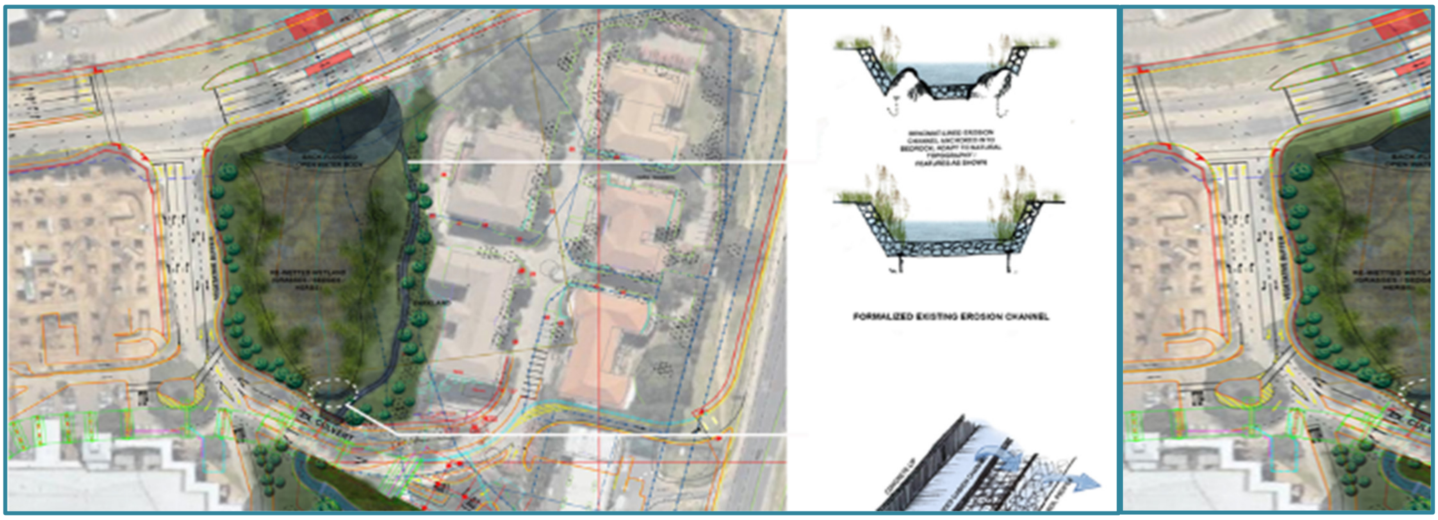
DORSTFONTEIN WEST COAL MINE EXPANSION:
Wetland Impact Assessment

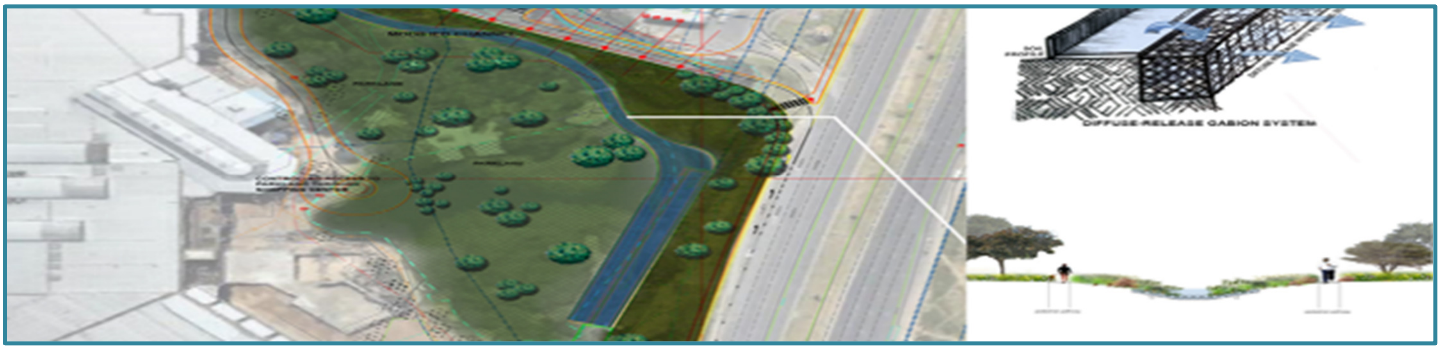
Prepared for:

NSOVO ENVIRONMENTAL CONSULTING

Prepared by:

Willem Lubbe
trading as
WaterMakers





March 2020

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.

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Willem Lubbe Pr.Sci.Nat

Wetland Specialist

SACNASP Reg. No. 004750

10/03/2020

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Date

EXECUTIVE SUMMARY

Dorstfontein West Mine (Pty) Ltd also known as Dorstfontein Coal Mine (Pty) Ltd (hereafter referred as DCM West) is an underground mine with both 2 and 4 Seams operated by Exxaro Coal Central (Pty) Ltd ("Exxaro"), located within the jurisdiction of Emalahleni Local Municipality in the Mpumalanga Province. DCM West previously mined 2 Seam and is now mining 4 Seam via board and pillar underground mining method on the western portion of their mining rights and is intending to expand the existing discard dump facility and to construct a conveyor belt at the DCM West which is located within the jurisdiction of Emalahleni Local Municipality in the Mpumalanga Province. The Life of mine is projected to be until 2042, while the existing discard dump is coming to the end of its life in 2022. The purpose of this expansion project is to extend the life of the discard dump facility, which is required to accommodate the disposal of the discard and slurry for the next 15 years of the Life of Mine (LOM) and to allow for easier transportation of coal from West to East through the conveyor belt. Subsequently, Exxaro proposes to undertake the following activities:

- The expansion of the existing discard dump which is coming to the end of its life a by 2022; and
- The construction of a conveyor belt and associated service road, from DCM West which will be linked to the conveyor systems at DCM East to ensure that coal is conveyed from DCM West to DCM East where the coal will be loaded into trains and thereafter transported to Richards Bay Coal Terminal

Nsovo Environmental Consulting was contracted to review the area and conduct the Environmental Impact Assessment (EIA) on their behalf. Subsequently, WaterMakers was appointed by Nsovo Environmental Consulting as independent specialists to conduct the relevant wetland-related studies in order to facilitate the required environmental authorisation and water use licence processes. The present study represents the baseline and wetland impact assessment of the study and aims to inform responsible decision making with regards to the project.

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;
- Site assessment for Identification and delineation of wetland habitat;
- Classification of identified wetland habitat;
- Identification of wetland goods and services by means of the Wet-EcoServices approach;
- Determination of the Present Ecological State of identified wetlands by means of the Wet-Health approach;
- Determination of the Ecological Importance and Sensitivity of identified wetlands; and
- Impact assessment with mitigation measures

Thirty-eight separate hydro-geomorphic units (HGM), comprising four HGM types, namely unchannelled valley bottom wetlands, channelled valley bottom wetlands hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within 500m surrounding the study area

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute

directly or indirectly to increased biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes

Combined area weighted Wet-Health results indicated that the wetlands from the study area have been moderately to largely altered in most instances as a result of changes in water inputs (derived from its catchment) and water retention and distribution patterns within the wetlands units, as well as vegetation changes within the wetlands and surrounding catchments due to historic and current anthropogenic impacts.

The valley bottom wetlands, HGM 1, HGM 2, HGM 3 and HGM 4 were regarded as having a high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment, more specifically the Olifants River.

The moderate Ecological Importance and Sensitivity assigned too many of the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing and fodder production which reduced the perceived biodiversity observed. However, as per the norm, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetlands (pans) in general received low scores for their Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and often incorporation into productions areas. However, HGM 29 and HGM 36 which were relatively large pans were considered intact from a hydrological and geomorphological perspective with a high Ecological Importance and Sensitivity assigned to them due to the perceived biodiversity associated with them.

