Scoping Report for the Freshwater Ecology & Agricultural Potential for the Agricultural and Pivot Expansion Project

Letsemeng Local Municipality, Free State

March 2022

CLIENT

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Report Name	**Scoping Report for the Freshwater Ecology & Agricultural Potential for the Agricultural and Pivot Expansion**
Reference	**Agricultural and Pivot Expansion**
Submitted to	savannah environmental
Report Writer	**Ivan Baker**
	Ivan Baker is Pr. Sci Nat registered (119315) in environmental science with Cand. Sci. Nat recognition in geological science. Ivan is a wetland and soil specialist with vast experience in wetlands, pedology, hydropedology and land contamination and has completed numerous specialist studies ranging from basic assessments to EIAs. Ivan has carried out various international studies following FC standards. Ivan completed training in Tools for Wetland Assessments with a certificate of competence and completed his MSc in environmental science and hydropedology at the North-West University of Potchefstroom. Ivan is also affiliated with the Fertiliser Society of South Africa after the acquiring a certificate of competence following the completion of the FERTASA training course.
Report Writer / Reviewer	**Andrew Husted**
	Andrew Husted is Pr Sci Nat registered (400213/11) in the following fields of practice: Ecological Science, Environmental Science and Aquatic Science. Andrew is an Aquatic, Wetland and Biodiversity Specialist with more than 12 years' experience in the environmental consulting field. Andrew has completed numerous wetland training courses, and is an accredited wetland practitioner, recognised by the DWS, and also the Mondi Wetlands programme as a competent wetland consultant.
Declaration	The Biodiversity Company and its associates operate as independent consultants under the auspice of the South African Council for Natural Scientific Professions. We declare that we have no affiliation with or vested financial interests in the proponent, other than for work performed under the Environmental Impact Assessment Regulations, 2017. We have no conflicting interests in the undertaking of this activity and have no interests in secondary developments resulting from the authorisation of this project. We have no vested interest in the project, other than to provide a professional service within the constraints of the project (timing, time and budget) based on the principals of science.

DECLARATION

I, Andrew Husted, declare that:

- 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.

Andrew Husted

Freshwater Ecologist

The Biodiversity Company

March 2022

DECLARATION

I, Ivan Baker, declare that:

- 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.

Ivan Baker

Pedologist

The Biodiversity Company

March 2022

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1 Introduction

The Biodiversity Company was appointed by Savannah Environmental (Pty) Ltd (Savannah) to undertake a scoping level assessment for the Agricultural and Pivot Expansion project. Freshwater ecology (wetlands and riverine) and soil (agricultural potential) components have both been included for this scoping assessment.

This assessment was conducted in accordance with the amendments to the Environmental Impact Assessment Regulations. 2014 (GNR 326, 7 April 2017), as amended of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). The approach has taken cognisance of the published Government Notices (GN) 320 in terms of NEMA, dated 20 March 2020: "Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, when applying for Environmental Authorisation" (Reporting Criteria).

This report, after taking into consideration the findings and recommendations provided by the specialist herein, should inform and guide the Environmental Assessment Practitioner (EAP) and regulatory authorities at a scoping level, enabling informed decision making.

1.1

1.2 Project Description

JN Venter Beleggings Trust is proposing the development of an expansion of a centre pivot irrigation farm on a site located southwest of Luckhoff and Koffiesfontein in the Free State Province. The proposed area of development is accessible via the R48. This expansion will be developed on farms Weltevreden 755, Lemoen-spruit 667 and Diepdraai 754. The total area on all three portions is 4800 ha, however only 2690 ha is proposed for development. The study area falls within the Letsemeng Local Municipality within the Xhariep District Municipality. The agricultural development will entail the following at a minimum:

- Development of centre pivot areas (cultivation and irrigation); and
- Construction of an abstraction pipeline from the existing irrigation canal to two water storage dams.

The current proposed water pipeline crossing will be approximately 68m downstream and north west of an existing road bridge crossing.

It is proposed that ~2690ha will be transformed across the property for the establishment of the agricultural development

The proposed development will require the following infrastructure:

Infrastructure	Purpose
315 mm PVC pipeline	Water for the pivots will be sourced from the Oranje Riet Water User Association's canal pumped 6km underground through 2 x 1.4m fibreglass pipes, which will be extended by further 500 m to reach the pivots
Centre Pivot Irrigation System	The underground PVC pipeline will provide water to a centre pivot irrigation system. A centre pivot irrigation system is a moveable pipe structure which usually spans the length of a field and rotates around a pivot in the centre of the field. As the irrigation system rotates around its central pivot, it supplies water to crops through sprinklers along its length.

1.3 Scope of Work

The principle aim of the assessment was to provide information to determine any level of risk posed by the proposed wind farm in regard to local freshwater and soil attributes. This was achieved through the following:

- A desktop assessment of all relevant national and provincial datasets. If available, municipal datasets were also considered;
- Completion of a desktop level impact assessment with supporting mitigation measures;
- Presentation of specialist Terms of Reference (ToR) for the impact phase of the process.

1.4 Assumptions and Limitations

The following assumptions and limitations are applicable for this assessment:

- The assessment has only been completed at a desktop level. It is assumed all datasets and information considered for the assessment is representative of the area and is well suited for the intended purposes of this scoping report; and
- This assessment has only considered freshwater habitats and soil.

1.5 Key Legislative Requirements

The legislation, policies and guidelines listed below in Table 1-1 are applicable to the current project. The list below, although extensive, may not be complete and other legislation, policies and guidelines may apply in addition to those listed below.

Table 1-1 A list of key legislative requirements relevant to biodiversity and conservation in the Free State

Region	Legislation / Guideline
International	Convention on Biological Diversity (CBD, 1993)
	The Convention on Wetlands (RAMSAR Convention, 1971)
	The United Nations Framework Convention on Climate Change (UNFCC,1994)
	The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1973)
	The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, 1979)
National	Constitution of the Republic of South Africa (Act No. 108 of 1996)
	The National Environmental Management Act (NEMA) (Act No. 107 of 1998)
	The National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
	The National Environmental Management: Biodiversity Act (Act No. 10 of 2004), Threatened or Protected Species Regulations
	Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, GNR 320 of Government Gazette 43310 (March 2020)
	Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of Sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, GNR 1150 of Government Gazette 43855 (October 2020)
	The National Environmental Management: Waste Act, 2008 (Act 59 of 2008);
	The Environment Conservation Act (Act No. 73 of 1989)
	National Protected Areas Expansion Strategy (NPAES)
	Natural Scientific Professions Act (Act No. 27 of 2003)
	National Biodiversity Framework (NBF, 2009)
	National Forest Act (Act No. 84 of 1998)
	National Veld and Forest Fire Act (101 of 1998)
	National Water Act (NWA) (Act No. 36 of 1998)
	National Spatial Biodiversity Assessment (NSBA)
	World Heritage Convention Act (Act No. 49 of 1999)

	Municipal Systems Act (Act No. 32 of 2000)
	Alien and Invasive Species Regulations and, Alien and Invasive Species List 20142020, published under NEMBA
	South Africa's National Biodiversity Strategy and Action Plan (NBSAP)
	Conservation of Agricultural Resources Act, 1983 (Act 43 of 1983) (CARA)
	Sustainable Utilisation of Agricultural Resources (Draft Legislation).
	White Paper on Biodiversity
Provincial	Boputhatswana Nature Conservation Act 3 of 1973
	Free State Nature Conservation Ordinance 8 of 1969

1.5.1 National Environmental Management Act (NEMA, 1998)

The National Environmental Management Act (Act No. 107 of 1998) (NEMA) and the associated Environmental Impact Assessment (EIA) Regulations, as amended in April 2017, state that prior to certain listed activities taking place, an environmental authorisation application (EA) process needs to be followed. This could follow either the Basic Assessment (BA) process or the Scoping and EIA process, depending on the scale of the impact. A Scoping and EIA process is being undertaken for the project.

GN 350 was gazetted on the 20 March 2020, which has replaced the requirements of Appendix 6 of the EIA Regulations in respect of certain specialist reports. These regulations provide the criteria and minimum requirements for specialist's assessments, in order to consider the impacts on soil for activities which require EA.

1.5.2 National Water Act (NWA, 1998)

The Department of Human Settlements Water and Sanitation (DHSWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The NWA allows for the protection of water resources, which includes the:

- Maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- Prevention of the degradation of the water resource; and
- Rehabilitation of the water resource.

A watercourse means;

- 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; and
- Any collection of water which the minister may, by notice in the gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The NWA recognises that the entire ecosystem and not just the water itself, and any given water resource constitutes the resource and as such needs to be conserved. No activity may therefore take place within a watercourse, unless it is authorised by the DHSWS. Any area within a wetland or riparian zone is therefore excluded from development unless authorisation is obtained from the DHSWS in terms of Sections 21 (c) and (i) of the NWA.

2 Receiving Environment

The location of the project area falls southwest of Luckhoff and Koffiesfontein in the Free State Province. The project area falls within the Letsemeng Local Municipality within the Xhariep District Municipality.

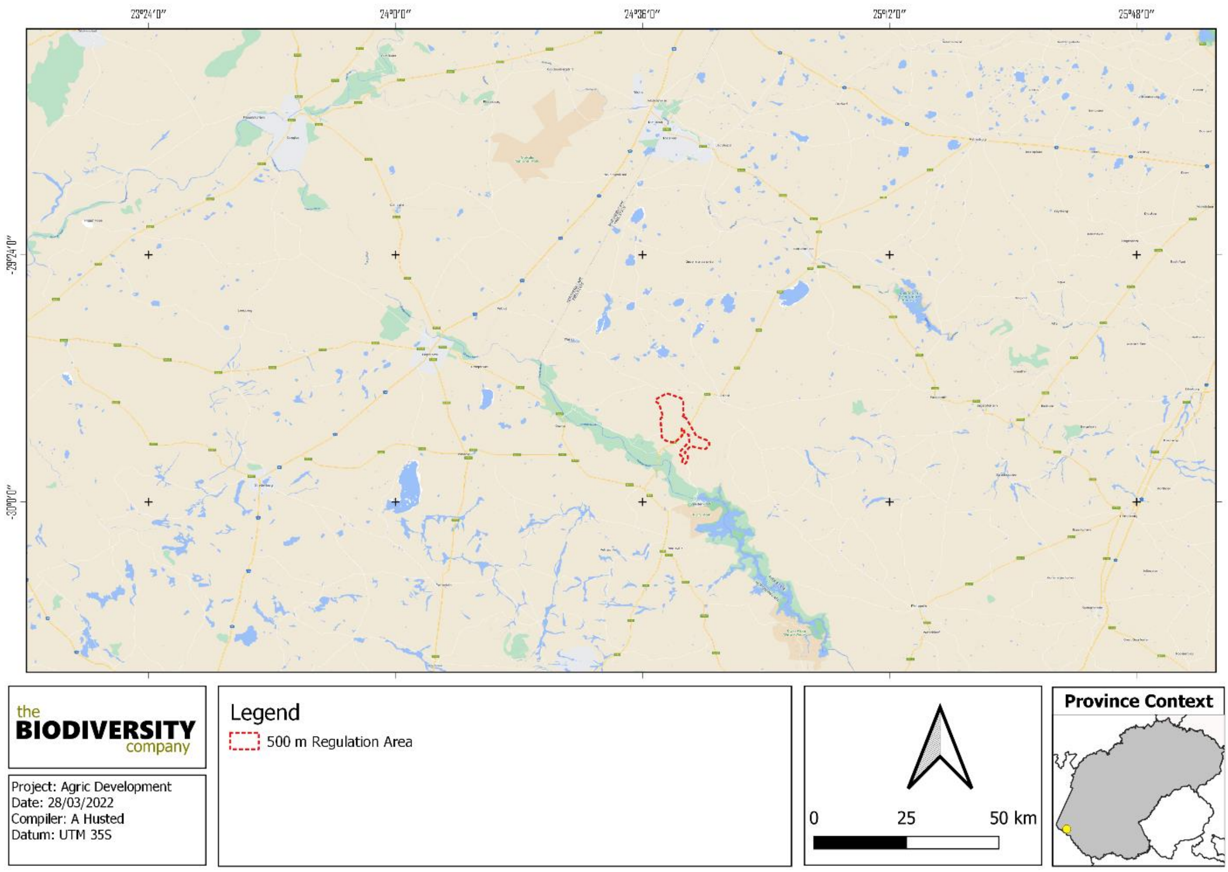

Figure 2-1 The location of the project area in relation to the general setting

2.1 Freshwater Ecology

2.1.1 Catchment

The project is situated in the D33A and D33C quaternary catchments, within the Upper Orange Water Management Areas (WMA 13).

The area surrounding the proposed project site consists of predominantly natural vegetation (bushveld) on the right bank, and extensive agricultural activities of the left bank of the Orange River. At a desktop level, the Orange River is considered largely modified, predominantly due to serious instream habitat modifications, modified flows, and physicochemical modifications. Further impacts include releases for hydropower, irrigation and several low water crossings.

According to StatsSA 2010, the Upper Orange WMA lies in the centre of South Africa, and extends over the southern Free State, and areas of the Eastern and Northern Cape. The system drains the highlands of Lesotho and the Senqu River contributes 60% of the surface water.

