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Enviro INSIGHT
environmental impact assessments

Appendix E (4):

Aquatic Biodiversity Assessment

BOTTERBLOM WIND ENERGY FACILITY:

AQUATIC SPECIALIST BIODIVERSITY, WETLAND AND RIPARIAN ASSESMENT– SCOPING PHASE

Prepared for:

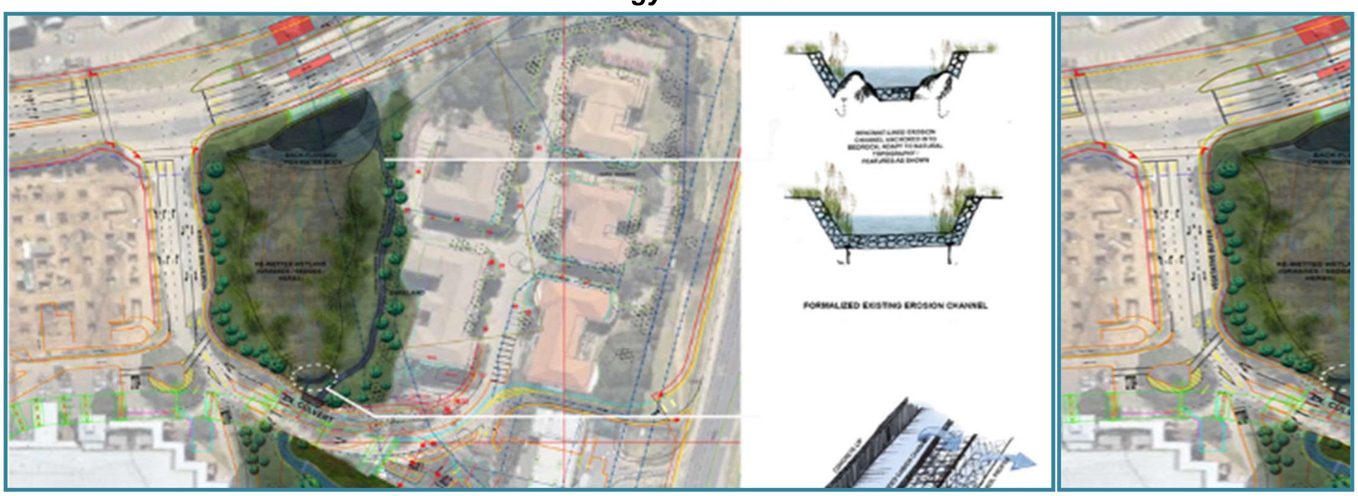
Enviro INSIGHT
environmental impact assessments

Prepared by:

WaterMakers

In association with:

Ecology-International



May 2021

Minimum Requirements for Aquatic Biodiversity Specialist Assessment as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Protocol ref	Aquatic Biodiversity Specialist Assessment	Section / Page
2.3.	The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	Section 2 and Section 3
2.3.1.	a description of the aquatic biodiversity and ecosystems on the site, including;	Section 2, 2.2.3; 2.2.4; 2.2.5
2.3.1. (a)	aquatic ecosystem types; and	
2.3.1. (b)	presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns;	
2.3.2.	the threat status of the ecosystem and species as identified by the screening too1[1];	2.2.4; 2.2.5
2.3.3.	indication of national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area or sub catchment, a strategic water source area, a priority estuary, whether or not they are free-flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area);	Section 2.2.4
2.3.4.	a description of the ecological importance and sensitivity of the aquatic ecosystem including:	Section 3.6
2.3.4. (a)	the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and	Section 3
2.3.4. (b)	the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Section 3
2.4.	The assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered appropriate.	Recommendations made for Impact assessment phase
2.5.	Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions:	Recommendations made for Impact assessment phase
2.5.1.	is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Impact assessment phase
2.5.2.	is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	Impact assessment phase
2.5.3.	how will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include:	Impact assessment phase
2.5.3. (a)	impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes);	Impact assessment phase
2.5.3. (b)	will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns);	Impact assessment phase
2.5.3. (c)	what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and	Impact assessment phase
2.5.3. (d)	to what extent will the risks associated with water uses and related activities change;	Impact assessment phase
2.5.4.	how will the proposed development impact on the functioning of the aquatic feature? This must include:	Impact assessment phase
2.5.4. (a)	base flows (e.g. too little or too much water in terms of characteristics and requirements of the system);	
2.5.4. (b)	quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river);	

[1] These ecosystems include the National Environmental Management Biodiversity Act. 2004(Act No. 10 of 2004) listed ecosystems.

Minimum Requirements for Aquatic Biodiversity Specialist Assessment as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Protocol ref	Aquatic Biodiversity Specialist Assessment	Section / Page
2.5.4. (c)	change in the hydrogeomorphic typing of the aquatic ecosystem (e.g,change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland);	Impact assessment phase
2.5.4. (d)	quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication);	
2.5.4. (e)	fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and	
2.5.4. (f)	the loss or degradation of all or part of any unique or important features, associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	
2.5.5.	how will the proposed development impact on key ecosystems regulating, and supporting services especially:	Impact assessment phase
2.5.5. (a)	flood attenuation;	
2.5.5. (b)	streamflow regulation;	
2.5.5. (c)	sediment trapping;	
2.5.5. (d)	phosphate assimilation;	
2.5.5. (e)	nitrate assimilation;	
2.5.5. (f)	toxicant assimilation;	
2.5.5. (g)	erosion control; and	
2.5.5. (h)	carbon storage?	
2.5.6.	how will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	
2.6.	In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered, in relation to:	Not applicable
2.6. (a)	size of the estuary;	
2.6. (b)	availability of sediment;	
2.6. (c)	wave action in the mouth;	
2.6. (d)	protection of the mouth;	
2.6. (e)	beach slope;	
2.6. (f)	volume of mean annual runoff; and	
2.6. (g)	extent of saline intrusion (especially relevant to permanently open systems),	

Minimum Content Requirements for Aquatic Biodiversity Specialist Reports as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Aquatic Biodiversity Specialist Assessment Report		
Protocol ref	Content requirement	Section / Page
2.7.1.	contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	Appendix B
2.7.2.	a signed statement of independence by the specialist;	Page v & vi
2.7.3.	a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 3
2.7.4.	the methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;	Appendix A
2.7.5.	a description of the assumptions made, any uncertainties or gaps in knowledge or data;	Section 1.3
2.7.6.	the location of areas not suitable for development, which are to be avoided during construction and operation, where relevant;	Section 3.3
2.7.7.	additional environmental impacts expected from the proposed development;	Impact assessment phase
2.7.8.	any direct, indirect and cumulative impacts of the proposed development on site;	
2.7.9.	the degree to which impacts and risks can be mitigated;	
2.7.10.	the degree to which the impacts and risks can be reversed;	
2.7.11.	the degree to which the impacts and risks can cause loss of irreplaceable, resources;	
2.7.12.	a suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies;	Section 4
2.7.13	proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr);	Impact assessment and see

		recommendations
2.7.14.	a motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a 'low" aquatic biodiversity sensitivity and that were not considered appropriate;	-
2.7.15.	a substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not; and	Page 40
2.7.16.	any conditions to which this statement is subjected.	

Minimum Content requirement for Aquatic Biodiversity Compliance Statements as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)

Aquatic Biodiversity Compliance Statement		
Protocol ref	Content requirement	Section / Page
3.1.	The compliance statement must be prepared by a suitably qualified specialist registered with the SACNASP, with expertise in the field of aquatic sciences.	Not applicable – associated with high sensitivity aquatic features thus treated as high sensitivity site
3.2.	The compliance statement must:	
3.2.1.	be applicable to the preferred site and the proposed development footprint;	
3.2.2.	confirm that the site is of "low" sensitivity for aquatic biodiversity; and	
3.2.3.	indicate whether or not the proposed development will have an impact on the aquatic features.	
3.3.	The compliance statement must contain, as a minimum, the following information:	
3.3.1.	contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	
3.3.2.	a signed statement of independence by the specialist;	
3.3.3.	a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	
3.3.4.	a baseline profile description of biodiversity and ecosystems of the site;	
3.3.5.	the methodology used to verify the sensitivities of the aquatic biodiversity features on the site including the equipment and modelling used where relevant;	
3.3.6.	in the case of a linear activity, confirmation from the aquatic biodiversity specialist that, in their opinion, based on the mitigation and remedial measures proposed, the land can be returned to the current state within two years of completion of the construction phase;	
3.3.7.	where required, proposed impact management outcomes or any monitoring requirements for inclusion in the EMPr;	
3.3.8.	a description of the assumptions made as well as any uncertainties or gaps in knowledge or data;	
3.3.9.	any conditions to which this statement is subjected.	
3.4.	A signed copy of the compliance statement must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	

Declaration of Independence by Specialist

I, **WILLEM LUBBE**, in my capacity as a specialist consultant, hereby declare that I -

- act as an independent consultant;
- 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;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- 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 has 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 National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability;
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered; and
- as a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member.

____

Willem Lubbe Pr.Sci.Nat

Wetland Specialist

SACNASP Reg. No. 004750

06/06/2021

____

Date

Declaration of Independence by Specialist

I, **BYRON GRANT**, in my capacity as a specialist consultant, hereby declare that I -

- act as an independent consultant;
- 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;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- 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 has 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 National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability;
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered; and
- as a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member.

07 July 2021

Byron Grant Pr.Sci.Nat.
Director & Principal Specialist
Ecology International (Pty) Ltd
SACNASP Reg. No. 400275/08

Date

EXECUTIVE SUMMARY

The Applicant wishes to apply for an environmental authorisation for the proposed development of a wind energy facility (WEF) and associated infrastructure within the Northern Cape Province. The proposed WEF will consist of up to 54 wind turbines with a generation capacity of up to 6.5 MW per turbine, with a hub height of up to 150m and a rotor diameter of up to 175m. Additional ancillary infrastructures to the WEF include the internal road network, workshop, storage room, office and laydown area for the construction period. Enviro-Insight Consulting was contracted to review the area and conduct the Environmental Impact Assessment (EIA) on the applicants behalf. Subsequently, WaterMakers was appointed by Enviro-Insight Consulting as independent specialists to conduct the relevant wetland and riparian related studies in order to assist the facilitation of the required environmental authorisation and water use licence processes.

In order to enable an adequate description of potential wetland habitat and so as to ensure that the wetland study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application, the following approach was to be undertaken:

- Desktop assessment of available freshwater ecosystems;
- Site assessment for identification and delineation of wetland and/or riparian habitat;
- Classification of identified wetland and/or riparian habitat;
- Identification of wetland goods and services by means of the Wet-EcoServices approach, where applicable;
- Determination of the Present Ecological State of identified wetlands by means of the Wet-Health approach, where applicable;
- Determination of Present Ecological State of identified riparian habitat by means of the VEGRAI approach, where applicable;
- Determination of the Ecological Importance and Sensitivity of identified wetlands and/or riparian habitat;
- Determination of potential functional buffer zones for the protection of the associated freshwater ecosystems to inform appropriate planning; and
- Provisional identification of expected impacts and associated mitigation measures to inform the Scoping Phase of the environmental process.

A total of five riparian networks were delineated within the study area and within 500m from the study area as well as sections further downstream of the study area. All five riparian networks feed into the Leeuberg and Klein-Rooiberg Rivers which joins the Krom River downstream. In addition there were several non-FEPA wetlands indicated on the NFEPA database that was investigated. Only the terrain unit indicator was confirmed for the indicated NFEPA database depression wetlands. None of the other three wetland indicators were present. However, these depressions do hold water for a few days a year and could act as potential temporary habitat for various faunal species, however, water is likely not retained for a long enough period for redox morphology to develop, thus they are not likely wetlands. Following a cautionary approach, these features are termed 'riparian/ephemeral depressions', with some of the depressions being isolated while a cluster of depressions are linked via riparian channels. Further infield research is necessary to establish whether these features should indeed be classified as watercourses and thus have regulatory standing. For now, a cautionary approach stands in order to facilitate an environmentally friendly and sustainable planning process. The same cautionary and conservative approach was taken where there were

doubt between differentiating between A section and B section channels, with A section channels likely included in the current delineation, especially on the highest lying areas where channels often do not carry baseflow.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category B). There are a few small areas that has been highly impacted through grazing practices (e.g. artificial waterholes, overnight camps etc), but collectively these heavily impacted zones form a very small percentage of the total riparian habitat

In terms of ecological importance and sensitivity, riparian habitat (Riparian 1 to Riparian 9) within the study area was designated as sensitive as a result of the ecological and functional values attributed to riparian areas in general, legal regulations and requirements as well as the supporting ecological services afforded to the downstream ecosystems.