The impact assessment identified the destruction of wetland habitat, surface water pollution including sedimentation as well as increased erosion, altered hydrological regimes, loss of wetland functionality and decreased downstream water quality as the major 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:

- An appropriate wetland and hillslope monitoring program must be implemented prior to the start of the construction phase;
- Appropriate wetland rehabilitation design and implementation must ensure that wetland functionality is restored;
- The outcome of the hydropedological assessment should determine the best option and final designs of the discard facility extension in terms of mitigation measures in base preparation and clean and dirty water separation design in order to prevent recharge and or interflow interaction between the discard facility and the vadose zone. A clean water cut-off trench, informed by the

hydropedological study must be designed and installed on the northern side of the existing and extended discard dump footprint in order to prevent more clean water from being polluted within the vadose zone. The water must be routed and delivered to the unaffected eastern section of HGM 19 via a diffuse release intervention also to be designed in conjunction with the information obtained from the hydropedological study.

- A wetland mitigation and rehabilitation plan will have to be designed to compensate for a minimum loss of of 4,45 healthy hectare wetland equivalents (the final multiplication factor to be determined in conjunction with DWS)
- All soils, especially wetland soils within the footprint of the discard facility must be appropriately separated and stored. A soil management program must be implemented before construction are initiated in order to secure all wetland soils in situ as these will be utilised for mitigating wetland loss through the wetland mitigation and rehabilitation plan.
- For the conveyor routing, Route A should only be constructed during the winter months. A special works program must be implemented which ensures that a wetland specialist is part of the design and construction team (to minimise impacts on wetland habitat) and that the wetland monitoring program makes provision for increased monitoring intensity for the conveyor route specifically. The construction process must be supervised and signed off by a wetland specialist. The monitoring program must focus on wetland crossings and special measures must be designed and put in place to prevent coal spillages in the vicinity of wetland habitat.

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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

Dorstfontein West Mine (Pty) Ltd also known as Dorstfontein Coal Mine (Pty) Ltd (hereafter referred as DCM West) is an underground mine with both 2 and 4 Seams operated by Exxaro Coal Central (Pty) Ltd ("Exxaro"), located within the jurisdiction of Emalahleni Local Municipality in the Mpumalanga Province. DCM West previously mined 2 Seam and is now mining 4 Seam via board and pillar underground mining method on the western portion of their mining rights and is intending to expand the existing discard dump facility and to construct a conveyor belt at the DCM West which is located within the jurisdiction of Emalahleni Local Municipality in the Mpumalanga Province. The Life of mine is projected to be until 2042, while the existing discard dump is coming to the end of its life in 2022. The purpose of this expansion project is to extend the life of the discard dump facility, which is required to accommodate the disposal of the discard and slurry for the next 15 years of the Life of Mine (LOM) and to allow for easier transportation of coal from West to East through the conveyor belt. Subsequently, Exxaro proposes to undertake the following activities:

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1.2 Scope of Work

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
- The wetland delineation should be conducted following the guidelines contained in the DWAF Guideline document entitled "A Practical Field Procedure for Identification and delineation of wetlands and riparian areas" (DWAF, 2008);
- Corroborate field and desktop data and classify confirmed wetlands into hydrogeomorphic units;
- Determine the functionality of wetlands, using a Level 2 Wet-EcoServices (Kotze *et al.*, 2005) assessment for wetlands within the study area;
- Determine the Present Ecological Status (PES) of identified wetlands within the study area through applying a Level 2 Wet-Health assessment (Macfarlane *et al*., 2008);
- Determine the Ecological Importance and Sensitivity (EIS) of identified wetlands by utilising methodology described by Rountree (2013);
- Determine and ground truth the NFEPA status of any wetlands on site, if any;
- Impact assessment for the proposed activities as well as potential mitigation measures.

A site visit to the area to be affected by the proposed activity was undertaken on the 7th, 8thth, 9th, 26th, 27th and 28th of February 2019. 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, or mining areas with existing infrastructure, 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). As such, wetland and riparian delineations as provided are based on indicators where available and the author's interpretation of the current extent and nature of the wetlands and riparian areas associated with the proposed activity;
- Some precision agricultural techniques such as topographical manipulation and soil redistribution ploughing were evident within the study area which in some instances could obscure pedological signs of wetness and hydric soil forms;
- 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 as well as successional changes in species composition in relation to its original /expected benchmark condition;
- Delineations of wetland areas were largely dependent on the extrapolation of field indicator data obtained during field surveys, 5m 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; and
- Wetlands outside of the study area boundary was extrapolated using aerial imagery, although some sampling was done outside of the study boundaries in order to confirm findings and better interpret hydropedological characterisation of the study area.
- With regards to Ecological Importance and Sensitivity for pans, very little research has been conducted on the invertebrate biodiversity of endorheic and exhorheic depressions within South-Africa and therefore EIS within this report are based without any detailed aquatic assessment of invertebrate biodiversity.

2. GENERAL CHARACTERISTICS

2.1 Location

The proposed development is within the jurisdiction of Emalahleni Local Municipality in Mpumalanga Province, near the town of Kriel (Figure 1).

2.2 Biophysical Attributes

Climate

The climate for the study area was derived from recorded data (en.climate-data.org and worldweatheronline.com). The area around the study area receives seasonal summer rainfall and has generally very dry winters. Rainfall ranges between 620 – 750 mm, with the long term average around 650 mm. Most rain fall between November and March, peaking between December and February. Summer day temperatures fluctuate daily on average between 14°C and 25°C in January, but higher temperatures are experienced. The daily winter temperatures in July fluctuate on average between 1°C and 16°C. Incidence of frost is frequent which helps grasslands to persist.

2.2.2 Historic vegetation overview

Mpumalanga is known for its extensive grasslands and numerous wetlands, in which natural dominance of high shrubs and/or trees is largely prevented by frequent frost occurrences (and other factors) during winter, which tufted perennial grasses are better adapted to survive. Mpumalanga is host to approximately 21% of South Africa's flora. The majority (64 %) of these plant species are soft herbs and bulbous plants (geophytes) situated in the grassland biome. The majority of these species remain dormant during winter or very dry seasons, and re-sprout during early summer if rains are sufficient.

The grassland biome is made up of a mosaic of many different vegetation types, which vary according to the prevailing abiotic conditions. According to the delineation of these vegetation types, as described and mapped for South Africa (in Mucina and Rutherford, 2006 and updated 2012 on BGIS), the study area was historically covered with Eastern Highveld Grassland (Gm 12) as well as Eastern Temperate Freshwater Wetland (AZf 3) Vegetation (Mucina and Rutherford, 2006).

Eastern Highveld Grassland (Gm 12) historically covered the slightly to moderately undulating plains between Belfast in the east and the eastern side of Johannesburg in the west and extending southwards to Bethal, Ermelo and west of Piet Retief (Mucina and Rutherford, 2006). The vegetation of this grassland type consists of short dense grassland dominated by the usual Highveld grass composition (*Aristida, Digitaria, Eragrostis, Themeda*, and *Tristachya*). Small, scattered rocky outcrops have a variable cover of wiry, sour grasses and some woody species (*Acacia caffra, Celtis africana, Diospyros lycioides* subsp. *lycioides, Parinari capensis, Protea caffra, P. welwitschii* and *Rhus magalismontanum*) (Mucina and Rutherford, 2006).

