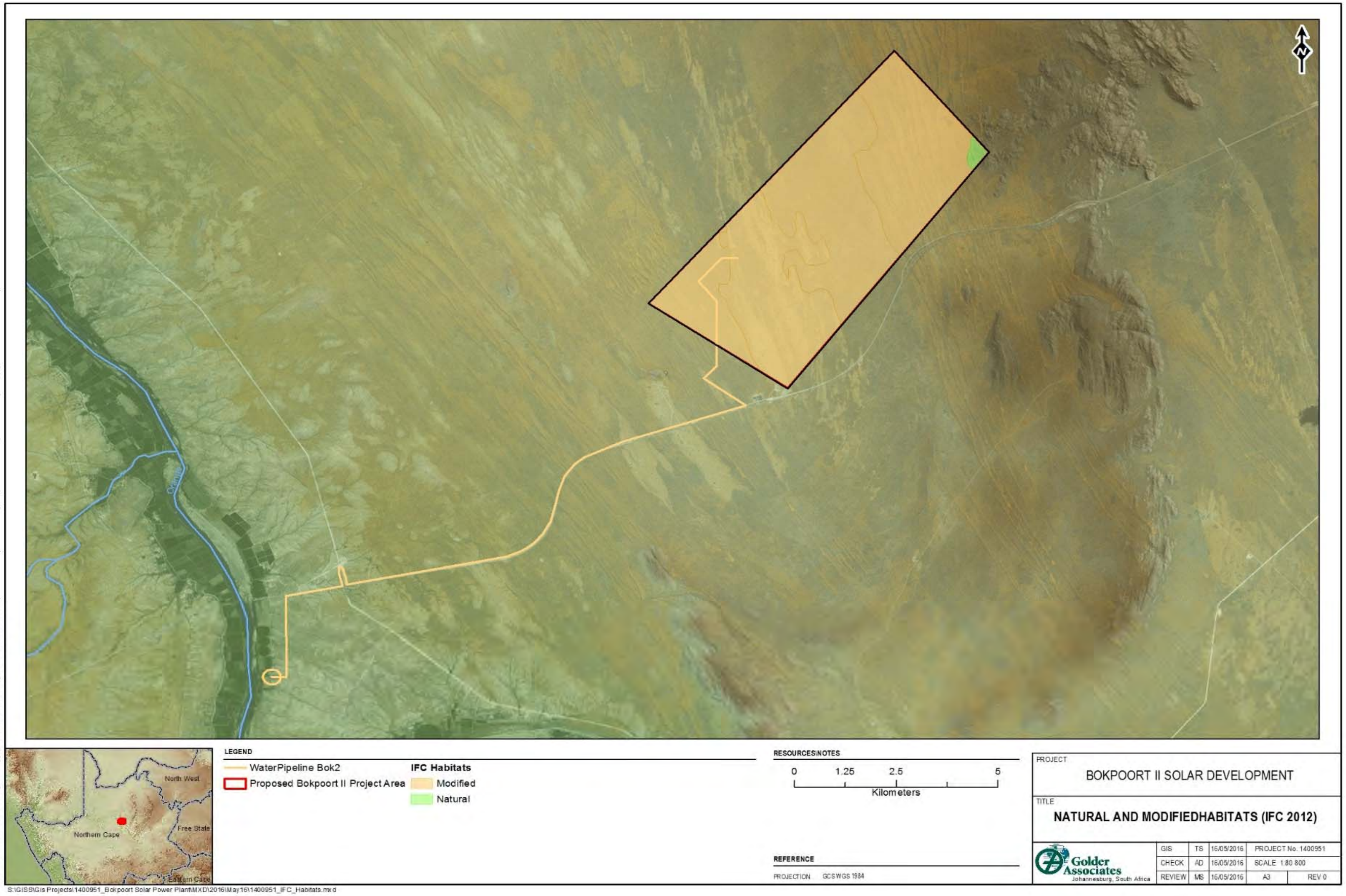

Figure 12: Natural and modified habitat in the study area

5.6.4 Critical Habitat

Critical habitat designation, typically, should be determined on a case-by-case basis according to the concepts of irreplaceability and vulnerability (IFC 2012b). Hence, when applying this guidance, it is often possible to identify critical habitat using the five primary criteria provided by the IFC (2012a), that is:

1) Habitat of significant importance to critically endangered and/or endangered species.

2) Habitat of significant importance to endemic and/or restricted-range species.

3) Habitat supporting globally significant concentrations of migratory species and/or congregatory species.

4) Highly threatened and/or unique ecosystems.

5) Areas associated with key evolutionary processes.

The biodiversity features of the Study Area are screened against the first three (*quantitative*) critical habitat determination criteria on Table 12 overleaf.

Criterion 4 and 5, and other *qualitative* criteria, are addressed on Table 13.

Table 12: Screening of quantitative critical habitat criteria against Study Area biodiversity features

Criteria	Tier 1 Critical Habitat requirement	Study Area	Tier 2 Critical Habitat requirement	Study Area
1. Critically Endangered (CR)/ Endangered (EN) Species	(a) Habitat required to sustain ≥10 percent of the global population of a CR or EN species/subspecies where there are known, regular occurrences of the species and where that habitat could be considered a discrete management unit for that species. (b) Habitat with known, regular occurrences of CR or EN species where that habitat is one of 10 or fewer discrete management sites globally for that species.	No CR/EN species confirmed or expected present within the Study Area	(c) Habitat that supports the regular occurrence of a single individual of a CR species and/or habitat containing regionally-important concentrations of a Red-listed EN species where that habitat could be considered a discrete management unit for that species/ subspecies. (d) Habitat of significant importance to CR or EN species that are wide-ranging and/or whose population distribution is not well understood and where the loss of such a habitat could potentially impact the long-term survivability of the species. (e) As appropriate, habitat containing nationally/regionally important concentrations of an EN, CR or equivalent national/regional listing.	No CR/EN species confirmed or expected present within the Study Area

Criteria	Tier 1 Critical Habitat requirement	Study Area	Tier 2 Critical Habitat requirement	Study Area
2. Endemic/ Restricted Range Species	(a) Habitat known to sustain ≥95 percent of the global population of an endemic or restricted-range species, where that habitat could be considered a discrete management unit for that species (e.g., a single-site endemic).	Some flora and fauna species of regional conservation interest occur, however none can be considered restricted range as defined by IFC[1], and even if that were the case, no habitat on site supports ≥ 95 percent of the global population of any species	(b) Habitat known to sustain ≥1 percent but <95 percent of the global population of an endemic or restricted-range species where that habitat could be considered a discrete management unit for that species, where data are available and/or based on expert judgment.	Two Kalahari endemic plant species have been recorded within the Study Area; however it is highly unlikely that these species occur at a scale which would represent ≥1 percent of the global population of the species, given the size of the extent of occurrence (the Kalahari region) compared to the size of the Study Area.

[1] For terrestrial vertebrates, a restricted-range species is defined as those species which have an extent of occurrence of 50,000 km^2 or less. For freshwater systems, an IUCN study of African freshwater biodiversity applied thresholds of 20,000 km^2 for crabs, fish, and molluscs and 50,000 km^2 for odonates (dragonflies and damselflies. For plants, restricted-range species may be listed as part of national legislation, and are more commonly referred to as “endemic”, an endemic species being one that has ≥ 95 percent of its global range inside the country or region of analysis (IFC, 2012b).

Criteria	Tier 1 Critical Habitat requirement	Study Area	Tier 2 Critical Habitat requirement	Study Area
3. Migratory/ Congregatory Species	(a) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle where that habitat could be considered a discrete management unit for that species.	Migratory/congregatory species confirmed/ considered likely present within the Study Area include the bat species, however these are crevice/bark roosting species which typically congregate in small numbers (<20 and often individually) and therefore do not fit the ≥95 percent of the global population criteria	(b) Habitat known to sustain, on a cyclical or otherwise regular basis, ≥1 percent but <95 percent of the global population of a migratory or congregatory species at any point of the species' lifecycle and where that habitat could be considered a discrete management unit for that species, where adequate data are available and/or based on expert judgment. (c) For birds, habitat that meets BirdLife International's Criterion A4 for congregations and/or Ramsar Criteria 5 or 6 for Identifying Wetlands of International Importance. (d) For species with large but clumped distributions, a provisional threshold is set at ≥5 percent of the global population for both terrestrial and marine species. (e) Source sites that contribute ≥1 percent of the global population of recruits.	The expected numbers of populations of any congregatory bat species encountered in the Study Area is not expected to constitute ≥1% of the global population (see Golder Associates Africa, 2016a. For birds, see Specialist Ornithology Preconstruction Monitoring report (ARCUS, 2016).

The remaining *qualitative* critical habitat criteria outlined in PS6 are addressed in the context of the Study Area in Table 13.

Table 13: Qualitative critical habitat determination criteria in the context of the Study Area

Criteria	Study Area context
4. Highly threatened or unique ecosystems	The Lower Gariep Alluvial Vegetation type is considered Endangered, due to largely due to transformation of approximately 50% of its extent for agricultural cultivation and via alluvial diamond mining (Mucina & Rutherford, 2006). About 6% is statutorily conserved inside National Parks, and an additional 25% is targeted for conservation. It is likely that transformation is ongoing in this vegetation unit, although the rate of decline is not known. It is classified as being of High Conservation Value (IFC PS6 GN35), as it is considered to be an Endangered ecosystem. As an endangered ecosystem that has suffered at least a 50% loss to transformation, and given that the rate of current loss is unknown, this vegetation unit qualifies as critical habitat under Criterion 4 highly threatened ecosystems, as it is an area of high conservation value that may be at risk of significantly decreasing in area or quality (IFC PS6 GN90). The proposed abstraction point is located within the mapped area of this vegetation unit; however this area is already transformed by agricultural cultivation, and as a result of the construction of the existing abstraction point, and no longer supports natural vegetation; therefore the area where the abstraction pipeline is proposed is classified as modified habitat.
5. Key Evolutionary Processes	Examples of habitat triggering this criterion are peat-forming wetlands which develop over the course of millennia, or islands where new species have developed as a result of isolation. No key evolutionary processes are associated with the Study Area.
6. Areas required for seasonal refugia for critically endangered (CR) and/or endangered (EN) species	No significant numbers of CR or EN species confirmed/expected within the Study Area.
7. Ecosystems of known special significance to critically endangered or endangered species for climate adaptation purposes	No significant numbers of CR or EN species confirmed/expected within the Study Area.

Criteria	Study Area context
8. Concentrations of vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be critically endangered or endangered	No such species confirmed/expected within the Study Area.
9. Areas of primary/old-growth/pristine forests and/or other areas with especially high levels of species diversity	None present within the Study Area.
10. Landscape and ecological processes (for example, water catchments, areas critical to erosion control, disturbance regimes) required for maintaining critical habitat	No such landscapes/ecosystems occur within the Study Area.
11. Habitat necessary for the survival of keystone species; that is, species that act as ecosystem engineers and drive ecosystem process an functions e.g. elephants in their role as ecosystem engineers	No such species confirmed/expected to occur within the Study Area.
12. Areas of high scientific value, such as those containing concentrations of species new and/or little known to science	None identified within the Study Area.
13. An area of known high concentrations of natural resources exploited by local people	Apart from livestock grazing, no natural resource harvest/use by local people has been observed within the Study Area.
14. Areas that meet the criteria of the IUCN's Protected Area Management Categories Ia, Ib and II, although areas that meet criteria for Management Categories III-VI may also qualify depending on the biodiversity values inherent to those sites	None present within/in close proximity the Study Area.
15. Key Biodiversity Areas (KBAs), which encompass inter alia Ramsar Sites, Important Bird Areas, Important Plant Areas (IPA) and Alliance for Zero Extinction Sites	None present within/in close proximity the Study Area.
16. Areas determined to be irreplaceable or of high priority/significance based on systematic conservation planning techniques carried out at the landscape and/or regional scale by governmental bodies, recognized academic institutions and/or other relevant qualified organizations (including internationally-recognized NGOs)	None present within/in close proximity the Study Area.
17. High Conservation Value (HCV) areas	None present within/in close proximity the Study Area.

In summary, the Lower Gariep Alluvial Vegetation unit qualifies as Critical Habitat within the Study Area, under Criterion 4; however the area proposed abstraction point is already transformed by agricultural cultivation, and as a result of the construction of the existing abstraction point, and no longer supports natural vegetation; therefore the area where the abstraction pipeline is proposed is classified as modified habitat.

The Project must therefore demonstrate that no significant effects on any adjacent areas of Lower Gariep Alluvial Vegetation will occur as a result of the proposed activities, and appropriate steps of the mitigation hierarchy (avoid, minimise, mitigate, offset) are taken to ensure no net loss of this vegetation unit (ref. section 7.0).

6.0 BIODIVERSITY IMPACT ASSESSMENT

6.1 Predicted Impacts

Potential impacts of the Project on biodiversity were identified, taking cognisance of those already outlined in the Scoping Report (Golder Associates, 2016); the previous terrestrial biodiversity impact assessments for the proposed Project footprint (RHDV, 2014b; BEC, 2010), and the previous aquatic impact assessment for the Orange River abstraction point (DHV, 2014a; Enviross, 2010). The predicted impacts on biodiversity for the construction, operational and closure phases of this Project are outlined in the following sections.

6.1.1 Identified Impacts for the Construction Phase

The main impact on biodiversity during the construction phase arises from changes in land cover due to the proposed construction of the Project and all associated infrastructure, resulting in direct impacts on the extent and composition of vegetation communities and associated faunal groups. Specific project impacts that could occur include:

- Reduction in extent of habitats within the Project footprint;
- Loss/disturbance of flora and fauna species of conservation concern;
- Loss/disturbance of other fauna species;
- Reduction in extent of Natural Habitat;
- Reduction in extent of Critical Habitat;
- Soil erosion and sediment loading of surface water runoff; and
- Expansion of abstraction area at Orange River and effects on riparian and aquatic ecosystems.

6.1.2 Identified Impacts for the Operational Phase

Predicted impacts on biodiversity during the operational phase of the Project relate to disturbance to resident fauna species as a result of the presence of the solar PV facility and contamination risks for the Orange River. The specific operational impacts that are anticipated include:

- Disturbance of resident faunal species caused by ongoing operation and maintenance activities at the facility (e.g. security lighting at night, security patrols of the boundary throughout the day);
- Reflective surfaces (associated with the PV infrastructure) may attract insect species; and
- Water abstraction at the Orange River and effects on quantity and quality of water and riparian habitat downstream.

6.1.3 Identified Impacts for the Decommissioning/Closure Phase

Predicted impacts on biodiversity and ecosystem services during the decommissioning and closure phase of the Project include the following:

- Spread of invasive species;
- Soil erosion and loss/disturbance of ecosystems of conservation concern; and
- Contamination of surface water and aquatic ecosystems.

6.2 Impact Assessment for Project Phases

The Project components and activities potentially affecting biodiversity are broken down by Phase and assessed individually as follows.

6.2.1 Construction Phase Impacts

Predicted impacts on biodiversity during the construction phase of the Project relate to vegetation clearance within the PV1 development footprint, resulting in direct effects on species and ecosystems of conservation concern, indirect effects on ecosystem integrity due to dust and sediment generation causing contamination of surface water systems. The impact assessment matrix summarises construction-phase related impacts to biodiversity (Table 14); specific impacts are discussed in the paragraphs that follow.

Loss of extent of habitats within the Project footprint

Site clearance within the footprint of the PV1 development will result in a combined loss of approximately 250 Ha of existing vegetation within the study area, including calcareous low shrub plains, and open shrub plains. Both of these vegetation communities were considered to be relatively degraded as a result of livestock grazing pressure, and were ascribed a moderate ecological integrity status.

The magnitude of loss of these habitats is considered low in the context of the expansive area covered by the regional Kalahari Karroid shrubland vegetation type (Figure 3) which supports these vegetation communities. The loss will be for the duration of the Project until such a time as the PV1 facility is decommissioned and the site rehabilitated, so will be long-term in duration. Effects will be felt on the site only; therefore the overall impact significance is considered moderate.

The magnitude of impacts could be reduced to minor, and the overall impact significance to low, through the application of the recommended mitigation measures (section 8.0).

Introduction/spread of exotic invasive species

Exotic invasive species have been recorded within the Study Area; vegetation clearance works in advance of construction may spread these species throughout the Study Area and further afield if earth movements take place. The impact magnitude could be high as exotic species are capable of rapidly spreading throughout a locality; and the duration is considered permanent as many exotic species are costly and difficult to eradicate. The probability of this occurring is considered medium, given that some exotics have already been recorded within the Study Area. The overall impact significance is considered **moderate** prior to mitigation.

Application of the recommended mitigation measures reduces the potential magnitude and extent of effects, leaving an impact of low significance post- mitigation.

Loss/disturbance of flora and fauna species of conservation concern

Vegetation clearance for construction of Bokpoort II will result in the loss/disturbance of habitat for species of conservation concern, particularly flora species and also Bat-Eared Fox and Cape Fox, whose prey species inhabit the vegetation within the Study Area for foraging and shelter. Construction activities could cause fatalities to individuals of slow-moving or burrowing species of conservation concern which may not be able to escape oncoming machinery e.g. Suricate, Karoo Round-eared Sengi, Cape Short-tailed Gerbil, and Highveld Gerbil. In addition, indirect effects due to the presence of people and heavy machinery may impact faunal species of conservation concern in the wider landscape.

The potential impact of loss/disturbance of species of conservation concern is assessed as high, due to the confirmed presence of several species of conservation concern, and the predicted presence of several others (Table 10).

The predicted impacts can be reduced to **low** significance, provided that the recommended mitigation measures are applied; specifically the appointment of an Environmental Control Officer for the duration of construction, and additional targeted surveys in for resting areas/dens of mammal species of conservation concern that are known to be present within the Study Area, such as Honey Badger, Aardvark, Striped Polecat, and Bat-eared Fox, directly in advance of clearance works.

Loss/disturbance of other fauna species

Vegetation clearance could result in direct impacts including mortality and injury of other fauna. This is considered to be an impact of moderate significance – although species may not be of specific conservation concern, they contribute to the overall regional biodiversity and ecological integrity of the Study Area.

Provided that the recommended mitigation measures are put in place, the predicted impact can be reduced to one of **low** significance.

Reduction in extent of Natural habitats

Natural habitat within the Study Area consists of the rocky outcrop in the northern corner of the Study Area.

The magnitude of predicted effects on this habitat are considered to potentially be of moderate significance, as although only a small area of habitat would be affected in the context of the total area of those habitat types, the good-pristine ecological integrity assigned to these areas and its classification as Natural Habitat (IFC, 2012) increases the biodiversity value of these habitats. The IFC requires no net loss of Natural Habitats, therefore provided that the application of the recommended mitigation measures is adhered to, i.e. avoidance of any construction works or vegetation clearance in this habitat, the predicted effects can be reduced to **low** significance.

Reduction in extent of Critical Habitat

Expansion of the abstraction area at the Orange River could include riparian vegetation clearance and additional loss of the Lower Gariep Alluvial vegetation type, which is considered critical habitat under IFC criterion 4. Vegetation clearance in this area could also introduce invasive plant species to the riparian environment. Additional clearance of Lower Gariep Alluvial vegetation is considered to be of a moderate magnitude as although a very small area of this vegetation type would be lost when compared with the total area of the vegetation type, it is an Endangered ecosystem. The loss would be permanent; however the probability of this occurring is considered low, since the area where the pipeline and abstraction point will be constructed are already transformed. An impact of moderate significance is therefore predicted before mitigation.

The Project intends to minimise loss of riparian vegetation, through using the existing cleared servitude and minor expansion of the existing abstraction point. The magnitude, probability and extent of impact can all be reduced in this way, therefore the residual impact on Lower Gariep Alluvial vegetation post-mitigation is one of **low** significance.

Soil erosion and sediment loading of surface water runoff

Dust is expected to be generated during construction activities and earthworks; dust can suppress photosynthesis and affect the growth rates of some plant species. This can have knock-on effects on the ability of vegetation communities to support wildlife; it can also affect the quality of riparian and wetland habitats through changes in water chemistry. In addition, the clearance of the vegetation on site is expected to create conditions more conducive to soil erosion as a result of wind and storm water runoff, which can also contribute to sedimentation of surface water systems. The impact significance is predicted to be **medium** prior to mitigation, due to the limited extent and duration of predicted effects which would be greatest during seasonal rains.

With the application of recommended mitigation measures (section 7.0), the duration, extent and probability of impact can all be reduced; reducing the resulting impact to one of **low** environmental significance post-mitigation.

Table 14: Biodiversity impact rating - Construction Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Scale	Probability			Magnitude	Duration	Extent	Probability		
Vegetation clearance in advance of construction works	Direct loss of extent of vegetation communities within the CSP development footprint	4	4	1	4	36	Moderate	2	4	1	4	28	Low
	Introduction/spread of exotic invasive species	8	5	2	3	45	Moderate	4	2	1	3	21	Low
	Loss and disturbance of flora and fauna species of conservation concern	8	4	1	5	65	Moderate	8	4	1	2	26	Low
	Loss and disturbance of other faunal species	6	4	1	5	55	Moderate	6	4	1	2	22	Low
	Reduction in extent of ecosystems of conservation concern	8	5	1	5	70	Moderate	8	1	0	2	18	Low
Construction of a new pipeline and water abstraction point	Reduction in extent of critical habitat	6	5	2	3	39	Moderate	4	5	1	2	20	Low
Soil Erosion Dust and sediment generation from earthworks and vehicles	■ Suppressing of plant photosynthesis and effects on plant growth; ■ Contamination of surface water ecosystems; and ■ Additional loss of extent of adjacent vegetation communities.	4	2	2	5	40	Medium	4	1	2	2	14	Low

6.2.2 Operation Phase Impacts

Predicted operational phase impacts relate to disturbance to resident fauna species as a result of the presence of the solar PV solar facility and contamination risks for the Orange River.

The impact assessment matrix summarises operation phase-related impacts to biodiversity (Table 14); specific impacts are discussed in the paragraphs that follow.

Direct loss (injury/mortality) of fauna species via roadkill

Increased vehicular traffic in the study area during the operation of the CSP tower development is likely to result in increased incidences of road kill, particularly at night. Magnitude in this case refers to the number of wildlife road deaths, which is considered to be potentially high. The impact would be long-term and would affect wildlife on a local scale with an estimated high probability of occurrence, resulting in an impact of moderate significance.

Although the application of mitigation measures would reduce the number of road kill deaths (magnitude) and the probability of vehicle-animal collisions happening, the impact remains one of **moderate** significance post-mitigation.

Disturbance of faunal species of conservation concern – site lighting

Based on observations of the Bokpoort I facility made during the field work conducted in September 2015, the Bokpoort II facility will be well-lit at night. In addition, frequent security patrols of the boundary throughout the day were observed. These, together with on-going operation and maintenance activities at the facility, are expected to cause disturbance to faunal species of conservation concern in surrounding areas, particularly bats foraging at night time. The magnitude of the effects is expected to be moderate given the extent of lighting observed at the existing facility. The predicted impact is thus considered to be of moderate significance prior to mitigation.

Once the recommended mitigation measures are applied, the magnitude of effects on bats and the probability of effects on other faunal species (some of the more adaptable fauna species e.g. foxes may become accustomed to a certain level of disturbance over time) can be reduced, reducing the significance of the overall impact to **low**.

Disturbance of faunal species of conservation concern – barrier to movement

Security fencing of the CSP tower development compound will present a barrier to movement for mammal species of conservation concern such as Aardvark, Bat-eared Fox and Honey Badger, as well as larger reptiles. This may reduce mammal movement capability through the landscape, forcing affected species to make longer, more energetically-expensive journeys to get around the fenced areas. The magnitude of potential effects is considered moderate, as no direct mortality or injury to species of conservation concern is anticipated. The effects would be long-term, occur at a local scale and have a moderate likelihood of occurrence, given the relatively sparse mammal population within the study area. The overall significance of impact is considered to be moderate. It is difficult to mitigate the presence of the security fence during the lifetime of the Project; effects would only be reduced following closure and decommissioning, Therefore, the potential impacts remain of **moderate** significance for the lifetime of the Project.

Attractive properties of reflective surfaces of photovoltaic units to insects

Solar panels can act as ‘ecological traps’ that attract insects, particularly aquatic insects, due to the similarity in reflectiveness between the surface of solar panels and large water bodies (Horvath *et al.,* 2010). Large areas of solar panels could cause sufficient interference in normal aquatic insect distribution to result in reproductive failure and mortality, and potentially contribute to rapid population declines or collapse (Horvath *et al.,* 2010).

However, the Orange River presents a vastly larger and more obvious water source than the proposed panels, and is located approximately 13 km from the project site; therefore the likelihood of the panels attracting significant quantities of aquatic insects to potentially affect populations in a signficant way is considered low., Therefore the predicted impact is one of **Low** significance prior to mitigation. No specific mitigation is proposed as no significant impacts of this sort are predicted.

Water abstraction at the Orange River and effects on quantity and quality of water and riparian habitat downstream

The amount of water being abstracted from the Orange River is negligible by comparison to the available water resource (Ref. Chapter 9.0, Surface Water Baseline and Impact Assessment Report, 2016). Water abstraction in itself is not expected to significantly contribute to any negative effects on water quality within the Orange River during operation; however some changes in the river flow patterns (e.g. scour of substrate around the abstraction point) may have a limited effect on habitat availability for invertebrates in the immediate area of the abstraction point. These potential impacts are considered to be of low magnitude and will occur at a site scale only, however it is definite so it is therefore considered to be of moderate environmental significance. Providing that the specific mitigation measures outlined in the surface water assessment (Ref. Chapter 9.0, Surface Water Baseline and Impact Assessment Report, 2016) are adhered to, the impact post-mitigation is considered to be of **low** environmental significance.

Table 15: Biodiversity Impact Rating - Operational Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Scale	Probability			Magnitude	Duration	Scale	Probability		
Increased vehicular traffic	Direct loss of fauna through road kill	8	4	2	4	56	Moderate	4	4	2	3	30	Moderate
Site lighting and maintenance	Disturbance of fauna species of conservation concern	6	4	2	5	60	Moderate	4	4	2	2	24	Low
Site security fencing	Disturbance of fauna species of conservation concern through barriers to movement	6	4	2	3	36	Moderate	6	4	2	3	36	Moderate
Photovoltaic panels – reflective surfaces	Attracting aquatic insects	2	4	1	2	14	Low	2	4	1	2	14	Low
Water abstraction	Reduction in quantity of water available downstream of the abstraction point in the Orange River system	2	4	1	5	35	Moderate	1	4	1	5	30	Low

6.2.3 Closure/Decommissioning Phase Impacts

Predicted impacts on biodiversity during the decommissioning and closure phase of the project relate to the spread of invasive species as a result of large-scale ground works, and contamination of surface water systems with resultant effects on aquatic species of conservation concern; in particular frogs and fish of conservation concern (ref. section 5.6.1).

Spread of invasive plant species

The spread of invasive species, particularly invasive plant propagules by heavy machinery and earth works could cause an impact of **high** environmental significance, depending on the invasive plant species that occur in the area. The application of effective mitigation measures as recommended in section 0 is critical in ensuring an impact of **low** environmental significance post-mitigation.

Contamination of surface water and aquatic ecosystems

Impacts on aquatic ecosystems during the decommissioning and closure period are mostly associated with soil erosion and sediment loading of surface water runoff and subsequently aquatic ecosystems, incorrect disposal of hazardous waste and possible surface water pollution due to the leaching of contaminants. Provided the approved design principles and rehabilitation program are implemented, no significant impacts on aquatic ecosystems are expected after closure phase of the site thereby reducing the ranking to **low.**

Table 16: Environmental Impact Rating: Decommissioning and Closure Phase

Aspect	Impact	Rating – Pre mitigation				Total Rating	Significance Points	Rating – Post mitigation				Total Rating	Significance Points
		Magnitude	Duration	Extent	*Probability*			Magnitude	Duration	Extent	*Probability*		
Removal of mining infrastructure, ground works for rehabilitation	Spread of invasive exotic species, displacing native vegetation and faunal species	6	4	3	5	65	Medium	4	1	1	3	18	Low
	Transportation of sediment from newly rehabilitated areas during intense rainfall events into surface water bodies will result in siltation which could smother frogs and their spawning sites	8	5	3	5	80	High	6	5	3	1	14	Low

7.0 MITIGATION MEASURES

Mitigation measures to avoid/minimise effects on ecosystems and species of conservation concern and restore affected areas are presented in sections 7.1, 7.2 and 7.3 below.

7.1 Construction Phase Mitigation Measures

- No surface disturbance or vegetation clearance should occur in the rocky outcrop that consists of Natural Habitat as defined by IFC. This habitat plus a 250 m boundary should be demarcated and no construction activity should occur within the demarcated zone;
- New areas of surface disturbance and associated vegetation clearance should be avoided and minimised wherever possible. Areas proposed for vegetation clearance should be clearly marked and no heavy vehicles should travel beyond the marked works zone;
- Minimisation of any disturbance to riparian vegetation during construction of the proposed new abstraction point is essential in preventing potential impacts on the Lower Gariep Alluvial vegetation type;
- A specific invasive plant species survey of the site should be conducted prior to the clearance works, and specific measures developed to address removal of any exotic invasive species from the site;
- The retention of a vegetated buffer zone between the edge of the proposed infrastructure footprint and the outer boundary of the facility, within which the existing vegetation is retained, is recommended. This will reduce disturbance associated with construction activity (presence of people and heavy machinery, disturbance of faunal species of conservation concern), and will also contribute to the conservation of natural vegetation within the project boundary;
- Targeted searches for less mobile species of conservation concern with high probability of occurring within the Project footprint (i.e. small mammals, medium mammals that may have dens/resting places

within the footprint) should be conducted immediately prior to commencement of clearance activities to allow relocation to take place where necessary, and avoid mortalities of these species;

- Collection of propagules including seeds, cuttings and seedlings of floral species of conservation concern should be conducted, to preserve genetic diversity and retain these species for specific conservation actions.

  Where possible, these should be replanted in areas of the study area that are proposed for rehabilitation. Specific plans for this should be outlined in a Biodiversity Management/Action Plan for the Project; and

- An Environmental Control Officer should be employed by ACWA Power in order to supervise clearance and construction works and stop works where necessary (e.g. a breeding/resting site of a species of conservation concern is discovered) so that the appropriate conservation measures can be undertaken.

7.2 Operational Phase Mitigation Measures

- Site lighting options such as directional shading to prevent excessive light spillage and the use of light bulbs that are not as attractive to insects (e.g. LED bulbs) should be investigated and applied where feasible;
- Effective diversion of storm water and maintenance of the storm water management system should remain ongoing throughout the lifespan of the Project. The surface drainage management plan for the project should be strictly adhered to. Annual monitoring of the Orange River upstream and downstream of the abstraction point should remain ongoing throughout the lifespan of the Project;
- Traffic speed limits of at most 40 kph should be imposed on all site roads and site access roads to the Project to reduce road kill fatalities;
- Information signs regarding the mammals that may be crossing roads in the vicinity of the Project should be erected (e.g. ‘Caution, Honey Badger Crossing’); and
- Native species planting should be put in place around the Site boundary and in any areas which have exposed soils to aid in the reduction of soil erosion and additional loss of vegetation beyond the footprint of cleared areas.

7.3 Closure/Decommissioning Phase Mitigation Measures

- The Project area being rehabilitated and the borrow area from where soils will be imported must be surveyed for the presence of invasive species prior to commencement of closure/rehabilitation works;
- An invasive species management plan for operations and rehabilitation works should be developed. This will include the identification of target areas for invasive species control, and species-specific eradication methods and measures that will need to be enacted;
- Ongoing annual monitoring of river and stream aquatic health through sampling of amphibian, fish and aquatic macroinvertebrate communities, upstream and downstream of the abstraction point, during rehabilitation works and post-closure is required to ensure that the works (e.g. soil moving works) do not impact the downstream aquatic environment; and
- Restoration/rehabilitation of the Project footprint must include consideration of compatible measures for biodiversity enhancement.

  Such measures should include planting of native species vegetation using the plants/propagules maintained since construction phase (ref. section 7.1), and demarcation of rehabilitated areas as conservation areas only i.e. no livestock grazing should take place in these areas.

8.0 FUTURE MONITORING RECOMMENDATIONS

Recommendations for future monitoring of biodiversity features of concern on which residual effects are predicted are outlined in Table 17.

Table 17: Future monitoring recommendations

Monitoring feature	Monitoring objective	Responsible entity	Monitoring Frequency
Soil erosion	Monitoring of soil erosion should be undertaken, particularly at the site boundary where effects may spread into adjoining lands, to determine whether bare site areas have contributed to increased rates of soil erosion in the locality	ACWA power to commission independent soil scientist	Annual
Invasive plants	The site should be monitored for the presence of invasive plant species on an ongoing basis and removed as discovered.	ACWA power	Ongoing
Road kill	Site access roads and roads within the Project area should be monitored for roadkill. As this should occur on a daily basis, staff working at the facility should be encouraged to report any observances of roadkill and a record of these should be maintained by a responsible entity e.g. site environment manager.	ACWA power	Ongoing

9.0 CUMULATIVE IMPACTS

The Project is located adjacent to the existing Bokpoort I development, and the proposed PV2 and CSP Tower also proposed for the Bokpoort II facility. In addition, the proposed Solafrica Sand Draai 75 MW PV Project in !Keis LM is situated on the farm directly adjacent to the Project (No. 19, Figure 13), and the proposed Kheis Solar Park 1 PV project (No. 14, Figure 13) is located in similar habitat approximately 20 km north of the Project.

Potential residual (post-mitigation) impacts of the Bokpoort CSP tower Project that may contribute to the cumulative effects of other proposed and permitted solar developments in the region relate to potential indirect impacts on fauna. The Project may contribute to cumulative impacts on fauna through increased incidences of road kill as a result of increased vehicular traffic and the creation of a barrier to normal movement of medium-large mammals and reptiles due to the physical barrier that will be created by the site security fencing.

The Bokpoort PV1 Project will avoid additional riparian vegetation clearance through use of the existing Shalom abstraction point being operated for the Bokpoort I development, and therefore should not contribute to cumulative impacts on the 'Lower Gariep Alluvial vegetation'.

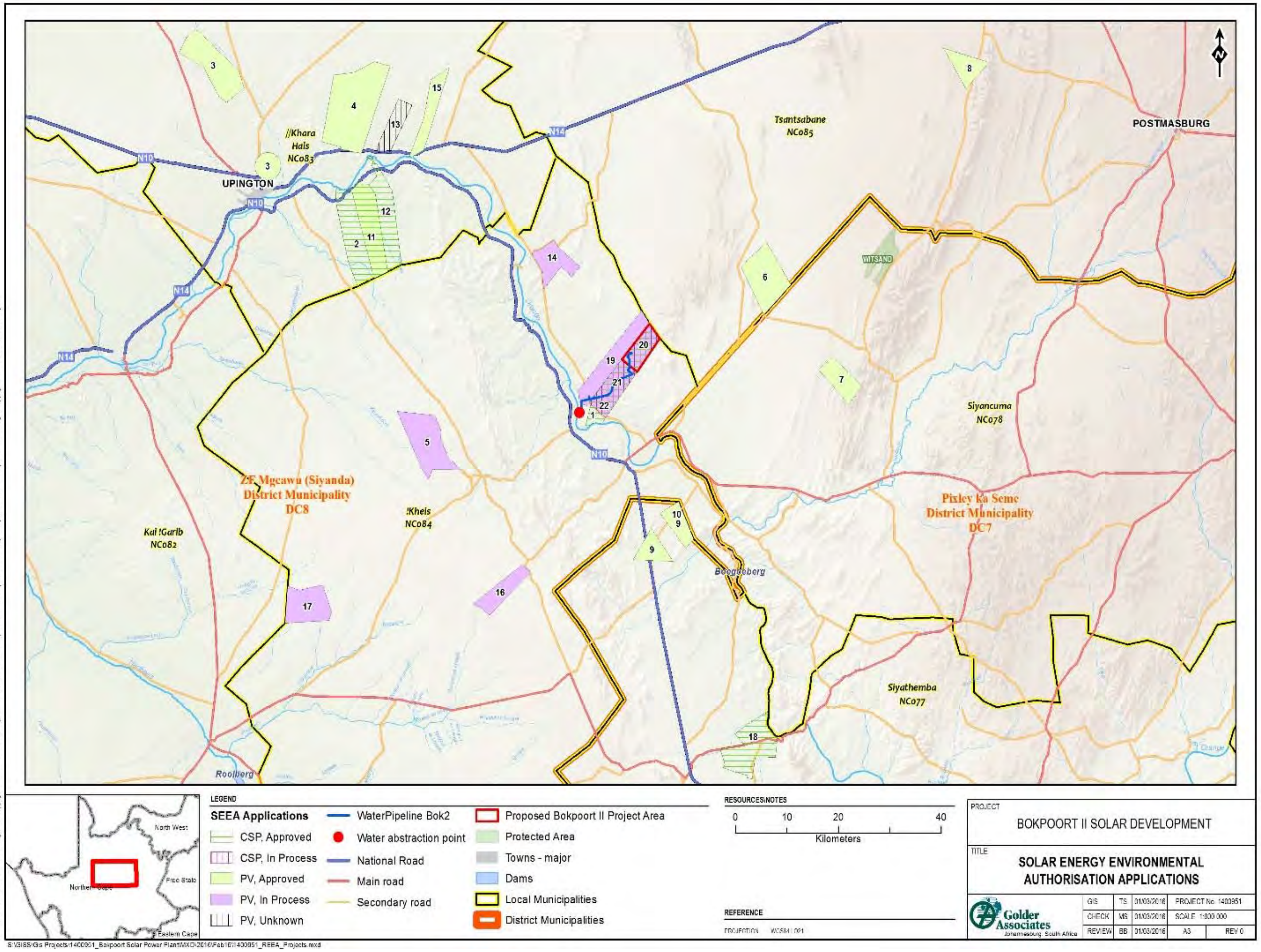

Figure 13: Other solar developments that may pose cumulative impacts on biodiversity

10.0 SUMMARY AND CONCLUSION

The PV1 Project will potentially affect biodiversity in three main ways; loss in extent of vegetation communities and loss and associated disturbance of species of conservation concern during construction; effects on species of conservation concern as a result of site lighting, security fencing and increased road traffic during operation, and the spread of invasive species and potential contamination of aquatic ecosystems during closure.

Aquatic ecosystems within the Study Area are represented by the Orange River. The water quality in the river is currently categorised as 'moderately modified'. The baseline environment in the vicinity of the proposed abstraction point supports a diversity of habitat biotopes for macroinvertebrates and the aquatic macroinvertebrate community structure is thought to be representative of natural conditions in the river. The construction of the proposed abstraction point may temporarily reduce habitat availability for macroinvertebrates and fish in the immediate vicinity during construction; however no serious long-term impacts are expected.

Vegetation communities recorded within the Study Area that will be lost as a result of the proposed development have been generally ascribed moderate ecological integrity statuses, largely as a result of degradation due to livestock grazing pressure. The rocky outcrop in the northern extent of the site is considered pristine, however no direct impacts of loss are predicted in this area. The Project will result in the loss of some of the open shrub duneveld vegetation community, which is classified as a Natural Habitat. The development of Bokpoort II will cause land cover changes through vegetation clearance, potential direct loss of species of conservation concern, and may contribute to the spread of invasive species. Increased presence of people and night-time lighting over the course of the operation of the Project will result in increased sensory disturbance to fauna, reducing the area of foraging habitat available to them.

Although several species of conservation concern have been recorded within the study area, no species that could trigger Critical Habitat as defined by IFC were recorded. The Lower Gariep Alluvial Vegetation mapped along the Orange River potentially qualifies as Critical Habitat, however the riparian area within the Study Area is already transformed by crop production and the existing abstraction point and no longer supports a natural alluvial vegetation community, therefore no impacts on this vegetation type are anticipated.

Appropriate surface and storm water management is essential for the prevention of serious pollution of aquatic ecosystems downstream of the project with contamination from surface water runoff from the Project footprint. In particular, construction of the new abstraction point for the proposed water pipeline must be conducted in such a way that any clearance of riparian vegetation is at least minimised and preferably avoided, in order to avoid any loss of intact areas of the endangered ecosystem Lower Gariep Alluvial Vegetation that may be present downstream.

Provided that the recommended mitigation measures are incorporated into the Project environmental management plan, and are enacted and reported upon to the relevant authority throughout the lifetime of the project, the environmental significance of most impacts on biodiversity and ecosystem services can be reduced to environmentally acceptable levels. However, the Project may contribute to cumulative impacts on fauna in the locality through increased incidences of road kill as a result of increased vehicular traffic and the creation of a barrier to normal movement of medium-large mammals and reptiles.

It is recommended that the recommended mitigation measures be incorporated into a Biodiversity Management Plan for the Project to assist with biodiversity management throughout the lifetime of the Project and contribute to auditable environmental management systems.

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APPENDIX A

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APPENDIX B

Baseline Study Reports

ACWA POWER SOLAFRICA BOKPOORT CSP POWER PLANT (PTY) LTD:

AMENDED ABSTRACTION POINT: BOKPOORT WATER PIPELINE, GROBLERSHOOP, NORTHERN CAPE.

AQUATIC ECOLOGICAL & IMPACT SURVEY.

Prepared for:

Royal Haskoning DHV

Report authors:	**Mathew Ross (*Pr Sci Nat,* MSc), Tahla Ross (PhD)**
EnviRoss CC Report Ref:	**RHDHV_Bokpoort Aquatic_08/14**
Date:	**Aug 2014**
Version:	**version FINAL**

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DECLARATION

This report has been prepared according to the requirements of the Environmental Impact Assessments Regulations (GNR 543) in Government Gazette 33306 of 18 June 2010, as well as the Department of Water Affairs (DWA, 2005) *Guidelines for Delineating Wetland and Riparian Zones* and Department of Water Affairs (DWA, 2007) *River EcoClassification: Manual for EcoStatus Determination (vers 2)*. We (the undersigned) declare the findings of this report free from influence or prejudice.

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Dr Tahla Ross

EXECUTIVE SUMMARY

ACWA Power Solafrica Bokpoort CSP Power Plant Proprietary Limited (Pty) Ltd (hereafter referred to as “ACWA Power Africa”) was granted environmental authorisation for the Bokpoort abstraction point on the Orange River that was associated with the Bokpoort Pipeline to supply the Bokpoort Concentrator Solar Plant (CSP). A more suitable abstraction point (Shalom abstraction point) was sited approximately 2 km upstream of the original site. EnviRoss CC was requested to undertake the aquatic ecological integrity and impact survey for the proposed abstraction point. A total of five field trips have been undertaken to the site to assess both the terrestrial and aquatic habitat units associated with the development since June 2010. The proposed Shalom abstraction point was assessed during a field survey undertaken during February 2014.

The aim of the survey was to ascertain the present ecological state of the surface water resources that could potentially be impacted by the proposed development and thereafter to determine the significance of the potential impacts emanating from a development of this nature during routine monitoring.

Materials and Methods.

The standard South African Department of Water Affairs (DWA) River EcoClassification and EcoStatus Models were utilised to determine the Present Ecological State (PES) the EcoStatus category and the Ecological Importance and Sensitivity (EIS) (DWA, 2007 & 2008). Three aquatic survey sites were chosen that would best allow for determining any deleterious impacts emanating from the proposed development activities, namely upstream of the impact, at the impact and downstream of the impact.

The following methodologies were applied during the survey:

- General riparian and habitat assessments:
    - Walk-about surveys at all survey sites;
- Aquatic habitat assessments:
    - Laboratory analysis of water samples taken at the survey site;
    - River IHI (Index of Habitat Integrity);
    - MIRAI (Macro-invertebrate Response Assessment Index);
    - FRAI (Fish Response Assessment Index) *Fish surveys were not included in this report.*
    - VEGRAI (Vegetation Response Assessment Index).

Results and Discussions

The EcoStatus models all indicated that the river segment within the survey area is subject to various forms of impacts and drivers of ecological change and has suffered various forms of degradation. The greatest impacting feature is as a result of the formal agricultural sector that utilises the riparian areas along the Orange River within the area. The EcoStatus models ultimately place the system within a C category (Moderately modified). The river provides a reliable source of irrigation water to a thriving commercial farming sector. As a result of this there is a lot of infrastructure along the riparian zones of the watercourse and it is these transformation features that are largely responsible for the overall moderately modified PES category. The Ecological Importance and Sensitivity of the system remains within a High category, however.

Water quality results indicated that the river segment has retained relatively good water quality and that water quality is not regarded as a limiting factor to supporting aquatic biodiversity.

Impact significance ratings show that all impacting features can be successfully mitigate to within acceptable limits.

Conclusions and Recommendations

Recommendations and general mitigation measures are outlined below:

- The river reach suffers a change from reference conditions in terms of biological integrity (macro-invertebrates and riparian vegetation) as well as instream and riparian habitat. The resultant Ecological Category is C class. Even though there are transforming and degrading features present within the river reach, the overall Ecological Importance and Sensitivity (EIS) remains *High*. Mitigation measures should be in place to ensure that these ecological categories are not degraded;
- The surface water quality throughout the survey area is considered good, with the aquatic system supporting a diversity of sensitive aquatic macro-invertebrate taxa. It is therefore imperative that the contamination of the surface waters through deleterious effluents and runoff water be avoided;
- Emergency procedures must be in place to timeously mitigate any accidental spillages and to isolate the impacting features as far as possible;

- Regular monitoring of water quality to enable early identification of contamination is recommended. The source of any contamination identified though the monitoring should be identified and managed according to best practice guidelines;
- Soil erosion emanating from disturbances within the riparian zones and other areas of steep gradients is thought to be the greatest impacting feature to potentially impact the overall ecological integrity of the aquatic system. Active storm water management should be implemented to stop silt and sediments from entering the aquatic system and smothering the habitat units. Disturbed soils and stockpiled soils should be protected from erosional features;
- The footprint of the actual development as well as the supporting structure and services during the construction phase should be retained as small as possible by construction vehicles being limited to designated roadways only. Destruction of the riparian habitat through the unnecessary clearing of vegetation should be avoided;
- Dumping of any excess rubble, building material or refuse must be prohibited within riparian and wetland habitat. Dumping of materials should only take place at designated and properly managed areas;
- Adequate toilet facilities must be provided for all construction crews to negate informal ablutions taking place within riparian zones;
- Fires within the riparian zones should be prohibited;
- Exotic vegetation identified presently at the site should be removed and any future exotic vegetation encroachment should be actively managed. This is largely dominated by *Prosopis glandulosa* within riparian areas. The degree of invasion by this species is regarded as problematic and will increase following disturbance features;
- Provided that erosion management, together with the implementation of mitigation measures to abate the negative ecological impacts of the features mentioned above, the overall ecological impact of the proposed development activities can be limited.

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1. INTRODUCTION & TERMS OF REFERENCE

1.1. Background

ACWA Power Solafrica Bokpoort CSP Power Plant Proprietary Limited (Pty) Ltd (hereafter referred to as "ACWA Power Africa") was granted environmental authorisation for the Bokpoort abstraction point on the Orange River that was associated with the Bokpoort Pipeline to supply the Bokpoort Concentrator Solar Plant (CSP). A more suitable abstraction point (Shalom abstraction point) was sited approximately 2 km upstream of the original site. Enviross CC was requested to undertake an aquatic ecological and impact evaluation for the revised abstraction point (Shalom abstraction point) pertaining to the alignment amendments of the Bokpoort pipeline that is to supply the Bokpoort Concentrated Solar Thermal Power (CSP) Plant. An original abstraction point located near the railway bridge was identified and sub sequentially surveyed during June 2010. A more appropriate abstraction point was identified approximately 1 km upstream of this site. Two field surveys were undertaken during January and February 2014 to address both terrestrial and aquatic aspects for these particular amendments, but five field surveys in total have been undertaken to the area to assess both the terrestrial and aquatic habitat units since June 2010. The locality of the survey area and the pipeline realignment is presented in Figure 1. The relative localities of the original abstraction point and the new proposed abstraction point are presented in Figure 2.

1.2. Scope of Work

The Scope of Work included an ecological survey for the riverine habitat to establish baseline data for the river reach that would be impacted by the development activities. These baseline data would then allow for impact evaluations (from both predictions as well as routine future monitoring) in order to evaluate the potential impacts on the system. A water sample was taken at the time of the sampling for comprehensive elemental analysis of all components. A general impact assessment for the surface water resources was to be developed, which would allow for mitigation measures to be proposed in order abate or manage overall negative ecological impacts.

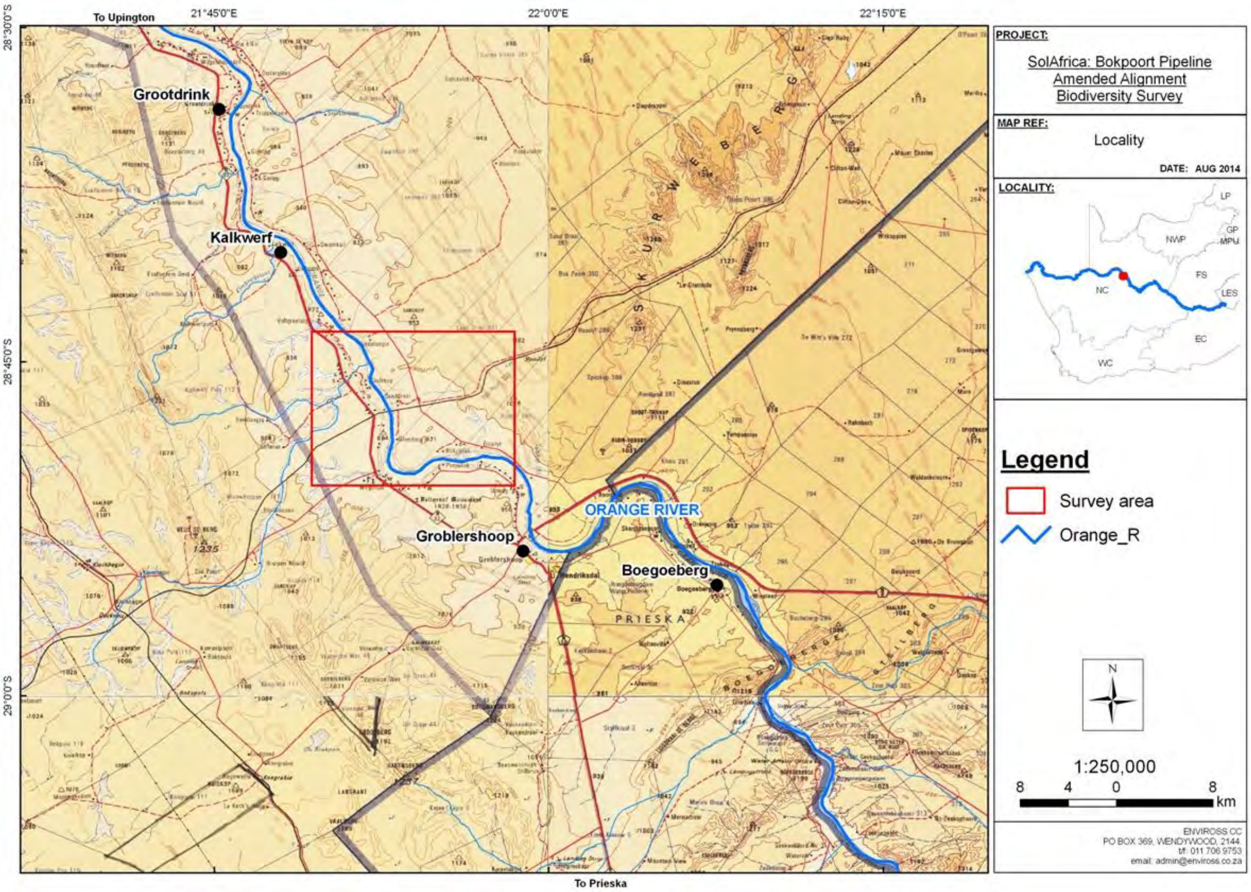

Figure 1: Locality of the study area.

1.3. Assumptions & Limitations

The Orange River has a vastness that is difficult to sample comprehensively. Therefore representative samples were taken from representative areas throughout a diversity of habitat types and under various flow conditions. The data was collected during a single survey with only one sample having been taken. The data presented in this report therefore represents a sample of the time of the survey and has no bearing on any ecological trends of the system, natural or otherwise. Fish sampling was also not included in this report. It is felt that fish community structures will not be impacted by the proposed development and assessment of the fish community structures would not yield information relevant to the project.

Reference is made in the report to engineering and design features and physical limitations on construction. These limitations are based upon perception of an ecologist and are not meant to conflict those opinions of the engineers.

Reference is made to various habitat types. The mapping of these units is based on generalisations and does not supersede more accurate mapping of these units from various specialist surveys. This is especially relevant to delineations of wetlands within the area.

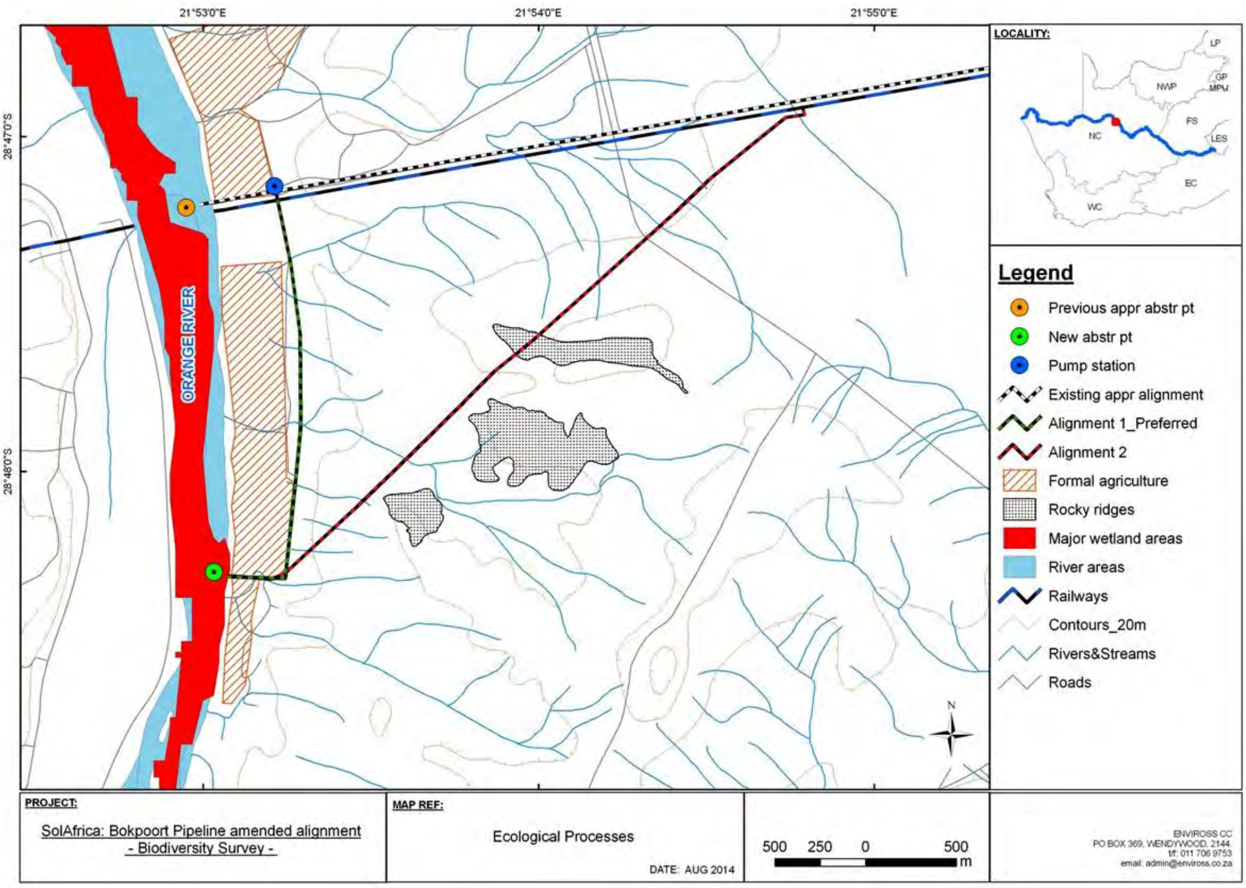

Figure 2: Localities of the abstraction points in relation to proposed pipeline alignment alternatives.

2. AIMS & OBJECTIVES

The objective of this report is to provide the relevant biological information pertaining to the surface water resources and the implications of the potential to the planning, management and construction teams of the proposed development activities, so as to manage and minimise the ecological impacts. It is also to provide baseline data that would serve as the benchmark data that would allow for trend analysis of future data. This document presents the findings of a field survey that was undertaken during January/February 2014.

3. GENERAL STUDY AREA CHARACTERISTICS

3.1. Regional

The survey area is located on the northern banks of the Orange River near the town of Groblershoop and approximately 2 km upstream of the railway crossing. The area falls within the Mixed Karoo region with a rainfall of less than 200 mm per annum, with the majority of the precipitation falling within the late summer season (Esler, *et al*., 2006). The Orange River forms a greenbelt through this predominantly otherwise desert/arid region and supports a riparian vegetation floral community as well as a thriving commercial agricultural sector. Further afield from the riparian zones, the surrounding area is largely open, natural veld, with the land use being dominated by livestock (low density) or game farming.

A formal irrigation scheme, supporting a large commercial agricultural sector, makes commercial agriculture the dominant land use within the areas adjacent to the river. The riparian zones are largely transformed to accommodate this land use. Agricultural fields are often protected from flood events by earth embankments, which have necessitated largescale transformation and landscaping of much of the riparian zones. Infrastructure along the river and within the riparian zones incorporates farm pumping equipment and buildings stations, surface water (stormwater) drains and access roadways.

The survey area falls within the Orange River (D) Primary Catchment, and within the DWA Lower Orange River Water Management Area (WMA14). It falls within the D73D Quaternary Catchment. The Orange River represents one of the very few perennial river systems within an otherwise arid region, with the vast majority of the rivers and streams being seasonal in nature. The predominant surrounding vegetation type is Lower Gariep Broken Veld of the Nama Karoo Biome and Bushmanland Bioregion (Mucina & Rutherford, 2006).

3.2. Local

Much of the vegetation within this zonal area has been transformed to accommodate agricultural crops and the vast majority of the farm infrastructure is located within these areas. This means that the natural vegetation features have largely been lost.

Figure 3: Various views of the proposed Shalom abstraction point, showing some of the existing infrastructure and impacting features.

This was the only area where exotic species encroachment was observed to be potentially problematic, with *Prosopis glandulosa, Nicotiniana glauca* and *Eucalyptus* spp being the species of greatest concern. The banks of the river were largely dominated by reedbeds made up of *Phragmites australis*. The high association that this area has with agricultural activities and infrastructure, together with the high incidence of exotic vegetation means that the potential for floral species of conservational concern being supported is regarded as low. Lower Gariep Alluvial Vegetation, as a vegetation unit, forms part of a *Critical Biodiversity Area (CBA)* due to the general ecological sensitivity of the unit. Cognisance of this feature should be noted and disturbances and construction footprints within this area should be minimised.

The aquatic habitat is dominated by slow to medium velocity deep water with a substrate dominated by sand and mud at the site. Some rocky outcroppings do occur within the local area where the water is shallower and the velocity increases, and the formation of islands do occur with interlinking channels. This creates a diversity of aquatic habitat types. Some emergent aquatic vegetation occurring within hydraulically-sheltered areas, often associated with localised sandbanks.

4. ECOCLASSIFICATION

4.1. Concepts and principles

EcoClassification is the term used for the Ecological Classification process and refers to the determination and categorisation of the Present Ecological State (PES i.e. the health of integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The purpose of EcoClassification is to gain insight and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river. The EcoClassification and EcoStatus determination are undertaken according to DWA guidelines (Kleynhans & Louw, 2007, Module A).

The steps followed in EcoClassification are as follows:

- Determine reference conditions for each component.
- Determine the PES for each component, as well as for the integrated EcoStatus.
- Determine the trend for each component, as well as for the EcoStatus.
- Determine the reasons for the PES and whether these are flow or non-flow related.
- Determine the Ecological Importance and Sensitivity (EIS) for the biota and habitats.
- Considering the PES and the EIS, suggest a realistic Recommended Ecological Category
- (REC) for each component, as well as for the EcoStatus.

4.1.1. EcoStatus

The EcoClassification process followed for this survey is based on a combination of the Desktop EcoStatus level and an EcoStatus Level I determination and involved the use of the following indices:

- Determination of the PES for each component using the various EcoStatus models:
  - Index of Habitat integrity (IHI): Kleynhans *et al*. (2009a).
  - Physico-chemical Assessment Index (PAI): Kleynhans *et al*. (2005b).
  - Fish Response Assessment Index (FRAI): Kleynhans (2007a).
  - Macroinvertebrate Assessment Index (MIRAI): Thirion (2007).
  - Riparian Vegetation Assessment index (VEGRAI): Kleynhans *et al*. (2007d).

- Determine the EcoStatus which involves integration of the individual Ecological Category (EC) values of the abovementioned components to obtain an overall EcoStatus category (as outlined below).
- Determination of the trend for the various driver and response PES and integrated EcoStatus.

The Present Ecological State (PES) of the river is expressed in terms of biophysical components:

- Drivers (physico-chemical, geomorphology, hydrology), which provide a particular habitat template; and
- Biological responses (fish, aquatic macro-invertebrates and riparian vegetation).

Different processes (indices) are followed to assign a category (A → F; A = Natural, and F = critically modified) to each component. Ecological categories are assigned the A to F categories within a continuum, with no clearly-defined boundaries. This concept is illustrated in Figure 4.

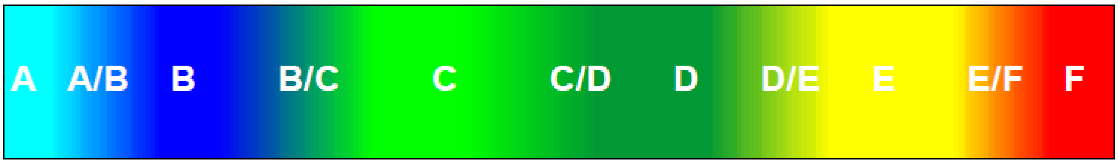

Figure 4: Illustration of the distribution of Ecological Categories on a continuum (from DWA, 2007).

Ecological evaluation in terms of expected reference conditions, followed by integration of these components, represents the Ecological Status or EcoStatus of a river. Thus, the EcoStatus can be defined as the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna (*modified from* Iversen *et al*., 2000). This ability relates directly to the capacity of the system to provide a variety of goods and services.

Table 1: Generic interpretation of the EcoStatus categories (*from* Kleynhans & Louw, 2007).

Ecological Category	Description
A (90-100%)	Unmodified, natural.
B (80-89%)	Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged.
C (60-79%)	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D (40-59%)	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E (20-39%)	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F (0-19%)	Critically /Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

4.1.2. Ecological importance and Sensitivity (EIS)

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Kleynhans & Louw, 2007).

4.2. Present Ecological State

4.2.1. Reference Conditions

The EcoStatus model would ordinarily call for a theoretical reference state to be determined for the river reach under question, as the Present Ecological State (PES) is discerned through determining by how much the present state differs from the reference state (under natural conditions). A background survey was undertaken for the site to gain a theoretical reference state model so that the EcoStatus models could be effectively applied. It should be noted, however, that this survey will be regarded as the reference state and any trending changes brought about by the proposed development activities will be benchmarked against these data in future. The theoretical reference conditions for the various components for the river reach under study are presented in Table 2.

Table 2: Theoretical reference conditions applicable to the river reach under study.

Component	Reference conditions	Conf
Physico-chemical characteristics	A comprehensive water quality assessment has been undertaken as part of the survey. Baseline data will serve as the reference data for future monitoring comparisons.	-
Riparian vegetation	**Marginal Zones:** The riparian zones of the river reach forms part of a macro channel that would normally flood under natural conditions. Substrate is therefore expected to be loose alluvial soils. *Inner marginal zones:* A steep and well-defined gradient is expected between the outer edges of the marginal zones and the inner zones where permanent moisture would occur. Reedbeds (predominantly *Phragmites australis*) would occur within these inner marginal zones and form dominant stands. *Outer marginal zones:* The outer marginal zones would see a greater inclusion of woody elements, including *Salix mucronata, Ziziphus mucronata, Searsia pendulina* and *Acacia karroo*. Outer marginal zones would see species representative of arid conditions, with *Tamarix usneoides* being dominant. Loose and unstructured soils would mean that soil dispersal by wind action would be common. It is therefore	4

Component	Reference conditions	Conf
	thought that some open areas (especially within areas of high gradients) would occur.	
Fish	The DWA provides a reference list of fish species that would be expected to occur at the site (Kleynhans, 2008). There is a DWA reference site located upstream of the site near Boegoeberg Dam. There are 11 indigenous species expected to occur at the site, namely *Austroglanis sclateri, Barbus anoplus, Labeobarbus aeneus, Labeobarbus kimberleyensis, Barbus paludinosus, Barbus trimaculatus*, *Clarias gariepinus*, *Labeo capensis*, *Labeo umbratus*, *Pseudocrenilabrus philander* and *Tilapia sparrmanii.* It is assumed that these species would all occur within the river reach associated with the site. *Fish sampling was not undertaken during the survey.*	4
Aquatic macro-invertebrates	SASS5 interpretation guidelines are provided by Dallas, 2005, wherein the expected macro-invertebrate scores are provided for various PES categories as follows: Category SASS Score ASPT A >108 >6.0 B 101-107 5.6-6.0 C 71-100 5.3-5.5 D 35-70 4.7-5.2 E/F 0.34 0-4.6 Under reference (natural conditions) a category A would be expected, with a SASS5 score of >109 and ASPT of >6.0.	4

4.2.2. Present Ecological State

Various indices were utilised to assign the river reach in question a baseline PES rating, which included the River Index of Habitat Integrity (River-IHI), MIRAI (Macro-invertebrate Response Assessment Index) and VEGRAI (Vegetation Response Assessment Index). The results from these various components are summarised in Table 3, where the overall EC (Ecological Category) is also provided.

Table 3: Summary of the EcoStatus results for the Shalom abstraction site and immediate surrounds.

Component	EC (%)	Ecological Category
Index of Habitat Integrity		
Instream IHI	79.3%	B/C
Riparian IHI	66.8%	C
Macro-invertebrate Response Assessment Index	65.8%	C/D
Vegetation Response Assessment Index	73.3%	C
ECOSTATUS		**C (Confidence: 4)**

4.2.3. Drivers of ecological change

4.2.3.1. Instream IHI

The instream IHI was rated relatively good (79.3% B/C). This is largely due to the presence of a diversity of habitat types (biotopes). A limiting feature is thought to be that the marginal vegetation is predominantly reeds.

4.2.3.2. Riparian IHI

The riparian IHI was also rated relatively good (66.8% C). Limiting factors to this feature was the clearing of adjacent terrestrial areas to accommodate agriculture, informal roadways that occur within the edges of the riparian zones, occurrence of the exotic species *Prosopis glandulosa* and the clearing of vegetation for other various reasons.