Climate within the WMA varies over the region, and rainfall ranges from over the 1000 mm/annum in the foothills, to 200 mm/annum in the west. The Gariep and Vanderkloof Dams in the Upper Orange WMA, where the two largest conventional hydropower installations in the country are located, also command the two largest storage reservoirs in South Africa. From the Gariep Dam a major inter-water management area transfer occurs via the 80 km long Orange-Fish Tunnel to the Fish to Tsitsikamma WMA. A significant portion of the yield of the Orange River is also released down the river for use in the Lower Orange WMA and by Namibia.

2.1.2 National Freshwater Ecosystem Priority Area Status

In an attempt to better conserve aquatic ecosystems, South Africa has categorised its river systems according to set ecological criteria (i.e. ecosystem representation, water yield, connectivity, unique features, and threatened taxa) to identify Freshwater Ecosystem Priority Areas (FEPAs) (Driver *et al.,* 2011). The FEPAs are intended to be conservation support tools and envisioned to guide the effective implementation of measures to achieve the National Environment Management Biodiversity Act's (NEM:BA) biodiversity goals (Nel *et al.,* 2011).

Figure 2-2 shows the location of the project area in relation to wetland FEPAs. Based on this information, priority and non-priority systems are located within the extent of the project area. Figure 2-3 presents the reach of the Lemoenspruit traversing the project area, which according to the NFEPA dataset is an 'upstream management area' (class 4).

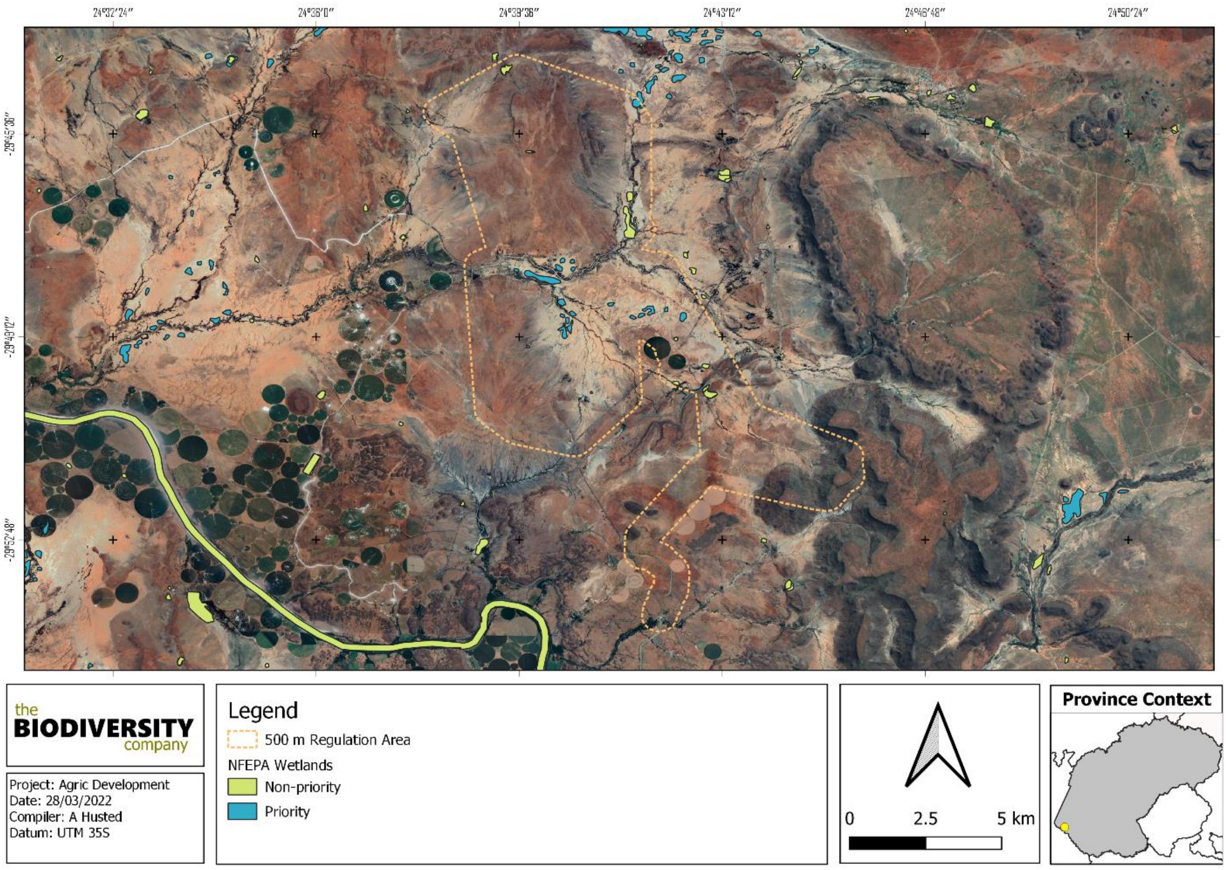

Figure 2-2 The location of NFEPA wetlands in relation to the project area

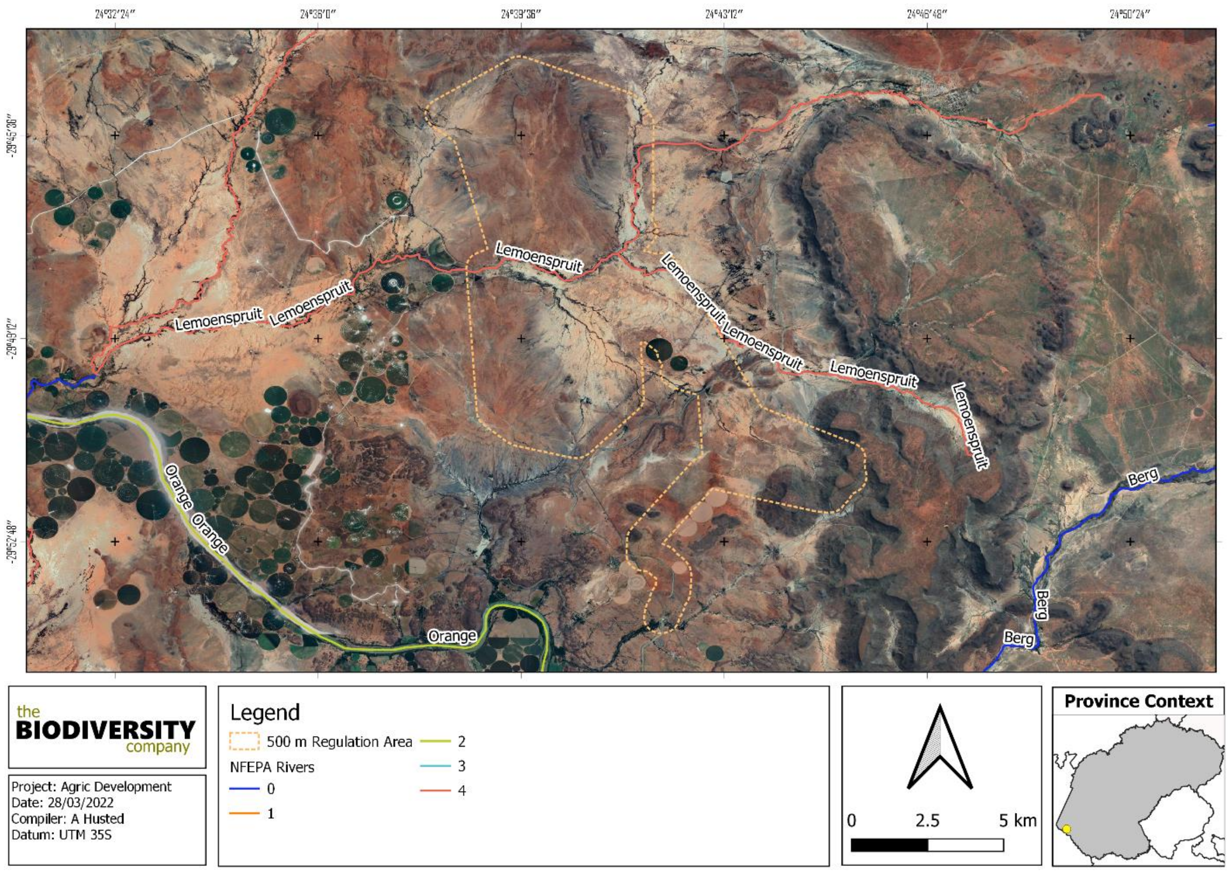

Figure 2-3 ***The location of NFEPA rivers in relation to the project area***

2.1.3 Aquatic Ecosystems

The South African Inventory of Inland Aquatic Ecosystems (SAIIAE) was released with the NBA 2018. Ecosystem threat status (ETS) of river and wetland ecosystem types are based on the extent to which each river ecosystem type had been altered from its natural condition. Ecosystem types are categorised as CR, EN, VU or LT, with CR, EN and VU ecosystem types collectively referred to as 'threatened' (Van Deventer *et al.,* 2019; Skowno *et al.,* 2019). River systems classified as Endangered (EN) and Least Threatened (LT) are both in proximity to the project area (Figure 2-4).

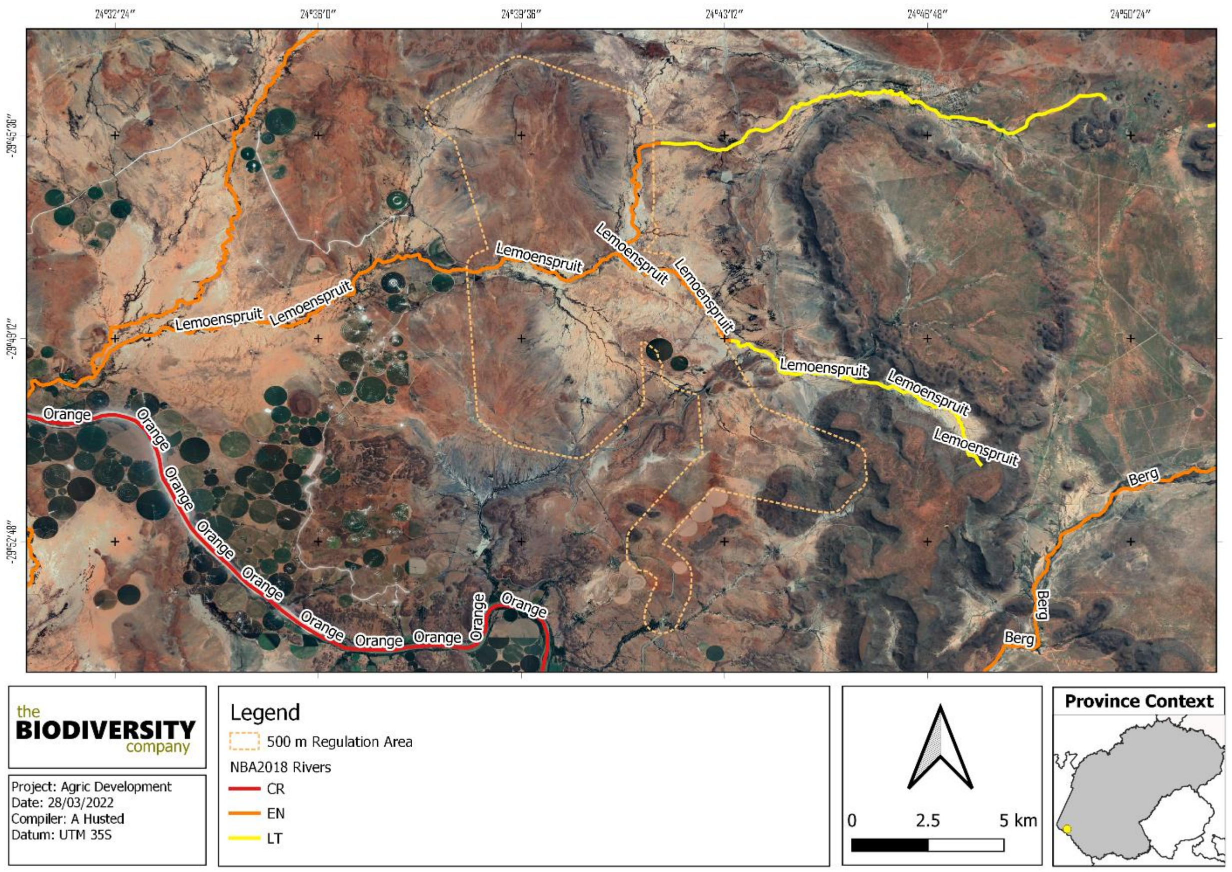

Figure 2-4 Map illustrating ecosystem threat status of river ecosystems

2.1.4 National Wetland Map 5

The National Wetland Map 5 (NWM5) spatial data was published in October 2019 (Deventer *et al*. 2019), in collaboration with the South African National Biodiversity Institute (SANBI), with the specific aim of spatially representing the location, type and extent of wetlands in South Africa. The data represents a synthesis of a wide number of official watercourse data, including rivers, inland wetlands and estuaries. This database does recognise the presence of wetlands within the extent of the project area, these include valley bottom systems and depressions.