Determination of the preliminary buffer requirements for riparian features associated with the proposed study area followed the approach of Macfarlane & Bredin (2016), whereby the preliminary required buffers were developed based on various factors, including assumed agricultural impacts, slope, annual precipitation, rainfall intensity, channel width, catchment to wetland ratio, etc. Accordingly, preliminary buffer requirements for the identified watercourse were determined to be 40m from the edge of the delineated riparian areas. Further field work with regards to separating less sensitive A section channels from B section riparian channels will likely lead to reduced buffer distances and or not be applicable in some instances.

Preliminary impact considerations identified destruction of water courses and associated habitat, surface water pollution including sedimentation as well as increased erosion, loss of wetland functionality and decreased downstream water quality as the major potential impacts during the construction and operational phase. Several general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Some of the most pertinent recommendations include:

- The layout should be adapted to ensure that wind turbines are not located within riparian habitat or associated buffers.
- It is essential that the road and other linear networks (cables) follow contour and lowest gradients as far as possible. Appropriate stormwater design for the road network is essential to prevent roads from serving as concentrated conduits for water run-off, significantly increasing erosion potential and sediment transport capacity. Water diversions along the road should be placed at regular intervals in order to divert water back into the natural veld on the downstream side of the road. This diverted water should be released in a diffuse manner on contour, e.g. appropriately designed swale.
- Access roads should preferably be dirt roads on contour. It is essential to choose appropriate water crossing for the road network in order to reduce potential negative impacts. Crossing points should preferably utilise watercourse sections which already contain exposed bedrock and has a low gradient in that particular section of the watercourse. These are ideal natural crossing points which needs little intervention so as to ensure that historic stormwater run-off regimes are not altered. Where necessitated crossings should be simple low water bridges that do not interrupt surface or subsurface flows. Concentration of water flow must be avoided. Where water is concentrated it

needs to be diffusely released through appropriate diffuse release infrastructure placed on contour and or cutting bedrock to contour, especially on the downstream side.

- Watercourse crossings should be aligned perpendicular to the natural flow regime and on contour in order to prevent flow concentration and associated negative impacts.
- It is recommended that the road lay-out and all final positions of watercourse crossings be appropriately "fine tuned" through field verification in the impact assessment phase in order to minimise potential impacts and reduce road construction cost.

Considering the type of development proposed and assuming that the necessary mitigation measures are appropriately designed and applied, the development is not likely to impact on the FEPA catchment classification associate with the study area.

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ACRONYMS

CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWA	Department of Water and Sanitation
DWS	Department of Water and Sanitation
EC	Ecological Category
FEPA	Freshwater Ecosystem Priority Area
GPS	Global Positioning System
HGM	Hydrogeomorphic
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas project
NWRS	National Water Resource Strategy
PES	Present Ecological State
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
VEGRAI	Vegetation Reponses Assessment Index
WMA	Water Management Areas
WRC	Water Research Commission
WWF	Worldwide Fund for Nature

1. INTRODUCTION

1.1 Project Description

The Applicant wishes to apply for an environmental authorisation for the proposed development of a wind energy facility (WEF) and associated infrastructure within the Northern Cape Province. The proposed WEF will consist of up to 54 wind turbines with a generation capacity of up to 6.5 MW per turbine, with a hub height of up to 150m and a rotor diameter of up to 175m. Additional ancillary infrastructures to the WEF include the internal road network, workshop, storage room, office and laydown area for the construction period. Enviro-Insight Consulting was contracted to review the area and conduct the Environmental Impact Assessment (EIA) on the applicant's behalf. Subsequently, WaterMakers was appointed by Enviro-Insight Consulting as independent specialists to conduct the relevant wetland and riparian-related studies in order to assist the facilitation of the required environmental authorisation and water use licence processes.

1.2 Scope of Work

In order to enable an adequate description of associated watercourses and to ensure that the freshwater ecosystem study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application as well as in accordance with the 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, the following approach was to be undertaken:

- Desktop assessment of available freshwater ecosystems;
- Site assessment for identification and delineation of wetland and/or riparian habitat;
- Classification of identified wetland and/or riparian habitat;
- Identification of wetland goods and services by means of the Wet-EcoServices approach, where applicable;
- Determination of the Present Ecological State of identified wetlands by means of the Wet-Health approach, where applicable;
- Determination of Present Ecological State of identified riparian habitat by means of the VEGRAI approach, where applicable;
- Determination of the Ecological Importance and Sensitivity of identified wetlands and/or riparian habitat;
- Determination of potential functional buffer zones for the protection of the associated freshwater ecosystems to inform appropriate planning; and
- Provisional identification of expected impacts and associated mitigation measures to inform the Scoping Phase of the environmental process.

A site visit to the area to be affected by the proposed activity was undertaken from the 28th of April to the 1st of May 2021. A detailed description of the methodology used to address the above Terms of Reference is provided in Appendix A.

1.3 Assumptions and Limitations

During the course of the present study, the following limitations were experienced:

- In order to obtain definitive data regarding the biodiversity, hydrology and functioning of particular wetlands, studies should ideally be conducted over a number of seasons and over a number of years.

The current study relied on information gained during a single field survey conducted during a single season, desktop information for the area, as well as professional judgment and experience;

- Wetland and riparian areas within transformed landscapes, such as urban and/or agricultural settings, especially areas that have undergone several successional changes due to repeated and prolonged overgrazing practices, are often affected by disturbances that restrict the use of available wetland indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of dense stands of alien vegetation, dumping, sedimentation, infrastructure encroachment and infilling). Hence, a wide range of available indicators were considered in order to aid in determining wetland and riparian boundaries more accurately;
- Wetland and riparian assessments are based on a selection of available techniques that have been developed through the Department of Water and Sanitation (DWS). These methods are, however, largely qualitative in nature with associated limitations due to the range of interdisciplinary aspects that have to be taken into consideration. Current and historic anthropogenic disturbance within and surrounding the study area has resulted in soil profile disturbances (especially through erosional processes) as well as successional changes in species composition in relation to its original /expected benchmark condition;
- Determination of the preliminary buffer requirements for watercourse features associated with the proposed study area followed the approach of Macfarlane & Bredin (2016), this methodology was adapted to be used for riparian buffers;
- Delineations of wetland areas were largely dependent on the extrapolation of field indicator data obtained during field surveys, contour data for the study area, and from interpretation of geo-referenced orthophotos and satellite imagery as well as historic aerial imagery data sets received from the National Department of Rural Development and Land Reform. As such, inherent ortho-rectification errors associated with data capture and transfer to electronic format are likely to decrease the accuracy of wetland boundaries in many instances.
- The author reserves the right to change impact ratings and mitigation measures as information surfaces.

2. GENERAL CHARACTERISTICS

2.1 Location

The Botterblom WEF footprint is approximately 5 745 hectares (ha) and will be located on a Portion of the Remainder of the Farm Sous 226, within the Hantam Local Municipality. The site can be reached via the gravel Granaatboskolk / Zout Dwaggas Road, which branches off the R357 (Figure 1). Approximate centre coordinates for the study area are 30°28'55.65"S and 19°32'25.27"E.

2.2 Biophysical Attributes

2.2.1 Climate

Loeriesfontein normally receives about 143mm of rain per year and because it receives most of its rainfall during winter, it has a considered to have a Mediterranean climate (www.saexplorer.co.za). The general rainfall pattern in Loeriesfontein indicates that the lowest rainfall is received in January whilst the highest is in June (www.saexplorer.co.za). The monthly distribution of average daily maximum temperatures indicates that the average midday temperatures for Loeriesfontein ranges from 17°C in July to 31.8°C in February (www.saexplorer.co.za). The region is the coldest during July when the mercury drops to 2.4°C on average during the night (www.saexplorer.co.za). The average minimum daily temperatures range from a high in the region of 14° C in February to a low of about 2° C around June (www.saexplorer.co.za).

2.2.2 Geology

Geology of the study site predominantly consist of Mudstones and shales of Ecca Group (Prince Albert and Volkrust Formations) and Dwyka tillites both of early Karoo age. It is estimated that 20% of rocky outcrops is formed by Jurassic intrusive dolerite sheets and dykes. Overlying soils are made up of shallow Mispah and Glenrosa forms, with lime generally present in the entire landscape and to a lesser extent, red-yellow apedal, freely drained soils with high base status.

2.2.3 Associated Aquatic Ecosystems

The NWRS-1 (National Water Resource Strategy, Version 1) originally established 19 Water Management Areas (WMA) within South Africa, and proposed the establishment of the 19 Catchment Management Agencies to correspond to these areas. In rethinking the management model, and based on viability assessments with respect to water resources management, available funding, capacity, skills and expertise in regulation and oversight, as well as to improve integrated water systems management, the original 19 designated WMAs have been consolidated into nine WMAs.

The proposed Botterblom WEF is situated primarily within Quaternary Catchment E31C, with only the northern-most extreme being within Quaternary Catchment D53F. Review of topographical data however suggests that the catchment delineations may be incorrectly captured, and the site is suggested to fall wholly within Quaternary Catchment E31C. Accordingly, the site would fall within the Berg-Olifants Water Management Area. Watercourses associated with the study area include the Klein-Rooiberg and its associated tributaries that traverses the eastern portion of the site, and the Leeuberg and its associated tributaries that traverses the extreme western portion of the site. With the exception of the Klein-Rooiberg where the watercourse exits the property, all watercourses associated with the study area are considered to be ephemeral and event-driven, likely flowing only for short periods following rainfall. Further, the Klein-Rooiberg and the Leeuberg are classified as being Upper Foothill watercourses in term of geomorphic zonation, and listed as Least Concern and not protected according to the latest National Biodiversity Assessment (Van Deventer et al., 2018).

In addition to the watercourses noted above, several depressional wetland features are considered to be present within the north-eastern portion of the site according to available 1:50,000 topographical maps and the latest National Biodiversity Assessment (Van Deventer et al., 2018). These wetlands are classified as Critically Endangered and not protected, and are listed as having a high risk category according to the National Biodiversity Assessment (Van Deventer et al., 2018). Further, the study area falls within the Nama Karoo Bushmanland wetland vegetation group (Macfarlane *et al*, 2014)

2.2.4 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim comprises a national and sub-national component. The national component aims to align DWS and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component aims to use three case study areas to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes at a sub-national level (Driver et al., 2011). The project further aims to maximize synergies and alignment with other national level initiatives such as the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation.

Based on current outputs of the NFEPA project (Nel et al., 2011; Figure 2; Figure 3), it was determined that the Klein-Rooiberg catchment associated with the study area is classified as a FEPA catchment on the basis of the river ecosystem type of the Klein-Rooiberg (Ephemeral-Nama Karoo-Upper Foothill). According to Driver et al. (2011), river FEPAs achieve biodiversity targets for river ecosystems and threatened/near-threatened fish species, and were identified in rivers that are currently in a good condition (Ecological Category A or B). Their FEPA status indicates that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. Further review of FEPA outputs indicated that while there are several wetlands identified within the study area, there are no FEPA-designated wetland or wetland clusters within the study area, with the nearest wetland cluster, which is associated with a FEPA-designated wetland, being located approximately 3.5km east of the study area.

2.2.5 Provincial Context

The Northern Cape Critical Biodiversity Area (CBA) Map updates, revises and replaces all older systematic biodiversity plans and associated products for the province. The map includes a collation of all the available data on biodiversity features, their condition, current Protected Areas and Conservation Areas, and opportunities and constraints for effective conservation. The Northern Cape CBA maps the distribution of the province's biodiversity into several categories for both the terrestrial and inland aquatic realms (Holness & Oosthuysen, 2016). These are ranked according to ecological and biodiversity importance and their contribution to meeting the quantitative targets set for each biodiversity feature.

The Northern Cape CBA Map uses the following terms to categorise the various land use types according to their biodiversity and environmental importance:

- Critical Biodiversity Area – 1 (CBA 1: Irreplaceable);
- Critical Biodiversity Area – 2 (CBA 2: Optimal);
- Ecological Support Area;
- Other Natural Area; and
- Protected Area.

CBAs are terrestrial and aquatic areas of the landscape that are considered of high biodiversity value and that need to be maintained in a natural or near-natural state, with no further loss of habitat or species, to ensure the continued existence and functioning of species and ecosystems and the delivery of ecosystem services. Thus, if these areas are not maintained in a natural or near natural state then biodiversity targets cannot be met. Maintaining an area in a natural state can include a variety of biodiversity compatible land uses and resource uses. Further, Ecological Support Areas (ESAs) are not essential for meeting biodiversity targets but play an important role in supporting the ecological functioning of CBAs and/or in delivering ecosystem services, while areas designated as Other Natural Areas consist of all those areas in good or fair ecological condition that fall outside the protected area network and have not been identified as CBAs or ESAs.