4.2.3.3. Fish

Fish sampling was not undertaken during the survey. The reference data for fish is recorded from an area relatively close to the survey site. The open connectivity of the channel, habitat availability and the generally good water quality leads to the assumption that the survey site would have a similar species community structure as that of the reference site.

4.2.3.4. Aquatic macro-invertebrates

The results of the aquatic macro-invertebrate survey also yielded relatively poor results. As was noted to be a limiting factor to the results of the fish survey, the high flows that occurred at the time of the survey limited accessibility to various habitat types. Instream habitat integrity was noted as being relatively good, as was the general water quality parameters. It is assumed, however, that pesticide usage within the agricultural areas that contaminates the watercourse, impacts on the macro-invertebrates and can be regarded as a limiting factor.

4.3. Ecological Importance and Sensitivity (EIS)

The use of biotic data in the assessment of the EIS considers the presence of rare and endangered species, unique species and species (including various life-history stages) with a particular sensitivity to flow (and flow-related water quality aspects) in combination with other ecological information on the study area. The EIS of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological Sensitivity refers to the ability of the system ability to tolerate disturbance and its resilience once an impact has taken place (Kleynhans, 1999b). The EIS of the system is regarded as being *High*. The most important and relevant points are summaries in Table 4.

Table 4: Summary of the relevant points of the EIS determination.

Determinant	Score	Conf	Reason
PRIMARY DETERMINANTS			
Rare and endangered species	4	4	*Labeobarbus kimberleyensis; Austroglanis sclateri*
Populations of unique/isolated species	3	4	*Aridity of the surrounding region means that the riparian zones and river habitat would be utilised by many unique and isolated species.*
Species / taxon richness	3	4	*Moderate/High* – 7/11 of the expected fish species.
Diversity of habitat types or features	3	4	*Moderate/High* - instream biotopes diverse through interlinking channels, islands.
Migration/breeding and foraging site for wetland/riparian species	2	4	The riparian zones form a greenbelt through an arid area that is readily utilised for agriculture. It is therefore important to maintain this for maintenance of migrations and connectivity.
Sensitivity to changes in natural hydrological regime	3	4	Many fish species that occur at the site are regarded as being flow dependent, with flow being a primary trigger for stimulating migratory movements.
Sensitivity to water quality changes	3	3	Some sensitive biodiversity noted within the aquatic habitat that would be impacted by deterioration of water quality.
Flood storage and energy dissipation	2	2	The Orange River has a large catchment area. There is limited capacity for flood attenuation due to limited flood plain interaction.
Base-flow augmentation and dilution	3	2	Large catchment with significant mean annual runoff, with the Orange River representing the main watercourse for the region.
MODIFYING DETERMINANTS			
Protected status	3	2	Aquatic and riparian habitats are statutorily protected.
Ecological importance (rarity of size/type/condition)	2	3	The Orange River represents the main watercourse for the region and one of the very few perennial systems within an arid environment.
TOTAL	***30***		
MEDIAN	**3**	**3**	
		EIS	**High**

5. WATER QUALITY – LABORATORY ANALYSIS

A water sample from the proposed Shalom abstraction point was sent to a laboratory for analysis. The results of the general water quality parameters are presented in Table 5. No values fall outside of the target ranges of the South African Target Water Quality Guidelines (1996).

Table 5: Results of the laboratory general water quality analyses.

Analyses in mg/ℓ (Unless specified otherwise)	Method Identification	Sample Identification
		Shalom site
pH – Value at 25°C	WLAB001	8.2
Electrical Conductivity in mS/m at 25°C	WLAB002	26.0
Total Dissolved Solids at 180°C	WLAB003	182
Suspended Solids at 105°C	WLAB004	14.0
Turbidity in N.T.U.	WLAB005	9.1
Total Alkalinity as $CaCO_3$	WLAB007	112
Chloride as Cl	WLAB046	10
Sulphate as SO_4	WLAB046	12
Fluoride as F	WLAB014	0.3
Nitrate as N	WLAB046	0.5
Total Coliform Bacteria / 100 mℓ	WLAB021	78
E. Coli / 100 mℓ	WLAB021	0
Free & Saline Ammonia as N	WLAB046	0.2

The results of the 52-element scan are presented in Table 6. Again, no elements tested for occur in concentrations that would be deleterious to overall aquatic health. Elements contained within the water are what would be expected for the catchment area and characteristics of the watercourse. Elevated levels of potassium, magnesium, and other trace elements are typical of a system that has a strong association with formal agriculture. These water quality values should be used as a benchmark to any future monitoring of water quality trends.

Table 6: Elemental scan results of the laboratory water quality analyses.

Element	Units	Detection limits	Survey site	Element	Units	Detection limits	Survey site
Ag	mg/ℓ	<0.01	<0.01	**Nb**	mg/ℓ	<0.01	<0.01
Al	mg/ℓ	<0.01	<0.01	**Nd**	mg/ℓ	<0.01	<0.01
As	mg/ℓ	<0.01	<0.01	**Ni**	mg/ℓ	<0.01	<0.01
Au	mg/ℓ	<0.01	<0.01	**Os**	mg/ℓ	<0.01	<0.01
B	mg/ℓ	<0.01	0,014	**P**	mg/ℓ	<0.80	<0.80
Ba	mg/ℓ	<0.01	0,039	**Pb**	mg/ℓ	<0.01	<0.01
Be	mg/ℓ	<0.01	<0.01	**Pd**	mg/ℓ	<0.01	<0.01
Bi	mg/ℓ	<0.01	<0.01	**Pr**	mg/ℓ	<0.01	<0.01
Ca	mg/ℓ	<0.01	25,3	**Pt**	mg/ℓ	<0.01	<0.01
Cd	mg/ℓ	<0.01	<0.01	**Rb**	mg/ℓ	<0.01	<0.01
Ce	mg/ℓ	<0.01	<0.01	**Re**	mg/ℓ	<0.01	<0.01
Co	mg/ℓ	<0.01	<0.01	**Ru**	mg/ℓ	<0.01	<0.01
Cr	mg/ℓ	<0.01	<0.01	**Sb**	mg/ℓ	<0.01	<0.01
Cs	mg/ℓ	<0.01	<0.01	**Sc**	mg/ℓ	<0.01	<0.01
Cu	mg/ℓ	<0.01	<0.01	**Se**	mg/ℓ	<0.01	<0.01
Dy	mg/ℓ	<0.01	<0.01	**Si**	mg/ℓ	<0.01	<0.01
Er	mg/ℓ	<0.01	<0.01	**Sm**	mg/ℓ	<0.01	<0.01
Eu	mg/ℓ	<0.01	<0.01	**Sn**	mg/ℓ	<0.01	<0.01
Fe	mg/ℓ	<0.01	0,021	**Sr**	mg/ℓ	<0.01	0,133
Ga	mg/ℓ	<0.01	<0.01	**Ta**	mg/ℓ	<0.01	<0.01
Gd	mg/ℓ	<0.01	<0.01	**Tb**	mg/ℓ	<0.01	<0.01
Ge	mg/ℓ	<0.01	<0.01	**Te**	mg/ℓ	<0.01	<0.01
Hf	mg/ℓ	<0.01	<0.01	**Th**	mg/ℓ	<0.01	<0.01
Hg	mg/ℓ	<0.01	<0.01	**Ti**	mg/ℓ	<0.01	0,015

Element	Units	Detection limits	Survey site	Element	Units	Detection limits	Survey site
Ho	mg/ℓ	<0.01	<0.01	**Tl**	mg/ℓ	<0.01	<0.01
Ir	mg/ℓ	<0.01	<0.01	**Tm**	mg/ℓ	<0.01	<0.01
K	mg/ℓ	<0.01	1,72	**U**	mg/ℓ	<0.01	<0.01
La	mg/ℓ	<0.01	<0.01	**V**	mg/ℓ	<0.01	<0.01
Li	mg/ℓ	<0.01	<0.01	**W**	mg/ℓ	<0.01	<0.01
Lu	mg/ℓ	<0.01	<0.01	**Y**	mg/ℓ	<0.01	<0.01
Mg	mg/ℓ	<0.01	11,4	**Yb**	mg/ℓ	<0.01	<0.01
Mn	mg/ℓ	<0.01	<0.01	**Zn**	mg/ℓ	<0.01	<0.01
Mo	mg/ℓ	<0.01	<0.01	**Zr**	mg/ℓ	<0.01	<0.01
Na	mg/ℓ	<0.01	12,7				

6 IMPACT SIGNIFICANCE & RATINGS OF PERCEIVED ECOLOGICAL IMPACTS

The potential impacts pertaining to a development of this nature have been identified that could be deleterious to the overall long term ecological functionality and integrity of the proposed development area have been shown to be readily managed to within acceptable limits by the implementation of realistic and achievable mitigation measures. It should be noted, however, that the successful implementation of the mitigation measures and the long-term impacts on the overall ecological integrity at the development site can only be possible with the sincere efforts of the management and construction teams associated with the project.

The significance points (SP) value is calculated by the following formula:

Where: SP = E + D + F + I +P

Where:
E = Spatial extent;
D = Duration;
F = Frequency;
I = Intensity;
P = Probability

Table 7: Rating scores for the various factors used for calculating the significance rating of a particular impact.

Extent		Duration		Frequency		Intensity		Probability		Cumulative impacts
Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating
Site specific	1	Very short	1	Very rare	1	Very low	1	Improbable	1	***Low:*** Low occurrence of similar infrastructure within the region. The development represents an isolated occurrence.
Local	2	Short term	2	Unusual	2	Low	2	Probable	2	***Medium:*** Emerging occurrence and development of similar infrastructure within the region.
Regional	3	Medium	3	Frequent	3	Medium	3	Likely	3	***High:*** High occurrence of similar infrastructure within the region. The development represents infrastructure development that will be largely unnoticed due to high occurrences of similar infrastructure.
National	4	Long term	4	Very frequent	4	Med-high	4	Very likely	4	
International	5	Permanent	5	Continuous	5	High	5	Definite	5	

Table 8: Significance assessment of the perceived major environmental impacts pertaining to a development of this nature and general ecological and habitat conservation both *before* and *after* mitigation measures that are applicable to the proposed development activities.

Potential environmental impact	Nature of the activity or issue	Environmental significance ***before*** mitigation						Environmental significance ***after*** mitigation as per EMPr					
		E	D	F	I	P	SR	E	D	F	I	P	SR
PRECONSTRUCTION & CONSTRUCTION PHASE													
Aquatic habitat destruction	**The construction of the abstraction infrastructure will lead to a certain level of aquatic habitat destruction.**	2	4	2	2	3	13	1	2	2	2	2	9
	<u>*Comment*</u>*:* *The proposed site already accommodates an agricultural water pump, with an established concrete jetty and electrical installations. Further localized infrastructure development is therefore not going to impose significant habitat change/destruction.*												
	<u>*Summary of pertinent mitigation points:*</u> *Limit this impact to the footprint and immediate support areas only and avoid indiscriminate destruction of habitat.*												
Riparian habitat destruction	**The construction of the abstraction infrastructure will lead to a certain level of aquatic habitat destruction.**	2	4	2	2	3	13	1	2	2	2	2	9
	<u>*Comment*</u>*:* *The proposed site already accommodates an agricultural pump, with an established concrete jetty. Further localized infrastructure development is therefore not going to impose significant habitat change/destruction.*												
	<u>*Summary of pertinent mitigation points:*</u> *Limit this impact to the footprint and immediate support areas only and avoid indiscriminate destruction of habitat.*												
Soil impacts	**Soil disturbances aggravating soil erosion; Erosion of unprotected soil stockpiles.**	2	4	3	3	4	16	2	2	1	2	1	8

Potential environmental impact	Nature of the activity or issue	Environmental significance *before* mitigation						Environmental significance *after* mitigation as per EMPr					
		E	D	F	I	P	SR	E	D	F	I	P	SR
	Comment: *Soil erosion may result from disturbed areas on steeper slopes. Severe soil erosion may result in impacts to the surface water resources within the area especially within the steeper-sloped riparian areas. Erosion of unprotected stockpiles of soil will lead to erosional features and smothering of surrounding habitat.*												
	Summary of pertinent mitigation points: *Soil erosion is readily mitigated for by the implementation of geotextiles and silt fencing on areas of steeper slopes, especially near aquatic habitats.*												
	Soil contamination	2	4	3	3	3	**15**	2	1	1	1	1	**6**
	Comment: Pollution of soils due to oil/fuel leaks & wastes that will affect biodiversity. This will pose a threat to the surface water resources within the area.												
	Summary of pertinent mitigation points: *Earthmoving and construction equipment should be serviced regularly to avoid fuel and oils leaks;* *Accidental spillages must be immediately reported to the ECO and clean up procedures implemented immediately. This would include the removal of the contaminated soils, which should be taken to a registered disposal facility.*												
Impacts on aquatic biodiversity	**Modification of hydraulic conditions to accommodate the abstraction infrastructure will potentially alter the aquatic biodiversity species community structures.**	2	4	3	3	5	**17**	2	2	2	2	1	**9**
	Comment: *This is a localized development that will be located at the edge of the watercourse. The significance of this impact is therefore regarded as being low. Poor designs could alter hydraulic conditions to the extent that substantive habitat transformation does occur.*												
	Summary of pertinent mitigation points: *Careful planning of the infrastructure to avoid substantive hydraulic functionality alterations.*												
MANAGEMENT PHASE													
Water quality impacts	**Poorly maintained equipment (pumps, etc.) could lead to fluid leaks that pose a threat to water quality.**	2	4	3	3	5	**17**	1	1	2	1	2	**7**
	Comment: *Hydrocarbon (fuels and oils) are a significant source of contamination of surface water resources and therefore any fluid spills or leaks should be avoided.*												
	Summary of pertinent mitigation points: *Equipment must be serviced and well maintained. Servicing of equipment should not take place at the edge of the watercourse but within designated areas only.*												
Soil contamination	**Soil contamination**	2	4	3	3	3	**15**	2	1	1	1	1	**6**
	Comment: Pollution of soils due to oil/fuel leaks & wastes that will affect biodiversity. This will impact surface water resources within the area.												
	Summary of pertinent mitigation points: *Earthmoving and construction equipment should be serviced regularly to avoid fuel and oils leaks;* *Accidental spillages must be immediately reported to the ECO and clean up procedures implemented immediately. This would include the removal of the contaminated soils, which should be taken to a registered disposal facility.*												

Potential environmental impact	Nature of the activity or issue	Environmental significance *before* mitigation						Environmental significance *after* mitigation as per EMPr					
		E	D	F	I	P	SR	E	D	F	I	P	SR
Soil erosion	**Formation of soil erosion following disturbances and incorrect reinstatement.**	2	4	3	3	4	**16**	2	2	1	1	1	**7**
	Comment: Inadequate site reinstatement and landscaping may lead to aggravation of soil erosion over the long term. This is pertinent at areas with relatively steeper slopes (e.g. the areas toward the riparian zones of the river) and will lead to habitat modification and degradation of water quality.												
	Summary of pertinent mitigation points: *Correct site reinstatement and landscaping details need to be adhered to and erosion management structures utilized in areas of steeper slopes. This potential impact is easily mitigated for with focused effort on the part of the contractors.*												
Biodiversity impacts	**Exotic vegetation encroachment following soil disturbances.**	2	4	3	3	5	**17**	2	2	1	2	2	**9**
	Comment: *Disturbances of the flora will lead to transformation of the vegetation structures, potentially enhancing the encroachment of exotic species, pioneering species and plagioclimax population structures. This is not thought a significant impact as the grasslands within the proposed substation footprint area that are already suffering from transformation and do not represent primary grasslands of the vegetation type.*												
	Summary of pertinent mitigation points: *Monitoring for exotic species recruitment should be undertaken on a regular basis and managed appropriately should recruitment be noted.*												
	DECOMMISSIONING PHASE												
Aquatic habitat destruction & disturbance	**Excavations to remove infrastructure will result in a degree of habitat destruction.**	2	4	3	3	5	**17**	2	2	2	2	2	**10**
	Comment: This will have the same magnitude of impact as per the construction phase												
	Summary of pertinent mitigation points: *Indiscriminate destruction of habitat must be avoided, and the impacting footprint should be restricted to as small an area as practical.*												
Soil contamination	**Contamination of soils from fluid leaks of construction vehicles during excavation and removal procedures.**	2	4	3	3	3	**15**	2	1	1	1	1	**6**
	Comment: Pollution of soils due to oil/fuel leaks & wastes that will affect biodiversity. This will impact on the surface water resources within the area.												
	Summary of pertinent mitigation points: *Earthmoving and construction equipment should be serviced regularly to avoid fuel and oils leaks;* *Accidental spillages must be immediately reported to the ECO and clean up procedures implemented immediately. This would include the removal of the contaminated soils, which should be taken to a registered disposal facility.*												
Soil erosion	**Formation of soil erosion following disturbances and incorrect reinstatement.**	2	4	3	3	4	**16**	1	2	1	2	1	**7**
	Comment: Inadequate site reinstatement and landscaping may lead to aggravation of soil erosion over the long term. This is pertinent at areas with relatively steeper slopes (e.g. the areas toward the riparian zones of the river).												

Potential environmental impact	Nature of the activity or issue	Environmental significance *before* mitigation						Environmental significance *after* mitigation as per EMPr					
		E	D	F	I	P	SR	E	D	F	I	P	SR
	Summary of pertinent mitigation points: Correct site reinstatement and landscaping details need to be adhered to and erosion management structures utilized in areas of steeper slopes. This potential impact is easily mitigated for with focused effort on the part of the contractors.												
Biodiversity impacts	**Exotic vegetation encroachment following soil disturbances.**	2	4	3	3	5	**17**	2	2	1	2	2	**9**
	Comment: Disturbances of the flora will lead to transformation of the vegetation structures, potentially enhancing the encroachment of exotic species, pioneering species and plagioclimax population structures. This is particularly pertinent to riparian areas.												
	Summary of pertinent mitigation points: Monitoring for exotic species recruitment should be undertaken on a regular basis and managed appropriately should recruitment be noted.												

SP ratings: 0-5 (Low), 6-10 (Medium), 11-15 (High); 15-20 (Very high).
E=Extent; D=Duration; I=Intensity; P=Probability of Occurrence; SR=Significance rating.
NOTE: All impacts are rated as a negative impact *(deleterious or adverse impact).*

Table 9: General mitigation measures proposed for the Construction phase of the proposed development activities.

Environmental Consideration	Environmental Impacts	Mitigation Measures	Time Frames	Responsible Party
Riparian habitat	• Construction within the riparian areas of the Orange River will impact on an ecologically sensitive habitat unit as well as impinge on an area regarded as a *Critical Biodiversity Area*.	• Limit the effects of erosion by utilizing silt traps and silt fencing, which should be in place before site disturbances occur. This is applicable to areas of steeper slopes, which is typical of riparian zones as well as dune crests; • Vehicular access should be limited to a single access roadway to limit the unnecessary compaction of soils within the riparian zones. Vehicles should be services regularly to ensure that no fluid leaks (oils and fuels) can occur that would contaminate soils and the watercourse. Oil and fuel leaks must be cleared immediately and the contaminated soils removed to an appropriate waste site; • Riparian zones and their associated conservation buffer should be demarcated as ecologically sensitive areas and access limited; • Any recruitment of exotic vegetation to be managed on an ongoing basis until indigenous pioneering vegetation has dominated the disturbed areas. These species should be limited to naturally-occurring species representative of the vegetation type for the locality. Ongoing monitoring of exotic vegetation recruitment should be undertaken and any recruitment controlled; • Undue destruction of riparian vegetation is to be avoided and larger, more established tree species	Ongoing throughout the construction phase	Contractor

Environmental Consideration	Environmental Impacts	Mitigation Measures	Time Frames	Responsible Party
		should be accommodated with a shift in location of the pumping infrastructure (if possible); • No construction material, vehicles or equipment should be stored within the riparian zones and designated buffers zones; • Excess building material is to be stored within designated areas (outside of the riparian zones and conservation buffer zones); • Upon completion of the construction phase, the surrounding riparian zones should be re-landscaped to resemble their original contours and any existing or potential erosion should be rehabilitated and managed. Areas outside of the construction footprint that were stripped of vegetation should be re-vegetated with a similar species community structure than that was removed. This does not apply to exotic species (much of the riparian vegetation within the area was dominated by exotic species); • Construction should also take place during the dry season to avoid soil erosion aggravation brought about by surface runoff during rainstorms. The effects of riverine floodwaters on disturbed soils and the coupled impact of soil erosion can then also be avoided.		
Aquatic Habitat	• Instream infrastructure development will destroy localised aquatic habitat and potentially alter hydraulic functioning at a local scale; • This could lead to displacement of species; • Altered hydraulic functioning could lead to bank erosion.	• Limit the construction footprint; • Stabilise river banks to abate impacts of bank erosion.	Continuous throughout the construction phase.	Contractor

Table 10: Mitigation measures proposed for the *Operations phase* of the proposed development activities.

Environmental Consideration	Environmental Impacts	Mitigation Measures
Riparian zones	• Encroachment of alien vegetation following site disturbances.	• Encroachment of alien vegetation to be monitored for regularly and controlled.
General	• Erosion management should be ongoing throughout the life of the project; • Indiscriminate habitat destruction must be avoided.	• The relevant mitigation measures proposed for the construction phase should be carried forward to operations, where potential environmental impacts may still occur. • Special conditions relating to operations, as stipulated in the RoD, need to be adhered to. • The contractor must perform appropriate maintenance functions, as required. Responsible parties must be competent in the necessary maintenance tasks. • Feedback must be provided to the ECO and project proponent on a frequent basis.

Table 11: Mitigation measures proposed for the *Decommissioning phase* of the proposed development activities.

Environmental Consideration	Environmental Impacts	Mitigation Measures
Riparian habitat	• Limit the construction footprint as far as possible; • Correct site reinstatement to avoid erosion formation and smothering of the aquatic habitat.	• Excavations should be filled and adequately landscaped in order to abate potential erosion; • Heavy machinery should be limited to single access roadways; • Workers and machinery to remain inside construction footprint. All labourers to be informed of disciplinary actions for the wilful damage to plants; • Encroachment of alien vegetation to be monitored for regularly and controlled; • All mitigation measures applicable to the construction phase will be applicable to the decommissioning phase.
Aquatic habitat	• Correct site reinstatement to resemble natural surrounding features.	• Ecologically sensitive areas should be retained as prohibited areas to workers; • Workers and machinery to remain inside construction footprint. All labourers to be informed of disciplinary actions for the wilful damage to plants and animals.

Rating scores for the various aspects are presented in Table 7. Table 8 presents the outcomes of the perceived ecological impacts on the conservation of aquatic ecological integrity for the proposed Shalom abstraction point. Impacts are described for the duration of the construction, management and decommissioning phases of the proposed development both before and after the implementation of mitigation measures. All impacts identified can be effectively reduced or negated through implementation of appropriate mitigation measures. Mitigation measures applicable to the construction, operations and decommissioning phases of the proposed development activities are presented in Table 9, Table 10 and Table 11, respectively.

7. CONSIDERATION OF INFRASTRUCTURE ALTERNATIVES

Two alternatives were also offered for the infrastructure design at the abstraction points pertaining to the types of abstraction infrastructure, namely a raft structure (without a floating boom) and infiltration galleries. It is noted that the infiltration galleries requires a larger footprint area and therefore will have a greater impact on sensitive habitat units (aquatic and riparian habitat). This methodology is therefore not preferred.

8. CONCLUSIONS & RECOMMENDATIONS

A field survey was undertaken during February 2014 to the proposed amended abstraction points pertaining to the ACWA Power SolAfrica (Pty) Ltd Bokpoort CSP pipeline on the Orange River near Groblershoop in the Northern Cape. Upon completion of the survey the following general conclusions were drawn and some mitigation measures proposed:

- The river reach suffers a change from reference conditions in terms of biological integrity (macro-invertebrates and riparian vegetation) as well as instream and riparian habitat. The resultant Ecological Category is C class. Even though there are transforming and degrading features present within the river reach, the overall Ecological Importance and Sensitivity (EIS) remains *High*. Mitigation measures should be in place to ensure that these ecological categories are not degraded;
- The surface water quality throughout the survey area is considered good, with the aquatic system supporting a diversity of sensitive aquatic macro-invertebrate taxa. It is therefore imperative that

the contamination of the surface waters through deleterious effluents and runoff water be avoided;

- Emergency procedures must be in place to timeously mitigate any accidental spillages and to isolate the impacting features as far as possible;
- Regular monitoring of water quality to enable early identification of contamination is recommended. The source of any contamination identified though the monitoring should be identified and managed according to best practice guidelines;
- Soil erosion emanating from disturbances within the riparian zones and other areas of steep gradients is thought to be the greatest impacting feature to potentially impact the overall ecological integrity of the aquatic system. Active storm water management should be implemented to stop silt and sediments from entering the aquatic system and smothering the habitat units. Disturbed soils and stockpiled soils should be protected from erosional features;
- The footprint of the actual development as well as the supporting structure and services during the construction phase should be retained as small as possible by construction vehicles being limited to designated roadways only. Destruction of the riparian habitat through the unnecessary clearing of vegetation should be avoided;
- Dumping of any excess rubble, building material or refuse must be prohibited within riparian and wetland habitat. Dumping of materials should only take place at designated and properly managed areas;
- Adequate toilet facilities must be provided for all construction crews to negate informal ablutions taking place within riparian zones;
- Fires within the riparian zones should be prohibited;
- Exotic vegetation identified presently at the site should be removed and any future exotic vegetation encroachment should be actively managed. This is largely dominated by *Prosopis glandulosa* within riparian areas. The degree of invasion by this species is regarded as problematic and will increase following disturbance features;
- Provided that erosion management, together with the implementation of mitigation measures to abate the negative ecological impacts of the features mentioned above, the overall ecological impact of the proposed development activities can be limited.

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APPENDIX A - METHODOLOGIES APPLIED DURING THIS BIOMONITORING ASSESSMENT – AQUATIC MACRO-INVERTEBRATE COLLECTION – SASS5 METHODOLOGY.

Sample Collection.

A standard SASS invertebrate net (300 x 300 mm square with 1mm gauge mesh netting) was used for the collection of the organisms. The available biotopes at each site were identified and each of the biotopes was sampled by different methods explained under the relevant sections.

The biotopes were combined into three different groups, which were sampled and assessed separately:

a) Stone (S) Biotopes:

Stones in current (SIC) or any solid object: Movable stones of at least cobble size (3 cm diameter) to approximately 20 cm in diameter, within the fast and slow flowing sections of the river. Kick-sampling is used to collect organisms in this biotope. This is done by putting the net on the bottom of the river, just downstream of the stones to be kicked, in a position where the current will carry the dislodged organisms into the net. The stones are then kicked over and against each other to dislodge the invertebrates (kick-sampling) for ± 2 minutes.

Stones out of current (SOOC): Where the river is still, such as behind a sandbank or ridge of stones or in backwaters. Collection is again done by the method of kick-sampling, but in this case the net is swept across the area sampled to catch the dislodged biota. Approximately 1 m^2 is sampled in this way.

Bedrock or other solid substrate: Bedrock includes stones greater than 30cm, which are generally immovable, including large sheets of rock, waterfalls and chutes. The surfaces are scraped with a boot or hand and the dislodged organisms collected. Sampling effort is included under SIC and SOOC above.

b) Vegetation (Veg) Biotopes:

Marginal vegetation (MV): This is the overhanging grasses, bushes, twigs and reeds growing on the edge of the stream, often emergent, both in current (MvegIC) and out of current (MvegOOC). Sampling is done by holding the net perpendicular to the vegetation (half in and half out of the water) and sweeping back and forth in the vegetation (± 2m of vegetation).

Submerged vegetation (AQV): This vegetation is totally submerged and includes Filamentous algae and the roots of floating aquatics such as water hyacinth. It is sampled by pushing the net (under the water) against and amongst the vegetation in an area of approximately one square meter.

c) Gravel, Sand and Mud (GSM) biotopes:

Sand: This includes sandbanks within the river, small patches of sand in hollows at the side of the river or sand between the stones at the side of the river. This biotope is sampled by stirring the substrate by shuffling or scraping of the feet, which is done for half a minute, whilst the net is continuously swept over the disturbed area.

Gravel: Gravel typically consists of smaller stones (2-3 mm up to 3 cm). It is sample in a similar fashion to that of sand.

Mud: It consists of very fine particles, usually as dark-collared sediment. Mud usually settles to the bottom in still or slow flowing areas of the river. It is sample in a similar fashion to that of sand.

d) Hand picking and visual observation:

Before and after disturbing the site, approximately 1 minute of “hand-picking” for specimens that may have been missed by the sampling procedures was carried out.

Basic Assessment and Water Use Licence for a proposed 15km Water Pipeline on the Farm Sanddraai 391 –Surface Water and Riparian Assessment Study

Acwa Power

September 2014

Royal HaskoningDHV
Enhancing Society Together

DOCUMENT DESCRIPTION

Client:

Acwa Power

Project Name:

Basic Assessment and Water Use Licence for a proposed 15km Water Pipeline on the Farm Sanddraai 391 –Surface Water and Riparian Assessment Study

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Compiled by:

Paul da Cruz

Date:

September 2014

Location:

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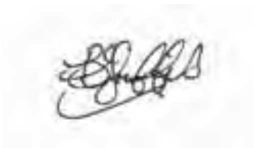
Approval: Bronwen Griffiths (PrSciNat – Environmental Science – 400169/11)



Signature

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Glossary of Terms

Aeolian	Wind-borne – i.e. referring to wind-borne and deposited materials, and erosion caused by wind
Alluvial Fan	An alluvial deposit that is typically fan-shaped that is formed by a stream or watercourse where its velocity is abruptly decreased, as at the mouth of a ravine or at the foot of a slope
Alluvial Material / Deposits	Sedimentary deposits resulting from the action of rivers, including those deposited within river channels, floodplains, etc.
Baseflow	The component of river flow that is sustained from groundwater sources rather than from surface water runoff
Calcrete	A type of rock cemented together by calcareous material, formed in soils in semi-arid conditions
Cumulative impact	The impact of an activity that in itself may not be significant but may become significant when added to the existing and potential impacts eventuating from similar or diverse activities or undertakings in the area.
Environmental Impact Assessment (EIA)	In relation to an application to which scoping must be applied, means the process of collecting, organising, analysing, interpreting and communicating information that is relevant to the consideration of that application as defined in NEMA.
Ephemeral	A river or watercourse that only flows at the surface periodically, especially those drainage systems that are only fed by overland flow (runoff).
Episodic	Relating to rivers and watercourses typically located within arid or semi-arid environments that only carry flow in response to isolated rainfall events
Fluvial	Pertaining to rivers and river flow and associated erosive activity
Herbaceous	A plant having little or no woody tissue and persisting usually for a single growing season
Hydric Soils	(= Hydromorphic soils) Soils formed under conditions of saturation, flooding or ponding for sufficient periods of time for the development of anaerobic conditions and thus favouring the growth of hydrophytic vegetation.
Hydrology	The science encompassing the behaviour of water as it occurs in the atmosphere, on the surface of the ground, and underground.
Hydroperiod	The term hydroperiod describes the different variations in water input and output that form a wetland, characterising its ecology – i.e. the water balance of the wetland
Interfluve	A watershed.
Phreatophyte	A plant with a deep root system that draws its water supply from near the water table.
Reach	A portion of a river
Riparian Area	the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas
Semi-desert	The transition zone between true desert and more mesic (moist) climatic areas, generally receiving annual rainfall in a range between 250 - 500mm/year. In terms of the Köppen climate classification, semi-desert climatic zones are intermediate between the desert climates and humid climates in ecological characteristics and agricultural potential.
Stream Order	A morphometric classification of a drainage system according to a hierarchy or orders of the channel segments. Within a drainage network the un-branched channel segments

which terminate at the stream head are termed as “first order streams”

Understorey The part of the forest / woodland which grows at the lowest height level below the canopy

Wrack (Flood Wrack) Material (primarily vegetative) that is transported along watercourses and rivers during floods, and which is typically deposited behind structures or large vegetation by the flood waters, especially at levels higher than the typical flow levels.

Specialist Declaration

I, **Paul da Cruz**, declare that I –

- act as a specialist consultant in the field of Surface Water assessment
- do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010;
- have and will not have any vested interest in the proposed activity proceeding;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2010; and
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not.

PAUL DA CRUZ

1 INTRODUCTION

Acwa Power has appointed **Royal HaskoningDHV** to undertake a **basic assessment study and water use licence application for a proposed 15km water pipeline**. The water pipeline received an Environmental Authorisation (EA) in March 2013 and its main use is to supply water to a solar power plant in the Groblershoop area of the Northern Cape. The need for a surface water study to be undertaken as part of the environmental studies (EIA substantive amendment and water use licence) was identified as the realigned portion of the pipeline crosses a number of surface water features that were not previously assessed as part of the original Basic Assessment Study.

The project is located in the Northern Cape, a highly arid part of South Africa. In this context drainage systems and their associated riparian zones are highly sensitive and environmentally important. Although not typically characterised by active flow of water, or the presence of hydric (wetland) soils, riparian zones of drainage features in this area are a critical component of the surface water drainage environment in the area, as they are distinct from the surrounding Karoo veld in terms of their species composition and physical structure. In the context of a semi-arid environment, these riparian environments are extremely sensitive as they are typically characterised by high levels of biodiversity and are critical for the sustaining of ecological processes as well as human livelihoods through the provision of water for drinking and other human uses. As such surface water resources and wetlands are specifically protected under the National Water Act, 1998 (Act No. 36 of 1998) and generally under the National Environmental Management Act, 1998 (Act No. 107 of 1998). In the context of the development of an underground water pipeline, the physical disturbance of these drainage systems and their riparian zones constitutes an important surface water-related impact. This report thus focuses on the potential impact of the proposed pipeline on the affected surface water features in the study area, and highlights how the potential impacts can be mitigated.

1.1 Aims of the Study (Project Terms of Reference)

The aims of the study are to:

- Assess the affected surface water features along the alignment alternatives in the field, to determine their characteristics using the VEGRAI Ecostatus tool.
- Delineate all riparian zones that are likely to be adversely affected by the proposed water pipeline.
- Determine the nature and degree of risk posed to surface water features by the proposed pipeline.
- Suggest suitable mitigation measures to ameliorate identified impacts.
- Comparatively Assess Alternatives and recommend preferred alternatives from a surface water perspective.

1.2 Assumptions and Limitations

This report has not assessed the potential impact of abstraction on the Orange River, as it is understood that this is being assessed under the auspices of a separate study.

This report only covers the realigned sections of the pipeline, and not the remainder of the original pipeline route, as this was previously assessed and an EA received in March 2013.

No design details of the infiltration gallery or proposed footprint at the Shalom abstraction point have been provided for assessment. It has thus not been possible to accurately assess the impact of this type of abstraction on the Orange River riparian zone.

1.3 Definition of Surface Water Features, Wetlands and Hydric Soils

1.3.1 Surface Water Features

In order to set out a framework in which to assess surface water features, it is useful to set out what this report defines as surface water resources. In this context the National Water Act is used as a guideline. The Act includes a number of features under the definition of water resources, i.e. watercourses, surface waters, estuaries and aquifers. The latter two do not apply as estuaries are marine features and this report does not consider groundwater, thus surface waters and water courses are applicable in this context. The Act defines a watercourse as (inter alia):

- a river or spring;
- a natural channel in which water flows regularly or intermittently;
- a wetland, lake or dam into which, or from which, water flows

The definition of a water course as used in the Act is taken to describe surface water features in this report. It is important to note that the Act makes it clear that **reference to a watercourse includes, where relevant, its bed and banks**. This is important in this report, as the riparian habitat associated with most linear drainage features in the study area have been included as an important part of surface water features and are thus given consideration in this report.

It is equally important to note that the Act does not discriminate on the basis of perenniality, and any natural channel, however ephemeral, is included within the ambit of water resources. This definition is applied in this report.

It should be noted that no wetlands were encountered in the study area due to the arid nature of the climate.

1.3.2 Riparian Habitat and Riparian Zones

The National Water Act defines riparian habitat as:

"the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas"

As detailed in the DWAF 2005 guidelines for the delineation of wetlands and riparian areas, riparian areas typically perform important ecological and hydrological functions, some of which are the same as those performed by wetlands (DWAF, 2005).

Riparian areas include plant communities adjacent to and affected by surface and underground water features such as rivers, streams, lakes, or watercourses. It is important to note that these areas may be a few metres wide along smaller systems or more than a kilometre in floodplains. Both perennial and non-perennial streams support riparian vegetation (DWAF, 2005).

Because riparian areas represent the interface between aquatic and upland ecosystems, the vegetation in the riparian area may have characteristics of both aquatic and upland habitats. Many of the plants in the riparian area require large volumes of water (moisture) and are adapted to shallow water table conditions. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth rate is high. This is certainly the case in riparian zones in the Karoo, as they typically contain trees and shrubs of a height, density and species diversity that is not present in the surrounding Karoo veld.

Riparian areas are important as they perform the following functions (DWAF, 2005):

- Storing water and thus assisting to reduce floods
- Stabilising stream banks
- Improving water quality by trapping sediment and nutrients;
- Maintaining natural water temperature for aquatic species;
- Providing shelter and food for birds and other animals;
- Providing corridors for movement and migration of different species;
- Acting as a buffer between aquatic ecosystems and adjacent land uses;
- Can be used as recreational sites; and
- Providing material for building, muti, crafts and curios.

These ecosystems may be considered 'critical transition zones' as they process substantial fluxes of materials from closely connected, adjacent ecosystems (Ewel *et al*, 2001).

As discussed below riparian habitat is important from a legislative perspective – in terms of the National Water Act. Section 3.3 of this document should also be referred to for a synopsis of the VEGRAI (Riparian Area Characterisation and Assessment) Template.

1.4 Legislative Context

The following section briefly examines the legislation that is relevant to the scope of the wetland assessment. The stipulations / contents of the legislation and policy that is relevant to the study are explored.

1.4.1 The National Water Act

It is important to note that water resources, including wetlands are protected under the National Water Act 36 of 1998 (NWA). Wetlands are defined as water resources under the Act. 'Protection' of a water resource, as defined in the Act entails:

- Maintenance of the quality of the quality of the water resource to the extent that the water use may be used in a sustainable way;
- Prevention of degradation of the water resource
- The rehabilitation of the water resource

In the context of the current study and the identification of pressures and threats acting on wetlands, the definition of pollution and pollution prevention contained within the Act is relevant. 'Pollution', as described by the Act is the direct or indirect alteration of the physical, chemical or biological properties of a water resource, so as to make it (inter alia)-

- Less fit for any beneficial purpose for which it may reasonably be expected to be used; or
- Harmful or potentially harmful to the welfare or human beings, to any aquatic or non-aquatic organisms, or to the resource quality.

The inclusion of physical properties of a water resource within the definition of pollution entails that any physical alterations to a water body, for example the excavation of a wetland or changes to the morphology of a water body can be considered to be pollution. Activities which cause alteration of the biological properties of a watercourse, i.e. the fauna and flora contained within that watercourse are also considered pollution.

In terms of section 19 of the Act owners / managers / people occupying land on which any activity or process undertaken which causes, or is likely to cause pollution of a water resource must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring. These measures may include measures to (inter alia):

- Cease, modify, or control any act or process causing the pollution
- Comply with any prescribed waste standard or management practice
- Contain or prevent the movement of pollutants
- Remedy the effects of the pollution; and
- Remedy the effects of any disturbance to the bed and banks of a watercourse

One of the key principles on which the National Water Act, as promulgated to replace the Water Act of 1956, was formulated was that that surface- and groundwater systems are indivisible from each other (le Maitre et al, 1999). This is important in the context of this report, as the drainage systems and their associated vegetation communities are understood to be sustained by the presence of not only surface water, but shallow groundwater which is very closely linked to surface water.

1.4.1.1 The National Water Act and Riparian Areas

Riparian habitat is afforded protection under the National Water Act in a number of ways. Firstly reference in the National Water Act to a watercourse includes its banks, on which riparian habitat is encountered. Riparian areas are thus afforded the same degree of protection as the rivers and channels alongside which they occur.

Riparian habitat is also important in the context of resource quality objectives that are a critical part of the Act. In terms of section 13(1) of the Act resource quality objectives must be determined for every significant water resource, and are central part of data type specifications relating to national monitoring systems and national information systems as determined in section 137(2) and section 139(2) of the Act respectively. Under Section 27 of the Act resource quality objectives must be taken into account in the issuing of any licence or general authorisation, and form a critical part of the duties of catchment management agencies. The purpose of resource quality objectives in the Act is to establish clear goals relating to the quality of the water resources. Resource quality is important in the context of riparian habitat as resource quality as defined in the Act means the quality of all aspects of a water resource and **includes the character and condition of the riparian habitat**. In terms of Section 26(4) of the Act, the need the conservation and protection of riparian habitat must be taken into account in the determination and promulgation of regulations under the Act.

The above stipulations of the Act have implications for the proposed development; as identified further on in this report the proposed development may be associated with certain direct or indirect impacts on wetlands in the area, some of which may affect the physical characteristics of the wetlands. These impacts are likely to be needed to be licensed under the Act. The National Water Act also stipulates requirements for permitting which would need to be followed.

1.5 Bioregional Conservation Planning Context – National Freshwater Ecosystem Database

The National Freshwater Ecosystem Priority Areas (NFEPA) Database has been analysed in order to determine whether any of the potentially-affected surface water resources on the development have been classified as being nationally or regionally important.

It should be noted that none of the episodic watercourses located away from the Orange River have been designated as being surface water features of national or regional importance. The Orange River however has been designated as both a NFEPA River and Wetland. In terms of its NFEPA wetland classification (relevant to parts of its riparian zone as assessed in this report) it is a floodplain wetland. The reach of the river adjacent to the site has been assigned an ecological category of “C” – being moderately modified (refer to section 3.2 below for the EcoStatus classes). The reach is not one of the final wetland Freshwater Ecosystem Priority Areas (FEPAs) selected (reviewed at NFEPA National Stakeholder Review Workshop, July 2010), nonetheless the impacts of any development on this river should be considered of regional importance, and should be avoided or adequately mitigated.

2 PROJECT DESCRIPTION

2.1 Project Technical Description

The project's aim is to construct a water supply system to supply filtered water from the Orange River to the Bokpoort Solar Power Plant utilising the following components based on the topography of the pipeline route.

2.1.1 Abstraction Options

There are two options for the abstraction of water from the Orange River:

- a raft structure without a floating boom (technically preferred) that would be placed within the channel of the Orange River
- infiltration galleries (not technically preferred)

It should be noted that the location of the proposed abstraction is at the Shalom abstraction point (refer to Figure 2 below), and not at the previously assessed abstraction point close to the Sishen-Saldanha Railway Bridge.

2.1.1.1 Raft System

Under the raft system two river pumps mounted on a raft structure will extract water from the Orange River. Two pumps would be stationed on a stainless steel floating device (raft) which will be anchored to concrete blocks. These anchor blocks will be on both sides of the quick coupling pipes on the side of the embankment fill and will be used to connect the raft when the water level rises. The pumps will not operate simultaneously, but will be altered automatically. In the case of one pump failing, the other pump will serve as the backup. Stabilising of the river embankment at the raw water extraction point must be done by means of Gabions, Reno mattresses or stone pitching. Each pump is designed to deliver water at a flow rate of 210m³/hr from the extraction point. This is 10% more volume than required. Providing a higher flow in the raw water rising main than the clear water rising main will ensure that the storage reservoir is always full and that the pumps are not required to pump 24hr/day.

2.1.1.2 Infiltration Gallery

Infiltration galleries are abstraction systems based on the intake capacity of screens fed gravitationally from a saturated horizon that is located within the sediment of a river bed. The infiltration galleries comprise a concrete trough sunk in to the bedrock below the saturated horizon. The trough design will be in accordance with the screen layout required to achieve the desired length (i.e. volume). Accordingly multiple lengths can be joined via a manifold. The trough is filled with filter pack (rounded and semi rounded gravel) sorted to obtain the required permeability. The screens and all other ancillary parts are secured by anchoring them into the trough or bedrock. The construction is then covered to the initial level with the natural sediment. Pumping can be carried out by using a submersible pump. When natural conditions are suitable the gallery can be fed into a vertical well drilled on the highest terrace. This is always the preferred solution as it provides easy access to the submersible pump and the pumping unit is accessible and away from the flooded zone (is protected from flooding). The construction of this type of water supply system requires the mobilisation of heavy earth moving equipment which can work in unstable conditions (unconsolidated sediments). High volume earth moving is required sometimes to depths of 6m or more below the natural surface. In order to provide safe working conditions high volume dewatering pumps and lateral support must be part of the design.

2.1.2 Pipeline Technical Details

Once abstracted, the water will be pumped through a 250mm diameter uPVC pipeline over a distance of approximately 340m to a pump station. Upon entering the pump station, the water will be treated with a sand filtration system and then pumped into a sectional steel reservoir. The sand filters will backwash on a time and pressure differential principle and the backwash water will be flushed into a nearby pond. The clear water will then be pumped along the pipeline into 2 x 47 500m^3 storage ponds at the power plant using the clear water pumps in the pump station. The system will be automated as much as possible without utilising a telemetry system.

For the pipeline alignment away from the abstraction area, the required work area is a 10m corridor. The drawing below (Figure 1) indicates the typical profile of the pipeline.

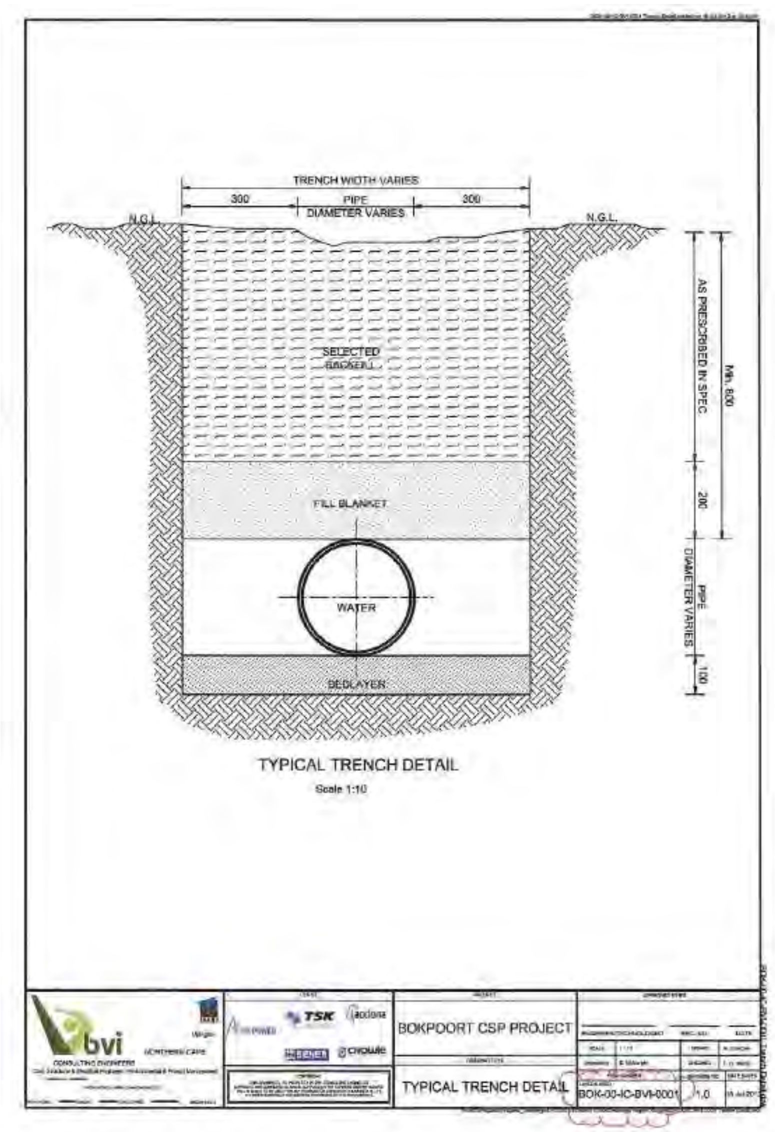

Figure 1 – Profile of the proposed pipeline trench

Once the pipeline has been laid, no vegetation with deep root systems will be allowed to occur over the pipeline.

2.1.3 Pipeline Alignment Alternatives

From the solar power plant, the pipeline is aligned roughly parallel to the Sishen-Saldanha Railway to a point east of the district road running parallel to, and east of the Orange River. From this point there are two alternatives (**refer to Figures 2&3 below**); under Alignment 1 the Pipeline continues in a westward alignment, crossing the district road and continuing to run roughly parallel to the railway and the Sanddraai Farmstead access road towards the river. At a point just to the south of Sanddraai Farmstead, Alignment 1 turns southwards under the railway to run along a local farm access track that runs parallel to the riparian zone of the Orange River towards the Glendana Farmstead. Alignment 1 intersects Alignment 2 close to the Shalom abstraction point and runs to the abstraction point on the river.

Alignment 2 originates along the original pipeline route to the east of the district road, running in a south-western direction immediately parallel to the farm (cadastral) boundary dividing the properties Sanddraai 391 and Bokpoort 390 and crossing both the Sishen-Saldanha Railway and the District Road. The alignment continues in a south-western direction along the cadastral boundary, turning westwards close to the Glendana Farmstead and intersecting Alignment 1 to the Shalom abstraction point.

2.2 Site Location and Description

The Study Site is located within the central part of the Northern Cape Province, being located to the north-west of the town of Groblershoop and to the south-east of Upington in the !Kheis Local Municipality. The area traversed by the pipeline route is rural in nature, with intensive cultivation occurring in a narrow strip alongside the Orange River. The remainder of the route comprises of rangeland that consists of sparse natural semi-desert vegetation, apart from the servitudes of the district road and railway line. The terrain along the route is flat along the Orange River corridor, becoming gently undulating away from the river. The pipeline route crosses a number of interfluves and valleys in rugged terrain, with the presence of dunes comprising of sand of aeolian origin along certain parts of the route. The Study area is indicated in Figures 2&3 below.

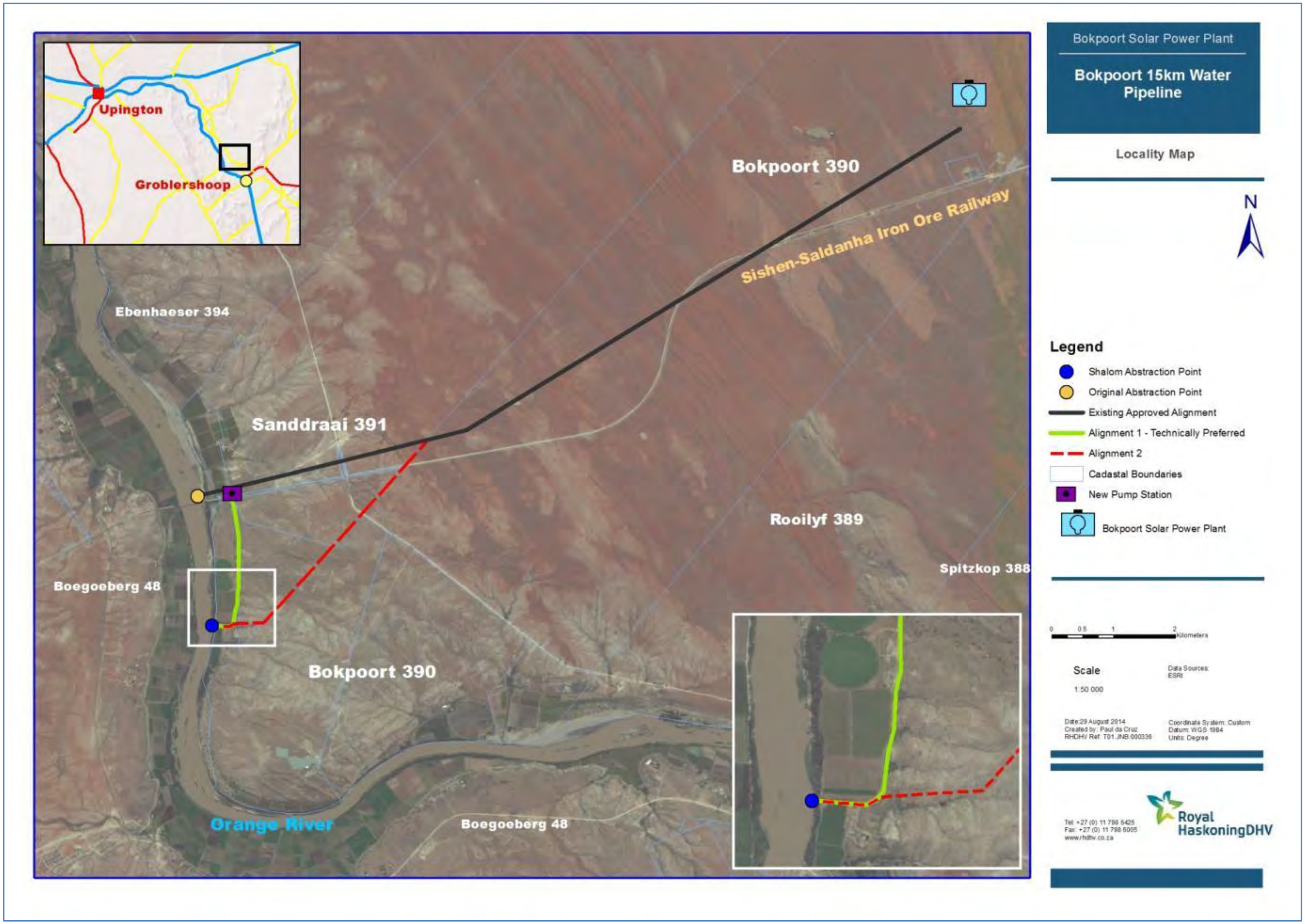

Figure 2 – Study Area

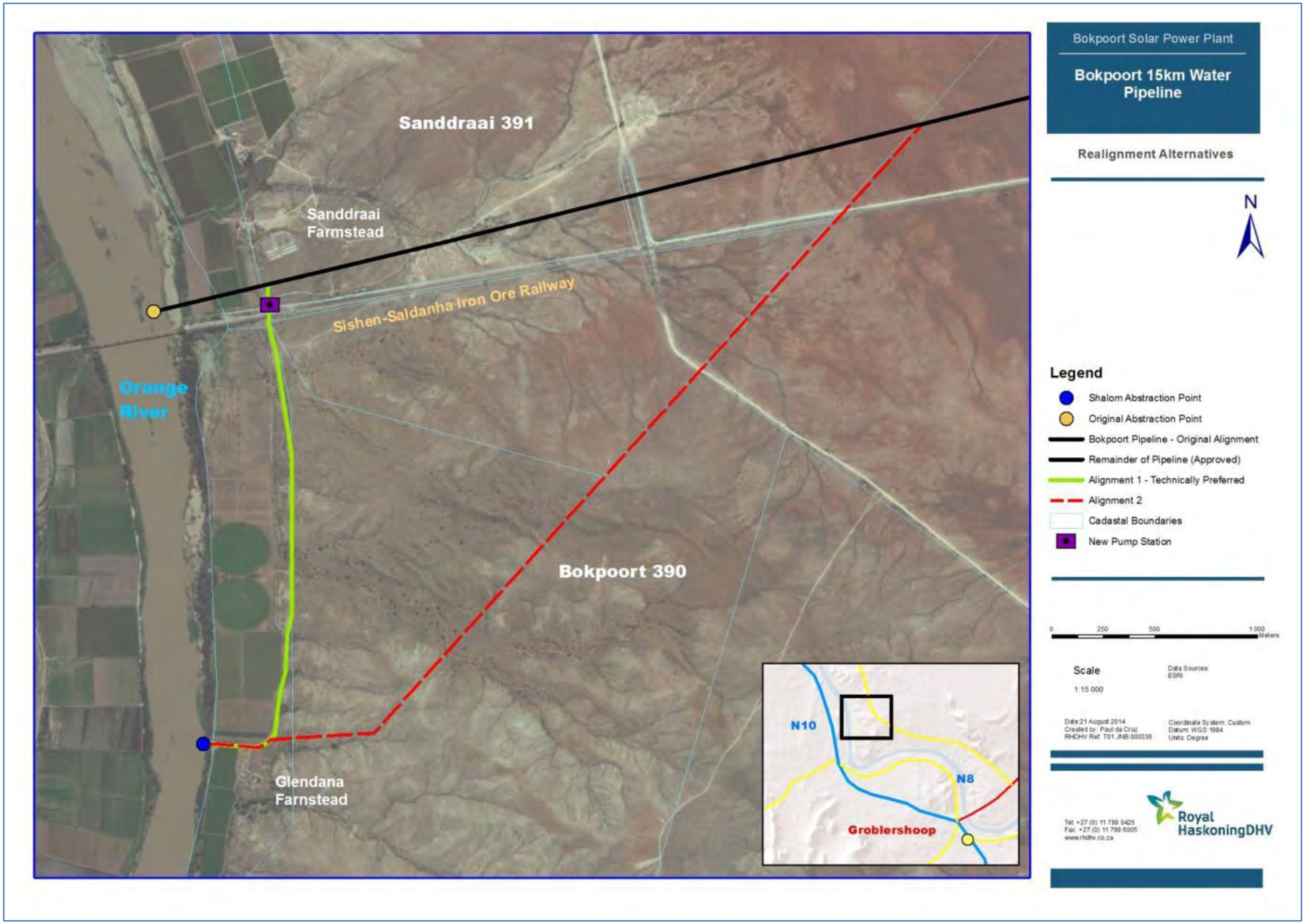

Figure 3 – Realigned Pipeline Alternatives

3 METHODOLOGY FOR ASSESSMENT

3.1 Field Assessment and Riparian Zone Delineation

A walk down of the realigned pipeline alternative route (Alignments 1 & 2) was undertaken in order to identify all surface water (drainage) features along it. Each watercourse crossed was assessed in the field, and a VEGRAI assessment was undertaken for the larger watercourses, as described below. Use was made of a GPS to identify important points (e.g. apparent boundaries of zones within the riparian corridors). These GPS points were converted into a GIS shapefile to allow these points to be mapped and to facilitate the delineation of the riparian boundaries.

3.2 Riparian Area characterisation and assessment template

The VEGRAI (Riparian Vegetation Response Assessment Index) assessment methodology (Kleynhans *et al*, 2007) was utilised as the primary tool to assess the riparian zones of the larger watercourses along Alignment 2. With the exception of the Orange River, all surface water features potentially affected by the proposed pipeline are ephemeral watercourses. The most important feature of these watercourses is their riparian corridor, and as such the VEGRAI tool was used to assess these features.

This section briefly introduces riparian zones in terms of the hydromorphological and vegetation classification as per the VEGRAI (Riparian Vegetation Response Assessment Index) assessment methodology (Kleynhans *et al*, 2007), which has been used to classify riparian zones in this report.

In terms of the VEGRAI structure, riparian areas are divided into three (3) vegetation zones:

- Marginal Zone
- Lower Zone
- Upper Zone

This vegetation zone classification has been based upon:

- Periodicity of hydrological influence
- Marked changes in lateral elevation or moisture gradients
- Changes in geomorphic structure
- Changes in plant species distribution or community composition along lateral gradients

In spite of these zones being vegetative, they are also distinguished based on a combination of other factors including geomorphic structure and elevation along with vegetation. Elevation within the riparian zone is used as a surrogate for hydrological activation, which is taken to be moistening or inundation of the substrate by water in the channel. The figure below (from Kleynhans *et al*, 2007) indicates a typical riparian zone:

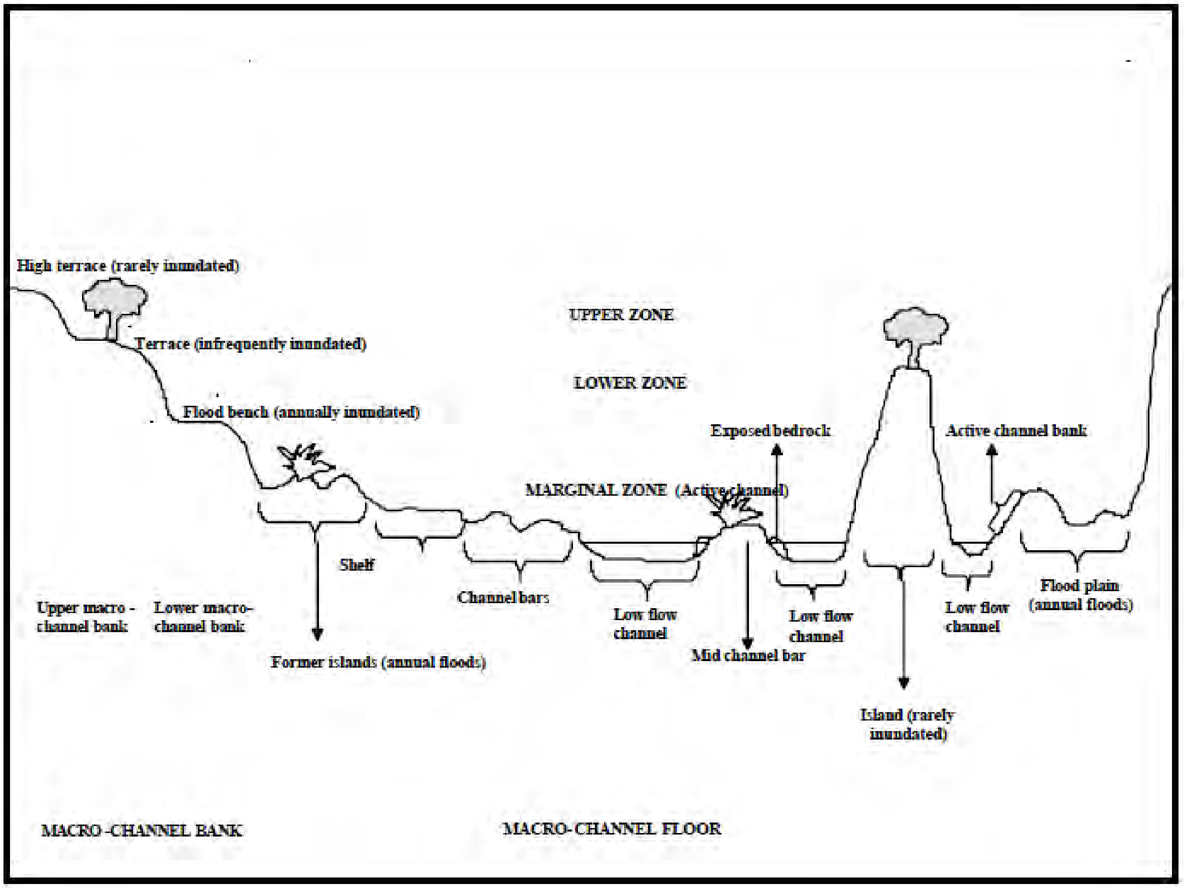

Figure 4 – Schematic diagram indicating the three zones within a riparian area relative to geomorphic diversity (Kleynhans et al, 2007)

3.2.1 Marginal Zone

The marginal zone incorporates the area from the water level at low flow (where present – if flow is not present areas that would be subject to baseflows would be included) to those features that are more or less permanently inundated. Vegetatively the marginal zone is typically characterised by the presence of hydrophytes that are vigorous in terms of abundance due to the near-permanent availability of moisture.

3.2.2 Lower Zone

The lower zone is the area of seasonal inundation (hydrological activation in this context is yearly inundation during high flows, or every 2-3 years), extending from the edge of the marginal zone to the point at which there is a marked increase in lateral elevation. This change in elevation may or may not be characterised by an associated change in species distribution patterns.

3.2.3 Upper Zone

The upper zone is characterised by hydrological activation on an ephemeral basis (less than every 3 years) and extends from the end of the lower zone to the end of the riparian corridor. The upper zone is usually characterised by steeper slopes and the presence of both riparian and terrestrial species, the latter typically having an enlarged structure as compared to the areas outside of the riparian area.

VEGRAI uses a number of metrics (measurement or ratings) for different riparian characteristics to define and rate riparian state:

- Abundance (how much indigenous vegetation there is under present condition)
- Cover (a measure of the extent to which the ground is covered by vegetation, and is measured as canopy cover)
- Recruitment (the arrival and establishment of new individuals into riparian populations / communities)
- Population structure (the relative abundance of life stages within respective populations of selected indicator species)
- Species composition (the arrangement of species in the riparian community that comprise the riparian assemblage in the study area)

All of these characteristics of riparian areas can be measured in terms of the level of divergence from what would be considered a reference state. Reference conditions for riparian zones are usually natural, i.e. conditions prior to significant human interaction with riparian structure and function. It is important that reference state be defined in terms of an understanding of the nature of impacts on a riparian corridor.

The VEGRAI methodology has defined six (6) different types of riparian vegetation to guide assessments of reference state:

- Tree-dominated state,
- Shrub-dominated state,
- Grass-dominated state,
- Herbaceous-dominated state,
- Reed-dominated state,
- Open-dominated state (substrate such as sand/rock).

There are degrees of flux between these different states that may be influenced by impacts on the riparian zone – e.g. the removal of woody vegetation from the riparian zone.

The key impacts that act on riparian zones include:

- **Vegetation Removal** – resulting in increases in water temperature, effecting aquatic primary production, and adversely affecting the ability of riparian areas to retain water
- **Exotic Invasion** – resulting in displacement of indigenous species and subsequently to a change in ecosystem properties, bank instability due to the exclusion of natural riparian vegetation due to vigorous growth, decrease of organic input, or a reduction in riparian habitat diversity

- **Water quantity change** (change in volume and seasonality of flows) – resulting in increased stream widths or down cutting of the streambed that can lead to the loss of riparian vegetation
- **Water quality change** – resulting in impacts on indigenous riparian plants and possible excessive growth of exotic riparian vegetation in the case of eutrophication.

Riparian zones can be divided up into a number of generic ecological categories based on their state of degradation (ecoStatus), as indicated in the figure below. The BVEGRAI EcoStatus Tool ascribes riparian reaches assessed into one of the following EcoStatus classes.

ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.	80-89
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible	0-19

Figure 5 – EcoStatus Classes (Ecological categories)

3.3 Identification of Surface Water and Riparian Zone Impacts and Mitigation Measures

All potential impacts that could be caused by the proposed pipeline and that would affect surface water features along the realigned route have been identified. Impacts specifically relating to the placing of servitudes through riparian areas have been investigated.

Mitigation measures to either ensure that the identified impact does not materialise, or to ameliorate / limit the impact to acceptable levels have been stipulated.

4 SUMMARY OF STUDY AREA SURFACE WATER DRAINAGE AND CHARACTERISTICS

Rivers and wetlands are very important features of the natural landscape both in a hydrological and an ecological context. The freshwater ecosystems that occur within rivers and wetlands, as well as the associated riparian habitats, are very important in the context of biodiversity, as unique plant and animal communities occur within them. This is particularly important in the context of the semi-arid Great Karoo and Kalahari, where the availability of moisture in the vicinity of watercourses has led to the development of vegetation communities distinct from the surrounding veld types.

The study area is located in a semi-arid climatic zone, being located on the boundary between the Great Karoo and the Kalahari semi-desert and receives a mean annual rainfall figure of approximately 215mm (Source: SA Rainfall Atlas Database). There is a relatively strong seasonality in the rainfall figures, indicating that the area falls within the summer rainfall areas within the subcontinent; most of the rainfall occurs in the late summer / autumn between the months of January and April. The scarcity of rainfall and nature of precipitation also entails that rainfall events are episodic in nature, i.e. single rainfall events will contribute a relatively significant portion of rainfall.