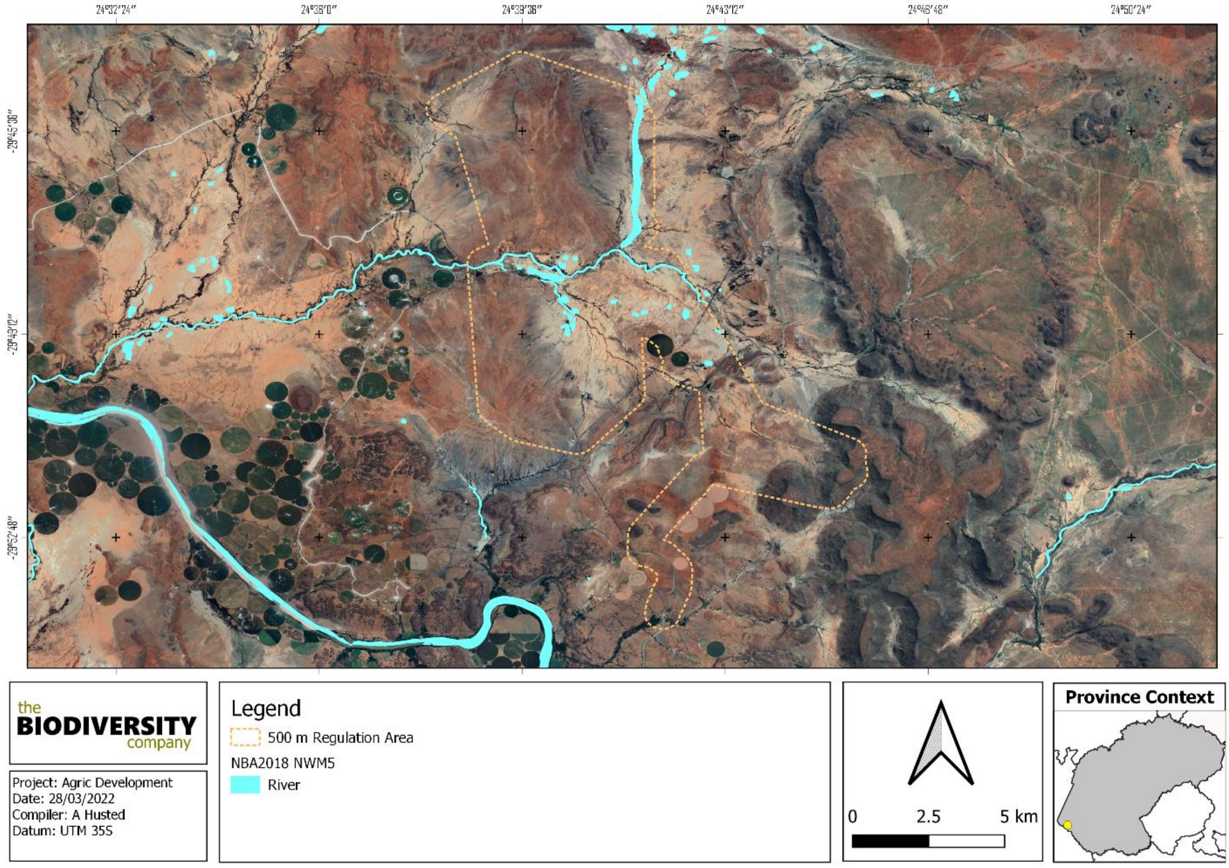

Figure 2-5 Map illustrating the NWM5 for the project area

2.1.5 Critical Biodiversity Areas and Ecological Support Areas

It is important to note that the Critical Biodiversity Areas (CBA) map accounts for terrestrial fauna and flora only. The inclusion of the aquatic component was limited to the Freshwater Ecosystem Priority Areas (FEPA) catchments (included in the cost layer and for the identification of Ecological Support Areas (ESAs)) and wetland clusters (included in the ESAs only).

A CBA is considered a significant and ecologically sensitive area and needs to be kept in a pristine or near-natural state to ensure the continued functioning of ecosystems (SANBI, 2017). A CBA represents the best choice for achieving biodiversity targets. ESAs are not essential for achieving targets, but they play a vital role in the continued functioning of ecosystems and often are essential for proper functioning of adjacent CBAs.

Figure 2-6 shows the project area superimposed on the Terrestrial CBA map. The project area overlaps with the respective CBA and ESA categories.

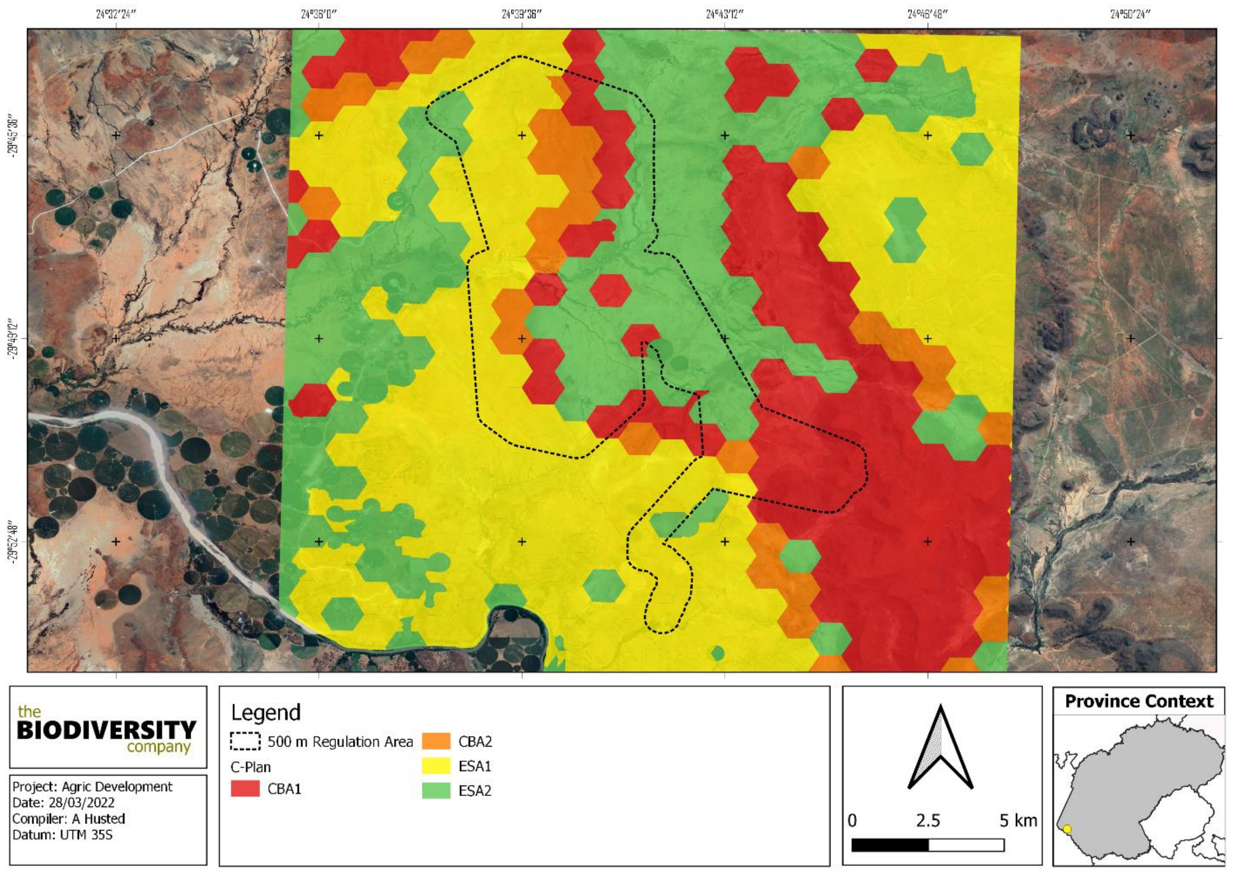

Figure 2-6 Map illustrating the locations of CBAs in the project area

2.1.6 Vegetation Type

The project area is predominantly situated within the Northern Upper Karoo (Nku 3) vegetation type. According to Mucina and Rutherford (2006) the distribution is from the Northern Cape and Free State Provinces: Northern regions of the Upper Karoo plateau from Prieska, Vosburg and Carnarvon in the west to Philipstown, Petrusville and Petrusburg in the east. Bordered in the north by Niekerkshoop, Douglas and Petrusburg and in the south by Carnarvon, Pampoenpoort and De Aar. A few patches occur in Griqualand West. Altitude varies mostly from 1 000–1 500 m.

The conservation status for the vegetation types is Least Threatened.

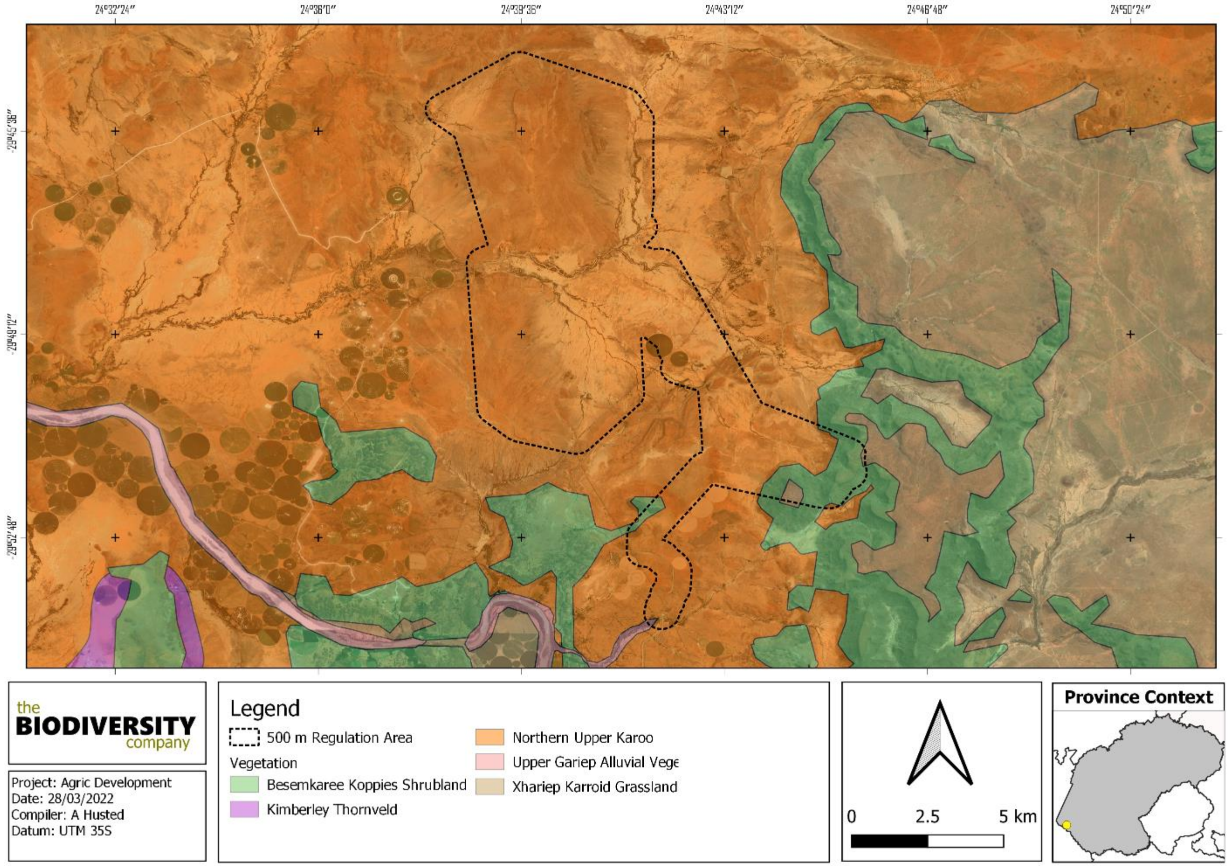

Figure 2-7 Project area showing the vegetation type based on the Vegetation Map of South Africa, Lesotho & Swaziland (BGIS, 2017).

2.1.7 Sensitivity

According to the SAIIAE dataset river systems classified as Endangered (EN) and Least Threatened (LT) are both in proximity to the project area. The NWM5 database does recognise the presence of wetlands within the extent of the project area, these are predominantly classified as Critically Endangered (CR). The aquatic biodiversity theme sensitivity as indicated in the screening report indicates some "Very High" sensitivity area, but predominantly areas of "Low" sensitivity (Figure 2-9). These "Very High" sensitivities are attributed to the presence of wetlands.