According to the current classification of CBAs in the Northern Cape (Holness & Oosthuysen, 2016), the Klein-Rooiberg as well as a 500m buffer on either side of the watercourse is be regarded as CBA 1 primarily due to the FEPA-designated nature of the watercourse. Areas classified as CBA 1 are representative of areas that are considered as irreplaceable, representing the only localities for which the conservation targets for one or more of the biodiversity features contained within can be achieved (i.e. there are no alternative sites available) (Figure 4). In addition to the Klien-Rooiberg, the depressional wetlands identified within the north-eastern portion of the study area as well as the Leeuberg watercourse are classified as Ecological Support Areas, which are areas required to ensure the persistence and maintenance of biodiversity patterns and ecological processes within the CBAs.

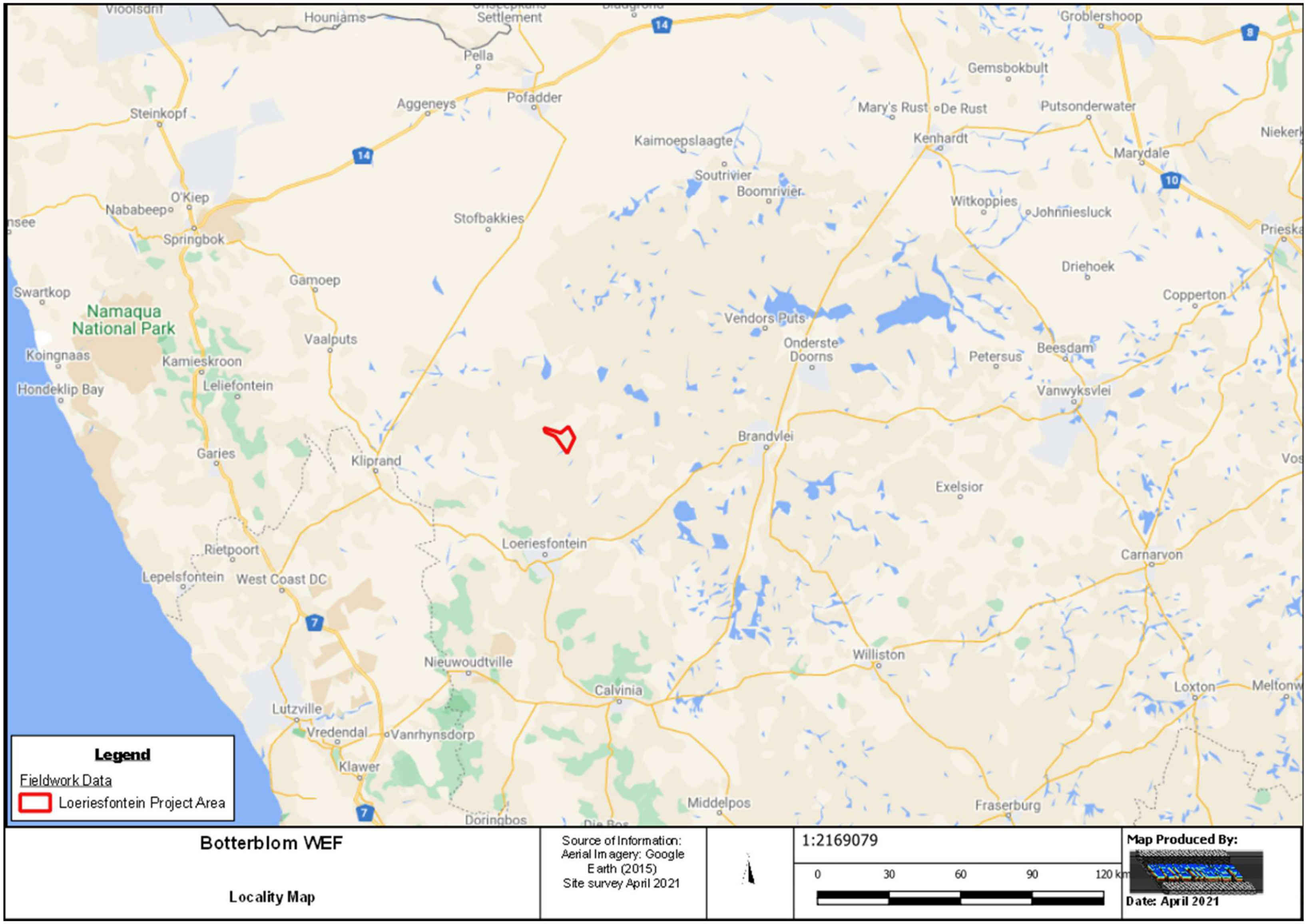

Figure 1: Locality Map

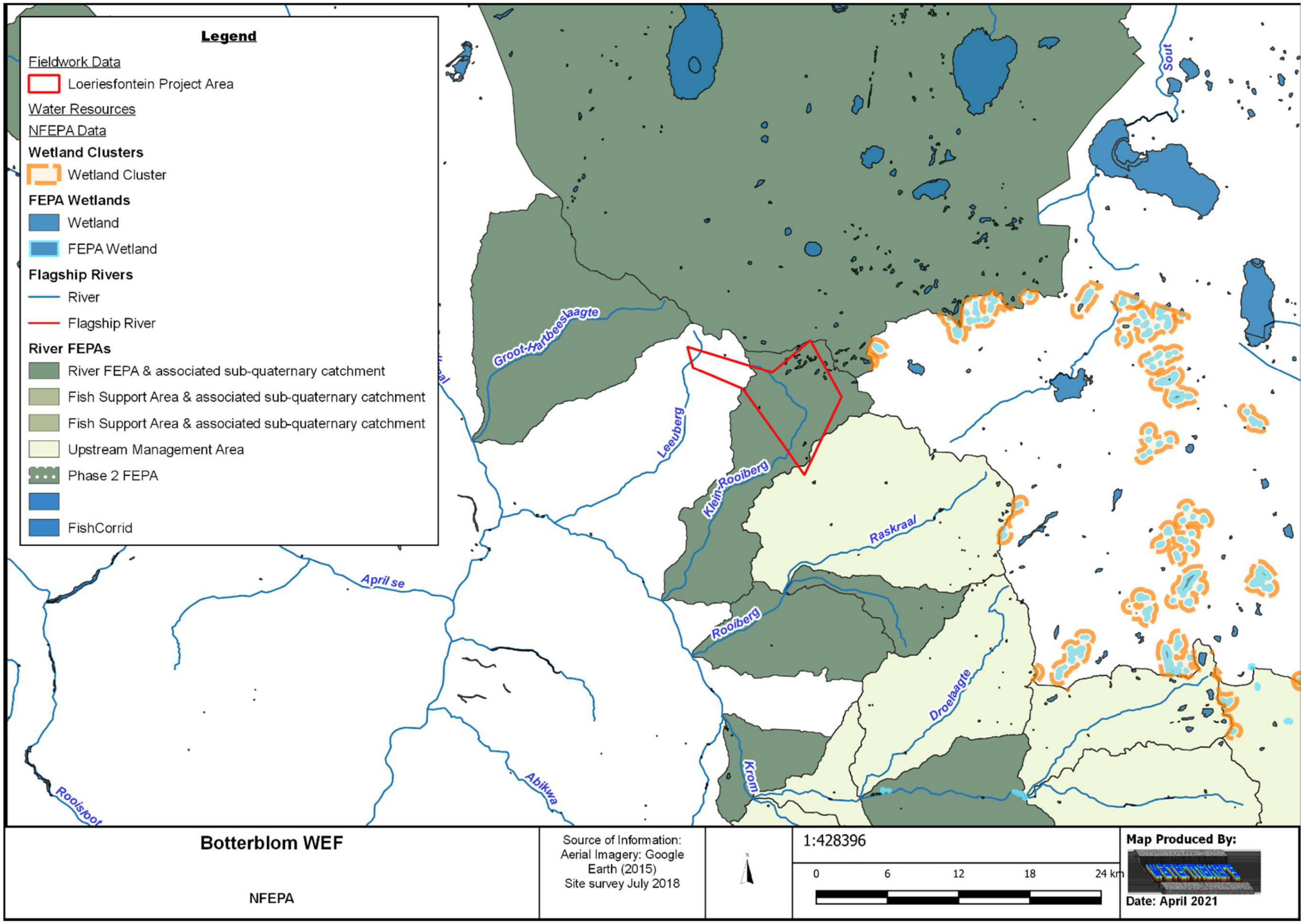

Figure 2: National Freshwater Ecosystem Priority Areas associated with the study area

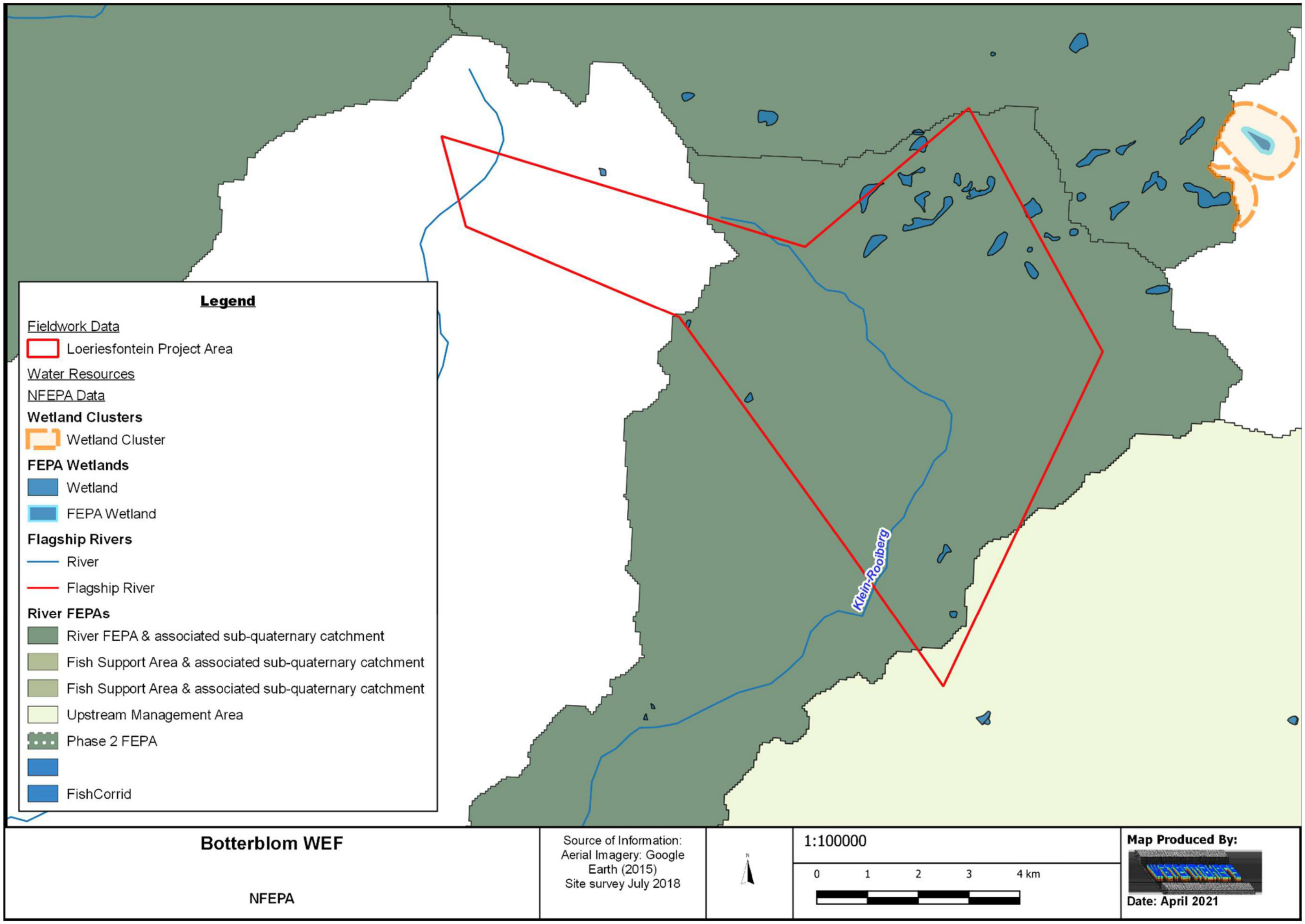

Figure 3: National Freshwater Ecosystem Priority Areas associated with the study area