In a macro drainage context, the study site is located adjacent to the Orange River, and thus occurs in the Lower Orange Water Management Area. The study site is located in the D73D quaternary catchment, a large quaternary catchment that encompasses a long reach of the Orange River from Kheis to the east of Groblershoop at the upstream end, to Lambrechtsdrift to the south-east of Upington at its downstream end, as well as a number of non-perennial tributaries of the Orange River along this reach of the river.

The primary surface water feature on the site is the Orange River, which runs in a north-south orientation on the study site. The proposed new abstraction point (Shalom) is located on the eastern bank of the Orange River, to the south of the Sanddraai Farmstead and the Sishen-Saldanha Iron Ore Railway Bridge, under which the previous abstraction point was located. To the east of the Orange River, the terrain rises up gently away from the riparian zone, with the landscape being gently undulating.

Away from the Orange River, the presence of surface water drainage in the area is dependent on slope and substrate. The eastern bank of the Orange River in the vicinity of the study area is characterised by the presence of rocky terrain that rises from the alluvial terrace within the Orange River valley bottom. The underlying geology in this area between the Orange River valley bottom (which is underlain by alluvium of recent geological age) and the district road consists of Quart-muscouite schist, quartzite, quart-amphibole schist and greenstone of the Brulpan Group of the Groblershoop Formation the with areas of relatively more resistant quartzite forming the low ridges (interfluves) in this area. Although this terrain is not very steeply sloping, there is a relatively high density of surface water drainage, with the presence of a number of first and second order drainage lines. However as one moves further away from the river, the terrain and substrate changes to being dominated by a highly sandy substrate, with the presence of low dunes (of Aeolian origin), or being defined by flat calcrete-dominated plains. This part of the study area (traversed by the portion of Alignment 2 to the north-east of the railway) is underlain by siliciclastic rocks of the Kalahari Group, with notable surface outcropping of calcrete. Parts of this area have been covered by wind-blown Kalahari sands, forming parallel-running dunes. This different geological substrate appears to be responsible for the flatter topography, in which a number of less incised drainage lines, or ‘washes’ exist. Where the highly porous sandy substrate occurs, surface water drainage is very poorly defined or even absent over large parts of this landscape type.

The two pipeline alternatives traverse the more sloping, rocky terrain located just behind the Orange River valley bottom. A number of ephemeral watercourses rise in this terrain, draining the valley bottoms between the low ridges in this area. Alignment 2 crosses a number of watercourses as it runs out of the Orange River riparian corridor and into the more undulating, rocky terrain away from the river. Alignment 1 runs parallel to the outer edge of the valley bottom (at the interface between the valley bottom and start of the footslopes) and thus similarly crosses a number of such watercourses that drain from the sloping area to the east of the Orange River valley bottom. Alignment 1 runs close to the outer edge of the Orange River riparian zone, and is thus likely to occur close to the interface between the alluvial sediments of the Orange River corridor and the schists as described in the above paragraph. The farm access track along which the pipeline alternative is proposed to be routed runs in the flat area at the valley bottom.

Figure 6 – Undulating topography in the vicinity of the valley bottom drained by the Crossing 2 watercourse

Alignment 2 crosses nine (9)[1] river crossings, as indicated on the map below, and Alignment 1 crosses (eight) 8[1] river crossings. Each crossing has been assigned a number.

Most of the watercourses crossed by Alignment 2 are very narrow first order watercourses in rocky terrain, but a lower order, larger watercourse with defined channel(s) and a well-defined riparian zone (Alt2_2) is crossed in the southern part of the alignment. More of the watercourses crossed by Alignment 1 are lower order streams with a well-defined riparian zone and channel due to its part of its alignment being located closer to the Orange River

[1] Both Alternative 1 and 2 cross the same watercourse, but each crossing has been labelled separately for this report.

valley bottom, however a number of poorly-defined drainage lines that drain a very small surface area are also crossed.

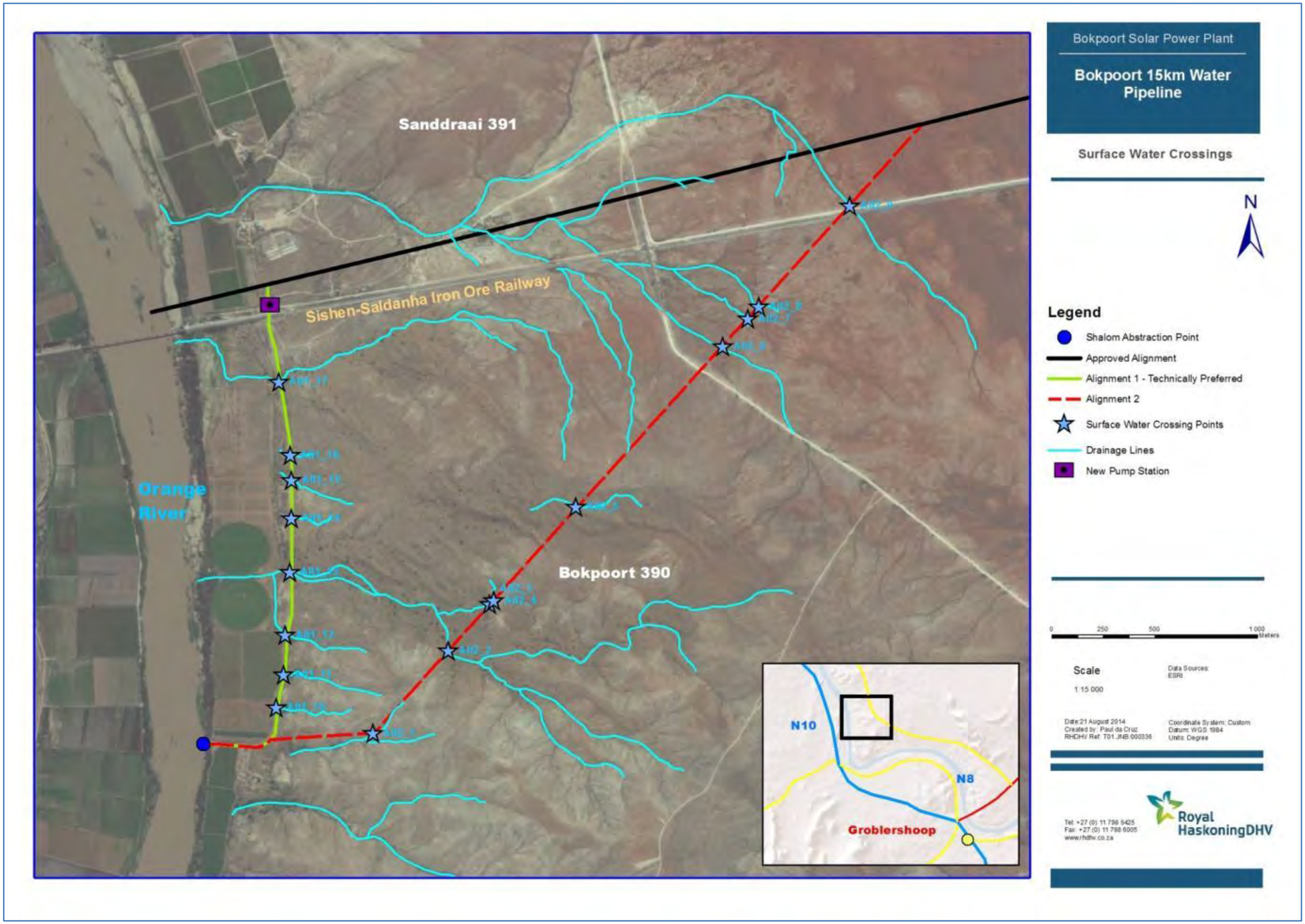

Figure 7 – Surface water drainage on the study site and location of surface water crossings along the two alternative alignments

5 PHYSICAL CHARACTERISTICS OF SURFACE WATER FEATURES IN THE STUDY AREA

This section describes the physical features of surface water features in the study area. Although the Orange River is affected through abstraction, the hydrological characteristics of this river are not explored in detail in this report as this is being assessed as part of a different study. Nonetheless the riparian characteristics of this river are assessed as the new abstraction point will be located with the Orange River riparian corridor. This section includes aspects of riparian zones as assessed through the VEGRAI tool.

5.1 Hydrology and Morphology of Ephemeral Watercourses in the study area

All watercourses on the study site with the exception of the Orange River are ephemeral / episodic. Flow regimes of rivers within the wider Succulent Karoo (a biome to the south-west of the study site, but with a similarly arid climate) are highly erratic with prominent temporal and spatial variability in flows even in the larger rivers (Le Maitre, *et al*, 2009). The nature of the soils in the catchments of watercourses and riparian areas, especially with respect to clay soils, entail that soil or mineral crusting (dispersed clay particles can form a 'cap' that significantly blocks infiltration into the soil – Esler *et al*, 2010) tends to be prevalent in overgrazed, bare areas. This has the result that when rainfall events occur there is a high degree of surface water runoff into the drainage systems, due to the reduced infiltration capacity in the soil. As a result the riverine habitats are naturally unstable and are subject to unpredictable flooding events, with consequent high levels of disturbance and soil movement (Palmer and Hoffamn, 1997). This is likely to be the case in the study area, as described above, as much of the study area is underlain by a rocky substrate and structured soils, on which a soil cap may have developed.

No evidence of active surface water flow was noted along any of the watercourses assessed in the field away from the Orange River, and all are likely to be strictly episodic, flowing only in response to rainfall events of sufficient duration and intensity. Evidence of periodic flow along these watercourses is provided primarily by the presence of wrack that is deposited on the upstream side of obstacles in the path of the watercourse, in particular the fence lines along which most of both pipeline alternative route run. In this context wrack is the (primarily vegetative) material washed down river courses during flood / spate flow events, and which is trapped behind branches and other obstacles, remaining in situ after the flood has passed. The evidence of wrack beyond the active channel indicates that these areas were inundated by flood waters and gives a good indication of the extent of higher / spate flows along the rivers in the study area. Although the presence of wrack does not provide an indication of the frequency of flooding, it does give an indication that a spate flow did occur along the water course, and the position of the wrack horizontally away from the channel, and vertically above the channel bed indicates the extent of the flooding and the volume of water that passed along the system, and is a reliable indicator of the extent of maximum hydrological activation and as such is a good indicator of the lateral extent of the riparian zone. Evidence of flow in the watercourses of the study area was also provided by the presence of water that had collected behind a dam wall across a watercourse in the southern part of the Alignment 2 alignment.

Figure 8 - Flood wrack trapped behind the fence line along which the realigned pipeline section runs at Crossing Alt2_6

Rainfall events of sufficient intensity are associated with significant runoff, and results in flows along the river systems for short periods of time. Once overland flow from the catchment area drops off, flows typically respond by decreasing and ceasing. Surface water is typically transpired into alluvial sediments, or is lost to evaporation. This hydrological regime of no surface baseflow punctuated by short-lined flow events in response to rainfall is typical of ephemeral watercourses, as found across the study area.

There is likely to be an interrelationship between groundwater and surface water in the watercourses of this semi-arid area. Although no extensive alluvial deposits were observed along all of the watercourses in the study area (only the larger watercourses were noted to be characterised by a wider, sandy bed comprising of deposited alluvial sediment), there is likely to be some form of hydrological connection between the watercourses and groundwater. Alluvium within rivers is hydrologically recharged by rain, surface water runoff, spring flow, flood recharge from rivers or by groundwater from the surrounding geology (IWR, 2011). In arid and semi-arid regions transmission losses of surface flow into alluvium can be substantial (IWR, 2011), and alluvial aquifers can hold relatively large volumes of water compared with rock-based aquifers where the water is confined to fractures and faults (le Maitre *et al*, 2009). Although not likely to exist on a large scale there is likely to be an element of such groundwater presence along watercourses located in valley bottoms, as evidenced by the presence of large trees which would depend on the presence of an underground water source. The presence of large trees (especially *Vachellia* (*Acacia) erioloba* and *Ziziphus mucronata*) along the larger watercourses cannot be attributed to surface flooding alone. This vegetation is likely to derive the majority of their required moisture inputs from alluvial groundwater. In the context of the delineation of riparian zones (as required by the regulatory requirements of the National Water Act) the hydrological connection between alluvial groundwater and surface flows along watercourses entails that the peripheries or areas beyond the primary channel(s) in which these larger shrubs and trees occur should be included as part of the riparian zone of the watercourse.

In a hydromorphological context most of the watercourses assessed in the field contained a main (active) channel, a feature of most fluvial systems. The high stream order of certain of the watercourses crossed by the pipeline alternatives is indicated by the relatively lack of incision and lateral extent of most of the channels of the watercourses crossed. The largest watercourse crossed (Crossing Alt2_2 and Crossing Alt1_13 at its downstream end) was characterised by a relatively un-incised central channel at the upstream crossing (Alt2_2), and narrow and shallow primary channel and a series of shallow side channels at the downstream crossing point (Alt1_13). Fluvial channels were not noted to be subject to significant degrees of channel bank erosion, and were well-vegetated. All channels were characterised by a sandy, alluvial substrate, with little vegetative cover. This alluvial substrate is likely to shorten the period of flow within the system following a rainfall event, as it would enhance the ability of overland flow entering and flowing down the system to permeate into the substrate. In the larger watercourses, especially upstream the access road along Alignment 1, the entire riparian corridor was noted to consist of alluvially-transported material (sand), with a number of interlinked / braided flow paths present within the wider 'bed' of the river. Evidence of the presence of deposition of pebbles and cobbles was noted in the main channel at crossing Alt1_13. Along Alignment 1 certain of the smaller watercourses drained through sandy substrate (low dunes) between the valley bottom and the rocky ground to the east, while the more southerly crossings located closer to the Shalom abstraction point drained through rocky terrain.

Figure 9 – Main channel of the watercourse at Crossing Alt2_2, looking upstream to the crossing point

Figure 10 – Narrow channel upstream of Crossing Alt1_15 in low duneveld, with the presence of rocky terrain upstream (in the background)

Some of the watercourses crossed by Alignment 2 – i.e. the north-most watercourses located along the pipeline route (between the district road and the railway) were very indistinctly defined in a hydromorphological context and displayed no evident of a channel. Rather these drainage systems are characterised by very diffuse overland flow during flow events, and as such could be termed as 'washes' rather than as classical watercourses. These watercourses were characterised by a clayey substrate which showed signs of previous wetting and drying at the surface.

Figure 11 – Vegetation and clayey soils within a 'wash' at Crossing Alt2_7

Along the two larger watercourses (crossings Alt2_2 & Alt1_13, and crossing Alt1_17) secondary lateral channels (note: all channels form part of the same watercourse crossing) were noted at the crossing point, The presence of these smaller lateral channel is indicative of the larger catchments of these two watercourses that has a potential to generate flows of greater volumes than some of the smaller watercourses with smaller catchments. The area between the primary channel and these smaller lateral channels was characterised by slightly higher-lying ground consisting of alluvially-deposited material, which would be termed as a bar or terrace in a hydromorphological context. These watercourses display the widest, most prominent riparian zones of all the watercourses crossed, as discussed further below.

Underlying substrate appears to have a bearing on the morphological form of the channels assessed, with channels in areas of rocky substrate being narrower and slightly more incised (e.g. crossing Alt2_1 and Alt1_12) than those where a sandy substrate (within the part of the study site where dunes and aeolian sand exists) – e.g. Crossing Alt2_2 or Alt1_15&16. Crossings Alt2_3 and Alt2_4 occur at the interface between such rocky substrate and aeolian substrate, with the watercourse's eastern bank and immediate catchment being characterised by rocky substrate covered with *Senegalia* (*Acacia) mellifera* shrubs, and the opposite (western) bank and catchment being akin to an uncovered dune face.

Figure 12 – Poorly defined drainage line (Alt2_5) looking downstream

In the context of the VEGRAI template, the delineation and zonation of the riparian zones of the watercourses can be undertaken based on the hydromorphological template that is evident for most of the watercourses crossed. Due to their episodic nature, the more simplistic zonation of the riparian corridor into two zones – the marginal zone and non-marginal zone is most appropriate. In all cases the marginal zone is not characterised by frequent hydrological activation, due to the ephemeral nature of the drainage systems, and thus a case could be made that the marginal zone in terms of definition based on hydrological activation would not exist in the study area. Nonetheless most of these systems display morphological indicators and vegetative indicators typical of the marginal zone. Thus the marginal zone is most suitably defined as being confined to the (narrow) channel, with the immediate channel banks or channel bar / terrace and secondary lateral channel (where present) comprising the non-marginal zone. Along the smaller systems, the non-marginal zone would be likely to be very narrow, due to the narrow extent of hydrological activation beyond the channel.

5.2 Vegetative Composition and Lateral Zonation of Ephemeral Watercourses

Riparian zones support distinctive vegetation that differs in structure and function from adjacent aquatic and terrestrial ecosystems. Riparian zones form the interface between aquatic and terrestrial ecosystems and, except in broad floodplains, are relatively narrow, linear features across the landscape (Holmes *et al*, 2005), as is the case in the study area. A number of processes shape riparian areas; especially disturbances associated with aquatic systems, such as flooding, debris flows and sedimentation processes (Tang & Montgomery, 1995). Riparian plants are typically adapted to fluctuations in the water-table, as river levels alternate between low base flows and floods (Holmes *et al*, 2005). However most of the rivers in the study area are episodic, with relatively scarce rainfall events causing short-lived periods of flow, as described above, and thus this vegetation along riparian zones in the study area does not need to be tolerant of frequent saturation. Rather shallow (alluvial) aquifers appear to be the main driver of riparian vegetation in the drainage systems within the study area, as explored above.

In the context of the Karoo (the wider area into which the study site falls), mean annual precipitation (MAP) is a key determinant of soil moisture availability which, in turn, together with soil fertility, has a controlling influence on the production of digestible biomass (Le Maitre *et al,* 2009).There are only a certain number of days in a year when soil moisture does not limit plant growth, thus the growing seasons are short (Le Maitre *et al,* 2009).The increased availability of sub-surface moisture in riparian areas of drainage systems in the Karoo accounts for the much denser and larger structure of plants as compared to surrounding upland areas. This is true of the study site as vegetation associated with the watercourses on the site differs in composition and structure from the surrounding upland shrubveld vegetation, although the presence of sandy substrate is an important driver of vegetation occurrence. This change in the vegetation composition and structure is an indication of the presence of the accumulation of both surface and groundwater (le Maitre et al, 2009).

The hydrology of the rivers and smaller drainage systems influences the vegetation through flooding, droughts and water-table fluctuations. Rivers are typically dynamic environments and flood events can change the channel structure and remove vegetation - riparian vegetation is shaped by disturbances associated with aquatic systems, such as flooding, debris flows and sedimentation processes (Holmes *et al*, 2005). Conversely fluvial processes can result in sediment deposition that provides new habitat for plant colonisation within the riparian zone. In the context of the study site, the nature of watercourses crossed, i.e. being mostly first order streams ensures that fluvial processes are not sufficiently well-developed to exert such an important effect on vegetation. Rather the presence of underground moisture appears to be more important in determining the structure and lateral composition of vegetation within riparian zones - the distribution of riparian vegetation types is primarily determined by gradients of available moisture and oxygen (Holmes *et al*, 2005). This is very important in the study area context - due to the ephemeral / episodic nature of most of the fluvial systems in the study area, riparian vegetation that occurs along these systems depends to a significant extent on groundwater availability to sustain the riparian vegetation communities. The relationship between riparian vegetation and groundwater is frequently complex; plants may source water stored in river banks or in alluvial aquifers. Moisture found within the substrate of drainage systems may emanate from periodic flooding that recharges into the aquifer or may be groundwater that discharges into the streams (le Maitre et al, 1999). The former is likely to be the case in the study area as discussed above.

Plants which are riparian specialists (referred to as obligate phreatophytes) are species adapted to fluctuating water tables; as such their roots typically remain in, or in contact with, the saturated soil layers (le Maitre et al, 1999). Although such species are typically vulnerable to long-term drawdown of groundwater levels due to over-abstraction (le Maitre *et al*, 1999), riparian plants are naturally adapted to fluctuations in the water-table, as river levels alternate between low base flows and floods (Holmes et al, 2005). A study by Milton (1990) demonstrated that rivers and associated riparian zones and washes had the highest plant species richness and structural diversity in the Karoo (in spite of occupying a minor percentage of the area), as compared to the surrounding plains and 'heuweltjies' (hillock) communities.

Figure 13 – *Ziziphus mucronata* tree in the non-marginal part of the riparian zone of Crossing Alt2_2

A number of lateral zones typically occur across the cross-sectional profile of a riparian zone, with the ability of plants to withstand flooding being an important determinant. This template is not typically expressed in the rivers of the wider Karoo and in the study area, as frequent flooding is not a significant factor, and access to underground water is more important. The most distinctive vegetative feature of all watercourses along the length of the pipeline alternatives is the presence of *Senegalia* (*Acacia) mellifera* shrubs. These typically lined the channel, forming a 10-15m wide strip of shrubs on either side of the channel, or occurring in small bush clumps. Along the two larger watercourses, in particular the largest watercourses, a few other shrub and even tree species were present on the margins of, and slightly away from the channel, including *Senegalia (Acacia) mellifera*, *Boscia albitrunca, Vachellia (Acacia) erioloba, and Ziziphus mucronata*. Smaller shrubs of the species *Lycium cinereum, Lycium oxycarpum* and *Nymania capensis* were encountered in the substratum close to the channel. *Senegalia (Acacia) mellifera* shrubs are found in non-riparian habitats on the site, especially in rocky terrain. However they do not occur as densely in this terrain as along watercourses, which reflects the relative supply of moisture along watercourses.

Channels and flow paths were typically noted to be un-vegetated, but lined with a relatively dense layer of grasses, of which *Stipagrostis namaquensis* was the most common, along with *Cenchrus ciliaris, Stipagrostis obtusa,* and *Stipagrostis ciliata.* The latter two species are not exclusively encountered along watercourses, but do occur in parts of the site where sandy soils of sufficient depth occur. In the largest watercourse at Crossing 2, where an intervening terrace is located between the primary channel and a lateral secondary channel, the sandy substrate on the terrace is densely vegetated by *Stipagrostis namaquensis.* A number of other shrub and succulent species found away from watercourses were also present in the non-marginal zone of the channel.

The VEGRAI tool requires that vegetation composition be assessed and differentiated between the marginal zone and non-marginal zones. The table below lists the vegetation species and type of plant (woody or non-woody) for the two most prominent watercourses in the area and their associated riparian zones.

Figure 14 – View into the riparian zone of Crossing Alt2_2 from its boundary, with dense stands of *Stipagrostis namaquensis* in the foreground and shrubs closer to the channel

Figure 15 – Boundary of the riparian zone of Crossing Alt2_6, showing the transition between the *Senegalia mellifera* shrub-dominated riparian zone and adjacent Karoo dwarf scrubland upland

Watercourse at Crossing Alt2_2				**Watercourse at Crossing Alt2_6**			
Marginal		**Non-Marginal**		**Marginal**		**Non-Marginal**	
Woody	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**
	Stipagrostis ciliata	*Senegalia mellifera*	*Stipagrostis ciliata*	*Senegalia mellifera*	*Cenchrus ciliaris*	*Senegalia mellifera*	*Cenchrus ciliaris*
	Stipagrostis namaquensis	*Vachellia erioloba*	*Cenchrus ciliaris*		*Stipagrostis ciliata*	*Lycium cinereum*	*Eriocephalus spinescens*
	Stipagrostis obtusa	*Ziziphus mucronata*	*Eragrostis lehmanniana*				*Pentzia incana*
		Boscia albitrunca	*Sacrostemma viminale*				*Rhigozum trichotomum*
		Nymania capensis					*Stipagrostis obtusa*
		Lycium cinereum					*Peliostomum leucorrhizum*
		Lycium oxycarpum					*Stipagrostis ciliata*
							Schmidtia pappophoroides
							Lycium cinereum
							Salsola tuberculata
							Fingerhuthia africana

Watercourse *upstream of* Crossing Alt1_13				**Watercourse *upstream of* Crossing Alt1_17**			
Marginal		**Non-Marginal**		**Marginal**		**Non-Marginal**	
Woody	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**	**Woody**	**Non-woody**
Ziziphus mucronata	*Eragrostis lehmanniana*	*Senegalia mellifera*	*Stipagrostis namaquensis*	*Vachellia erioloba*	*Stipagrostis namaquensis*	*Senegalia mellifera*	*Stipagrostis namaquensis*
	Osteospermum spp.	*Vachellia erioloba*	*Eragrostis lehmanniana*	*Lycium cinereum*	*Stipagrostis obtusa*	*Vachellia erioloba*	*Sacrostemma viminale*
		Lycium cinereum	*Osteospermum spp.*		*Osteospermum spp.*	*Ziziphus mucronata*	*Osteospermum spp.*
						Boscia albitrunca	
						Lycium oxycarpum	
						Lycium cinereum	

No alien invasive vegetation was noted along any of the watercourses assessed along Alignment 2, and only limited alien invasive vegetation was noted along Alignment 1 (with the presence of some *Prosopis spp.* trees in the road reserve along Alignment 1). This is an important factor in terms of the determination of the state of these watercourses, as the prevalence of alien vegetation within riparian vegetation can exert a significant impact on groundwater availability within riparian zones; groundwater is likely to be affected by deep-rooted alien invasive trees such as gums (*Eucalyptus spp.*), *Prosopis* and poplar (*Populus spp*.) (Milton, 2010).

5.3 State of Alteration of Ephemeral Watercourses

A basic distinction emerged between the state of the watercourses along Alignment 1 as opposed to those along Alignment 2. As discussed below, this is a significant factor in the comparative assessment of the two alternatives. The state of the watercourse reaches along Alignment 1 is substantially poorer than the state of the watercourses along Alignment 2. This is due to the significant, and often complete physical transformation of the watercourses along Alignment 1 as they enter the Orange River valley bottom, as detailed below. Alignment 2 runs along a cadastral boundary in an uninhabited part of the study area in which stock grazing occurs. Thus apart from certain potential impacts on these watercourses and their respective catchments due to livestock grazing pressure, the watercourses along Alignment 2 were noted to be subject to no pressures, and were concomitantly assessed to be in a state close to a reference state.

Alignment 1 runs along the edge of the zone of cultivation along the Orange River (along which a farm access track is aligned). The corridor adjacent to the river is subject to intense irrigated cultivation. In the study area a narrow band of riparian vegetation has typically been retained in the sloping area between the channel of the Orange River and a flat alluvial terrace lying behind. The flat terrace area extends from the current boundary of the riparian zone back from the river for a distance of approximately 200-280m. This terrace area has been completely transformed from a natural state with the establishment of orchards as well as a number of cultivated fields, some of which are irrigated centre pivots. It is also possible that this area has historically been levelled to facilitate the cultivation of crops and pastures and other irrigated areas.

This physical and vegetative modification of this alluvial terrace has exerted a severe impact on the numerous watercourses that naturally would have drained towards the Orange River from the higher-lying area to the east of the river. Under natural (pre-development) conditions these watercourses would have drained into the flatter valley bottom, either continuing to drain into the Orange River through its riparian zone, or could have formed an alluvial fan-like feature, naturally dissipating and draining (recharging) into the silty alluvial sediment on this terrace. However, with the exception of the most northerly watercourse (Alt1_17) all of the eight watercourses have been physically stopped from draining into the cultivated fields to the west of the access road. A berm of 2-3m in height consisting of soil and rocky material has historically been constructed along the outer boundary of the cultivated fields. Thus any water draining down the watercourses after draining over the farm access road will be impounded behind this berm, not reaching the fields behind. With the exception of the watercourse at Alt1_17, any evidence of any natural channels on the alluvial terrace now occupied by fields has been removed. In the case of the larger watercourse crossed at Alt1_13 (and at Alt2_2), the greater volume of flows down draining from this larger catchment necessitated further measures to manage the flows; two further retaining walls made of sand have been constructed along the width of the watercourse's riparian zone just upstream of the farm access road. These walls would likely help to impound flows temporarily in this area, before allowing them to drain through an opening on the northern side, across the access road and into the intervening area behind the rocky berm to prevent any water from flooding the fields behind. In the case of the northern-most watercourse (Alt1_17), a channel has been constructed downstream of the road, with an opening through the rocky berm. The modified channel drains through a vacant area cleared of vegetation and through a field, before entering the Orange River riparian zone.

Figure 16 – Berm / impounding wall (left) constructed across the width of the watercourse at Crossing Alt1_13, with area behind in which water is trapped

In all cases the watercourses have been significantly physically modified at the point at which they drain through fence separating the cultivated fields from the grazing camp. Along seven of the watercourses the hydrological regime of these watercourses has been completely modified, in that little or no surface water flow reaches the valley bottom. Complete physical (morphological) modification of the certain reaches of these drainage systems has occurred in that channels or natural depositional features have been completely removed. Lastly, the vegetative state of the affected reaches has been extensively modified, with the almost complete removal of naturally-occurring riparian vegetation (especially non-woody vegetation) that has left these reaches devoid of vegetation except for a few remnant trees and pioneer species which have colonised the area.

It is important to note that the pipeline along Alignment 1 crosses each of these eight watercourses across the reaches which have been modified. The pipeline runs immediately parallel to the farm access road on its upstream (eastern) side, thus crossing the watercourses at the point at which they become physically modified. Along the southern part of the alignment, the pipeline is routed along the current rocky berm, and thus any evidence of a surface water feature has been removed. However the watercourses will continue to drain into this area, and although in practical terms crossings Alt1_10-12 are no longer surface water crossings, the design of the pipeline will have to consider the need to manage these periodic flows down the system.

This degree of physical modification of these watercourses along Alignment 1 is an important factor, when the much improved hydromorphological and ecological state of the watercourses along Alignment 2 is considered.

Figure 17 – Photographs indicating the degree of physical modification of the watercourse downstream of crossing Alt1_17 as it drains through the berm (left) and through the alluvial terrace (right)

5.4 The Orange River Riparian Zone

The Orange River riparian zone is assessed in this report as the new proposed abstraction location is located on the banks of the Orange River, within the riparian corridor of the river. It should be noted that there is an existing abstraction point where two existing pumps abstract water for the farming activities on the Sanddraai Farm. A concrete ramp has been constructed into the riparian zone to allow access to the water for the pumps, and as such the riparian corridor at the location of the new abstraction point is already impacted, as discussed in the impact assessment section below. As described above two technical options for abstracting water from the Orange River have been presented, and the infiltration gallery in particular could impact on the river's riparian zone, hence the characteristics of the Orange River riparian corridor have been assessed.

The Orange River is a very large perennial River, being one of the largest rivers on the southern African subcontinent, draining a very large catchment that encompasses much of the eastern and western interior of South Africa. In spite of the highly arid nature of the climate in the study area, the perennial nature of the river ensures that a distinct and prominent riparian corridor naturally occurs along the River. The distinct nature of the riparian corridor of the Orange River is indicated in its classification as a distinct vegetation class – the Lower Gariep Alluvial Vegetation. This vegetation class is described as a complex of riparian thickets and reedbeds with flooded grasslands and herblands along sandbanks and terraces (Mucina and Rutherford, 2006). As discussed further below, it is important to note that this vegetation type is classified as an ***endangered terrestrial ecosystem*** under the National Environmental Management: Biodiversity Act (Act 10 of 2004).

Morphologically, the riparian corridor of the river is heavily fluvially influenced by flooding along the riverine corridor that results in the deposition of alluvial silt in the bed and banks of the river. At the current Shalom abstraction point, the cross-sectional profile of the river is characterised as a steep bank that slopes up from the water level to the top of the macro channel bank with no intervening terraces. Behind the macro channel bank an irrigation canal to transport the abstracted water has been constructed (running parallel to the river to the north and the south) and behind this the terrain slopes down to a lower-lying flatter area (wide terrace) that has been extensively transformed by agricultural cultivation as described in section 5.3 above. The access to the river at the abstraction point has cut into the macro channel bank to allow a less steep access to the water level, however the macro-channel bank remains on either side of the concreted access.

Figure 18 – Indigenous riparian vegetation adjacent to the existing Shalom abstraction point

The morphological template of the riparian zone is not homogenous, and varies according to factors such as bedrock outcropping and the curvature of the river, with the inner and outer banks differing in terms of degree of deposition versus erosion. Downstream of the abstraction point on the same (eastern) side of the river the riparian corridor is much wider and has a different cross-sectional profile. Bedrock outcrops downstream of the abstraction point, and this has allowed the creation of mudbanks at the margins of the channel and sandy, flood terraces adjacent to the margins that are partly un-vegetated and partly covered in *Phragmites australis* reedbeds. It should be noted that a secondary lateral channel is densely vegetated by *Phragmites* and *Typha capensis* reed species (these species, in particular *T. capensis* which is an obligate hydrophyte (i.e. always grows in saturated conditions) are indicative of a high degree of hydrological activation associated with likely seasonal inundation of this part of the channel). Moving away from the channel the substrate is silty and un-vegetated, and slopes up gently to a higher flood terrace where the first trees and shrubs are located. The higher bank further away from the channel is slightly steeper and is covered in dense thickets with the presence of large *Vachellia (Acacia) karroo* and *Ziziphus mucronata* trees. The thickets extend up the slope on silty alluvial substrate all the way up to the top of the macro-channel bank, behind which the heavily-transformed cultivated area is located.

Figure 19 – Sandy alluvial terrace and thickets along the macro channel bank downstream of the abstraction point

The vegetation in the riparian zone adjacent to the abstraction point consists of dense thickets of trees and shrubs with a dense understorey. The primary tree and shrub species noted were *Vachellia (Acacia) karroo, Ziziphus mucronata, Rhus lancea, Diospyros ramulosa* and *Lycium cinereum* in the substratum. A dense stand of the reed *Phragmites australis* occurred along the water's edge and up the macro channel bank on the southern side of the abstraction point. It was apparent that the riparian vegetation at this location had been invaded by *Prosopis spp.*, with an estimated 10-20% coverage of the riparian corridor by alien vegetation, primarily of this species.

It was noted that the vegetation adjacent to the existing abstraction point (on the southern side) had recently been disturbed through the movement of a large vehicle, with damage to the *Phragmites* reedbeds. The infiltration gallery (if selected for development) will have a footprint in the riparian zone, being likely to physically alter a part of the riparian zone. The potential impact of the abstraction footprint on the riparian zone is discussed in section 7.2 below.

6 RESULTS OF (VEGRAI) RIPARIAN STATE ASSESSMENT

The VEGRAI model has been used to calculate an ecological category for the two most prominent ephemeral watercourses along both Alignment 1 and 2 respectively. Although the fluvial regime of the watercourses in the area does not correspond to a classical fluvial and corresponding riparian morphological template, as characterised by differing degrees of hydrological activation within the riparian zone, and the presence of certain parts of the river cross section which are more or less permanently inundated, the VEGRAI tool remains a useful way to determine the state of the riparian zones of certain of the watercourses in the study area.

Only the more prominent drainage lines have been assessed as the other drainage lines are too poorly structurally defined to be properly assessed using the tool (i.e. the small headward watercourses crossed), or are similar in nature to the watercourse assessed, thus enabling the assessed watercourse to be used as a proxy. Along Alignment 2 landuse-related impacts and hydrology were noted to differ very little between the nine drainage lines, and the ecological category assigned to the two watercourses assessed can be relatively confidently applied to the other watercourses along the alignment. Along Alignment 1, all watercourses are subject to the same degree of extreme modification in the area between the Orange River riparian zone and the rising ground away from the valley bottom, thus the ecological categorisation for the two larger watercourses can be applied to the smaller watercourses.

The following riparian zone characteristics (as relevant to the VEGRAI assessment) were noted as part of the assessment:

Alignment 1

- Agricultural cultivation is the prominent land use within the Orange River valley bottom that has historically, and continues to exert a severe impact on the riparian zones along their most downstream reaches. An ***extreme degree of modification*** of the riparian zones in area between the farm access road and the current edge of the Orange River riparian zone has occurred – a high degree of hydrological modification (complete impoundment in the case of the watercourse at Alt1_13) that prevents any water from flowing into the valley bottom, morphological modification (destruction of naturally-occurring channels or depositional features on the valley bottom), and almost complete removal of naturally occurring riparian vegetation.
- Upstream of the fence separating the cultivated area from the rangeland (veld camp) to the east, the two watercourses were in a much more natural state (similar to the state of the watercourses along Alignment 2). There were no signs of physical modification or alien invasive plants, and overgrazing is the only potential pressure acting on these riparian zones.
- In the un-impacted sections the marginal zone was limited to the central active channels and smaller flow paths of the respective watercourses, as these areas parts of the riparian corridor are most likely to be hydrologically activated when surface flow occurs along these systems. The other parts of the riparian zone would only be hydrologically activated in significant flood events, thus being delineated as the non-marginal zone (i.e. a combination of the upper and lower zones).
- The channels / flows paths were found to be largely devoid of vegetation, with no woody vegetation present
- Coverage of non-woody vegetation was lower (20-40%) in the watercourse at Crossing Alt1_17 than that of the watercourse at Crossing Alt1_13 (60-80%), whereas woody vegetation cover was roughly the same (<10%) for both watercourses, irrespective of the crossing point.
- Lastly, an assessment of the reference state needed to be made, in relation to the above factors. Overall, the findings of the field assessment were that the watercourses assessed were relatively close to a reference state ***upstream of the fence between the cultivated area and rangeland*** due to the following factors;

- The absence of any alien invasive vegetation was a very important factor in this context.
- The vegetation coverage within the non-marginal riparian zone was noted to be relatively high, especially non-woody vegetation,
- A reasonable diversity of non-woody and woody species was encountered in the context of the climate of the area being highly arid.
- There were no obvious signs of erosion, and the palatable grass species and herbaceous species appeared to not be heavily grazed, although grazing in these areas is potentially reducing species diversity.

Alignment 2

- Stock farming is the prominent land use that would potentially affect the riparian zones along the alignment. It is difficult to fully assess the degree of impact of stock farming on riparian zones without having a more comprehensive understanding of current levels of rainfall; however this landuse appeared to have a relatively low impact footprint in the context of altering the vegetative composition and morphological structural integrity of riparian zones.
- An almost complete absence of alien invasive vegetation was noted along the alignment (in terms of the ephemeral watercourses), which is a very important factor in the context of the abundance metric.
- The marginal zone was limited to the central active channel of the respective watercourses, as the channel is the part of the riparian corridor most likely to be hydrologically activated when surface flow occurs along these systems. The other parts of the riparian zone would only be hydrologically activated in significant flood events, thus being delineated as the non-marginal zone (i.e. a combination of the upper and lower zones).
- The channels were found to be largely devoid of vegetation, with no woody vegetation present
- Coverage of woody vegetation was lower (10-20%) in the watercourse at Crossing Alt2_2 than that of the watercourse at Crossing Alt2_6 (c50%), whereas non-woody vegetation cover was roughly the same (60-80%) for both watercourses, irrespective of the crossing point.
- Lastly, an assessment of the reference state needed to be made, in relation to the above factors. Overall, the findings of the field assessment were that the watercourses assessed were relatively close to a reference state due to the following factors;
  - The absence of any alien invasive vegetation was a very important factor in this context.
  - The vegetation coverage within the non-marginal riparian zone was noted to be relatively high, especially non-woody vegetation,
  - A reasonable diversity of non-woody and woody species was encountered in the context of the climate of the area being highly arid.
  - There were no obvious signs of erosion, and the palatable grass species and herbaceous speciesappeared to not be heavily grazed.

The tables below present the outcomes of the VEGRAI assessment in terms of the ecological category assigned to each of the watercourses assessed.

Table 1 – VEGRAI Ecological Category Scores for Alignment 1 Crossings*

Crossing Point	Level 3 VEGRAI % score	VEGRAI Ecological Category
Crossing Alt1_13	**14.6**	**F**
Crossing Alt1_17	**21.7**	**E/F**

* - Note - the above scores represent the scores for the reaches of the watercourses crossed by the proposed pipeline – i.e. the most downstream reach of the watercourses on the Orange River valley bottom and the start of the footslopes to the east of the farm access track. The state of the riparian zones of the watercourses just upstream of the valley bottom is much more natural, and would be similar to the 'B' ecological category as assessed for the Alignment 2 crossings.

Table 2 – VEGRAI Ecological Category Scores for Alignment 2 Crossings

Crossing Point	Level 3 VEGRAI % score	VEGRAI Ecological Category
Crossing Alt2_2	**83.1**	**B**
Crossing Alt2_6	**84.4**	**B**

It is noteworthy that both watercourses along Alignment 2 (and the reaches of the watercourses upstream of the Orange River valley bottom) fall into the Ecological Category B – i.e. largely natural with few modifications. That is a small change in natural habitats and biota may have taken place for these watercourses but the ecosystem functions remain largely unchanged. This assessment of the state of riparian zones in the most prominent riparian zones is important, as the potential impacts of constructing and operating the pipeline within these areas could potentially be significant if not properly mitigated (refer to section 7 below for an assessment of the potential degradation of the ecological category of watercourses in the area if potential impacts were not mitigated).

Conversely, the reaches of the watercourses crossed along Alignment 1 were assigned an extremely low Ecological Category (EC) score, reflecting the extreme degree of modification of these watercourses within the Orange River valley bottom. The reach of the watercourse at Crossing Alt1_13, has effectively ceased to exist as a surface water feature, with complete hydrological, morphological and vegetative modification of due to the impounding function of the berms and ploughing of the valley bottom. The EC category score of 'F' is indicative of a critically modified state. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota, as is the case in this reach of the watercourse. The slightly higher score for the watercourse at Crossing Alt1_17 represents the residual hydrological connection between the upstream reaches and the Orange River riparian zone, but the reach has still been assessed to be in a serious state of modification. It is important to note that the other six crossings along Alignment 1have experienced similar complete modification to the watercourse of at Alt1_13, and thus would fall into the lowest ecological category.

6.1 Delineation and Zonation of Riparian Zones in the Study Area

As noted above, riparian zones were delineated based not only on hydromorphological factors, such as channel structure and areas of surface water-related hydrological activation (as prescribed in the VEGRAI template) but also based on the presence of vegetation of differing composition and structure to the surrounding Karoo veld, and thus the presence of alluvial groundwater supply. The riparian zones in the study area are indicated in the maps below.

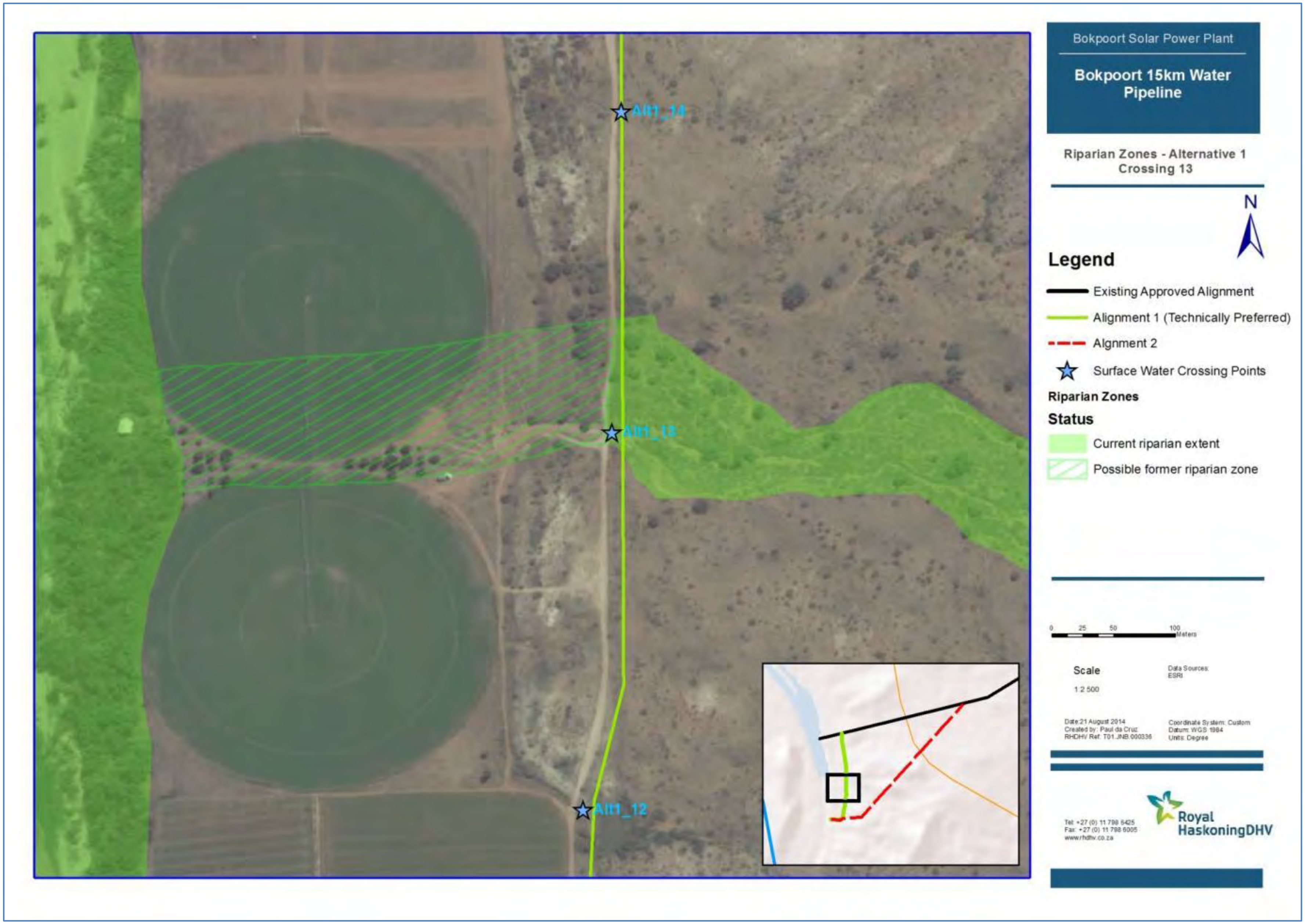

Figure 20 – Riparian zone of the Watercourse at Crossing Alt1_13

Figure 21 – Riparian zone of the Watercourse at Crossing Alt1_17

Figure 22 – Riparian Zone of the Watercourse at Crossing Alt2_2

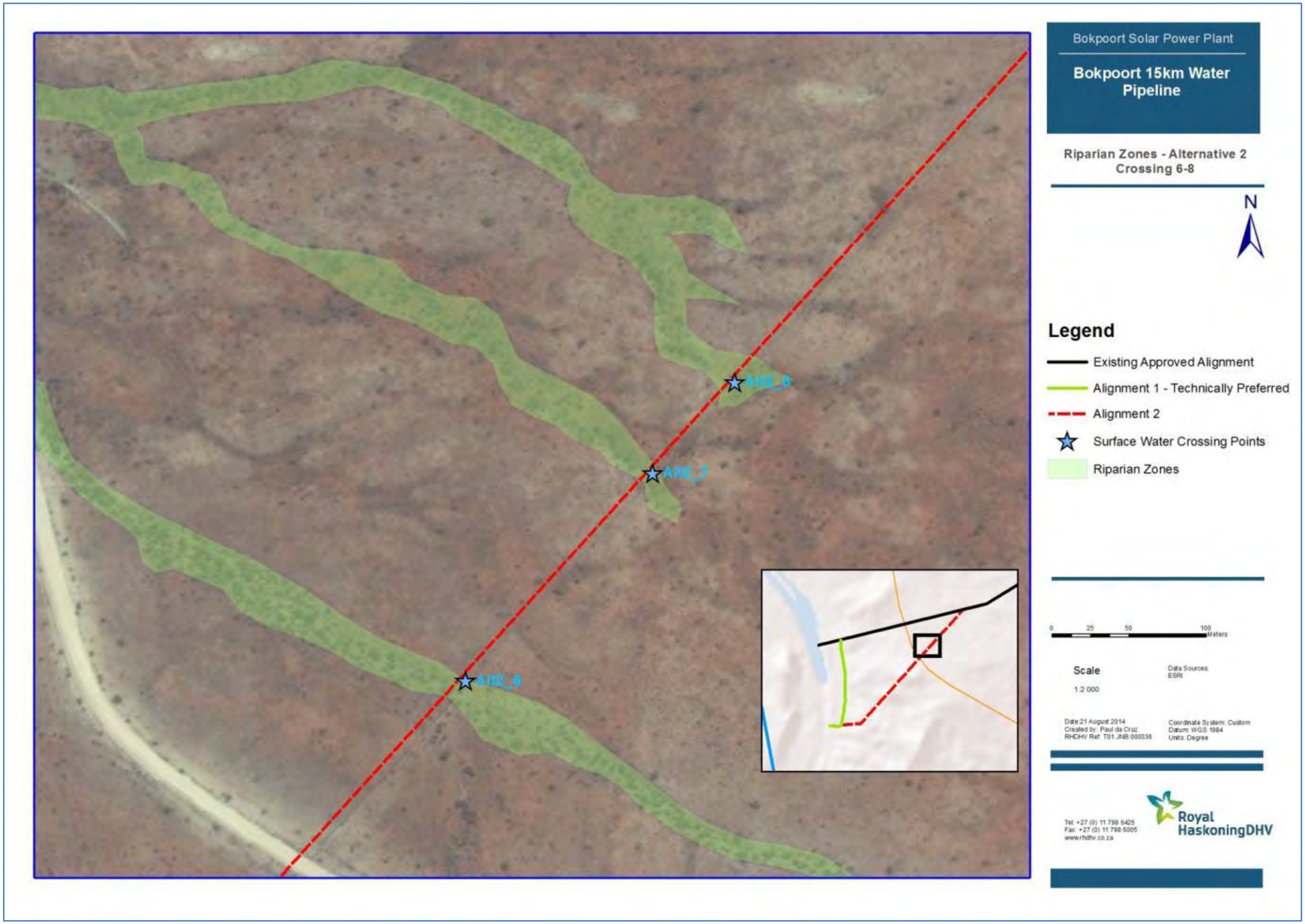

Figure 23 – Riparian Zones of Crossings Alt2_6-8

Figure 24 – Riparian Zone of the Orange River

7 IMPACTS AND MITIGATION ASSOCIATED WITH THE PROPOSED PIPELINE

7.1 Ephemeral Watercourses

The primary impact associated with the proposed pipeline is the disturbance of watercourses and associated riparian zones through excavation of the pipeline. The pipeline will be buried, and thus a pipeline trench will need to be excavated across the affected watercourses. This will result in the disturbance and erosion of substrate within and immediately adjacent to the watercourses. A trench line and adjacent working right of way will need to be established, thus vegetation in the riparian zone within the footprint of the works will need to be cleared. The creation of a working right of way for machinery and the excavation of a trench would result in the felling and removal of all vegetation, in particular woody vegetation. This would leave the servitude devoid of vegetation after construction, which is important for a number of reasons.

The felling of all vegetation impacts negatively on the structural integrity of the riparian zone. The removal of (woody) vegetation from the servitude is one of the most important impacts on riparian zones that can occur, as it alters the vegetative composition of the servitude, and exposes the understorey that is dependent to a large degree on the shade created by the canopy to the sun. Clearing of woody vegetation also exposes the understorey that is dependent on the protection offered by the typically spiny / thorny woody vegetation to grazing pressure by livestock. Combined, these two factors can result in much of the understorey being lost. Erosion may result from the clearing of vegetation and die off of roots that bind the soil, thus potentially resulting in the inundation of downstream reaches with sediment causing the impairing of filtering functions associated with the riparian zone.

In addition the clearing of most riparian vegetation from servitudes leaves the soils exposed to erosion – both water-borne and wind-borne erosion. This is significant as much of the substrate within the riparian corridors of the larger watercourses in the area was noted to be silty in nature and thus powdery and highly unconsolidated, thus being particularly vulnerable to erosion by water and wind if the vegetation cover that binds the underlying soil is removed. Although the watercourses along the pipeline rarely flow, when flow does occur along these watercourses it is possible that flows of high volume and velocity, although brief in duration, would occur along the watercourses. Such flows would be associated with a relatively high degree of erosive force and this would be greatly exacerbated if vegetation in the servitude was removed, leaving the sandy substrate highly vulnerable to erosion. The occurrence of a flow event through such an un-vegetated area could initiate a 'knick point' which may lead to development of gulley (donga) erosion into the upstream part of the watercourse. For this reason securing the servitude through measures such a re-vegetation is an important mitigation measure as discussed below.

Importantly the clearing of vegetation introduces another potential impact– that of the invasion of the riparian zone by alien invasive vegetation. This introduces the edge effect which can have an important effect on biota within the riparian zone, and create a very convenient 'entry point' into the riparian zone and wider riverine corridor for alien invasive vegetation – such human-related disturbances further exacerbate the natural susceptibility of riparian ecosystems to invasion by alien plants, as the transformed habitat is highly suitable for colonisation by alien invasives, and is less suitable for the less aggressive indigenous riparian species (Holmes et al, 2005). Riparian zones are particularly vulnerable to invasion by alien plants due to their dynamic hydrology and opportunities for recruitment following floods (Holmes et al, 2005). Servitude clearing is similar in that the cleared area is similar in nature to an area of the riparian corridor where flooding has washed away much of the vegetation. Many alien invaders of riparian habitats in South Africa are tall trees with higher water consumption than the indigenous vegetation (Holmes et al, 2005), and this could affect the vegetation-groundwater balance.

Although the actual spatial area of the cleared servitude is likely to be relatively small in the context of the wider riparian corridor, this could create a convenient foothold for the invasion of wider areas of the riparian corridor, and initiate an impact over a much wider area than simply the cleared servitude.

The ephemeral nature of these watercourses and the relatively shallow depth of the pipeline trench is unlikely to result in the presence of any shallow water tables that would result in seepage in the trench, as it often is in the case of the construction of pipelines through water features. It is unlikely that seepage water will be encountered within the trench (the top of the pipe would be located at a minimum of 0.8m below the natural ground level, thus the trench would be likely to be approximately 1.5m in depth), as such shallow groundwater is unlikely to be present unless construction occurs immediately following a large flow event.

A number of factors will determine the intensity of the impact of the pipeline construction on each watercourse; the length of the works through each riparian zone affected, the width of the works area, and the physical (especially vegetative) characteristics of the affected riparian zone, and possibly most importantly the current state of modification of the watercourses along Alignment 1 and Alignment 2 respectively. The highly modified state of the watercourses along Alignment 1 (especially crossings Alt10, 11 & 12) would be likely to result in relatively less damage to the riparian zone, especially as the alignment of the pipeline in all cases along this alternative alignment is immediately adjacent to a road, or along a berm. The watercourses along Alignment 2 are much less impacted and modified and the impact would be much greater.

If Alignment 2 were to be developed, the larger watercourses would be likely to be subject to an impact of greater intensity than most of the ephemeral first order watercourses that are narrow in width and which have a less developed riparian zone. The crossings are characterised by a lesser density of woody vegetation, and a less distinct vegetation community compared to the adjacent upland areas. The larger watercourses (especially Crossing Alt2_2 and to a lesser degree Crossing Alt2_6) display riparian zones that are well-developed and distinct from the upland areas in terms of species composition and vegetation structure and density. The riparian corridor of the Crossing Alt2_2 watercourse is relatively wide, and a signficantly larger area of riparian corridor would be subject to physical impact.

The re-instatement of vegetation within the riparian corridor of the watercourse after the pipeline trench has been reinstated is a critical factor in the prevention of impacts during the operational phase on the affected surface water feature. If vegetation is not re-instated after trenching, soils would remain exposed. This is exacerbated by the likely operational practice of keeping the pipeline servitude free of large *deep-rooted* woody shrubs and trees that may damage the pipeline through their roots. This is likely to preclude the reestablishment of the larger trees and shrubs over the pipeline trench, including *Vachellia* (*Acacia) erioloba* and *Senegalia (Acacia) mellifera.* The inability to re-establish a woody vegetation layer could hinder efforts to re-establish an understorey of grass and other shrubs, although coverage of woody vegetation is not greater than 70%, and the non-woody species that occur in the riparian zones are tolerant of exposure to full sun. Reinstatement of non-woody vegetation within the footprint of the works area is a very important priority once the pipeline trench has been reinstated.

Lastly, the incorrect reinstatement of the channel bed and banks could have an impact on the integrity of the riparian zone, and could result in an important hydrological impact. If the channel and banks of the drainage features, as well as features such as flood terraces were not restored to a pre-construction state, this could lead to a permanent alteration of the hydromorphological state of the watercourse and associated vegetation composition. It is important that the cross-sectional channel structure be restored to a pre-construction state as far as possible. The construction of any impounding structures across the channel, such as raised roads or berms across the channel that would trap water behind them and deprive the downstream reach of flow in a flow event could exert an important impact on the downstream riparian corridor as deprivation of downstream stretches of water could lead to the alteration and loss of riparian vegetation that rely on periodic flow (and associated sub-surface water) inputs, and thus the degradation of these stretches of the riparian corridor.

7.1.1 Results of Predictive Use of VEGRAI to assess the effect of the pipeline construction on Riparian Zones along Alignment 2

The VEGRAI tool can be applied for predictive use that can assist with the assessing of potential impacts of a development on a riparian zone of the watercourses along Alignment 2 that were assessed using the VEGRAI tool. Using the VEGRAI spreadsheet model, it is possible to make some qualitative predictions as to how the riparian vegetation is likely to respond when changes in driver components, and specifically particular driver metrics, occur. Essentially these predictions are scenario assessments and will be of a conceptual nature, with low confidence of how close to reality they actually are (Kleynhans *et al*, 2007).

The tool has been used in this way to simulate the impact of the proposed pipeline on the two more prominent riparian zones that were assessed using the tool under a scenario in which no mitigation measures were applied (i.e. a worst case scenario), and the resulting change in the Ecological Category that could materialise. The VEGRAI assessment gave the watercourses at Crossings 2 and 6 an Ecological Category Score that falls within Class B – largely natural with few modifications.

The following parameters would change under the scenario in which the pipeline would be constructed through the riparian zones with no / little mitigation applied:

- A strip of vegetation would be cleared from pipeline servitude, resulting in a corresponding change in vegetation cover and species composition of both woody and non-woody vegetation. Cover may be further reduced by the development of erosion that removes topsoil from the servitude area and potentially from upstream sections.
- The ‘opening-up’ of the riparian zone could create highly suitable conditions for the invasion of this part of the riparian zone by alien invasive plants that would result in a change in abundance of indigenous vegetation.
- Water quality in downstream reaches may be adversely affected through the creation of silt through the development of erosion from the cleared servitude.

Applying the changes to these parameters, the model has predictively assessed that the Ecological Category for both riparian zones assessed would potentially drop from a B into a C Class – moderately modified. In this context, it is critical that the mitigation measures stipulated below in section 7.4 are applied.

7.2 Impacts on the Orange River Riparian Zone

As described above there is an existing abstraction point at Shalom, being used for abstraction to supply the local farming (cultivation) activities. As such the riparian zone has been physically modified, with a concreted access to the river having being cut through the macro-channel bank. Two technical options have been presented for the abstraction. The first, a floating raft would be likely to be installed at the existing abstraction point (although this has not been confirmed in the technical information presented). Under this scenario there would be some disturbance to the bed or banks of the river with the installation of the concrete blocks to which the raft is anchored. If these concrete blocks are placed at the existing abstraction point, this will represent a consolidation of an existing impact with no likely further increase in the footprint of the existing impacted area.

In the case of the infiltration gallery the footprint will be much larger, and it is likely that a previously un-impacted area of the riparian zone would be impacted. No design details of the infiltration gallery or proposed footprint at the Shalom abstraction point have been provided for assessment. However bearing in mind the profile of the riparian zone at the Shalom abstraction point as described in section 5.4 above – a narrow and steeply sloping macro channel bank lying between the edge of the channel and the transformed area of cultivation behind with no intervening alluvial terraces – it is uncertain whether an infiltration gallery would be able to be placed at the Shalom point due to topographical limitations. It is not known whether the infiltration gallery could be placed in the cultivated area immediately behind the riparian zone and irrigation canal. The photographs in the technical document (Golder, 2014) indicate that the infiltration gallery would ideally be placed within an area of alluvial sediment adjacent to the channel of the river. No such alluvial terrace exists at the Shalom abstraction point with the closest such area occurring 900m to the north (downstream) on the eastern side of the eastern bank. However the design drawings for the older abstraction point (adjacent to the railway bridge) as presented in the Golder Report (Golder, 2014) show that a relatively large area of indigenous thicket vegetation would fall within the footprint of two infiltration galleries, that would be likely to result in the destruction / transformation of this area of indigenous vegetation. Due to the similar profile of the riparian zone on the eastern bank of the river at the Shalom abstraction point, a similar area of transformative impact thus appears likely to need to be developed at the Shalom abstraction point, to the north or south of the existing abstraction point.

More information is required in order to accurately assess the actual impact of the infiltration gallery on the riparian zone. However it is likely that the infiltration gallery would have a physical footprint within the riparian zone, being likely to lead to the destruction of riparian vegetation due to the need to excavate the area to lay the underground infrastructure. The impact on riparian vegetation would be less if the infiltration gallery was placed within an area of open sand or *Phragmites* reedbeds. *Phragmites* is a pioneer species that will recolonise an area once disturbed if a suitable shallow groundwater hydrological regime persists, and thus the area of disturbance could be naturally rehabilitated once construction was complete. However it appears more likely that the infiltration gallery would be placed within an area of mature indigenous thicket vegetation (as occurs adjacent to the Shalom abstraction point); it is important to note that the impact on this vegetation would be of greater significance. It should be noted that the Lower Gariep Alluvial Vegetation Type (AZa 3) is listed as an *Endangered* Ecosystem, and any impact on the mature thickets within this vegetation would be highly significant in both a localised context as well as a cumulative context. In this context it is important that the technical design of the infiltration gallery (if selected for development) attempt to minimise destruction / loss of riparian habitat.

7.3 Other Potential Construction-related Impacts

The process of constructing the pipeline through watercourses could potentially impact these features in other ways through a series of construction-related impacts. The following impacts on surface water features can result from construction activities along the pipeline servitude:

- The uncontrolled interaction of construction workers with watercourses that could lead to the pollution of these watercourses, e.g. dumping of construction material into the drainage system, washing of equipment (in the case of the Orange River) etc.
- The lack of provision of adequate sanitary facilities and ablutions on the servitude may lead to direct or indirect faecal pollution of surface water resources.
- Leakage of hazardous materials, including chemicals and hydrocarbons such as fuel, and oil, which could potentially enter nearby surface water resources through stormwater flows, or directly into the sandy soils within watercourses. This may arise from their incorrect use or incorrect storage. This is not only associated with a risk of pollution of surface water, but with a risk of the pollution of shallow groundwater within the riparian zone due to the presence of typically highly permeable alluvial substratum.

- The incorrect mixing (batching) of cement could lead to siltation and contamination of watercourses, as described above.
- Inadequate stormwater management and soil stabilisation measures in cleared areas could lead to erosion that could cause the loss of riparian vegetation and which would lead to siltation of nearby watercourses.
- The creation of new access roads for construction traffic across watercourses may lead to the erosion of banks and disturbance of riparian vegetation that may trigger the further development of gulley (donga) erosion.
- Construction of accesses across watercourses may impede the natural flow of water. This would alter the hydrology of the watercourse. Uncontrolled access of vehicles through surface water features, in particular wetlands (where these occur) can cause a significant adverse impact on the hydrology and soil structure of these areas through rutting (which can act as flow conduits) and through the compaction of soils.

7.4 Mitigation Measures

7.4.1 Pipeline Construction

A number of mitigation measures can be specified to minimise impact on the ephemeral watercourses and their associated riparian zones. As an overarching principle, it is very important that these surface water features, although mostly devoid of flow must be recognised as sensitive features, with care being taken to avoid unnecessary impacts on them.

- The footprint of the works area through these watercourses must be kept a narrow as possible, and be restricted to a width that allows construction vehicles and equipment to access the trench line, with provision made on the opposite side of the trench for stockpiling of excavated substrate.
- If Alignment 1 is developed, the current footprint of the works (and impacted area) must not be extended upstream into the riparian area beyond a reasonable construction footprint. No new impounding structures must be constructed into the upstream (un-impacted) riparian corridors as a measure to manage surface water (storm event) flows down the system. Rather flows entering the alluvial terrace must be managed in the area between the fence and the local access road where the crossings are already impacted.
- The pipeline must be strung outside of the riparian area, and extra space for stringing the pipeline must not be created within the works area within the riparian zone of watercourses.
- Both the trench line and working right of way must be clearly demarcated prior to any construction occurring through the affected watercourse.
- No stockpiles or lay down areas must be established in the riparian zone of any watercourse along the pipeline.
- No storage areas for hazardous materials must be located within 100m of the outer edge of a riparian zone.
- Once vegetation has been removed from these areas, the adjacent riparian zone that does not fall within the footprint of the works must be demarcated as a no-go area that must not be physically affected by the proposed works.
- Construction should ideally occur during the drier winter months, when the possibility of rainfall and thus flow within these drainage systems is reduced.

- Once the pipe has been laid, the original substrate must be reinstated as far as possible (it is recognised that padding material may need to be laid adjacent to the pipeline to protect it). Any excess material that is not required for reinstatement must be removed from the riparian zone and placed elsewhere.
- The channel and banks must be restored to a pre-construction state as far as possible. It is very important that the channel be reinstated to a level that is similar to the upstream and downstream level, and no structures that could impound water behind them must be constructed across the channel.
- Any track / road constructed within the channel and adjacent riparian zone must be fully removed once construction has ended.

7.4.2 Servitude Rehabilitation and Re-vegetation

It is important that re-vegetation be undertaken to ensure that the works footprint does not remain devoid of vegetation and thus vulnerable to erosion by aeolian and water-borne processes. A number of mitigation measures are pertinent in this case:

- The topsoil within the works area must be retained once excavation for the pipeline has been completed and must be reinstated over the pipeline as this will contain a natural seed bank that will assist with natural re-vegetation.
- Once reinstatement of the pipeline has been completed and the rehabilitation of the servitude through riparian areas is underway, the riparian area must be reseeded with a grass species mix consisting of grasses found in the local area such as *Cenchrus ciliaris* and *Stipagrostis spp*.
- It is important that a shrub layer be re-established, with non-deep rooted species being re-established, as detailed below
- Bare areas, such as reinstated banks and terraces, and especially those areas vulnerable to erosion by water during flow events must be protected from erosion while re-vegetation is occurring. It is recommended that geotextile be used to cover such areas, staked into the ground to protect seedlings.
- Where possible (e.g. in the footprint of the construction right of way), the growth of shrubs and bushes, as well as grasses must be encouraged, as this will assist in the protection of the understorey. It is recommended that shrubs of species indigenous to the area with shallow root systems be sourced from local nurseries and established in such areas.
- Monitoring of re-vegetated areas must be undertaken, and follow up re-vegetated measures undertaken if necessary.
- It is critical that operational procedures for the rehabilitation and subsequent management of the servitude include measures to remediate any developing erosion and to remove and prevent proliferation of alien invasive vegetation. This should be undertaken at an interval of at least 6 months. Thus for a period after construction the servitude through riparian areas must be monitored for the development of erosion, as well as the growth of alien invasive plant species.
- If erosion is noted to be developing, immediate measures must be taken to remediate the erosion. It is very important that the integrity of the riparian zone post-construction be checked
- In the case of alien invasive vegetation, all such species must be fully removed and measures taken to prevent further proliferation. In this context it is also very important that parts of the servitude adjacent to the watercourses (outside of riparian zones) also be subject to similar measures as without this the servitudes outside of the riparian zones would become ‘springboards’ for proliferation into the riparian area.