Dominant and/or prominent taxa in primary, undisturbed grasslands (Mucina and Rutherford, 2006) would have included following species:

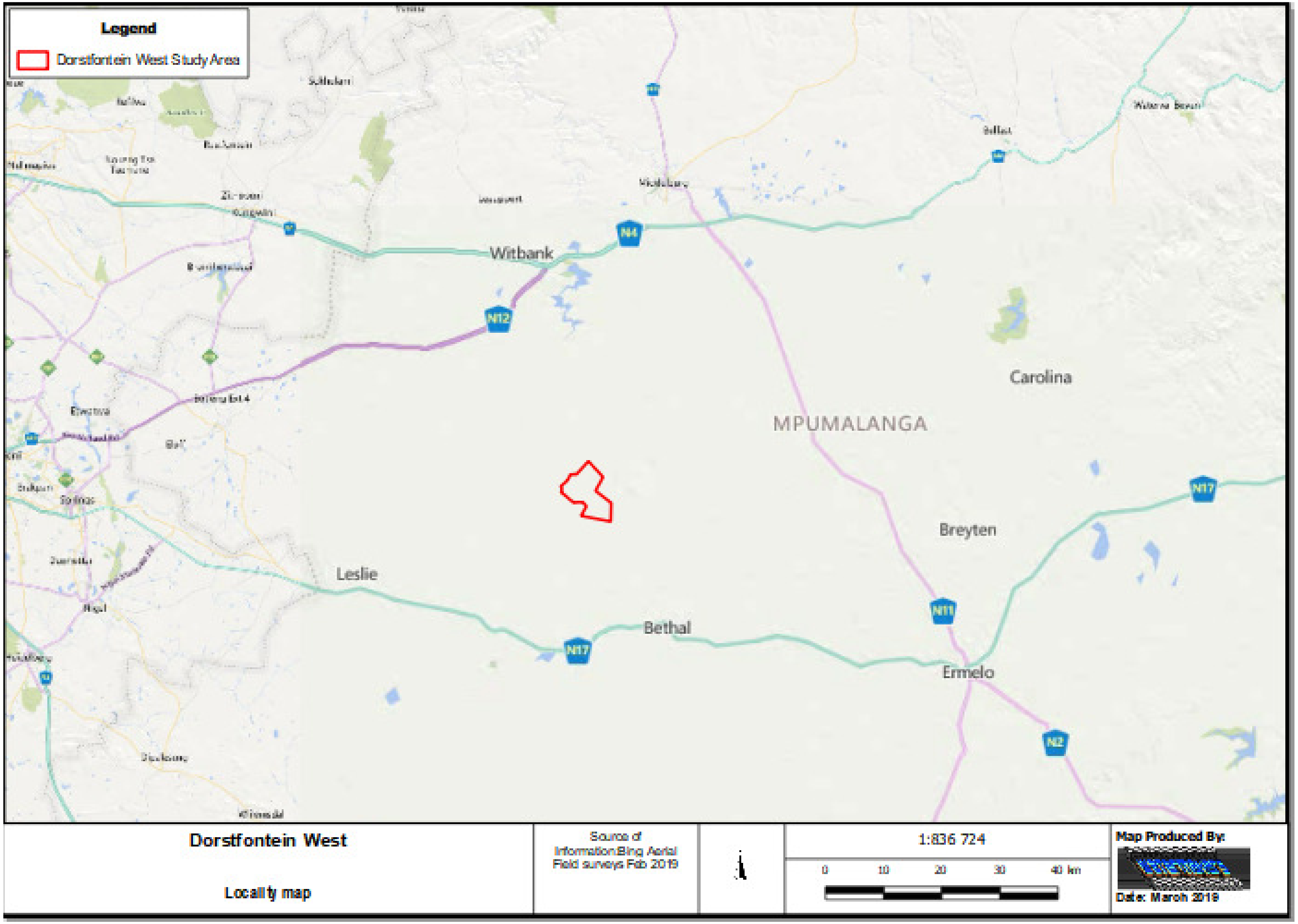


Figure 1: Locality map for the study area

Graminoids: *Aristida aequiglumis, A. congesta, A. junciformis subsp. galpinii, Brachiaria serrata, Cynodon dactylon, Digitaria monodactyla, D. tricholaenoides, Elionurus muticus, Eragrostis chloromelas, E. curvula, E. plana, E. racemosa, E. sclerantha, Heteropogon contortus, Loudetia simplex, Microchloa caffra, Monocymbium ceresiiforme, Setaria sphacelata, Sporobolus africanus, S. pectinatus, Themeda triandra, Trachypogon spicatus, Tristachya leucothrix, T. rehmannii, Alloteropsis semialata subsp. eckloniana.*
Herbs: *Berkheya setifera , Haplocarpha scaposa , Justicia anagalloides , Pelargonium luridum, Acalypha angustata, Chamaecrista mimosoides, Dicoma anomala, Euryops gilfillanii, E. transvaalensis subsp. setilobus, Helichrysum aureonitens, H. caespititium, H. callicomum, H. oreophilum, H. rugulosum, Ipomoea crassipes, Pentanisia prunelloides subsp. latifolia, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata.*
Geophytes: *Gladiolus crassifolius, Haemanthus humilis* subsp. *hirsutus, Hypoxis rigidula* var. *pilosissima, Ledebouria ovatifolia.*
Succulents: *Aloe ecklonis.*
Low Shrubs: *Anthospermum rigidum* subsp. *pumilum, Stoebe plumosa*.

Eastern Temperate Freshwater Wetlands are found on flat or gently undulating landscapes or shallow depressions filled with (temporary) water bodies such as pans, periodically flooded vleis, and edges of calmly flowing rivers that support zoned systems of aquatic and hygrophilous vegetation where grasslands are temporarily flooded. Dominant Taxa that can be expected in the different zones in wetlands include:

Marshes:
Graminoids: *Cyperus congestus, Agrostis lachnantha, Carex acutiformis, Eleocharis palustris, Eragrostis plana, E. planiculmis, Fuirena pubescens, Helictotrichon turgidulum, Hemarthria altissima, Imperata cylindrica, Leersia hexandra, Paspalum dilatatum, P. urvillei, Pennisetum thunbergii, Schoenoplectus decipiens, Scleria dieterlenii, Setaria sphacelata, Andropogon appendiculatus, A. eucomus*.
Herbs: *Centella asiatica, Ranunculus multifidus, Berkheya radula, B. speciosa, Berula erecta subsp. thunbergii, Centella coriacea, Chironia palustris, Equisetum ramosissimum, Falckia oblonga, Haplocarpha lyrata, Helichrysum difficile, H. dregeanum, H. mundtii, Hydrocotyle sibthorpioides, H. verticillata, Lindernia conferta, Lobelia angolensis, L. flaccida, Mentha aquatica, Monopsis decipiens, Pulicaria scabra, Pycnostachys reticulata, Rorippa fluviatilis var. fluviatilis, Rumex lanceolatus, Senecio inornatus, S. microglossus, Sium repandum, Thelypteris confluens, Wahlenbergia banksiana.*
Geophytes: *Cordylogyne globosa, Crinum bulbispermum, Gladiolus papilio, Kniphofia ensifolia, K. fluviatilis, K. linearifolia, Neobolusia tysonii, Satyrium hallackii* subsp. *hallackii.*

Reed and sedge beds:
Graminoids: *Phragmites australis, Schoenoplectus corymbosus, Typha capensis, Cyperus immensus. Carex rhodesiaca.*

Water bodies:
Aquatic Herbs: *Aponogeton junceus, Ceratophyllum demersum, Lagarosiphon major, L. muscoides, Marsilea capensis, Myriophyllum spicatum, Nymphaea lotus, N. nouchali var. caerulea, Nymphoides thunbergiana, Potamogeton thunbergii.*
Carnivorous Herb: *Utricularia inflexa.*
Herb: *Marsilea farinosa* subsp. *farinosa*. (Mucina & Rutherford, 2006).

Geology

The project area is situated on the Witbank coal field, which forms part of the Karoo basin extensively covering the central areas of South Africa. The basement rocks within the Karoo Basin are overlain by the Karoo Super Group. The basement of the Karoo Super Group is the Dwyka tillites that are fairly regularly deposited over the basin with the exception of paleo-topographical highs (Figure 2). The Dwyka tillites are overlain by the Vryheid formation which include the coal seams. The Vryheid formation consists of various sequences of sandstones, shales and siltstones with the various coal seams located within them. In terms of the areas structural geology, during the Jurassic period a large number of dolerite dykes and sills intruded into the Karoo formation acting as important geological structures diverting and impending groundwater movements (DWA, 2009). A dolerite intrusion is indicated in the south of the mining area (1:250,000 Geological map for the study area (2628 Eastrand; Department of Mines – Geological Survey). Further, there are porhyritic rhyolite intrusions with interbedded mudstone and siltsone in the north eastern and eastern sections of the study area.

2.2.4 Associated Aquatic Ecosystems and Drainage

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. Dorstfontein West Mine is situated in Quaternary catchments B11B, B11C and B11D in the Upper Olifants Water Management Area (WMA) which is situated in the north eastern part of South Africa, in the Mpumalanga Province. The Olifants River originates east of the mine flows in a northerly direction. The Steenkoolspruit is located south and west of the mine. These two rivers converge north of the mine, from which point the river is called the Olifants River.