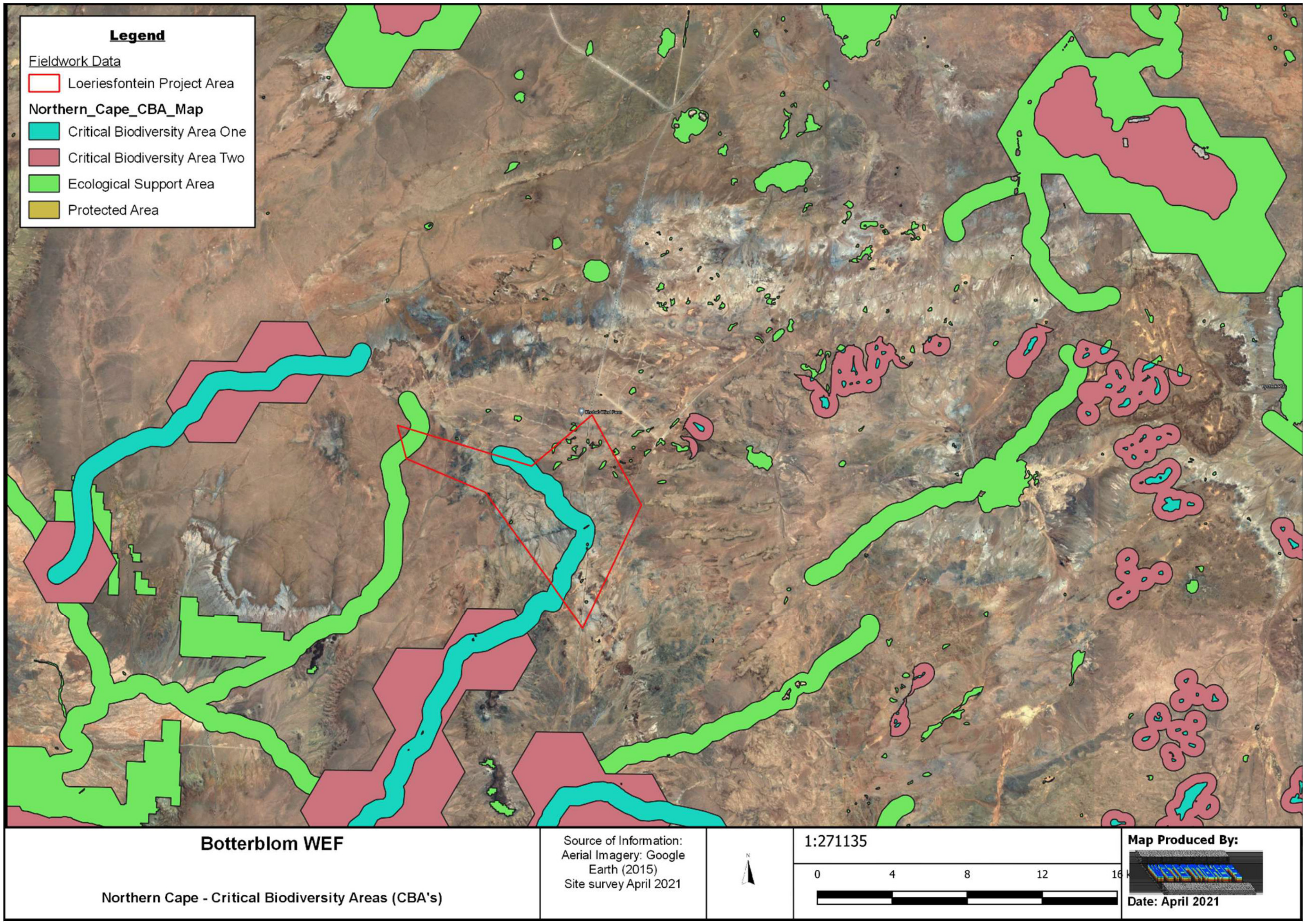

Figure 4: Northern Cape - Critically Biodiversity Areas Map

3. ASSOCIATED WETLANDS/RIPARIAN AREAS

3.1 Wetland and Riparian soils

According to the Department of Water Affairs and Forestry (DWAF) (2005), the permanent zone of a wetland will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991). The seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu. Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (Department of Water Affairs and Forestry, 2005).

The traversed catena within the study area itself produced none of the recognised hydromorphic soil forms according to DWAF (2005; 2008). Soil forms identified within the study area included Mispah, Glenrosa, Coega, Augrabies, Brandvlei, Olienhout, Clovelly and Burgersford soil forms (Figure 5; Figure 6; Figure 7; Figure 8). The terrain was typically dominated by shallow calcic soils (<40cm) with exposed rock in some areas and calcium carbonate precipitates abundant, a result of the arid climate where evaporation far exceeds rainfall. It should be noted that the Glenrosa soil from that was associated with the study area contained saprolithic and geolithic subsoil horison which is considered to be terrestrial Glenrosa variant (and not associated with the gleylithic subsoil Glenrosa variant which is considered a hydromorphic soil form). Some freely drained yellow apedal soils were noted more commonly towards the western extreme of the study area (shallow Clovelly's)

In general watercourses were dominated by very shallow soils consisting mostly of alluvium deposits, although not deep enough stratified alluvium deposits were observed in the study area that could be classified as the Dundee soil form (it is expected that the Dundee soil form would be observed lower down in the watercourses just south of the study area) (Figure 10).

Further, potential wetland features (depressions) indicated as non-FEPA wetlands (Nel et al, 2011), were investigated for verification of wetland status. Preliminary field verification indicated that it would likely not classify as wetlands as three out of the four main criteria for wetland status were absent, including soil wetness, redox morphology and vegetation adapted to wetland conditions. Soils were mostly shallow yellow, freely drained with some salt precipitates noted (Figure 9), however, calcium carbonate formations are abundant throughout the landscape and it would therefore take more in-depth research to determine whether the precipitates within the depressions could qualify as an indicator of temporary wetness. There was however no recognised wetland hydric soil form observed during the field investigation. Further, most of the depressions were noted to form part of a larger riparian drainage network, with only three depressions being truly isolated from other drainage networks.

According to Tooth and McCarthy (2015), the origin of pans are diverse and include several alluvial as well as non-alluvial process. Regardless of the varying origins and developmental histories of pans, ultimately, they commonly form local or regional topographic lows that focus the limited moisture supplies derived from river inflows, local runoff, and/or groundwater (Tooth and McCarthy, 2015). This further restricts the development of integrated surface drainage, so that many pans represent closed basins with no through-going drainage or outflow, and thus function as sediment sinks. Tooth and McCarthy (2015) further states that sedimentation in pans may include a clastic component, with fine-grained sediments (sand, silt, clay) being derived from episodic river inflows or aeolian processes, but often is dominantly chemical, with evaporites (eg, carbonates, sulphates, chlorides) accumulating on and within near-surface sediments as water bodies desiccate after inundation events (Shaw and Thomas, 1997; in Tooth and McCarthy, 2015). Over time, clastic and chemical sedimentation may result in the accumulation of thick deposits in the pan floors but this is commonly counteracted by aeolian deflation in the intervals between inundation events, which serves to maintain or deepen the depression (Tooth and McCarthy, 2015). During the preliminary field investigations it could not be established if there is a higher concentration of precipitates associated with the depressions on site compared to the neighbouring terrestrial environment. Further, soil investigations thus far indicated that the sediments pertaining to the depressions are free draining and has thus far not revealed any areas which contain clastic build-up as is usually present within pans.

Figure 5: Exposed bare rock within a drainage line within the study area

Figure 6: Hard carbonate layer exposed through road construction that developed on top of lithic horizon, a result of the high evaporation rates associated with the region

Figure 7: Shallow Clovelly soil form

Figure 8: Typical shallow Mispah soil form in the study area

Figure 9: Soil sample taken within one of the indicated non-FEPA wetland depressions that exhibited salt precipitates.

Figure 10: Deeper alluvium deposits in a riverbed just south of the study area

According to the Department of Water Affairs and Forestry (2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence due to the fact that soil wetness indicators remain in wetland soils in most instances, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil), or non-hydric (non-wetland soil) (Collins, 2005). Redoximorphic features were absent within all sampled soil profiles of the study area, Some limited, light redoximorphic signs were noticed within riparian habitat's saprolites that were indicative of intermittent wetness likely through subsurface return and or small intermittent interflow pathways (Figure

11). Redox morphology within the saprolites of riparian habitat is thus a helpful indicator for riparian channel classification.

Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of iron and manganese oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Redoximorphic features typically occur in three types (Collins, 2005):

- **A reduced matrix** - i.e. an *in situ* low chroma (soil colour), resulting from the absence of Fe^{3}+ ions which are characterised by "grey" colours of the soil matrix..
- **Redox depletions** - the "grey" (low chroma) bodies within the soil where Fe - Mn oxides have been stripped out, or where both Fe-Mn oxides and clay have been stripped. Iron depletions and clay depletions can occur.
- **Redox concentrations** - Accumulation of iron and manganese oxides (also called mottles). These can occur as:
    - Concretions - harder, regular shaped bodies;
    - Mottles - soft bodies of varying size, mostly within the matrix, with variable shape appearing as blotches or spots of high chroma colours; and,
    - Pore linings – zones of accumulation that may be either coatings on a pore surface, or impregnations of the matrix adjacent to the pore. They are recognised as high chroma colours that follow the route of plant roots, and are also referred to as oxidised rhizospheres

Figure 11: Slight redoximorphic signs within lithic strata within riparian habitat just south off the study area, slight moisture is present within the plains of the sedimentary rock, approximately a month after a rainfall event

3.2 Wetland and Riparian Vegetation

According to the Department of Water Affairs and Forestry (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands. Vegetation also forms a central part of the wetland definition in the National Water Act, Act 36 of 1998. Using vegetation as a primary wetland indicator however, requires undisturbed conditions (Department of Water Affairs and Forestry, 2005). A cautionary approach must be taken as vegetation alone cannot be used to delineate a wetland, as several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind. There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterized by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside of the wetland (Department of Water Affairs and Forestry, 2005). It is important to identify the vegetative indicators which determine the three wetness zones (temporary, seasonal and permanent) which characterize wetlands. Each zone is characterized by different plant species which are uniquely suited to the soil wetness within that zone. There were no hydrophilic plants observed within the study area.

Identified riparian habitats (watercourse within the study area) were dominated by small shrubs and graminoids such as *Stipagrostis* sp., *Rhigozum* spp., *Salsola* spp., *Pentzia* sp and *Eriocephalus* sp. Although most of these species was also found within terrestrial habitat, individuals within the riparian habitat grew with a lot more vigour than their terrestrial counterparts (Figure 12; Figure 13; Figure 14). A mid-winter survey is recommended in order to determine if there are any hydrophilic species and other riparian species present post adequate precipitation.

Total historic anthropogenic impact on vegetation within the larger region is likely poorly understood. What was evident is that historic livestock practices on the farm did have an impact on vegetation, especially where livestock infrastructure such as overnight camps and artificial waterholes were placed (Figure 15)

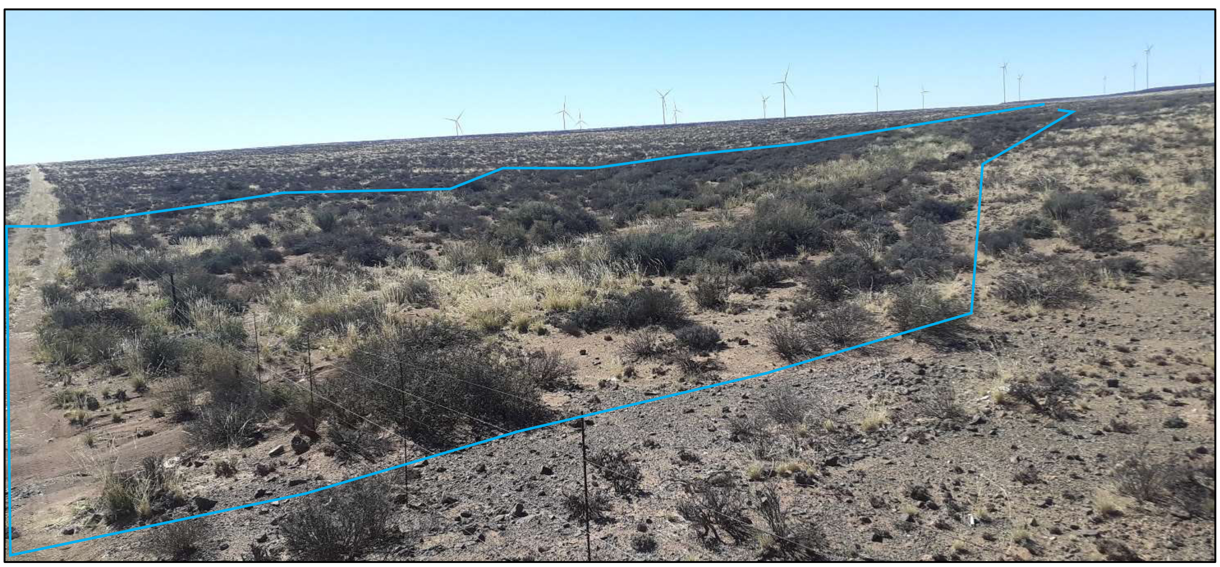

Figure 12: Example of riparian habitat within the study area that is distinguishable from typical terrestrial vegetation