7.4.3 Abstraction-related construction

- It is strongly recommended that the raft abstraction methodology be developed as this would have a much lesser footprint than the infiltration gallery type of abstraction.
- In the construction of the raft methodology, design must attempt to ensure that the construction and development footprint does not extend into any un-impacted adjacent areas of the riparian corridor, and that the footprint be limited to the existing abstraction footprint.

7.5 Comparative Assessment of Alignments

7.5.1 Alignment Alternatives

Two alignment alternatives have been presented for comparative assessment. The respective alternative alignments cross a similar number of crossings, thus the respective state of the crossings needs to be taken into account as the most important factor in comparatively assessing the two alternative routes.

Alignment 2 runs along a cadastral boundary but otherwise would run through a greenfield area with no current development impacts except for the presence of the district road and the railway. Developing this alternative would entail that a number of currently un-impacted watercourses would be affected, but would also likely result in the impacting / disturbance of the catchment areas of each watercourse, with the creation of construction (and possibly operational) accesses along the pipeline that could lead to indirect impacts on the watercourses such as increased siltation from erosion in the catchment during periods of rainfall.

Conversely, a large portion of Alignment 1 is proposed to run along an existing farm access track, as well as running on the edge of a highly transformed area of intense cultivation. The presence of this area of intense cultivation has significantly transformed the watercourses that drain into this area as explored in detail above, thus if the pipeline is aligned on the edge of this area, it will cross the watercourses at the point at which they are already transformed. All of the eight watercourses crossed are highly transformed in this way.

As a result the development of Alignment 1 would represent a consolidation of existing impacts on the watercourses in the area traversed by each alternative, rather than extending the development footprint into a currently un-impacted area. Alignment 1 is thus strongly preferred from a surface water perspective.

7.5.2 Abstraction Alternatives

Two alternative techniques for abstraction have been presented for assessment. Although no design or footprint of the infiltration galleries at the Shalom abstraction point have been provided for assessment, the design drawings for the older abstraction point (adjacent to the railway bridge) as presented in the Golder Report (Golder, 2014) show that a relatively large area of indigenous thicket vegetation would fall within the footprint of two infiltration galleries, that would be likely to result in the destruction / transformation of this area of indigenous vegetation. This seems likely to be similar to the scenario at the Shalom abstraction point. Impacting of riparian thickets in this way would be significant in the context of the thicket vegetation falling within an endangered ecosystem, and would represent a localised impact as well as a cumulative impact on this endangered ecosystem.

Conversely the raft technique would presumably be able to be installed at the existing Shalom abstraction point which has already disturbed the riparian zone of the river. This technique would result in no further, or limited damage to the existing riparian corridor.

As such the raft method of abstraction is strongly preferred, as it is associated with a much lower physical transformative footprint on the riparian zone of the Orange River and on the Lower Gariep Alluvial vegetation type.

7.6 Impact Rating Matrix

The Impact rating matrix for the project appears below.

Table 3 Impact Rating Matrix Consideration

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
Construction	• Irresponsible construction practices could lead to the pollution of watercourses and rivers (e.g. faecal contamination, or pollution of surface water through hydrocarbons) • Poor stormwater management could lead to the siltation (pollution) of surface waters • Temporary accesses across watercourses could cause hydrological and morphological impacts and degrade the resource quality • Excessive removal of / damage to vegetation would degrade the resource quality of the riparian zone	**Extent:** Local (-2) **Duration:** Long-term (-3) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-9)**	• Construction to be monitored by an ECO according to the stipulations of the EMPr • No batching or chemical / fuel storage areas to be located within any surface water feature or **within 100m of a surface water feature** • Clearing of vegetation to be limited to the construction footprint • No temporary construction accesses (other than the construction right of way) to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a construction activity • Watercourse channels and other parts of the surface water feature must be restored to as close a pre-construction state as possible.	**Extent:** Site (-1) **Duration:** Short-term (-1) **Intensity:** Low (-1) **Probability:** Possible (-2) **Significance: Low (-5)**
Operations	• The pipeline servitude as it crosses riparian areas will be kept cleared of most woody trees and shrubs due to the limitations relating to deep root systems, thus constituting an impact on the affected part of the riparian corridor for the entire operational length of the pipeline. • Improper rehabilitation of the construction works area through riparian areas would leave such parts of the riparian zones vulnerable to erosion by water and wind. • In addition, the cleared servitude through the riparian corridor will pose a risk of encroachment of alien invasive vegetation into the riparian zone due to the servitude creating favourable	**Extent:** Local (-2) **Duration:** Long term (-3) **Intensity:** Moderate (-2) **Probability:** Highly Probable (-3) **Significance: Medium (-10)**	• All construction footprint areas through riparian areas must be fully rehabilitated with the re-establishment of a vegetative cover that matches pre-construction vegetative cover. • Any development of erosion must be carefully monitored and managed. • It is critical that all alien invasive vegetation management in the servitude be undertaken at regular intervals (at least every 6 months) for the operational life of the pipeline servitude. This must not just be undertaken for riparian areas but for servitudes in adjacent areas. As part of this management all alien invasive vegetation within the servitude must be removed.	**Extent:** Local (-2) **Duration:** Long term (-3) **Intensity: Low** (-1) **Probability: Possible** (-2) **Significance: Medium (-8)**

Phase	Potential Aspect and or Impact	Significance rating of impacts before mitigation	Mitigation	Significance rating of impacts after mitigation
	conditions for the establishment of alien pioneers. The risk will be even greater should operational management of the servitude not be properly undertaken.			
Decom-missioning	• The termination of servitude management through riparian corridors post-decommissioning could increase the risk of alien invasive plant encroachment into the servitude area, and thus into adjoining riparian habitat.	**Extent:** Local (-2) **Duration:** Medium-term (-2) **Intensity:** Moderate (-2) **Probability:** Possible (-2) **Significance: Medium (-8)**	• Decommissioning to be monitored by an ECO according to the stipulations of the EMPr • No temporary accesses to be constructed through any surface water feature and no machinery to enter any wetland unless authorised under the EMPr by the ECO as part of a decommissioning activity • After decommissioning of the pipeline, management of alien invasive vegetation should continue for a period.	**N/A**
Cumulative	• Cumulative loss of riparian habitat due to clearing of riparian vegetation and due to the risk of increased proliferation of alien invasive plant species within the riparian corridor associated with the new servitude could occur. These cumulative effects exist in the context of the most important existing impacts on riparian zones which are clearing of riparian vegetation for cultivation and proliferation of alien invasive vegetation in riparian zones. • Impacts on individual surface water features across the site could result in a cumulative impact on respective catchments, although other land use-related practices are more likely to cause degradation of watercourses and their associated riparian zones. • Pollutants released into more than one surface water features through construction activities could result in downstream impacts, although this is thought to be unlikely.		• Refer to activity / phase specific mitigation measures above	**N/A**

8 PHOTOGRAPHIC RECORD OF CROSSINGS ALONG ALIGNMENT 1

8.1.1 Crossing Alt1_10

GPS Co-ordinate(s) of Crossing: -28.80379; 21.88774

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.2 Crossing Alt1_11

GPS Co-ordinate(s) of Crossing: -28.80254 21.88797

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.3 Crossing Alt1_12

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: -28.80058; 21.88815

Southern edge of riparian zone: -28.80077; 21.88816

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.4 Crossing Alt1_13

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: - 28.79692 21.88835

Southern edge of riparian zone: -28.79785 21.88833

Riparian zone Ecological Category (as assessed by VEGRAI) – Category F

8.1.5 Crossing Alt1_14

GPS Co-ordinate(s) of Crossing:: - 28.79545   21.88835

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.6 Crossing Alt1_15

GPS Co-ordinate(s) of Crossing:: - -28.79372 21.88835

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.7 Crossing Alt1_16

GPS Co-ordinate(s) of Crossing:: - - 28.79289 21.88834

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

8.1.8 Crossing Alt1_17

GPS Co-ordinate(s) of Crossing: northern edge of riparian zone: - -28.78917 21.88781

Southern edge of riparian zone: - -28.78952 21.88786

Riparian zone Ecological Category (as assessed by VEGRAI) – Category E/F

9 PHOTOGRAPHIC RECORD OF CROSSINGS ALONG ALIGNMENT 2

9.1.1 Crossing Alt2_1

GPS Co-ordinate(s) of Crossing: -28.8048; -28.8048

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.2 Crossing Alt2_2

GPS Co-ordinate(s) of Crossing: South-western edge of riparian zone: -28.80137, 21.89506

North-eastern edge of riparian zone: -28.80094, 21.89551

Riparian zone Ecological Category (as assessed by VEGRAI) – Ecological Category B

9.1.3 Crossing Alt2_3 &4

GPS Co-ordinate(s) of Crossing: -28.79912, 21.89713

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.4 Crossing Alt2_5

GPS Co-ordinate(s) of Crossing: -28.7949, 21.90078

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.5 Crossing Alt2_6

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.78798, 21.9071

North-eastern edge of riparian zone: -28.78789, 21.90721

Riparian zone Ecological Category (as assessed by VEGRAI) – Ecological Category B

9.1.6 Crossing Alt_7

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.78673, 21.90825

North-eastern edge of riparian zone: -28.78664, -28.78664

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.7 Crossing Alt2_8

GPS Co-ordinate(s) of Crossing: south-western edge of riparian zone: -28.786, 21.90891

North-eastern edge of riparian zone: -28.7863, 21.90868

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

9.1.8 Crossing Alt2_9

GPS Co-ordinate(s) of Crossing: -28.781895, 21.912732

Riparian zone Ecological Category (as assessed by VEGRAI) – Not Assessed

10 CONCLUSIONS AND RECOMMENDATIONS

The two alternatives of the proposed realigned pipeline section cross a number of ephemeral watercourses that are characterised by a well-developed to poorly developed riparian zone, depending on their size. The larger drainage systems along both alignments have been assessed with the VEGRAI tool and the results have shown that the two larger drainage systems along Alignment 2 (and by proxy the other smaller watercourses crossed) display riparian corridors that are largely natural with few modifications (category B). In contrast physical modifications have resulted in all eight crossings of watercourses along Alignment 1 being highly impacted, with the two larger watercourses that were assessed by the VEGRAI tool having been assigned a serious or critically modified state (category E/F or F)

The proposed pipeline would traverse the narrow Orange River riparian corridor at the proposed Shalom abstraction point, however the riparian corridor is already disturbed at this location due to the presence of two existing abstractions for farming activities. Two technical alternatives for abstraction from the river have been presented for assessment (a floating raft and infiltration gallery). Utilising the raft option, it has been assumed that the pipeline and associated abstraction footprint will be able to be limited to this existing transformed area, thus not entailing the further damage to the adjacent riparian vegetation, whereas the infiltration gallery has assessed to be likely to result in the destruction of an area(s) of riparian vegetation. Due to these factors, the raft option for abstraction is strongly preferred.

The proposed pipeline could result in a number of potential impacts on the ephemeral watercourses crossed, especially if rehabilitation of the pipeline servitude and works area through the associated riparian corridors is not properly undertaken. This could lead to the exposure of the sandy substrate to wind and water erosion, and could result in the long term degradation of the riparian zones of the affected watercourses. A number of mitigation measures have been specified for the proposed pipeline. Should these be implemented, the likely impacts of the proposed pipeline on surface water features will be able to be mitigated to acceptable levels.

In the context of the comparative assessment of the two alignment alternatives, Alignment 1 is strongly preferred. Due to the alignment of Alignment 1 adjacent to the boundary of a heavily impacted area of cultivation and along an access track, the impacts associated with the pipeline would occur within an area of existing impacts, whereas Alignment 2 traverses a largely un-impacted area. The development of alignment 1 would represent the consolidation of impacts on these watercourses into an area in which they are already highly modified, and thus the development of this alternative is recommended from a surface water perspective.

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11.1 Web pages referred to in the text

South Africa Rainfall Atlas: http://134.76.173.220/rainfall/index.html

SOLAFRICA THERMAL ENERGY (PTY) LTD. PROPOSED THERMAL POWER PLAN, ORANGE RIVER, NORTHERN CAPE.

AQUATIC BIOMONITORING & IMPACT SURVEY – JUNE 2010.

Prepared for:

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EnviRoss CC Report Ref:	**ENV_SolAfrica_Aqu_08/10**
Date:	**Aug 2010**

Declaration

This report has been prepared according to the requirements of Section 33 (2) of the Environmental Impact Assessments Regulations, 2006 (GNR 385). We (the undersigned) declare the findings of this report free from influence or prejudice.

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MJRoss

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TRoss

___________________ Date: __16 August 2010______

Tahla Ross

EXECUTIVE SUMMARY

Introduction and Background.

Bohlweki-SSI Environmental requested Enviross CC to undertake an aquatic biomonitoring and impact assessment survey for the Orange River for the proposed SolAfrica (Pty) Ltd. Thermal Power Plant. Two site options were presented, namely Olyvenhoutsdriftsdrift and Bokpoort, with two alternatives offered at each site. Of the two sites proposed at Olyvenhoutsdrift, only one was considered close enough to the river to impose any impacts. This site is located on a side channel of the main watercourse of the Orange River.

The aim of the survey was to ascertain the present ecological state (PES) of the river at the proposed sites and to ascertain the potential aquatic ecological impacts that would emanate from a development of this nature. This was ascertained during a field survey undertaken in June 2010.

Materials and Methods.

The following methodologies were applied during the survey:

- General riparian and habitat assessments:
    - Walk-about surveys both upstream and downstream of the survey site;
- Aquatic habitat assessments:
    - *In situ* water quality (pH, oxygen content, dissolved oxygen, electro-conductivity (EC), total dissolved solids (Tds) and temperature);
    - IHAS (Integrated Habitat Assessment System) for habitat particular to aquatic macro-invertebrates;
    - IHI (Index of Habitat Integrity). A general impact assessment tool for each river reach.
- Ichthyofauna:
    - Electro-narcosis and cast netting at each site.
- Aquatic macro-invertebrates:
    - SASS5 collection protocol.

Results and Discussions.

General habitat descriptions:

Observations from general habitat descriptions and "walk-about" surveys indicated that the riparian habitat ecological integrity has been largely retained at both Bokpoort sites. Surrounding land use at these sites is agriculture. Riparian and instream habitat has been modified and impacted by various forms of infrastructure development at the Olyvenhoutsdrift site, which was also found the closest to the urban area of Upington.

Aquatic habitat descriptions:

The Olyvenhoutsdrift site was located along a side channel of the main watercourse and was dominated by bedrock, boulders and sand. Both the Bokpoort sites were dominated by a deep sandy single channel, with site Bokpoort_2 including some islands within the macro-channel. This increased habitat diversity.

Water quality.

The results from the *in situ* water quality parameter testing indicated that there were no limiting factors in terms of water quality that could potentially limit the aquatic biota. Slightly elevated levels (relative to the other sites) of salinity and electro-conductivity values were recorded at the Olyvenhoutsdrift site. This is due to the site being located downstream and in close proximity to the urban areas of Upington, where it would receive urban runoff, sewerage effluents and other forms of extrinsic pollutants.

Macro-invertebrate sampling:

The limiting factor to supporting large abundance and diversity of aquatic macro-invertebrates was thought to be habitat availability at site Bokpoort_1. The other two sites showed relatively good SASS5 ratings, being indicative of good water quality and habitat diversity and availability.

Fish sampling:

The desktop survey indicated that the river reach supports numerous indigenous fish species. This was taken from the results from a reference site located upstream of the various sites (Kleynhans, 2007). The fish survey did not yield the abundance and diversity of fish that were indicated in the desktop survey. Various fish species were sampled during the survey at the Olyvenhoutsdrift site, but none at the Bokpoort sites. This, however, is not an indication of degraded ecological conditions, but rather a factor of the vastness of the river that made comprehensive sampling difficult.

Impact significance ratings.

From the impact significance ratings and assessments, it was found that development at the Olyvenhoutsdrift site would have the least ecological impact. This is mainly due to the site being located on a side channel from the main watercourse and that the site offered the best foundation material – both instream and in the riparian areas. This would limit the need for deep excavations to located suitable foundation material, thereby minimising the impacts during the construction phase.

Conclusions and Recommendations.

Recommendations and general mitigation measures are outlined below:

- Any development of infrastructure within the watercourse that could potentially block up and downstream migratory activity of fish and other aquatic biota should incorporate a fishway. The input of a suitably qualified fish ecologist should be sought when the weirs are designed and constructed;
- Particular attention must be paid to controlling soil erosion as siltation will impact on sensitive aquatic habitats downstream of the site;
- Adequate stormwater management must be provided that won't aggravate the erosion of the river banks;
- An Environmental Conservation Officer (ECO) should be present to facilitate watercourse and riparian habitat rehabilitation efforts;
- The ECO should be educated in general river rehabilitation measures and how to identify emerging and potential problems;
- The footprint of the development during the construction phase should be retained as small as possible by construction vehicles being limited to designated roadways only. Destruction of the riparian habitat through the unnecessary clearing of vegetation should be avoided;
- Dumping of any excess rubble, building material or refuse must be prohibited within the riparian habitat. Dumping of materials should only take place at designated and properly managed areas;
- Adequate toilet facilities must be provided for all construction crews to negate informal ablutions taking place within riparian zones;

- Fires within the riparian zones should be prohibited;
- Fishing and hunting of local fauna should be prohibited;
- Exotic vegetation identified presently at the site should be managed;
- Follow-up surveys are recommended to potentially identify emerging impacts following post-construction within both the aquatic and riparian areas. This is important so as to implement any further mitigatory measures required for emerging problems (e.g. soil erosion forming through poor stormwater management feature design, recruitment of exotic vegetation, formation of instream migratory barriers, etc). The appointed ECO should be well-versed in identifying potential emerging environmental concerns.

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1. INTRODUCTION & TERMS OF REFERENCE.

1.1. Background.

SolAfrica Thermal Energy (Pty) Ltd. has proposed a solar power plant that requires water abstraction from a river. Two potential development sites have been proposed along the Orange River in the Upington district (Figure 1), one on the farm Olyvenhoutsdrift and the other on the farm Bokpoort. The localities of the proposed sites are indicated in Figure 3 and Figure 4.

1.2. Scope of Work.

The Scope of Work included an assessment of the current ecological status of the river segment that could be potentially affected by the proposed development activities. This included a standard bio-monitoring assessment at three sites, one at Olyvenhoutsdrift and two at Bokpoort, where the fish and aquatic macro-invertebrate populations were assessed. Physical features of the habitat quality and *in situ* water quality parameters were also assessed. On completion of the survey, an impact rating of the proposed construction activities could be assessed and mitigation measures to abate the potentially-negative ecological impacts could be proposed.

1.3. Assumption & Limitations.

The Orange River has a vastness that is difficult to sample comprehensively. Therefore representative samples were taken from representative areas throughout a diversity of habitat types and under various flow conditions. The data was collected during a single survey with only one sample having been taken. The data presented in this report therefore represents a sample of the time of the survey and has no bearing on any ecological trends of the system, natural or otherwise.

Reference is made in the report to engineering and design features and physical limitations on construction. These limitations are based upon perception of an ecologist and are not meant to conflict those opinions of the engineers.

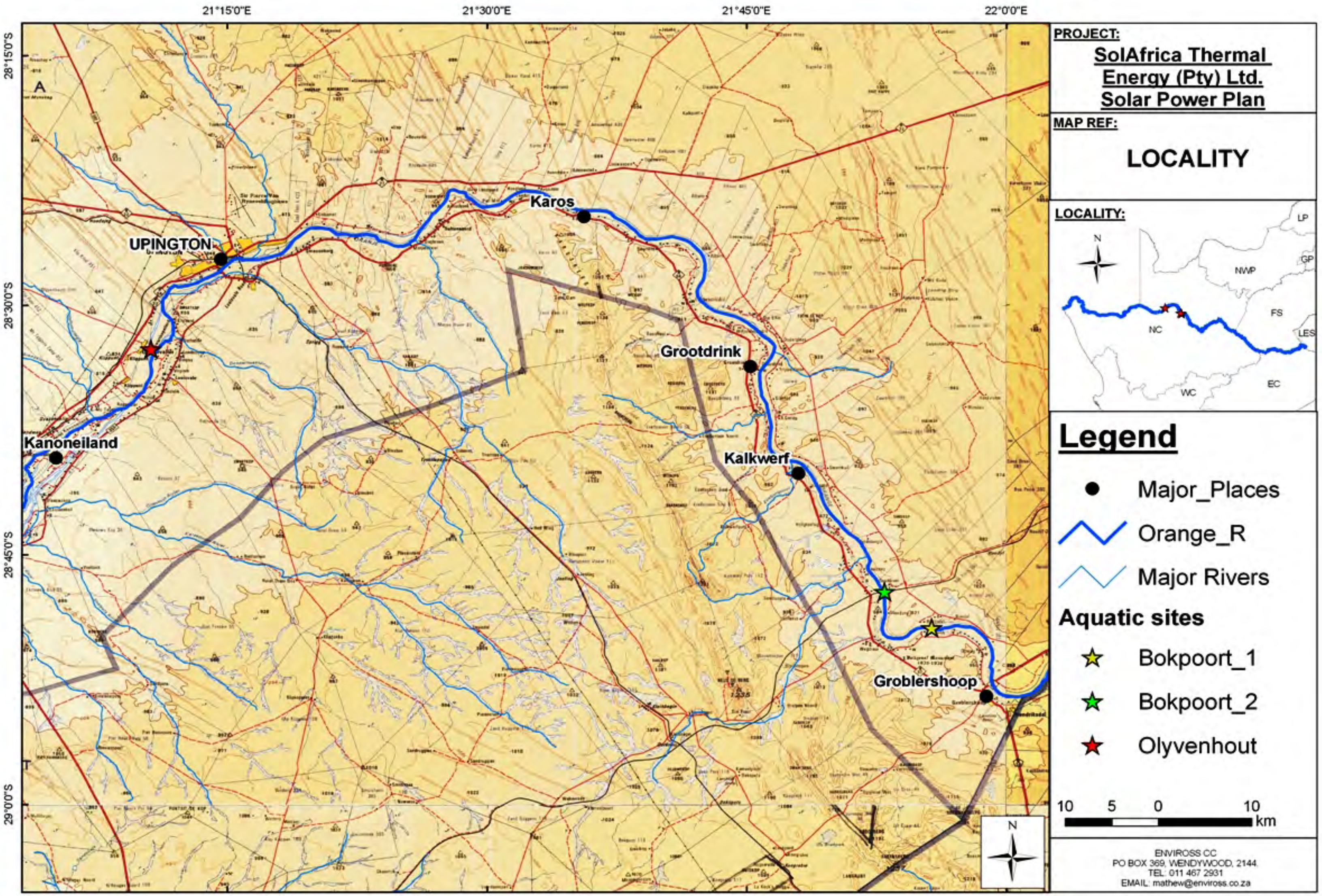

Figure 1: Locality of the survey area.

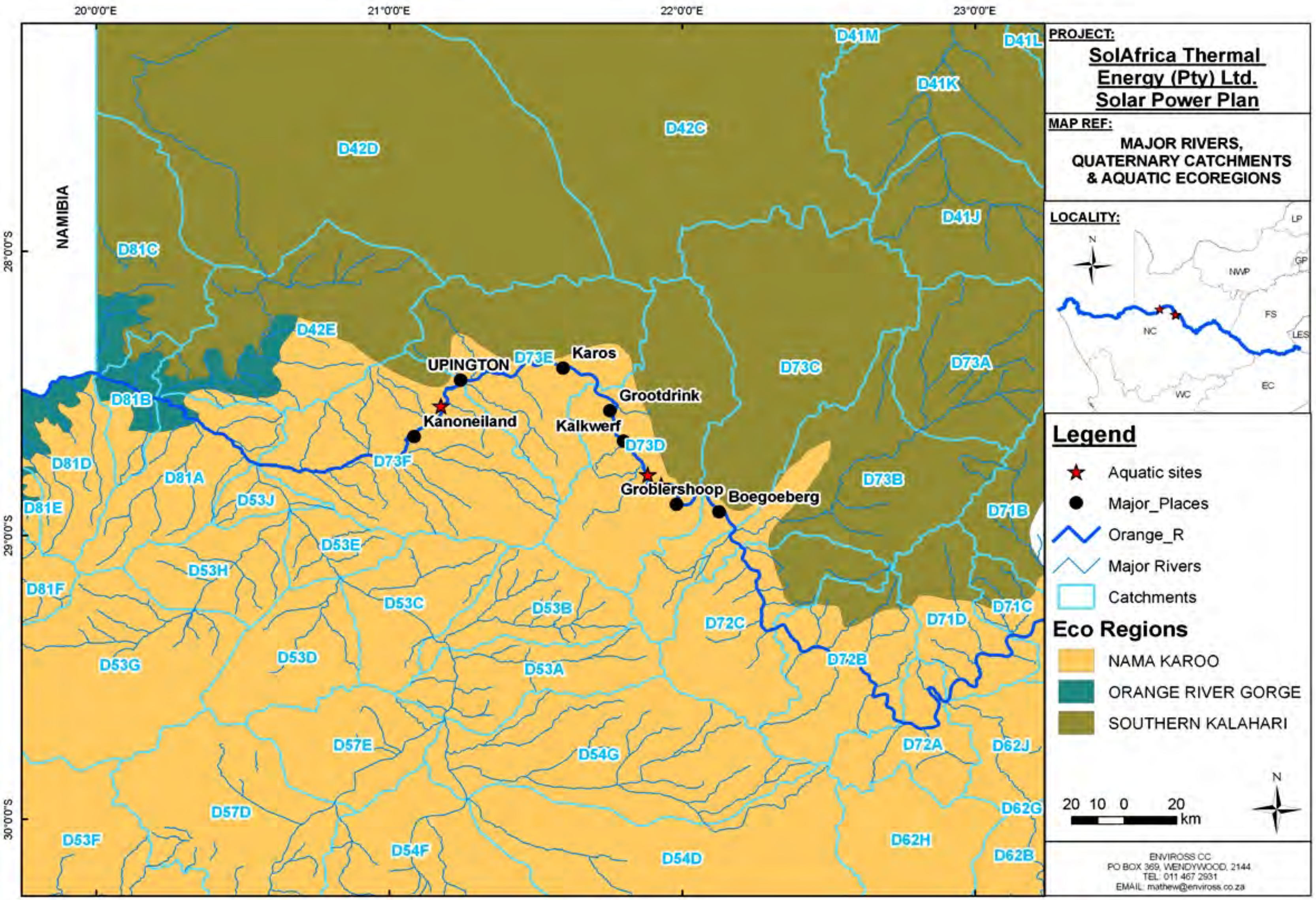

Figure 2: Catchment details of the proposed development area and surrounding region.

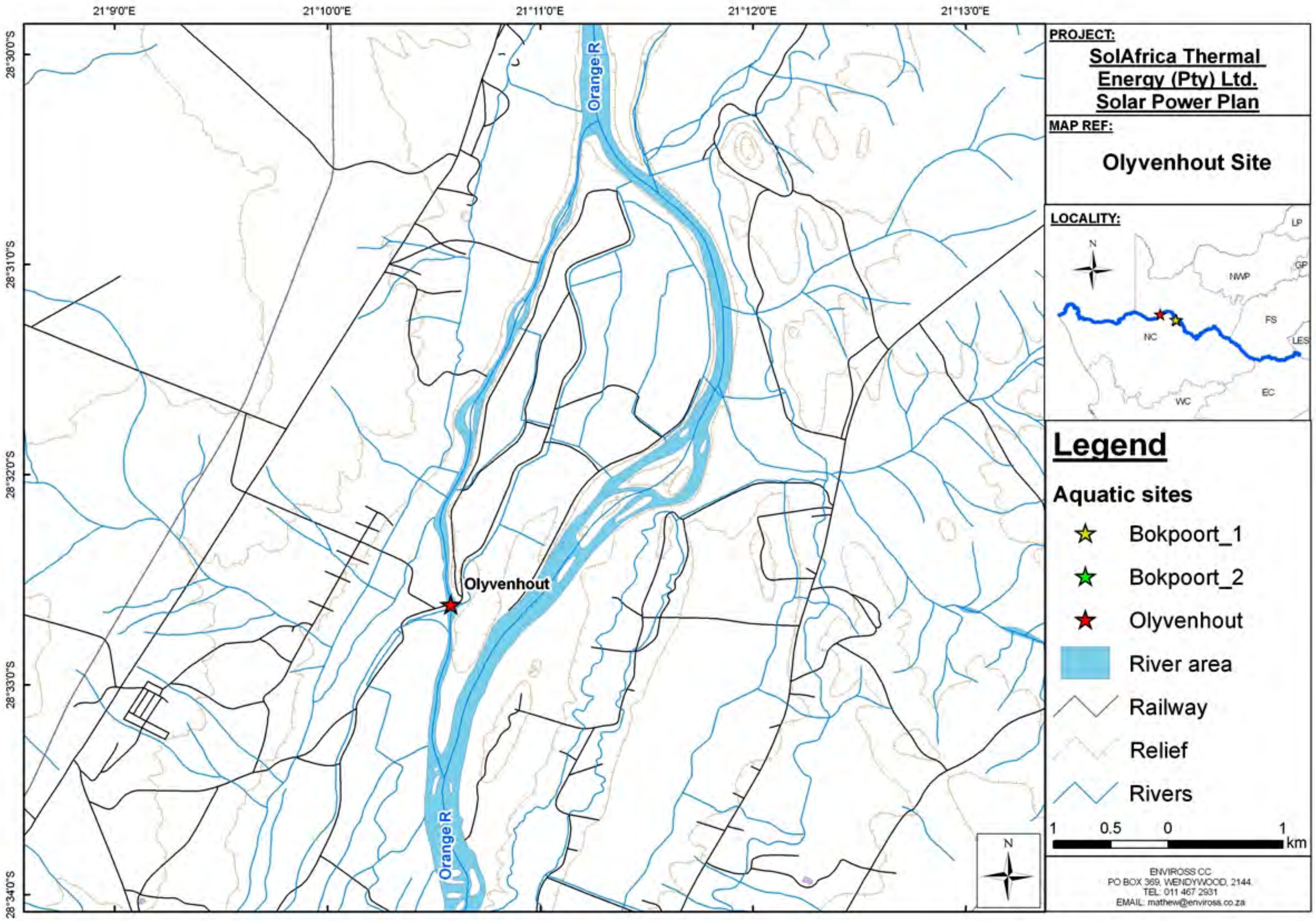

Figure 3: The proposed development site at Olyvenhoutsdrift - west of Upington.

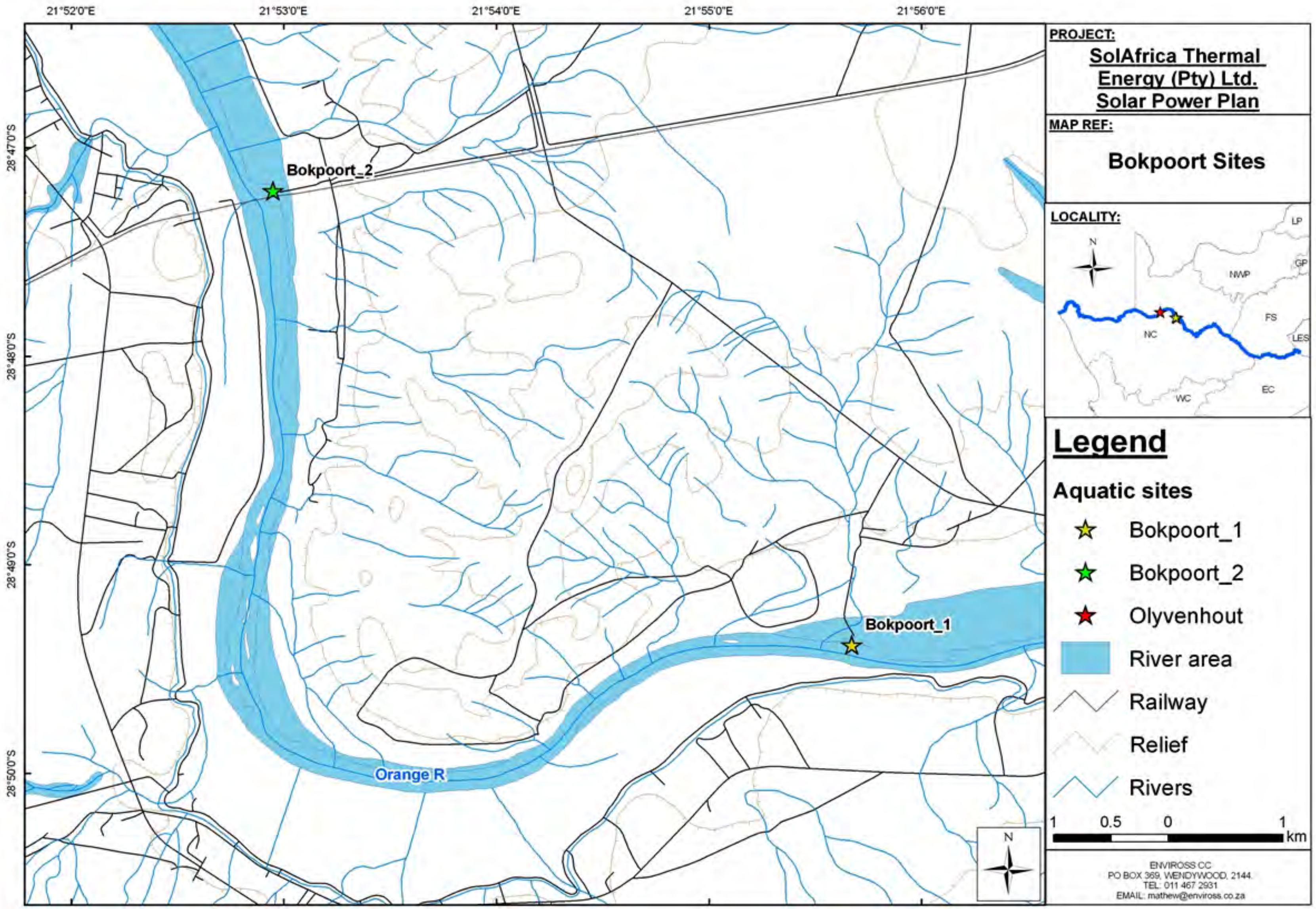

Figure 4: The proposed development sites at Bokpoort - east of Upington.

2. AIMS & OBJECTIVES.

The objective of this report is to provide the biological information to the engineers, planners and construction teams that will allow for mitigation of the negative ecological impacts on the aquatic environment emanating from the construction of the various forms of infrastructure. It is also to provide a description of the various impacts that will be imposed on the aquatic environment due to the various construction activities. This document presents the findings of the field survey that was undertaken in June 2010, where the proposed development site alternatives were surveyed to evaluate the present ecological state of the aquatic environment to better mitigate any potential negative impacts imposed by the proposed development activities. A comparative analysis of the proposed alternative sites is then also offered.

3. STUDY AREA.

The proposed development site alternatives were provided by The Client. The study area then comprised of various aquatic sites surrounding these proposed development areas that would allow for better interpretation of the aquatic biodiversity and overall ecological integrity. The surrounding area was also surveyed using aerial photographs, topographical maps and GIS datasets to evaluate the aquatic habitats both upstream and downstream of the proposed construction areas. This was done in order to better interpret the biological data that were gathered during the field assessment. The proposed development falls within the Orange (D) Primary Catchment, with the Olyvenhoutsdrift site and Bokpoort sites falling into the Water Management Areas (WMA's) or Quaternary Catchments of D73F and D73D, respectively (Figure 2).

The survey area incorporates segments of the Orange River, to the west and east of Upington in the Northern Cape Province. The section of the river near Upington is highly regulated and flows through a series of weirs that are utilised for abstraction and gauging. Many weirs were observed to be redundant, made apparent by the failure of much of the infrastructure. The surrounding land use is largely dominated by agriculture as the river offers valuable irrigation water along riparian areas in an otherwise arid region.

4. MATERIALS & METHODS.

Standard, DWAF-endorsed bio-monitoring protocols and methodologies were followed for the aquatic survey for all of the sites that are based on the nationally-implemented River Health Programme. The outline of the ecological indicators that were utilised in order to ascertain the ecological integrity of the various study sites are outlined in Table 1.

Table 1: The various components of the ecological indicators selected for characterisation of the aquatic and associated riparian sites.

Ecological indicators	Measurable ecological components.
Stressor indicators	*In situ* water quality
Habitat indicators	General habitat assessment; Index of Habitat Integrity (IHI); Integrated Habitat Assessment System (IHAS)
Response indicators	Aquatic macro-invertebrates (SASS v5); Ichthyofauna

4.1. Habitat characterisation.

The assessment of the physical habitat characteristics of an aquatic system that are available for inhabitation by aquatic fauna plays an important role in determining whether a particular site is inhabitable or not. This is an important aspect to consider when interpreting the biological data that are gathered at each study site. An example of this aspect is that a system with good water quality and poor habitat availability will show poor aquatic faunal inhabitation, whereas a system with good water quality and good habitat availability will show a diverse aquatic faunal species community structure. Therefore, habitat evaluations are as important in interpreting aquatic ecological integrity of a site as the determination of the water quality.

In river systems with variable-use catchment areas, the use of the *Integrated Habitat Assessment System (IHAS)* is regarded as being an important habitat evaluating tool. The IHAS is aimed at determining the instream habitat integrity for suitability for aquatic macro-invertebrate inhabitation (coupled to SASS5 data). A reason why the IHAS tool (together with the SASS5 protocols) are regarded a being reliable aquatic ecological integrity indicators is that aquatic macro-invertebrates are highly mobile within a system as the majority of the taxa have adult terrestrial life-stages capable of flight. Therefore, periodically impacted stretches of river systems are rapidly recolonised when the negative impact disappears.

The IHAS methodology recognises three major biotopes within aquatic systems. These include:

- *Stones* (including stones in current, stones out of current and bedrock);
- *Gravel, sand & mud* (both in current and out of current); and
- *Vegetation* (including aquatic, emergent and marginal, both in current and out of current).

The IHAS evaluates the quality and quantity of these three major biotopes and this is expressed as a percentage score per site. It is further split into Sampling habitat (constituting 55% of the total IHAS score rating) and Stream condition (constituting 45% of the total IHAS rating). See Appendix C for methodologies and calculations specific to the IHAS.

The use of the IHI (*Index of Habitat Integrity*) is a generalised habitat evaluation tool that is modified slightly to make it more applicable to the various study sites as many aspects of the IHI are undeterminable due to unknown factors that fall outside of the scope of the survey. Only applicable aspects of the IHI will therefore be reported on. See Appendix D for methodologies, calculations and explanations specific to the IHI.

4.1.1. Vegetation and general riparian area.

The three aquatic sites (two at Bokpoort and one at Olyvenhoutsdrift) were inspected on foot for a distance both upstream and downstream of the actual study site. General readily-observable indicators of ecological integrity were noted. This was aimed at evaluating potential soil erosion, refuse dumping within the riparian zones, encroachment of exotic vegetation, etc. Site photographs were also taken for both upstream and downstream habitat for these sites.

4.1.2. Water quality.

The *in situ* water quality of all of the aquatic biomonitoring sites were taken using a *Hanna model 9828* multiparameter water quality meter. These data are important to the interpretation of the biological data that are gathered during the sampling at the various sites. The parameters that were recorded were: Dissolved oxygen (%), Oxygen content (mg/ℓ), pH, Total dissolved solids (Tds) (ppm), Electro-conductivity (EC) (µS/cm) and Temperature (°C).

4.1.3. Site categorisation and classification.

The ecological state of a stretch of a river is compared to a *reference state,* which is regarded as the ideal ecological state of a river within a similar river reach as the study site. The ecological state model allows for the classification of the system according to various combinations of index scores (Dallas, 2007). To ensure applicability, a *reference state model* was created that takes into account the natural variations that river reaches within similar geographical area are subjected to. The reference state model most applicable to the rivers of the *Nama Karoo Lower* Ecoregion is presented in Figure 5 and Table 2.

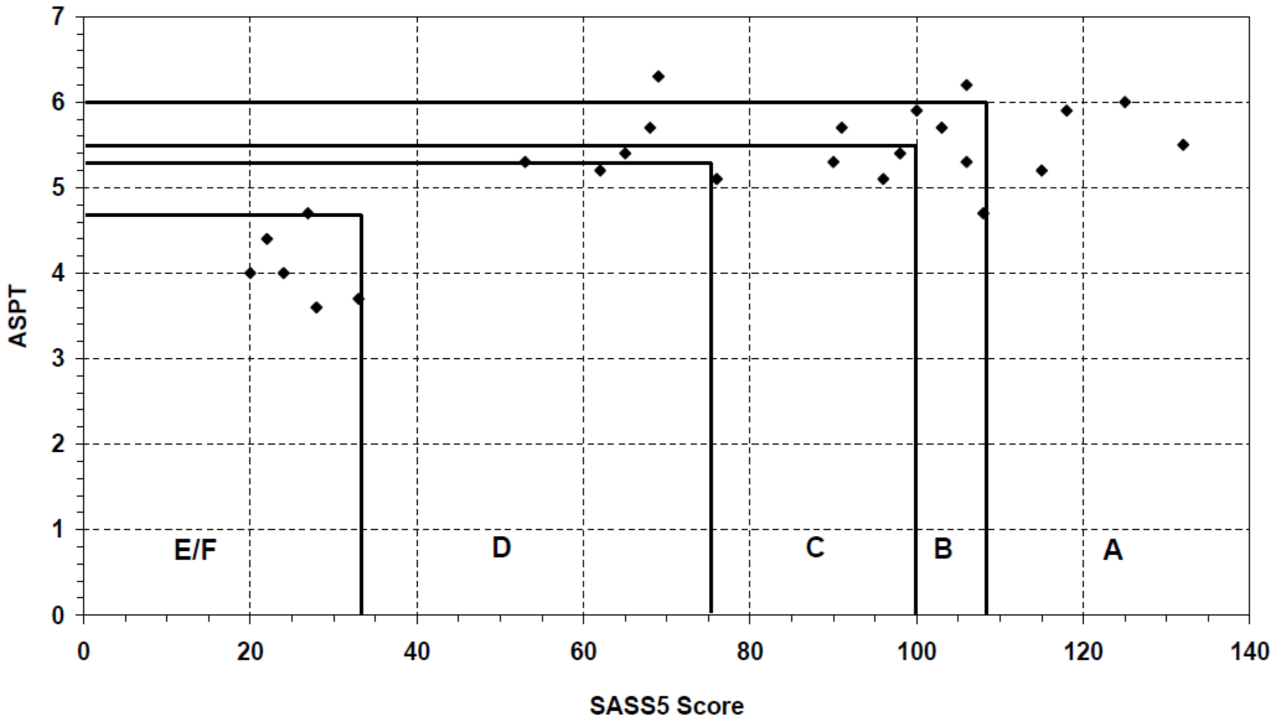

Figure 5: Reference state conditions for the *Nama Karoo Lower Aquatic Ecoregion* (*from* Dallas, 2007).

Table 2: Eco-classification model for determining the Present Ecological State for *Nama Karoo Lower* rivers, based on SASS5 and ASPT* scores (*adapted from* Dallas, 2007).

SASS5 Score	ASPT	Description	Class
>108	>6.0	**Excellent/Unimpaired.** Community structures and functionality comparable to the best situation that can be expected. This is the optimum community structure for stream size and habitat quality.	A
101-108	5.6-6.0	**Very Good/Minimally impaired.** Largely natural with few modifications. A small change in community structure may have taken place, but ecosystem functionality remains essentially unchanged.	B
76-100	5.4-5.5	**Good/Moderately impaired.** Community structure and function less than the reference condition. Community composition lower than expected due to loss of some sensitive taxa. Basic ecosystem functionality remains predominantly unchanged.	C
33-75	4.7-5.3	**Fair/Largely impaired.** Fewer taxa presented than expected due to loss of sensitive species. This is indicative of a loss of basic ecosystem functionality.	D
<33	<4.7	**Poor/Seriously impaired.** Few aquatic taxa are present due to loss of most of the sensitive species. This is indicative of an extensive loss of basic ecosystem functionality.	E/F

***ASPT = Average Score per Taxon.**

4.2. Biological Sampling.

4.2.1. Aquatic macro-invertebrate sampling.

Benthic macro-invertebrate communities of the selected sites were investigated according to the South African Scoring System, version 5 (SASS5) approach (Dickens & Graham, 2001). This method is based on the British Biological Monitoring Working Party (BMWP) method and has been adapted for South African conditions by Dr. F. M. Chutter (Thirion *et al*., 1995). The SASS5 method is a rapid, simple and cost effective method, which has progressed through four different upgrades/versions. The current upgrade is Version 5, which is specifically designed to comply with international accreditation protocols. Accredited SASS5 practitioners applied this protocol. Refer to Appendix A for the sampling method details.

4.2.2. Ichthyofauna.

The assessment of fish community structures is often a useful tool in ascertaining the ecological integrity of a river system as fish represent a different trophic level to aquatic macro-invertebrates and, whereas aquatic macro-invertebrates are indicators of short term stressors, fish are indicators of more long term impacts on a system. The fish community structure is, however, very often governed by factors other than local habitat integrity and water quality. The presence or absence of fish in a river reach is largely determined by natural cyclic seasonal factors, often leading to the absence of fish at a site during the winter season. Other reasons for poor fish species representation at a particular site is the lack of accessibility to the specific reaches due to instream migratory barriers. Whereas aquatic macro-invertebrates are capable of overcoming many of these barriers due to morphological adaptations, fish often cannot and are consequently excluded from colonising a river reach upstream of a migratory barrier. These barriers are often in the form of low-level bridges, gauging and other weir structures, dam walls, culverts, etc. Rivers and streams that have highly urbanised catchment areas (especially) are well-known to suffer greatly from this impact. Therefore, the absence of fish species within certain study sites is not necessarily an indication of poor localised habitat or water quality, but may be due to migratory barriers that are often located relatively far downstream of the study site. A desktop survey of both upstream and downstream habitat through review of topographical maps, aerial photographs and available GIS data was undertaken prior to undertaking the field survey in order to pinpoint the closest major migratory barriers relevant to the project.

Fish were sampled throughout the study area to determine the fish community structures within the river reach associated with the various proposed development areas. Fish were surveyed with the use of electro-narcosis and cast-netting as sampling techniques. Electronarcosis makes use of an electric current that is passed through the water that induces a temporary narcotic and paralysed state in the fish. The fish can then be netted using hand-held nets and placed into a bucket away from the electrical current. The different species are then identified and measured, to later be released back into the system. This collection method is regarded as the most effective collection technique for riverine habitat where the physical habitat and hydrology allows for it where the water does not exceed wading depth. Deeper and faster-flowing waters were sampled using cast-netting.

5. RESULTS & DISCUSSIONS.

5.1. General site descriptions.

Site localities are presented in Figure 2, Figure 3 and Figure 4.

5.1.1. Olyvenhoutsdrift.

Two sites were proposed at Olyvenhoutsdrift, but only one was close enough to the river to warrant an impact evaluation. The site is located to the west of Upington. The river splits within the area of the site, and the proposed site is located on a side channel of the main river. A vehicular bridge crosses the river at the site. This bridge had replaced an older bridge, presumably due to infrastructure failure of inadequate water clearance during flooding events. Much of the old infrastructure has remained at the site. A pipeline encased in concrete also crosses the channel at water level, which has created some inundation upstream of the site. There are numerous weirs within close proximity to the proposed site, many of which have failing infrastructure and are therefore redundant.

The riparian habitat is dominated by bedrock and sand. Instream habitat is also dominated by boulders, bedrock and sand. Land use within the surrounding area is dominated by agriculture, which relies on the river for irrigation water. The proximity of the site to the busy urban area of Upington means that the site would presumably suffer from extrinsic catchment impacts, such as sewerage effluent, urban runoff and other sources of pollution. Figure 6 shows various views of the site.

Figure 6: Various views of the site at Olyvenhoutsdrift.

5.1.2. Bokpoort sites.

There are also two site alternatives offered at Bokpoort, which is located to the east of Upington. Site Bokpoort_1 is locates upstream of Bokpoort_2. Bokpoort_1 has not associated infrastructure development, barring mobile irrigation pumps. The instream habitat is dominated by deep sand and mud, as is the riparian area. Riparian vegetation is dominated by reeds. The watercourse is a single macro-channel within this area and is dominated by slow to medium-flowing deep water. The surrounding area is dominated by agriculture. The rurality of the catchment area means that extrinsic impacts are minimal. Figure 7 presents various views of the Bokpoort_1 site.

Figure 7: Various views of Site Bokpoort_1.

Site Bokpoort_2 is located downstream of Bokpoort_1. There is a high-level railway bridge associated with the site, the pillars of which are placed mainly on islands within the channel. This bridge was also constructed long enough ago to allow for natural rehabilitation to have occurred. This bridge therefore has a minimal impact on the system at present. The macro-channel incorporates a series of islands within the area of the proposed site, therefore increasing the habitat diversity at the site. This site also does not suffer undue impacts from extrinsic sources. The surrounding area is dominated by agriculture, which relies on the river for irrigation water. Figure 8 presents various views of the Bokpoort_2 site.

Figure 8: Various views of Site Bokpoort_2.

5.2. Water quality.

In situ water quality parameters were taken at various points throughout the survey area to best gain average water quality parameter values for the river segment at the time of the biological sampling. Water quality determination forms an integral part of enabling accurate interpretations of the biological data as the final ecological class allocation is a combination between the habitat quality, water quality and biological integrity. Various water quality parameters were tested for using a hand-held *Hanna Multiparameter water quality meter: Model 9828*. The parameters tested for and the results from each site sample are presented in Table 3.

It should be noted that, as this was a once-off survey, no reference data could be obtained pertaining to water quality and therefore any deviations from natural conditions could not be ascertained. Many of the impacts pertaining to water quality parameters refer to deviations from natural fluctuation cycles. Without reference data, this cannot be determined.

Table 3: *In situ* water quality results for each site. Highlighted values fall outside of the SAWQG's (1996) guideline values for aquatic ecosystems.

Sample site	Temp (°C)	pH	DO (mg/ℓ)	DO (%)	TDS (ppm)	EC (µS/cm)	Salinity
Olyvenhoutsdrift	10.09	8.08	10.39	100.5	165	329	0.16
Bokpoort_1	10.24	8.12	10.53	102.7	126	252	0.12
Bokpoort_2	10.93	8.07	9.93	98.5	135	271	0.13

5.2.1. Water temperature.

Water temperature plays an integral role in biochemical processes and therefore governs the rate of associated metabolic processes of poikilothermic ("cold-blooded") aquatic organisms. The metabolic rate of aquatic organisms is governed by temperature and therefore the rate of development and growth as well as repair of damaged tissue and the functionality of associated stress-coping mechanisms of aquatic organisms is also all governed by the water temperature. The South African Water Quality Guidelines (SAWQG's) (1996) stipulate that water temperature should not fluctuate by more than 2°C or 10% of the normal daily temperature cycle of a system for the season associated with the sampling. Different river systems and even different reaches of the same river system have differing temperature regimes due to the origin of the water source or the habitat through which the watercourse passes. Underground water fed streams display typically colder water temperatures than that of the midwaters of a wide river that has been exposed to radiant temperature for a longer period of time. Aquatic organisms have evolved to survive within an optimal range of water temperatures for a given reach of a river and therefore any sudden fluctuations that are artificially induced adversely affect their survival rates.

The water temperatures recorded at the time of sampling ranged between 10.09 and 10.24°C (Table 3). These values are thought to be typical of the season and locality and therefore are not thought to be a limiting factor to supporting faunal biodiversity.

5.2.2. pH.

The pH of the natural waters of a river system is influenced by both geological and atmospheric factors as well as biological processes that take place within the water. Most natural waters are relatively well buffered to pH fluctuations due to the presence of bicarbonates and other buffering chemicals (SAWQG's, 1996) and therefore aquatic organisms have evolved to function optimally within a generally very narrow pH range. An undue fluctuation in pH of a system therefore has adverse effects on the survival of aquatic organisms.

According to the SAWQG's (1996), pH of a river system should not fall outside of the range of 6 to 8 pH units. The fluctuation of pH during one 24-hr cycle should also not exceed 0.5 pH units or 5% of the natural pH range for a given system at any given time.

The pH of the sites ranged between 8.07 and 8.12 (Table 3). These values are viewed as being within the guideline values; however, long-term monitoring would be necessary to determine the "normal" pH fluctuations within the system. The pH values are close to neutral (pH of 7) and therefore are not viewed as being a limiting factor to supporting aquatic life.

5.2.3. Dissolved oxygen and oxygen content.

The maintenance of adequate dissolved oxygen (DO) concentrations is critical for the survival and functioning of the aquatic biota because it is required for the respiration of all aerobic organisms. Therefore, the DO concentration provides a useful measure of the health of an aquatic ecosystem (SAWQG's, 1996). This can be measured as oxygen saturation expressed as a percentage, or as dissolved oxygen concentration, expressed in mg/ℓ. The general guideline value of oxygen content for supporting aquatic life is >5mg/ℓ. Oxygen saturation of the water varies and is dependent on the temperature of the water. In general, the cooler the water, the higher the saturation (100%) point. As the water approaches freezing temperature, its saturation point for oxygen content is at its greatest, explaining the reason why ice floats on the surface of water.

Many factors influence the oxygen content of water. The most influential oxygen depleting mechanism applicable to urban systems is nutrient and hydrocarbon contamination. High nutrient contamination has a consequential high biological oxygen demand (BOD), which, in turn, depletes the water of oxygen to be utilised in biochemical processes to metabolise the nutrients. These nutrients are typically in the form of sewerage (both raw as well as processed) and fertilisers from lawns (golf courses, gardens, etc.) and therefore are not limited to urban systems. Hydrocarbon contamination from spilled fuels and motor oils on roadways that enter the water course through runoff storm waters have a high chemical oxygen demand (COD). The chemical interactions of hydrocarbons with water on entering the watercourse also then deplete the system of oxygen available for sustenance of aquatic life. Many aquatic organisms are specifically adapted to life under low oxygen conditions, and an abundance of these organisms is often an indication of low oxygen content within the system. Oxygen content can be increased in a system first and foremost by photosynthesis of aquatic plants as well as by mechanical means as a result of turbulence that exposes more of the water surface for oxygen exchange with the atmosphere, such as flowing over weirs, etc. Oxygen content within the survey area is shown to be relatively high and is thought to be a factor of the combination of flowing water, a relatively high turbulence the colder water temperatures. Oxygen content is therefore not a limiting factor at any of the sites.

5.2.4. Total dissolved solids.

The measure of total dissolved solids (Tds) is coupled to the measure of the salinity of the water. This is, in turn, coupled to the electro-conductivity (EC) of the water. Aquatic organisms are dependent on salts within the system for normal metabolic functionality as well as to maintain osmoregulation (salt balance) within their bodies. Too high salinity values (>1,000ppm) are considered, however, to be a limiting factor especially to many aquatic macro-invertebrates (SAWQG's, 1996). The EC values at the survey site ranged between 252 and 329µS/cm. The increase EC value of 329 µS/cm at Olyvenhoutsdrift is due to its proximity to the urban area of Upington, where the river would receive sewerage effluent, urban runoff and other pollution sources.

The Tds of a system should not range by more than 15% for the "normal range" for any given system. This, however, requires more extensive surveys to gain cyclic data in order to interpret accurately. The Tds values recorded at the time of biological sampling was between 126 and 165ppm (Table 3). Both the EC and TDS values are not considered limiting factors to supporting aquatic biota, but are considered to be far lower than would be expected from the natural state for the system.

5.3. Habitat characterisation.

5.3.1. Integrated Habitat Assessment System (IHAS), version 2.

Habitat integrity and water quality forms the basis for aquatic faunal inhabitation. Assessing the habitat integrity therefore forms the basis for accurate data interpretation following the biological sampling of a system. The Instream Habitat Assessment System (Version 2) (IHAS) (McMillan, 1998) is a habitat evaluation tool used in conjunction with the SASS5 methodology. Table 4 presents the results from the IHAS application at all of the biomonitoring sites.

The IHAS score is presented as a percentage – with 100% representing ideal habitat quality. It is therefore thought that a score of above 65% indicates *good* habitat quality (green); 55-64% indicates *adequate* habitat quality (blue). A score of less than 55% indicates *poor* habitat quality (red) and is regarded as being a limiting factor to aquatic macro-invertebrate inhabitation. A score of above 65% represents a biomonitoring site that has adequate representation of all the major biotopes, whereas a score of between 55 and 65% is indicative of a sampling site that lacks adequate representation of certain biotopes or biotopes of poor quality. A score of less than 55% is indicative of the complete lack of certain biotopes or biotopes of critically modified or transformed biotopes.

Table 4: Results from the IHAS survey conducted at each site.

Site	IHAS			Description
	Sampling habitat (55)	Stream condition (45)	Total (%)	
Olyvenhoutsdrift	54	29	83	Good
Bokpoort_1	31	20	51	Poor
Bokpoort_2	57	24	81	Good

The instream habitat units (biotopes) were well represented at the Olyvenhoutsdrift site. The Bokpoort sites were both dominated by deep, slow-flowing water, with the substrate being dominated by sand and mud. Bokpoort_2 had a section of white waters that greatly improved its instream habitat integrity. IHAS score from Olyvenhoutsdrift and Bokpoort_2 sites indicated *Good* habitat quality (Table 4). The good IHAS scores make for the expectation that the SASS5 scores would be comparably good. The poor IHAS scores recorded at Bokpoort_2 are indicative of a system that lacks the diversity of biotopes, which makes for the expectation of comparatively low SASS5 scores. This is a natural feature of the system, however, and is not due to anthropogenic or extrinsic features. The full details for the IHAS score sheets are presented in Appendix C.

5.3.2. Index of Habitat Integrity (IHI).

Another procedure for assessing habitat integrity is the Index of Habitat Integrity (IHI). This tool was developed as a rapid habitat assessment tool that evaluates the general and readily-observable perceived impacts on a specific river segment in the field. This index takes riparian habitat as well as instream aquatic habitat into consideration. Table 5 presents the results from the application of the IHI to all of the sites surveyed.

Table 5: Results of the IHI after application at each survey site.

	Sites	Olyvenhoutsdrift	Bokpoort_1	Bokpoort_2
Instream habitat quality (Impact score out of 25)				
Primary:				
Criteria	**weight**			
Water abstraction	14%	5	5	5
Flow modification	13%	15	5	5
Bed modification	13%	12	5	5
Channel modification	13%	8	2	6
Water quality	14%	6	2	2
Inundation	10%	6	1	1
Sub Total:	**77%**	**26.76**	**10.56**	**12.64**

	Sites	Olyvenhoutsdrift	Bokpoort_1	Bokpoort_2
Secondary:				
Exotic macrophytes	9%	2	2	2
Exotic fauna	8%	5	5	5
Solid waste disposal	6%	15	2	2
Total (75):	**23%**	**5.92**	**2.8**	**2.8**
Instream habitat integrity (%):	**100%**	**67**	**87**	**85**
Instream habitat integrity class:		**C**	**B**	**B**
Riparian zone habitat integrity (Impact score out of 25)				
Indigenous vegetation removal	13%	16	5	8
Exotic vegetation encroachment	12%	4	2	2
Bank erosion	14%	2	2	2
Channel modification	12%	8	2	2
Water abstraction	13%	5	5	5
Vegetation inundation	11%	1	1	1
Flow modification	12%	15	5	5
Water quality	13%	6	2	2
Total:	**100%**	**28.56**	**12.12**	**13.68**
Riparian habitat integrity score (%):		**71.44**	**87.88**	**86.32**
Riparian habitat integrity class:		**C**	**B**	**B**
Total integrity score (%):		**69**	**87**	**85**
Total integrity class:		**C**	**B**	**B**

From Table 5, the results of the IHI indicate that both sites at Bokpoort presently do not suffer from habitat modification and degraded habitat quality due to anthropogenically-induced features. Both these sites are largely representative of unimpacted habitat. The vastness of the river channel at these sites contributes greatly to the significance of any impacts. The site at Olyvenhoutsdrift suffers modification through infrastructure development (both historically and presently) in the form of weirs and bridges. This is typical of a site that is closely associated with urban areas. This site would also suffer a relatively poorer water quality due to its proximity to the urban area.

The IHI results do not concur entirely with the results of the other habitat index (IHAS) due to the measurable impacts that each index represents – the IHAS focuses primarily on aquatic sampling habitat, whereas the IHI incorporates terrestrial riparian habitat as well and the extrinsic impacts on a system. Various priority weights are also designated in different impact areas that differ between the various indices and therefore the average values after application of all of the indices are ultimately regarded as the most accurate reflection of habitat integrity.

5.4. Aquatic macro-invertebrate sampling.

The results of the SASS5 (biological sampling) are presented in conjunction with the IHAS (habitat integrity) scores in Table 6. The IHAS scores indicated that the habitat quality for supporting aquatic macro-invertebrates at site Bokpoort_1 was poor (51%) due to the total lack of certain biotopes (rocks in current, etc.). The SASS5 scores were therefore expected to be comparatively low at that site as well. Instream habitat diversity was good at both the Olyvenhoutsdrift and Bokpoort_2 sites and therefore the SASS5 scores were expected to be relatively good. Habitat quality at these sites can therefore not be regarded as a limiting factor to macro-invertebrate inhabitation.

Table 6: Results from the SASS5 sampling.

Site	SASS				IHAS Score
	SASS score	No of Taxa	ASPT	Class	
Olyvenhoutsdrift	116	21	5.5	A	83
Bokpoort_1	48	11	4.4	D	51
Bokpoort_2	85	16	5.3	C	81

The results from the SASS5 survey at the Olyvenhoutsdrift site showed that the aquatic macro-invertebrate community structures were representative of largely natural conditions. The presence of taxa considered as being intolerant to water pollution such as Heptageniidae show that water quality integrity at this site had also been retained. The reference conditions for this aquatic ecoregion (Nama Karoo) indicate that the site has retained an “A” class, which translates to largely natural conditions. Site Bokpoort_1 showed a poor overall SASS5 rating, which is mostly due to the lack of habitat diversity. The generally lower ASPT score also indicates that water quality at this site played a role in limiting the aquatic macro-invertebrates. The water was observed to include more silt at this site that at the remaining sites, which would contribute to lowering the overall SASS5 scores. Site Bokpoort_2 (located upstream of Bokpoort_1) showed an increase in SASS5 score and ASPT from Bokpoort_1. This is largely due to the habitat diversity available for invertebrate inhabitation. The increased ASPT score also indicates that the site supported a community of organisms that are less tolerant to pollution.

5.5. Ichthyofauna.

A desktop review pertaining to distribution and habitat preference of fish species indicated that the proposed construction sites have historical records of supporting various fish species (Kleynhans, 2007). This was then cross-referenced to the available habitat units present at the site.

Table 7: Fish species expected to inhabit the river reach associated with the proposed development area. The relative abundance values are taken from Kleynhans, 2007.

Species	Common name	FROC Sites		
		140F5 Bokpoort	140F6 Olyvenhoutsdrift	140F7 Olyvenhoutsdrift
Austroglanis sclateri	Rock catfish			3
Barbus anoplus	Chubbyhead barb			3
Barbus paludinosus	Straightfin barb	2	2	3
Barbus trimaculatus	Threespot barb			3
Labeobarbus aeneus	Smallmouth yellowfish	2	2	3
Labeobarbus kimberleyensis	Largemouth yellowfish			3
Cyprinus carpio	Common carp			3
Clarias gariepinus	Sharptooth catfish			3
Labeo capensis	Orange River labeo	2	2	3
Labeo umbratus	Moggel			3
Pseudocrenilabrus philander	Southern mouthbrooder	2	2	3
Tilapia sparrmanii	Banded tilapia		2	3

Table 7 presents the fish species that would potentially occur within the river reach associated with the survey area. These species have all been sampled at a reference site located downstream and upstream of the survey areas (Kleynhans, 2007) at a site known as 140F5 (associated to the Bokpoort sites) and 140F6 and 140F7 (associated to the Olyvenhoutsdrift site). These reference sites are known as FROC (Frequency of Occurrence) sites and are shown in Figure 9and Figure 10.

Species abundance and richness is shown to be greatest at 140F7 (downstream of Olyvenhoutsdrift). This is due to the greater diversity of habitat types and flow conditions available to fish. Upstream of Olyvenhoutsdrift (140F6) shows relatively less abundance and diversity of species, with 140F5 (upstream of the Bokpoort sites) showing even less diversity and abundance.

Only *Labeobarbus kimberleyensis, Labeobarbus aeneus* and *Tilapia sparrmanii* were sampled at the Olyvenhoutsdrift site during the survey, but this is by no means an indication of the potential for the various sites to support a diversity of fish species. The extent of the river at the sites meant that comprehensive sampling was impossible given the timeframes and nature of the survey.

The greatest threat to the fish abundance and diversity of species from a development of this nature is the creation of migratory barriers when weirs are constructed for water abstraction points. That is the main reason for recommending that the Olyvenhoutsdrift site is the preferred option as this is to be done on a side channel and not within the main watercourse. This aspect is expanded on under section 6 *Significance ratings of perceived environmental impacts.*

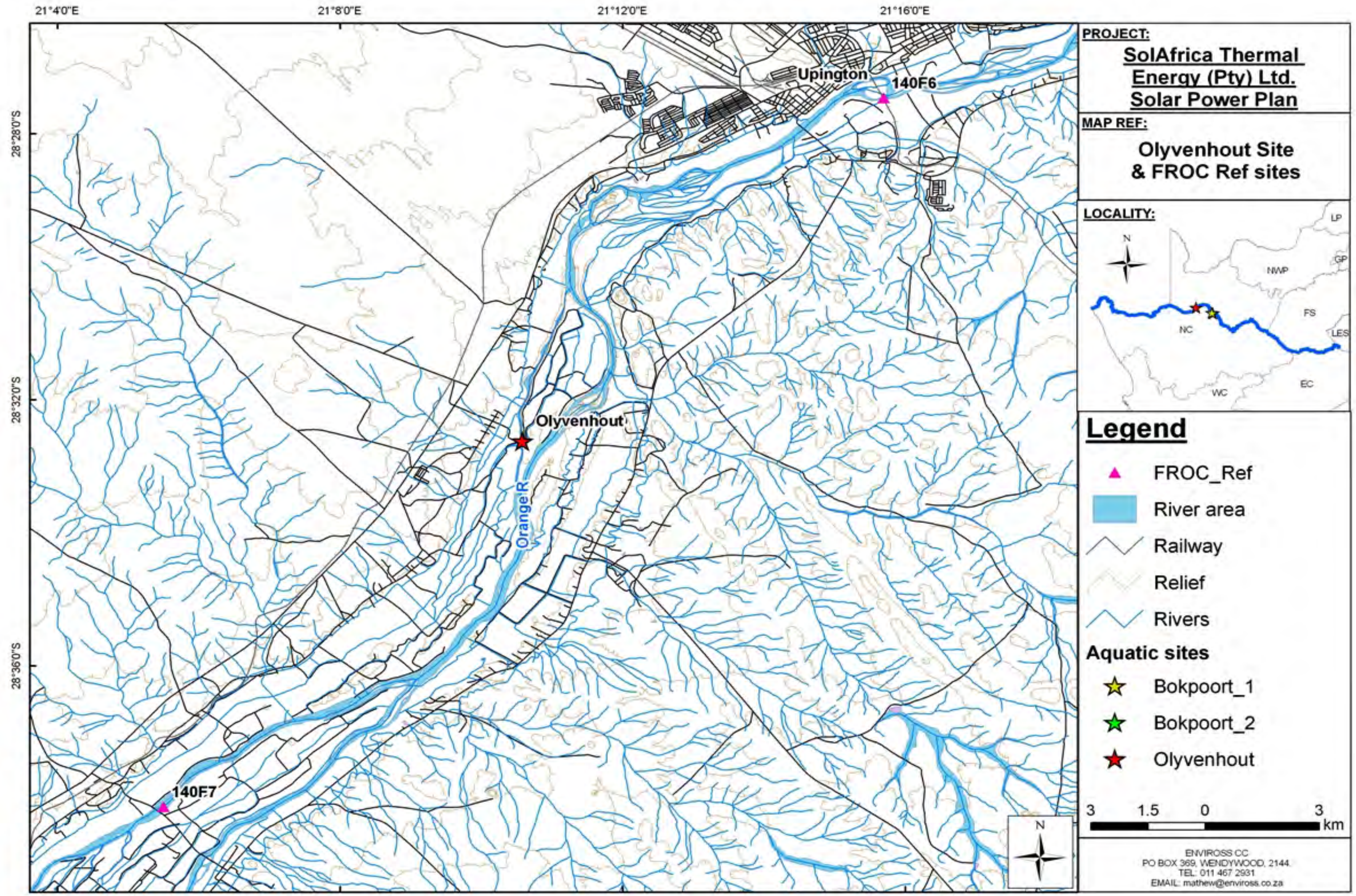

Figure 9: Olyvenhoutsdrift site and associated FROC reference sites.