2.2.5 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.

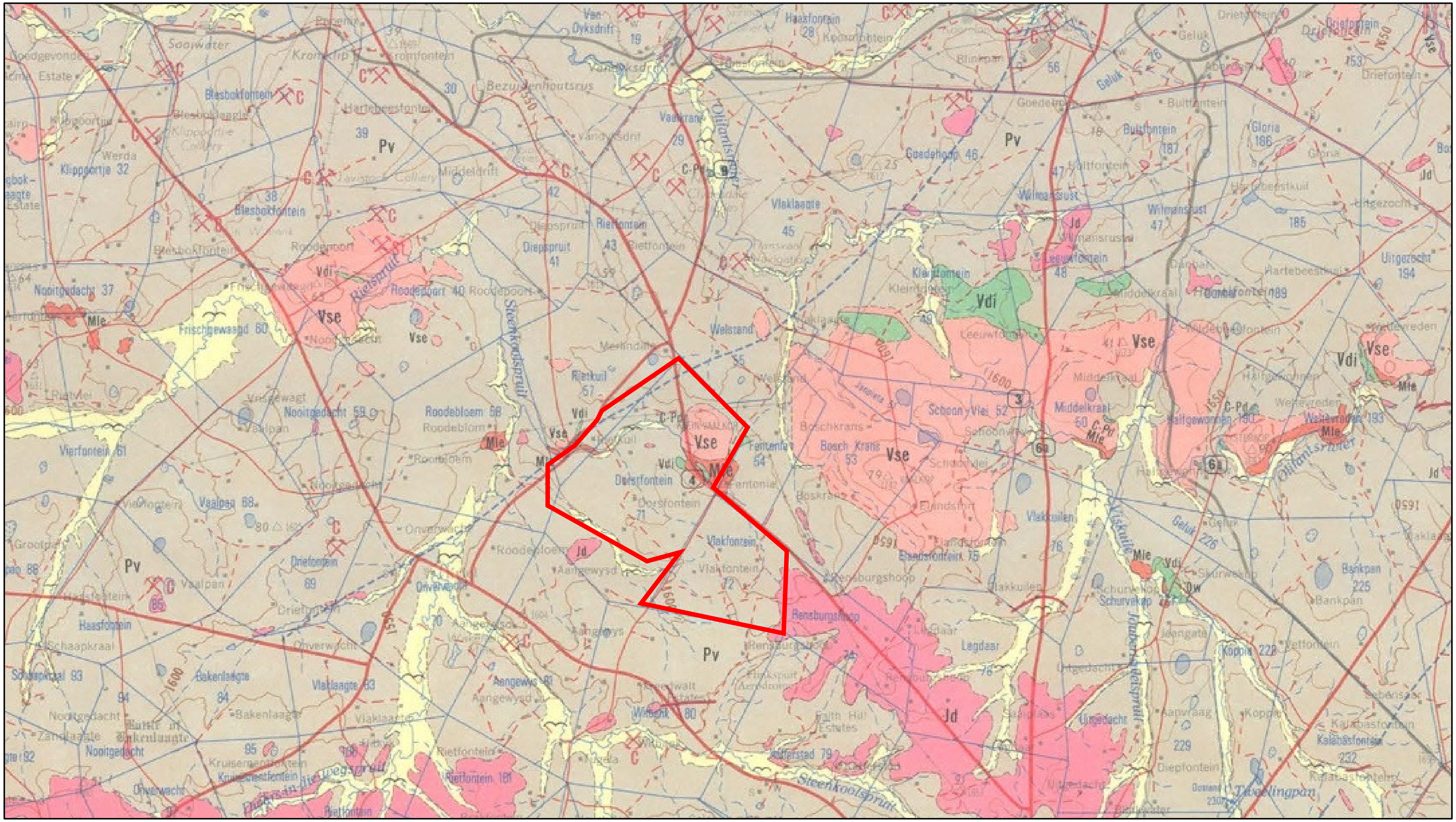


Figure 2: Geology of the study area (2628 Eastrand 1:250 000; Department of Mines – Geological Survey) with the approximate study area indicate by red polygon of the map inset

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 3), no FEPA wetlands or wetland clusters were located within the study area or within several kilometres from the stusy area. (Figure 3).

2.2.6 Wetland Vegetation Group

According to Nel et al. (2011), the study area falls within the Mesic Highveld Grassland Group 4 wetland vegetation group. According to Macfarlane et al. (2014), the Mesic Highveld Grassland Group 4 wetland vegetation group is regarded as being Critically Endangered (Macfarlane et al., 2014)

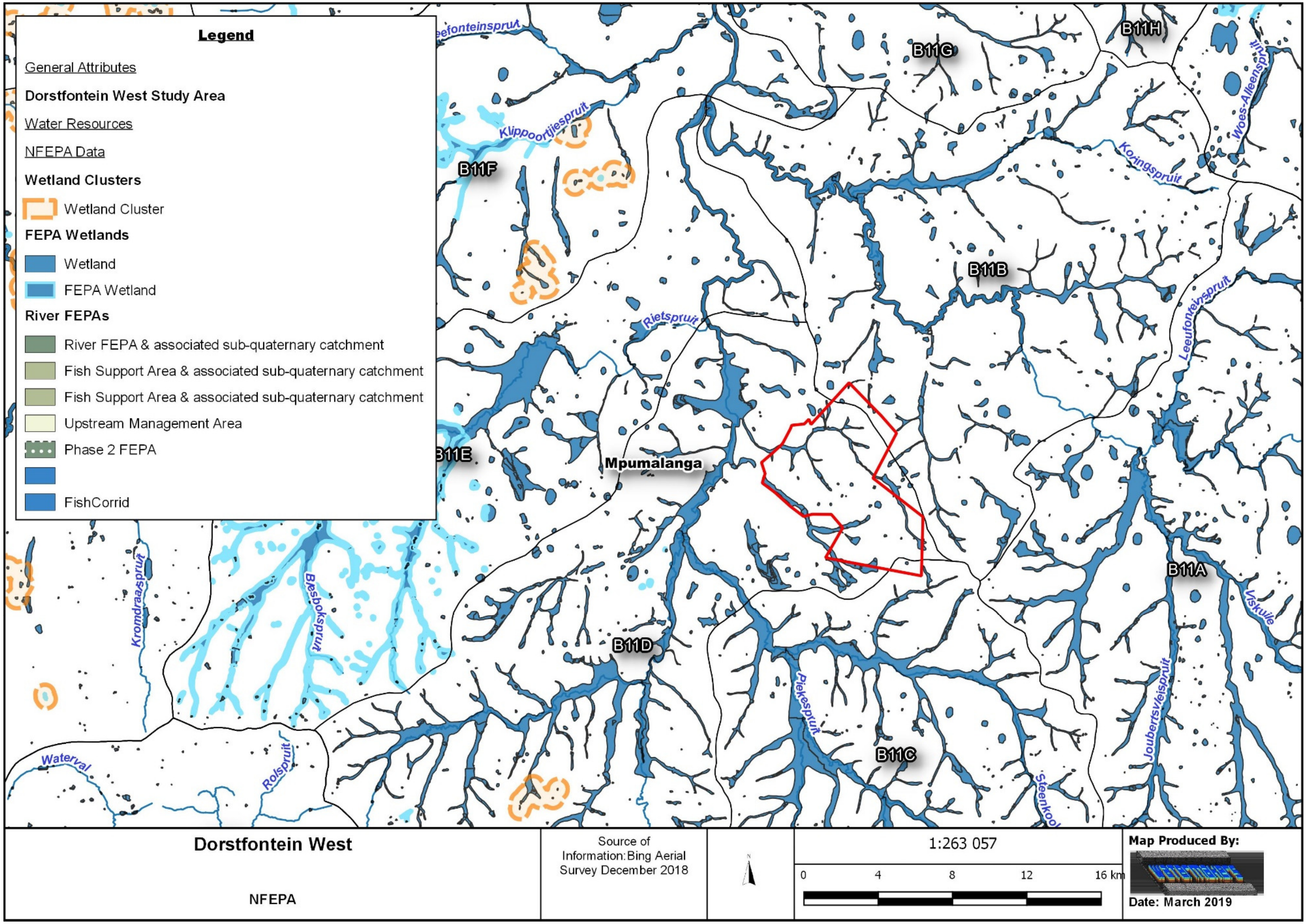


Figure 3: NFEPA map indicating closest FEPA features in relation to the study area

3. ASSOCIATED WETLANDS

3.1 Wetland soils

According to the Department of Water Affairs and Forestry (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). Hydric soil forms identified within the study area included the soil forms Avalon, Bainsvlei, Bloemdal, Dresden, Glencoe, Glenrosa, Katspruit, Rensburg, Longlands, Westleighs, Tukula, Kroonstad, Sepane and Wasbank.