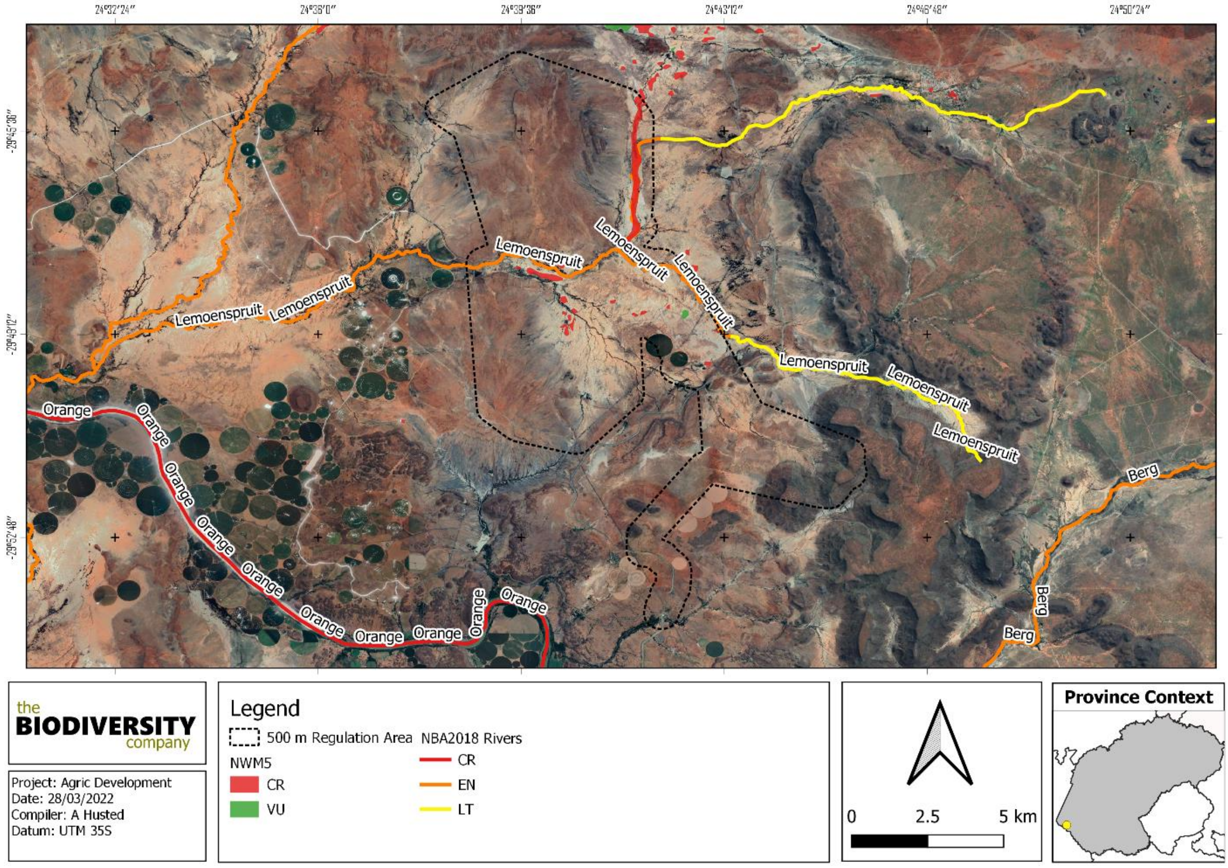

Figure 2-8 The threat status for local freshwater systems

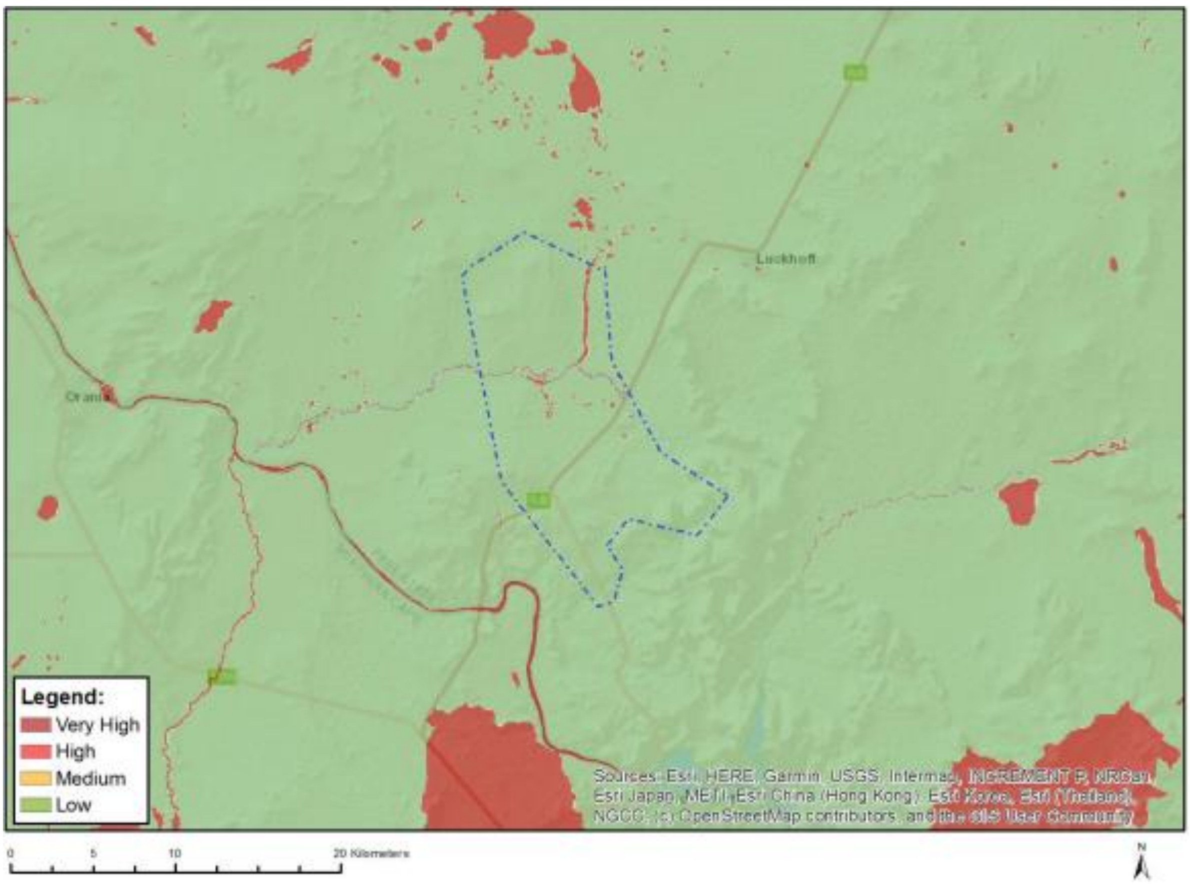

Figure 2-9 The aquatic biodiversity theme sensitivity classification

2.2 Land Capability

As part of the desktop assessment, soil information was obtained using published South African Land Type Data. Land type data for the site was obtained from the Institute for Soil Climate and Water (ISCW) of the Agricultural Research Council (ARC) (Land Type Survey Staff, 1972 - 2006). The land type data is presented at a scale of 1:250 000 and comprises the division of land into land types. In addition, a Digital Elevation Model (DEM) as well as the slope percentage of the area was calculated by means of the National Aeronautics and Space Administration (NASA) Shuttle Radar Topography Mission Global 1 arc second digital elevation data by means of Quantum geographic information system (QGIS) and System for Automated Geoscientific Analyses (SAGA) software.

2.2.1 Climate

This region's climate is characterised by rainfall peaks in autumn (March). Mean Annual Precipitation (MAP) ranges from about 190 mm in the west to 400 mm in the northeast. Mean maximum and minimum monthly temperatures for Britstown are 37.9°C and –3.6°C for January and July, respectively. Corresponding values are 37.1°C and –4.8°C for De Aar and 39.0°C and –2.3°C for Kareekloof (northwest of Strydenburg) (Mucina and Rutherford, 2006).

2.2.2 Geology and Soil

The geology of this area is characterised by shales of the Volksrust Formation and to a lesser extent the Prince Albert Formation (both of the Ecca Group) as well as Dwyka Group diamictites form the underlying geology. Jurassic Karoo Dolerite sills and sheets support this vegetation complex in places. Wide stretches of land are covered by superficial deposits including calcretes of the Kalahari Group. Soils are variable from shallow to deep, red-yellow, apedal, freely drained soils to very shallow Glenrosa and Mispah forms. Mainly Ae, Ag and Fc land types. (Mucina and Rutherford, 2006).

According to the land type database (Land Type Survey Staff, 1972 - 2006), the project area is characterised by the Ae 278, Ag 150, Ag 151, Da 103 and Fb 85 land types (see Figure 2-10). The Da land type is characterised by prismacutanic and/or pedocutanic horizons with the possibility of red apedal B-horizons occurring. The Ae land type consists of red-yellow apedal soils which are freely drained. The soils tend to have a high base status and is deeper than 300 mm.

The Ag land type is characterised by freely drained Red or Yellow-Brown Apedal soils with red soils being dominant. These soils are characterised by a high base status and is likely to be less than 300 mm deep. The Fb land type consists of Glenrosa and/or Mispah soil forms with the possibility of other soils occurring throughout. Lime is generally present within the entire landscape.

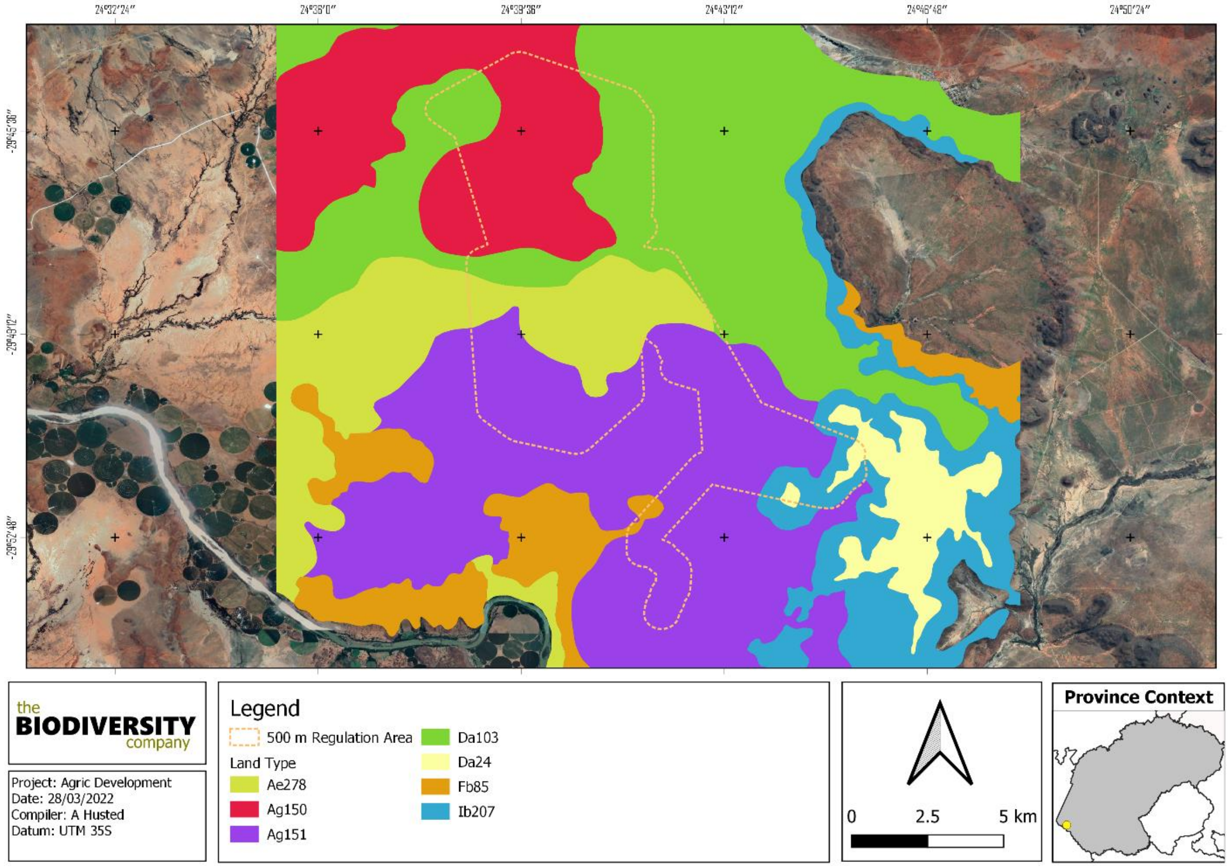

Figure 2-10 Land Types present within the project area

The land terrain units for the featured land types are illustrated from Figure 2-11 to Figure 2-17 with the expected soils listed in Table 2-1 to Table 2-7.