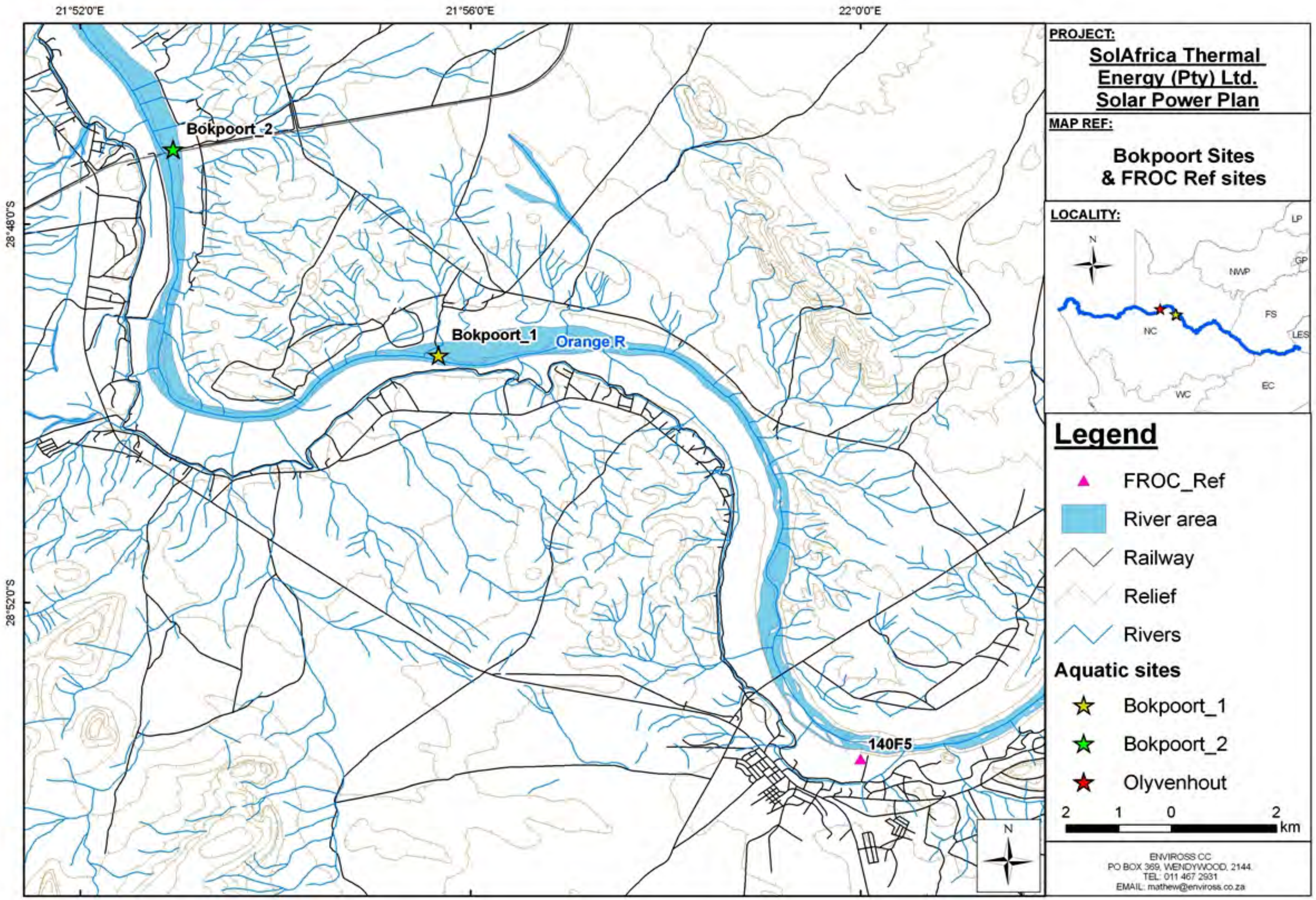

Figure 10: Bokpoort sites and associated FROC reference sites.

6. SIGNIFICANCE RATINGS OF PERCEIVED ENVIRONMENTAL IMPACTS.

6.1. Olyvenhoutsdrift.

Table 8 presents the significance ratings of the potential ecological impacts for the *pre-construction and construction* as well as the *management phases* of the proposed development activities if undertaken at the *proposed Olyvenhoutsdrift site*. The ratings are calculated for the scenarios of both before and after the implementation of mitigatory measures. This was done in order to show how the degree of impacts can be reduced by careful planning and the following of relatively simple mitigatory measures.

Table 8: The significance ratings both before and after implementation of mitigatory measures of the main potential ecological impacts perceived to be associated to the proposed development activities if undertaken at the proposed *Olyvenhoutsdrift site*.

Potential environmental impact	Project activity or issue	Environmental significance *before* mitigation**								Environmental significance *after* mitigation**							
		S	D	I	E	R	P	Conf	SP	S	D	I	E	R	P	Conf	SP
PRECONSTRUCTION & CONSTRUCTION PHASES																	
Riparian Vegetation Impacts	Clearing of riparian vegetation, due to preconstruction activities, leading to habitat loss and potential soil erosion aggravation.	2	1	3	3	3	4	High	24	1	1	1	2	3	2	High	4
Soil erosion	Soil stripping, soil compaction and vegetation removal will increase rates of erosion and entry of sediment into the general aquatic ecosystem.	2	2	3	3	3	4	High	28	1	1	1	2	3	2	High	4
Soil erosion	Erosion of stockpiled topsoil & disturbance of soils due to vegetation stripping leading to erosion and habitat smothering.	2	2	3	3	3	4	High	28	1	1	1	2	3	2	High	4
Habitat destruction	Vegetation removal, soil stripping and dumping leading to habitat loss.	1	4	3	3	3	3	High	24	1	1	1	1	4	1	High	0
Impacts on aquatic fauna	Direct impacts due to instream destruction for weir construction.	2	5	3	4	1	4	High	52	2	5	1	2	1	4	High	36
MANAGEMENT PHASE																	
Biodiversity impacts	Exotic vegetation encroachment following soil disturbances.	2	2	1	2	3	3	High	12	1	1	1	1	4	1	High	0
Biodiversity impacts	Change in hydrological regime due to weir construction leading to modification of aquatic community structures.	3	5	5	4	3	4	High	64	1	1	1	2	4	2	High	2
Biodiversity impacts	Construction of abstraction weirs that will create a migratory barrier and affect fish community structures.	3	5	5	4	3	4	High	64	1	1	1	2	4	2	High	2
Soil erosion	Resulting from runoff through poor stormwater drainage management.	2	4	3	3	3	3	High	36	1	1	1	2	4	1	High	1

*****See Appendix E for calculations & methodologies.***
SP ratings: 0-33 (Low), 34-74 (Medium), 75-100 (High)

6.1.1. Pre-Construction & Construction Phase.

These phases of the proposed development activities usually result in the greatest ecological impacts. The indiscriminent use of heavy machinery by uninformed operators leading to the unnecessary destruction of habitat is perceived to be the leading cause of ecological impacts that are easily avoided. Careful planning, basic education of operators and on-site management will all enable the impacts to be significantly reduced.

The nature of the proposed development activities will result in many impacts being unavoidable. Aspects such as “riparian vegetation impacts” and “habitat destruction” are inevitable consequences of the proposed development activities. These impacts can, however, be significantly reduced by ecologically-sensitive construction methods and the following of a carefully formulated Environmental Management Plan (EMP). By keeping the footprint of the impacts reduced to a minimum by only allowing heavy machinery to operate on designated access roadways and by avoiding the unnecessary degradation of habitat within areas adjacent to the actual construction areas, the ecological impacts can be greatly reduced. The perceived ecological impacts have been rated as *low* to *medium*. This is largely through the localised spatial extent of the development activities. It can be seen that the impacts can be significantly reduced through the implementation of mitigatory measures.

6.1.1.1. Riparian vegetation impacts.

The destruction of areas of riparian vegetation and habitat is inevitable due to the nature of the proposed development that requires vegetation stripping to allow for the establishment of infrastructure. This impact has a duration considered to be over a relatively short period that will continue for the construction phase. The spatial extent and the effects that it will have on important ecosystems are all dependent, however, on the specific methods employed during the construction phases. Careful planning and restrictions on construction footprint areas will abate negative ecological impacts. The riparian habitat has already been largely impacted by agriculture and infrastructure development.

Indiscriminent dumping of excess building material and unnecessary soil and vegetation stripping will also lead to associated undue habitat destruction. This is an easily mitigated potential impact feature that should be implemented through a carefully-designed EMP as well as general education of construction crews and management.

6.1.1.2. Soil erosion.

Soil erosion of riverbanks following construction activities is a leading cause of habitat destruction that can be easily avoided through careful planning and ecologically-sensitive construction methods. The normally-steep gradient of riverbanks coupled to the scouring effects of the flowing water within the channel means that any disturbances of the riparian soils and vegetation stripping will inevitably lead to soil erosion with the consequence of siltation and smothering of the aquatic habitat. This is an impact that, if left unabated, is ongoing and has an exponential effect as it worsens. It is, however, easily mitigated if planned for and implemented as part of the construction process.

6.1.1.3. Impacts on aquatic fauna.

The construction of infrastructure within the watercourse, such as for the establishment of an abstraction weir, will inevitably lead to aquatic habitat destruction and displacement of aquatic fauna during the construction phase. The significance of this impact is reduced due to the proposed activities taking place on a side channel and not within the main watercourse of the river. Side channels, however, do provide for important refugia, especially as these areas are very often utilised as nursery areas for breeding fish. Site re-establishment following the construction phase is therefore imperative to the overall ecological integrity of the aquatic system.

The construction of weirs will create an instream migratory barrier, which could potentially lead to community isolation due to the splitting of communities below the weir from those communities above the weir. This will only happen of the abstraction weir is constructed across the entire watercourse. This impact can easily be mitigated by the design and implementation of a fish bypass facility (fishway) that can be incorporated into the weir design, which will facilitate free passage of migratory species both up and downstream. The input of a specialist in the field should be sought to aid in the design of a fishway that can be incorporated into the weir design.

The severity of the impact is also lessened within this area as the channel is relatively narrower than the main watercourse. The riparian and instream substrate is also dominated by bedrock and therefore the excavations to locate suitably stable foundation material will be minimised. All these aspects mean that the site disturbance duration will be lessened and minimised.

6.1.2. Management Phase.

The management phase of the proposed development should include follow-up surveys of both the aquatic and riparian habitats to determine the extent of functionality of the mitigation measures provided for during the construction phases of the bridge construction.

6.1.2.1. Biodiversity impacts.

The potential for exotic vegetation encroachment within the riparian zones following the site disturbances through the construction activities is high and therefore mitigation measures should be implemented to manage any recruitment by such species. This will ensure protection of the riparian zones and the retention of natural biodiversity features. Encroachment of exotic vegetation will negatively affect avifaunal diversity within the area as well as leading to aggravated erosion of the riverbanks. This is therefore an important aspect that requires active management. Follow-up surveys should be conducted in order to identify potential development of these impacts to the biodiversity.

Instream weirs constructed within the watercourse will inundate upstream habitat that will effectively displace those aquatic faunal species that relied on naturally faster, shallower waters. The aquatic faunal community structures will therefore be transformed and dominated by species with a preference to inundated conditions.

A fish bypass facility requires monitoring to measure its ongoing effectiveness. The input of a specialist in the field should be sought to aid in the design of a fishway that can be incorporated into the weir design. The specialist can then also do routine monitoring for a fixed period during the management phase to measure the effectiveness of the fishway.

6.1.2.2. Soil erosion.

Stormwater management from the increased hard and impermeable surfaces requires particular attention. The increased surface area of impermeable surfaces will lead to the increased runoff potential of stormwaters that will lead to increased soil erosion of riverbanks if no measures to abate it are implemented. Careful planning by engineers and careful attention to design specifications of stormwater outfalls by construction crews are vital features to successfully mitigate this aspect. It is also recommended that this feature be assessed through follow-up surveys following completion of the construction phase in order to allow for the early identification of any potential development of soil erosion through poor stormwater management.

6.2. Bokpoort.

Table 9 presents the significance ratings of the potential ecological impacts for the *pre-construction and construction* as well as the *management phases* of the proposed development activities if undertaken at the *proposed Bokpoort sites*. The two sites have been dealt with collectively due to the similar physical characteristics of the sites, rendering the potential impacts similar in nature.

The ratings are calculated for the scenarios of both before and after the implementation of mitigatory measures. This was done in order to show how the degree of impacts can be reduced by careful planning and the following of relatively simple mitigatory measures.

Table 9: The significance ratings both before and after implementation of mitigatory measures of the main potential ecological impacts perceived to be associated to the proposed development activities if undertaken at the proposed *Bokpoort sites*.

Potential environmental impact	Project activity or issue	Environmental significance *before* mitigation**								Environmental significance *after* mitigation**							
		S	D	I	E	R	P	Conf	SP	S	D	I	E	R	P	Conf	SP
PRECONSTRUCTION & CONSTRUCTION PHASES																	
Riparian Vegetation Impacts	Clearing of riparian vegetation, due to preconstruction activities, leading to habitat loss and potential soil erosion aggravation.	2	1	5	4	2	4	High	40	1	1	3	3	3	2	High	10
Soil erosion	Soil stripping, soil compaction and vegetation removal will increase rates of erosion and entry of sediment into the general aquatic ecosystem.	2	2	3	3	3	4	High	28	1	1	1	2	3	2	High	4
Soil erosion	Erosion of stockpiled topsoil & disturbance of soils due to vegetation stripping leading to erosion and habitat smothering.	2	2	3	3	3	4	High	28	1	1	1	2	3	2	High	4
Habitat destruction	Vegetation removal, soil stripping and dumping leading to habitat loss.	1	4	3	3	3	3	High	24	1	1	1	1	4	1	High	0
Impacts on aquatic fauna	Direct impacts due to instream destruction for weir construction.	2	5	3	4	1	4	High	52	2	5	3	3	1	4	High	48
MANAGEMENT PHASE																	
Biodiversity impacts	Exotic vegetation encroachment following soil disturbances.	2	2	1	2	3	3	High	12	1	1	1	1	4	1	High	0
Biodiversity impacts	Change in hydrological regime due to weir construction leading to modification of aquatic community structures.	3	5	5	4	3	4	High	64	1	1	1	2	4	2	High	2
Biodiversity impacts	Construction of abstraction weirs that will create a migratory barrier and affect fish community structures.	3	5	5	4	3	4	High	64	1	1	1	2	4	2	High	2
Soil erosion	Resulting from runoff through poor stormwater drainage management.	2	4	3	3	3	3	High	36	1	1	1	2	4	1	High	1

****See Appendix E for calculations & methodologies.***
SP ratings: 0-33 (Low), 34-74 (Medium), 75-100 (High)

6.2.1. Pre-Construction & Construction Phase.

The potential impacts at either of the Bokpoort sites during the pre-construction and construction phases are significantly higher than those at the Olyvenhoutsdrift site. This is due to the highly dispersive, deep soils that dominate the riparian areas and instream habitat, which will necessitate deep excavations in order to locate stable foundation material for the establishment of infrastructure. The construction phase would therefore be for a longer period and of a greater scale, thereby significantly increasing the potential impacts of the construction.

6.2.1.1. Riparian vegetation impacts.

The destruction of areas of riparian vegetation and habitat is inevitable due to the nature of the proposed development that requires vegetation stripping to allow for the establishment of infrastructure. This impact has a duration considered to be permanent. The spatial extent and the effects that it will have on important ecosystems are all dependent, however, on the specific methods employed during the construction phases. Careful planning and restrictions on construction footprint areas will abate negative ecological impacts.

The riparian habitat is dominated by deep sands – a feature shared by both Bokpoort sites. This means that any infrastructure development would require deep excavations in order to located stable foundation material (this is an assumption and was not subject to any engineering or geotechnical scrutiny). If this is the case, it will necessitate heavy machinery to be active for longer periods and over a greater footprint within this area than at Olyvenhoutsdrift, thereby increasing the overall ecological impact. The loose soils are all alluvial in nature and therefore compaction of these soils will alter the dynamics of the riverbanks, potentially influencing erosion features within other areas.

Indiscriminent dumping of excess building material and unnecessary soil and vegetation stripping will also lead to associated unnecessary habitat destruction. The soils within these areas are highly dispersive, and therefore any disturbances will aggravate soil erosion. This is an easily mitigated impact that should be implemented through a carefully-designed EMP as well as general education of construction crews and management.

6.2.1.2. Soil erosion.

Soil erosion of riverbanks following construction activities is a leading cause of habitat destruction that can be easily avoided through careful planning and ecologically-sensitive construction methods. The normally-steep gradient of riverbanks coupled to the scouring effects of the flowing water within the channel means that any disturbances of the riparian soils and vegetation stripping will inevitably lead to soil erosion with the consequence of siltation and smothering of the aquatic habitat. This is an impact that, if left unabated, is ongoing and has an exponential effect as it worsens. It is, however, easily mitigated if planned for and implemented as part of the construction process.

Largescale excavation within riparian areas as well as within the watercourse will lead to erosion if not mitigated and managed on site both before and during the construction process. Follow-up surveys are then also recommended to identify any potential and emerging erosion concerns.

6.2.1.3. Impacts on aquatic fauna.

The localised associated aquatic habitat is not regarded as an important area for fish or aquatic macro-invertebrate conservation as it does not offer the diversity of habitat required to support a diversity of species. The concerns associated with the proposed development within this area are the disturbance of the sediments during the construction phase, which will lead to siltation and smothering of the aquatic habitat downstream, as well as the potential formation of a migratory barrier through the construction of a weir. These features could significantly alter the dynamics of the system. If a weir is to be constructed that could potentially inhibit migratory behaviour of aquatic organisms, then provision should be made for a fishway, which should be incorporated into the design of the weir.

6.2.1.4. Compaction of soils.

The compaction of soils within the riparian zones will inhibit the natural succession and regeneration of the vegetation layers within these areas. Compaction of soils will also influence the hydrology of the system, potentially creating emerging erosion problems elsewhere. By restricting vehicular access to only designated roadways, this impact can be negated.

6.2.2. Management Phase.

The management phase of the proposed development should include follow-up surveys of both the aquatic and riparian habitats to determine the extent of functionality of the mitigation measures provided for during the construction phases of the bridge construction.

6.2.2.1. Biodiversity impacts.

The potential for exotic vegetation encroachment within the riparian zones following the site disturbances through the construction activities is high and therefore mitigation measures should be implemented to manage any recruitment by such species. This will ensure protection of the riparian zones and the retention of natural biodiversity features. Encroachment of exotic vegetation will negatively affect avifaunal diversity within the area as well as leading to aggravated erosion of the riverbanks. This is therefore an important aspect that requires active management. Follow-up surveys should be conducted in order to identify potential development of these impacts to the biodiversity.

The aridity of the surrounding region means that a large seedbank for exotic species is not present within the area. The riparian areas do, however, offer ideal habitat for aggressively-growing exotic species, which will quickly out-compete and displace indigenous species.

6.2.2.2. Soil erosion.

Stormwater management from the increased road surface will require particular attention. The increased surface area of impermeable surfaces will lead to the increased runoff potential of stormwaters that will lead to increased soil erosion of riverbanks if no measures to abate it are implemented. Careful planning by engineers and careful attention to design specifications of stormwater outfalls by construction crews are vital features to successfully mitigate this aspect. It is also recommended that this feature be assessed through follow-up surveys following completion of the construction phase in order to allow for the early identification of any potential development of soil erosion through poor stormwater management.

7. COMPARISON OF ALTERNATIVES.

There are three alternative sites proposed for the proposed development activities, namely two sites at Bokpoort and one at Olyvenhoutsdrift, which are both along the Orange River. The three proposed sites represent different habitat characteristics and these three sites also incorporate varying degrees of existing infrastructure development. These two factors, as well as the degree of potential impact and the overall ecological sensitivity at the three sites were taken into consideration when evaluating the most suitable site in terms of potential overall aquatic and riparian impacts emanating from the proposed development activities. Table 10 summarises the advantages and disadvantages of development at each site.

Table 10: Main advantages and disadvantages of development at each proposed site.

Site	Main features	Advantages	Disadvantages	Expected success of mitigation
Olyvenhoutsdrift	Side channel away from main watercourse; There is an existing vehicular bridge, pipelines, etc.; Medium depth, faster flowing water; Instream habitat dominated by bedrock; Riparian habitat dominated by rock.	Development within a side channel lessens overall impact on biodiversity; Stability of instream and riparian habitat substrate will mean less excavating for infrastructure development – overall less impacts; Existing instream infrastructure also means less overall impact of new development.	Instream habitat characteristics biodiversity is relatively higher than at other sites.	High

Site	Main features	Advantages	Disadvantages	Expected success of mitigation
Bokpoort_1	Wide, deep, slow-flowing water; Instream habitat dominated by mud and sand; No existing infrastructure; Riparian habitat dominated by deep sands.	Slow-flowing deep water with instream habitat dominated by mud and sand means that biodiversity is relatively low at the site.	Unstable riparian and instream substrate means that deep excavations will be necessary to locate suitable foundation material; No existing infrastructure means overall impacts will be high.	Low
Bokpoort_2	Wide channel with mixed slow-deep to shallow-fast instream habitat; Existing railway bridge; Riparian habitat dominated by deep sands.	Existing railway bridge has already impact site to a small degree.	Unstable riparian and instream substrate means that deep excavations will be necessary to locate suitable foundation material; Instream habitat diversity means that biodiversity at site will be expected to be high.	Medium

From Table 10, the most suitable site is thought to be the site proposed at Olyvenhoutsdrift. The main reasons for this being that the proposed development is to take place along a side channel of the main watercourse and will therefore not have an undue negative effect on the aquatic biodiversity within the system and the stability of the foundation material within the watercourse and riparian habitat means that relatively less excavation would be necessary to locate stable foundation material. There is also a high degree of instream infrastructure within the river reach that is already impacting on the overall ecological integrity of the channel.

Table 11: Summary of the impact ratings for both the Olyvenhoutsdrift and Bokpoort sites.

Site	Impact*	Rating before mitigation	Rating after mitigation	Potential success of mitigation
Olyvenhoutsdrift	**Preconstruction & Construction Phase**			
	Riparian Vegetation Impacts	24	4	High
	Soil erosion	28	4	High
	Soil erosion	28	4	High
	Habitat destruction	24	0	High
	Impacts on aquatic fauna	52	36	Medium
	Management Phase			
	Biodiversity impacts	12	0	High
	Biodiversity impacts	64	2	High
	Biodiversity impacts	64	2	High
	Soil erosion	36	1	High
	AVERAGE RATINGS:	**37**	**6**	**High**
Bokpoort	**Preconstruction & Construction Phase**			
	Riparian Vegetation Impacts	40	10	Medium
	Soil erosion	28	4	High
	Soil erosion	28	4	High
	Habitat destruction	24	0	High
	Impacts on aquatic fauna	52	48	Low
	Management Phase			

	Biodiversity impacts	12	0	High
	Biodiversity impacts	64	2	High
	Biodiversity impacts	64	2	High
	Soil erosion	36	1	High
	AVERAGE RATINGS:	**39**	**8**	**High**

**Impacts descriptions correlate to those given in Table 8 and Table 9.*

Table 11 shows a comparison between the scoring of the potential impacts at the Olyvenhoutsdrift site and the Bokpoort sites. The scoring indicates that, even though the Olyvenhoutsdrift site was shown to be richer in biodiversity and habitat diversity, there would be a greater impact suffered at the Bokpoort sites, with mitigation measures being less successful.

8. CONCLUSIONS & RECOMMENDATIONS.

The SolAfrica Thermal Energy (Pty) Ltd Solar Power Plant development has been proposed at two alternative sites on the Orange River within the Upington district that required an assessment of the PES of the aquatic habitat as well as an impact significance survey. Two sites were proposed at Bokpoort, and one at Olyvenhoutsdrift. A further site was proposed at Olyvenhoutsdrift, but is located far enough from the watercourse and will therefore not pose a significant risk to the system. A field survey was undertaken during June 2010.

Following the aquatic surveys at the various sites, the following conclusions were reached and the main mitigation measures are summarised:

- The most suitable site for the proposed development activities from an ecological perspective is thought to be at Olyvenhoutsdrift. The site is located along a side channel of the main watercourse and instream and riparian habitat disturbances through historical and existing infrastructure meant that the system is regulated and transformed. This site also offers the best foundation material (bedrock) that will reduce the need for excavations during the construction phase. This will greatly reduce the overall impact of the proposed development activities;
- The sites proposed at Bokpoort are both characterised by deep sand that will require deep excavations to locate suitable foundation material. This will greatly increase the overall impact of the system, both locally and downstream of the site. These sites are also located along the main channel of the watercourse;
- Weirs should incorporate fishways into the designs so that the weirs do not pose as migratory barriers to migratory species;

- Water quality within the Orange River is regarded as being good, as reflected in SASS5 and ASPT scores. Preservation of this feature should be a top priority throughout the various phases of the development;
- Particular attention must be paid to controlling soil erosion as siltation will impact on sensitive aquatic habitats downstream of the site;
- Adequate stormwater management must be provided that won't aggravate the erosion of the river banks;
- An Environmental Conservation Officer (ECO) should be present to facilitate watercourse and riparian habitat rehabilitation efforts;
- The ECO should be educated in general river rehabilitation measures and how to identify emerging and potential problems;
- The footprint of the development during the construction phase should be retained as small as possible by construction vehicles being limited to designated roadways only. Destruction of the riparian habitat through the unnecessary clearing of vegetation should be avoided;
- Dumping of any excess rubble, building material or refuse must be prohibited within the riparian habitat. Dumping of materials should only take place at designated and properly managed areas;
- Adequate toilet facilities must be provided for all construction crews to negate informal ablutions taking place within riparian zones;
- Fires within the riparian zones should be prohibited;
- Fishing and hunting of local fauna should be prohibited;
- Exotic vegetation identified presently at the site should be managed;
- Follow-up surveys are recommended to potentially identify emerging impacts following post-construction within both the aquatic and riparian areas. This is important so as to implement any further mitigatory measures required for emerging problems (e.g. soil erosion forming through poor stormwater management feature design, recruitment of exotic vegetation, formation of instream migratory barriers, etc). The appointed ECO should be well-versed in identifying potential emerging environmental concerns.

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APPENDIX A - METHODOLOGIES APPLIED DURING THIS BIOMONITORING ASSESSMENT – AQUATIC MACRO-INVERTEBRATE COLLECTION – SASS5 METHODOLOGY.

Sample Collection.

A standard SASS invertebrate net (300 x 300 mm square with 1mm gauge mesh netting) was used for the collection of the organisms. The available biotopes at each site were identified and each of the biotopes was sampled by different methods explained under the relevant sections.

The biotopes were combined into three different groups, which were sampled and assessed separately:

a) Stone (S) Biotopes:

Stones in current (SIC) or any solid object: Movable stones of at least cobble size (3 cm diameter) to approximately 20 cm in diameter, within the fast and slow flowing sections of the river. Kick-sampling is used to collect organisms in this biotope. This is done by putting the net on the bottom of the river, just downstream of the stones to be kicked, in a position where the current will carry the dislodged organisms into the net. The stones are then kicked over and against each other to dislodge the invertebrates (kick-sampling) for ± 2 minutes.

Stones out of current (SOOC): Where the river is still, such as behind a sandbank or ridge of stones or in backwaters. Collection is again done by the method of kick-sampling, but in this case the net is swept across the area sampled to catch the dislodged biota. Approximately 1 m^2 is sampled in this way.

Bedrock or other solid substrate: Bedrock includes stones greater than 30cm, which are generally immovable, including large sheets of rock, waterfalls and chutes. The surfaces are scraped with a boot or hand and the dislodged organisms collected. Sampling effort is included under SIC and SOOC above.

b) Vegetation (Veg) Biotopes:

Marginal vegetation (MV): This is the overhanging grasses, bushes, twigs and reeds growing on the edge of the stream, often emergent, both in current (MvegIC) and out of current (MvegOOC). Sampling is done by holding the net perpendicular to the vegetation (half in and half out of the water) and sweeping back and forth in the vegetation (± 2m of vegetation).

Submerged vegetation (AQV): This vegetation is totally submerged and includes Filamentous algae and the roots of floating aquatics such as water hyacinth. It is sampled by pushing the net (under the water) against and amongst the vegetation in an area of approximately one square meter.

c) Gravel, Sand and Mud (GSM) biotopes:

Sand: This includes sandbanks within the river, small patches of sand in hollows at the side of the river or sand between the stones at the side of the river. This biotope is sampled by stirring the substrate by shuffling or scraping of the feet, which is done for half a minute, whilst the net is continuously swept over the disturbed area.

Gravel: Gravel typically consists of smaller stones (2-3 mm up to 3 cm). It is sample in a similar fashion to that of sand.

Mud: It consists of very fine particles, usually as dark-collared sediment. Mud usually settles to the bottom in still or slow flowing areas of the river. It is sample in a similar fashion to that of sand.

d) Hand picking and visual observation:

Before and after disturbing the site, approximately 1 minute of “hand-picking” for specimens that may have been missed by the sampling procedures was carried out.

APPENDIX B – RESULTS FROM THE SASS5 SURVEY.

SITE: OLYVENHOUT

Taxon		S	Veg	GSM	TOT	Taxon		S	Veg	GSM	TOT	Taxon		S	Veg	GSM	TOT
PORIFERA (SPONGE)	5					**HEMIPTERA (BUGS)**						**DIPTERA (FLIES)**					
COELENTERATA (CNIDARIA)	1					Belostomatidae* (Giant water bugs)	3					Athericidae	10				
TURBELLARIA (FLATWORMS)	3	A			A	Corixidae* (Water boatmen)	3		B	A	B	Blepharoceridae (Mountain midges)	15				
ANNELIDA						Gerridae* (Pond skaters/Water striders)	5		B		B	Ceratopogonidae (Biting midges)	5			1	1
Oligochaeta (Earthworms)	1	A		A	B	Hydrometridae* (Water measurers)	6					Chironomidae (Midges)	2	A		A	B
Leeches	3					Naucoridae* (Creeping water bugs)	7					Culicidae* (Mosquitoes)	1				
CRUSTACEA						Nepidae* (Water scorpions)	3					Dixidae* (Dixid midge)	10				
Amphipoda	13					Notonectidae* (Backswimmers)	3					Empididae (Dance flies)	6				
Potamonautidae* (Crabs)	3	A		A	B	Pleidae* (Pygmy backswimmers)	4					Ephydridae (Shore flies)	3				
Atyidae (Shrimps)	8		B		B	Veliidae/M...veliidae* (Ripple bugs)	5		B		B	Muscidae (House flies, Stable flies)	1				
Palaemonidae (Prawns)	10					**MEGALOPTERA**						Psychodidae (Moth flies)	1				
HYDRACARINA (MITES)	8					Corydalidae	8					Simuliidae (Blackflies)	5	B	A	B	C
PLECOPTERA (STONEFLIES)						Sialidae	6					Syrphidae* (Rat tailed maggots)	1				
Notonemouridae	14					**TRICHOPTERA CADDISFLIES)**						Tabanidae (Horse flies)	5				
Perlidae	12					Dipseudopsidae	10					Tipulidae (Crane flies)	5			A	A
EPHEMEROPTERA						Ecnomidae	8					**GASTROPODA (SNAILS)**					
Baetidae 1sp	4		C			Hydropsychidae 1 sp	4					Ancylidae (Limpets)	6	A		A	B
Baetidae 2 sp	6	C		C		Hydropsychidae 2 sp	6	A		B		Bulininae*	3				
Baetidae > 2 sp	12				C	Hydropsychidae > 2 sp	12				B	Hydrobiidae*	3				
Caenidae (Squaregills/Cainfles)	6	B		B	C	Philopotamidae	10					Lymnaeidae* (Pond snails)	3				
Ephemeridae	15					Polycentropodidae	12					Physidae* (Pouch snails)	3		A		A
Heptageniidae (Flatheaded mayflies)	13	A		1	A	Psychomyiidae/Xiphocentronidae	8					Planorbinae* (Orb snails)	3				
Leptophlebiidae (Prongills)	9					**Cased caddis:**						Thiaridae* (=Melanidae)	3				
Oligoneuridae (Brushlegged mayflies)	15					Barbarochthonidae SWC	13					Viviparidae* ST	5				
Polymitarcyidae (Pale Burrowers)	10					Calamoceratidae ST	11					**PELECYPODA (BIVALVES)**					
Prosopistomatidae (Water specs)	15					Glossosomatidae SWC	11					Corbiculidae	5				
Teloganodidae SWC	12					Hydroptilidae	6					Sphaeriidae (Pills clams)	3				
Tricorythidae (Stout Crawlers)	9					Hydrosalpingidae SWC	15					Unionidae (Perly mussels)	6				
ODONATA (DRAGONFLIES & DAMSELFLIES)						Lepidostomatidae	10					**SASS Score**		57	42	71	**116**
Calopterygidae ST,T	10					Leptoceridae	6					**No. of Taxa**		11	9	14	**21**
Chlorocyphidae	10					Petrothrincidae SWC	11					**ASPT**		5.2	4.7	5.1	5.5
Synlestidae (Chlorolestidae)(Sylphs)	8					Pisuliidae	10					**Other biota:**					
Coenagrionidae (Sprites and blues)	4		A		A	Sericostomatidae SWC	13										
Lestidae (Emerald Damselflies)	8					**COLEOPTERA**											
Platycnemidae (Brook Damselflies)	10					Dytiscidae/Noteridae* (Diving beetles)	5										
Protoneuridae	8					Elmidae/Dryopidae* (Riffle beetles)	8										
Aeshnidae (Hawkers & Emperors)	8					Gyrinidae* (Whirligig beetles)	5		B		B						
Corduliidae (Cruisers)	8					Haliplidae* (Crawling water beetles)	5										
Gomphidae (Clubtails)	6	1		A	A	Helodidae (Marsh beetles)	12										
Libellulidae (Darters)	4			1	1	Hydraenidae* (Minute moss beetles)	8					**Comments:**					
LEPIDOPTERA						Hydrophilidae* (Water scavenger beetles	5										
Crambidae (Pyralidae)	12					Limnichidae	10										
						Psephenidae (Water Pennies)	10										

SITE: BOKPOORT_1

Taxon		S	Veg	GSM	TOT
PORIFERA (SPONGE)	5				
COELENTERATA (CNIDARIA)	1				
TURBELLARIA (FLATWORMS)	3				
ANNELIDA					
Oligochaeta (Earthworms)	1			A	B
Leeches	3				
CRUSTACEA					
Amphipoda	13				
Potamonautidae* (Crabs)	3				
Atyidae (Shrimps)	8		B		B
Palaemonidae (Prawns)	10				
HYDRACARINA (MITES)	8				
PLECOPTERA (STONEFLIES)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA					
Baetidae 1sp	4		C		
Baetidae 2 sp	6			C	C
Baetidae > 2 sp	12				
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (DRAGONFLIES & DAMSELFLIES)					
Calopterygidae ST,T	10				
Chlorocyphidae	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies)	8				
Platycnemidae (Brook Damselflies)	10				
Protoneuridae	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters)	4				
LEPIDOPTERA					
Crambidae (Pyralidae)	12				

Taxon		S	Veg	GSM	TOT
HEMIPTERA (BUGS)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3		B		B
Gerridae* (Pond skaters/Water striders)	5		B		B
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5		B		B
MEGALOPTERA					
Corydalidae	8				
Sialidae	6				
TRICHOPTERA CADDISFLIES)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6		A		A
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5		B		B
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles)	5				
Limnichidae	10				
Psephenidae (Water Pennies)	10				

Taxon		S	Veg	GSM	TOT
DIPTERA (FLIES)					
Athericidae	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2			A	A
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5				
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (SNAILS)					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3		A		A
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (BIVALVES)					
Corbiculidae	5				
Sphaeriidae (Pills clams)	3				
Unionidae (Perly mussels)	6				
SASS Score		0	43	9	**48**
No. of Taxa		0	9	3	**11**
ASPT		-	4.8	3.0	4.4
Other biota:					
Comments:					

SITE: BOKPOORT_2

Taxon		S	Veg	GSM	TOT
PORIFERA (SPONGE)	5				
COELENTERATA (CNIDARIA)	1				
TURBELLARIA (FLATWORMS)	3	1			1
ANNELIDA					
Oligochaeta (Earthworms)	1	A		A	B
Leeches	3				
CRUSTACEA					
Amphipoda	13				
Potamonautidae* (Crabs)	3	A			A
Atyidae (Shrimps)	8		B		B
Palaemonidae (Prawns)	10				
HYDRACARINA (MITES)	8				
PLECOPTERA (STONEFLIES)					
Notonemouridae	14				
Perlidae	12				
EPHEMEROPTERA					
Baetidae 1sp	4		C		
Baetidae 2 sp	6	C		C	
Baetidae > 2 sp	12				C
Caenidae (Squaregills/Cainfles)	6				
Ephemeridae	15				
Heptageniidae (Flatheaded mayflies)	13				
Leptophlebiidae (Prongills)	9				
Oligoneuridae (Brushlegged mayflies)	15				
Polymitarcyidae (Pale Burrowers)	10				
Prosopistomatidae (Water specs)	15				
Teloganodidae SWC	12				
Tricorythidae (Stout Crawlers)	9	A		A	B
ODONATA (DRAGONFLIES & DAMSELFLIES)					
Calopterygidae ST,T	10				
Chlorocyphidae	10				
Synlestidae (Chlorolestidae)(Sylphs)	8				
Coenagrionidae (Sprites and blues)	4		A		A
Lestidae (Emerald Damselflies)	8				
Platycnemidae (Brook Damselflies)	10				
Protoneuridae	8				
Aeshnidae (Hawkers & Emperors)	8				
Corduliidae (Cruisers)	8				
Gomphidae (Clubtails)	6				
Libellulidae (Darters)	4	1		1	1
LEPIDOPTERA					
Crambidae (Pyralidae)	12				

Taxon		S	Veg	GSM	TOT
HEMIPTERA (BUGS)					
Belostomatidae* (Giant water bugs)	3				
Corixidae* (Water boatmen)	3		B		B
Gerridae* (Pond skaters/Water striders)	5		B		B
Hydrometridae* (Water measurers)	6				
Naucoridae* (Creeping water bugs)	7				
Nepidae* (Water scorpions)	3				
Notonectidae* (Backswimmers)	3				
Pleidae* (Pygmy backswimmers)	4				
Veliidae/M...veliidae* (Ripple bugs)	5				
MEGALOPTERA					
Corydalidae	8				
Sialidae	6				
TRICHOPTERA CADDISFLIES)					
Dipseudopsidae	10				
Ecnomidae	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6	A		A	
Hydropsychidae > 2 sp	12				B
Philopotamidae	10				
Polycentropodidae	12				
Psychomyiidae/Xiphocentronidae	8				
Cased caddis:					
Barbarochthonidae SWC	13				
Calamoceratidae ST	11				
Glossosomatidae SWC	11				
Hydroptilidae	6				
Hydrosalpingidae SWC	15				
Lepidostomatidae	10				
Leptoceridae	6				
Petrothrincidae SWC	11				
Pisuliidae	10				
Sericostomatidae SWC	13				
COLEOPTERA					
Dytiscidae/Noteridae* (Diving beetles)	5				
Elmidae/Dryopidae* (Riffle beetles)	8				
Gyrinidae* (Whirligig beetles)	5		B		B
Haliplidae* (Crawling water beetles)	5				
Helodidae (Marsh beetles)	12				
Hydraenidae* (Minute moss beetles)	8				
Hydrophilidae* (Water scavenger beetles	5				
Limnichidae	10				
Psephenidae (Water Pennies)	10				

Taxon		S	Veg	GSM	TOT
DIPTERA (FLIES)					
Athericidae	10				
Blepharoceridae (Mountain midges)	15				
Ceratopogonidae (Biting midges)	5				
Chironomidae (Midges)	2	A		A	B
Culicidae* (Mosquitoes)	1				
Dixidae* (Dixid midge)	10				
Empididae (Dance flies)	6				
Ephydridae (Shore flies)	3				
Muscidae (House flies, Stable flies)	1				
Psychodidae (Moth flies)	1				
Simuliidae (Blackflies)	5	B	A	B	C
Syrphidae* (Rat tailed maggots)	1				
Tabanidae (Horse flies)	5				
Tipulidae (Crane flies)	5				
GASTROPODA (SNAILS)					
Ancylidae (Limpets)	6	A		A	B
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond snails)	3				
Physidae* (Pouch snails)	3		A		A
Planorbinae* (Orb snails)	3				
Thiaridae* (=Melanidae)	3				
Viviparidae* ST	5				
PELECYPODA (BIVALVES)					
Corbiculidae	5				
Sphaeriidae (Pills clams)	3				
Unionidae (Perly mussels)	6				
SASS Score		45	37	39	**85**
No. of Taxa		10	8	8	**16**
ASPT		4.5	4.6	4.9	5.3
Other biota:					
Comments:					

APPENDIX C - METHODOLOGIES APPLIED DURING THIS BIOMONITORING ASSESSMENT – INTEGRATED HABITAT ASSESSMENT (IHAS) METHODOLOGY AND CALCULATIONS.

Sampling Habitat Score	OLYVENHOUT		BOKPOORT_1		BOKPOORT_2	
Stones In Current (SIC)	Descr	Score	Descr	Score	Descr	Score
Total length of white water rapids (ie: bubbling water) (in m)	>5	5	None	0	>5	5
Total length of submerged stones in current (run) (in m)	>10	4	None	0	>10	4
Number of separate SIC area's kicked	>5	4	0	0	>5	4
Average stone sizes kicked (in cm's)	11-20	3	None	0	11-20	3
Amount of stone surface clear (in %)	>75	4	N/A	0	>75	4
Protocol: time spent actually kicking SIC's (in mins)	>3	5	0	0	>3	5
SIC score (max 20)		**25**		**0**		**25**
Vegetation (VEG)						
Length of marginal vegetation sampled (banks) (in m)	2	4	>2	5	2	4
Amount of aquatic vegetation/algae sampled (underwater in m^2)	None	0	None	0	0-0.5	1
Fringing vegetation sampled in or out of current	mix	5	mix	5	mix	5
Type of veg. (percent leafy as apposed to stems/shoots)	26-50	3	26-50	3	51-75	4
Veg score (max 15)		**12**		**13**		**14**
Other Habitat / General (O.H.)						
Stones Out Of Current (SOOC) sampled (in square m^2)	1	3	None	0	0-0.5	1
Sand sampled (in minutes)	0-0.5	2	>1	5	1	4
Mud sampled (in minutes)	0-0.5	2	>0.5	4	0.5	3
Gravel sampled (in minutes)	0-0.5	1	0-0.5	1	0.5	2
Bedrock sampled (all = no SIC, sand, gravel)	some	1	None	0	None	0
Algal presence (m^2)	none	5	none	5	none	5
Tray identification	corr.	3	corr.	3	corr.	3
O.H. score (max 20)		**17**		**18**		**18**
Sampling habitat totals (max 55)		**54**		**31**		**57**
Stream Condition						
Physical	Descr	Score	Descr	Score	Descr	Score
River make up	3 mix	5	run	2	3 mix	5
Average width of stream (in meters)	>10	1	>10	1	>10	1
Average depth of stream (in meters)	>0.5-1	3	>0.5-1	3	>2	0
Approximate velocity of stream	mix	5	slow	1	mix	5
Water colour	discol	3	opaque	1	opaque	1
Recent disturbances	none	5	none	5	none	5
Bank/Riparian vegetation	grass	2	grass	2	grass	2
Surrounding impacts	farm	1	farm	1	farm	1
Left bank cover (rocks and vegetation) (in %)	81-95	2	81-95	2	81-95	2
Right bank cover (rocks and vegetation) (in %)	81-95	2	81-95	2	81-95	2
Stream condition total (max 45)		**29**		**20**		**24**
Total IHAS score (%)		**83**		**51**		**81**

APPENDIX D - METHODOLOGIES APPLIED DURING THIS BIOMONITORING ASSESSMENT – INDEX OF HABITAT INTEGRITY (IHI) METHODOLOGY AND CALCULATIONS.

- The Habitat Integrity of the stream segment was scored according to 12 different criteria (Table 12), which represent the most important, and easily quantifiable, anthropogenically-induced impacts on the system. The instream and riparian zones were analyzed separately, and the final assessment was made separately for each, in accordance with Kleynhans' (1999) approach to Habitat Integrity Assessment. Data for the riparian zone are however primarily interpreted in terms of the potential impact on the instream component;
- The assessment of the severity of impact of modifications is based on six descriptive categories with ratings ranging from 0 (no impact), 1 to 5 (small impact), 6 to 10 (moderate impact), 11 to 15 (large impact), 16 to 20 (serious impact) and 21 to 25 (critical impact), in accordance with the level of the impact created by the criterion (Table 13).
- Analysis of the data was carried out by weighting each of the criteria. The weights given to the different instream and riparian factors used in the Intermediate Habitat Integrity are listed in Table 14.
- Based on the relative weights of the criteria, the impact of each criterion is estimated as follows: Rating for the criterion/maximum value (25) x weight (percent);
- The instream and riparian habitat integrity for each segment was calculated by adding the weighted scores of the appropriate criteria separately and subtracting the resulting values from one hundred, thus obtaining provisional Habitat Integrity scores (expressed as percentages) for instream and riparian habitats;
- In cases where riparian zone criteria and the water abstraction, flow, bed and channel modification, water quality and inundation criteria of the instream component exceeded ratings of large, serious or critical, an additional negative weight was applied. The aim of this is to accommodate the possible cumulative effect (and integrated) negative effects of such impacts (Kemper *et al*. 1999).

The following rules were applied in this respect:

- Impact = Large, lower the integrity status by 33% of the weight for each criterion with such a rating.
- Impact = Serious, lower the integrity status by 67% of the weight for each criterion with such a rating.

- Impact = Critical, lower the integrity status by 100% of the weight for each criterion with such a rating.
- The negative weights were added for the instream and riparian facets respectively and the total additional negative weight subtracted from the provisionally determined intermediate integrity to arrive at a final intermediate habitat integrity estimate (Kemper *et al*., 1999).
- The eventual total scores for the instream and riparian zone components are then used to place the habitat integrity of both in a specific intermediate habitat integrity class/category. These classes are indicated in Table 15;
- By calculating the mean of the instream and riparian Habitat Integrity scores, an overall Habitat Integrity score is obtained.

Table 12: Criteria used in the assessment of habitat integrity (Kleynhans, 1996).

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Also impacted in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in the temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al.,* 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow, which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependant upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.
Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon et al., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochthonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 13: Descriptive classes for the assessment of modifications to habitat integrity (from Kleynhans, 1996).

Impact category	Description	Score
None	No discernible impact or the factor is located in such a way that it has no impact on habitat quality diversity, size and variability.	0
Small	The modification is limited to a very few localities and the impact on habitat quality, diversity, size and variability is also very small.	1 – 5
Moderate	The modification is present at a small number of localities and the impact on habitat quality, diversity, size and variability is also limited.	6 – 10
Large	The modification is generally present with a clearly detrimental impact on quality habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11 – 15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability almost the whole of the defined section are affected. Only small areas are not influenced.	16 – 20
Critical	The modification is present overall with a high intensity; the habitat quality, diversity, size and variability in almost the whole of the defined section are detrimentally influenced.	21 – 25

Table 14: Criteria and weights used for the assessment of intermediate habitat integrity (from Kleynhans, 1996).

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid Waste Disposal	6		
TOTAL	**100**	**TOTAL**	**100**

Table 15: Intermediate Habitat Integrity Assessment Classes (from Kleynhans, 1996).

Class	Description	Score (% of total)
A	Unmodified, natural.	90-100
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the basic ecosystem functions are essentially unchanged.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

APPENDIX E – IMPACT RATING SIGNIFICANCE METHODOLOGIES & CALCULATIONS.

The significance rating (SP) is calculated by the following formula:

SP = Consequence X Probability (P)

Where: Consequence = (S + D + I + E) – R

S= Spatial extent
D=Duration
I=Intensity
E=Effects on important ecosystems
R=Reversibility

Table 16: Rating scores for the various factors used for calculating the significance rating of a particular impact.

S		D		I		E		R		P	
Rating	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
Site specific	1	Short (0-15yrs)	1	Low	1	None	1	Irreversible	0	Improbable	1
Local	2	Medium (2-15yrs)	2	Medium	3	Negligible	2	Largely irreversible	1	Possible	2
Regional	3	Long (16-30yrs)	3	High	5	Insignificant	3	Somewhat reversible	2	More than likely	3
National	4	Discontinuous	4			Significant	4	Largely reversible	3	Highly probable	4
International	5	Permanent	5			Vast	5	Totally reversible	4	Definite	5

Confidence limits:

The impact ratings are all defined in terms of confidence limits. A High impact rating with a High degree of confidence is considered to have the greatest significance. A High impact rating with a Low confidence rating therefore has a limited significance. It should be noted that a Low degree of confidence could either be attributed to a lack of sufficient data that would allow for accurate measurement of the potential impact, or that the impact falls outside the scope of the survey. This is indicated where applicable.

Project code: SSI – CSP - 2011/04

Biodiversity Impact Assessment for the proposed Concentrated Solar Thermal Power Pant (Siyanda District, Northern Cape Province) on a portion of the Farm Bokpoort 390,

compiled by

B E C

Bathusi Environmental Consulting

August 2010

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I PROJECT DETAILS

Client: SSI Environmental/ Solafrica Thermal Energy (Pty) Ltd

Report name: Biodiversity Impact Assessment for the proposed Concentrated Solar Thermal Power Pant (Siyanda District, Northern Cape Province) on a portion of the Farm Bokpoort 390

Report type: Biodiversity EIA Report

Project name: Solafrica Concentrating Solar Thermal Power Plant in the Northern Cape Province, Siyanda District

BEC Project number: SSI - CSP – 2011/04

Authority Reference: 12/12/20/1920

Compiled by: R. A. J. Robbeson (Pr.Sci.Nat.), Bathusi Environmental Consulting cc

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III SPECIALIST INVESTIGATORS

The Natural Scientific Professions Act of 2003 aims to '*provide for the establishment of the South African Council of Natural Scientific Professions (SACNASP), and for the registration of professional, candidate and certified natural scientists; and to provide for matters connected therewith'.*

Quoting the Natural Scientific Professions Act of 2003: '*Only a registered person may practice in a consulting capacity*' (20(1) – pg 14).

Floristic Investigator:	**Riaan Robbeson (Pr.Sci.Nat.)**
Qualification:	M.Sc. (Botany), UP
Affiliation:	South African Council for Natural Scientific Professions
Fields of Expertise:	Botanical Scientist & Ecological Scientist
Registration Number:	*400005/03*
Affiliation:	Grassland Society of Southern Africa
Membership Status:	Professional Member
Membership Number:	*667.08/08*
Investigator:	**Dewald Kamffer (Pr.Sci.Nat.)**
Qualification:	M.Sc. (Conservation Biology), UP
Affiliation:	South African Council for Natural Scientific Professions
Fields of expertise:	Ecological Scientist & Zoological Scientist
Registration number:	*400204/05*

IV DECLARATION OF INDEPENDENCE

All specialist investigators, project investigators and members of companies employed for the purpose of conducting this biodiversity investigation declare that:

- we act as independent ecologists compiling this report
- we consider ourselves bound to the rules and ethics of the South African Council for Natural Scientific Professions;
- at the time of completing this report, we did not have any interest, hidden or otherwise, in the proposed development or activity as outlined in this document, other than financial compensation for work performed in a professional capacity in terms of the Environmental Impacts Assessment Regulations, 2005;
- we will not be affected in any manner by the outcome of the environmental process of which this report forms part of, other than being part of the general public;
- we do not have any influence over decisions made by the governing authorities;
- undertake to disclose, to the competent authority, any material information that have or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the Environmental Impact Assessment Regulations, 2005;
- will provide the competent authority with access to all information at my disposal regarding the application, whether such information is favourable to the applicant or not;
- we do not necessarily object to or endorse the proposed development, but aim to present facts and recommendations based on scientific data and relevant professional experience; and
- should we consider ourselves to be in conflict with any of the above declarations, we shall formally submit a Notice of Withdrawal to all relevant parties and register as an Interested and Affected Party.

____

Signature of principal ecologist:

Bathusi Environmental Consulting cc (CK1999/052182/23)

____

Name of company:

10th August 2010

____

Date:

V SURVEY DETAILS

Field surveys were conducted during the period of 20th to 23rd April 2010.

VI LEGISLATION

Compliance with provincial, national and international legislative aspects is strongly advised in the planning, assessment, authorisation and execution of this particular project. Legislative aspects taken cognisance of during the compilation of this report included the following, but may not necessarily be limited to the following:

Table 1: Legislative guidance for this project	
Biodiversity Act (No. 10 of 2004)	To provide for the management and conservation of South Africa's biodiversity within the framework of the National Environmental Management Act 1998; the protection of species and ecosystems that warrant national protection; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; the establishment and functions of a South African National Biodiversity Institute; and for matters connected therewith.
Conservation of Agricultural Resources Act 43 of 1983	The conservation of soil, water resources and vegetation is promoted. Management plans to eradicate weeds and invader plants must be established to benefit the integrity of indigenous life.
Constitution of the Republic of South Africa (Act 108 of 1996)	The Bill of Rights, in the Constitution of South Africa (No. 108 of 1996), states that everyone has a right to a non-threatening environment and requires that reasonable measures are applied to protect the environment. This protection encompasses preventing pollution and promoting conservation and environmentally sustainable development. These principles are embraced in NEMA and given further expression.
Convention on Biological Diversity, 1995	International legally binding treaty with three main goals; conserve biological diversity (or biodiversity); ensure sustainable use of its components and the fair and equitable sharing of benefits arising from genetic resources.
Convention on International Trade in Endangered Species of Wild Life and Fauna	International agreement between governments, drafted as a result of a resolution adopted in 1963 at a meeting of members of the International Union for Conservation of Nature (IUCN). Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival and it accords varying degrees of protection to more than 33,000 species of animals and plants.
Environmental Conservation Act (No. 73 of 1989)	To provide for the effective protection and controlled utilization of the environment and for matters incidental thereto.
National Environmental Management Act (No. 107 of 1998)	Requires adherence to the principles of Integrated Environmental Management (IEA) in order to ensure sustainable development, which, in turn, aims to ensure that environmental consequences of development proposals be understood and adequately considered during all stages of the project cycle and that negative aspects be resolved or mitigated and positive aspects enhanced.
National Environmental Management Act (No 10 of 2004)	Restriction of activities involving alien species, restricted activities involving certain alien species totally prohibited and duty care relating to listed invasive species.

Table 1: Legislative guidance for this project

National Forest Act, 1998 (No 84 of 1998)	Cutting, disturbing, damaging or destroying any indigenous, living tree in a natural forest, except in terms of a licence issued under section 7(4) or section 23; or an exemption from the provisions of the subsection published by the Minister in the Gazette. The sections include protected tree species, a particular tree, a group of trees or particular woodland to be a protected tree, group of trees, woodland or species. In terms of section 15, no person may cut, disturb, damage, destroy or remove any protected tree; or collect, remove, transport, export, purchase, sell, donate or in any other manner acquire of dispose of any protected tree, except under a licence granted by the Minister.
Protected Areas Act (No. 57 of 2003)	To provide for the protection and conservation of ecologically viable areas representative of South Africa's biological diversity and its natural landscapes and seascapes; for the establishment of a national register of all national, provincial and local protected areas; for the management of those areas in accordance with national norms and standards; for intergovernmental co-operation and public consultation in matters concerning protected areas; and for matters in connection therewith.

VII GLOSSARY OF TERMS

Alternatives: A possible course of action, in place of another, that would meet the same purpose and need but which would avoid or minimize negative impacts or enhance project benefits. These can include alternative locations/sites, routes, layouts, processes, designs, schedules and/or inputs. The "no-go" alternative constitutes the 'without project' option and provides a benchmark against which to evaluate changes; development should result in net benefit to society and should avoid undesirable negative impacts.

Biome: Any major ecological community of organisms, usually characterized by a dominant vegetation type.

Cumulative impacts: The combined or additive effects on biodiversity or ecosystem services over time or in space. They may seem to be insignificant when seen in isolation, but collectively they have a significant effect

Direct impacts: Those that take place at the same time and in the same space as the activity, e.g. clearing of natural vegetation for agriculture.

Direct, indirect and cumulative impacts: Decision makers need to know the direct, indirect and cumulative impacts of a proposed activity on the environment, if they are to take informed decisions in line with sustainable development.

Do-nothing Alternative: The option of not undertaking the proposed alternative.

Ecologically sensitive ecosystem: One where relatively even minor disturbances may result in substantial and significant changes.

Ecosystems: Include living (e.g. plants, animals) and non-living (e.g. minerals, soil, water) components, which can be defined in terms of distinguishing characteristics (e.g. a wetland ecosystem, a freshwater ecosystem, a terrestrial ecosystem, a forest ecosystem, etc.).

Endemic or range-restricted species or ecosystem: One whose distribution is confined to a particular and often very limited geographical region.

Environment: Broadly covers our surroundings and the characteristics of those surroundings that influence our health and wellbeing. That is, the environment includes all living organisms (plants, animals and other life), the physical environment (land, water and air), as well as social, economic and cultural conditions. Sometimes we speak of 'the natural environment' and 'the built environment', to differentiate between natural and man-made systems.

Habitat: The place or type of site where an organism or population naturally occurs.

Indigenous: Native to a particular area.

Impact assessment: A process that is used to identify, predict and assess the potential positive and negative impacts of a proposed development (including reasonable alternatives) on the environment, also proposing appropriate management actions and monitoring programmes. Impact assessment is used to inform decision-making by the project proponent, relevant authorities and financing institutions. The process includes some or all of the following components: screening, scoping, impact assessment and decision-making.

Indirect impacts: Occur later in time or at a different place from the activity, e.g. extraction of groundwater for irrigation leads to changes in the water table and affects distant water users.

Irreplaceable loss: When it results in the loss of a resource without substitute, and which cannot be replaced. An impact leading to irreplaceable loss of biodiversity is, by definition, irreversible

Irreversible impact: One that arguably cannot be reversed in time (e.g. decrease in area of a specific vegetation type, loss of genetic diversity through reduction in size of populations of a particular species). Some, but not all, irreversible impacts will lead to irreplaceable loss of biodiversity. They may, or may not, be acceptable to society or stakeholders in terms of their current values

Issue: A context-specific question that asks "what, or how severe, will the impact of some activity/aspect of the development be on some element of the environment?"

Natural resources: Include living and non-living materials that can be exploited or used by people. Natural resources form part of ecosystems, and our living natural resources contribute to biodiversity. Some people use 'natural resources' to mean the same thing as biodiversity or ecosystem services.

Precautionary Principle: States that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

Protected area: As defined by National Environmental Management: Protected Areas Act, 2003 (No. 57 of 2003).

Protected species or ecosystem: One that is protected by law from particular activities and land uses.

Red Data Book' or 'Red List': Provides information on threatened species.

Significance: A term used to evaluate how severe an impact would be, taking into account objective or scientific data as well as human values. A specific significance rating should not be confused with the acceptability of the impact (i.e. an impact of low significance is not automatically “acceptable”).

Species: A group of plants, animals, micro-organisms or other living organisms that are morphologically similar; that share inheritance from common ancestry; or whose genes are so similar that they can breed together and produce fertile offspring.

Sustainable development: Development that meets the needs of the current generation without compromising the ability of future generations to meet their own needs and aspirations, or improving the quality of human life while living within the carrying capacity of supporting ecosystems”.

Threatened species or ecosystem: Species/ Ecosystems that are at risk of going extinct in its natural range. It may be ‘critically endangered’ at extremely high risk, ‘endangered’ at very high risk, or ‘vulnerable’ at high risk. Species or ecosystems at low or no risk are not ‘threatened’, and fall into the ‘near threatened’ or ‘least concern’ categories.

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1 EXECUTIVE SUMMARY

1.1 Biophysical Environment

The proposed site is situated on the farm Bokpoort 390, located in the Siyanda District Municipality, Northern Cape Province comprising approximately 4,780ha. No area of permanent surface water is present on the site. Evidence of non-perennial drainage lines could be viewed on the Google Earth image and visually in the southern part of the proposed site, but these areas are only expected to contain flowing water during periods of exceptional high rainfall. The study area lies within the Lower Orange Water Management Area and the Orange River is the primary water resource for the area. This river is used extensively for irrigation, and is heavily cultivated along its banks. No significant wetlands, estuaries, Ramsar Sites or major dams are present within the immediate vicinity of the study sites. The most significant impact that currently affects the status of smaller riparian systems in the region is the effect of grazing and trampling of cattle in areas where natural habitat are grazed intensively.

The study area is located in a region that comprises extensive areas of natural habitat with extremely limited transformed areas to the south of the study area, mainly the result of agriculture. The extremely low transformation factor of the region renders the fragmentation and habitat isolation factors of the region extremely low. A relative low density of road infrastructure in the region is basically the only aspect that contributes towards habitat isolation and fragmentation. Towns and urban areas are mostly located on the banks of the Orange River and is relative small in size, representing limited habitat transformation. Habitat transformation in the region is mostly attributed to agriculture (irrigated agriculture) in the immediate vicinity of the Orange River. The site itself exhibit extremely limited habitat transformation and is generally composed by ‘Thicket & Bushland’ and ‘Shrubland’ land cover categories. Grazing by cattle, sheep and game represents the most important land use.

The ENPAT database revealed that the study area does not areas where significant slopes are present, but it should however be noted that the ENPAT database slope classes is based on a high contour interval (100m). The study area generally characterised by Dune Hills (parallel crests) and Lowlands in the northern part and Extremely Irregular Plains in the south, sloping towards the Orange River in a south-eastern direction from a high point of approximately 1,100m in the north to approximately 900m in the south at a general gradient of approximately 1.1%. Part of the Korannaberg foothills is located in the extreme northern section of the study area, comprising a small section of the site, characterized by the presence of boulders, high slopes and mountainous topography.

The following VEGMAP (Mucina & Rutherford, 2006) vegetation types are situated within the respective study areas:

- Bushmanland Arid Grassland (Least Threatened);
- Gordonia Duneveld (Least Threatened);
- Kalahari Karroid Shrubland (Least Threatened); and
- Koranna-Langeberg Mountain Bushveld (Least Threatened).

The general geology of the site mainly comprises red-brown, coarse-grained granite gneiss; and quartz-muscouite schists, quartzite, quartz-amphibole schists and greenstones of the Groblershoop formation, Brulpan group. Calcrete is also found especially on the south eastern part of the area.

Soils are typically weakly structured with low organic content and which soils drain freely resulting in a soil surface susceptible to erosion, especially wind erosion when the vegetation cover is sparse. Soils of the flat lowland areas can be described as red, eutrophic (high base status) and excessively drained sandy soils. The soils often overlay thick layers of calcrete, which is known for its hardness. The average clay content of the topsoil is less than 10 – 15% and the soil depth varies between 400 and 750mm. The study area is underlain be the following land type units:

- Ae4;
- Af7;
- Ag4; and
- Ic4.

Results of the biophysical sensitivity assessment indicate that the largest extent of the study area comprises biophysical habitat attributes of a moderate sensitivity. The northern section of the study area comprises habitat of high sensitivity, related to the presence of the Korannaberg foothills and rocky outcrops. The 'Extremely Irregular Plains' topographical unit was found to be of moderate sensitivity as the topographical variation is not so severe to result in highly varying habitat conditions, hence a moderate biophysical sensitivity was ascribed. Areas of medium sensitivity comprised untransformed/ natural habitat that are not included in any of the higher categories.

The absence of extensive areas of low and medium-low biophysical sensitivity is a characteristic of the region that reveals the natural status of habitat. Natural habitat of the region is largely unaffected by human activities and is generally in a pristine condition. Areas included in the Low biophysical category represent all degraded habitat, including areas of agriculture, urban areas, roads, degraded habitat, etc.

1.2 FLORA

The study site is located within the Kalahari variation of the Savanna Biome, which although referred to as a desert, is not a true desert as it does not approximate the extreme aridity of a true desert. This area is densely covered by grasses, shrubs and trees. The SANBI database indicates the presence of approximately 5,315 plant species within the Northern Cape Province, with only 91 species within the ¼ degree grids in which the study sites are located, reflecting a poor floristic knowledge of the region. The species diversity comprises a diversity of growth forms dominated by herbs, dwarf shrubs and grasses. Trees and tall shrubs comprise a relative low part of the total, reflecting on the open savanna/ shrubland physiognomy of the region.

A total of 112 plant species were identified during the site investigation. The regional setting dictates the physiognomic dominance of the herbaceous and shrub component. Trees occur sporadically throughout the study area. Taking the setting of the study area into consideration, the species composition of untransformed vegetation types is regarded representative of the regional vegetation. A total of 35 plant families were represented in the study area, dominated by Poaceae, Fabaceae and Asteraceae.

Taking the setting of the study area into consideration, the species composition of the natural vegetation types is regarded representative of the regional vegetation. In spite of a relative homogenous appearance to much of the regional habitat, with the exception of extensive mountain ranges, a relative obvious physiognomic variability is noted in the study area with plains alternating with parallel dunes and mountain foothills in the northern parts. Many plant species occur across all of the habitat types, but many of the differences between units are ascribed purely on the basis of terrain morphology, soil characteristics or changes in the dominance and structure of the plant species. Surface water and rainfall in this part of the Kalahari is scarce and, together with substrate, is a major driving force of vegetation development.