The traversed catenas within the study area were dominated by a plinthic topo-sequence. Plinthic soils are characterized by their susceptibility to prolonged seasonal wetness due to a fluctuating water table, which creates reducing redox conditions that are expressed as mottles and sometimes Iron and Manganese concretions. Plinthic soils in which the Orthic A horizon grades directly into a plinthic horizon (e.g. Westleigh soil form) or where the Orthic A horizon grades indirectly through an E horizon (e.g. Longlands soil form) are generally wetter than soils which contain a yellow-brown apedal B horizon on top of a soft plinthic horison (e.g. Pinedene soil form). Furthermore, presence of an E horizon on plinthic soils such as in the Longlands form generally indicates greater susceptibility to wetness than those soils with a yellow-brown apedal B horizon such as the Pinedene soil form (typically midslope). The G horizon of Kroonstad soils is generally saturated with water for most of the year and is one of the commonly well-known wetland soils, typically found along valley bottom wetlands and wetter sections of the hillslope seepage wetlands. Many of the Pinedene soils had a fairly well drained upper solum of ca. 500-650mm, although faint signs of wetness beneath this depth were identified. Drainage in some of the Wasbank soils was often restricted by the impervious layer of hard plinthic horizon at the shallow depth of 350mm. Wasbank, Kroonstad and Longlands soils were in various instances regarded as interflow soils situated between the upland recharge soils (Huttons) and the responsive soils located in the valley bottom position (Figure 4)

Hydric soils that were observed in the valley bottom position of the landscape comprised of Kroonstad, Rensburg, Sepane and Katspruit soil forms (Figure 5; Figure 6). The Kroonstad soil family has a characteristic bleached E and gleyed G horizons, both of which are indicative of prolonged water saturation. The Katspruit soil form also has the G horizon with marked gleyed features indicative of a permanent wetland zone. The Westleigh, Kroontastad and Longlands soil forms were also identified on midslope and footslope positions of the landscape, often associated hillslope seepage wetlands connected to a valley bottom wetland.

Figure 4: Longlands soil form indicating permanent wet condition on a hillslope seepage wetland

Terrestrial soil forms within the catchment of the wetlands of the study area included the Clovelly, Hutton, Mispah, Oakleaf, Lichtenburg and Witbank soil forms. Large terrestrial sections within the upland areas contained deep soils such as the Hutton soil form which allow for recharge of the underlying vadose zone. Soil profiles located within areas associated with historic infrastructure development (e.g. farm steads and mining areas) were often highly disturbed and classified as the Witbank soil form (S.C.W.G., 1991).

Figure 5: Sepane soil form in valley bottom position with pedocutanic and gleyic subsoil horisons

According to the DWAF (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 present within soil profiles of the disturbed valley bottom wetland as well as within the hillslope seepage wetland including black, orange and red mottles and rhizospheres (Figure 5).

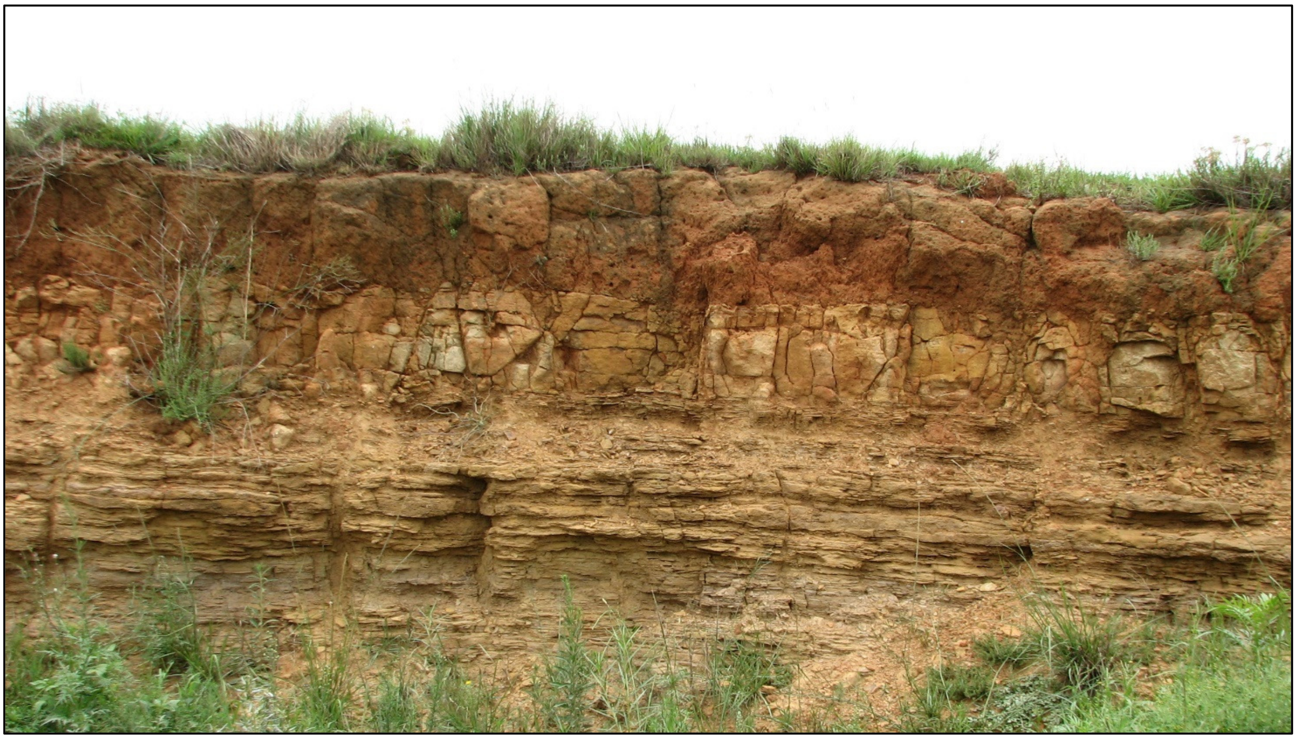


Figure 6: Terrestrial Mispah soil form responsible for recharge through cracked hard rock, note however the very bottom gleyed saprolitic strata indicating a hydropedological flow path

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 (Figure 7).
- **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 (Figure 7); 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 7: Reduced matrix (grey) with orange and yellow mottles as well as black manganese concretions observable within an augered soil sample from the permanent zone of a hillslope seepage wetland in the study area

The new Soil Classification working Group (2018) classification system has incorporated several changes to the previous soil classification Soil Classification Working Group (1991). The new open classification system allows for the classification of whole-soil profiles which potentially enhances studies of water flows in river basins where soil morphology is recognised as an important hydrological indicator of water flow paths and storage mechanisms in hillslopes. The new Soil Classification working Group (2018) soil classification system's open classification structure also allows "natural soils" and "anthropogenic materials" to be separated at the highest category with their respective criteria and structures. This was relevant in the study area itself where historic borrowpit activities are responsible for the complete removal of horisons while more recently applied precision farming techniques are likely responsible for soil disturbances and topographical manipulation to increase maize production. Physically disturbed anthrosols identified within the study area included Grabouw 1000 and Grabouw 2000 cf, transported technosols included Witbank 1100, Witbank 1300, Cullinan 1000 whereas hydric technosols included Stilfontein 3100 (Figure 8).

Figure 8: Anthropogenic Open Excavation Technosols, Cullinan 1000, associated with a historic borrowpit.