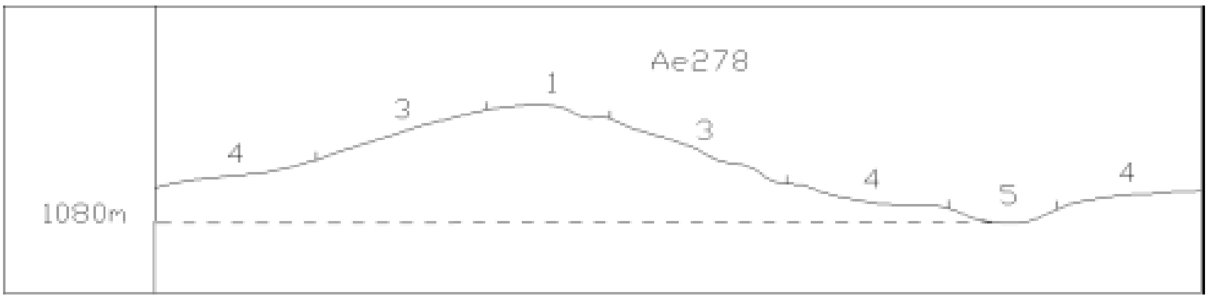

Figure 2-11 Illustration of land type Ae 278 terrain unit (Land Type Survey Staff, 1972 - 2006)

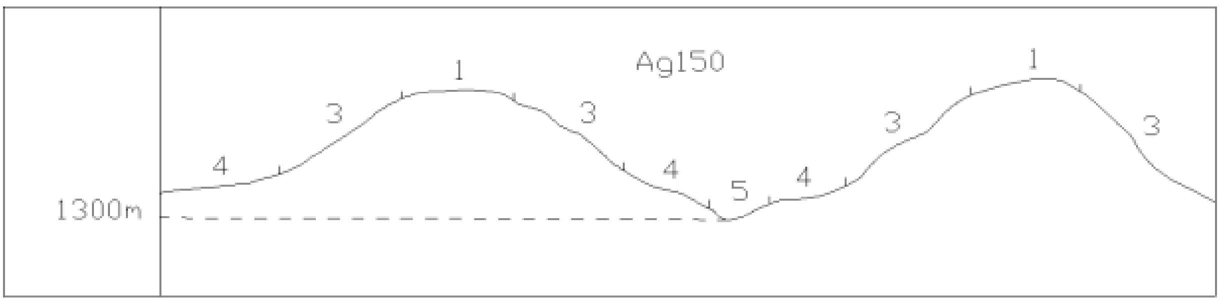

Figure 2-12 Illustration of land type Ag 150 terrain unit (Land Type Survey Staff, 1972 - 2006)

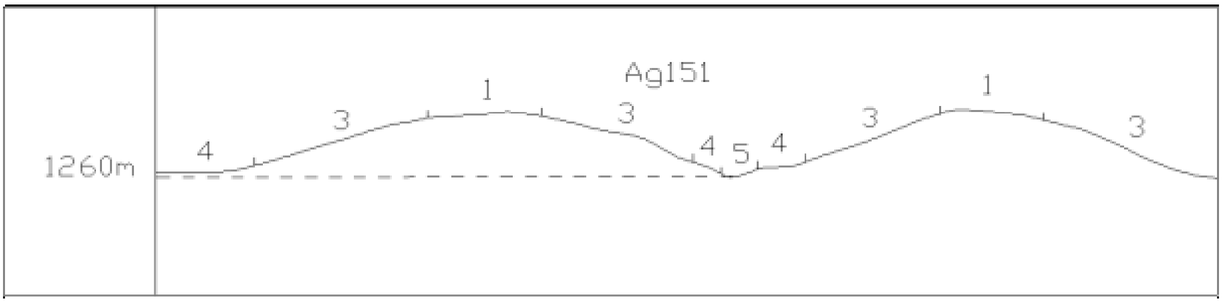

Figure 2-13 Illustration of land type Ag 151 terrain unit (Land Type Survey Staff, 1972 - 2006)

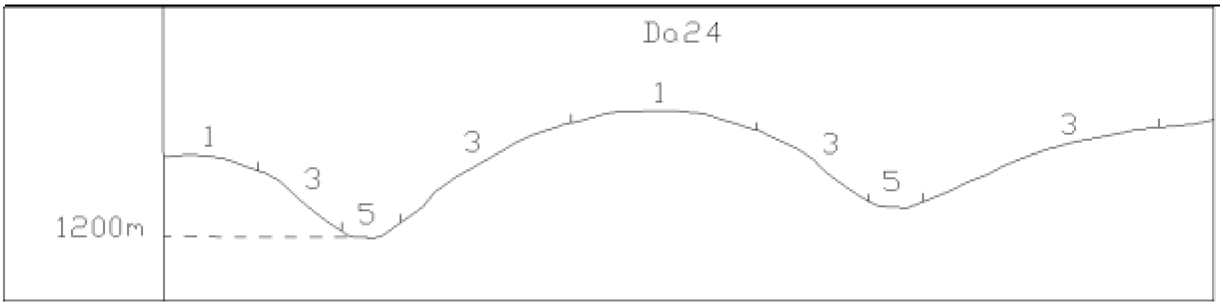

Figure 2-14 Illustration of land type Da 24 terrain unit (Land Type Survey Staff, 1972 - 2006)

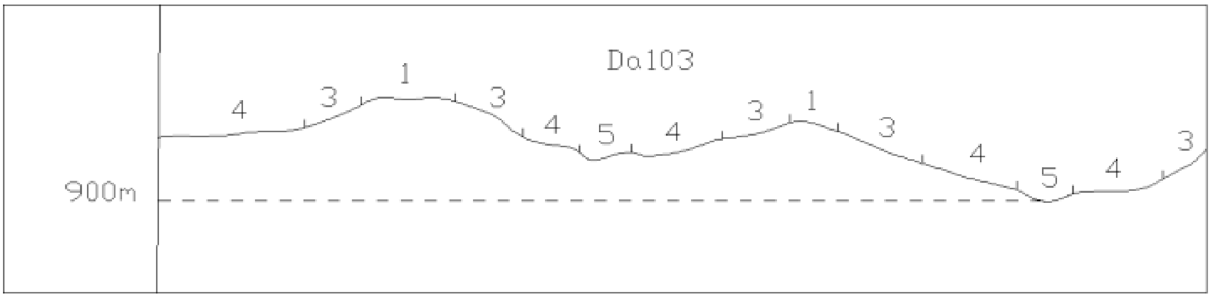

Figure 2-15 Illustration of land type Da 103 terrain unit (Land Type Survey Staff, 1972 - 2006)

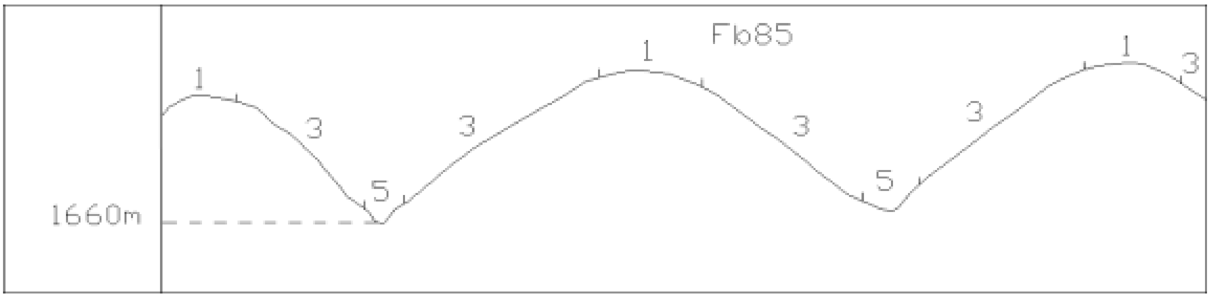

Figure 2-16 Illustration of land type Fb 85 terrain unit (Land Type Survey Staff, 1972 - 2006)

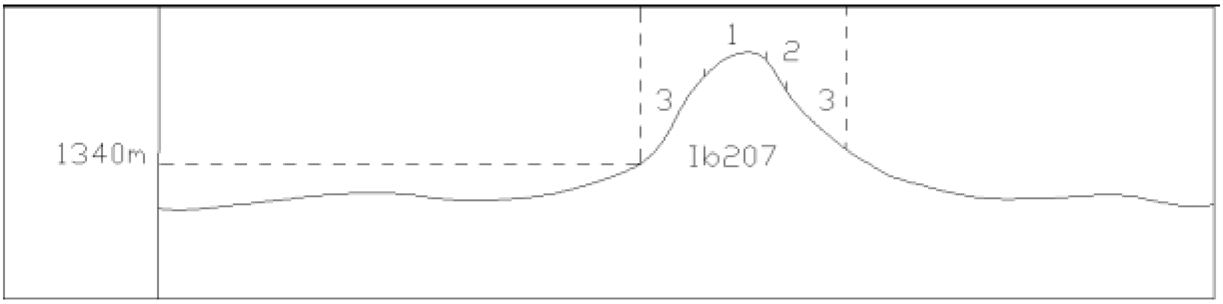

Figure 2-17 Illustration of land type Ib 207 terrain unit (Land Type Survey Staff, 1972 - 2006)

Table 2-1 Soils expected at the respective terrain units within the Ae 278 land type (Land Type Survey Staff, 1972 - 2006)

Terrain units							
1 (10%)		**3 (45%)**		**4 (40%)**		**5 (5%)**	
Hutton	60%	Hutton	55%	Hutton	35%	Clovelly	40%
Mispah	25%	Clovelly	25%	Clovelly	35%	Hutton	30%
Clovelly	15%	Mispah	10%	Oakleaf	15%	Oakleaf	15%
		Valsrivier	5%	Valsrivier	10%	Valsrivier	10%
		Oakleaf	5%	Mispah	5%	Streambeds	5%

Table 2-2 Soils expected at the respective terrain units within the Ag 150 land type (Land Type Survey Staff, 1972 - 2006)

Terrain units							
1 (30%)		**3 (45%)**		**4 (20%)**		**5 (5%)**	
Bare Rock	50%	Hutton	50%	Hutton	65%	Hutton	30%
Mispah	30%	Bare Rock	20%	Mispah	20%	Bare Rock	25%
Hutton	10%	Mispah	20%	Bare Rock	10%	Mispah	25%
Shortlands	10%	Shortlands	10%	Shortlands	5%	Shortlands	10%
						Oakland	10%

Table 2-3 Soils expected at the respective terrain units within the Ag 151 land type (Land Type Survey Staff, 1972 - 2006)

Terrain units							
1 (30%)		**3 (55%)**		**4 (7%)**		**5 (8%)**	
Bare Rock	60%	Hutton	72%	Hutton	50%	Hutton	40%
Mispah	15%	Bare Rock	10%	Oaklands	30%	Oaklands	35%
Glenrosa	10%	Mispah	8%	Mispah	5%	Streambeds	15%
Hutton	10%	Glenrosa	5%	Bare Rock	5%	Bare Rock	5%
Shortlands	5%	Shortlands	5%	Glenrosa	5%	Glenrosa	5%
				Shortlands	5%		

Table 2-4 Soils expected at the respective terrain units within the Da 24 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units					
1 (95%)		**3 (3%)**		**5 (2%)**	
Swartland	55%	Bare Rock	35%	Oakleaf	30%
Mispah	20%	Mispah	30%	Valsrivier	30%
Glenrosa	10%	Swartland	25%	Swartland	28%
Bare Rock	10%	Glenrosa	5%	Bare Rock	5%
Hutton	5%	Hutton	5%	Mispah	5%

Table 2-5 Soils expected at the respective terrain units within the Da 103 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units							
1 (5%)		**3 (10%)**		**4 (70%)**		**4 (15%)**	
Mispah	60%	Glenrosa	45%	Valsrivier	65%	Valsrivier	40%
Glenrosa	30%	Mispah	35%	Oakleaf	20%	Oakleaf	40%
Valsrivier	10%	Valsrivier	20%	Glenrosa	10%	Pans	15%
				Mispah	5%	Glenrosa	5%

Table 2-6 Soils expected at the respective terrain units within the Fb 85 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units					
1 (5%)		**3 (90%)**		**5 (5%)**	
Mispah	50%	Mispah	75%	Oakleaf	30%
Bare Rock	25%	Glenrosa	10%	Valsrivier	29%
Glenrosa	15%	Bare Rock	10%	Bare Rock	15%
Hutton	5%	Swartland	3%	Mispah	10%
Swartland	5%	Hutton	2%	Glenrosa	10%
				Hutton	5%
				Streambeds	1%

Table 2-7 Soils expected at the respective terrain units within the Ib 207 land type (Land Type Survey Staff, 1972 - 2006)

Terrain Units							
1 (10%)		**3 (5%)**		**4 (10%)**		**5 (5%)**	
Bare Rock	30%	Bare Rock	100%	Bare Rock	75%	Bare Rock	35%
Mispah	25%			Mispah	10%	Mispah	20%
Swartland	25%			Glenrosa	5%	Glenrosa	15%
Glenrosa	20%			Swartland	5%	Valsrivier	15%
				Shortlands	5%	Swartland	10%
						Streambeds	5%

2.2.3 Terrain

The slope percentage of the project area has been calculated and is illustrated in Figure 2-18. Most of the project area is characterised by a slope percentage between 0 and 20%, with some smaller patches within the project area characterised by a slope percentage up to 120%. This illustration indicates a uniform topography within the project area, with alternating hills and steep cliffs surrounding flatter areas at high elevation. The DEM of the project area (Figure 2-19) indicates an elevation of 1 069 to 1 497 Metres Above Sea Level (MASL).