Results of the photo analysis and site investigations revealed the presence of the following habitat types:
- Calcareous Low Shrub Plains (Medium Floristic Sensitivity);
- Open Shrub Duneveld (Medium-High Floristic Sensitivity);
- Open Shrub Plains (Medium Floristic Sensitivity);
- Quartzitic Low Shrub Plains (High Floristic Sensitivity);
- Rocky Outcrops/ Foothills (High Floristic Sensitivity);
- Transformed Areas (Low Floristic Sensitivity); and
- Riparian Habitat (Medium-High Floristic Sensitivity).

SANBI records for the region indicate the presence of no Red Data flora species within the ¼ degree grids in which the study area is located. Two protected tree species occur within the study area, including *Acacia erioloba* and *Boscia albitrunca*. The following exotic plant species occur in the study area:

- *Prosopis glandulosa* (Category 2 Invader);
- *Rhigozum trichotomum* (Declared indicator of encroachment); and
- *Acacia mellifera* (Declared indicator of encroachment).

1.3 FAUNA

- A total of 12 butterflies were observed in the study area; most of these species are common and widespread; if not in Southern Africa then in the drier western regions of the subcontinent. It is highly likely that many other species will complement the observed assemblage of butterflies should the study be repeated in early summer (the only flight time of some Lepidoptera groups, notably Lycaenidae).
- During the field study, the presence of eight reptiles was confirmed to occur in the study area by means of observation techniques as well as by the landowner.
- A total of 30 bird species was observed in the study area during the field survey. The diversity of the species observed in the study area confirms the natural and diverse nature of the faunal habitats of the study area.
- A total of 25 mammals were confirmed in the study area during the field investigation. It must be noted that many of the ungulate species listed here as residents of the study area are a direct result of the hunting-related activities of the farm on which the study area is located; they cannot be considered free-roaming and are fenced in for hunting purposes. The study area proved to have a significant number of carnivores including Bat-eared Fox, Cape Fox, Slender Mongoose, Yellow Mongoose, Suricate, Caracal, Striped Polecat and Black-backed Jackal. This is testament to the diversity and functionality of the ecosystem of which the study areas forms part of.

Red Data animals known to be present in the Q-grids were considered potential inhabitants of the study area. Additionally, species observed in the study sites during the field investigation were added to the list of species considered relevant to the study area. The likelihood of each species' presence in the study areas were estimated based on known ecological requirements of species; these requirements were compared to the ecological conditions found in the study area and surrounding faunal habitat.

- Linda's Hairtail is the only potential Red Data butterfly inhabitant of the study area. There is no data on the larval host of this butterfly, but it is thought to potentially be *Acacia erioloba*.
- The Giant Bullfrog, *Pyxicephalus adspersus* (NT), is widespread in South Africa and is known from all nine provinces as well as Swaziland and Lesotho and is considered to have a moderate-high probability of occurring in the study area.
- No Red Data reptiles are known from the Q-grids of the study area.
- Two Red Data mammals were confirmed to occur in the study area: Bushveld Gerbil (DD) and Honey Badger (NT).

The close relationship between vegetation units and specific faunal composition has been noted in several scientific studies. For the purpose of this investigation the floristic units identified in the floristic assessment are considered representative of the faunal habitat types. The following faunal sensitivities were estimated for the habitat types of the study area:

- Calcareous Low Shrub Plains (Medium Faunal Sensitivity);
- Open Shrub Duneveld (Medium Faunal Sensitivity);
- Open Shrub Plains (Medium-Low Faunal Sensitivity);
- Quartzitic Low Shrub Plains (Medium-High Faunal Sensitivity);
- Rocky Outcrops/ Foothills (High Faunal Sensitivity);
- Transformed Areas (Low Faunal Sensitivity); and
- Riparian Habitat (High Floristic Sensitivity).

The study area investigated does not represent a significant portion of the remaining untransformed areas of any of the regional vegetation communities; indeed the larger region in which the study area is located remains largely natural and well-connected. It can be reasoned that the proposed project and associated impacts are unlikely to influence any animal species, assemblage or community significantly based on above-mentioned facts.

The relative sensitivities of the faunal habitats are based on the potential impacts of the proposed project on the faunal communities of these habitats relative to each other. Wetland and ridge faunal assemblages (mostly of invertebrates, birds, reptiles and frogs) are intrinsically limited in space and are therefore naturally vulnerable to habitat degradation and –transformation processes. With regards to mammals, one of the most important impacts (albeit an indirect impact potentially associated with the proposed project) is the increase in road traffic volumes and associated road kills.

1.4 Ecological Sensitivity

The following ecological sensitivities were estimated for the habitat types of the study area:

- Calcareous Low Shrub Plains (Medium Ecological Sensitivity);
- Open Shrub Duneveld (Medium-High Ecological Sensitivity);
- Open Shrub Plains (Medium Ecological Sensitivity);
- Quartzitic Low Shrub Plains (High Ecological Sensitivity);
- Rocky Outcrops/ Foothills (High Ecological Sensitivity);
- Riparian Habitat (High Ecological Sensitivity).
- Transformed Areas (Low Ecological Sensitivity); and

Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes and rocky outcrops. The status of these areas is moderately pristine and are therefore considered suitable habitat for a variety of Red Listed flora and fauna species. These areas are relative small in size and are not well represented in the general region. A medium-high ecological sensitivity is exhibited by the natural duneveld areas of the study area, particularly as a result of the potential presence of several Red Data species and the high suitability of these areas for Red Data species.

The largest extent of the study area exhibit medium ecological attributes and the proposed activity is not expected to result in significant impacts in these areas.

1.5 Impact Assessment

Development within areas of high ecological sensitivity is generally associated with high significance impacts on biodiversity attributes. This is mainly a result of the limited presence of these habitat types as well as the high likelihood that Red Data flora and fauna species that occupy these areas will be affected adversely by the proposed development. In contrast, habitat types that are common to the region and that are not likely to be occupied by Red Data flora or fauna species, exhibit lower sensitivity to the proposed development. It is therefore strongly recommended that the proposed development be place within the Open Shrub Plain habitat type. Furthermore, it will be beneficial for the environment if this proposed development is placed in close vicinity to existing areas of degradation, preferably as close as possible to the existing substation and roads, thereby limiting the spread of impacts and the necessity of additional roads and linear infrastructure.

Placement of any development structures and required infrastructure in close vicinity to high sensitivity habitat should be avoided at all costs.

2 TERMS OF REFERENCE

The major objective of this Biodiversity Impact Assessment is to determine environmental "opportunities" and "constraints" (sensitivity analysis) of the Bokpoort site with the ultimate aim of considering feasible locations of the proposed development plant, taking cognisance of biological attributes characterising the area.

The Terms of Reference for the floristic investigation are as follows:

- Obtain all relevant Précis and Red Data flora information;
- Conduct a photo analysis of the proposed area;
- Identify preliminary floristic variations;
- Survey preliminary habitat types to obtain an understanding of the floristic diversity (common flora species, Red Listed flora species, alien and invasive plant species and medicinal plant species);
- Assess the presence of Red List flora species according to information obtained from SANBI;
- Incorporate existing knowledge of the study area;
- Describe the variation in floristic communities in terms of biophysical attributes and phytosociological characteristics (species presence, dominance, structure);
- Compile a floristic sensitivity analysis;
- Incorporate results into the Biodiversity Impact Evaluation;
- Map all relevant aspects;
- Provide pertinent recommendations; and
- Present all results in a suitable format.

The Terms of Reference for the faunal investigation are as follows:

- Obtain available faunal distribution records and Red Data faunal information
- Survey the site for faunal diversity by means of relevant survey methods;
- Assess the potential presence of Red Data fauna species;
- Incorporate existing knowledge of the study area;
- Describe the status of available habitat in terms of faunal attributes, preferences and conservation potential;
- Compile a faunal sensitivity analysis;
- Incorporate results into the Biodiversity Impact Evaluation;
- Map all relevant aspects; and
- Present all results in a suitable format.

3 INTRODUCTION

The loss, transformation and degradation of natural habitat are some of the most important causal mechanisms of biodiversity loss (UNEP, 2002). Conversion of natural habitat types by cultivation, grazing, urban developments, forestation, mining, dams, industries and alien plant invasions results in ecosystem degradation and species loss. The impact on biodiversity has been substantial, and significant proportions of South Africa's flora and fauna are threatened (Wynberg, 2002).

It is estimated that about 16.5% of South Africa's land cover is transformed, and a further 10% degraded (Wynberg, 2002). Sensitive arid habitat such as the Succulent Karoo Biome of the Northern Cape Province is particularly prone to degradation as a result of overgrazing, alien invasive species and mining (CEPF, 2003). In addition, the aridity of the climate precludes rapid recovery of degraded areas. When examining veld degradation in terms of severity and rate of degradation, the Northern Cape emerged as the third most degraded province in South Africa, after the Limpopo Province and KwaZulu-Natal (Hoffman and Ashwell, 2001).

In 1992, the Convention of Biological Diversity, a landmark convention, was signed by more than 90 % of all members of the United Nations. The enactment of the National Environmental Management Biodiversity Act, 2004 (Act No. 10 of 2004), together with the abovementioned treaty, focuses on the preservation of all biological diversity in its totality, including genetic variability, natural populations, communities, ecosystems up to the scale of landscapes. Hence, the local and global focus changed to the sustainable utilisation of biological diversity.

Bathusi Environmental Consultants (BEC) has been appointed as independent ecological specialists to conduct a strategic biodiversity scoping evaluation of the biological environment that will be affected by the proposed development. Dewald Kamffer (Faunal Specialists Incorporated FSI) conducted the faunal assessment; Riaan Robbeson (BEC) conducted the floristic assessment, provided the ecological interpretation and compiled the ecological sensitivity analysis.

4 LIMITATIONS OF THIS INVESTIGATION

Although care was taken to ensure the proper investigation of all areas, it is only reasonable to expect that not all species could be located or identified during a single survey. Because rare and endemic species normally don't occur in great densities and because of customary limitations in the search and identification of Red Listed species, the detailed investigation of these species was not possible.

Results of this investigation are therefore based on a snapshot investigation of the study area and not on the detailed long-term investigation of all environmental attributes and the varying degrees of biological diversity that may be present in the study area. No concrete conclusions may therefore be drawn with regards to biological diversity or conservation strategies as far as this study area is concerned.

It is emphasised that information, as presented in this document, only have bearing on the site as indicated on the accompanying maps. This information cannot be applied to any other area, however similar in appearance or any other aspect, without proper investigation.

Furthermore, additional information may come to light during a later stage of the process or development. This company, the consultants and/or specialist investigators do not accept any responsibility for conclusions, suggestions, limitations and recommendations made in good faith, based on the information presented to them, obtained from the surveys or requests made to them at the time of this report.

5 PROJECT BACKGROUND

Bohlweki-SSI Environmental (Bohlweki-SSI) has been appointed as an Environmental Assessment Practitioner (EAP) by Solafrica, to undertake the appropriate environmental studies for this proposed project. Bathusi Environmental Consulting (BEC) was appointed as independent specialist consultants to conduct the Biodiversity Impact Assessment for the proposed project. Faunal Specialists Incorporated (FSI) was responsible for the faunal discipline; BEC conducted the floristic assessment, provided the ecological interpretation and compiled the Impact Assessment.

5.1 GENERAL

In 2006, Eskom Holdings Limited conducted an Environmental Impact Assessment (EIA) study for a pilot CSP plant with an installed capacity of approximately 100MW. Through a series of feasibility and high-level screening studies undertaken by Eskom, the Northern Cape Province ranked as the most favourable area for the establishment of a new CSP plant. Within the Northern Cape Province, Upington and Groblershoop were identified as preferred sites for the establishment of the CSP plant. Subsequent to the Scoping and EIA studies, the farm Olyfenhouts Drift was selected as the preferred site and with consideration of the site specific environmental sensitivities, a preferred location for the plant on the farm was selected. Eskom received authorisation from the Department of Environmental Affairs to construct the CSP plant during 2006.

The fundamental principle of concentrating solar power (CSP) technologies is to collect the energy carried by sunrays, allowing a heat transfer fluid (HTF) to absorb the collected energy and thereby converting the thermal energy into further useful forms such as electricity.

Against the backdrop of the above study, Solafrica intends constructing a CSP plant and associated infrastructure with a maximum generation capacity of 75MW in the Northern Cape Province on the Bokpoort 390 site that was identified during the Eskom CSP EIA study. The footprint of the proposed CSP plant is approximately 100ha and the components will most likely include:

- A power block consisting of heat exchangers, turbines, generators and cooling block (the height of the power block is estimated to be between two to five storeys high);
- Collection field – at present this could either include trough mirrors (trough technology) or heliostats (power tower technology) depending on the final technology selected for project;
- Storage tanks (if required);
- Distribution power lines and associated structures (pylons);
- Office (including store room);
- Temporary staff accommodation (if required);
- Ablution facilities; and
- Access and internal roads.

5.2 ALTERNATIVES

In determining the most appropriate site for the establishment of a new Concentrating Solar Thermal Power Plant, various options were investigated by Eskom during previous EIA studies conducted for the pilot CSP plant. This site selection process considered the following criteria:

- The availability and accessibility of primary resources required for the operation of the power plant, such as sun (i.e. the required Direct Normal Insolation) and water;
- Availability of land to locate the site and associated infrastructure;
- The availability and accessibility of infrastructure for the provision of services, manpower and social structure for the construction and operation of the power plant;
- The ease of integration of the new power plant into the existing National Transmission network/grid and the environmental impacts associated with this integration; and
- General environmental acceptability in terms of social impacts, water utilisation, general ecology, etc.

Through a series of feasibility and high-level screening studies undertaken by Eskom the Northern Cape Province ranked as the most favourable area for the establishment of a new concentrating solar power plant. Two sites were included as alternatives for the proposed project, namely:

- Farm Olyfenhouts Drift (15km west of Upington); and
- Farm Bokpoort 390 (25km southeast of Groblershoop).

Ultimately the client has indicated the preference for the Bokpoort site; this was mainly based on technical engineering considerations. The consequence of this decision for the EIA process is that the Olyfenhouts Drift site is withdrawn from the application process and this Biodiversity Impact Assessment will only address the Bokpoort site.

5.3 'Do-Nothing' Alternative

The 'Do-Nothing' Alternative is the option of not establishing a new Concentrated Solar Thermal Plant at a site in the Northern Cape Province. This alternative was investigated by SSI Environmental and the need for alternative energy production methods were highlighted in the Environmental Scoping Report (ESR). Ultimately it was concluded that without the implementation of this project, the use of renewable options for power supply will be compromised in the future, which will have potentially significant negative impacts on environmental and social well-being. The 'Do-Nothing' option is therefore not considered a feasible option on this proposed project.

6 APPROACH TO THE BIODIVERSITY INVESTIGATION

While a proper knowledge of the biodiversity of the region is not negotiable to the ultimate success of this project, an attempt was made to remove any subjective opinions that might be held on any part of the study area as far as possible. Inherent characteristics of a project of this nature implies that no method will be foolproof, mainly as a result of shortcomings in available databases and lack of site specific detail that could be obtained from limited detailed site investigations conducted over a short period of time. It is an unfortunate fact that inherent sensitivities within certain areas are likely to exist that could not be captured or illustrated during the process. This is a shortcoming of every scientific study that has ever been conducted; it simply is not possible to know everything or to consider aspects to a level of molecular detail. However, the approach followed in this study is considered effective in presenting objective comments on the comparison of biodiversity sensitivity of parts in the study area.

In order to present an objective opinion of the biodiversity sensitivity of the study area and how this relates to the suitability/ unsuitability of any area within the site in terms of the proposed development, all opinions and statements presented in this document are based on the following aspects, namely:

- A desk-top assessment of all available biological and biophysical data;
- Augmentation of existing knowledge by means of site specific and detailed field surveys;
- Specialist interpretation of available data, or known sensitivities of certain regional attributes;
- A GIS analysis, mapping and description of results obtained from the process; and
- An objective impact assessment process, estimating potential impacts on biological and biophysical attributes.

6.1 Background Information

The overall goal of this section of the biodiversity investigation is to establish a reference point for the biophysical and biological sensitivities of the study area by means of the Ecosystem Approach or Landscape Ecology. The Ecosystem Approach is advocated by the Convention on Biological Diversity. It recognizes that people and biodiversity are part of the broader ecosystems on which they depend, and that it should thus be assessed in an integrated way. Principles of the Ecosystem Approach include the following:

- The objectives of ecosystem management are a matter of societal choice;
- Ecosystem managers should consider the effects of their activities on adjacent and other systems;
- Conservation of ecosystem structure and functioning, to maintain ecosystem services, should be a priority target;
- Ecosystems must be managed within the limits of their functioning;
- The approach must be undertaken at appropriate spatial and temporal scales;
- Objectives for ecosystem management should be set for the long-term;
- Management must recognise that change is inevitable;
- The approach should seek an appropriate balance between, and integration of, conservation and use of biodiversity;
- All forms of relevant information should be considered; and
- All relevant sectors of society and scientific disciplines should be involved.

For the purpose of this particular study a local scale was selected as suitable in terms of the size of the study area. The approach of Landscape Ecology includes the assessment of biophysical and societal causes, consequences of landscape heterogeneity and factors that causes disturbance to these attributes. In laymen's terms it implies that if sensitive habitat types/ ecosystems (frequently associated with biodiversity elements of high sensitivity or conservation importance) are protected, species that are highly sensitive to changes in the environment will ultimately be protected. Species conservation is therefore largely replaced by the concept of habitat conservation. This approach is regarded effective since the protection of sensitive ecosystems will ultimately filter down to species level.

It is inevitable that the Landscape Ecology Approach will not function effectively in all cases since extremely localised and small areas of sensitivity do occur scattered in the study area, which can not always be captured on available databases or might have been missed during the site investigations. In addition to the compilation of basic species lists and the identification and description of localised ecological habitat it was also regarded important to identify areas of sensitivity on a local scale and, where possible, communities or species that are considered sensitive in terms of impacts that are likely to result from the proposed development.

This investigation therefore aims to:

- Determine the biological sensitivity of the receiving natural environment as it relates to the construction and operation of the plant and associated infrastructure in a natural environment;
- Highlight the known level of biodiversity;
- Highlight flora and fauna species of conservation importance that are likely to occur within the study area;
- Estimate the level of potential impacts of the construction and operation of proposed power lines on the biological resources of the study area;
- Apply the Precautionary Principal throughout the assessment[1].

6.2 Assessment of Biophysical Attributes

6.2.1 Data Selection Process

Available databases of biophysical attributes are implemented to identify regional areas of importance as it relates to biodiversity. Biophysical attributes that are known to be associated with biodiversity aspects of importance, conservation potential or natural status of the environment were implemented to compile the ecological sensitivity analysis of the study area. These attributes include the following:

- Areas of known biological importance (ENPAT);
- Areas of surface water (ENPAT);
- Degradation classes (ENPAT Land Cover Classes);
- Regional vegetation types (VEGMAP);
- Land cover categories (ENPAT); and
- Ridges and outcrops.

The first step in assessing the biophysical aspects of importance is the delineation of natural habitat, or the exclusion of transformed or degraded habitat. Areas that are transformed as a result of human activities, including agriculture, mining, urban development, etc, constitute parts of the study area where no natural habitat remains and where natural biodiversity is entirely compromised, to the extent that any recovery to a previous, pristine status is regarded impossible. These areas are generally suitable for the purpose of construction and development since impacts on important/ sensitive biological resources are regarded unlikely. Ultimately, areas that are characterised by high levels of transformation or degradation or which are characterised by low occurrences of biophysical aspects or biodiversity importance, will be considered more suitable for the proposed development, compared to areas constituting large tracts of untransformed and sensitive habitat types.

Secondly, sensitivity values are ascribed to biophysical attributes based on how these contribute to biological diversity or sensitivity. Ultimately all the information is compiled to present a holistic picture of the areas where biophysical aspects of importance occur,

[1] (www.pprinciple.net/the_precautionary_principle.html).

presenting a map that depicts regional biodiversity sensitivities based on biophysical attributes.

6.2.2 Biophysical Sensitivities - GIS Analysis

This method is believed to present a holistic overview of the biophysical sensitivity of the area, based on available data as well as the specialist's interpretation of the sensitivity of aspects that are contained in the databases. In specific cases an adjustment of sensitivity of certain areas were made based on information that was obtained from field surveys as well as information that was presented from landowners and interested parties.

The GIS analysis of data was compiled in following stages, namely:

- As a first approximation an assessment was compiled during which available databases were assessed for suitability of use in this particular project. Every attempt was made to utilise the most recent available data; databases were replaced as newer information became available even during late stages of the assessment. Each database was separated into different aspects in terms of how it affects biodiversity sensitivity on a local and regional scale:
    - A biodiversity sensitivity category was ascribed to respective biophysical attributes. For example, the 'Land Cover' database was separated into respective classes in the manner in which it affects the local and regional biodiversity sensitivity, i.e. classes such as 'Agricultural', 'Urban Developments' and 'Degradation' was grouped and ascribed a LOW value;
    - Care was taken to avoid duplicity between the various databases, for instance, aspects such as 'Woodland' and 'Grassland' was omitted from the 'Land Cover' database as these classes are adequately represented by the VEGMAP database;
    - Care was also taken of existing gaps of information in available databases, for example; while the ENPAT database of rivers does reflect larger rivers on a national scale, additional data is available in other databases that are not necessarily captured in the ENPAT database;
    - Where a single database contains different classes of sensitivity, these databases were split in the respective classes for layering;
    - Available databases were subsequently integrated in order to determine the maximum sensitivity of a particular parcel of land; and
    - The resultant map provided a basic assessment of the potential biophysical sensitivity on a local and regional scale.

6.3 FLORISTIC ASSESSMENT

The floristic assessment was conducted by R. A. J. Robbeson (Pr.Sci.Nat.).

6.3.1 General Floristic Attributes

The vegetation investigation is based on a variation of the Braun-Blanquet method whereby vegetation is stratified on aerial images with physiognomic[2] characteristics as a first approximation. These initial stratifications are then surveyed for floristic and environmental diversity during a site investigation and ultimately subjected to a desktop analysis to establish differences/ similarities between observed units.

In preparation for the site survey, physiognomic homogenous units are identified and delineated on digital aerial photos, using standard aerial photo techniques. A site visit was conducted to examine the general floristic attributes and -diversity of the study area. Qualitative observations were made at every sample plot and the following data were recorded:

- all plant species and life forms;
- cover abundance values of each species, based on the Braun-Blanquet scale;
- crown cover and average height of different life forms;
- ecological quality of the area (with reference of to degree of disturbance and proportion of weeds and invasive species;
- the physical landscape (soil, topography, rockiness, slope, aspect, etc.); and
- digital photographs of all pertinent attributes.

A desktop analysis of sample data was conducted to establish differences/ similarities between delineated vegetation units, which were subsequently described in terms of species composition and dominance as well as driving (developmental) environmental parameters. Preliminary results and species lists that are provided should be interpreted with normal liabilities in mind.

6.3.2 Red Data Flora

Red Listed flora information, as presented by SANBI was used as a point of departure for this assessment. Since a snapshot investigation of an area, such as this particular investigation, represents a severe limitation in terms of locating and identification potential Red Listed flora species, particular emphasis was placed on the identification of habitat deemed suitable for the possible presence of Red Listed plant species and associating the suitability of the habitat to known habitat types of Red Listed flora species.

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[2] Physiognomy refers to the visual appearance of vegetation in terms of different growth classes, biomass, height, etc.

6.3.3 Floristic Sensitivity

The aim of this exercise is to determine the inherent sensitivity of vegetation communities by means of the comparison of weighted floristic attributes. Results of this exercise are not 'stand-alone' and will eventually be presented in conjunction with results obtained from the faunal investigation.

The first step in the process is the identification of **Sensitivity Criteria**. These criteria represent floristic attributes of the area that contribute towards the inherent sensitivity/ degradation of the different vegetation types. A **Weighting** is applied to each of the Sensitivity Criterion and this is determined by means of ranking of each criterion against all other Sensitivity Criteria, placing the criteria on a scale of increasing importance from 1 to 10, where 10 represents the highest importance category and 1 the lowest.

Each vegetation unit is subjectively rated on a scale of 1 to 10 (**Sensitivity Values**) in terms of the influence that the particular Sensitivity Criterion has on the floristic status of the plant community. Separate Values are multiplied with the respective Criteria Weighting, which emphasises the importance/ triviality that the individual Sensitivity Criteria have on the status of each community. **Ranked Values** are then added and expressed as a percentage of the maximum possible value (**Floristic Sensitivity Value**) and placed in a particular class, namely:

High	80% – 100%
Medium – high	60% – 80%
Medium	40% – 60%
Medium – low	20% – 40%
Low	0% – 20%

This method is considered effective in highlighting sensitive areas, based on observed floristic attributes rated across the spectrum of communities. Phytosociological attributes (species diversity, presence of exotic species, etc.) and physical characteristics, e.g. human impacts, size, fragmentation are important in assessing the status of the various communities.

High Sensitivity Index Values indicate areas that are considered pristine, unaffected by human influences or generally managed in an ecological effective manner. These areas can be compared to nature reserves and even well managed farm areas. Low Sensitivity Index Values indicate areas of lower ecological status or importance in terms of vegetation attributes, or areas that have been negatively affected by human impacts or poor management. Sensitivity Criteria employed in assessing the floristic sensitivity of separate units may vary between different areas, depending on location, type of habitat, size, etc. As part of this analysis the following factors were assumed as important in determining the sensitivity of vegetation units of this particular site:

- Habitat suitability for the potential presence of Red Listed species;

- Landscape or habitat significance;
- Floristic status;
- Plant species diversity; and
- Ecological performance/fragmentation.

6.4 Faunal Assessment

The faunal assessment was conducted by D Kamffer (Pr.Sci.Nat.).

6.4.1 Invertebrates

Suitable habitat is investigated to establish the presence/ absence of Red Listed species as well as compiling a list of species that occur in the area. Visual observations and other sampling methods were implemented, as follows:

6.4.2 Frogs

Suitable areas are identified and active search and capture and acoustic identification methods are employed to obtain a species list of the region.

6.4.3 Reptiles

Suitable areas are identified and active search and capture methods are employed to obtain a species list of the region.

6.4.4 Birds

Please note that certain avifaunal aspects are addressed in a separate report of which the objectives are to highlight impacts on specific species and groups of birds (compiled by C. van Rooyen). Avifaunal comments are included in this particular fauna report to illustrated general biodiversity aspects.

- The study area is actively surveyed for the presence of bird species.
- Visual and acoustic identification methods are used to compile a list of bird species of the area.
- All available habitats are assessed in terms of suitability for Red Listed bird species.
- High potential Red Listed bird habitat is flagged as sensitive.

6.4.5 Mammals

- Trapping is conducted to survey habitat for the of small mammal species.
- The study area is also actively surveyed for the presence of Red Listed mammals.
- All available habitats are assessed in terms of suitability for potentially occurring Red Listed species.

- High potential Red Listed mammal habitat is flagged as sensitive.
- Visual observation methods and signs and tracts are used to compile a list of mammal species occurring in the area.

6.4.6 Data analysis

- All GPS acquired data is converted from text to shapefiles to allow GIS analyses.
- Shapefiles of environmental attributes such as geology, soil, hydrology and vegetation are incorporated in the analyses of available faunal habitats.
- Sensitivity maps are compiled, where relevant, subsequent to data analyses.
- Species lists are compiled for relevant taxa using fieldwork data, literature and data supplied by various other institutions and specialists.

6.4.7 Red Listed fauna Probabilities

Three parameters are used to assess the Probability of Occurrence of each Red Listed species:

- Habitat requirements (HR) - Red Listed animals have specific habitat requirements and the presence of these habitat characteristics in the study area is evaluated.
- Habitat status (HS) - The status or ecological condition of available habitat in the study area is assessed. Often, a high level of degradation of a specific habitat type will negate the potential presence of Red Listed species (especially wetland-related habitats where water quality plays a major role); and
- Habitat linkage (HL) - Movement between areas used for breeding and feeding purposes forms an essential part of ecological existence of many species. The connectivity of the study area to surrounding habitats and adequacy of these linkages are evaluated for the ecological functioning of Red Listed species within the study area.

The estimated Probability of Occurrence for Red Data fauna species is presented in five categories, namely:

- very low;
- low;
- moderate;
- high; and
- very high.

6.4.8 Faunal Habitat Sensitivities

Faunal habitat sensitivities are subjectively estimated based on the following criteria:

- Habitat status;
- Connectivity;
- Observed species composition & RD Probabilities; and
- Functionality,

and is place in one of the following classes:

- High;
- Medium-high
- Medium;
- Medium-low; or
- Low

6.5 IMPACT EVALUATION

6.5.1 Criteria for the classification of an impact:

Nature
A brief description of the environmental aspect being impacted upon by a particular action or activity is presented.

Extent (Scale)
Considering the area over which the impact will be expressed. Typically, the severity and significance of an impact have different scales and as such bracketing ranges are often required. This is often useful during the detailed assessment phase of a project in terms of further defining the determined significance or intensity of an impact.

National	The whole of South Africa
Regional	Provincial (and parts of neighbouring provinces)
Local	Within a radius of 2 km of the construction site
Site	Within the construction site

Duration
Indicates what the lifetime of the impact will be

Permanent	The only class of impact which will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact can be considered transient
Long-term	The impact will continue or last for the entire operational life of the development, but will be mitigated by direct human action or by natural processes thereafter
Medium-term	The impact will last for the period of the construction phase, where after it

	will be entirely negated
Short-term	The impact will either disappear with mitigation or will be mitigated through natural process in a span shorter than the construction phase

Intensity

Describes whether an impact is destructive or benign.

Very high	Natural, cultural and social functions and processes permanently cease.
High	Natural, cultural and social functions and processes temporarily cease
Medium	Effected environment is altered, but natural, cultural and social functions and processes continue albeit in a modified way
Low	Impact affects the environment in such a way that natural, cultural and social functions and processes are not affected

Probability

Describes the likelihood of an impact actually occurring

Definite	Impact will certainly occur
Highly probable	Most likely that the impact will occur
Possible	The impact may occur
Improbable	Likelihood of the impact materialising is very low

Significance

Significance is determined through a synthesis of impact characteristics. It is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required. The total number of points scored for each impact indicates the level of significance of the impact.

6.5.2 Impact Categories

The impact assessment must take account of the nature, scale and duration of likely effects on the environment whether such effects are positive (beneficial) or negative (detrimental). Where necessary, the proposal for mitigation or optimisation of an impact is noted. A brief discussion of the impact and the rationale behind the assessment of its significance is also included. A rating system is applied to the potential impact on the receiving environment and includes an objective evaluation of the mitigation of the impact. In assessing the significance of each issue the following criteria (including an allocated point system) is used:

- **Extent**

National	4
Regional	3
Local	2
Site	1

- **Duration**

Permanent	4
Long term	3
Medium term	2
Short term	1

- **Intensity**

Very high	4
High	3
Moderate	2
Low	1

- **Probability of Occurrence**

Definite	4
Highly probable	3
Possible	2
Impossible	1

Using the scoring from the previous section, the significance of impacts is rated as follows:

Low impact	4-7 points (No permanent impact of significance. Mitigatory measures are feasible and are readily instituted as part of a standing design, construction or operating procedure)
Medium impact	8-10 points (Mitigation is possible with additional design and construction inputs)
High impact	11-13 points (Design of the site may be affected. Mitigation and possible remediation are needed during construction and/or operational phases. Effects of the impact may affect the environment)
Very high impact	14-16 points (Design of the site may be affected. Intensive remediation as needed during construction and/or operational phases. Activities which results in a "very high impact" is likely to be a fatal flaw)

Status

Denotes the perceived effect of the impact on the affected area

Positive (+)	Beneficial impact
Negative (-)	Deleterious or adverse impact
Neutral	Impact is neither beneficial nor adverse

It is important to note that the status of an impact is assigned based on the *status quo* – i.e. should the project not proceed. Therefore not all negative impacts are equally significant. The suitability and feasibility of all proposed mitigation measures will be included in the assessment of significant impacts. This will be achieved through the comparison of the significance of the impact before and after the proposed mitigation measure is implemented.

7 THE BIOPHYSICAL ENVIRONMENT

7.1 LOCATION

The proposed site is situated on the farm Bokpoort 390, located in the Siyanda District Municipality, Northern Cape Province (Figure 1). The study area comprises mostly natural shrubveld and the farm is extensively utilised for grazing by cattle, sheep and game. The Garona Substation is located on the eastern part of the farm, and the Sishen-Saldanha railway line is adjacent to the south-eastern part of the farm. A general GPS point for the study area is S28°42'57.34" and E21°59'37.35". The study area comprises approximately 4,780ha.

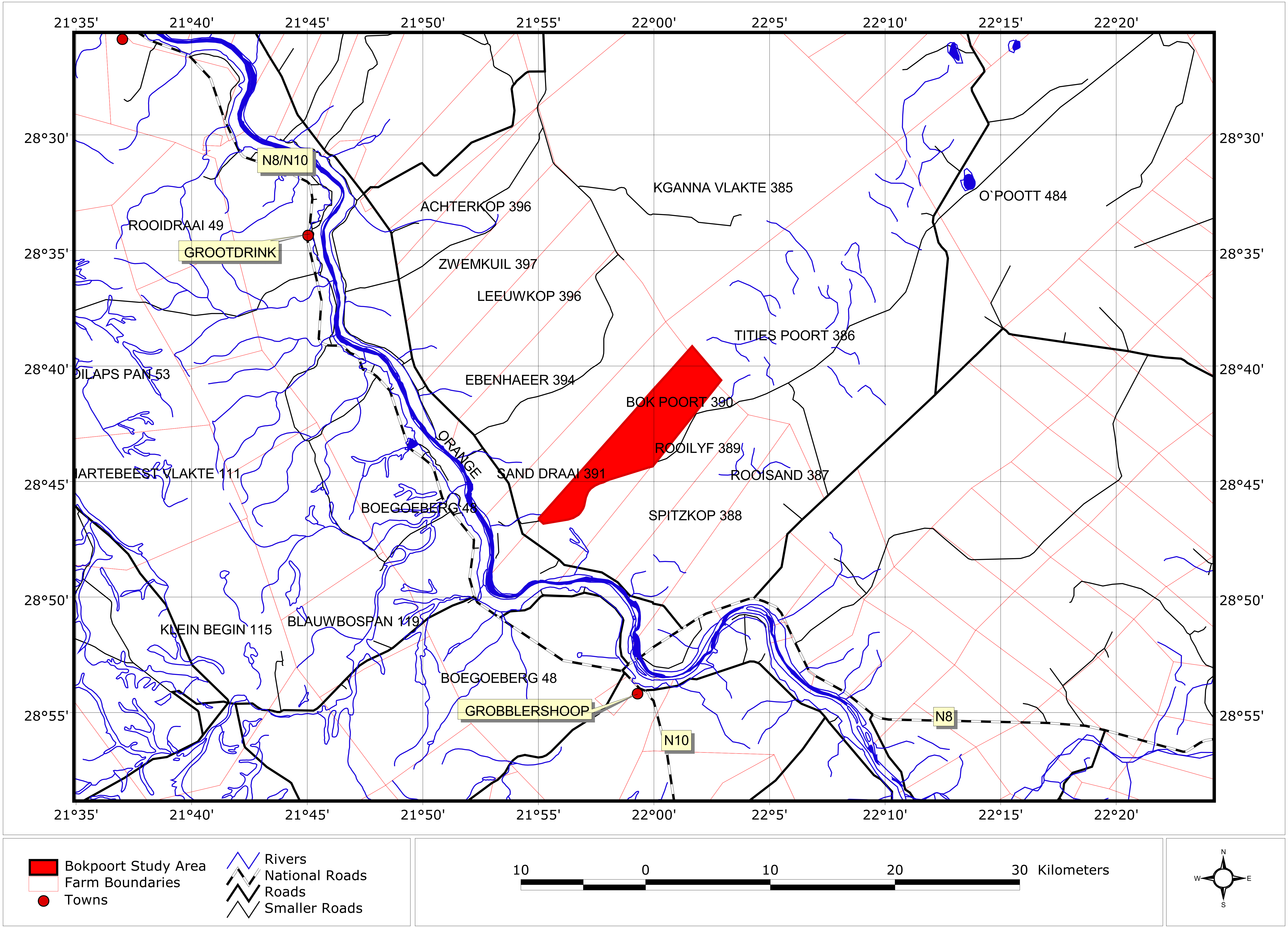
A Google Earth image of the study area is presented in Figure 2.

7.2 SURFACE WATER

Areas of surface water contribute significantly towards the local and regional biodiversity of an area due to the atypical habitat that is available within the ecotonal areas. These ecotones (areas or zones of transition between different habitat types) are frequently occupied by species that occur in both the bordering habitat types, and is therefore generally rich in species. In addition, many flora and fauna species are specifically adapted to exploit the temporal or seasonal fluctuation in moisture levels in these areas and exhibits extremely narrow habitat variation tolerance levels. These areas are also visited by all terrestrial animals that utilise water sources. Ecotonal interface areas form narrow bands around areas of surface water and they constitute extremely small portions when calculated on a purely mathematical basis. However, taking the high species richness into consideration these areas are extremely important on a local and regional scale. Rivers also represent important linear migration routes for a number of fauna species as well as a distribution method for plant seeds.

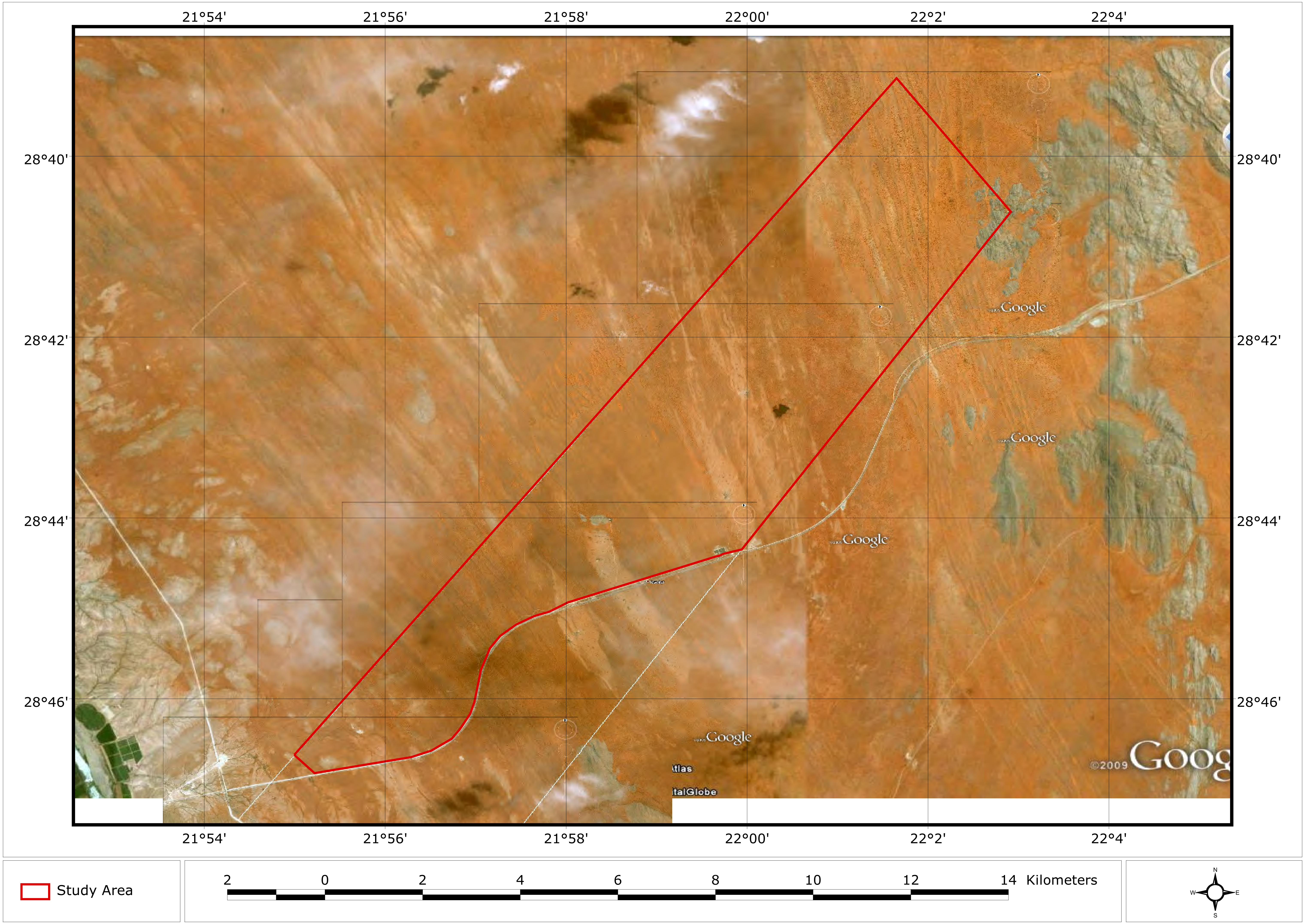
No area of permanent surface water is present on the site. Evidence of non-perennial drainage lines could be viewed on the Google Earth image (Figure 2) and visually in the southern part of the proposed site, but these areas are only expected to contain flowing water during periods of exceptional high rainfall. The study area lies within the Lower Orange Water Management Area and the Orange River is the primary water resource for the area. This river is used extensively for irrigation, and is heavily cultivated along its banks. No significant wetlands, estuaries, Ramsar Sites or major dams are present within the immediate vicinity of the study sites. The most significant impact that currently affects the status of smaller riparian systems in the region is the effect of grazing and trampling of cattle in areas where natural habitat are grazed intensively.

Figure 1: Regional setting of the study area



21°35'
21°40'
21°45'
21°50'
21°55'
22°00'
22°5'
22°10'
22°15'
22°20'
28°30'
28°35'
28°40'
28°45'
28°50'
28°55'
N8/N10
ROOIDRAAI 49
GROOTDRINK
ACHTERKOP 396
KGANNA VLAKTE 385
O`POOTT 484
ZWEMKUIL 397
LEEUWKOP 396
TITIES POORT 386
OILAPS PAN 53
EBENHAEER 394
BOK POORT 390
ROOILYF 389
ORANGE
HARTEBEEST VLAKTE 111
SAND DRAAI 391
ROOISAND 387
BOEGOEBERG 48
SPITZKOP 388
KLEIN BEGIN 115
BLAUWBOSPAN 119
BOEGOEBERG 48
GROBBLERSHOOP
N10
N8
Bokpoort Study Area
Farm Boundaries
Towns
Rivers
National Roads
Roads
Smaller Roads
10
0
10
20
30 Kilometers
N
W
E
S

Figure 2: Google Earth image of the study area



21°54'
21°56'
21°58'
22°00'
22°2'
22°4'
28°40'
28°42'
28°44'
28°46'
Google
©2009
Study Area
2
0
2
4
6
8
10
12
14
Kilometers
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7.3 LAND COVER & LAND USE OF THE IMMEDIATE REGION

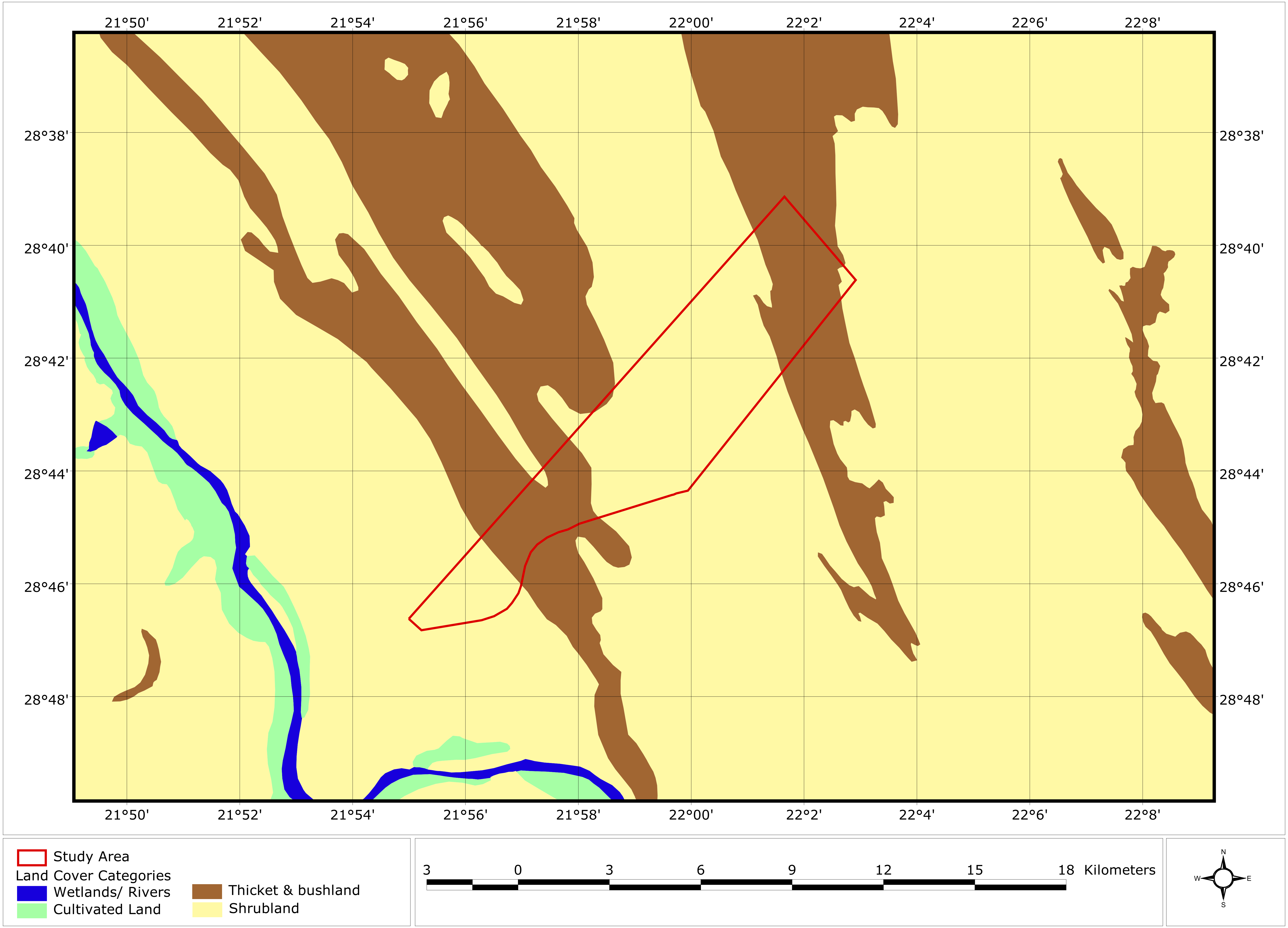
Land cover categories are presented in Figure 3. For the purpose of this biodiversity assessment, land cover are loosely categorised into classes that represent natural habitat and land use categories that contribute to habitat degradation and transformation on a local or regional scale. In terms of the importance for biodiversity the assumption is made that landscapes that exhibit high levels of transformation are normally occupied by plant communities and faunal assemblages that does not reflect the original or pristine status of an area or region. This is particularly important in the case of Red Data species as these plants and animals have extremely low tolerances levels to any disturbance, which is one of the main reasons for being threatened. Any significant changes to the status of habitat available to these species are therefore likely to result in severe impacts on these species and their conservation status.

Three important aspects are associated with habitat changes that accompany certain land uses. Permanent transformation of natural habitat by land uses such as agriculture, mining and urbanisation results in the permanent decimation of available habitat for flora and fauna species as these areas will not return to the original pristine status. A second aspect of habitat transformation or degradation is that it affects species directly, namely a change in species composition of an area results from an exodus of some species that are no longer able to exist in changed habitat conditions, the decrease in abundance of certain species as a result of decreased habitat or an influx of species that are not normally associated with the original or pristine habitat, but is suitably adapted to the changed environment. While some, or most, of the species that occupy these changed habitat conditions might be indigenous to a region, they are not endemic to an area. Lastly a larger threat to the natural biodiversity of a region is represented by the influx of invasive exotic species and weeds that can effectively sterilise large tracts of remaining natural habitat.

The study area is located in a region that comprises extensive areas of natural habitat with extremely limited transformed areas to the south of the study area, mainly the result of agriculture. The extremely low transformation factor of the region renders the fragmentation and habitat isolation factors of the region extremely low. A relative low density of road infrastructure in the region is basically the only aspect that contributes towards habitat isolation and fragmentation. Towns and urban areas are mostly located on the banks of the Orange River and is relative small in size, representing limited habitat transformation. Habitat transformation in the region is mostly attributed to agriculture (irrigated agriculture) in the immediate vicinity of the Orange River.

The site itself exhibit extremely limited habitat transformation and is generally composed by ‘Thicket & Bushland’ and ‘Shrubland’ land cover categories. Grazing by cattle, sheep and game represents the most important land use.

Figure 3: Land cover classes of the general region


21°50'
21°52'
21°54'
21°56'
21°58'
22°00'
22°2'
22°4'
22°6'
22°8'
28°38'
28°40'
28°42'
28°44'
28°46'
28°48'
Study Area
Land Cover Categories
Wetlands/ Rivers
Cultivated Land
Thicket & bushland
Shrubland
3
0
3
6
9
12
15
18
Kilometers
N
W
E
S

7.4 RIDGES & TOPOGRAPHY

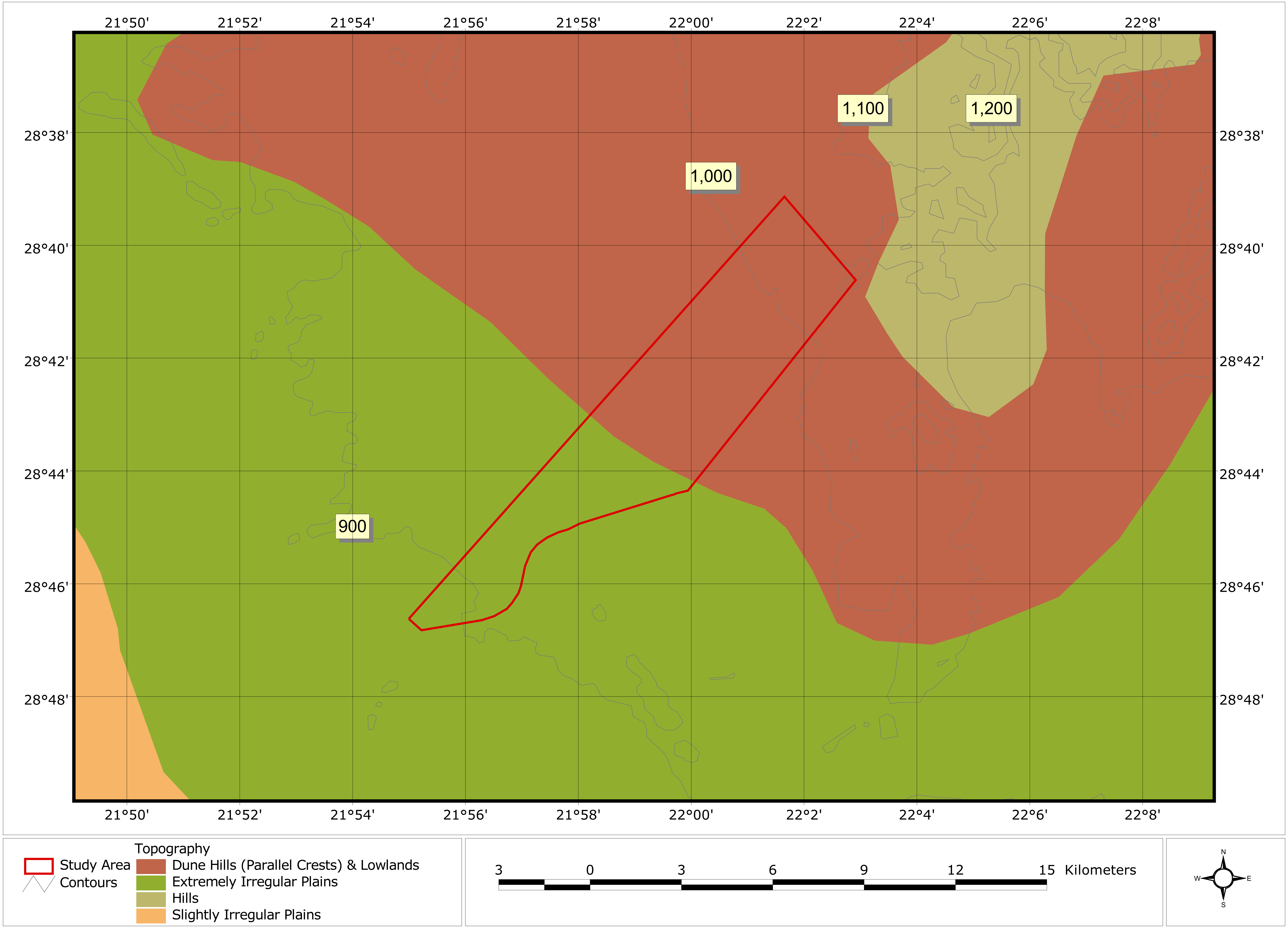
Varied topography is recognised as one of the most powerful influences contributing to the high biodiversity of southern Africa. Landscapes composed of spatially heterogeneous abiotic conditions provide a greater diversity of potential niches for plants and animals than do homogeneous landscapes. The richness and diversity of flora has been found to be significantly higher in sites with high geomorphological heterogeneity and it can reasonably be assumed that associated faunal communities will also be significantly more diverse in spatially heterogeneous environments.

Ridges and rocky outcrops are characterised by high spatial heterogeneity due to the range of differing aspects (north, south, east, west and variations thereof), slopes and altitudes all resulting in differing soil (e.g. depth, moisture, temperature, drainage, nutrient content), light and hydrological conditions. Temperature and humidity regimes of microsites vary on both a seasonal and daily basis. Moist cool aspects are more conducive to leaching of nutrients than warmer drier slopes. Variation in aspect, soil drainage and elevation/altitude has been found to be especially important predictors of biodiversity. It follows that ridges will be characterized by a particularly high biodiversity.

Many Red Data / threatened species of plants and animals inhabit ridges. Due to their threatened status, Red Data species require priority conservation efforts in order to ensure their future survival. Ridges may have a direct effect on temperature/radiation, surface airflow/wind, humidity and soil types. Ridges also influence fire in the landscape, offering protection for those species that can be described as "fire-avoiders". Because of the influence of topography on rainfall, many streams originate on ridges and control water inputs into wetlands. The protection of the ridges in a natural state will thus ensure the normal functioning of ecosystem processes. In contrast, development of a ridge will alter these major landscape processes. For example, water runoff into streams and wetlands will increase.

The ENPAT database revealed that the study area does not areas where significant slopes are present, but it should however be noted that the ENPAT database slope classes is based on a high contour interval (100m). With the use of more detailed data, the identification of smaller areas of significant slopes will be possible. The study area generally characterised by Dune Hills (parallel crests) and Lowlands in the northern part and Extremely Irregular Plains in the south, sloping towards the Orange River in a south-eastern direction from a high point of approximately 1,100m in the north to approximately 900m in the south at a general gradient of approximately 1.1% (Figure 4). Part of the Korannaberg foothills is located in the extreme northern section of the study area, comprising a small section of the site, characterized by the presence of boulders, high slopes and mountainous topography.

Figure 4: Topography of the study area and general surrounds



21°50'
21°52'
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21°56'
21°58'
22°00'
22°2'
22°4'
22°6'
22°8'
28°38'
28°40'
28°42'
28°44'
28°46'
28°48'
1,100
1,200
1,000
900
Study Area
Contours
Topography
Dune Hills (Parallel Crests) & Lowlands
Extremely Irregular Plains
Hills
Slightly Irregular Plains
3 0 3 6 9 12 15 Kilometers
N
W
E
S

7.5 Regional Vegetation - VEGMAP

The following VEGMAP (Mucina & Rutherford, 2006) vegetation types are situated within the respective study areas (Figure 5):

- Bushmanland Arid Grassland;
- Gordonia Duneveld;
- Kalahari Karroid Shrubland; and
- Koranna-Langeberg Mountain Bushveld.

7.5.1 Bushmanland Arid Grassland

The southern border of the unit is formed by edges of the Bushmanland Basin while in the northwest this vegetation unit borders on desert vegetation (northwest of Aggeneys and Pofadder). The northern border (in the vicinity of Upington) and the eastern border (between Upington and Prieska) are formed with often intermingling units of Lower Gariep Broken Veld, Kalahari Karroid Shrubland and Gordonia Duneveld. Altitude varies mostly from 600-1,200m.

Vegetation and landscape features extensive to irregular plains on a slightly sloping plateau sparsely vegetated by grassland dominated by white grasses (*Stipagrostis* species) giving this vegetation type the character of semi desert 'steppe'. In places low shrubs of *Salsola* change the vegetation structure. In years of abundant rainfall rich displays of annual herbs can be expected. The conservation of this unit is regarded Least Threatened. Only small patches statutorily conserved in Augrabies Falls National Park and Goegab Nature Reserve. Very little of the area has however been transformed. Biogeographically Important Taxa (Bushman land endemic) include the succulent herb *Tridentea dwequensis*, the succulent shrubs *Dinteranthus pole-evansii*, *Larryleachia dinteri*, *L. marlothii*, *Ruschia kenhardtensis* and the herbs *Lotononis oligocephala* and *Nemesia maxii*. Important Taxa (Western and Eastern regions only) include the following:

- **Graminoids**

Aristida adscensionis, A. congesta, Enneapogon desvauxii, Eragrostis nindensis, Schmidtia kalahariensis, Stipagrostis ciliata, S. obtusa, Cenchrus ciliaris, Enneapogon scaber, Eragrostis annulata, E. porosa, E. procumbens, Panicum lanipes, Setaria verticillata, Sporobolus nervosus, Stipagrostis brevifolia, S. uniplumis, Tragus berteronianus and *T racemosus.*

- **Small Trees**

Acacia mellifera subsp*. detinens* and *Boscia foetida* subsp*. foetida.*

- **Tall Shrubs**

Lycium cinereum, *Rhigozum trichotomum*, *Cadaba aphylla* and *Parkinsonia africana.*

- **Low Shrubs**

Aptosimum spinescens, Hermannia spinosa, Pentzia spinescens, Aizoon asbestinum, A. schellenbergii, Aptosimum elongatum, A. lineare, A. marlothii, Barleria rigida, Berkheya annectens, Blepharis mitrata, Eriocephalus ambiguus, E. spinescens, Limeum aethiopicum, Lophiocarpus polystachyus, Monechma incanum, M. spartioides, Pentzia pinnatisecta, Phaeoptilum spinosum, Polygala seminuda, Pteronia leucoclada, P mucronata, P sordida, Rosenia humilis, Senecio niveus, Sericocoma avolans, Solanum capense, Talinum arnotii, Tetragonia arbuscula and *Zygophyllum microphyllum.*

- **Succulent Shrubs**

Kleinia longiflora, Lycium bosciifolium, Salsola tuberculata and *S. glabrescens.*

- **Herbs**

Acanthopsis hoffmannseggiana, Aizoon canariense, Amaranthus praetermissus, Barleria lichtensteiniana, Chamaesyce inaequilatera, Dicoma capensis, Indigastrum argyraeum, Lotononis platycarpa, Sesamum capense, Tribulus pterophorus, T terrestris, Vahlia capensis, Gisekia pharnacioides, Psilocaulon coriarium and *Trianthema parvifolia.*

- **Geophytic Herb**

Moraea venenata

7.5.2 Gordonia Duneveld

Vegetation and landscape features are characteristically parallel dunes about 3-8 m above the plains. This unit also occurs as a number of loose dune cordons south of the Orange River near Keimoes and between Upington and Putsonderwater. It is typically an open shrubland with ridges of grassland dominated by *Stipagrostis amabilis* on the dune crests and *Acacia haematoxylon* on the dune slopes, also with *A. mellifera* on lower slopes and *Rhigozum trichotomum* in the interdune streets are typical of this unit. The conservation status of this unit is regarded Least Threatened with only 14% statutorily conserved in the Kgalagadi Transfrontier Park. Very little of the area is transformed and erosion is very low.

Biogeographically Important Taxa (Kalahari Endemics) include the tall shrub *Acacia haematoxylon*, the graminoids *Stipagrostis amabilis, Anthephora argentea, Megaloprotrachne albescens* and the herbs *Helichrysum arenicola, Kohautia ramosissima* and *Neuradopsis austro-africana*. Important taxa include the following:

- **Small Tree**

Acacia mellifera subsp*. detinens*

- **Tall Shrubs**

Grewia flava and *Rhigozum trichotomum.*

- **Low Shrubs**

Aptosimum albomarginatum, *Monechma incanum* and *Requienia sphaerosperma.*

- **Succulent Shrubs**

Lycium bosciifolium, *L. pumilum* and *Talinum caffrum.*

- **Graminoids**

Schmidtia kalahariensis, Brachiaria glomerata, Bulbostylis hispidula, Centropodia glauca, Eragrostis lehmanniana, Stipagrostis ciliata, S. obtusa and *S. uniplumis.*

- **Herbs**

Hermbstaedtia fleckii, *Acanthosicyos naudinianus, Hermannia tomentosa, Limeum arenicolum*, *L. argute-carinatum*, *Oxygonum dregeanum* subsp*. canescens* var*. canescens, Sericorema remotiflora, Sesamum triphyllum* and *Tribulus zeyheri.*

7.5.3 Kalahari Karroid Shrubland

This vegetation type occurs in the Northern Cape Province, typically forming belts alternating with belts of Gordonia Duneveld on plains northwest of Upington through Lutzputs and Noenieput to the Rietfontein/ Mier area in the north. Other patches occur around Kakamas and north of Groblershoop. The unit is also found in the neighbouring Namibia. The vegetation and landscape features are typically low karroid shrubland on flat, gravel plains. Karoo-related elements (shrubs) meet here with northern floristic elements, indicating a transition to the Kalahari region and sandy soils. The geographically important taxon (South-western distribution limit) graminoid *Dinebra retroflexa* is present in this unit.

The conservation status is Least Threatened. Very little of this unit is statutorily conserved in Augrabies Falls National Park. Although only a small area has been transformed many of the belts of this types were preferred routes for early roads, thus promoting the introduction of alien plants (about a quarter of the unit has scattered *Prosopis* species). Vegetation of this mapping unit shows transitional features between the Kalahari proper (Savanna Biome) and the northern Nama-Karoo.

Important taxa include the following:

- **Small Trees**

Acacia mellifera subsp*. detinens*, *Parkinsonia africana* and *Boscia foetida* subsp*. foetida.*

- **Tall shrub**

Rhigozum trichotomum

- **Epiphytic Semiparasitic shrub**

Tapinanthus oleifolius

- **Low Shrubs**

Hermannia spinosa, Limeum aethiopicum, Phaeoptilum spinosum, Aizoon schellenbergii, Aptosimum albomarginatum, A. lineare, A. marlothii, A. spinescens, Barleria rigida, Hermannia modesta, Indigofera heterotricha, Leucosphaera bainesii, Monechma genistifolium subsp*. genistifolium, Phyllanthus maderaspatensis, Polygala seminuda, Ptycholobium biflorum* subsp*. biflorum, Sericocoma avolans, Solanum capense* and *Tephrosia dregeana.*

- **Herbs**

Dicoma capensis, Chamaesyce inaequilatera, Amaranthus praetermissus, Barleria lichtensteiniana, Chamaesyce glanduligera, Chascanum garipense, Cleome angustifolia subsp*. diandra, Cucumis africanus, Geigeria ornativa, Hermannia abrotanoides, Indigastrum argyraeum, Indigofera alternans, I. auricoma, Kohautia cynanchica, Limeum argute-carinatum, Mollugo cerviana, Monsonia umbellata, Sesamum capense, Tribulus cristatus, T. pterophorus* and *T. terrestris.*

- **Succulent Herbs**

Gisekia africana, G. pharnacioides and *Trianthema parvifolia.*

- **Graminoids**

Aristida adscensionis, Enneapogon desvauxii, E. scaber, Stipagrostis obtusa, Aristida congesta, Enneapogon cenchroides, Eragrostis annulata, E. homomalla, E. porosa, Schmidtia kalahariensis, Stipagrostis anomala, S. ciliata, S. hochstetteriana, S. uniplumis, Tragus berteronianus and *T. racemosus.*

7.5.4 Koranna-Langeberg Mountain Bushveld

The vegetation and landscape features of this unit include rugged mountains and steep slopes in parts of the Korannaberg but with few cliffs in the Langeberg to the south. Generally supporting open shrubland with moderately open grass cover. *Croton gratissimus* is common in places, becoming particularly diminutive south of the Langeberg. The conservation status of this unit is regarded Least Threatened. None is conserved in statutory conservation areas, but is partly conserved in private reserves such as the Tswalu Kalahari Reserve. Virtually none of this unit is transformed. This unit forms the first, almost unbroken mountain barrier to the east of the Kalahari on the Gordonia plains. Biogeographically important species include the low shrub *Justicia puberula* and the graminoid *Digitaria polyphylla.*

Important taxa of this unit include the following:

Small Trees

Acacia mellifera subsp*. detinens, Boscia albitrunca, Ficus cordata* and *Maytenus undata.*

Tall Shrubs

Ehretia rigida subsp. *rigida, Euclea undulata, Grewia flava, Hibiscus micranthus, Rhigozum obovatum, Searsia burchellii, Tarchonanthus camphoratus* and *Tephrosia longipes.*

Low Shrubs

Croton gratissimus, Artemisia afra, Felicia muricata, Indigofera poliotes, Jamesbrittenia albiflora, Leucas capensis, Lophiocarpus polystachyus, Melhania prostrata, Nolletia arenosa, Pegolettia retrofracta and *Psiadia punctulata.*

Succulent Shrubs

Aloe hereroensis var. *hereroensis, Euphorbia avasmontana* and *E. rectirama.*

Semiparasitic Shrub

Thesium hystrix

Woody Climber

Putterlickia Pyracantha

Woody Succulent Climber

Sarcostemma viminale

Graminoids

Aristida diffusa, Eragrostis curvula, Brachiaria nigropedata, Cenchrus ciliaris, Digitaria eriantha subsp. eriantha, Heteropogon contortus and *Stipagrostis uniplumis.*

Herb

Ceratotheca triloba

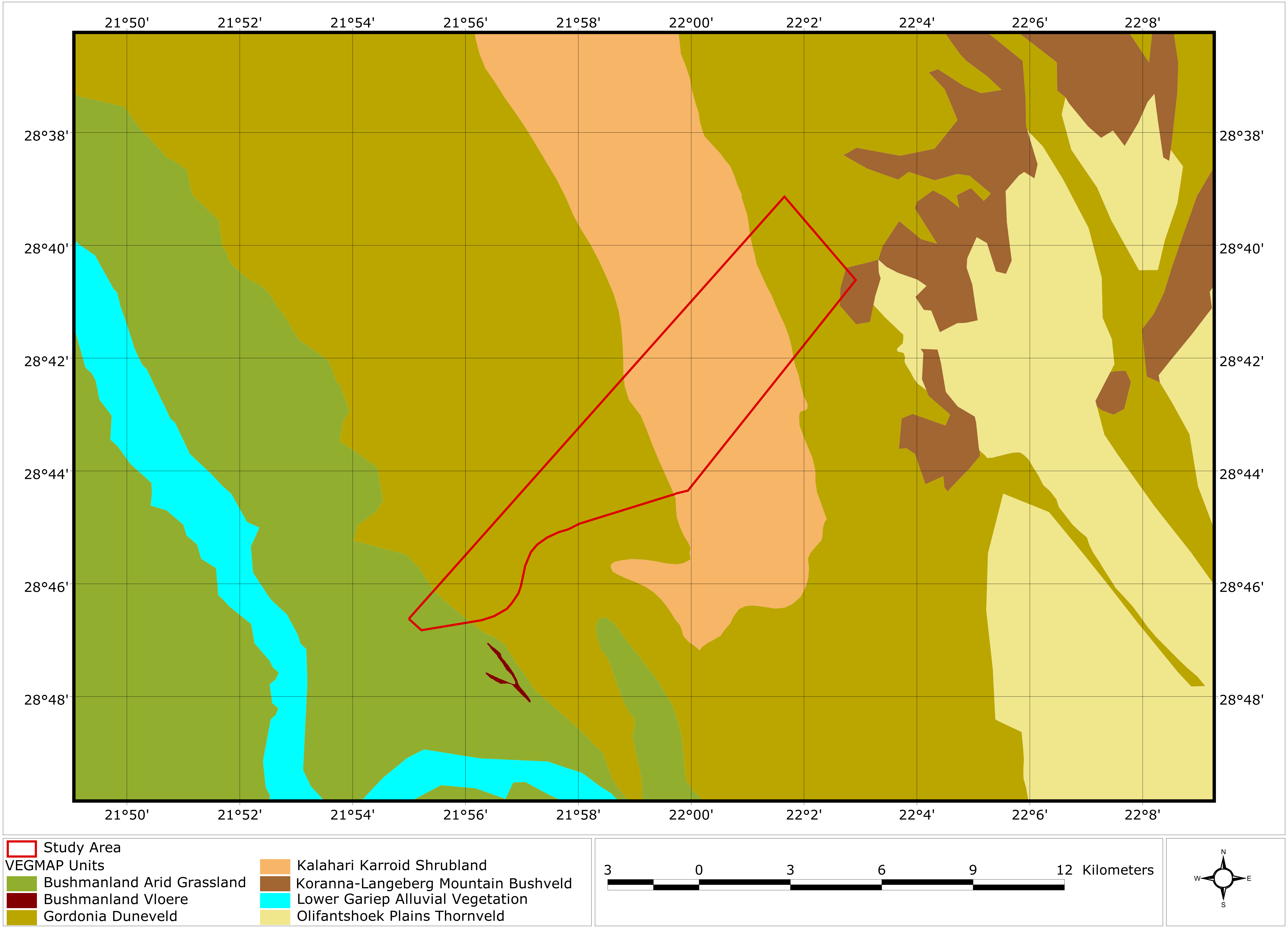
Geophytic Herbs

Boophane disticha, Cheilanthes hirta, Pellaea calomelanos and *Sansevieria aethiopica.*

7.6 Conservation Areas

The Witsand Nature Reserve is located approximately 40km to the east of the Bokpoort site, but is unlikely to be affected by the proposed development. No other area currently registered as conservation areas are impacted on by the proposed development. According to the Environmental Potential Atlas (ENPAT) this area has a high scenic value, a high environmental resources index and low population pressure an is therefore, listed as an areas with high environmental resources conservation requirements; placed within the highest category for environmentally sustainable tourism and/or ecotourism development.