Figure 13: Riparian habitat in the study area often exhibited vigorous growth forms compared to same specimens found in neighbouring terrestrial environments

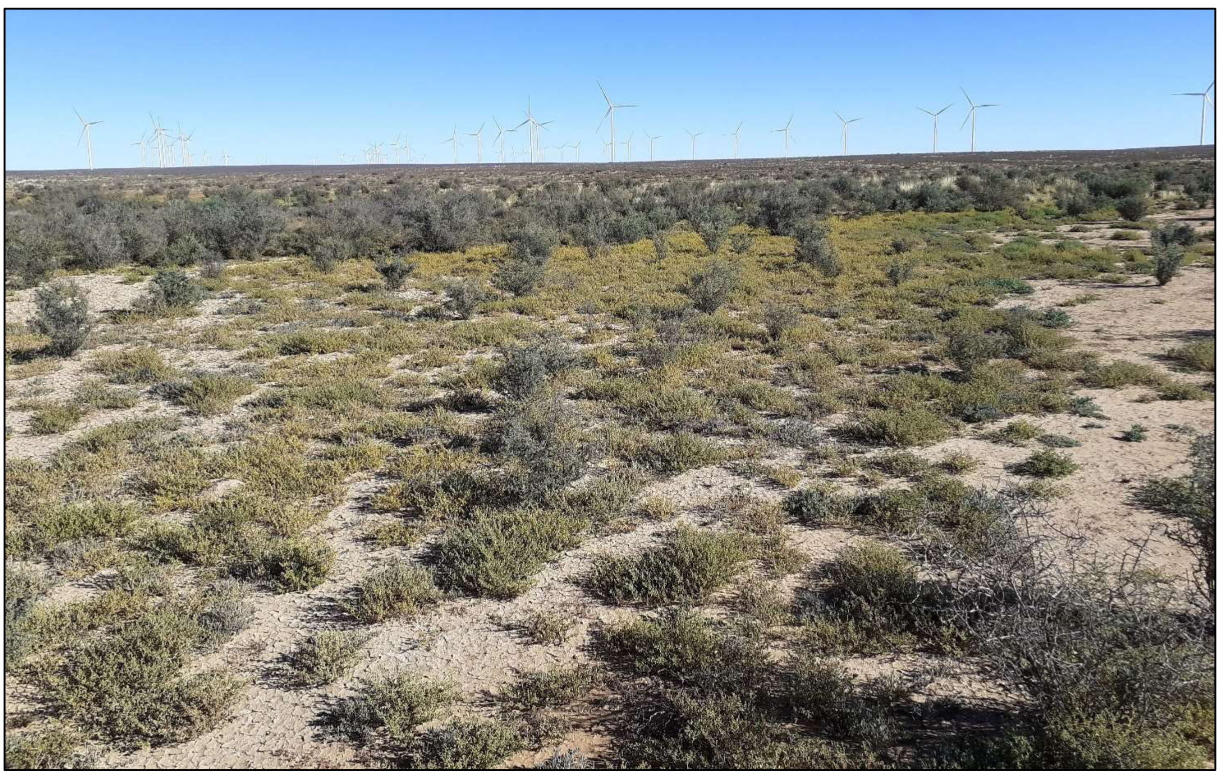

Figure 14: Example of a non-FEPA depression 'wetland' in the northern section of the study area, vegetation is dominated by *Salsola sp. cf*

Figure 15: Riparian section with historic camp and artificial waterhole that has been heavily impacted by livestock farming in the past

3.3 Delineated Wetland and Riparian Areas

According to the National Water Act (Act no 36 of 1998) a wetland is defined as, "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." Wetlands typically occur on the interface between aquatic and terrestrial habitats and therefore display a gradient of wetness – from permanent, to seasonal, to temporary zones of wetness - which is represented in their plant species composition, as well as their soil characteristics. It is important to take cognisance of the fact that not all wetlands have visible surface water. An area which has a high water table just below the surface of the soil is as much a wetland as a pan that only contains water for a few weeks during the year. Hydrophytes and hydric soils are subsequently used as the two main wetland indicators. The presence of these two indicators is symptomatic of an area that has sufficient saturation to classify the area as a wetland. Terrain unit, which is another indicator of wetland areas, refers to the land unit in which the wetland is found.

In practice all indicators should be used in any wetland assessment/delineation exercise, the presence of redoximorphic features being most important, with the other indicators being confirmatory. An understanding of the hydrological processes active within the area is also considered important when undertaking a wetland assessment. Indicators should be 'combined' to determine whether an area is a wetland and to delineate the boundary of a wetland. According to Department of Water Affairs and Forestry (2005), the more wetland indicators that are present the higher the confidence of the delineation. In assessing whether an area is a wetland, the boundary of a wetland or a non- wetland area should be considered to be the point where indicators are no longer present.

Only the terrain unit indicator was confirmed for the indicated NFEPA database depression wetlands. None of the other three wetland indicators were present. However, these depressions do hold water for a few days a year and could act as potential temporary habitat for various faunal species, but water is likely not retained for a long enough period for redox morphology to develop, thus they are not likely wetlands. Following a cautionary approach, these features are termed 'riparian/ephemeral depressions', with some of the depressions being isolated while a cluster of depressions are linked via riparian channels. Further infield research is necessary to establish whether these features should indeed be classified as watercourses and thus have regulatory standing. For now a cautionary approach stands in order to facilitate an environmentally friendly planning process with further research to be undertaken.

Besides the 'riparian/ephemeral depressions', a total of five riparian networks were delineated within the study area and within 500m from the study area as well as sections further downstream of the study area (Figure 16). All five riparian networks feed into the Leeuberg and Klein-Rooiberg Rivers which joins the Krom River downstream. According to Department of Water Affairs and Forestry (2005), riparian zones can be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas. Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel (Department of Water Affairs and Forestry, 2005).

Channel differentiation should be based on the classification of river channels outlined in the DWAF delineation guideline for wetlands and riparian areas Department of Water Affairs and Forestry (2005). The channel network is divided into three types of channel, which are referred to as A Section, B Section or C Section channels. The essential difference between the "A", "B" and "C" Sections is their position relative to the zone of saturation in the riparian area. The zone of saturation must be in contact with the channel network for base flow to take place at any point in the channel and the classification separates the channel sections that do not have base flow (A Sections) from those that sometimes have base flow (B Sections) and those that always have base flow (C Sections). Riparian networks within the study area were regarded as A and B Section channels. The A section channels is often difficult to separate from the B section channels as a result of the arid environment and potential impact of historic pasture management. The A Sections are those headward channels that are situated well above the zone of saturation at its highest level and because the channel bed is never in contact with the zone of saturation, these channels do not carry baseflow (DWAF, 2005). The A Sections are the least sensitive watercourses in terms of impacts on water yield from the catchment and are not regarded as having riparian habitat according to the National Water Act. A precautionary and conservative approach was therefore taken in many instances in order to afford the downstream environment increased protection. Therefore, some of the highest lying peripheral sections of the currently delineated riparian habitat might be excluded through further infield investigations.

3.4 Aquatic Biota

The habitat available to invertebrates in a temporary system is not as diverse and is also more variable than that in perennial systems (Bêche et al. 2006). For example, marginal vegetation, cobbles and bedrock habitat may be lost to biota as the river dries out. In temporary systems, gravel, sand and mud in pools are habitat types that persist the longest, with pools and perennial tributaries or rivers in the vicinity acting as refugia for aquatic biota (Boulton and Lake 1992, Chutter and Heath 1993, Uys 1996; cited in Watson & Dallas, 2013). As their water levels rise and fall, habitats expand and contract, with certain habitats becoming isolated and resource availability shifting (e.g. Palmer et al. 1991, Bêche et al. 2006; cited in Watson & Dallas, 2013).

Non-perennial rivers (including ephemeral systems) are ecosystems that place extreme stress on the organisms inhabiting them by exhibiting highly variable physical and chemical attributes, of which the most obvious is the unpredictable and highly variable flow patterns of the watercourses themselves (Rossouw et al., 2005). Consequently, invertebrates found in non-perennial systems are those that are adapted to the harsh conditions and are specialized in the sense that they are able to reproduce and survive in extremely variable conditions. Species tend to have life-cycle strategies that can cope with periodic and unpredictable flood and desiccation, with some aestivating and others depending on pools as refugia. Species that cannot cope with such conditions tend to be rare or absent, whilst even those that can may, or may not, appear in any one pool in any one year.

The ability to rapidly recolonise a recently dry system once re-inundation has occurred is one such mechanism that many macroinvertebrate taxa have developed to help to ensure survival. These specialised strategies vary widely between families, but the three main sources of recolonisation originate from previously laid resting eggs, invertebrate forms capable of aestivation, and eggs laid by flying adults immediately after re-inundation (Harrison, 1966).

Studies on the recolonisation of non-perennial watercourses by aquatic macroinvertebrates families are few, but it appears that Chironomidae (Midges), Oligochaeta (Earthworms) and Simulidae (Black Flies; only in true-running streams) are some of the early colonizers (Rossouw et al., 2005). This corroborates observations made previously by Harrison (1966), who reported that early-colonisers (i.e. within the first ten days) included oligochaetes, small crustaceans and small insect larvae. However, it should be noted that species typical of permanent streams only returned within one month of re-inundation in lentic pools and within four to six weeks in lotic streams (Rossouw et al., 2005). According to Watson & Dallas (2013), ephemeral rivers have been shown to have a higher proportion of insensitive taxa relative to perennial rivers.

Consequently, aquatic biota likely to be present within the study area during times of surface water presence, if any, are expected to be depauperate and limited to those taxa that are tolerant of such variable and temporary ecosystems. Further, given the expected event-driven nature of the watercourses present, it is highly unlikely that an aquatic macroinvertebrate assemblage typical of permanent streams would be able to become established, as surface water retention within the study area is likely to be limited. Still, the depressional systems identified within the channel network within the north-eastern extent of the study area may support aquatic macroinvertebrate taxa that have evolved to breed in such systems (depending on the period of inundation).

Further, it is highly unlikely that any fish species would be present within the study area given the ephemeral nature of the associated watercourses.