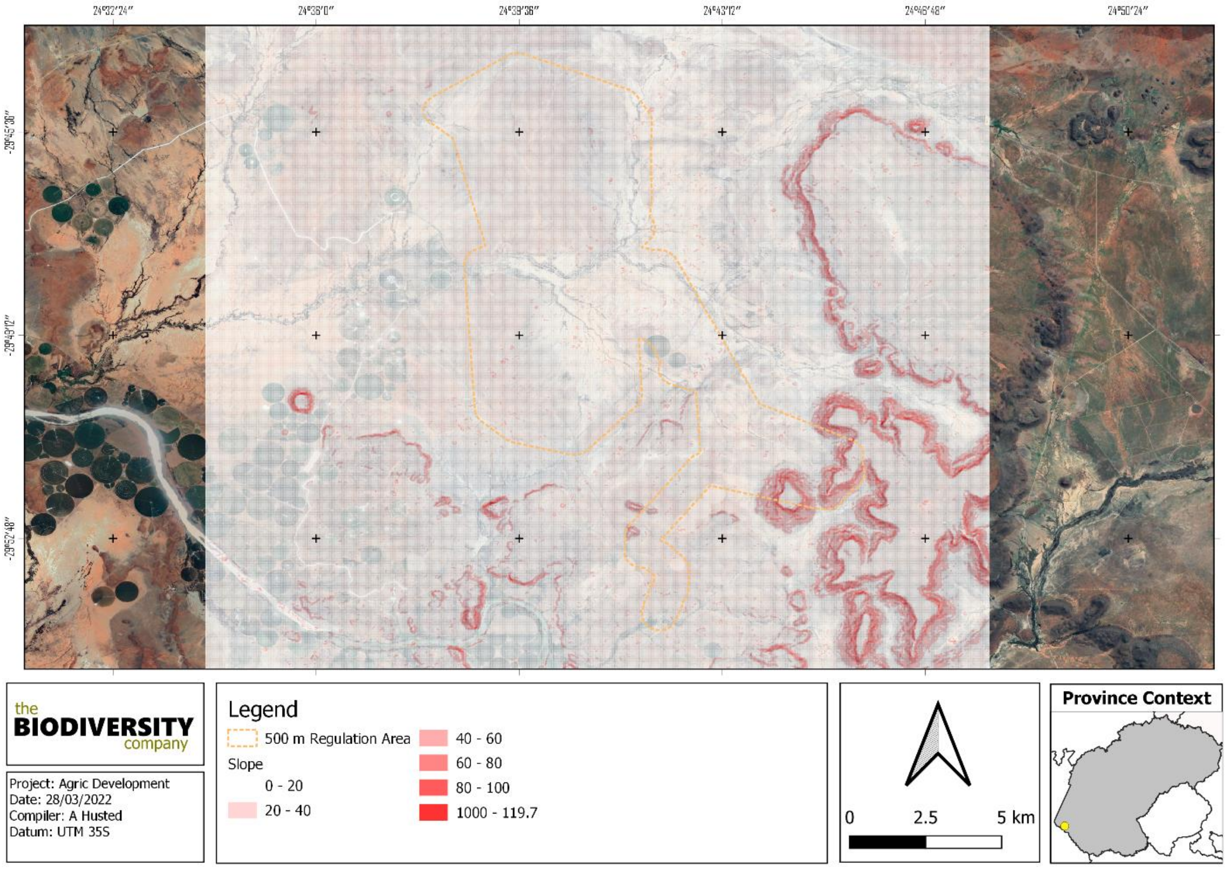

Figure 2-18 The slope percentage calculated for the project area

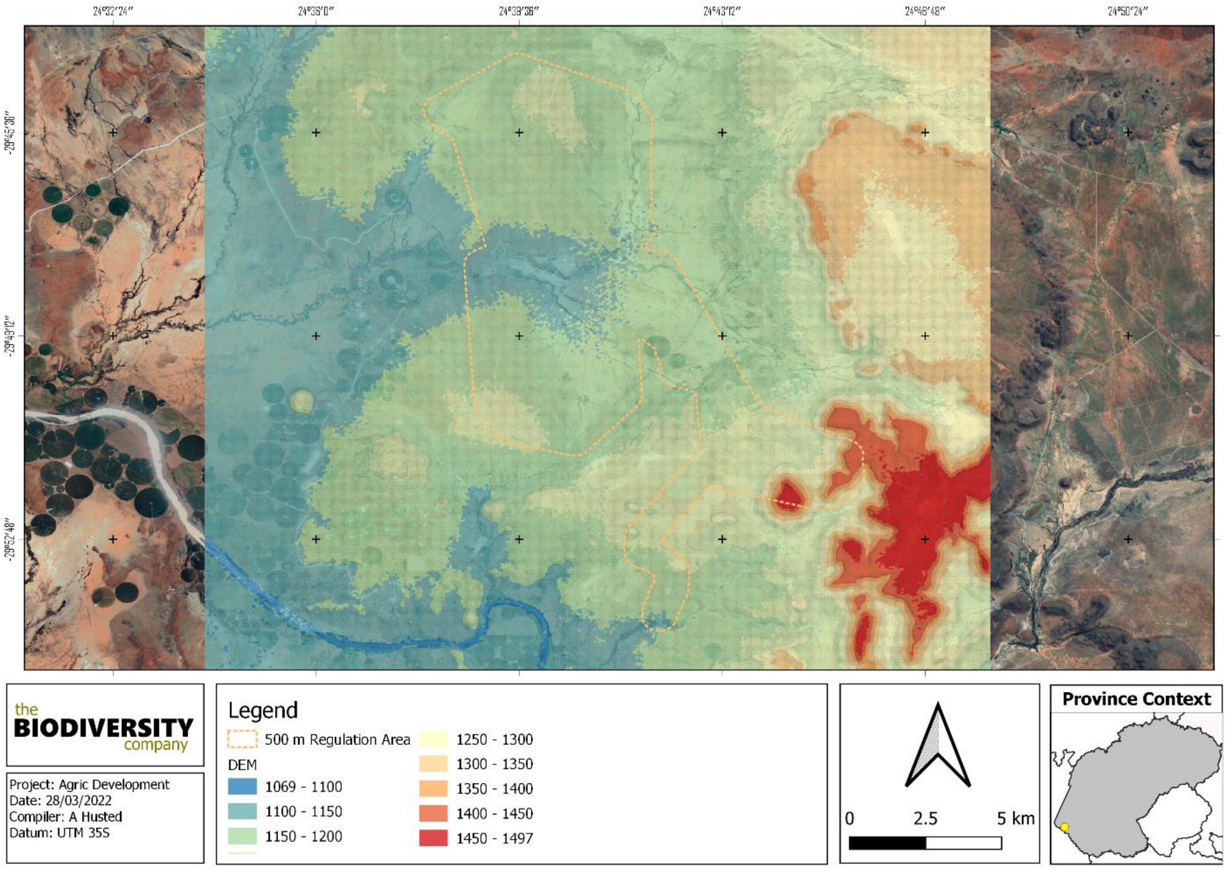

Figure 2-19 The DEM generated for the project area

2.2.4 Sensitivity

The agriculture theme sensitivity as indicated in the screening report indicates predominantly a combination of “Low” and “Medium” sensitivities, with isolated areas of “High” sensitivity (Figure 2-20). It is worth noting that “High” sensitivity areas within the project area are associated with existing pivot circles.

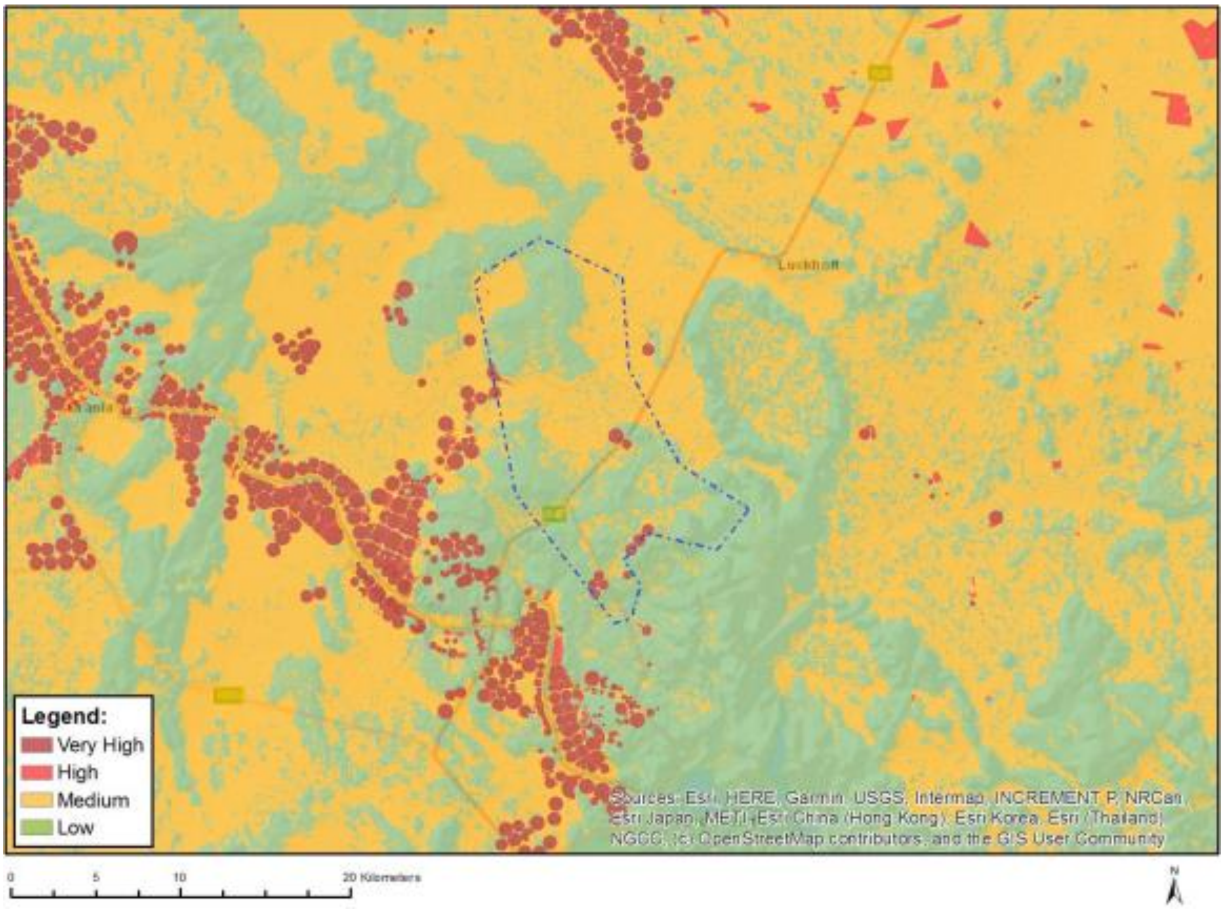

Figure 2-20 The agriculture theme sensitivity

3 Terms of Reference

3.1 Freshwater Assessment

3.1.1 Wetland Identification and Mapping

The National Wetland Classification Systems (NWCS) developed by the SANBI was considered for this assessment. This system comprises a hierarchical classification process of defining a wetland based on the principles of the hydrogeomorphic (HGM) approach at higher levels. In addition, the method also includes the assessment of structural features at the lower levels of classification (Ollis et al., 2013).

The wetland areas are delineated in accordance with the DWAF (2005) guidelines, a cross section is presented in Figure 3-1. The outer edges of the wetland areas were identified by considering the following four specific indicators, the:

- Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur;
- Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991), which are associated with prolonged and frequent saturation.
  - The soil forms (types of soil) found in the landscape were identified using the South African soil classification system namely; Soil Classification: A Taxonomic System for South Africa (Soil Classification Working Group, 1991);
- Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile due to prolonged and frequent saturation; and
- Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

Vegetation is used as the primary wetland indicator. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role.

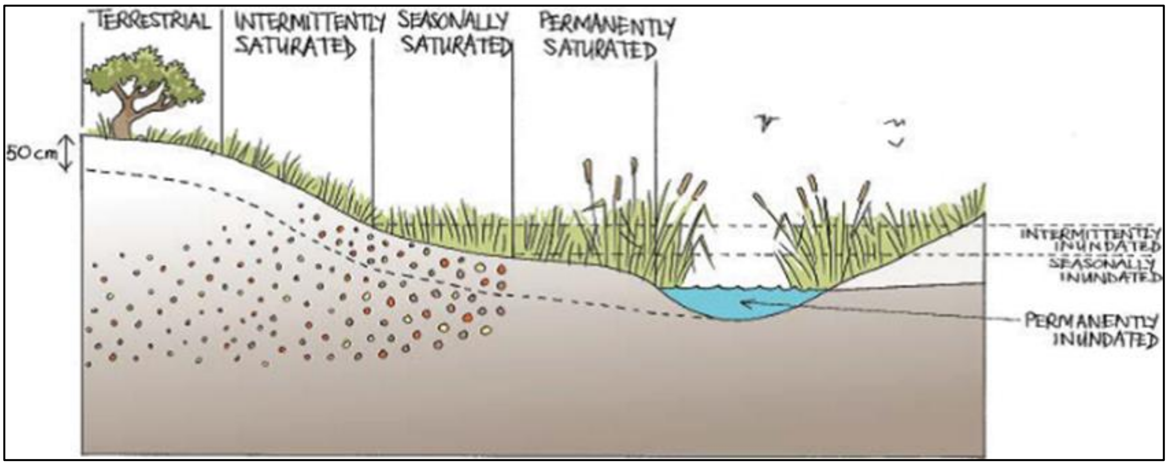

Figure 3-1 Cross section through a wetland, indicating how the soil wetness and vegetation indicators change (Ollis et al., 2013).