Figure 9: Stilfontein 3100 Hydric Technosol, the result of agriculture and road infrastructure run-off causing concentrated flow paths with resulting headcut erosion through highly erodible Longlands (cf) soil form with thick E (albic) horisons (blue arrows)

3.2 Wetland 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 therefore 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 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.

Areas identified within the study area with permanent zonation and associated high water tables contained hydrophylic plants such as *Typha capensis, Persicaria lapathifolia, Persicaria* sp., *Phragmites australis*, as well as grasses and sedges such as *Leersia hexandra, Hemarthria altissima, Eleocharis limosa* and *Agrostis lachnanta. Typha capensis, Persicaria lapathifolia* and *Phragmites australis* were able to grow in water of up to 50cm deep while areas with standing water of up to 20cm was dominated by graminoids and geophytes such as *Schoenoplectus brachyceras, Berkheya seminivea, Lobelia angolensis, Eleocharis limosa, Crinum bulbispermum, Leersia hexandra, Pycreus macranthus* and *Paspalum* sp., while *Miscathus junceus, Ranunculus multifidus, Arctotis arctotoides, Agrostis lachnanta* and *Paspalum urvillei* were evident in areas with minimal standing water. *Agrostis lachnanta*, an obligatory wetland species, was present in all three wetland zones but flourished more abundantly in seasonal zones. Temporary and seasonal wetland zones were dominated by grass species such as *Eragrostis curvula, E. cloromelas, Eragrostis* spp., *Pennisetum clandestinum, Cynodon dactylon Andropogeon eucomus, Sporobolus pyramidalis, Arundinella nepalensis, Imperata cilindrica* and *Paspalum urvillei* as well as sedges such as *Bulbostylis* sp., *Pycereus* sp*., Cyperus* denudatus *C. esculentus, C. longus, Juncus* spp.*, Kyllinga alata, Schoenoplectus brachyceras, Schoenoplectus corymbosus* and *Schoenoplectus decipiens.*

Several seepages and unchanneled valley bottom wetlands were identified within the study area and would be classified as moist grassland from a vegetation perspective. According to O'Conner & Kuyler (2009), South Africa's moist grassland harbours globally significant biodiversity, supplies essential ecosystem services, supports crop and livestock agriculture, yet is poorly conserved. In addition, moist grasslands provide habitat to a large number of threatened plant species. In addition, provincially protected plants such as the grass orchids and *Brunsvigia radulosa* could potentially occur within some of the moist grasslands of the study site. *Leersia hexandra* (Rice Grass) was confirmed to be located within several of the permanent wet zonations of wetlands within the study area. This species of obligate wetland climate grass species is the larval host plant for *Metisella meninx* (Marsh Sylph), a butterfly species that is regarded as being Rare in South Africa due to its habitat specialisation (Dobson, 2013).

Many of the temporary and seasonal seepage wetlands showed significant basal cover reductions owing to the land use practices and deliberate attempts by farmers to plant *Eragrostis curvula* and *Eragrostis cf. chloromelas* within these areas for pasture purposes due to their unsuitability for maize cultivation (Photograph 8). Further, several sections of hillslope seepages were also incorporated into maize and soyabean production areas through precision farming techniques which involves the horizontal and vertical displacement of soils to improve drainage, thereby also causing severe successional changes within the vegetation composition, areas typically dominated by pioneer and rudimentary species where crops fail.

Figure 10: Hillslope seepage dominated by sedges and grasses such as *Agrostis lachanantha* in the foreground and obligatory wetland species such as Phragmites australis and Typha capensis dominating in the background

Figure 11: Disturbed hillslope seepage dominated by rudimentary and pioneer species such as *Verbena bonariensis*

3.3 Delineated Wetland 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 at or 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. Classification for the purpose of the current project therefore focused on classifying watercourses according to the most dominant hydrological and geomorphological drivers, especially in terms of relating potential impacts of the potential development on especially the watercourses associated with the study area. Wetland boundaries determined within the study area focused on identifying terrain units, soil forms, perceived organic content and the presence of vegetation species that are adapted to saturated conditions.

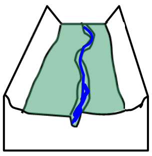
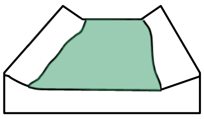
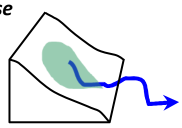
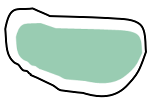
Thirty-eight separate hydro-geomorphic units (HGM), comprising four HGM types, namely unchannelled valley bottom wetlands, channelled valley bottom wetlands hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within 500m surrounding the study area (Figure 11).

HGM units encompass three key elements (Kotze *et al.*, 2005):

(1) Geomorphic setting. This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
(2) Water source. There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
(3) Hydrodynamics, which refers to how water moves through the wetland.

Table 1 describes the characteristics that form the basis for the classification of the HGM units within the study area. The disturbance caused by anthropogenic impacts and resulting successional vegetation changes made the use of vegetation indicators complex in various circumstances, especially on the temporary boundaries of wetlands. Therefore, identifying wetland features on site was primarily done by identifying terrain unit, soil forms and soil wetness features such as the presence of mottling, a gleyed matrix and/or Fe and Mg concretions. However, vegetation indicators did confirm to delineated boundaries and wetness zonation in many instances. Further, the exact extent of hydrological features could not always be determined due to subtle landscape gradients combined with various disturbances and high degree of transformation (including mining and areas manipulated though precision farming techniques) within various sections of the associated catchments and within the wetlands. Further, although HGM 3, HGM 3 and HGM 4 were classified as channelled valley bottom wetlands, it is possible that these watercourses were unchanneled historically.

Table 1: Wetland hydro-geomorphic types typically supporting inland wetlands in South Africa within the vicinity of the study area (adapted from Kotze et al., 2008)

Hydro-geomorphic types	**Description**	**Source of water maintaining the wetland[1]**	
		Surface	**Sub-surface**
Valley bottom with a channel 	Valley bottom areas with a well defined stream channel but lacking characteristic floodplain features. May be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.	***	*/ ***
Valley bottom without a channel 	Valley bottom areas with no clearly defined stream channel, usually gently sloped and characterized by alluvial sediment deposition, generally leading to a net accumulation of sediment. Water inputs mainly from channel entering the wetland and also from adjacent slopes.	***	*/ ***
Hillslope seepage feeding a watercourse 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse.	*	***
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.	*/ ***	*/ ***

[1] Precipitation is an important water source and evapotranspiration an important output in all of the above settings

Water source: * Contribution usually small

*** Contribution usually large

*/ *** Contribution may be small or important depending on the local circumstances