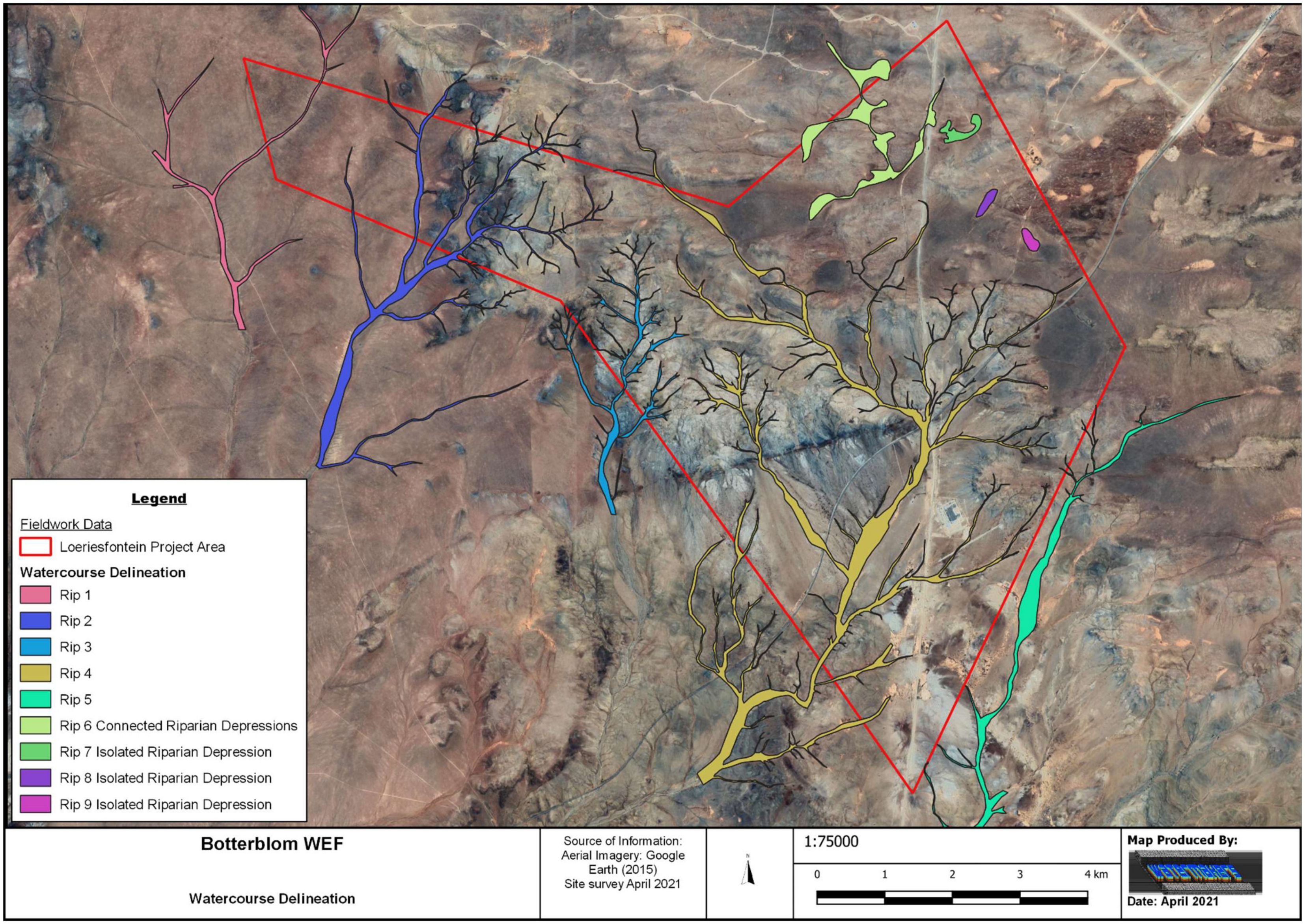

Figure 16: Watercourse delineation for the study area

3.5 Functional and Present Ecological State Assessment

3.5.1 Riparian habitat

The Present Ecological State of the riparian zone was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Level 3 approach (Kleynhans et al., 2007). Riparian vegetation areas were divided into two sub-zones which included marginal and non-marginal zones. Recognition of the different zones are important given that riparian vegetation distribution and species composition varies in different sub-zones, which has implications for flow-related impacts. Since all VEGRAI assessments are relative to the natural unmodified conditions (reference state) it is necessary and important to define and describe the reference state for the study area (Kleynhans et al., 2007). This was done (in part) before going into the field using historic aerial imagery, present and historic species distributions, general vegetation descriptions of the study area, knowledge of the area and comparison of the study area characteristics to other comparable sections of the stream that might be in a better state. According to Kleynhans et al. (2007), the reference (and present state) is quantified on site; the assessor reconstructs and quantifies the reference state from the present state by understanding how visible impacts have caused the vegetation to change and respond.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category B; Table 2). There are a few small areas that has been highly impacted through grazing practices (e.g. artificial waterholes, overnight camps etc), but collectively these heavily impacted zones form a very small percentage of the total riparian habitat

Table 1: VEGRAI score for the riparian vegetation calculated for riparian habitat associated with the various riparian areas associated with the present study area

Riparian Unit	VEGRAI Score	Ecological Category
Riparian 1	81.8	B
Riparian 2	83.1	B
Riparian 3	82.9	B
Riparian 4	81.2	B
Riparian 5	83.3	B
Riparian 6	80.4	B
Riparian 7	82.2	B
Riparian 8	84.0	B
Riparian 9	84.5	B

3.6 Ecological Importance and Sensitivity

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment. All flood lines, riparian zones and wetlands along with corresponding buffer zones must be designated as sensitive.

Ecological importance refers to biophysical aspects in the sub-quaternary reach that relates to its capacity to function sustainably. In contrast, ecological sensitivity considers the attributes of the sub-quaternary reach that relates to the sensitivity of biophysical components to general environmental changes such as flow, physico-chemical and geomorphic modifications. Essentially, the ecological importance and the ecological sensitivity of the relevant reaches are assessed to obtain an indication of its vulnerability to environmental modification within the context of the PES. This would relate to the ability of the sub-quaternary reach to endure, resist and recover from various forms of human use (Department of Water and Sanitation, 2014).

According to the Department of Water and Sanitation (2014), the mean ecological importance of the mainstem Klein-Rooiberg is considered to be moderate. Further, the watercourse's mean ecological sensitivity is considered to be high based to some degree on the riparian/wetland vegetation's intolerance to water level changes (marginal and non-marginal species require variable seasonal flows) as well as the riparian/wetland/instream vertebrates (excl. fish) intolerance to water level/flow changes, with *Amietia fuscigula* requiring seasonally wet conditions to breed. In contrast, the mean ecological importance as well as the mean ecological sensitivity of the mainstem Leeuberg is considered to be moderate (Department of Water and Sanitation, 2014).

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of:

- Provision of goods and service or valuable ecosystem functions which benefit people;
- biodiversity support and ecological value; and
- Reliance of subsistence users (especially basic human needs uses).

Water resources which have high values for one or more of these criteria may thus be prioritised and managed with greater care due to their ecological importance (for instance, due to biodiversity support for endangered species), hydrological functional importance (where water resources provide critical functions upon which people may be dependent, such as water quality improvement) or their role in providing direct human benefits (Rountree et al., 2013). The Ecological Importance and Sensitivity of the riparian habitat in the study area were determined using the River Ecological Importance & Sensitivity (EIS) DWAF riverine EIS tool (Kleynhans, 1999). A Summary of results are displayed in Table 3 below.

Table 2: Ecological Importance and Sensitivity scores for Riparian habitat within the study area.

Riparian Unit	**EIS Score (0 – 5)**	**Class**
Riparian 1	2.7	**Moderate**
Riparian 2	2.6	**Moderate**
Riparian 3	2.2	**Moderate**
Riparian 4	DWS (2014)	**High**
Riparian 5	2.3	**Moderate**
Riparian 6	2.1	**Moderate**
Riparian 7	2.1	**Moderate**
Riparian 8	2.4	**Moderate**
Riparian 9	2.6	**Moderate**

In terms of ecological importance and sensitivity, riparian habitat (Riparian 1 to Riparian 9) within the study area was designated as sensitive as a result of the ecological and functional values attributed to riparian areas in general, legal regulations and requirements as well as the supporting ecological services afforded to the downstream ecosystems. The Klein-Rooiberg River is also considered a FEPA River.

Further, in support of the above statement, riparian functions have both on-site and off-site effects, some of which may be expressed as goods and services available to society (Table 3). For example, functions related to hydrology and sediment dynamics include storage of surface water and sediment, which reduces damage from floodwaters downstream from the riparian area. Similarly, the function of cycling and accumulating chemical constituents has been measured in a number of studies on nitrogen and phosphorus cycling (Anon, 2002). These studies have shown that nutrients are intercepted, to varying degrees, as runoff passes through managed and natural riparian zones. The societal benefit is the buffering effect of pollutant removal, a service that has been a major motivation for protecting and managing riparian areas.

The hydrologic, nutrient cycling, and habitat/food web functions of riparian areas correspond to goods and services such as support of biodiversity, flood peak reduction, and removal of pollutants from runoff (Anon, 2002). Except for support of biodiversity, some of the environmental services of riparian areas can be provided by technologies, such as reservoirs for flood peak reduction and wastewater treatment plants for pollutant removal. However, these substitutions are directed at single functions rather than the multiple functions that riparian areas carry out simultaneously and with little direct costs to society (Anon, 2002). However, considering the ephemeral nature of the riparian habitat within the study area, riparian functionality are likely to be reduced or even absent, especially compared to wetter environments such as the eastern part of Southern Africa

Table 3: Functions of riparian areas and their relationship to environmental services (Anon, 2002)

Examples of functions	Indicators that functions exist
Hydrology and Sediment Dynamics	
Stores surface water over the short term	Floodplain connected to stream channel
Maintains a high-water table	Presence of flood-tolerant and drought intolerant plant species
Accumulates and transports sediments	Riffle-pool sequences, point bars, and other features
Biogeochemistry and Nutrient Cycling	
Produces organic carbon	A balanced biotic community
Contributes to overall biodiversity	High species richness of plants and animals
Cycles and accumulates chemical constituents	Good chemical and biotic indicators
Sequesters carbon in soil	Organic-rich soils (marginal zone)
Habitat and Food Web Maintenance	
Maintains streamside vegetation	Presence of shade-producing canopy
Supports characteristic terrestrial vertebrate populations	Appropriate species having access to riparian area
Supports characteristic aquatic vertebrate populations	Migrations and population maintenance of fish

According to Anon (2002), the effects of functions sometimes are expressed of-site as well. Indicators are often used to evaluate whether or not a function exists, and are commonly used as shortcuts for evaluating the condition of riparian areas. The functions listed in Table 4 are examples only and are not comprehensive.

Table 4: Examples of on-site and of-site riparian functions in terms of goods and services valued by society (modified from NRC, 1995)

On-site or of-site Effects of Functions	Goods and Services Valued by Society
Attenuates downstream flood peaks	Reduces damage from floodwaters (Daily, 1997)
Maintains vegetation structure in arid climates	Contributes to regional biodiversity through habitat (e.g., forest canopy) provision (Szaro, 1991; Ohmart, 1996; James et al., 2001)
Contributes to fluvial geomorphology	Creates predictable yet dynamic channel and floodplain dynamics (Beschta et al., 1987a; Klingeman et al., 1999)
Provides energy to maintain aquatic and terrestrial food webs	Supports populations of organisms (Gregory et al., 1991; Meyer and Wallace, 2001)
Provides reservoirs for genetic diversity	Contributes to biocomplexity (Szaro, 1991; Naiman and Rogers, 1997; Pollock et al., 1998)
Intercepts nutrients and toxicants from runof	Removes pollutants from runof (Bhowmilk et al., 1980; Peterjohn and Correll, 1984)
Contributes to nutrient retention and to sequestration of carbon dioxide from the atmosphere	Potentially ameliorates global warming (Van Cleve et al., 1991)
Provides shade to stream during warm season	Creates habitat for fish dependant on colder water (Beschta et al., 1987b; McCullough, 1999)
Allows daily movements to annual migrations	Supplies objects for bird watching, wildlife enjoyment,and game hunting (Green and Tunstall, 1992; Flather and Cordell, 1995)
Allows migratory fish to complete life cycles	Provides fish for food and recreation (Nehlsen et al, 1991; Naiman et al., 2000)

Anon (2002) further states that riparian areas, in proportion to their area within a watershed, perform more biologically productive functions than do uplands (terrestrial habitat). Riparian areas provide a wide range of functions such as microclimate modification and shade, bank stabilization and modification of sedimentation processes, contributions of organic litter and large wood to aquatic systems, nutrient retention and cycling, wildlife habitat, and general food-web support for a wide range of aquatic and terrestrial organisms. Thus, even though they occupy only a small proportion of the total land base in most watersheds, they are uniquely positioned between the aquatic and terrestrial ecosystems to provide a wide range of functions critical for many aquatic and terrestrial species, for maintenance of water quality, for aesthetics, for the production of goods and services, and for a wide range of social and cultural values (Anon, 2002). Because riparian areas are located at the convergence of terrestrial and aquatic ecosystems, they are regional hot spots of biodiversity and often exhibit high rates of biological productivity in marked contrast to the larger landscape. This is particularly dramatic in arid regions, as evidenced by the high number of plant and animal species that find crucial habitats along watercourses and washes. Riparian areas provide connectivity at all spatial and temporal scales, helping maintain landscape biodiversity by countering the negative ecological effects of habitat fragmentation (Anon, 2002).

Despite the large anthropogenic impacts that occurred within and surrounding the study area, some of the potential functions of the riparian habitat in the vicinity of the study area included:

- sediment trapping;
- nutrient trapping;

- bank stabilization and bank maintenance;
- flow energy dissipation;
- maintenance of biotic diversity; and
- primary production.

Despite the current Ecological condition associated with the vegetation of the riparian habitat, all riparian habitat within and surrounding the study area was designated as sensitive as a result of the high ecological and functional values attributed to riparian areas in general, legal regulations and requirements.

4. FRESHWATER ECOSYSTEM BUFFERS

Buffer zones associated with water resources have been shown to perform a wide range of functions, and have been proposed as a standard measure to protect water resources and associated biodiversity on this basis. These functions can include (Macfarlane & Bredin, 2016):

- Maintaining basic aquatic processes;
- Reducing impacts on water resources from upstream activities and adjoining land uses;
- Providing habitat for aquatic and semi-aquatic species;
- Providing habitat for terrestrial species; and
- A range of ancillary societal benefits.

However, despite the range of functions potentially provided by buffer zones, buffer zones are unable to address all water resource-related problems. For example, buffers can do little to address impacts such as hydrological changes caused by for example stream flow reduction activities or changes in flow brought about by abstractions or upstream impoundments. Buffer zones are also not the appropriate tool for mitigating against point-source discharges (e.g. sewage outflows), which can be more effectively managed by targeting these areas through specific source-directed controls (Macfarlane & Bredin, 2016).