Figure 5: Regional vegetation types (VEGMAP)



21°50'
21°52'
21°54'
21°56'
21°58'
22°00'
22°2'
22°4'
22°6'
22°8'
28°38'
28°40'
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28°44'
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28°48'
Study Area
VEGMAP Units
Bushmanland Arid Grassland
Bushmanland Vloere
Gordonia Duneveld
Kalahari Karroid Shrubland
Koranna-Langeberg Mountain Bushveld
Lower Gariep Alluvial Vegetation
Olifantshoek Plains Thornveld
3 0 3 6 9 12 Kilometers
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S
E
W

7.7 Geology & Soils

This aspect is addressed in more detail in a separate report and only aspects relating to the vegetation is highlighted in this section.

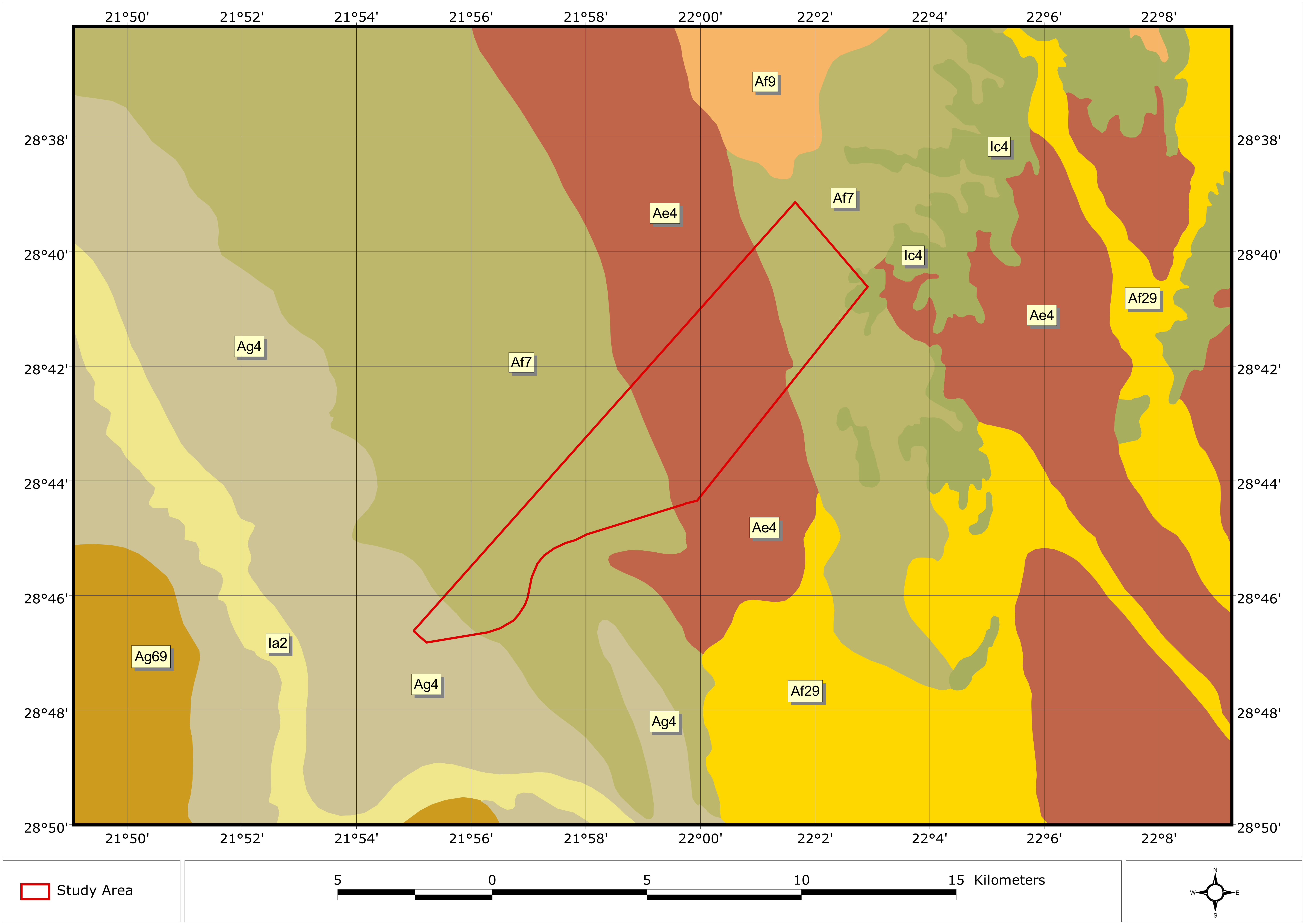
The general geology of the site mainly comprises red-brown, coarse-grained granite gneiss; and quartz-muscouite schists, quartzite, quartz-amphibole schists and greenstones of the Groblershoop formation, Brulpan group. Calcrete is also found especially on the south eastern part of the area.

The geology of the area is characterised by the metamorphosed sediments and volcanics, intruded by granites and is known as the Namaqualand Metamorphic Province. The soils are reddish, moderately shallow, sandy and often overlaid layers of Calcrete of varying depths and thickness. Soils are typically weakly structured with low organic content and which soils drain freely resulting in a soil surface susceptible to erosion, especially wind erosion when the vegetation cover is sparse. Soils of the flat lowland areas can be described as red, eutrophic (high base status) and excessively drained sandy soils. The soils often overlay thick layers of calcrete, which is known for its hardness. The average clay content of the topsoil is less than 10 – 15% and the soil depth varies between 400 and 750mm. The study area is underlain be the following land type units (Figure 6):

- Ae4;
- Af7;
- Ag4; and
- Ic4.

Map units Aa – Ai refer to yellow and red soils without water tables and belonging in one or more of the following soil forms: Inanda, Kranskop, Magwa, Hutton, Griffin and Clovelly. The map units refer to land which does not qualify as a plinthic catena and in which one or more of the above soil forms occupy at least 40% of the area. Ia refers to land types with a soil pattern difficult to accommodate elsewhere, at least 60% of which comprises pedologically youthful, deep (more than 1,000mm to underlying rock), unconsolidated deposits. Common soil forms are Dundee and Oakleaf. Ic refers to land types with exposed rock (exposed country rock, stones or boulders) covering more than 80% of the area. The rocky portions of Ic may be underlain by soil which would have qualified the unit for inclusion in another broad soil pattern were it not for the surface rockiness.

Figure 6: Land types of the study area



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28°38'
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28°44'
28°46'
28°48'
28°50'
Af9
Ic4
Af7
Ae4
Ic4
Af29
Ae4
Ag4
Af7
Ae4
Ia2
Ag69
Ag4
Af29
Ag4
Study Area
5
0
5
10
15
Kilometers
N
W
E
S

7.8 BIOPHYSICAL SENSITIVITIES - ANALYSIS

Ascribed biophysical sensitivities are based on a combination of the likelihood of a specific biophysical attribute being important in terms of biodiversity attributes and the expected reaction of the particular attribute to impacts associated with the proposed development as perceived relevant to this particular project. Sensitivities are ultimately collated and a biophysical sensitivity map was produced that presents an overview of the biophysical sensitivity of the study area on a local and regional scale (Figure 7).

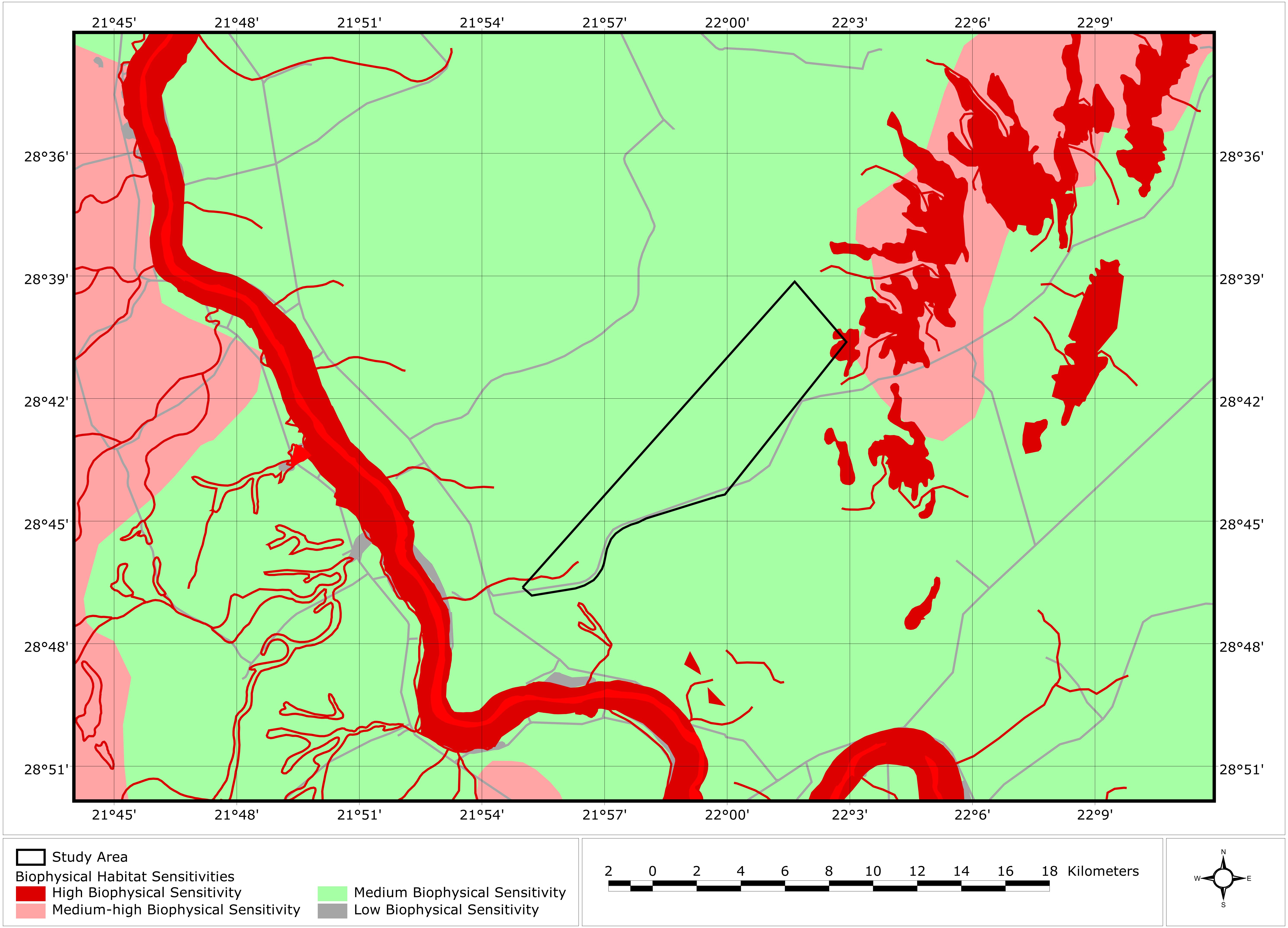
Shortcomings of this approach are that localised and small areas of importance that are not captured in existing databases or that were not observed during the extensive field survey will not be reflected on the sensitivity map. Particular reference is made to the extent of areas of surface water, including rivers, streams and moist grasslands, hillside seepages, bottomland wetlands, etc. It should be noted that important areas of a small extent will be identified and appropriately avoided during the final walk-through of the project.

Areas of high biophysical sensitivity present within the study area are frequently associated with wetland and riparian habitat. Particular reference is made of the Orange River located to the south of both sites. Included in the High biophysical sensitivity category is regional vegetation types classified as Endangered (Lower Gariep Alluvial Vegetation). Areas of medium high sensitivity is regarded important on a local scale and include morphological heterogeneous habitat (hills, mountains).

Results of the assessment indicate that the largest extent of the study area comprises biophysical habitat attributes of a moderate sensitivity. The northern section of the study area comprises habitat of high sensitivity, related to the presence of the Korannaberg foothills and rocky outcrops. The ‘Extremely Irregular Plains’ topographical unit was found to be of moderate sensitivity as the topographical variation is not so severe to result in highly varying habitat conditions, hence a moderate biophysical sensitivity was ascribed. Areas of medium sensitivity comprised untransformed/ natural habitat that are not included in any of the higher categories.

The absence of extensive areas of low and medium-low biophysical sensitivity is a characteristic of the region that reveals the natural status of habitat. Natural habitat of the region is largely unaffected by human activities and is generally in a pristine condition. Areas included in the Low biophysical category represent all degraded habitat, including areas of agriculture, urban areas, roads, degraded habitat, etc.

Figure 7: Biophysical habitat sensitivities of the region


21°45'
21°48'
21°51'
21°54'
21°57'
22°00'
22°3'
22°6'
22°9'
28°36'
28°39'
28°42'
28°45'
28°48'
28°51'
Study Area
Biophysical Habitat Sensitivities
High Biophysical Sensitivity
Medium-high Biophysical Sensitivity
Medium Biophysical Sensitivity
Low Biophysical Sensitivity
2 0 2 4 6 8 10 12 14 16 18 Kilometers
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E
W

8 FLORISTIC ATTRIBUTES OF THE STUDY AREA

8.1 Regional Diversity

The Northern Cape Province is characterised by five biomes. Table 2 presents the area coverage and proportion of each biome within the Northern Cape Province.

Table 2: Extent of biomes within the Northern Cape Province		
Biome	**Area**	**Percentage**
Fynbos	663,527ha	1.83%
Grassland	123,837ha	0.34%
Nama Karoo	19,593,363ha	54.05%
Savanna	10,686,003ha	29.48%
Succulent Karoo	5,182,370ha	14.30%

The proposed site is mainly located within the Savanna Biome, with a small southern portion situated within the Nama Karoo Biome. The Savanna Biome is known to support more than 5,700 plant species, exceed only by the Fynbos Ecoregion in species richness. The study sites are located within the Kalahari variation of the Savanna Biome, which although referred to as a desert, is not a true desert as it does not approximate the extreme aridity of a true desert. This area is densely covered by grasses, shrubs and trees.

The Nama Karoo Biome, the second largest biome in Southern Africa, is characterised by plains of dwarf shrubs and grasses, dotted with characteristic koppies. It is essentially a grassy, dwarf shrubland; the ration of grasses to shrubs increase progressively, until the Nama Karoo merges with the Grassland Biome. The species richness of this region is not particularly rich; only 2,147 species, of which 386 (18%) are endemic and 67 are threatened, occur.

The SANBI database indicates the presence of approximately 5,315 plant species within this province, with only 91 species within the ¼ degree grids in which the study sites are located (2821DB, DD, 2822CA). This low diversity reflects the poor floristic knowledge of the region. The species diversity comprises a diversity of growth forms, presented in Table 3, dominated by herbs (32 species, 35.2%), dwarf shrubs (24 species, 26.4%) and grasses (18 species, 19.8%). Trees and tall shrubs comprise a relative low part of the total, reflecting on the open savanna/ shrubland physiognomy of the region.

Table 3: Growth forms of the		
Growth Form	**Total**	**Percentage**
Climbers	1	1.1%
Dwarf shrubs	24	26.4%
Geophytes	1	1.1%
Graminoids	18	19.8%

Table 3: Growth forms of the		
Growth Form	**Total**	**Percentage**
Herbs	32	35.2%
Parasites	2	2.2%
Shrubs	7	7.7%
Succulents	1	1.1%
Trees	5	5.5%
Total	**91**	

8.2 DIVERSITY – SURVEY RESULTS

The species list that was compiled during the site investigation is considered moderately comprehensive. A total of 112 plant species were identified during the site investigations (Appendix 1). The regional setting dictates the physiognomic dominance of the herbaceous component (Table 4) with 47 forb species (41.96%) and 24 grass species (21.43%). Trees and shrubs occur extensively throughout most of the study area (26 species 28.58%).

Table 4: Growth forms for the study area		
Growth Form	**Number**	**Percentage**
Climber	4	3.57%
Forb	47	41.96%
Geophyte	2	1.79%
Grass	24	21.43%
Parasite	1	0.89%
Sedge	1	0.89%
Shrub	20	17.86%
Succulent	7	6.25%
Tree	6	5.36%
Total	**112**	

Taking the setting of the study area into consideration, the species composition of untransformed vegetation types is regarded representative of the regional vegetation. A total of 35 plant families are represented in the study area, dominated by Poaceae (grass family, 24 species, 21.43%), Fabaceae (16 species, 14.29%) and Asteraceae (daisy family, 12 species, 10.71%) (Table 5).

Table 5: Growth forms for the study area		
Growth Form	**Number**	**Percentage**
Acanthaceae	5	4.46%
Aizoaceae	4	3.57%
Amaranthaceae	4	3.57%
Amaryllidaceae	1	0.89%
Anacardiaceae	2	1.79%
Apocynaceae	1	0.89%
Asclepiadaceae	3	2.68%
Asteraceae	12	10.71%

Table 5: Growth forms for the study area

Growth Form	Number	Percentage
Bignoniaceae	1	0.89%
Boraginaceae	1	0.89%
Capparaceae	4	3.57%
Chenopodiaceae	2	1.79%
Commelinaceae	1	0.89%
Cucurbitaceae	3	2.68%
Cyperaceae	1	0.89%
Euphorbiaceae	2	1.79%
Fabaceae	16	14.29%
Geraniaceae	1	0.89%
Lamiaceae	1	0.89%
Liliaceae	3	2.68%
Loranthaceae	1	0.89%
Oxalidaceae	1	0.89%
Pedaliaceae	1	0.89%
Plumbaginaceae	1	0.89%
Poaceae	24	21.43%
Polygonaceae	1	0.89%
Portulacaceae	2	1.79%
Rhamnaceae	1	0.89%
Santalaceae	1	0.89%
Scrophulariaceae	2	1.79%
Solanaceae	4	3.57%
Sterculiaceae	1	0.89%
Tiliaceae	1	0.89%
Verbenaceae	1	0.89%
Zygophyllaceae	2	1.79%

8.3 Floristic Habitat types

In spite of a relative homogenous appearance to much of the regional habitat, with the exception of extensive mountain ranges, a relative obvious physiognomic variability is noted in the study area with plains alternating with parallel dunes and mountain foothills in the northern parts. It is highly likely that various smaller phytosociological differences are present within each of the identified habitat types, but for the purpose of this assessment, the observed ecological units are considered similar in major phytosociological, physiognomic and biophysical attributes. Many plant species occur across all of the habitat types, but many of the differences between units are ascribed purely on the basis of terrain morphology, soil characteristics or changes in the dominance and structure of the plant species. Surface water and rainfall in this part of the Kalahari is scarce and, together with substrate, is a major driving force of vegetation development.

Results of the photo analysis and site investigations revealed the presence of the following habitat types (Figure 8):

- Calcareous Low Shrub Plains;
- Open Shrub Duneveld;
- Open Shrub Plains;
- Quartzitic Low Shrub Plains;
- Rocky Outcrops/ Foothills;
- Transformed Areas; and
- Riparian Habitat.

The extent and coverage of habitat types within the study area is presented in Table 6.

Table 6: Extent of habitat types within the study area

Habitat Type	Extent (ha)	Percentage
Calcareous Low Shrub Plains	905.73ha	18.94%
Open Shrub Duneveld	1,538.11ha	32.16%
Open Shrub Plains	2,168.18ha	45.33%
Quartzitic Low Shrub Plains	71.87ha	1.50%
Riparian Habitat	16.54ha	0.35%
Rocky Outcrops/ Foothills	75.88ha	1.59%
Transformed Areas	6.67ha	0.14%

8.3.1 Calcareous Low Shrub Plains

This unit comprises approximately 905.73ha (18.94%) of the study area. The topography of these areas are characterised by relative flat or slightly undulating plains where the substrate comprises whitish calcareous and compact sandy soils (grey to brown, not red). The vegetation is characterised by low shrubs and grasses; tall shrubs and trees are generally absent from this unit, or occur at extremely low intervals. Prominent species include the grasses *Enneapogon desvauxii, Eragrostis obtusa, Eragrostis truncata, Fingerhuthia africana, Stipagrostis ciliata*, the shrub Salsola etoshensis and the forbs *Pentzia calcarea, Eriocephalus spinescens, Monechma genistifolium* subsp. *australe, Geigeria* species. The shrubs *Rhigozum trichotomum* and *Lycium horridum* were observed in this unit.

The status of these areas appears to be relative degraded due to high grazing pressure and a moderate status is therefore ascribed.

Table 7: Plant species for the Calcareous Low Shrub Plains unit

Species Name	Growth Form	Family
Acacia erioloba	Tree	Fabaceae
Acacia haematoxylon	Tree	Fabaceae
Acacia mellifera	Shrub	Fabaceae
Anthephora pubescens	Grass	Poaceae
Aptosimum procumbens	Forb	Scrophulariaceae
Aristida congesta subsp. *congesta*	Grass	Poaceae
Aristida stipitata	Grass	Poaceae

Table 7: Plant species for the Calcareous Low Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Asparagus laricinus	Shrub	Liliaceae
Asparagus species	Shrub	Liliaceae
Acacia mellifera	Shrub	Fabaceae
Adenium oleifolium	Succulent	Apocynaceae
Aristida congesta subsp*. congesta*	Grass	Poaceae
Barleria species	Forb	Acanthaceae
Boscia albitrunca	Tree	Capparaceae
Cenchrus ciliaris	Grass	Poaceae
Chrysocoma obtusata	Forb	Asteraceae
Enneapogon desvauxii	Grass	Poaceae
Eragrostis obtusa	Grass	Poaceae
Eragrostis truncata	Grass	Poaceae
Eriocephalus spinescens	Forb	Asteraceae
Fingerhuthia africana	Grass	Poaceae
Geigeria species	Forb	Asteraceae
Lycium bosciifolium	Shrub	Solanaceae
Lycium horridum	Shrub	Solanaceae
Monechma genistifolium subsp*. australe*	Forb	Acanthaceae
Nerine laticoma	Geophyte	Amaryllidaceae
Pentzia calcarea	Forb	Asteraceae
Rhigozum trichotomum	Shrub	Bignoniaceae
Salsola etoshensis	Shrub	Chenopodiaceae
Salsola tuberculatiformis	Shrub	Chenopodiaceae
Schmidtia kalihariensis	Grass	Poaceae
Setaria verticillata	Grass	Poaceae
Stipagrostis ciliata	Grass	Poaceae
Stipagrostis obtusa	Grass	Poaceae
Tribulus zeyheri	Forb	Zygophyllaceae
Ziziphus mucronata	Tree	Rhamnaceae

8.3.2 Open Shrub Duneveld

This unit comprises approximately 1,538.11ha (32.16%) of the study area. The major physiognomic attribute of this unit is the presence of low dunes with characteristic crests, slopes and streets. Each of these units could be described as a variation of this unit on the basis of distinctive habitat attributes and species composition, but for the purpose of this investigation, they are considered holistically as they always occur in association with each other.

The physiognomy conforms to an open tree savanna. Dominant species include the tree *Acacia mellifera* and the grass *Schmidtia kalahariensis*. Other prominent woody species are *Acacia haematoxylon*, *Parkinsonia africana*, *Rhigozum trichotomum*, *Boscia albitrunca* and *Acacia erioloba* and occasionally *Lycium bosciifolium*. Besides *Schmidtia kalahariensis,* the grass layer is characterised by *Eragrostis lehmanniana*, *Centropodia glauca*, *Stipagrostis amabilis*, *Brachiaria glomerata Stipagrostis obtusa* and *S. ciliata*. Herbs that are found in this unit include *Hermannia tomentosa*, *Hermbstaedtia fleckii*, *Requienia sphaerosperma*, *Dicoma capensis*, *Momordica balsamina* and the climber *Pergularia daemia*. The species composition of this unit is indicated in Table 8.

Table 8: Plant species for the Open Shrub Duneveld unit		
Species Name	**Growth Form**	**Family**
Acacia erioloba	Tree	Fabaceae
Acacia haematoxylon	Tree	Fabaceae
Acacia mellifera	Shrub	Fabaceae
Anthephora pubescens	Grass	Poaceae
Aptosimum procumbens	Forb	Scrophulariaceae
Aristida congesta subsp. *congesta*	Grass	Poaceae
Aristida stipitata	Grass	Poaceae
Asparagus laricinus	Shrub	Liliaceae
Asparagus species	Shrub	Liliaceae
Boscia albitrunca	Tree	Capparaceae
Brachiaria glomerata	Grass	Poaceae
Bulbostylis hispidula	Sedge	Cyperaceae
Centropodia glauca	Grass	Poaceae
Chascanum pumilum	Forb	Verbenaceae
Citrullus lanatus	Climber	Cucurbitaceae
Cleome angustifolia	Forb	Capparaceae
Cleome gynandra	Forb	Capparaceae
Commelina species	Forb	Commelinaceae
Crotalaria spartioides	Shrub	Fabaceae
Cucumis africanus	Forb	Cucurbitaceae
Dicoma capensis	Forb	Asteraceae
Eragrostis lehmanniana	Grass	Poaceae
Eragrostis species	Grass	Poaceae
Eragrostis trichophora	Grass	Poaceae
Heliotropium ciliatum	Forb	Boraginaceae
Hermannia tomentosa	Forb	Sterculiaceae
Hermbstaedtia fleckii	Forb	Amaranthaceae
Hermbstaedtia odorata	Forb	Amaranthaceae
Hirpicium gazanioides	Forb	Asteraceae
Indigofera alternans	Forb	Fabaceae
Indigofera charlieriana var. *charlieriana*	Forb	Fabaceae
Lebeckia linearifolia	Shrub	Fabaceae
Leucas capensis	Forb	Lamiaceae
Limeum fenestratum	Forb	Aizoaceae
Limeum sulcatum	Forb	Aizoaceae
Limeum viscosum	Forb	Aizoaceae
Lycium bosciifolium	Shrub	Solanaceae
Lycium species	Shrub	Solanaceae
Momordica balsamina	Climber	Cucurbitaceae
Monechma incanum	Shrub	Acanthaceae
Nolletia arenosa	Forb	Asteraceae
Oxalis semiloba	Geophyte	Oxalidaceae
Oxygonum dregeanum	Forb	Polygonaceae

Table 8: Plant species for the Open Shrub Duneveld unit		
Species Name	**Growth Form**	**Family**
Parkinsonia africana	Tree	Fabaceae
Pergularia daemia	Climber	Asclepiadaceae
Plinthus sericeus	Shrub	Aizoaceae
Requienia sphaerosperma	Forb	Fabaceae
Rhigozum trichotomum	Shrub	Bignoniaceae
Rhynchosia species	Forb	Fabaceae
Schmidtia kalihariensis	Grass	Poaceae
Senna italica	Forb	Fabaceae
Stipagrostis amabilis	Grass	Poaceae
Stipagrostis ciliata	Grass	Poaceae
Stipagrostis obtusa	Grass	Poaceae
Tapinanthus oleifolius	Parasite	Loranthaceae
Tribulus terrestris	Forb	Zygophyllaceae
Tribulus zeyheri	Forb	Zygophyllaceae

The presence of the grass species *Schmidtia kalihariensis* is generally accepted as an indicator of high utilisation pressure. This habitat type is representative of the Gordonia Duneveld vegetation type (Mucina & Rutherford, 2006) and is in a relative good condition. A moderate status and moderate-high sensitivity is therefore ascribed to this unit due to the association with dune habitat.

8.3.3 Open Shrub Plains

This habitat type comprises the largest part of the study area, approximately 2,168.18ha (45.33%). Biophysical attributes include open plains (flat or slightly undulating) with high shrubs and scattered trees on deep sandy, red soils or gravel plains and a well-developed herbaceous layer.

The species diversity is relative low; only 24 species were observed during the survey period. Prominent tall woody species in this undulating landscape are *Acacia erioloba, A. mellifera, Parkinsonia africana, Grewia flava* and *Boscia albitrunca*. Low shrubs include *Lebeckia linearifolia, Lycium bosciifolium, Rhigozum trichotomum* and *Salsola etoshensis.* Conspicuous grass species include *Schmidtia kalahariensis*, *Eragrostis lehmanniana* and *Stipagrostis ciliata*. Prominent forb species include *Monechma genistifolium* subsp. *genistifolium* and *Indigofera* species.

Table 9: Plant species for the Open Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Acacia erioloba	*Tree*	*Fabaceae*
Acacia mellifera	*Shrub*	*Fabaceae*
Asparagus species	*Shrub*	*Liliaceae*
Blepharis species	Forb	Acanthaceae
Boscia albitrunca	Tree	Capparaceae

Table 9: Plant species for the Open Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Bulbostylis hispidula	Sedge	Cyperaceae
Cenchrus ciliaris	Grass	Poaceae
Eragrostis lehmanniana	Grass	Poaceae
Euphorbia species	Succulent	Euphorbiaceae
Grewia flava	Shrub	Tiliaceae
Indigofera species	Forb	Fabaceae
Lebeckia linearifolia	Shrub	Fabaceae
Limeum viscosum	Forb	Aizoaceae
Lycium bosciifolium	Shrub	Solanaceae
Monechma genistifolium subsp*. australe*	Forb	Acanthaceae
Parkinsonia africana	Tree	Fabaceae
Pergularia daemia	Climber	Asclepiadaceae
Plinthus sericeus	Shrub	Aizoaceae
Rhigozum trichotomum	Shrub	Bignoniaceae
Salsola etoshensis	Shrub	Chenopodiaceae
Schmidtia kalihariensis	Grass	Poaceae
Stipagrostis ciliata	Grass	Poaceae
Stipagrostis obtusa	Grass	Poaceae
Tapinanthus oleifolius	Parasite	Loranthaceae

This habitat type is representative of the regional vegetation type Kalahari Karroid Shrubland (Mucina & Rutherford, 2006), which typically forms bands alternating with bands of Gordonia Duneveld. A moderate floristic status is ascribed to this unit.

8.3.4 Quartzitic Low Shrub Plains

This fairly unique habitat is situated in the southern part of the study area, comprising a small portion of the study area (71.87ha, 1.50%) that is situated on plains of quartzitic stones where soils are shallow and stony. The vegetation of these areas conforms to a more succulent nature, with various succulents occurring exclusively in this habitat type. Al though not noted during the survey period, the succulent *Hoodia* species, also occurs in this unit. Other succulents include *Aloe claviflora, Kleinia longiflora, Cadaba aphylla, Anacampseros ustilata, A. albidiflora* and *Euphorbia* species. Prominent grasses include *Enneapogon desvauxii, Eragrostis* species, *Fingerhuthia africana* and *Stipagrostis obtusa.* Woody species are generally absent with only the low shrub *Salsola etoshensis* occurring regularly.

This habitat type is not representative of the regional vegetation type and therefore represents an atypical and important variation. A high floristic status and sensitivity is therefore ascribed.

Table 10: Plant species for the Quartzitic Low Shrub Plains unit		
Species Name	**Growth Form**	**Family**

Table 10: Plant species for the Quartzitic Low Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Acacia mellifera	Shrub	Fabaceae
Adenium oleifolium	Succulent	Apocynaceae
Aloe claviflora	Succulent	Liliaceae
Anacampseros albidiflora	Succulent	Portulacaceae
Anacampseros ustulata	Succulent	Portulacaceae
Aptosimum lineare	Forb	Scrophulariaceae
Aptosimum procumbens	Forb	Scrophulariaceae
Blepharis species	Forb	Acanthaceae
Cadaba aphylla	Succulent	Capparaceae
Cucumis africanus	Forb	Cucurbitaceae
Dicoma capensis	Forb	Asteraceae
Enneapogon desvauxii	Grass	Poaceae
Eragrostis species	Grass	Poaceae
Eriocephalus spinescens	Forb	Asteraceae
Euphorbia species	Succulent	Euphorbiaceae
Felicia species	Forb	Asteraceae
Fingerhuthia africana	Grass	Poaceae
Geigeria species	Forb	Asteraceae
Hoffmannseggia burchellii subsp. *burchellii*	Forb	Fabaceae
Kleinia longiflora	Succulent	Asteraceae
Leucosphaera bainesii	Shrub	Amaranthaceae
Monechma genistifolium subsp. *australe*	Forb	Acanthaceae
Monsonia angustifolia	Forb	Geraniaceae
Pentzia calcarea	Forb	Asteraceae
Ptycholobium biflorum	Forb	Fabaceae
Salsola etoshensis	Shrub	Chenopodiaceae
Stipagrostis obtusa	Grass	Poaceae
Tribulus terrestris	Forb	Zygophyllaceae

8.3.5 Riparian Habitat

This habitat type is situated in the southern part of the study area, comprising approximately 16.5ha (0.35%) of the study area. It conforms to drainage lines which are mostly non-functional during most parts of the year; only flowing for short periods after significant rains has fallen. The vegetation is dominated by a prominent tree layer, consisting of *Acacia mellifera*, *Ziziphus mucronata*, *Boscia albitrunca* and the invasive species *Prosopis glandulosa.* The herbaceous layer is poorly develop with only the graminoids *Eragrostis porosa*, *Enneapogon scoparius Setaria verticillata* and *Cenchrus ciliaris* occurring at relative high densities. The fob component comprises the weedy species *Pentarrhinum insipidum*, *Berkheya species*, *Flaveria bidentis* and *Kyphocarpa angustifolia.*

Table 11: Plant species for the Quartzitic Low Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Acacia mellifera	Shrub	Fabaceae
Aptosimum lineare	Forb	Scrophulariaceae

Table 11: Plant species for the Quartzitic Low Shrub Plains unit		
Species Name	**Growth Form**	**Family**
Berkheya species	Forb	Asteraceae
Boscia albitrunca	Tree	Capparaceae
Cenchrus ciliaris	Grass	Poaceae
Cucumis africanus	Forb	Cucurbitaceae
Enneapogon desvauxii	Grass	Poaceae
Enneapogon scoparius	Grass	Poaceae
Eragrostis porosa	Grass	Poaceae
Eragrostis species	Grass	Poaceae
Flaveria bidentis	Forb	Asteraceae
Geigeria ornativa	Forb	Asteraceae
Kyphocarpa angustifolia	Forb	Amaranthaceae
Lycium bosciifolium	Shrub	Solanaceae
Monechma divaricatum	Forb	Acanthaceae
Pentarrhinum insipidum	Climber	Asclepiadaceae
Pentzia calcarea	Forb	Asteraceae
Prosopis glandulosa	Tree	Fabaceae
Setaria verticillata	Grass	Poaceae
Stipagrostis ciliata	Grass	Poaceae
Tapinanthus oleifolius	Parasite	Loranthaceae
Ziziphus mucronata	Tree	Rhamnaceae

In spite of a poor floristic status, a high sensitivity is ascribed due to the association with riparian conditions. This habitat also frequently occurs in close vicinity to the Quartzitic Low Shrub Plains habitat type.

8.3.6 Rocky Outcrops/ Foothills

This habitat type occurs in the far northern section of the study area, comprising approximately 75.88ha (1.59%) of the study area. The major physiognomic characteristic of this unit is the prevalence of rocks/ boulders, rendering the appearance of the unit extremely rugged. This unit probably forms part of the southern outliers of the Langeberg Mountain group. Soils in this unit are characteristically shallow and poor in nutrients. All other habitat types had little or nor rock cover and deeper soils. The species composition compares well to the Koranna-Langeberg Mountain Bushveld described by Mucina and Rutherford (2006). The physiognomy is an open tall shrubveld; a prominent herbaceous stratum with interspersed tall shrubs, bushes and low trees is observed.

This unit was found to be in an extremely pristine condition and, due to the association with high slopes, are generally regarded as sensitive.

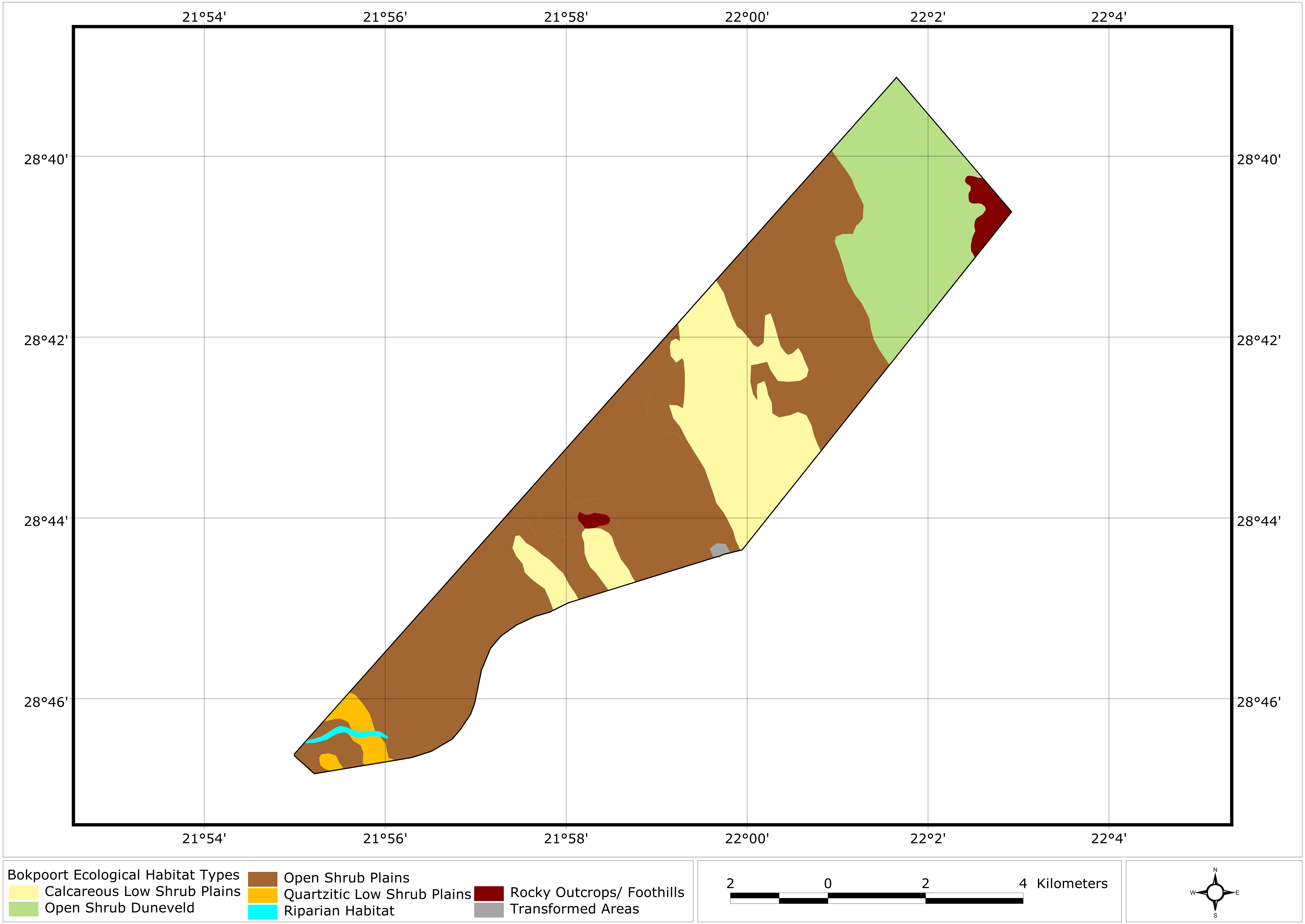
A moderate species diversity was noted (27 species) with a relative equal distribution of herbs, grasses and shrubs (Table 12). The shrubs *Croton gratissimus* and *Searsia burchelli* appears prominently in this unit. Prominent grasses include *Cymbopogon pospischilii, Aristida* species, *Digitaria eriantha, Enneapogon scoparius, Cenchrus ciliaris* and *Stipagrostis* *ciliata.* Prominent forbs include *Asparagus* species, *Geigeria* species, *Indigofera* species and *Thesium* species.

Table 12: Plant species for the Rocky Outcrops/ Foothills unit		
Species Name	**Growth Form**	**Family**
Acacia mellifera	Shrub	Fabaceae
Aristida species	Grass	Poaceae
Asparagus species	Shrub	Liliaceae
Berkheya species	Forb	Asteraceae
Boscia albitrunca	Tree	Capparaceae
Cenchrus ciliaris	Grass	Poaceae
Ceratotheca triloba	Forb	Pedaliaceae
Croton gratissimus	Shrub	Euphorbiaceae
Cymbopogon pospischilii	Grass	Poaceae
Digitaria eriantha	Grass	Poaceae
Enneapogon desvauxii	Grass	Poaceae
Enneapogon scoparius	Grass	Poaceae
Eragrostis lehmanniana	Grass	Poaceae
Geigeria species	Forb	Asteraceae
Gomphocarpus fruticosus	Shrub	Asclepiadaceae
Indigofera species	Forb	Fabaceae
Kleinia longiflora	Succulent	Asteraceae
Melinis repens	Grass	Poaceae
Plumbago species	Shrub	Plumbaginaceae
Rhynchosia species	Forb	Fabaceae
Searsia burchelli	Shrub	Anacardiaceae
Searsia species	Shrub	Anacardiaceae
Solanum supinum	Forb	Solanaceae
Stipagrostis ciliata	Grass	Poaceae
Tephrosia species	Forb	Fabaceae
Thesium species	Forb	Santalaceae
Tribulus terrestris	Forb	Zygophyllaceae

8.3.7 Transformed Areas

No natural vegetation remains in this area, and a low floristic status is ascribed.

Figure 8: Floristic habitat types of the study area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Bokpoort Ecological Habitat Types
Calcareous Low Shrub Plains
Open Shrub Duneveld
Open Shrub Plains
Quartzitic Low Shrub Plains
Riparian Habitat
Rocky Outcrops/ Foothills
Transformed Areas
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8.4 FLORA SPECIES OF CONSERVATION IMPORTANCE

Table 13: Red List Categories used by SANBI (2009)

Category	Description
EX (Extinct)	A taxon is Extinct when there is no reasonable doubt that the last individual has died. Taxa should be listed as extinct only once exhaustive surveys throughout the historic range have failed to record an individual.
EW (Extinct in the Wild)	A taxon is Extinct in the Wild when it is known to only survive in cultivation or as a naturalised population (or populations) well outside the past range.
CR PE (Critically Endangered, Possibly Extinct)	Critically Endangered (possibly extinct) taxa are those that are, on the balance of evidence, likely to be extinct, but for which there is a small chance that they may be extant. Hence they should not be listed as Extinct until adequate surveys have failed to record the species.
CR (Critically Endangered)	A taxon is Critically Endangered when the best available evidence indicates that it meets any of the five IUCN criteria for Critically Endangered, and is therefore facing an extremely high risk of extinction in the wild.
EN (Endangered)	A taxon is Endangered when the best available evidence indicates that it meets any of the five IUCN criteria for Endangered, and is therefore facing a very high risk of extinction in the wild.
VU (Vulnerable)	A taxon is Vulnerable when the best available evidence indicates that it meets any of the five IUCN criteria for Vulnerable, and is therefore facing a high risk of extinction in the wild.
NT (Near Threatened)	A taxon is Near Threatened when available evidence indicates that it nearly meets any of the five IUCN criteria for Vulnerable, and is therefore likely to qualify for a threatened category in the near future.
Critically Rare	A taxon is Critically Rare when it is known to only occur at a single site, but is not exposed to any direct or plausible potential threat and do not qualify for a category of threat according to the five IUCN criteria.
Rare	A taxon is Rare when it meets any of the four South African criteria for rarity, but is not exposed to any direct or plausible potential threat and do not qualify for a category of threat according to the five IUCN criteria.
Declining	A taxon is Declining when it does not meet any of the five IUCN criteria and does not qualify for the categories Critically Endangered, Endangered, Vulnerable or Near Threatened, but there are threatening processes causing a continuing decline in the population.
LC (Least Concern)	A taxon is Least Concern when it has been evaluated against the five IUCN criteria and does not qualify for the categories Critically Endangered, Endangered, Vulnerable and Near Threatened, or the South African categories Critically Rare, Rare or Declining. Widespread and abundant taxa are typically listed in this category.
DDD (Data Deficient - Insufficient Information)	A taxon is DDD when there is inadequate information to make an assessment of its risk of extinction. Data Deficient is not a category of threat, however, listing of taxa in this category indicates that more information is required and that future research could show that a threatened classification is appropriate
DDT (Data Deficient - Taxonomically Problematic)	A taxon is DDT when taxonomical problems hinder its distribution range and habitat from being well defined, so that an assessment of risk of extinction is not possible.

Thr*	Taxa that have been identified as likely to be threatened during the final stages of the compilation of this Red List. Their status has however not yet been finalized.

PRECIS data from SANBI indicate no Red Data flora species present within the ¼ degree grids in which the study area is situated. However, the following species of conservation importance are known to occur in the region, or was observed in the study area (Table 14). Species in **red bold** was observed in the study area. Species indicated in **black bold** are regarded likely inhabitants of the study area, taking cognisance of the habitat available.

Table 14: Conservation important flora species for the region

Species	Family	Threat status
Acacia erioloba	**Fabaceae**	**Protected Tree (National Forest Act, 1998)**
Acacia haematoxylon	**Fabaceae**	**Kalahari Endemic**
Anthephora argentea	**Poaceae**	**Regionally important (VEGMAP)**
Boscia albitrunca	**Capparaceae**	**Protected Tree (National Forest Act, 1998)**
Cucumis heptadactylus	Cucurbitaceae	SA Endemic
Digitaria polyphylla	Poaceae	Regionally important (VEGMAP)
Dinebra retroflexa	Poaceae	Regionally important (VEGMAP)
Dinteranthus pole-evansii	Mesembryanthemaceae	Regionally important (VEGMAP)
Haworthia venosa subsp. tessellata	Asphodelaceae	SA Endemic
Helichrysum arenicola	**Asteraceae**	**Regionally important (VEGMAP)**
Heliophila remotiflora	Brassicaceae	SA Endemic
Hyobanche sanguinea	Orobanchaceae	SA Endemic
Justicia puberula	Acanthaceae	SA Endemic, Regionally important (VEGMAP)
Justicia thymifolia	Acanthaceae	SA Endemic
Kohautia ramosissima	Rubiaceae	Regionally important (VEGMAP)
Larryleachia dinteri	Apocynaceae	Regionally important (VEGMAP)
Larryleachia marlothii	Apocynaceae	Regionally important (VEGMAP)
Lotononis oligocephala	Fabaceae	Regionally important (VEGMAP)
Megaloprotrachne albescens	**Poaceae**	**Regionally important (VEGMAP)**
Nemesia maxii	Scrophulariaceae	Regionally important (VEGMAP)
Neuradopsis austro-africana	**Neuradaceae**	**Regionally important (VEGMAP)**
Pharnaceum viride	Molluginaceae	SA Endemic
Ruschia kenhardtensis	Aizoaceae	Regionally important (VEGMAP)
Senecio intricatus	Asteraceae	SA Endemic
Stipagrostis amabilis	**Poaceae**	**Kalahari endemic**
Tridentea dwequensis	Asclepiadaceae	Regionally important (VEGMAP)
Zygophyllum lichtensteinianum	Zygophyllaceae	SA Endemic

8.5 Alien & Invasive Species

Invading alien organisms pose the second largest threat to biodiversity after direct habitat destruction (UNEP, 2002). Invasive species are a threat to indigenous species through the following mechanisms:

- displacement by direct competition;
- reduction of structural diversity;
- disruption of the prevailing vegetation dynamics;
- impacts on fire regimes due to increases in biomass;
- alteration of local hydrology; and
- modification of nutrient cycling (Van Wilgen and Van Wyk, 1999).

CARA (2001) makes provision for four groups of problem plants:

- Declared weeds (Category 1 plants) – alien species prohibited on any land or water surface in South Africa; must be controlled or eradicated where possible;
- Declared invaders (Category 2 plants, commercial and utility plants) – alien species allowed only in demarcated areas providing there is a permit and that steps are taken to prevent their spread;
- Declared invaders (Category 3 plants, ornamentals) – alien species that may no longer be planted; existing plants may remain provided that all reasonable steps are taken to prevent their spread; prohibited within the floodline of watercourses and wetlands; and
- Declared indicators of bush encroachment – indigenous species that under certain circumstances e.g. overgrazing may cause bush densification.

The following species occur in the study area:

Table 15: Declared invasive and exotic flora species for the study area

Species	Family	Threat status
Prosopis glandulosa	Fabaceae	Category 2 Invader
Rhigozum trichotomum	Bignoniaceae	Declared indicator of encroachment
Acacia mellifera	Fabaceae	Declared indicator of encroachment

8.6 FLORISTIC SENSITIVITY

Floristic sensitivity estimations are presented in Table 16 and illustrated in Figure 9. The extent of floristic sensitivities within the study area is presented in Table 17.

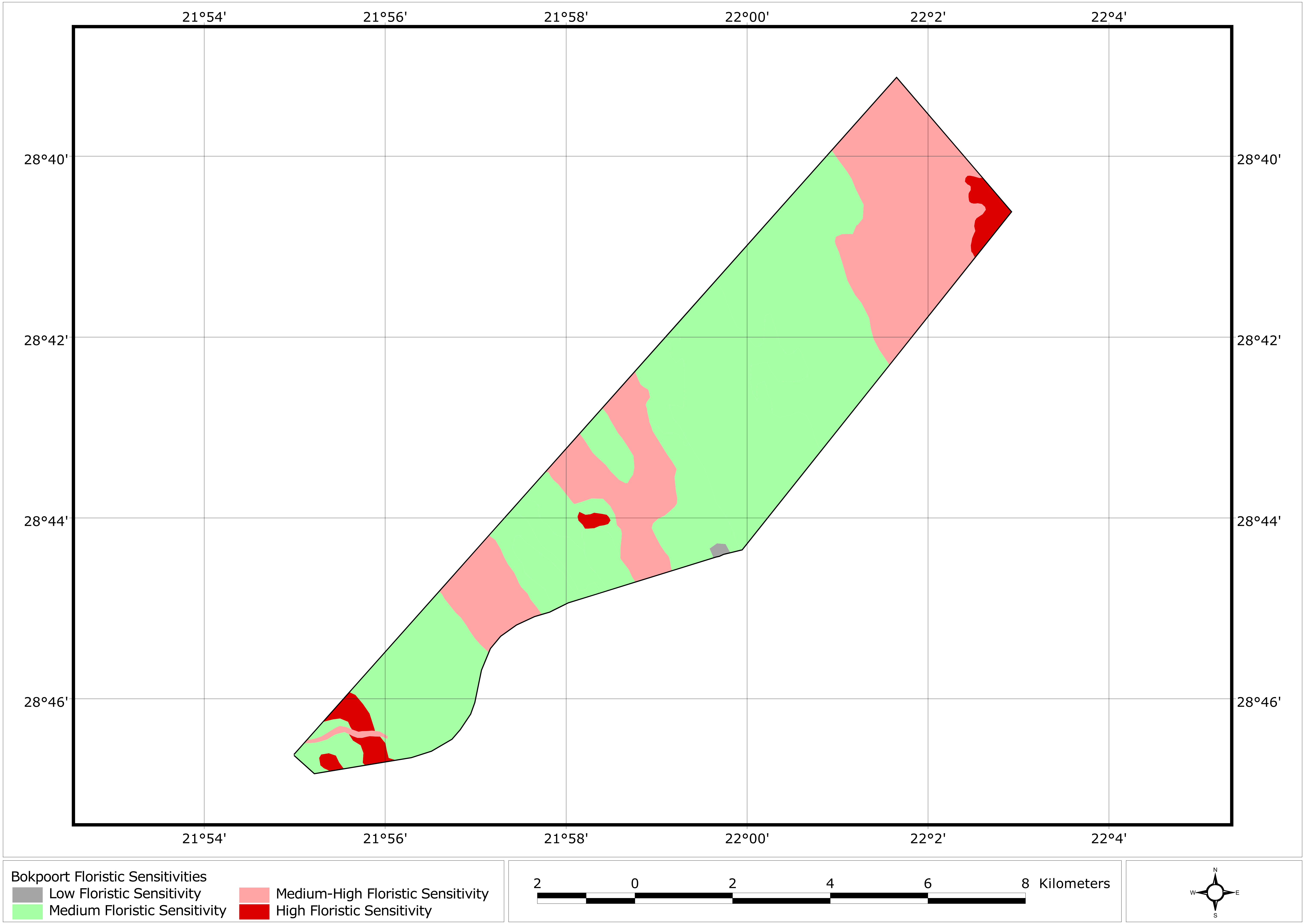
Table 16: Floristic sensitivity estimations for the respective habitat types

Criteria	RD species	Landscape sensitivity	Ecology Status	Species diversity	Functionality / fragmentation	TOTAL	SENSITIVITY INDEX	SENSITIVITY CLASS
Community	**Criteria Ranking**							
Calcareous Low Shrub Plains	4	4	6	7	9	170	53%	Medium
Open Shrub Duneveld	5	8	8	9	9	234	73%	Medium-High
Open Shrub Plains	4	6	6	7	8	183	57%	Medium
Quartzitic Low Shrub Plains	8	8	9	9	9	270	84%	High
Riparian Habitat	4	10	6	6	4	198	62%	Medium-High
Rocky Outcrops/ Foothills	8	10	9	8	9	281	88%	High
Transformed Areas	0	0	0	0	0	0	0%	Low

Table 17: Extent of floristic sensitivities within the study area

Sensitivity Class	Extent	Percentage
Low	6.67ha	0.14%
Medium	3,073.90	64.27%
Medium-High	1,554.65	32.50%
High	147.75	3.09%

Figure 9: Floristic sensitivities of habitat types within the study area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Bokpoort Floristic Sensitivities
Low Floristic Sensitivity
Medium Floristic Sensitivity
Medium-High Floristic Sensitivity
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9 FAUNA OF THE STUDY AREA

9.1 GENERAL DIVERSITY

9.1.1 Invertebrates

The invertebrates observed in the study area during the field investigation attested to a healthy, functioning ecosystem on the microhabitat as well as source-sink population dynamics scales. A total of 12 butterflies were observed in the study area; most of these species are common and widespread; if not in Southern Africa then in the drier western regions of the subcontinent (Table 18). It is highly likely that many other species will complement the observed assemblage of butterflies should the study be repeated in early summer (the only flight time of some Lepidoptera groups, notably Lycaenidae). The drier western regions of South Africa have significantly fewer butterflies than the wetter east; consequently the number of species observed during the field survey (given timing of the survey as well geographic location of the study area) confirms the untransformed and un-fragmented nature of the study area.

Table 18: Butterfly species of the study area

Biological Name	**English Name**	**Status**
Belenois aurota	Brown-veined White	Least Threatened
Catopsilla florella	African Migrant	Least Threatened
Cigaritis phanes	Silvery Bar	Least Threatened
Colotis eris	Banded Gold Tip	Least Threatened
Colotis lais	Kalahari Orange Tip	Least Threatened
Danaus chryssipus	African Monarch	Least Threatened
Junonia hierta	Yellow Pansy	Least Threatened
Pinacopteryx eriphia	Zebra White	Least Threatened
Spialia diomus	Common Sandman	Least Threatened
Zintha hintza	Hintza Blue	Least Threatened
Zizeeria knysna	Sooty Blue	Least Threatened
Zizula hylax	Gaika Blue	Least Threatened

9.1.2 Herpetofauna

During the field study, the presence of eight reptiles was confirmed to occur in the study area by means of observation techniques as well as by the landowner (Table 19). Species confirmed by the landowner included well-known species such as Cape Cobra and Puff Adder; these species are easily identifiable and changes of erroneous identification are unlikely. No frogs were observed during the field investigation and is regarded to reflect the combination of the dry nature of the habitat (there are far fewer species in the Northern Cape than for instance in KZN) and the timing of the field investigation (if the study is repeated after the first spring rains it is expected that at least a couple of species would prove to reside in the study area).

Table 19: Herpetofauna species of the study area		
Biological Name	**English Name**	**Status**
Agama atra	Southern Rock Agama	Least Threatened
Bitis arietans	Puff Adder	Least Threatened
Naja nivea	Cape Cobra	Least Threatened
Pedioplanis lineoocellata	Spotted Sand Lizard	Least Threatened
Psammobates oculiferus	Kalahari Tent Tortoise	Least Threatened
Ptenopus garrulus	Common Barking Gecko	Least Threatened
Trachylepis striata	Striped Skink	Least Threatened
Varanus albigularis	Rock Monitor	Least Threatened

9.1.3 Avifauna

A total of 30 bird species was observed in the study area during the field survey (Table 20). Please note that avifauna is only treated briefly in this general faunal assessment as part of the general animal diversity and –sensitivity with regards to the proposed project. The reader is referred to the Avifauna Assessment Document (C. van Rooyen) for a more detailed discussion on the birds and bird-related sensitivities. Of the observed species, three are listed as Red Data, namely Kori Bustard (VU), Secretarybird (NT) and Martial Eagle (VU). The number and diversity of the species observed in the study area confirms the natural and diverse nature of the faunal habitats of the study area.

Photo 1: The Southern Pale Chanting Goshawk (*Melierax canorus*) is one of many raptor species that is commonly found in the region of the study area.

Table 20: Bird species of the study area		
Biological Name	**English Name**	**Status**
Afrotis afraoides	Northern Black Korhaan	Least Threatened
Ardeotis kori	Kori Bustard	Vulnerable
Bradornis infuscatus	Chat Flycatcher	Least Threatened
Burhinus capensis	Spotted Thick-knee	Least Threatened

Table 20: Bird species of the study area		
Biological Name	**English Name**	**Status**
Cinnyris fuscus	Dusky Sunbird	Least Threatened
Circaetus pectoralis	Black-chested Snake-Eagle	Least Threatened
Corvus albus	Pied Crow	Least Threatened
Coturnix coturnix	Common Quail	Least Threatened
Cursorius temminckii	Temminck's Courser	Least Threatened
Dryoscopus cubla	Black-backed Puffback	Least Threatened
Emberiza capensis	Cape Bunting	Least Threatened
Eremopterix verticalis	Grey-backed Sparrowlark	Least Threatened
Laniarius atrococcineus	Crimson-breasted Shrike	Least Threatened
Lanius collaris	Common Fiscal	Least Threatened
Malcorus pectoralis	Rufous-eared Warbler	Least Threatened
Melierax canorus	Southern Pale Chanting Goshawk	Least Threatened
Myrmecocichla formicivora	Anteating Chat	Least Threatened
Oena capensis	Namaqua Dove	Least Threatened
Oenanthe pileata	Capped Wheatear	Least Threatened
Passer melanurus	Cape Sparrow	Least Threatened
Philetairus socius	Sociable Weaver	Least Threatened
Plocepasser mahali	White-browed Sparrow-Weaver	Least Threatened
Polemaetus bellicosus	Martial Eagle	Vulnerable
Psophocichla litsipsirupa	Groundscraper Thrush	Least Threatened
Pterocles namaqua	Namaqua Sandgrouse	Least Threatened
Quelea quelea	Red-billed Quelea	Least Threatened
Sagittarius serpentarius	Secretarybird	Near Threatened
Streptopelia senegalensis	Laughing Dove	Least Threatened
Urocolius indicus	Red-faced Mousebird	Least Threatened
Vanellus coronatus	Crowned Lapwing	Least Threatened

9.1.4 Mammals

A total of 25 mammals were confirmed in the study area during the field investigation (Table 21). Again, some of the species were confirmed as residents of the study area by the landowner. It must be noted that many of the ungulate species listed here as residents of the study area are a direct result of the hunting-related activities of the farm on which the study area is located; they cannot be considered free-roaming and are fenced in for hunting purposes. Listed species that should not be considered free-roaming include Njala, Red Hartebeest, Blue Wildebeest, Waterbuck, Gemsbok and Springbok.

During the small mammal trapping (using baited small mammal live traps), the Red Data species *Tatera leucogaster* (DD), Bushveld Gerbil, was confirmed in the Open Shrub Duneveld of the study area. The species is relatively widespread in the region of the study area and sandy soils of the subcontinent.

The study area proved to have a significant number of carnivores including Bat-eared Fox, Cape Fox, Slender Mongoose, Yellow Mongoose, Suricate, Caracal, Striped Polecat and

Black-backed Jackal. This is testament to the diversity and functionality of the ecosystem of which the study areas forms part of.

Photo 2: The Bushveld Gerbil (*Tatera leucogaster*) was observed in the study area's Open Shrub Duneveld habitat.

Table 21: Mammal species of the study area		
Biological Name	**English Name**	**Status**
Alcelaphus buselaphus	Red Hartebeest	Least Threatened
Antidorcas marsupialis	Springbok	Least Threatened
Canis mesomelas	Black-backed Jackal	Least Threatened
Caracal caracal	Caracal	Least Threatened
Connachaetus taurinus	Blue Wildebeest	Least Threatened
Cynictis penicillata	Yellow Mongoose	Least Threatened
Galerella sanguinea	Slender Mongoose	Least Threatened
Hystrix africaeaustralis	Porcupine	Least Threatened
Ictonyx striatus	Striped Polecat	Least Threatened
Kobus ellipsiprymnus	Waterbuck	Least Threatened
Lepus saxatilis	Scrub Hare	Least Threatened
Mellivora capensis	Honey Badger	Near Threatened
Orycteropus afer	Aardvark	Least Threatened
Oryx gazella	Gemsbok	Least Threatened
Otocyon megalotis	Bat-eared Fox	Least Threatened
Pedetes capensis	Springhare	Least Threatened
Pronolagus rupestris	Smith's Red Rock Rabbit	Least Threatened
Raphicerus campestris	Steenbok	Least Threatened
Suricata suricatta	Suricate	Least Threatened
Sylvicapra grimmia	Common Duiker	Least Threatened
Tatera leucogaster	Bushveld Gerbil	Data Deficient
Tragelaphus angasii	Nyala	Least Threatened
Tragelaphus strepsiceros	Kudu	Least Threatened

Table 21: Mammal species of the study area		
Biological Name	**English Name**	**Status**
Vulpes chama	Cape Fox	Least Threatened
Xerus inauris	Cape Ground Squirrel	Least Threatened

9.2 Red Data Fauna Assessment

Please note that Red Data avifauna assessments are not included in this document as it is addressed specifically in the Avifauna Assessment Document.

As a result of restrictions with regards to database availability only specific faunal groups are used during the red data aspect of this faunal assessment. Data on the Q-degree level is available for the following faunal groups:

- Invertebrates: Butterflies (South African Butterfly Conservation Assessment – http://sabca.adu.org.za)
- Amphibians: Frogs (Atlas and Red Data Book of the South Africa, Lesotho and Swaziland)
- Reptiles: Snakes and other Reptiles (South African Reptile Conservation Assessment - http://sarca.adu.org.za)
- Mammals: Terrestrial Mammals (Red Data Book of the Mammals of South Africa: A Conservation Assessment.)

Red Data animals known to be present in the Q-grids 2821DB, 2821DD and 2822CA in the above-mentioned databases were considered potential inhabitants of the study area. Additionally, species observed in the study sites during the field investigation were added to the list of species considered relevant to the study area. The likelihood of each species' presence in the study areas were estimated based on known ecological requirements of species; these requirements were compared to the ecological conditions found in the study area and surrounding faunal habitat.

- Linda's Hairtail is the only potential Red Data butterfly inhabitant of the study area. It is known from "only a few localities in Arid Savanna near Witsand, Northern Cape, near the Langeberge." There is no data on the larval host of this butterfly, but it is thought to potentially be *Acacia erioloba*. The species cannot be discounted as a potential inhabitant of the study area and is deemed to have at least a moderate likelihood of occurring in the study area.
- The Giant Bullfrog, *Pyxicephalus adspersus* (NT), is widespread in South Africa and is known from all nine provinces as well as Swaziland and Lesotho. It is known from the Savanna and Nama-Karoo biomes and is a potential inhabitant of the study area (it has been observed in the very dry Central Kalahari Game Reserve in Botswana – pers. obs.) and is considered to have a moderate-high probability of occurring in the study area.
- No Red Data reptiles are known from the Q-grids of the study area.
- Two Red Data mammals were confirmed to occur in the study area: Bushveld Gerbil (DD) and Honey Badger (NT).