 Wetland

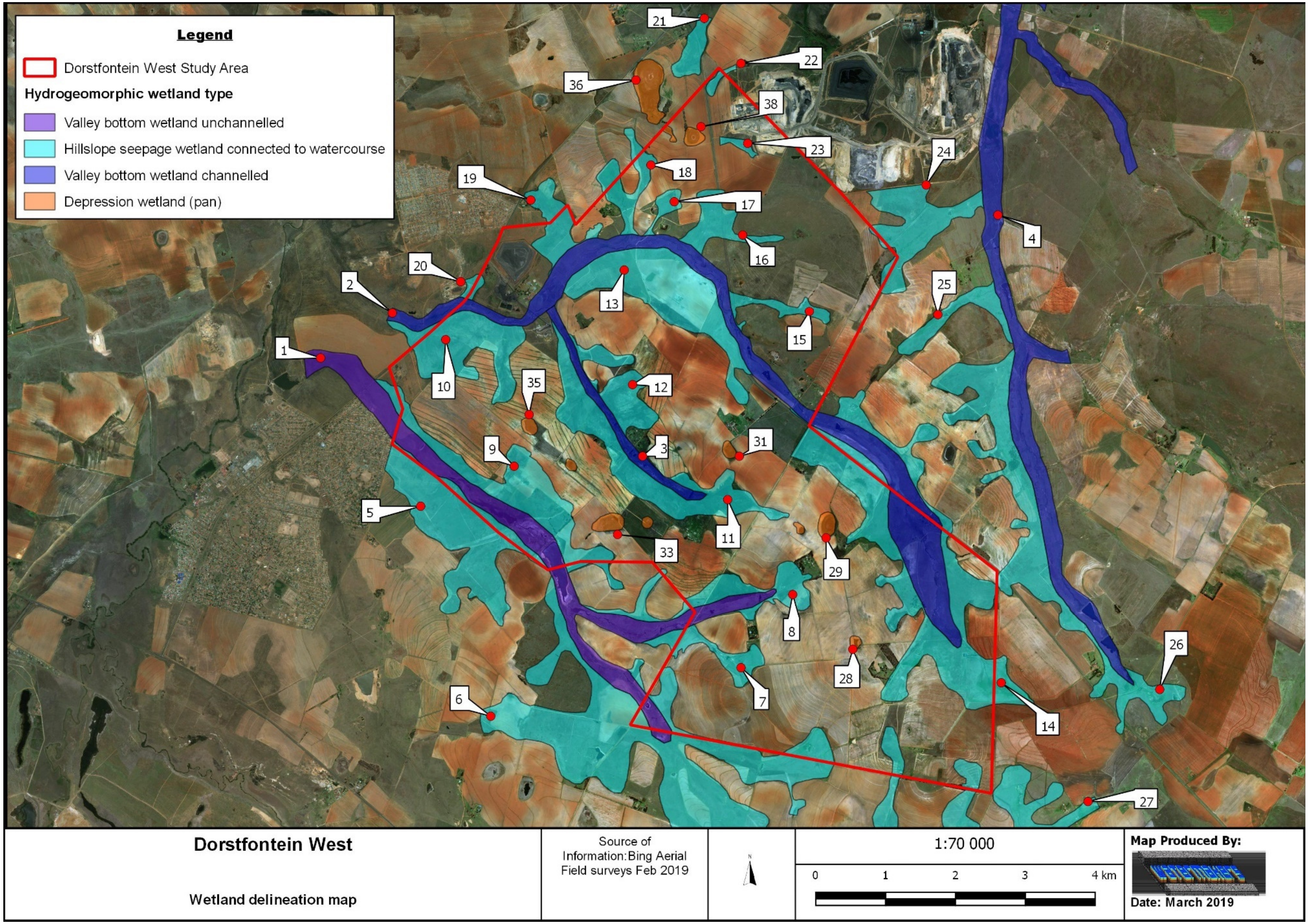


Figure 12: Delineated wetlands within the study area and within 500m

3.4 Functional and Present Ecological State Assessment

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increase biodiversity within the transformed study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes (Table 2).

Hydro-geomorphic units are inherently associated with hydrological characteristics related to their form, structure and particularly their position in the landscape. This, together with the biotic and abiotic character (or biophysical environment) of wetlands, means that certain wetland types are able to contribute better to some ecosystem services than to others (Kotze et al., 2005) (Table 3).

Table 2: Potential wetland services and functions in study area

Function	Aspect
Water balance	Streamflow regulation
	Flood attenuation
	Groundwater recharge
Water purification	Nitrogen removal
	Phosphate removal
	Toxicant removal
	Water quality
Sediment trapping	Particle assimilation
Harvesting of natural resources	Reeds, Hunting, etc.
Foraging	Water for animals
	Grazing for animals

Table 3: Preliminary rating of the hydrological benefits potentially provided by a wetland given its particular hydro-geomorphic type (Kotze *et al*., 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	HYDROLOGICAL BENEFITS POTENTIALLY PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phos-phates	Nitrates	Toxicants[2]
Valley bottom - channelled	+	0	0	++	+	+	+	+
Valley bottom - unchannelled	+	+	+?	++	++	+	+	++
Hillslope seepage feeding a stream channel	+	0	+	++	0	0	++	++
Pan/ Depression	+	+	0	0	0	0	+	+

[2]Toxicants are taken to include heavy metals and biocides

Rating: 0 Benefit unlikely to be provided to any significant extent +
Benefit likely to be present at least to some degree
++ Benefit very likely to be present (and often supplied to a high level)

Each wetland's ability to contribute to ecosystem services within the study area is also dependant on the particular wetland's Present Ecological State (PES) in relation to a benchmark or reference condition. Present Ecological State scores were determined for wetlands within the study area using Wet-Health Level 2 assessment. Through the use of a scoring system, the perceived departure of elements of each particular system from the "natural-state" was determined (current state versus anticipated future rehabilitated state). The following elements were considered in the assessment:

- Hydrologic: Flow modification (has the flow, rates, volume of run-off or the periodicity changed);
- Geomorphic (Canalisation, impounding, topographic alteration and modification of key drivers);
- Biota (Changes in species composition and richness, Invasive plant encroachment, over utilization of biota and land-use modification)

For the purpose of the present assessment, the determined Present Ecological State and wetland ecosystem services provided by wetlands within the study area are discussed in more detail below.

3.4.1 Valley-bottom Wetlands

HGM 1, HGM 2, HGM 3 and HGM 4 received its highest ecosystem services scores from the Wet-EcoServices assessment for flood attenuation, sediment trapping, erosion control, maintenance of biodiversity, carbon storage and the provision of natural resources (Figure 13, Figure 14). The relatively relaxed gradient associated with these valley bottom wetlands would allow for high levels of sediment deposition. Stream channel input will be spread diffusely across the wetlands even in low flows, resulting in extensive areas of the wetlands remaining saturated and tending to have high levels of soil organic matter. During flow events shallow water pools are present which would promote sunlight penetration, contributing to the photodegradation of certain toxicants. In addition there are also several farm dams with shallow water sections which would also further facilitate photodegradation processes.

The valley bottom wetlands occupied a relatively wide area with a relaxed gradient that would have played a significant role in flood attenuation (especially HGM 2). However, phosphate retention levels would of likely been lower than in floodplains because a certain amount of phosphate may be re-mobilized under prolonged anaerobic conditions (Cronk and Siobhan Fennessy, 2001; Keddy, 2002).

The valley bottom wetlands are supported by subsurface water flows including a lateral seepage component from the adjacent hillslopes as well as return flows via the vadose zone which would enhance the wetlands importance for stream flow regulation. Some nitrate and toxicant removal potential would be expected, particularly from the water being delivered from the adjacent hillslopes as well as a few open water bodies present (The Federal Interagency Stream Restoration Working Group, 1998). From a biodiversity perspective, a species of conservation concern was observed during the field survey, and the potential exist that more may be present despite the majority of the wetland being intensely utilised for grazing. Further, the valley bottom network serves as a movement corridor for fauna to connect terrestrial grassland and wetland habitat to each other.

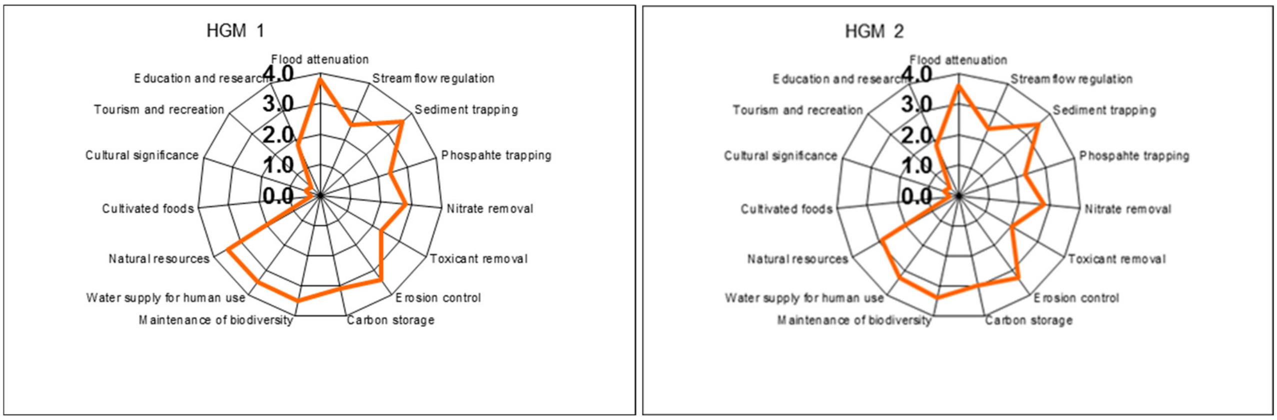


Figure 13: Radar diagrams depicting ecosystem services for HGM 1 and HGM 2 within the study area