3.1.2 Functional Assessment

Wetland Functionality refers to the ability of wetlands to provide healthy conditions for the wide variety of organisms found in wetlands and humans. EcoServices serve as the main factor contributing to wetland functionality.

The assessment of the ecosystem services supplied by the identified wetlands was conducted per the guidelines as described in WET-EcoServices (Kotze et al. 2008). An assessment was undertaken that examines and rates the following services according to their degree of importance and the degree to which the services are provided (Table 3-1).

Table 3-1 Classes for determining the likely extent to which a benefit is being supplied

Score	Rating of likely extent to which a benefit is being supplied
< 0.5	Low
0.6 - 1.2	Moderately Low
1.3 - 2.0	Intermediate
2.1 - 3.0	Moderately High
> 3.0	High

3.1.3 Present Ecological Status

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present Ecological Status (PES) score. This takes the form of assessing the spatial extent of impact of individual activities/occurrences and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact. The Present State categories are provided in Table 3-2.

Table 3-2 The Present Ecological Status categories (Macfarlane et al., 2009)

Impact Category	Description	Impact Score Range	PES
None	**Unmodified, natural**	**0 to 0.9**	**A**
Small	Largely Natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1.0 to 1.9	B
Moderate	Moderately Modified. A moderate change in ecosystem processes and loss of natural habitats has taken place, but the natural habitat remains predominantly intact.	2.0 to 3.9	C
Large	Largely Modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4.0 to 5.9	D
Serious	Seriously Modified. The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognizable.	6.0 to 7.9	E
Critical	Critical Modification. The modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.0 to 10	F

3.1.4 Importance and Sensitivity

The importance and sensitivity of water resources is determined to establish resources that provide higher than average ecosystem services, biodiversity support functions or are particularly sensitive to impacts. The mean of the determinants is used to assign the Importance and Sensitivity (IS) category, as listed in Table 3-3 (Rountree and Kotze, 2013).

Table 3-3 Description of Ecological Importance and Sensitivity categories

EIS Category	Range of Mean	Recommended Ecological Management Class
Very High	3.1 to 4.0	**A**
High	2.1 to 3.0	**B**
Moderate	1.1 to 2.0	**C**
Low Marginal	< 1.0	**D**

3.1.5 Riverine Ecology

The overall Present Ecological Status of the associated aquatic ecosystems will be determined using the River Eco-status Monitoring Programme (REMP) Ecological Classification manual (Kleynhans and

Louw, 2007). The PES will be calculated based on the results of the various abovementioned biological indexes. The methods that will be utilised are summarised in the table below.

Table 3-4 Summary of the proposed Riverine Ecology Methods

Aspect	Analyses
Water Quality	*In situ* (DWAF, 1996)
Habitat	Intermediate Habitat Integrity Assessment (Kleynhans, 1996) Integrated Habitat Assessment System (McMillan, 1998) Biotope assessment (Tate and Husted, 2015)
Biotic indices	SASS5 (Dickens and Graham, 2002); The Average Score Per Taxon (ASPT); Macroinvertebrate Response Assessment Index (MIRAI); (Thirion,2007) Fish Response Assessment Index (Kleynhans, 2007)

3.1.6 Determining Buffer Requirements

The "Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries" (Macfarlane et al., 2014) was used to determine the appropriate buffer zone for the proposed activity.

3.2 Land Capability

Land capability and agricultural potential will be determined by a combination of soil, terrain and climate features. Land capability is defined by the most intensive long-term sustainable use of land under rain-fed conditions. At the same time an indication is given about the permanent limitations associated with the different land use classes.

Land capability is divided into eight classes and these may be divided into three capability groups. Table 3-5 shows how the land classes and groups are arranged in order of decreasing capability and ranges of use. The risk of use and sensitivity increases from class I to class VIII (Smith, 2006).

Table 3-5 Land capability class and intensity of use (Smith, 2006)

Land Capability Class	Increased Intensity of Use									Land Capability Groups
I	W	F	LG	MG	IG	LC	MC	IC	VIC	**Arable Land**
II	W	F	LG	MG	IG	LC	MC	IC		
III	W	F	LG	MG	IG	LC	MC			
IV	W	F	LG	MG	IG	LC				
V	W	F	LG	MG						**Grazing Land**
VI	W	F	LG	MG						
VII	W	F	LG							
VIII	W									**Wildlife**
W - Wildlife		**MG - Moderate Grazing**			**MC - Moderate Cultivation**					
F- Forestry		**IG - Intensive Grazing**			**IC - Intensive Cultivation**					
LG - Light Grazing		**LC - Light Cultivation**			**VIC - Very Intensive Cultivation**					

Land capability has been classified into 15 different categories by the DAFF (2017) which indicates the national land capability category and associated sensitivity related to soil resources.

The land potential classes are determined by combining the land capability results and the climate capability of a region as shown in Table 3-6. The final land potential results are then described in Table 3-7. These land potential classes are regarded as the final delineations subject to sensitivity, given the comprehensive addition of climatic conditions as those relevant to the DAFF (2017) land capabilities. The main contributors to the climatic conditions as per Smith (2006) is that of MAP, Mean Annual Potential Evaporation (MAPE), mean September temperatures, mean June temperatures and mean annual temperatures. These parameters will be derived from Mucina and Rutherford (2006) for each vegetation type located within a relevant project area. This will give the specialist the opportunity to consider micro-climate, aspect, topography etc.

Table 3-6 The combination table for land potential classification

Land capability class	Climate capability class							
	C1	C2	C3	C4	C5	C6	C7	C8
I	L1	L1	L2	L2	L3	L3	L4	L4
II	L1	L2	L2	L3	L3	L4	L4	L5
III	L2	L2	L3	L3	L4	L4	L5	L6
IV	L2	L3	L3	L4	L4	L5	L5	L6
V	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei	Vlei
VI	L4	L4	L5	L5	L5	L6	L6	L7
VII	L5	L5	L6	L6	L7	L7	L7	L8
VIII	L6	L6	L7	L7	L8	L8	L8	L8

Table 3-7 The Land Potential Classes.

Land potential	Description of land potential class
L1	Very high potential: No limitations. Appropriate contour protection must be implemented and inspected.
L2	High potential: Very infrequent and/or minor limitations due to soil, slope, temperatures or rainfall. Appropriate contour protection must be implemented and inspected.
L3	Good potential: Infrequent and/or moderate limitations due to soil, slope, temperatures or rainfall. Appropriate contour protection must be implemented and inspected.
L4	Moderate potential: Moderately regular and/or severe to moderate limitations due to soil, slope, temperatures or rainfall. Appropriate permission is required before ploughing virgin land.
L5	Restricted potential: Regular and/or severe to moderate limitations due to soil, slope, temperatures or rainfall.
L6	Very restricted potential: Regular and/or severe limitations due to soil, slope, temperatures or rainfall. Non-arable
L7	Low potential: Severe limitations due to soil, slope, temperatures or rainfall. Non-arable
L8	Very low potential: Very severe limitations due to soil, slope, temperatures or rainfall. Non-arable

3.2.1 Climate Capability

According to Smith (2006), climatic capability is determined by taking into consideration various steps pertaining to the temperature, rainfall and Class A-pan of a region. The first step in this methodology is to determine the MAP to Class A-pan ratio.

Table 3-8 Climatic capability (step 1) (Smith, 2006)

Climatic Capability Class	Limitation Rating	Description	MAP: Class A pan Class
C1	None to Slight	Local climate is favourable for good yields for a wide range of adapted crops throughout the year.	0.75-1.00

C2	Slight	Local climate is favourable for a wide range of adapted crops and a year-round growing season. Moisture stress and lower temperature increase risk and decrease yields relative to C1.	0.50-0.75
C3	Slight to Moderate	Slightly restricted growing season due to the occurrence of low temperatures and frost. Good yield potential for a moderate range of adapted crops.	0.47-0.50
C4	Moderate	Moderately restricted growing season due to the occurrence of low temperatures and severe frost. Good yield potential for a moderate range of adapted crops but planting date options more limited than C3.	0.44-0.47
C5	Moderate to Severe	Moderately restricted growing season due to low temperatures, frost and/or moisture stress. Suitable crops at risk of some yield loss.	0.41-0.44
C6	Severe	Moderately restricted growing season due to low temperatures, frost and/or moisture stress. Limited suitable crops that frequently experience yield loss.	0.38-0.41
C7	Severe to Very Severe	Severely restricted choice of crops due to heat and moisture stress.	0.34-0.38
C8	Very Severe	Very severely restricted choice of crops due to heat and moisture stress. Suitable crops at high risk of yield loss.	0.30-0.34

In the event that the MAP: Class A-pan ratio is calculated to fall within the C7 or C8 class, no further steps are required, and the climatic capability can therefore be determined to be C7 or C8. In cases where the above-mentioned ratio falls within C1-C6, steps 2 to 3 will be required to further refine the climatic capability.

Step 2

Mean September temperatures;

- <10℃ = C6
- 10 - 11℃ = C5
- 11 - 12℃ = C4
- 12 - 13℃ = C3
- >13℃ = C1

Step 3

Mean June temperatures;

- <9℃ = C5
- 9 - 10℃ = C4
- 10 - 11℃ = C3
- 11 - 12℃ = C2

3.2.2 Current Land Use

A generalised land-use will be derived for the larger project area considering agricultural productivity.

- Mining;
- Bare areas;
- Agriculture crops;
- Natural veld;
- Grazing lands;
- Forest;
- Plantation;
- Urban;
- Built-up;
- Waterbodies; and
- Wetlands.

4 Impact Assessment

Figure 4-1 presents the preliminary layout for the proposed agricultural development, which has been considered for the scoping level impact assessment. This assessment has considered both direct and indirect risks to the freshwater and soil attributes for the area.

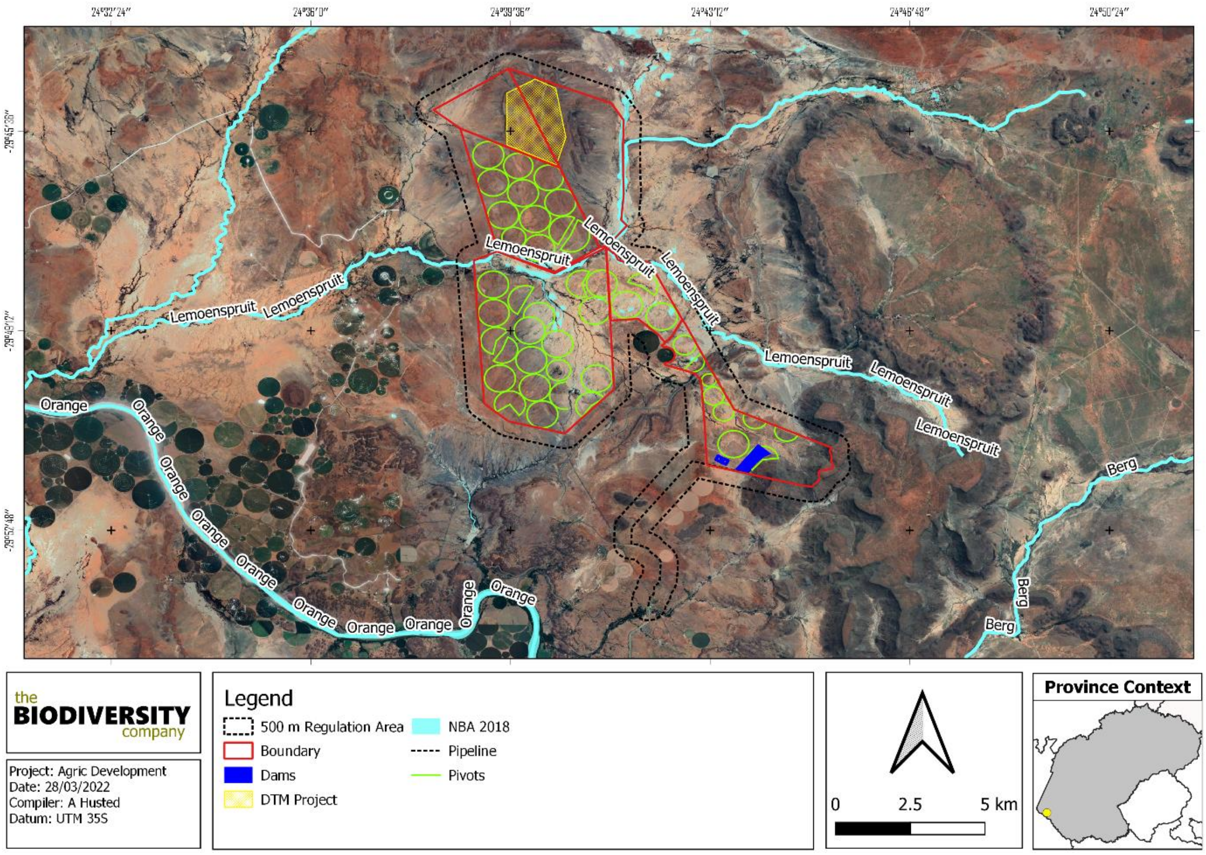

Figure 4-1 Proposed layout for the agricultural development project

4.1 Freshwater Impact Assessment

Both riverine and also wetland areas are expected for the project area. Albeit it limited, these systems are expected to be characterised by alluvial (riverine) and hydromorphic properties, with supporting riparian and hydrophytic vegetation.