Table 22: Red Data probabilities for the study area			
Biological Name	**English Name**	**STATUS**	**PROBABILITY**
LEPIDOPTERA			
Anthene lindae	Linda's Hairtail	Vulnerable	moderate
AMPHIBIANS			
Pyxicephalus adspersus	Giant Bullfrog	Near Threatened	moderate-high
MAMMALS			
Atelerix frontalis	South African Hedgehog	Near Threatened	high
Crocidura cyanea	Reddish-grey Musk Shrew	Data Deficient	moderate
Elephantulus intufi	Bushveld Elephant-shrew	Data Deficient	high
Equus zebra hartmannae	Hartmann's Mountain Zebra	Endangered	low
Mellivora capensis	Honey Badger	Near Threatened	confirmed
Myosorex varius	Forest Shrew	Data Deficient	low
Paratomys littledalei	Littledale's Whistling Rat	Near Threatened	moderate-low
Petromys typicus	Dassie Rat	Near Threatened	moderate-low
Rhinolophus darlingi	Darling's Horseshoe Bat	Near Threatened	moderate-low
Rhinolophus denti	Dent's Horseshoe Bat	Near Threatened	moderate
Tatera leucogaster	Bushveld Gerbil	Data Deficient	confirmed

9.3 Faunal Habitat Sensitivities

The close relationship between vegetation units and specific faunal composition has been noted in several scientific studies. For the purpose of this investigation the floristic units identified in the floristic assessment are considered representative of the faunal habitat types. For a description of the habitat structure and physiognomy, the reader is therefore referred to Section 8 of this document.

Faunal habitat sensitivities are subjectively estimated based on the following criteria:

- Habitat status;
- Connectivity;
- Observed species composition & RD Probabilities; and
- Functionality,

The calculation of faunal sensitivities are presented in Table 23 and visually presented in Figure 10.

Table 23: Faunal Habitat Sensitivities for the study area						
Community	**Status**	**Connectivity**	**Species Comp & RD Likelihood**	**Functionality**	**Average**	**SENS. CLASS**
Calcareous Low Shrub Plains	6	8	2	6	55%	Medium
Open Shrub Duneveld	6	6	3	6	53%	Medium
Open Shrub Plains	4	5	2	4	38%	Medium-Low
Quartzitic Low Shrub Plains	8	7	6	7	70%	Medium-High
Riparian Habitat	6	9	9	8	80%	High
Rocky Outcrops/ Foothills	9	9	9	8	88%	High
Transformed Areas	0	0	0	0	0%	Low

Habitat types that exhibit high faunal sensitivities frequently exhibit habitat characteristics that are associated with wetlands, pristine terrestrial habitat and the presence of Red Data species in these areas are generally confirmed or a high likelihood is ascribed to the potential presence of such species. These habitat types are often associated with environmental features that are also generally regarded as sensitive, such as riparian zones aquatic regions and rocky outcrops.

9.4 Discussion

The study area includes diverse, unfragmented faunal habitats that are natural and untransformed in nature and represent well-functioning ecosystems that are also well-connected to adjacent regions of large, natural faunal habitat characteristic of the Savanna and Nama-Karoo of the Northern Cape Province in South Africa. This is reflected in the species richness and – diversity of the animals confirmed for the study area (by personal observation and confirmation of the landowner), including five red data species (two mammals and three birds).

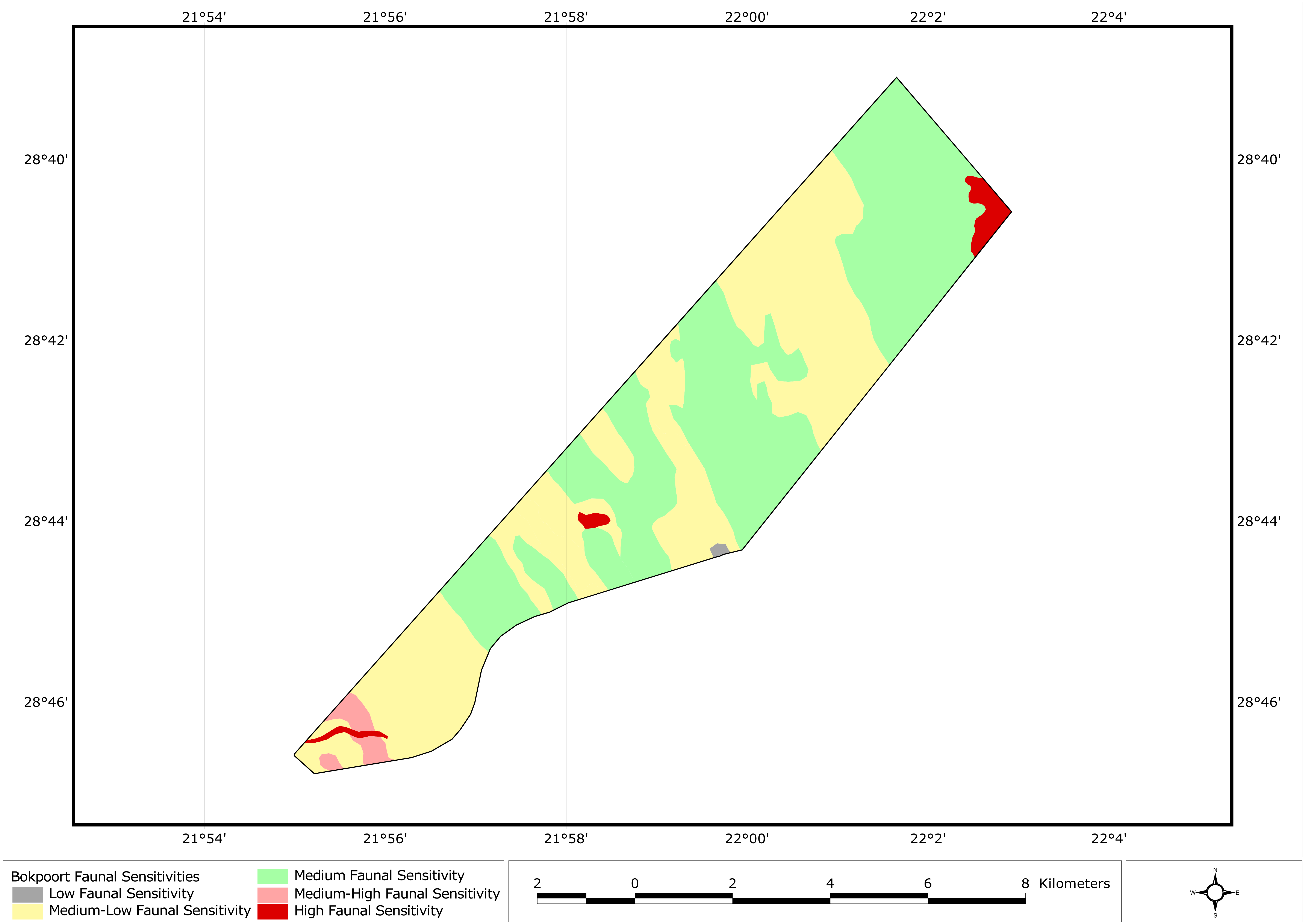
However, the faunal habitats of the study area represent regional vegetation communities that are largely untransformed and not considered to be under threat. The Bushmanland Arid Grassland (99.4% remaining), Gordonia Duneveld (99.8% remaining), Kalahari Karroid Shrubland (99.2% remaining) and Koranna-Langeberg Mountain Bushveld (99.9% remaining) are all listed as Least Threatened (VEGMAP, 2006). The study area investigated does not represent a significant portion of the remaining untransformed areas of any of these regional vegetation communities; indeed the larger region in which the study area is located remains largely natural and well-connected. It can be reasoned that the proposed project and associated impacts are unlikely to influence any animal species, assemblage or community significantly based on above-mentioned facts.

The relative sensitivities of the faunal habitats are based on the potential impacts of the proposed project on the faunal communities of these habitats relative to each other. For instance, it is estimated that the impacts of the proposed project are more likely to be significant with regards to the faunal assemblages limited to the riparian and ridge (rocky outcrops) habitat found in the study area than those of the Open Shrub Plains and Open Shrub Duneveld. Wetland and ridge faunal assemblages (mostly of invertebrates, birds, reptiles and frogs) are intrinsically limited in space and are therefore naturally vulnerable to habitat degradation and –transformation processes. With regards to mammals, one of the most important impacts (albeit an indirect impact potentially associated with the proposed project) is the increase in road traffic volumes and associated road kills.

Photo 3: Porcupine (*Hystrix africaeaustralis*) a medium-sized mammal that is vulnerable to road kills.

Photo 4: Striped Polecat (*Ictonyx striatus*) vulnerable to road kills.

Figure 10: Faunal sensitivity of the study area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Bokpoort Faunal Sensitivities
Low Faunal Sensitivity
Medium-Low Faunal Sensitivity
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10 ECOLOGICAL INTERPRETATION

Respective results of the floristic and faunal sensitivity analysis are combined to present an overview of the ecological sensitivity of the study area.

In order to present the reader with an indication of the ecological sensitivity of the respective communities, the highest sensitivity for each ecological unit is selected as being representative of the ecological sensitivity of the specific ecological unit. Results are determined in Table 24 and visually presented in Figure 11.

Table 24: Ecological Sensitivity of the study area

Community	Floristic	Faunal	Ecological
Calcareous Low Shrub Plains	Medium	Medium	**Medium**
Open Shrub Duneveld	Medium-High	Medium	**Medium-High**
Open Shrub Plains	Medium	Medium-Low	**Medium**
Quartzitic Low Shrub Plains	High	Medium-High	**High**
Riparian Habitat	Medium-High	High	**High**
Rocky Outcrops/ Foothills	High	High	**High**
Transformed Areas	Low	Low	**Low**

The extent of respective sensitivity classes are presented in Table 25.

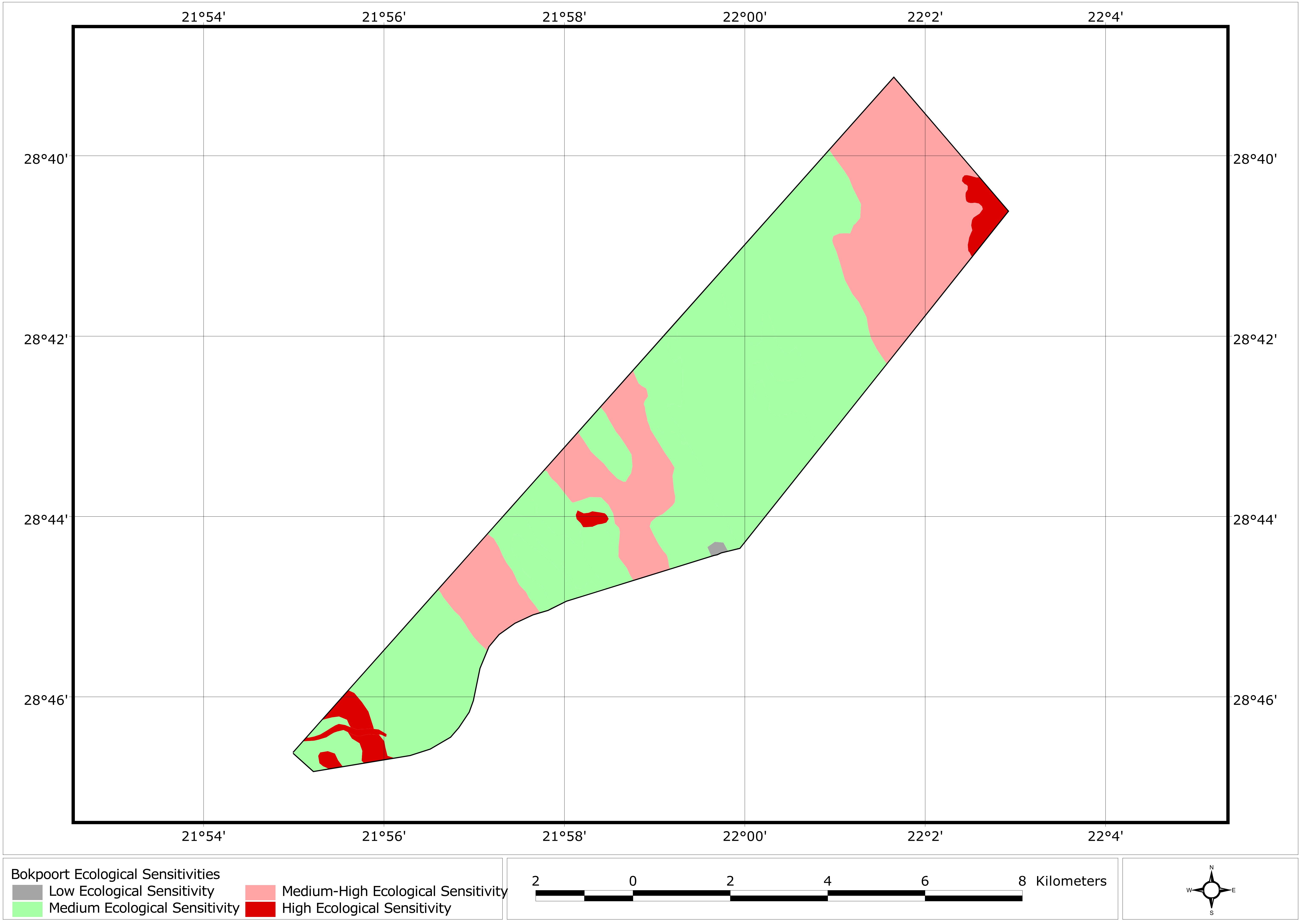
Table 25: Extent of ecological habitat sensitivities within the study area

Sensitivity Class	Extent	Percentage
Low ecological sensitivity	6.67ha	0.14%
Medium ecological sensitivity	3073.90ha	64.27%
Medium-high ecological sensitivity	1538.11ha	32.16%
High ecological sensitivity	164.29ha	3.43%

Combined results from the floristic and faunal sensitivity analysis indicate the high sensitivity of the areas associated with wetland regimes and rocky outcrops. The status of these areas is moderately pristine and are therefore considered suitable habitat for a variety of Red Listed flora and fauna species. These areas are relative small, comprising small portions of the study area. A medium-high ecological sensitivity is exhibited by the natural duneveld of the study area, particularly as a result of the likely presence of several Red Data species and the high suitability of these areas for Red Data species.

The largest extent of the study area exhibit low and medium sensitivity ecological attributes and the proposed activity is not expected to result in significant impacts in these areas.

Figure 11: Ecological sensitivity of the study area



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Bokpoort Ecological Sensitivities
Low Ecological Sensitivity
Medium Ecological Sensitivity
Medium-High Ecological Sensitivity
High Ecological Sensitivity
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11 BIODIVERSITY IMPACT ASSESSMENT

Results of the floristic and faunal investigations were incorporated in order to present an overview of the impacts on the ecological environment. Results indicate the Medium or lower ecological sensitivities of the following areas:

- Calcareous Low Shrub Plains;
- Open Shrub Plains; and
- Transformed Areas (omitted from impact assessment).

The likelihood that sensitive biological attributes might occur in these areas is considered extremely low and the likely impacts resulting from the proposed development on biological attributes within these areas are considered insignificant. Results of the ecological assessment indicate Medium-High or High ecological sensitivities of the following areas:

- Open Shrub Duneveld;
- Quartzitic Low Shrub Plains;
- Rocky Outcrops/ Foothills; and
- Riparian Habitat.

Likely impacts resulting from the proposed development within these parts of the study area might be unacceptable should no suitable mitigation measures be implemented, or even with the implementation of mitigation measures.

The impact assessment is aimed at presenting a description of the nature, extent significance and potential mitigation of identified impacts on the biological environment. A summary of these discussions are presented in Section 11.4 in the form of Impact Rating Matrix for each identified impact within the respective habitat types.

11.1 Identification of Impacts

No impacts were identified that could lead to a beneficial impact on the ecological environment of the study area since the proposed development is largely destructive.

Impacts resulting from the construction and operation of this development on ecological attributes of the study area are largely restricted to the physical impacts on biota or the habitat in which they occur. Direct impacts, such as habitat destruction and modifications, are regarded immediate, long-term and of high significance. These impacts are mostly measurable and fairly easy to assess as the effects thereof is immediately visible and can be determined to an acceptable level of certainty. In contrast, the effect of indirect impacts is not immediately evident and can consequently not be measured immediately. A measure of estimation is therefore necessary in order to evaluate these impacts. Lastly, impacts of a cumulative nature places direct and indirect impacts of this projects into a regional and national context, particularly in view of similar or resultant developments and activities. Ten impacts were identified that are of relevance to any development in a natural environment. These impacts might not all occur, or the extent of impact might be limited and the relevance of these impacts will firstly be determined prior to being implemented in the Impact Assessment. Impacts were placed in three categories, namely:

- **Direct impacts:**
  - Destruction of threatened and protected flora species;
  - Direct impacts on threatened fauna species;
  - Destruction of sensitive/ pristine habitat types;
  - Direct impacts on common fauna species;
- **Indirect Impacts:**
  - Floristic species changes subsequent to development;
  - Faunal interactions with structures, servitudes and personnel;
  - Impacts on surrounding habitat/ species;
- **Cumulative Impacts:**
  - Impacts on SA's conservation obligations & targets (VEGMAP vegetation types);
  - Increase in local and regional fragmentation/ isolation of habitat; and
  - Increase in environmental degradation.

Other, more subtle impacts on biological components, such as changes in local, regional and global climate, effects of noise pollution on fauna species, increase in acid rain, ground water deterioration, the effect of EMF on fauna species, etc. are impacts that cannot be quantified to an acceptable level of certainty and is mostly subjective in nature as either little literature is available on the topic or contradictory information exist.

The relevance of respective impacts to the proposed development will be assessed in the following section.

11.2 Nature of Impacts

11.2.1 Destruction of Threatened & Protected Flora Species

This impact is regarded a direct impact as it results in the physical damage or destruction of Red Data or Threatened species or areas that are suitable for these species, representing a significant impact on the biodiversity of a region. Threatened species, in most cases, do not contribute significantly to the biodiversity of an area in terms of sheer numbers as there are generally few of them, but a high ecological value is placed on the presence of such species in an area as they represent an indication of pristine habitat conditions. Conversely, the presence of pristine habitat conditions can frequently be accepted as an indication of the potential presence of species of conservation importance, particularly in moist habitat conditions.

Red Data species are particularly sensitive to changes in their environment, having adapted to a narrow range of specific habitat requirements. Habitat changes, mostly a result of human interferences and activities, are one of the greatest reasons for these species having a threatened status. Surface transformation/ degradation activities within habitat types that are occupied by flora species of conservation importance will ultimately result in significant impacts on these species and their population dynamics. Effects of this impact are usually permanent and recovery or mitigation is generally not perceived as possible.

One of the greatest drawbacks in terms of limiting this particular impact is that extremely little information is available in terms of the presence, distribution patterns, population dynamics and habitat requirements of Red Data flora species in the study area. In order to assess this impact, it is necessary to assess the presence/ distribution of habitats frequently associated with these species. Furthermore, by applying ecosystem conservation principles to this impact assessment and subsequent planning and development phases, resultant impacts will be limited to a large extent.

The presence of protected tree species within the study area was confirmed during the site investigation. Furthermore, the likelihood of Red Data flora species occurring within the parts of the study area is likely as these areas were found to be highly suitable for some of these species. The likelihood of this impact occurring is therefore regarded high and will therefore be evaluated in the Impact Assessment.

11.2.2 Direct Impacts on Threatened Fauna Species

Direct threats to threatened fauna species is regarded low in probability, mainly as a result of the ability of fauna species to migrate away from areas where impacts occur, also considering the type of development and activities. Probably the only exception to this statement will be in the event where extremely localised habitat that are occupied by threatened fauna species are impacted by construction and operational activities to the extent that the habitat no longer satisfy the habitat requirements of the particular species, or where an increase in the isolation and fragmentation factors renders the remaining habitat inadequate.

Most of the threatened fauna species potentially occurring in the study area have relatively wide habitat preferences and ample suitable habitat is presently available throughout the study area. To place this aspect into context it is estimated that habitat loss and transformation resulting from often overlooked impacts, such as overgrazing, infestation by invasive shrubs and agriculture probably contribute more to impacts on most threatened fauna species than this development. However, some Red Data fauna species might occur in the study area that does have specific habitat requirements.

The presence of Red Data fauna species was confirmed during the site investigation. Furthermore, the likelihood of other Red Data fauna species occurring within the parts of the study area is likely as these areas were found to be highly suitable for these species. The likelihood of this impact occurring is

therefore regarded high and will therefore be included as part of the Impact Assessment.

11.2.3 Destruction of Sensitive/ Pristine Habitat Types

The loss of pristine habitat types or habitat that are regarded sensitive as a result of restricted presence in the larger region (atypical habitat) represents a potential loss of habitat and biodiversity on a regional scale. Sensitive habitat types include mountains, ridges, koppies, wetlands, rivers, streams and localised habitat types of significant physiognomic variation and unique species composition. These areas represent centres of atypical habitat and contain biological attributes that are not frequently encountered in the greater surrounds. A high conservation value is generally ascribed to floristic communities and faunal assemblages that occupy these areas as they contribute significantly to the biodiversity of a region.

Furthermore, these habitat types are generally isolated and are frequently linear in nature, such as rivers and ridges. Any impact that disrupts this continuous linear nature will risk fragmentation and isolation of existing ecological units, affecting the migration potential of some fauna species adversely, pollinator species in particular.

Micro-habitat conditions are changed as a result of the removal of the vegetation layer, affecting shade conditions, habitat competition, germination success of the herbaceous layer, etc. and is likely to result in the establishment of a species composition that is entirely different than original conditions and the immediate surrounds, in many cases also comprising species of an invasive nature, particularly shrubs.

Relative small parts of the study area are regarded highly sensitive and are highly likely to be occupied by a diverse species composition as well as flora and fauna species of conservation importance. The likelihood of this impact occurring is therefore regarded high and will therefore be included as part of the Impact Assessment.

11.2.4 Direct Impacts on Common Fauna Species

The likelihood of this impact occurring is relatively low as a result of the ability of animal species to migrate away from direct impacts. The tolerance levels of common animal species occurring in the study area is of such a nature that surrounding areas will suffice in habitat requirements of species forced to move from areas of impact. It is also unlikely that the conservation status of common animal species will be affected as a result of direct and indirect impacts of power lines on these species and their habitat.

The nature of the development is expected to result in direct impacts on fauna species in spite of the ability of most animals to avoid direct contact. This impact is unavoidable and will therefore be included as part of the Impact Assessment.

11.2.5 Floristic Species Changes Subsequent to Development

This impact is regarded an indirect impact. The transformation of natural habitat during the construction process will inevitably result in the establishment of habitat types that are not considered representative of the region. While impacts are generally regarded to be of low severity, impacted areas are frequently invaded by species not normally associated with the region (exotic and invasive species). In addition, many species that are not necessarily abundant in the region will increase in abundance as a result of more favourable habitat conditions being created as a result of habitat manipulation activities (encroacher species). This effect is more pronounced in the floristic component, but changed habitat conditions in the habitat will inevitably imply minor changes in the faunal component that occupies the habitat.

If left unmitigated, this risk will result in decreased habitat, increased competition and lower numbers of endemic biota, the genetic pool of species might eventually be influenced by the introduction of non-endemic species. Different faunal assemblages and plant communities have developed separate gene structures as a result of habitat selection and geographical separation and the introduction of individuals of the same species that might be genetically dissimilar to the endemic species might lead to different genetic selection structures, eventually affecting the genetic structure of current populations and assemblages.

Construction will result in alteration of the vegetation in parts of the study area and it is likely that the current vegetation will become infested with weeds and invasive species. This impact will therefore be evaluated as part of the Impact Assessment.

11.2.6 Faunal Interactions with Structures, Servitudes & Personnel

It should be noted that animals generally avoid contact with human structures, but do grow accustomed to structures after a period. While the structures are usually visible, injuries and death of animals do occur sporadically as a result of accidental contact. An aspect that is of concern is the presence of vehicles on access and infrastructure roads, leading to road kills, particularly amongst nocturnal animals that abound in the study area. This impact was frequently observed in the study area during the site investigation period.

Alteration of habitat conditions within the development areas does not necessarily imply a decrease in faunal habitation. These areas are frequently preferred by certain fauna species. The establishment of a dominant grass layer generally results in increased presence of grazer species, which might lead to an unlikely, but similar increase in predation within these areas.

The presence of personnel within the development area during construction and maintenance periods will inevitably result in some, but normally limited, contact with animals. While most of the larger animal species are likely to move away from human contact, dangerous encounters with snakes, scorpions and possibly larger predators always remain likely. Similarly, the presence of humans within areas of natural habitat could potentially result in killing of animals by means of snaring, poaching, poisoning, trapping, etc.

The nature of the proposed development is expected to result in indirect impacts on the fauna species. In addition, direct interaction of fauna species with infrastructure is likely to occur. This impact will therefore be evaluated as part of the Impact Assessment.

11.2.7 Impacts on Surrounding Habitat/ Species

Surrounding areas and species present in the direct vicinity of the study area could be affected by indirect impacts resulting from construction and operation activities. This indirect impact could potentially include all of the above impacts, depending on the sensitivity and status of surrounding habitat and species as well as the extent of impact activities. Considering the type of development, the extent of this impact is expected to be relative small.

The indirect nature of this impact dictates that potential impacts spreading from the proposed development into bordering areas is likely to affect natural habitat adversely. This impact is relevant and will therefore be included as part of the Impact Assessment.

11.2.8 Impacts on SA's Conservation Obligations & Targets

This impact is regarded a cumulative impact since it affects the status of conservation strategies and targets on a local as well as national level and is viewed in conjunction with other types of local and regional impacts that affects conservation areas. The importance of regional habitat types is based on the conservation status ascribed to vegetation types, but only includes Least Threatened vegetation types. Furthermore, no declared conservation areas will be affected by the proposed development.

Loss of parts of the natural vegetation is expected to result in an insignificant, indirect impact on the conservation status of the regional vegetation types and no declared conservation areas will be affected. This impact is therefore not regarded relevant and will therefore be excluded from the Impact Assessment.

11.2.9 Increase in Local & Regional Fragmentation/ Isolation of Habitat

Uninterrupted habitat is a precious commodity for biological attributes in modern times, particularly in areas that are characterised by moderate and high levels of transformation. The loss of natural habitat, even small areas, implies that biological attributes have permanently lost that ability of occupying that space, effectively meaning that a higher premium is placed on available food, water and habitat resources in the immediate surrounds. This, in some instances might mean that the viable population of plants or animals in a region will decrease proportionally with the loss of habitat, eventually decreasing beyond a viable population size.

The danger in this type of cumulative impact is that effects are not known, or is not visible; with immediate effect and normally when these effects become visible they are beyond repair. Linear developments affect the migratory success of animals in particular. An important mitigation measure in this regard is to utilise existing causal factors of habitat fragmentation.

The general region is characterised by low levels of transformation and the introduction of new developments are sometime perceived as the 'thin end of the wedge', paving the way for additional developments, ultimately resulting in a fragmented landscape. Cumulative effects of habitat transformation are regarded relevant and this impact is therefore included as part of the Impact Assessment.

11.2.10Increase in Environmental Degradation

Cumulative impacts associated with this type of development will lead to initial, incremental or augmentation of existing types of environmental degradation, including impacts on the air, soil and water present within available habitat. Pollution of these elements might not always be immediately visible or readily quantifiable, but incremental or fractional increases might rise to levels where biological attributes could be affected adversely on a local or regional scale. In most cases are these effects are not bound and is dispersed, or diluted over an area that is much larger than the actual footprint of the causal factor.

Similarly, developments in untransformed and pristine areas are usually not characterised by visibly significant environmental degradation and these impacts are usually most prevalent in areas where continuous and long-term impacts have been experienced.

The nature of the development dictates that the biological environment is unlikely to be affected by effluents, spillages or any chemical that is extracted or transported. However, the susceptibility of sensitive habitat types towards even low levels of degradation does represent a threat. This impact is therefore relevant and will be included as part of the Impact Assessment.

11.3 Recommended Mitigation Measures

The most important mitigation measure is the exclusion of sensitive areas from the proposed development. By limiting development to areas of lower ecological sensitivity, most of the impacts associated with high significance events will be avoided altogether. The following mitigation measures are recommended.

11.3.1 Compliance & Monitoring

Mitigation Measure 1 - Appoint the Environmental Control Officer (ECO) prior to start of construction. Responsibilities should include, but not be limited to, ensuring adherence to EMP guidelines, guidance of activities, planning, reporting;

Mitigation Measure 2 - Compile and implement environmental monitoring programme, the aim of which should be ensuring long-term success of rehabilitation and prevention of environmental degradation. Environmental monitoring should be conducted at least twice per year (summer, winter);

Mitigation Measure 3 - Construction sites/camps need a detailed ecological assessment prior to construction;

11.3.2 Construction/ Infrastructure/ Access Roads

Mitigation Measure 4 - The Contractor shall select a suitable level area free of rock and large bushes for tower assembly in the case of required power lines;

Mitigation Measure 5 - Demarcate construction areas in order to control movement of personnel, vehicles, providing boundaries for construction sites in order to limit spread of impacts;

Mitigation Measure 6 - Access is to be established by vehicles passing over the same track on natural ground; multiple tracks are not permitted;

Mitigation Measure 7 - Prohibit construction of new access roads as far as possible. Use should be made of existing roads, ensuring proper maintenance/ upgrade;

Mitigation Measure 8 - Provide temporary on-site ablution, sanitation, litter and waste management and hazardous materials management facilities during entire construction period;

Mitigation Measure 9 - Abluting anywhere other than in provided toilets shall not be permitted. Under no circumstances shall use of the veld be permitted;

Mitigation Measure 10 - Remove and store topsoil separately in areas where excavation/ degradation takes place. Topsoil should be used for rehabilitation purposes in order to facilitate regrowth of species that occur naturally in the area;

Mitigation Measure 11 - Ensure off site storage of hazardous materials, chemicals, fuels, oils, etc. in order to prevent accidental spillage, contamination or pollution;

Mitigation Measure 12 - Develop emergency maintenance operational plan to deal with any event of contamination, pollution or spillages, particularly in sensitive areas;

Mitigation Measure 13 - Ensure proper surface restoration and resloping in order to prevent erosion, taking cognisance of local contours and landscaping;

11.3.3 Vegetation

Mitigation Measure 14 - All declared aliens must be identified and managed in accordance with the Conservation of Agricultural Resources Act, 1983 (Act No. 43 of 1983) (see Appendix 3), the implementation of a monitoring programme in this regard is recommended, being the responsibility of the ECO/ ecologist;

Mitigation Measure 15 - Weed control methods should be confirmed with the ECO to prevent any undesirable secondary impacts;

Mitigation Measure 16 - Removal of vegetation/ plants shall be avoided until such time as soil stripping is required and similarly exposed surfaces must be re-vegetated or stabilised as soon as is practically possible;

Mitigation Measure 17 - Disturbance of vegetation must be limited to areas of construction;

Mitigation Measure 18 - The removal or picking of any protected or unprotected plants shall not be permitted and no horticultural specimens (even within the demarcated working area) shall be removed, damaged or tampered with unless agreed to by the ECO;

Mitigation Measure 19 - No painting or marking of rocks or vegetation to identify locality or other information shall be allowed as it will disfigure the natural setting. Marking shall be done by steel stakes with tags, if required;

Mitigation Measure 20 - Cut vegetation (grass and shrubs) only if and when required. No clearing of vegetation or soil by grading machinery shall be undertaken;

Mitigation Measure 21 - Limit damage/ pruning/ cutting of indigenous trees to a minimum;

Mitigation Measure 22 - Exposed areas with slopes less than 1:3 should be rehabilitated with a grass mix that blends in with the surrounding vegetation;

Mitigation Measure 23 - The grass mix should consist of indigenous grasses adapted to the local environmental conditions;

Mitigation Measure 24 - The revegetated areas should be temporarily fenced to prevent damage by grazing animals;

Mitigation Measure 25 - Re-vegetated areas showing inadequate surface coverage (less than 30 % within eight months after re-vegetation) should be prepared and re-vegetated from scratch;

Mitigation Measure 26 - Damage to re-vegetated areas should be repaired promptly;

Mitigation Measure 27 - Re-vegetated should be monitored every four months for the first 12 months and once a year thereafter for the maintenance period of two years;

Mitigation Measure 28 - All individuals/ stands of Protected trees must be clearly and visibly marked prior to the start of construction or maintenance procedures;

Mitigation Measure 29 - Marking should be done by means of semi-permanent (removable) marker tape;

Mitigation Measure 30 - Information pertaining to these plants should be included in the induction for all workers and contractors;

Mitigation Measure 31 - Cutting/ pruning/ damaging of any Protected tree species (*Acacia erioloba, Boscia albitrunca*) individual, should not be allowed under any circumstances;

Mitigation Measure 32 - All Protected tree individuals should be clearly marked and GPS referenced prior to the commencement of construction activities;

Mitigation Measure 33 - Should impacts on Protected tree individuals be unavoidable, obtain necessary and required approval per application for damage/ removal/ cutting/ pruning of Protected tree species from Department of Forestry, as per National Forests Act (Act No. 84 of 1998) under Government Notice GN 1012 of 2004 and GN 767 of 2005;

11.3.4 Fires

Mitigation Measure 34 - Use of branches of trees and shrubs for fire making purposes is strictly prohibited;

Mitigation Measure 35 - Prevent open fires, provide demarcated fire-safe zones, facilities and fire control measures;

Mitigation Measure 36 - Fire fighting equipment shall be made available on all vehicles and at various suitable points within the development site;

11.3.5 Fauna

Mitigation Measure 37 - No animal may be hunted, trapped or killed for any purpose whatsoever;

Mitigation Measure 38 - Ensure proper substrate anchorage, provide 'dummy pole' for power lines in order to prevent damage/ injury of mammals as a result of direct contact with pole structures;

Mitigation Measure 39 - In the event that animals are present that may pose a risk to human safety, a suitable animal handler must be requested to removed the animal in an environmentally responsible manner. This specifically refers to snakes and scorpions;

11.4 IMPACT ASSESSMENT SUMMARY

Potential Environmental Impact	Environmental Significance Before Mitigation							Environmental Significance After Mitigation					
	Extent	Duration	Intensity	Prob	Total	Sens		Extent	Duration	Intensity	Prob	Total	Sens
Issues related to Biodiversity - Calcareous Low Shrub Plains													
Direct impacts on RD flora	4	4	3	1	12	high		3	3	2	1	9.0	medium
Direct impacts on RD fauna	4	4	3	1	12	high		3	3	2	1	9.0	medium
Destruction of sensitive habitat types	3	4	2	2	11	high		3	3	2	1	9.0	medium
Direct impacts on common fauna	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Species changes	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Faunal Interactions w structures	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Impacts on surrounding habitat	1	3	2	3	9	medium		1	2	2	2	7.0	low
Increase in fragmentation & isolation	2	4	2	3	11	high		3	4	2	3	12.0	high
Increase in environmental degradation	2	3	2	1	8	medium		2	3	1	1	7.0	low
Average Impact Status					**10.0**	**medium**		**Average Impact Status**				**8.6**	**medium**
Issues related to Biodiversity - Open Shrub Duneveld													
Direct impacts on RD flora	4	4	3	3	14	very high		4	4	2	2	12.0	high
Direct impacts on RD fauna	4	4	3	3	14	very high		4	4	2	2	12.0	high
Destruction of sensitive habitat types	3	4	3	3	13	high		3	3	2	3	11.0	high
Direct impacts on common fauna	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Species changes	2	3	3	2	10	medium		2	3	2	2	9.0	medium
Faunal Interactions w structures	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Impacts on surrounding habitat	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Increase in fragmentation & isolation	3	4	2	2	11	high		3	4	2	1	10.0	medium
Increase in environmental degradation	2	3	2	1	8	medium		2	3	1	1	7.0	low
Average Impact Status					**10.8**	**high**		**Average Impact Status**				**9.4**	**medium**

Potential Environmental Impact	Environmental Significance Before Mitigation							Environmental Significance After Mitigation					
	Extent	Duration	Intensity	Prob	Total	Sens		Extent	Duration	Intensity	Prob	Total	Sens
Issues related to Biodiversity - Open Shrub Plains													
Direct impacts on RD flora	4	4	3	1	12	high		3	3	2	1	9.0	medium
Direct impacts on RD fauna	4	4	3	1	12	high		3	3	2	1	9.0	medium
Destruction of sensitive habitat types	2	4	2	1	9	medium		2	2	2	1	7.0	low
Direct impacts on common fauna	2	3	1	2	8	medium		2	2	1	2	7.0	low
Species changes	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Faunal Interactions w structures	1	3	2	3	9	medium		1	2	2	2	7.0	low
Impacts on surrounding habitat	1	3	2	3	9	medium		1	2	2	2	7.0	low
Increase in fragmentation & isolation	2	4	2	3	11	high		2	3	2	2	9.0	medium
Increase in environmental degradation	2	3	2	1	8	medium		2	3	1	1	7.0	low
Average Impact Status					**9.7**	**medium**		**Average Impact Status**				**7.8**	**Low**
Issues related to Biodiversity - Quartzitic Low Shrub Plains													
Direct impacts on RD flora	4	4	3	3	14	very high		4	4	2	3	13.0	high
Direct impacts on RD fauna	4	4	3	2	13	high		4	4	2	2	12.0	high
Destruction of sensitive habitat types	3	4	2	2	11	high		3	4	2	2	11.0	high
Direct impacts on common fauna	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Species changes	2	4	3	3	12	high		2	3	3	2	10.0	medium
Faunal Interactions w structures	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Impacts on surrounding habitat	1	3	3	3	10	medium		1	3	2	2	8.0	medium
Increase in fragmentation & isolation	3	4	3	3	13	high		3	4	3	2	12.0	high
Increase in environmental degradation	2	3	2	1	8	medium		2	3	1	1	7.0	low
Average Impact Status					**11.0**	**high**		**Average Impact Status**				**9.9**	**medium**

Potential Environmental Impact	Environmental Significance Before Mitigation							Environmental Significance After Mitigation					
	Extent	Duration	Intensity	Prob	Total	Sens		Extent	Duration	Intensity	Prob	Total	Sens
Issues related to Biodiversity - Rocky Outcrops/ Foothills													
Direct impacts on RD flora	4	4	3	2	13	high		4	4	2	2	12.0	high
Direct impacts on RD fauna	4	4	3	3	14	very high		4	4	2	3	13.0	high
Destruction of sensitive habitat types	3	4	3	4	14	very high		3	3	3	4	13.0	high
Direct impacts on common fauna	2	3	3	4	12	high		2	2	3	4	11.0	high
Species changes	2	4	3	4	13	high		2	4	3	3	12.0	high
Faunal Interactions w structures	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Impacts on surrounding habitat	1	4	3	3	11	high		1	4	3	2	10.0	medium
Increase in fragmentation & isolation	3	4	3	4	14	very high		3	4	3	3	13.0	high
Increase in environmental degradation	2	3	3	1	9	medium		2	3	2	1	8.0	medium
Average Impact Status					**12.1**	**high**		**Average Impact Status**				**11.1**	**high**
Issues related to Biodiversity - Riparian Habitat													
Direct impacts on RD flora	4	4	3	2	13	high		4	4	2	2	12.0	high
Direct impacts on RD fauna	4	4	3	3	14	very high		4	4	2	3	13.0	high
Destruction of sensitive habitat types	3	4	3	3	13	high		3	3	3	3	12.0	high
Direct impacts on common fauna	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Species changes	2	3	2	2	9	medium		2	2	2	2	8.0	medium
Faunal Interactions w structures	1	3	2	3	9	medium		1	3	2	2	8.0	medium
Impacts on surrounding habitat	1	3	2	3	9	medium		1	2	2	2	7.0	low
Increase in fragmentation & isolation	3	4	3	3	13	high		3	4	2	3	12.0	high
Increase in environmental degradation	2	3	3	1	9	medium		2	3	3	1	9.0	medium
Average Impact Status					**10.9**	**high**		**Average Impact Status**				**9.9**	**medium**

12 DISCUSSION

A summary of the Impact Assessment is presented in Table 26.

Table 26: Impact Assessment summary

Habitat Type	No Mitigation	Post Mitigation
Calcareous Low Shrub Plains	10.0 (Medium)	8.6 (Medium)
Open Shrub Duneveld	10.8 (High)	9.4 (Medium)
Open Shrub Plains	9.7(Medium)	7.8 (Low)
Quartzitic Low Shrub Plains	11.0 (High)	9.9 (Medium)
Rocky Outcrops/ Foothills	12.1 (High)	11.1 (High)
Riparian Habitat	10.9 (High)	9.9 (Medium)

It is evident that development within areas of high ecological sensitivity is generally associated within high significance impacts on biodiversity attributes. This is mainly a result of the limited presence of these habitat types as well as the high likelihood that Red Data flora and fauna species that occupy these areas will be affected adversely by the proposed development. In contrast, habitat types that are common to the region and that are not likely to be occupied by Red Data flora or fauna species, exhibit lower sensitivity to the proposed development. It is therefore strongly recommended that the proposed development be place within the Open Shrub Plain habitat type. Furthermore, it will be beneficial for the environment if this proposed development is placed in close vicinity to existing areas of degradation, preferably as close as possible to the existing substation and roads, thereby limiting the spread of impacts and the necessity of additional roads and linear infrastructure.

Placement of any development structures and required infrastructure in close vicinity to high sensitivity habitat should be avoided at all costs.

13 PHOTOGRAPHIC RECORDS

Photo 1: Example of the Rocky Outcrop habitat type

Photo 2: Example of the Open Shrub Duneveld habitat type

Photo 3: Example of the Open Shrub Duneveld habitat type

Photo 4: Example of the Open Shrub Plains habitat type

Photo 5: Example of the Calcareous Low Shrub Plains habitat type

Photo 6: Example of the Riparian habitat type

Photo 7: Example of Quartzitic Low Shrub Plains

Photo 8: *Anacampseros ustulata*

Photo 9: *Euphorbia* species

Photo 10: Slender Mongoose

Photo 11: Rock Monitor

Photo 12: Cape fox

14 APPENDIX 1 – PLANT SPECIES LIST FOR THE STUDY AREA

Taxon	Growth Form	Family	Status/ Properties/ Uses
Acacia erioloba	Tree	Fabaceae	Protected Tree (National Forest Act, 1998), edible parts, medicinal uses, firewood
Acacia haematoxylon	Tree	Fabaceae	Kalahari Endemic
Acacia mellifera	Shrub	Fabaceae	Declared indicator of encroachment, medicinal uses, poison source
Adenium oleifolium	Succulent	Apocynaceae	Poisonous parts
Aloe claviflora	Succulent	Liliaceae	None
Anacampseros albidiflora	Succulent	Portulacaceae	None
Anacampseros ustulata	Succulent	Portulacaceae	Food preparation
Anthephora pubescens	Grass	Poaceae	High grazing potential. Decreaser species
Aptosimum lineare	Forb	Scrophulariaceae	None
Aptosimum procumbens	Forb	Scrophulariaceae	Medicinal uses (sheep)
Aristida congesta subsp. *congesta*	Grass	Poaceae	None
Aristida species	Grass	Poaceae	None
Aristida stipitata	Grass	Poaceae	None
Asparagus laricinus	Shrub	Liliaceae	Edible parts
Asparagus species	Shrub	Liliaceae	None
Barleria species	Forb	Acanthaceae	None
Berkheya species	Forb	Asteraceae	Weed
Blepharis species	Forb	Acanthaceae	None
Boscia albitrunca	Tree	Capparaceae	Protected Tree (National Forest Act, 1998)
Brachiaria glomerata	Grass	Poaceae	None
Bulbostylis hispidula	Sedge	Cyperaceae	None
Cadaba aphylla	Succulent	Capparaceae	Medicinal properties, potentially poisonous
Cenchrus ciliaris	Grass	Poaceae	Palatable grazing species, Decreaser
Centropodia glauca	Grass	Poaceae	Palatable grazing species, Decreaser
Ceratotheca triloba	Forb	Pedaliaceae	Medicinal properties
Chascanum pumilum	Forb	Verbenaceae	None
Chrysocoma obtusata	Forb	Asteraceae	None
Citrullus lanatus	Climber	Cucurbitaceae	Edible parts
Cleome angustifolia	Forb	Capparaceae	None
Cleome gynandra	Forb	Capparaceae	Edible parts
Commelina species	Forb	Commelinaceae	None
Crotalaria spartioides	Shrub	Fabaceae	None
Croton gratissimus	Shrub	Euphorbiaceae	Medicinal uses
Cucumis africanus	Forb	Cucurbitaceae	Edible parts
Cymbopogon pospischilii	Grass	Poaceae	None
Dicoma capensis	Forb	Asteraceae	Medicinal uses
Digitaria eriantha	Grass	Poaceae	Weaving, palatable
Enneapogon desvauxii	Grass	Poaceae	None

Taxon	Growth Form	Family	Status/ Properties/ Uses
Enneapogon scoparius	Grass	Poaceae	None
Eragrostis lehmanniana	Grass	Poaceae	Weaving
Eragrostis obtusa	Grass	Poaceae	Indicator of poor habitat conditions
Eragrostis porosa	Grass	Poaceae	None
Eragrostis species	Grass	Poaceae	None
Eragrostis trichophora	Grass	Poaceae	Moderate grazing potential
Eragrostis truncata	Grass	Poaceae	None
Eriocephalus spinescens	Forb	Asteraceae	None
Euphorbia species	Succulent	Euphorbiaceae	None
Felicia species	Forb	Asteraceae	None
Fingerhuthia africana	Grass	Poaceae	Moderate grazing potential
Flaveria bidentis	Forb	Asteraceae	None
Geigeria ornativa	Forb	Asteraceae	Potentially poisonous, indicator of poor habitat conditions
Geigeria species	Forb	Asteraceae	None
Gomphocarpus fruticosus	Shrub	Asclepiadaceae	Medicinal uses
Grewia flava	Shrub	Tiliaceae	Edible parts, weaving
Heliotropium ciliatum	Forb	Boraginaceae	None
Hermannia tomentosa	Forb	Sterculiaceae	None
Hermbstaedtia fleckii	Forb	Amaranthaceae	None
Hermbstaedtia odorata	Forb	Amaranthaceae	None
Hirpicium gazanioides	Forb	Asteraceae	None
Hoffmannseggia burchellii subsp. *burchellii*	Forb	Fabaceae	None
Indigofera alternans	Forb	Fabaceae	None
Indigofera charlieriana var. *charlieriana*	Forb	Fabaceae	None
Indigofera species	Forb	Fabaceae	None
Kleinia longiflora	Succulent	Asteraceae	Traditional uses
Kyphocarpa angustifolia	Forb	Amaranthaceae	None
Lebeckia linearifolia	Shrub	Fabaceae	None
Leucas capensis	Forb	Lamiaceae	None
Leucosphaera bainesii	Shrub	Amaranthaceae	None
Limeum fenestratum	Forb	Aizoaceae	None
Limeum sulcatum	Forb	Aizoaceae	None
Limeum viscosum	Forb	Aizoaceae	None
Lycium bosciifolium	Shrub	Solanaceae	None
Lycium horridum	Shrub	Solanaceae	None
Lycium species	Shrub	Solanaceae	None
Melinis repens	Grass	Poaceae	None
Momordica balsamina	Climber	Cucurbitaceae	Edible parts, medicinal uses
Monechma divaricatum	Forb	Acanthaceae	None
Monechma genistifolium subsp. *australe*	Forb	Acanthaceae	Medicinal uses
Monechma incanum	Shrub	Acanthaceae	Palatable grazing
Monsonia angustifolia	Forb	Geraniaceae	None
Nerine laticoma	Geophyte	Amaryllidaceae	Medicinal uses, potentially poisonous

Taxon	Growth Form	Family	Status/ Properties/ Uses
Nolletia arenosa	Forb	Asteraceae	None
Oxalis semiloba	Geophyte	Oxalidaceae	Edible parts
Oxygonum dregeanum	Forb	Polygonaceae	None
Parkinsonia africana	Tree	Fabaceae	Grazing potential, edible parts
Pentarrhinum insipidum	Climber	Asclepiadaceae	Edible parts
Pentzia calcarea	Forb	Asteraceae	None
Pergularia daemia	Climber	Asclepiadaceae	Medicinal uses
Plinthus sericeus	Shrub	Aizoaceae	None
Plumbago zeylanica	Shrub	Plumbaginaceae	None
Prosopis glandulosa	Tree	Fabaceae	Category 2 Invader
Ptycholobium biflorum	Forb	Fabaceae	None
Requienia sphaerosperma	Forb	Fabaceae	None
Rhigozum trichotomum	Shrub	Bignoniaceae	Declared indicator of encroachment
Rhynchosia species	Forb	Fabaceae	None
Salsola etoshensis	Shrub	Chenopodiaceae	None
Salsola tuberculatiformis	Shrub	Chenopodiaceae	None
Schmidtia kalihariensis	Grass	Poaceae	None
Searsia burchelli	Shrub	Anacardiaceae	Edible parts
Searsia species	Shrub	Anacardiaceae	None
Senna italica	Forb	Fabaceae	Medicinal uses
Setaria verticillata	Grass	Poaceae	Edible parts
Solanum supinum	Forb	Solanaceae	Medicinal uses
Stipagrostis amabilis	Grass	Poaceae	Kalahari endemic, weaving
Stipagrostis ciliata	Grass	Poaceae	None
Stipagrostis obtusa	Grass	Poaceae	None
Tapinanthus oleifolius	Parasite	Loranthaceae	None
Tephrosia species	Forb	Fabaceae	None
Thesium species	Forb	Santalaceae	None
Tribulus terrestris	Forb	Zygophyllaceae	None
Tribulus zeyheri	Forb	Zygophyllaceae	None
Ziziphus mucronata	Tree	Rhamnaceae	Edible parts, medicinal uses

15 APPENDIX 3 - COMBATING OF CATEGORY 2 PLANTS

Taken from Act 43 of 1983

(1) Category 2 plants may not occur on any land or inland water surface other than a demarcated area or a biological control reserve.
   (a) The executive officer may on application in writing demarcate an area as an area where category 2 plants may occur, be established and be maintained.
   (b) An area in respect of which a water use licence for stream flow reduction activities has been issued in terms of section 36 of the National Water Act, 1998 (Act No. 36 of 1998) shall be deemed to be a demarcated area.

(2) The executive officer shall demarcate an area for the occurrence, establishment and maintenance of category 2 plants only if:
   (a) the category 2 plants in the area are cultivated under controlled circumstances; and
   (b) the land user concerned has been authorized to use water in terms of the National Water Act, 1998 (Act No. 36 of 1998); and
   (c) the category 2 plants or products of category 2 plants in the area are demonstrated to primarily serve a commercial purpose, use as a woodlot, shelter belt, building material, animal fodder, soil stabilization, medicinal or other beneficial function that the executive officer may approve; and
   (d) all reasonable steps are taken to curtail the spreading of propagating material of the category 2 plants outside the demarcated areas.

(3) When an area is demarcated for the occurrence, establishment and maintenance of category 2 plants the executive officer may impose such additional conditions as may reasonably be deemed necessary to keep the category 2 plants in the area in check.

(4) No person shall sell propagating material of category 2 plants or any category 2 plants to another person unless such other person is a land user of a demarcated area or of a biological control reserve.

(5) No person shall acquire propagating material of category 2 plants or any category 2 plants unless such material or such plants are intended for use in a demarcated area or in a biological control reserve.

(6) Propagating material of category 2 plants or category 2 plants shall only be imported or sold in accordance with the provisions of the Plant Improvement Act, 1976 (Act No. 53 of 1976), the Agricultural Pests Act, 1983 (Act No. 36 of 1983) and the environment conservation regulations.

(7) A land user shall control any category 2 plants that occur on any land or inland water surface in contravention of the provisions of sub-regulation (1) by means of the methods prescribed in regulation 15E.

(8) Unless authorized thereto in terms of the National Water Act, 1998 (Act No. 36 of 1998), no land user shall allow category 2 plants to occur within 30 meters of the 1:50 year flood line of a river, stream, spring, natural channel in which water flows regularly or intermittently, lake, dam or wetland.

(9) The executive officer may, on good cause shown in writing by the land user, grant written exemption from compliance with one or more of the requirements of sub-regulations (1), (3), (5), (6), (8) and (9) on such conditions as the executive officer may determine in each case.

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DETAILS OF SPECIALIST AND DECLARATION OF INTEREST

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Application for integrated environmental authorisation and waste management licence in terms of the-

(1) National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010; and

(2) National Environmental Management Act: Waste Act, 2008 (Act No. 59 of 2008) and Government Notice 718, 2009

PROJECT TITLE

Proposed 75 MW Photovoltaic Development (PV1) on the Remaining Extent of the Farm Bokpoort 390 near Groblershoop in the !Kheis Local Municipalitly, Northern Cape.

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4.2 The specialist appointed in terms of the Regulations_

I, Aisling Dower , declare that --

General declaration:

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Aisling Dower

Signature of the specialist:

Golder Associates Africa Pty Ltd

Name of company (if applicable):

18 April 2016

Date:

Att: Marié Schlechter
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Date: 2016-04-28

REVIEW: Biodiversity Baseline and Impact Assessment: Proposed 75 MW Photovoltaic Solar Development (PV1) on the Remaining Extent of Farm Bokpoort 390 – DEA Reference Number: 14/12/16/3/3/2/881

1. BACKGROUND

ACWA Power Africa Holdings (Pty) Ltd is investigating the feasibility of a solar power facility on the farm Bokpoort 390, near Groblershoop, Northern Cape Province. The company appointed Golder Associates Africa (Pty) Ltd to undertake an Environmental and Social Impact Assessment (ESIA) to meet requirements of South African legislation and the International Finance Corporation (IFC). Golder Associates Africa (Pty) Ltd appointed Rob Palmer, Nepid Consultants CC, to provide independent reviews of the biodiversity baseline and impact assessments for the proposed PV1, PV2 and CSP Tower developments. This letter summarizes key findings of the review of the proposed PV1 development. Detailed comments were inserted directly into the report.

2. TERMS OF REFERENCE

The Terms of Reference for this review were detailed in a sub-consultant appointment and not repeated here. The main tasks of the review were to detail the following:

- *The appropriateness of the baseline and identification of key issues to be assessed*
- *The appropriateness of the approach and methodology to the assessment*
- *The appropriateness of the impact assessment and mitigation proposed*

[Extracted from letter from Golder Associates, dated 26 April 2016].

3. REVIEWER QUALIFICATIONS

Rob Palmer is an aquatic scientist with a PhD in Zoology. He is registered with the South African Council for Natural Scientific Professions as a Biological Scientist (Reg No. 400108/95). An abbreviated CV is attached in Annexure A.

4. APPROACH

The approach to this review was to focus on problem areas of the biodiversity specialist report in terms of the following criteria:

a) compliance with the Terms of Reference as stated in the Specialist Report;
b) compliance with the Objectives as stated in the Specialist Report;
c) requirements for Specialist Reports as specified in Section 23 of GN R982 (App. 6) of the 2014 EIA Regulations promulgated in terms of the National Environmental Management Act (No 107 of 1998), and;
d) requirements of IFC Performance Standard 6 and Guidance Note 6 (IFC 2012).

5. ASSUMPTIONS AND LIMITATIONS

a) Some comments made in this review may be matter of style and may therefore not justify any corrective actions to be taken.
b) This review concerns the main report only, and does not consider supporting appendices.
c) Birdlife Africa guidelines to minimise impacts of solar facilities on birds were not considered in this review, as the baseline and impact assessment for birds was reported separately.
d) The time allocation for this review was 2hrs.

6. KEY FINDINGS

6.1 Appropriateness of the Baseline and Identification of Key Issues

a) The report is impartial, well-written, error-free and easy to read, and provides a comprehensive review of relevant literature.

b) The title of the of report "Biodiversity Baseline…" raises the expectation that the report covers key aspects of biodiversity, yet birds are explicitly excluded from the report, with no explanation as to why this should be so. The title of the report is therefore misleading and should be modified to indicate that birds were excluded, and an explanation of this should be provided in the text. Alternatively, the specialist report on birds should be incorporated as part of an integrated biodiversity report.

c) The main limitation of the report as a baseline is the limited quantitative or semi-quantitative information against which future changes may be compared. For example, the report lists three species of alien plant recorded in the Study Area, but there is no indication of how abundant these species were, or where they were located. This makes it difficult to set quantitative targets for long-term monitoring. This is an obvious gap of the initial baseline vegetation report that has not been addressed.

d) The report discusses the IFC classification of habitats, but does not discuss or indicate where these areas are. It is suggested that a map that shows the classification of habitats *sensu* IFC categories should be included in the report.

a) The report classifies the riparian zone as Critical Habitat on the basis of an endangered vegetation type. However, just because a project takes place in an endangered vegetation type should not automatically afford it Critical Habitat status. If this approach were to be applied, then nearly every project on the Highveld would be located in Critical Habitat! The key issue here is the proportion of endangered vegetation that could be impacted by the proposed development. I suggest that the classification of Critical Habitat should be reconsidered in the light of the area that may be impacted by the proposed development.

6.2 Appropriateness of the Approach and Methodology

a) The approach and methodology used in the report complies to international standards. The report also complies to the Terms of Reference as stated in the report, and complies to most of the objectives as stated in the report. The report also complies to the requirements of IFC Performance Standard 6 and Guidance Note 6. However, the report has not addressed several requirements specified in Section 23 of GN R982 (App. 6) of the 2014 EIA Regulations promulgated in terms of the National Environmental Management Act (No 107 of 1998). Outstanding components include:

- details of the expertise of the specialist(s) that compiled the report;
- curriculum vitae of specialists;
- dates and season of the site investigations, and the relevance of this to the outcome of the assessment;
- assumptions and limitations;
- consideration of alternatives;
- a reasoned opinion as to whether the proposed activity should be authorised;
- details of any consultation process.

b) The report fails to detail key components of the Study Area that should be included, such as:

- zones and areas (ha) of potential direct and indirect influences, with accompanying map;

- length of conveyance route (km) and the distance from the conveyance route that was assessed. (Judging from the maps presented in the report it would appear that the conveyance route was not assessed);
- coordinates for the proposed abstraction point;
- coordinates for the existing abstraction point, with location indicated on a map.

c) Conclusions of the report are poorly structured, so I suggest that conclusions should link back to the objectives to ensure that each objective has been addressed.

6.3 Appropriateness of the Impact Assessment and Mitigation

a) The report provides few details on the proposed project design and operation relevant to biodiversity, or how PV1 differs from PV2 or the CSP Tower. Key information needed to assess impacts should include the number of people that are likely to be employed during construction and operation; where employees or contractors are likely to live; details of security fencing; discharge streams (if any); waste streams; storage of hazardous materials; traffic patterns etc. A more detailed description of the proposed project as it relates to potential impacts on biodiversity is therefore recommended, and reconsideration of key impacts is recommended.

b) The report describes and assesses the potential direct and indirect impacts of the proposed development on biodiversity, but does not quantify the areas that may be impacted. The report could be improved by quantifying the areas (ha) of various vegetation types that are likely to be impacted.

c) The project is likely to increase vehicle traffic and this would increase road kills, especially at night, yet road kills are not addressed.

d) Security fencing is likely to impact on the movement of game and larger reptiles, yet fencing is not mentioned.

e) The report makes no distinction between mitigation and monitoring. It is suggested that the report could be improved by separating these two aspects.

f) The report falls short of developing a monitoring programme that focusses on key issues. The report should detail the objectives and targets for monitoring, and detail the basic components of a monitoring programme (i.e. what, where, when, how etc.).

g) The report recommends annual monitoring of river health, even though residual impacts on river health were classified as “Low”. On the other hand, the report makes no mention of monitoring riparian vegetation, even though this is classified in the report as “Critical

Habitat”. Furthermore, the report recommends annual monitoring of frogs, yet no frogs were recorded during the baseline survey. The proposed monitoring programme is therefore incomplete and inconsistent with the available baseline data and the priorities of potential impacts.

h) The report recommends that solar panels should be appropriately spaced to minimise impacts on aquatic insects. This recommendation is based on speculation because there is little, if any, evidence to suggest that spacing the units differently would make any difference to insect oviposition behaviour. Furthermore, there is little if any evidence to inform what "appropriate" spacing may be. The report states that solar panels could cause rapid population decline of aquatic insects. This statement may apply to temperate areas, but is unlikely for aquatic insects from the Orange River, partly because the insects that occur here are adapted to environmental conditions that are highly variable, so fecundity rates are high, and partly because the total area of solar panels is small when compared to the length of the middle reaches of the Orange River.

i) The report recommends dust suppression during operation. It is not clear why dust suppression is recommended for operation and not construction, but either way dust suppression is impractical and environmentally inappropriate for the Northern Cape because high day temperatures and low humidity in the area would necessitate spraying on an almost continuous basis. Furthermore, naturally occurring dust storms in the area would make any dust impacts associated with the project pale into insignificance.

I hope that this review will provide sufficient information to facilitate decision making. Please let me know if you have any comments or queries.

R.Palmer

Rob Palmer
Director: Nepid Consultants CC

Disclaimer

This review was based on the author’s best scientific and professional knowledge and information available at the time of writing. The review was undertaken in an independent, objectives and unbiased manner. However, Nepid does not warrant or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of the information presented in this report.

Annexure A: Curriculum Vitae

Profession	:	Aquatic Ecologist
Date of Birth	:	15 Dec 1961
Name of Firm	:	Nepid Consultants CC
Position in Firm	:	Director
Years with Firm	:	11
Nationality	:	South African

Qualifications:

• PhD [River Ecology]	Rhodes University, Grahamstown, RSA	1992
• BSc (Hons) [Mammalogy]	Pretoria University, RSA	1985
• BSc [Zoology]	University of Cape Town, RSA	1984

Professional Registrations:

- SA Council for Natural Scientific Professions: No. 400108/95
- SA Environmental Assessment Practitioner: No. 0080/06
- SASS5 Accreditation (Water Affairs): 2007 - 2017

Membership in Professional Societies:

- International Association for Theoretical and Applied Limnology
- South African Council for Natural Scientific Professions (Biological Science)
- International Association for Impact Assessment (South Africa)
- Southern African Society of Aquatic Scientists

Languages:

	Speaking	Reading	Writing
English (home):	Excellent	Excellent	Excellent
Afrikaans:	Good	Good	Poor
Xhosa:	Fair	Poor	Poor
Portuguese:	Poor	Fair	Poor

Countries of Work Experience: (short-term consultancies) Angola, Burkina Faso, Cameroon, Democratic Republic of the Congo, Eritrea, Ethiopia, Lesotho, Malawi, Mozambique, Namibia, Sierra Leone, South Africa, Swaziland, Uganda and Zambia.

Key Qualifications:

- Over 20 years of experience of river research and management, aquatic surveys, data analysis and report writing;
- Over 15 years experience in environmental project management, including the design of environmental monitoring and mitigation programmes, impact assessment and water resource planning studies;
- Over 10 years experience in general company administration, including proposal writing, marketing, contract administration and bookkeeping;
- Specialist knowledge of river ecology, river regulation, aquatic invertebrates, instream flow requirements, impacts of dams, and control of pest blackflies (Diptera: Simuliidae);
- Team leader for various mining and water resource development projects and environmental impact assessments, involving coordination of multi-disciplinary teams.

Employment Record:

2005 – present	Nepid Consultants CC	Founder Director
1997 – 2004	AfriDev Consultants Pty Ltd	Associate from 1997; Director from 2000
1991 – 1997	Onderstepoort Veterinary Institute	Research Fellow
1986 – 1991	Rhodes University	PhD Student

Contact Details: Email: rob@nepid.co.za; Tel: +27(0)82 574 4486; PO Box 4349, White River, 1240, RSA
Website: www.nepid.co.za

Dated: 29 March 2016

TECHNICAL MEMORANDUM

DATE 13 May 2016 **PROJECT No.** 1400951

TO Marie Schlecter

CC Brent Baxter, Dr. Rob Palmer

FROM Aisling Dower **EMAIL** adower@golder.com

PEER REVIEW OF BIODIVERSITY BASELINE AND IMPACT ASSESSMENT: PROPOSED 75 MW PHOTOVOLTAIC SOLAR DEVELOPMENT (PV1) ON THE REMAINING EXTENT OF FARM BOKPOORT 390 – DEA REFERENCE NUMBER: 14/12/16/3/3/2/881

Dear Marie

The comments contained in the peer review letter dated 24 April 2016 (Attachment A) have now been addressed in the respective reports. The responses are summarised in Table 1 below.

Table 1: Responses to peer review comments received for biodiversity baseline and impact assessment

Comment Reference No.	Response
6.1 Appropriateness of baseline and ID of key issues	
a	Acknowledged
b	Title has been changed
c	Report is a desk-top study based on data compiled in previous study reports, within which quantitative data for vegetation communities were not provided. The areas of each recorded vegetation community within the Bokpoort II footprint which will be lost/indirectly affected by the PV1 development are included.
d	See updated Section 5.6.4, Figure 8.
e	Critical habitat exists independent of the Project (IFC PS6 Guidance Note GN66). Lower Gariep Alluvial vegetation has undergone at least 50% loss to transformation for agriculture and alluvial diamond mining (Mucina Rutherford 2006), and is likely to have undergone additional loss since then. This could qualify this vegetation type as critical habitat under Criterion 4 Highly threatened or unique ecosystems, on the basis of being at risk of significantly decreasing in area or quality (GN90). However, the mapped area of this vegetation type within the study area is now transformed. See Table 13, Section 5.6.4.
6.2 Appropriateness of Approach and Methodology	
a	Author CV now included. No CV's are provided for the specialist reports used as part of the desk study. The date of the 2015 site visit conducted by Golder is included, the dates of the specific field assessments done for the reviewed specialists reports are given via report reference date. Assumptions and limitations section 2.2 now included. No consideration of alternatives is done as no alternatives options were provided by client. No recommendation as to whether the proposed activity should be authorised is made as this is not the mandate of the impact assessment. No consultation process was undertaken.
b	The study area is defined in Section 3.1 and illustrated on Figure 1. The pipeline is not included in the study area as it will be constructed within the existing disturbed

Comment Reference No.	Response
	servitude and no additional land-take will be required. No coordinates have been provided by the client for the proposed new abstraction point. The existing abstraction point is located at approximately S -28.805248°, E 21.884447°
c	See updated Section 10.0
6.3 Appropriateness of impact assessment and mitigation	
a	See new Section 1.1
b	See updated Section 6.3
c	Increased vehicular traffic and road kill risk has been included in the impact assessment. See updated Section 6.4
d	Security fencing has been included in the impact assessment. See updated Section 6.4
e	Separate Mitigation and Monitoring recommendations are now provided. See updated Section 7.0 and new Section 8.0
f	Monitoring recommendations revised. See new Section 8.0
g	Monitoring recommendations revised. See new Section 8.0
h	See updated Section 6.4, Section 7.0
i	Dust suppression as mitigation removed. See updated Section 7.0 and new Section 8.0

Kind regards,

Aisling Dower
Terrestrial Ecologist