Nevertheless, buffer zones are well suited to perform functions such as sediment trapping and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts linked with diffuse storm water runoff from land-uses / activities planned adjacent to water resources. These must, however, be considered in conjunction with other mitigation measures which may be required to address specific impacts for which buffer zones are not well suited (Macfarlane & Bredin, 2016).

Determination of the preliminary buffer requirements for riparian features associated with the proposed study area followed the approach of Macfarlane & Bredin (2016), whereby the preliminary required buffers were developed based on various factors, including assumed agricultural impacts, slope, annual precipitation, rainfall intensity, channel width, catchment to wetland ratio, etc. Accordingly, preliminary buffer requirements for the identified watercourse were determined to be 40m from the edge of the delineated riparian areas (Figure 15). However, final site specific and section specific riparian buffers will be designed during the impact assessment phase. As a cautionary and conservative approach were taken during the scoping assessment, further field work with regards to separating less sensitive A section channels from B section riparian channels will likely lead to reduced buffer distances or not be applicable in some instances (especially on the highest lying areas where channels often do not carry baseflow).

5. RECOMMENDATIONS

From a pre-liminary perspective, possible impacts and their sources associated with the proposed activities are provided in Table 6 (construction phase) and Table 7 (operational phase). Some of the impacts are relevant during more than one phase and has therefore only been described once under the initial phase.

Table 6: Possible impacts arising during the construction phase

Possible impact	Source of impact
Destruction of riparian/ watercourse habitat	Construction activities and infrastructure placed within watercourses
Sedimentation of watercourse	Runoff from construction activities associated with clearing of natural vegetation and excavations, soils transportation, storage etc.
Increased erosion and increased run-off received by water courses	Heavy machines clearing vegetation & construction of roads
Introduction and spread of invasive vegetation	Disturbance / destruction of indigenous vegetation making ecosystem vulnerable to invasions
Impacts on ground and surface water quality as well as soils	Activities of workforce, e.g., concrete mixing and sediment release including hydrocarbon spillages

Table 7: Possible additional impacts arising during the operational phase

Possible impact	Source of impact
Altered hydrological regime	The establishment of hard surfaces and increases in hard surfaces into the area leads to increased stormwater runoff volume and intensity and reduced subsurface flow supporting slow release mechanisms, could potentially negatively affect watercourse systems downstream.

The proposed preliminary lay-out of wind turbines along with the watercourses and associated 40m freshwater ecosystem buffer is displayed in Figure 17.

The following preliminary mitigation measures are proposed in order to reduce potential negative impacts:

- The layout should be adapted to ensure that wind turbines are not located within riparian habitat or associated buffers.
- It is essential that the road and other linear networks (cables) follow contour and lowest gradients as far as possible. Appropriate stormwater design for the road network is essential to prevent roads from serving as concentrated conduits for water run-off, significantly increasing erosion potential and sediment transport capacity. Water diversions along the road should be placed at regular intervals in order to divert water back into the natural veld on the downstream side of the road. This diverted water should be released in a diffuse manner on contour, e.g. appropriately designed swale.

- Access roads should preferably be dirt roads on contour. It is essential to choose appropriate water crossing for the road network in order to reduce potential negative impacts. Crossing points should preferably utilise watercourse sections which already contain exposed bedrock and has a low gradient in that particular section of the watercourse. These are ideal natural crossing points which needs little intervention so as to ensure that historic stormwater run-off regimes are not altered. Where necessitated crossings should be simple low water bridges that do not interrupt surface or subsurface flows. Concentration of water flow must be avoided. Where water is concentrated it needs to be diffusely released through appropriate diffuse release infrastructure placed on contour.
- Watercourse crossings should be aligned perpendicular to the natural flow regime and on contour in order to prevent flow concentration and associated negative impacts.
- It is recommended that all final positions of watercourse crossings be appropriately "fine tuned" through field verification in the impact assessment phase in order to minimise potential impacts and reduce road construction cost.
- Topsoil preparation and bush clearing must be done in a phased approach, only strip what is needed immediately prior to construction / field preparation.
- The construction of surface stormwater drainage systems during the construction phase must be done in a manner that would protect the quality and quantity of the downstream system. Where applicable, the use of swales, which could then be grassed for the operational phase, is recommended as the swales would attenuate run-off water and facilitate the settling of sediment within the swale rather than within watercourses. For example, on the downslope edge of the infrastructure camp before vegetation clearing commences.
- An effective 40m Freshwater Ecosystem Buffer which include all riparian habitat must be established prior to any construction activities taking place. No person or vehicle will be allowed within the Buffer Zone, except for officially marked crossings.
- Management should be vigilant in preventing personnel taking short-cuts across the Buffer Zones between construction sites.
- All livestock should be removed from the site prior to the initiation of rehabilitation or construction activities. This would increase veld condition and thereby afford the study area higher basal coverages with associated higher sediment and erosion control properties.
- Further, no veld fires should be allowed for the next 5 years in order to aid veld restoration processes.
- All stockpiles must be protected from erosion, stored on flat areas where run-off will be minimized, and be surrounded by bunds. It should also only be stored for the minimum amount of time necessary.
- An ecologically-sound stormwater management plan must be implemented at the onset of the construction phase. This must include sustainable and sensitive stormwater design for the new road network and base infrastructure. Stormwater run-off must reach riparian and freshwater ecosystem buffers in a diffuse manner;
- The above guidelines can be achieved through diffuse release of stromwater flows utilising the natural topography and associated contours, vegetated channels, riparian buffers and veld restoration techniques, gabion baskets, eco-logs etc;
- A riparian monitoring program should be initiated prior to the start of the construction phase, the details of such a monitoring program to be included within the impact assessment phase.
- An alien invasive monitoring and control program must be initiated prior to the commencement of construction activities.

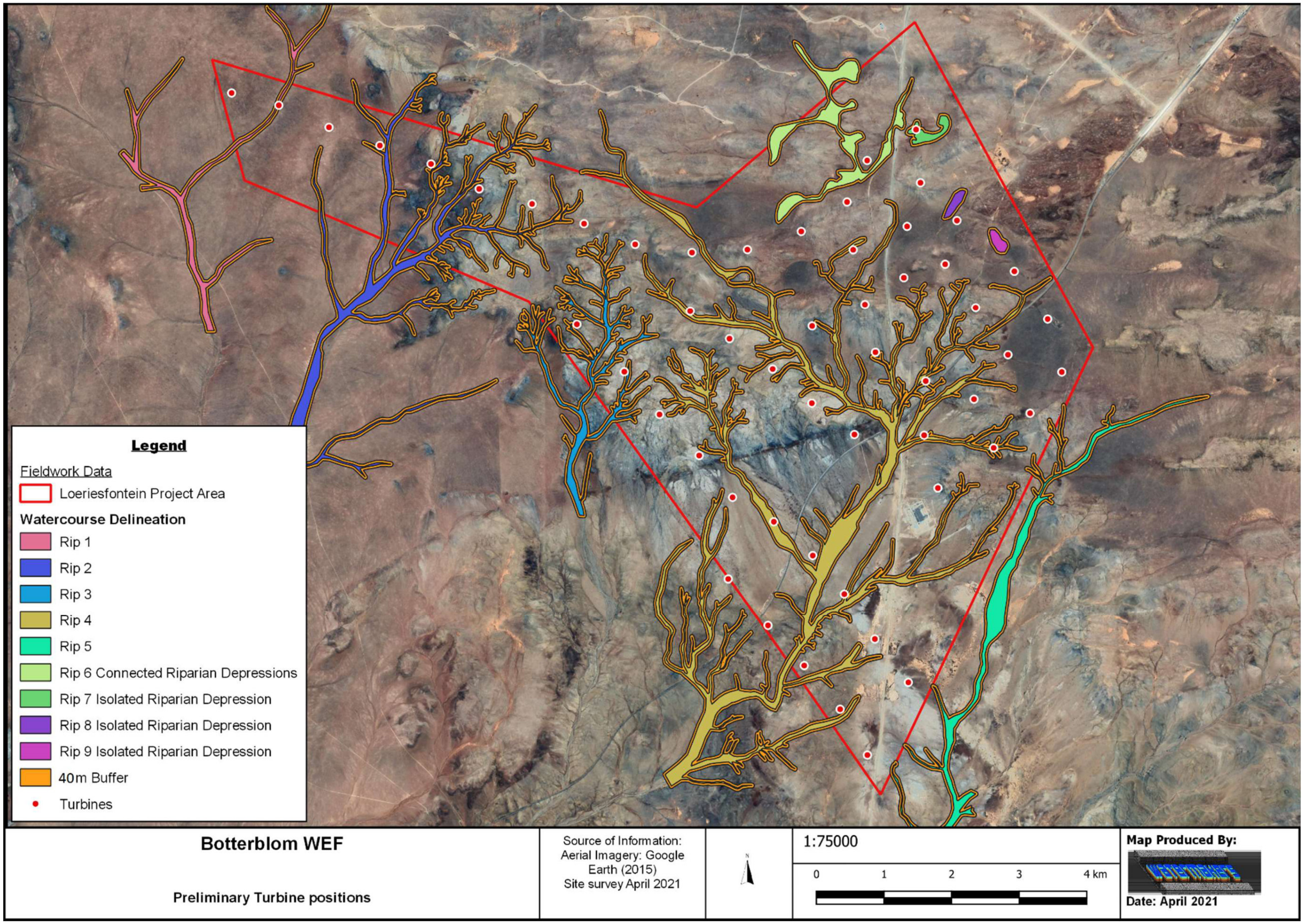

Figure 17: Preliminary turbine positions in relation to potential watercourse sensitivities and 40m buffer

6. CONCLUSION AND RECOMMENDATIONS

A total of five riparian networks were delineated within the study area and within 500m from the study area as well as sections further downstream of the study area. All five riparian networks feed into the Leeuberg and Klein-Rooiberg Rivers which joins the Krom River downstream. In addition there were several non-FEPA wetlands indicated on the NFEPA database that was investigated. Only the terrain unit indicator was confirmed for the indicated NFEPA database depression wetlands. None of the other three wetland indicators were present. However, these depressions do hold water for a few days a year and could act as potential temporary habitat for various faunal species, however, water is likely not retained for a long enough period for redox morphology to develop, thus they are not likely wetlands. Following a cautionary approach, these features are termed 'riparian/ephemeral depressions', with some of the depressions being isolated while a cluster of depressions are linked via riparian channels. Further infield research is necessary to establish whether these features should indeed be classified as watercourses and thus have regulatory standing. For now, a cautionary approach stands in order to facilitate an environmentally friendly and sustainable planning process. The same cautionary and conservative approach was taken where there were doubt between differentiating between A section and B section channels, with A section channels likely included in the current delineation, especially on the highest lying areas where channels often do not carry baseflow.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category B). There are a few small areas that has been highly impacted through grazing practices (e.g. artificial waterholes, overnight camps etc), but collectively these heavily impacted zones form a very small percentage of the total riparian habitat

In terms of ecological importance and sensitivity, riparian habitat (Riparian 1 to Riparian 9) within the study area was designated as sensitive as a result of the ecological and functional values attributed to riparian areas in general, legal regulations and requirements as well as the supporting ecological services afforded to the downstream ecosystems.

Determination of the preliminary buffer requirements for riparian features associated with the proposed study area followed the approach of Macfarlane & Bredin (2016), whereby the preliminary required buffers were developed based on various factors, including assumed agricultural impacts, slope, annual precipitation, rainfall intensity, channel width, catchment to wetland ratio, etc. Accordingly, preliminary buffer requirements for the identified watercourse were determined to be 40m from the edge of the delineated riparian areas. Further field work with regards to separating less sensitive A section channels from B section riparian channels will likely lead to reduced buffer distances and or not be applicable in some instances.