The proposed project is likely to result in the loss of some wetland areas due to the placement of pivots in these areas. Infrastructure will also traverse watercourses but the significance of the impact resulting from this is considered to be negligible. The abstraction of water for irrigation is likely to result in altered flows from the donor system, but this will also contribute to altered surface flow dynamics. The agricultural project may also contribute to erosion of the catchment, resulting in sedimentation of the receiving watercourses. Run-off from the catchment during the operation phase of the project could also result in impaired water quality in the event fertilisers and non-organics are used for the production.

Table 4-1 Scoping evaluation table summarising the impacts identified to freshwater systems

Impact Freshwater deterioration / loss			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Disturbance / degradation / loss to wetland soils or vegetation due to	<u>Direct impacts:</u>	Regional	Water resources and buffer area

the pivots and associated infrastructure, such as crossings	» Disturbance / degradation / loss to wetland soils or vegetation Indirect impacts: » Loss of ecosystem services		
Altered instream flows	Direct impacts: » Abstraction of water, causing altered flows and loss of habitat Indirect impacts: Loss of habitat	Regional	Adhere to Ecological Water Requirements
Altered hydro-dynamics from infrastructure traversing watercourses	Direct impacts: » Erosion and clearing of vegetation for the embankments Indirect impacts: Sedimentation of downstream reaches	Regional	Water resources and buffer area, limit footprint area.
Increased erosion and sedimentation & contamination of resources	Direct impacts: » Erosion and structural changes to the systems Indirect impacts: » Sedimentation & contamination of downstream reaches	Regional	None identified at this stage
Description of expected significance of impact The development of the area could result in the encroachment into water resources and result in the loss or degradation of these systems, most of which are functional and provide ecological services. Water resources are also likely to be traversed by linear infrastructure which might create a barrier to flow and biotic movement across the systems. These disturbances could also result in the infestation and establishment of alien vegetation would affect the functioning of the systems. Earthworks will expose and mobilise earth materials which could result in sedimentation of the receiving systems. A number of machines, vehicles and equipment will be required, aided by chemicals and concrete mixes for the project. Leaks, spillages or breakages from any of these could result in contamination of the receiving water resources. Contaminated water resources are likely to influence the associated biota. It is anticipated to increase stormwater runoff due to the clearance of vegetation, resulting in altered flow regimes. The changes could result in physical changes to the receiving systems caused by erosion, run-off and also sedimentation, and the functional changes could result in changes to the vegetative structure of the systems. The reporting of surface run-off to the systems could also result in the contamination of the systems, transporting (in addition to sediment) diesel, hydrocarbons, pollutants, and soil from the operational areas. The abstraction of water from the donor system could result in altered flows within the system, causing habitat loss downstream of the abstraction point.			
Gaps in knowledge & recommendations for further study » This is completed at a desktop level only. » Identification, delineation and characterisation of water resources. » Undertake a functional assessment of systems where applicable. » Determine a suitable buffer width for the resources. **Recommendations with regards to general field surveys** » Field surveys to prioritise the development areas, but also consider the 500 m regulation area. » Prescribed Ecological Water Requirements for the reach » Beneficial to undertake fieldwork during the wet season period.			

4.1.1 Cumulative Impacts

Cumulative impacts are assessed in context of the extent of the proposed project area; and the overall general loss and transformation of resources resulting from other activities in the area (Table 4-2).

Table 4-2 Cumulative wetland impact assessment

Impact Wetland disturbance / loss			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Disturbance / degradation / loss of water resources	Direct impacts:	Regional	Water resources and buffer area

	» Disturbance / degradation / loss of resources Indirect impacts: » Loss of ecosystem services		
Altered instream flows	Direct impacts: » Abstraction of water, causing altered flows and loss of habitat Indirect impacts: » Loss of habitat	Regional	Adhere to Ecological Water Requirements
Description of expected significance of impact The expected post-mitigation risk significance for the project in isolation is expected to be medium to low, but in consideration of the surrounding agricultural projects the overall cumulative impact is expected to be medium to high. This is expected due to the expected loss of wetland areas, and also the water demands of the project.			
Gaps in knowledge & recommendations for further study » This is completed at a desktop level only. » Identification, delineation and characterisation of water resources. » Undertake a functional assessment of systems where applicable. » Determine a suitable buffer width for the resources. **Recommendations with regards to general field surveys** » Field surveys to prioritise the development areas, but also consider the 500 m regulation area. » Prescribed Ecological Water Requirements for the reach » Beneficial to undertake fieldwork during the wet season period.			

4.2 Soil Impact Assessment

Considering the occurrence of various soil forms that are commonly associated with high land capabilities, it is likely that areas with high land capability sensitivity do occur within the project area. However, due to the poor climatic capability, the ultimate land potential is more likely to be low.

Table 4-2 Scoping evaluation table summarising the impacts identified to soils

Impact Loss of land capability			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Loss of land capability due to increase in traffic and use of machinery	Direct impacts: » Loss of soil / land capability Indirect impacts: » Loss of land capability	Local	None
Loss of land capability due to construction and operation of dams and pipelines	Direct impacts: » Loss of soil / land capability Indirect impacts: Loss of land capability	Local	High sensitivity land capability areas
Description of expected significance of impact The development of the area could result in the encroachment into areas characterised by high land potential properties, which can ultimately result in the loss of land capability. These disturbances could also result in the infestation and establishment of alien vegetation, which in turn can have a detrimental impact on soil resources. Earthworks will expose and mobilise earth materials which could result in compaction and/or erosion. A number of machines, vehicles and equipment will be required, aided by chemicals and concrete mixes for the project. Leaks, spillages or breakages from any of these could result in contamination of soil resources, which could affect the salinity or pH of the soil, which can render the fertility of the soil unable to provide nutrition to plants. During the operational phase, the impacts associated with dams and pipelines will be easily managed by best "housekeeping" practices. As for the proposed pivot irrigation systems, it is advisable that high potential land capability areas be utilised due to the fact that crop production requires suitable land capability resources. The baseline data acquired during the site assessment will provide insight to whether or not high potential areas are available within the project area,			

Gaps in knowledge & recommendations for further study
» This is completed at a desktop level only. » Identification and delineation of soil forms. » Determine of soil sensitivity. **Recommendations with regards to general field surveys** » Field surveys to prioritise the development areas.

4.2.1 Cumulative Impacts

Cumulative impacts are assessed in context of the extent of the proposed project area; other developments in the area; and general loss of high-quality land capability areas (Table 4-4).

Table 4-4 Cumulative soil impact assessment

Impact Loss of land capability			
Issue	**Nature of Impact**	**Extent of Impact**	**No-Go Areas**
Compaction/soil stripping/transformation of land use which leads to loss of land capability	Direct impacts: » Loss of soil / land capability Indirect impacts: » Loss of land capability	Regional	None identified at this stage
Description of expected significance of impact The expected post-mitigation risk significance is expected to be low, and the overall cumulative impact is therefore expected to be low. The expected post-mitigation risk significance for the project in isolation is expected to be low, but in consideration of the larger agricultural development area.			
Gaps in knowledge & recommendations for further study » This is completed at a desktop level only. » Identification and delineation of soil forms. » Determine of soil sensitivity. **Recommendations with regards to general field surveys** » Field surveys to prioritise the development areas.			

5 Conclusion

5.1 Freshwater

A number of wetland and riverine systems are located in proximity to the project area, with the conservation status of these systems ranging from Least Threatened to Critically Endangered.

The expected post-mitigation risk significance for the project in isolation is expected to be medium to low, but in consideration of the surrounding agricultural projects the overall cumulative impact is expected to be medium to high. This is expected due to the expected loss of wetland areas, and also the water demands of the project.

5.2 Land Capability

Various soil forms are expected throughout the project area, of which some are commonly associated with high land capabilities. Even though the soil depth, texture and permeability of these soils ensure high land capability, the climatic capability of the area often reduces the land potential considerably. Therefore, very few areas characterised by "High" land potential are expected (without irrigation/in natural condition).

Considering the lack of sensitivity, together with holistic mitigation measures, it has been determined that none of the aspects scored during the impact assessment (post-mitigation) are associated with any scores higher than "Moderate". It is recommended that the site assessment to be conducted for focus areas that potentially are characterised by greater micro-climates (i.e. aspect) and low laying areas characterised by deep soils.

6 References

Department of Water and Forestry (DWAF). 1996. South African Water Quality Guidelines. Volume 7: Aquatic Ecosystems.

Department of Water Affairs and Forestry (DWAF). 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Pretoria: Department of Water Affairs and Forestry.

Dickens CWS and Graham PM. 2002. The South African Scoring System (SASS) Version 5: Rapid bioassessment method for rivers. African Journal of Aquatic Science. 27 (1): 1 -10.

Kleynhans CJ. 1996. A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo System, South Africa) Journal of Aquatic Ecosystem Health 5:41-54.

Kleynhans CF. 2007. Module D: Volume 1 Fish Response Assessment Index. Water Research Commission. Report number TT 330/08.

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.C. & Collins, N.B. (2009). A Technique for rapidly assessing ecosystem services supplied by wetlands. Mondi Wetland Project.

Land Type Survey Staff. (1972 - 2006). Land Types of South Africa: Digital Map (1:250 000 Scale) and Soil Inventory Databases. Pretoria: ARC-Institute for Soil, Climate, and Water.

Macfarlane DM and Bredin IP. 2017. Part 1: technical manual. Buffer zone guidelines for wetlands, rivers and estuaries

Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C., Dickens, C.W.S. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Final Consolidated Report. WRC Report No TT 610/14, Water Research Commission, Pretoria.

Macfarlane, D.M., Dickens, J. & Von Hase, F. (2009). Development of a methodology to determine the appropriate buffer zone width and type for developments associated with wetlands, watercourses and estuaries Deliverable 1: Literature Review. INR Report No: 400/09.

McMillan PH. 1998. An Invertebrate Habitat Assessment System (IHASv2), for the Rapid Biological Assessment of Rivers and Streams. A CSIR research project, number ENV – P-I 98132 for the Water Resource Management Program, CSIR. Ii + 44p.

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

Nel JL, Murray KM, Maherry AM, Petersen CP, Roux DJ, Driver A, Hill L, Van Deventer H, Funke N, Swartz ER, Smith-Adao LB, Mbona N, Downsborough L and Nienaber S. 2011. Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Ollis DJ, Snaddon CD, Job NM, and Mbona N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI Biodiversity Series 22. South African Biodiversity Institute, Pretoria.

Rountree, M.W. and Kotze, D.M. 2013. Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2.0). Joint Department of Water Affairs/Water Research Commission Study. Report No 1788/1/12. Water Research Commission, Pretoria.

Skowno, A.L., Raimondo, D.C., Poole, C.J., Fizzotti, B. & Slingsby, J.A. (eds.). (2019). South African National Biodiversity Assessment 2018 Technical Report Volume 1: Terrestrial Realm. South African National Biodiversity Institute, Pretoria.

Smith, B. (2006). The Farming Handbook. Netherlands & South Africa: University of KwaZulu-Natal Press & CTA.

Soil Classification Working Group. (1991). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

Soil Classification Working Group. (2018). Soil Classification A Taxonomic system for South Africa. Pretoria: The Department of Agricultural Development.

Tate RB and Husted A. 2015. Aquatic macroinvertebrate responses to pollution of the Boesmanstroom river system above Carolina, South Africa. African Journal of Aquatic Science, DOI: 10.2989/16085914.2015.1037237.

Thirion CA. 2007. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. Pretoria, South Africa: Department of Water Affairs and Forestry.

Van Deventer, H., Smith-Adao, L., Collins, N.B., Grenfell, M., Grundling, A., Grundling, P-L., Impson, D., Job, N., Lötter, M., Ollis, D., Petersen, C., Scherman, P., Sieben, E., Snaddon, K., Tererai, F. and Van der Colff D. 2019. South African National Biodiversity Assessment 2018: Technical Report. Volume 2b: Inland Aquatic (Freshwater) Realm. CSIR report number CSIR/NRE/ECOS/IR/2019/0004/A. South African National Biodiversity Institute, Pretoria. http://hdl.handle.net/20.500.12143/6230.

Van Deventer, H., Smith-Adao, L., Mbona, N., Petersen, C., Skowno, A., Collins, N.B., Grenfell, M., Job, N., Lötter, M., Ollis, D., Scherman, P., Sieben, E. & Snaddon, K. 2018. South African National Biodiversity Assessment 2018: Technical Report. Volume 2a: South African Inventory of Inland Aquatic Ecosystems (SAIIAE). Version 3, final released on 3 October 2019. Council for Scientific and Industrial Research (CSIR) and South African National Biodiversity Institute (SANBI): Pretoria, South Africa.