Preliminary impact considerations identified destruction of water courses and associated habitat, surface water pollution including sedimentation as well as increased erosion, loss of wetland functionality and decreased downstream water quality as the major potential impacts during the construction and operational phase. Several general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Some of the most pertinent recommendations include:

- The layout should be adapted to ensure that wind turbines are not located within riparian habitat or associated buffers.
- It is essential that the road and other linear networks (cables) follow contour and lowest gradients as far as possible. Appropriate stormwater design for the road network is essential to prevent roads from serving as concentrated conduits for water run-off, significantly increasing erosion potential and sediment transport capacity. Water diversions along the road should be placed at regular intervals in order to divert water back into the natural veld on the downstream side of the road. This diverted water should be released in a diffuse manner on contour, e.g. appropriately designed swale.
- Access roads should preferably be dirt roads on contour. It is essential to choose appropriate water crossing for the road network in order to reduce potential negative impacts. Crossing points should preferably utilise watercourse sections which already contain exposed bedrock and has a low gradient in that particular section of the watercourse. These are ideal natural crossing points which needs little intervention so as to ensure that historic stormwater run-off regimes are not altered. Where necessitated crossings should be simple low water bridges that do not interrupt surface or subsurface flows. Concentration of water flow must be avoided. Where water is concentrated it needs to be diffusely released through appropriate diffuse release infrastructure placed on contour and or cutting bedrock to contour, especially on the downstream side.
- Watercourse crossings should be aligned perpendicular to the natural flow regime and on contour in order to prevent flow concentration and associated negative impacts.
- It is recommended that the road lay-out and all final positions of watercourse crossings be appropriately “fine tuned” through field verification in the impact assessment phase in order to minimise potential impacts and reduce road construction cost.

Considering the type of development proposed and assuming that the necessary mitigation measures are appropriately designed and applied, the development is not likely to impact on the FEPA catchment classification associate with the study area.

7. BIBLIOGRAPHY

Collins, N.B. (2005). *Wetlands: The basics and some more*. Free State Department of Tourism, Environment and Economic Affairs

Darwall, W.R.T., Smith, K.G., Tweddle, D. & Skelton, P. (2009). *The status and distribution of freshwater biodiversity in Southern Africa*. Gland, Switzerland: IUCN and Grahamstown, South Africa: SAIAB

Department of Water Affairs and Forestry. (2005). *A practical field procedure for identification and delineation of wetlands and riparian areas*. Department of Water Affairs and Forestry, Pretoria, South Africa

Department of Water Affairs (2011b). Directorate Water Resource Classification. July 2011. Classification of Significant Water Resources in the Olifants Water Management Area (WMA 4): Integrated Units of Analysis Delineation Report. Report No: RDM/WMA04/00/CON/CLA/0311. Pretoria. South Africa.

Department of Water Affairs, South Africa, January 2013. Classification of Significant Water Resources in the Olifants Water Management Area (WMA 4): Management Classes of the Olifants WMA. Report No: RDM/WMA04/00/CON/CLA/0213

Dickens, C.W.S. & Graham, P.M. (2002). The South African Scoring System (SASS) Version 5 rapid bioassessment method for rivers. *African Journal of Aquatic Science* 27: 1–10

Driver, A., Nel, J.L., Snaddon, K., Murray, K., Roux, D.J., Hill, L., Swartz, E.R., Manuel, J. & Funke, N. (2011). *Implementation manual for Freshwater Ecosystem Priority Areas*. WRC Report No. 1801/1/11. Water Research Commission, Pretoria, South Africa

Ewel, C. (1997). Water quality improvement by wetlands. In: Daily G (ed), *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D. C.

Gren, I. (1995). The value of investing in wetlands for nitrogen abatement. *European Review of Agricultural Economics* 22: 157–172

Kleynhans, C., Mackenzie, J. & Louw, M. (2007a). *River Ecoclassification: Manual for Ecostatus Determination (Version 2). Module F: Riparian Vegetation Response Assessment Index (VEGRAI)*. WRC Report TT 333/08. Water Research Commission, Pretoria, South Africa

Kleynhans, C.J., Thirion, C.A., Moolman, J. & Gaulana, L. (2007b). *A Level II River Ecoregion classification System for South Africa, Lesotho and Swaziland*. Report No. N/0000/00/REQ0104. Department of Water Affairs and Forestry - Resource Quality Services, Pretoria, South Africa

Kotze, D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. & Collins, N.B. (2008). *WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. WRC Report No TT 339/08*. WRC Report No. 339/08. Water Research Commission, Pretoria, South Africa

Macfarlane, D., Holness, S.D., von Hase, A., Brownlie, S. & Dini, J. (2014). *Wetland offsets: a best-practice guideline for South Africa*. South African National Biodiversity Institute and the Department of Water Affairs, Pretoria, South Africa

Macfarlane, D.M. & Bredin, I.P. (2016). *Buffer zone guidelines for rivers, wetlands and estuaries. Part 1: Technical Manual*. WRC Report No. TT 715/1/17. Water Research Commission, Pretoria, South Africa

Macfarlane, D.M., Kotze, D.C., Ellery, W.N., Walters, D., Koopman, V., Goodman, P. & Goge, C. (2008). *WET-Health: A technique for rapidly assessing wetland health*. WRC Report No. TT340/09. Water Research Commission

Mbona, N., Job, N., Smith, J., Nel, J., Holness, S., Memani, S. & Dini, J. (2015). *Supporting better decision-making around coal mining in the Mpumalanga Highveld through the development of mapping tools and refinement of spatial data on wetlands*. WRC Report No TT 614/14. Water Research Commission, Pretoria, South Africa

Muscutt, A.D., G.L., H., Bailey, S.W. & Davies, D.B. (1993). Buffer zones to improve water quality: a review of their potential use in UK agriculture. *Agriculture, Ecosystems and Environment* 45: 59–77

Nel, J.L., Driver, A., Strydom, N.A., Maherry, A.M., Peterson, C., Hill, L., Roux, D.J., Nienaber, S., van Deventer, H., Swartz, E.R. & Smith-Adao, L.B. (2011). *Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources.* WRC Report No. TT 500/11. Water Research Commission, Pretoria, South Africa

Nel, J.L., Maree, G., Roux, D., Moolman, J., Kleynhans, C.J., Sieberbauer, M. & Driver, A. (2004). *South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 2: River Component*. CSIR Report Number ENV-S-I-2004-063. Council for Scientific and Industrial Research, Stellenbosch

Postel, S. & Carpenter, S. (1997). Freshwater ecosystem services. In: Daily G (ed), *Nature's Services: Societal Dependence on Natural Ecosystems*. Island Press, Washington, D. C.

Rogers, F.E., Rogers, K.H. & Buzer, J.S. (1985). *Wetlands for wastewater treatment: with special reference to municipal wastewaters*. WITS University Press, Johannesburg, South Africa

Rountree, M.W., Malan, H.L. & Weston, B.C. (2013). *Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Vers.2.0).* WRC Report No. 1788/1/12. Water Research Commission, Pretoria, South Africa

Scott, L. (2013). Freshwater Ecoregions of the World: Southern Temperate Highveld. http://www.feow.org/ecoregions/details/575. Accessed 05/06/2017

Soil Classification Working Group. (1991). *Soil classification. A taxonomic system for South Africa*. Department of Agricultural Development, Pretoria, South Africa

Tooth S. and McCarthy T.S. (2015) Wetlands in drylands: geomorphological and sedimentological characteristics, with emphasis on examples from southern Africa. 1Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, SY23 3DB, UK 2School of Geosciences, University of the Witwatersrand, Wits 2050, South Africa

APPENDIX A – Methodology

Wetland and Riparian Delineation

The report incorporated a desktop study, as well as field surveys, with site visits conducted during April 2021. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps;
- ortho-rectified aerial photographs;
- Historic imagery from NGI; and
- Contour data.

A pre-survey wetland and riparian delineation was performed in order to assist the field survey. Identified wetland and riparian areas during the field survey were marked digitally using GIS (changes in vegetation composition within wetlands/riparian areas as compared to surrounding non-wetland/riparian vegetation sometime show up as a different hue on the orthophotos, thus allowing the identification of wetland/riparian areas). These potential wetland/riparian areas were confirmed or dismissed and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation was based on the legislatively required methodology as described by Department of Water Affairs and Forestry (2005; 2008). The DWAF delineation guide uses four field indicators to confirm the presence of wetlands, namely:

- terrain unit indicator (i.e. an area in the landscape where water is likely to collect and a wetland to be present);
- soil form indicator (i.e. the soils of South Africa have been grouped into classes / forms according to characteristic diagnostic soil horizons and soil structure);
- soil wetness indicator (i.e. characteristics such as gleying or mottles resulting from prolonged saturation); and
- vegetation indicator (i.e. presence of plants adapted to or tolerant of saturated soils).

The wetland delineation guide makes use of indirect indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device.

The riparian delineation was based on the legislatively required methodology as described by Department of Water Affairs and Forestry (2005; 2008) Although the Department of Water Affairs and Forestry's manual discusses wetlands and riparian areas as separate concepts, it makes good sense to delineate both habitats during the same field visit, if necessary. It is likely that wetlands and riparian areas will overlap, and delineating both habitats during the same visit can save much time and effort. The delineation procedure is summarised here (Department of Water Affairs and Forestry 2005; 2008). In the case of a riparian area, look for the active channel or the lowest part of the river course. Most likely cues like water with associated emergent vegetation, sedges and reeds or alluvial soil and bedrock will be visible. From this point some topographic units like sandbars, active channel bank, flood benches and macro channel bank with associated riparian vegetation will be identifiable. Proceed upwards towards the macro channel bank, taking note of alluvial soil, topographic units and vegetation indicators. The outer boundary will be the point on the edge of the macro channel bank where there is a distinct difference between the riparian and terrestrial vegetation. In some cases where riparian vegetation is unrecognisable, because of land-use activities, indicators like alluvial material and topographical units can still be used to visualize the edge of a riparian area. If you are adjacent to a watercourse, it is also important to check for the presence of riparian indicators. Although a specific method for delineating riparian areas has not been defined in this manual, the general approach and principles outlined for wetlands can be used, with substitution of riparian indicators for wetland indicators.

Determination of Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. As wetlands outside of the study area were only partially visited, there could easily be oversight as detailed studies are required to increase the confidence of the assessment which relied heavily on the experience of the author. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments, and the work conducted by Kotze et al. (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree et al., 2013). An example of the scoring sheet is attached as Table 20. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 21.

Table 5: Example of scoring sheet for Ecological Importance and sensitivity

Ecological Importance	**Score (0-4)**	***Confidence (1-5)***	Motivation
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			

Table 6: Category of score for the Ecological Importance and Sensitivity

Rating	Explanation
Very low (0-1)	Rarely sensitive to changes in water quality/hydrological regime.
Low (1-2)	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate (2-3)	Some elements sensitive to changes in water quality/hydrological regime.
High (3-3.5)	Many elements sensitive to changes in water quality/ hydrological regime.
Very high (+3.5)	Very many elements sensitive to changes in water quality/ hydrological regime.

Riparian Assessment

The Present Ecological State of the riparian zone was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Level 3 approach (Kleynhans et al., 2007). Riparian vegetation areas were divided into two sub-zones which included marginal and non-marginal zones. Recognition of the different zones are important given that riparian vegetation distribution and species composition varies in different sub-zones, which has implications for flow-related impacts. Since all VEGRAI assessments are relative to the natural unmodified conditions (reference state) it is necessary and important to define and describe the reference state for the study area (Kleynhans et al., 2007). This was done (in part) before going into the field, using historic aerial imagery, present and historic species distributions, general vegetation descriptions of the study area, knowledge of the area and comparison of the study area characteristics to other comparable sections of the stream that might be in a better state. According to Kleynhans et al. (2007), the reference (and present state) is quantified on site; the assessor reconstructs and quantifies the reference state from the present state by understanding how visible impacts have caused the vegetation to change and respond.

Impacts on riparian vegetation at the site are then described and rated. Kleynhans et al. (2007) further states that it is important to distinguish between a visible / known impact (such as flow manipulation) and the response of riparian vegetation to other impacts such as erosion and sedimentation, alien invasive species and pollution. If there is no response to riparian vegetation, the impact is noted but not rated since it has no visible / known effect. These impacts are then rated as per a scale from 0 (No Impact) to 5 (Critical Impact). Once the riparian zone and sub- zones have been delineated, the reference and present states have been described and quantified (basal cover is used) and species description for the study area has been compiled, the VEGRAI metrics were rated and qualified. The riparian ecological integrity was assessed using the spreadsheet tool that is composed of a series of metrics and metric groups, each of which was rated in the field with the guidance of data collection sheets. The metrics in VEGRAI describe the following attributes associated with both the woody and non-woody components of the lower and upper zones of the riparian area:

- Removal of the riparian vegetation; Invasion by alien invasive species;

- Flow modification; and
- Impacts on water quality.

Results from the lower and upper zones of the riparian vegetation were then combined and weighted with a value that reflects the perceived importance of that criterion in determining habitat integrity, allowing this to be numerically expressed in relation to the perceived benchmark. The score is then placed into one of six classes (Table 11).

Table 7: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) for riparian habitat following the VEGRAI application (Kleynhans et al., 2007)

Score (% of Total)	Category	Description
90 - 100	A	Unmodified, natural.
80 - 89	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.
60-79	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
40-59	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
20-39	E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
0 - 19	F	Critically modified. Modifications have reached a critical level and there has been 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.

Appendix B – CV's