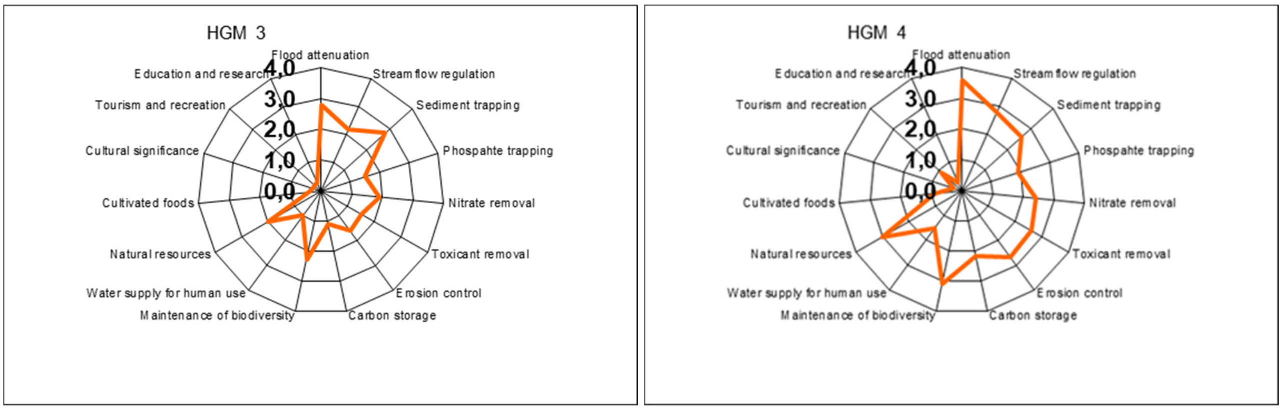


Figure 14 Radar diagrams depicting ecosystem services for HGM 3 and HGM 4 within the study area

Historic and current impacts on the wetland in combination with land use changes in the surrounding catchment resulted in geomorphological, hydrological and vegetation changes within the valley bottom wetlands. Impact on the hydrology of the valley bottom wetlands included evidence of channel formation within most reaches of the watercourses. Channel formation was attributed to concentrated dam outflow as well as concentrated preferential pathways formed from road crossings and maize field run-off. Further, within the valley bottom wetland's catchments, decreased surface roughness associated with extensive maize fields, dirt roads, negative successional vegetation changes as well as some of the supporting seepage wetlands with decreased basal cover were determined to contribute to a lower hydrological score obtained within the valley-bottom wetlands.

From a geomorphological perspective, the highest impact calculated within the valley bottom wetlands were related to altered runoff characteristics, which are likely to affect the entire extent of the wetland as a result of multiple pathways. Further impacting features with regards to the geomorphology included the presence of dams (excavations), roads (excavations and infill), and some limited erosional features, although their magnitude of impact were determined to be limited in several instances due to the average gully width in relation to the width of the wetlands.

Due to the nature of historic and current land uses within the catchment, species composition within the wetlands is expected to have changed relative to the perceived natural condition of the wetlands, especially as a result of overgrazing practices. This was also evident in the supporting recharge areas which were dominated by maize cultivation, as well as seepages and a few sections within the valley bottom wetlands themselves used for the planting of pasture grasses to facilitate grazing of cattle where maize cultivation was not deemed suitable. While pasture establishment does not necessarily contribute to decreased basal cover within these areas, such practices decrease the natural diversity, abundance and associated functionality provided by the wetland's benchmark species composition.

Based on the assessment of the individual drivers of the wetlands, the Present Ecological State for HGM 1, HGM 2 and HGM 3 were determined to be representative of a Category C (moderately modified), with HGM 4 representing a Category D (largely modified) (Table 4).

Table 4: Wet-Health scores for HGM 1, HGM 2, HGM 3 and HGM 4

HGM Unit	Hydrology	Geomorphology	Vegetation	PES category
HGM 1	3.2	2.0	6.8	**C (3.8)**
HGM 2	3.0	2.0	6.6	**C (3.7)**
HGM 3	3.0	2.5	6.5	**C (3.9)**
HGM 4	3.5	3.0	6.5	**D (4.6)**

3.4.2 Hillslope Seepage Wetlands connected to a watercourse

The highest scoring eco-services attributes for hillslope seepage wetlands within the study area were nitrate removal, streamflow regulation, and provision of natural resources (Figure 15 to Figure 26). The accumulation of organic matter and fine sediments in the wetland soils results in the wetland slowing down the sub-surface movement of water down the slope. This "plugging effect" increases the storage capacity of the slope above the wetland and prolongs the contribution of water to the stream system during low flow periods (Kotze, 2005). Seepage wetlands are commonly considered to supply a number of water quality enhancement benefits, for example, removing excess nutrients and inorganic pollutants produced by agriculture, industry and domestic waste (Rogers *et al*., 1985; Gren, 1995; Ewel, 1997; Postel, 1997). Hillslope seepage wetlands generally would be expected to have a relatively high nitrogen removal potential. Nitrogen, and specifically nitrate removal, could be expected as the groundwater emerges through low redox potential zones within the wetland soils, with the wetland plants contributing to the necessary supply of organic carbon. Particularly effective removal of nitrates has been recorded from diffuse sub-surface flow, as characterizes hillslope seepages (Muscutt *et al*., 1993). The extensive commercial maize production taking place within the catchment of the seepage wetlands and within some of the seepage wetlands themeselves would likely act as a considerable source of nitrates and phosphates through fertilizer application. The seepage wetlands are expected to contribute to biodiversity through serving as a movement corridor for several species as well as through the provision of habitat (for species of conservation concern e.g. *Crinum bulbispermum* and *Disa* sp.). Further, from a natural resource utilisation perspective, most seepage wetlands within the study area were highly utilised for grazing. Large sections of the hillslope seepage wetlands (e.g. HGM 13) were also cultivated for soyabean and maize production which significantly increase services rendered for crop production but reduces their contribution to biodiversity. Extensive areas of the hillslope seeapges were utilised for natural resources including grazing and fodder production as well as some ad-hoc hunting opportunities, mostly for fowl.

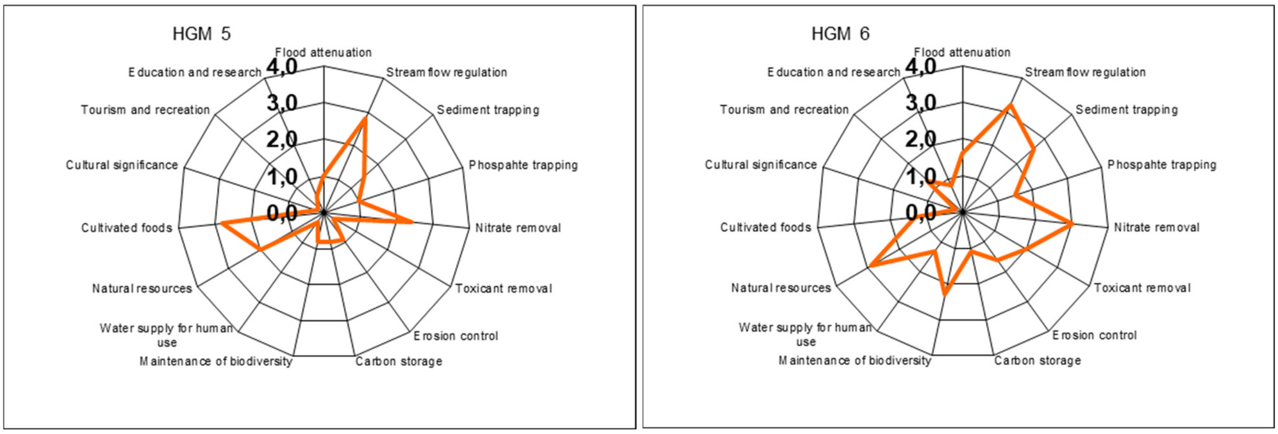


Figure 15: Radar diagrams depicting ecosystem services for HGM 5 and HGM 6 within the study area

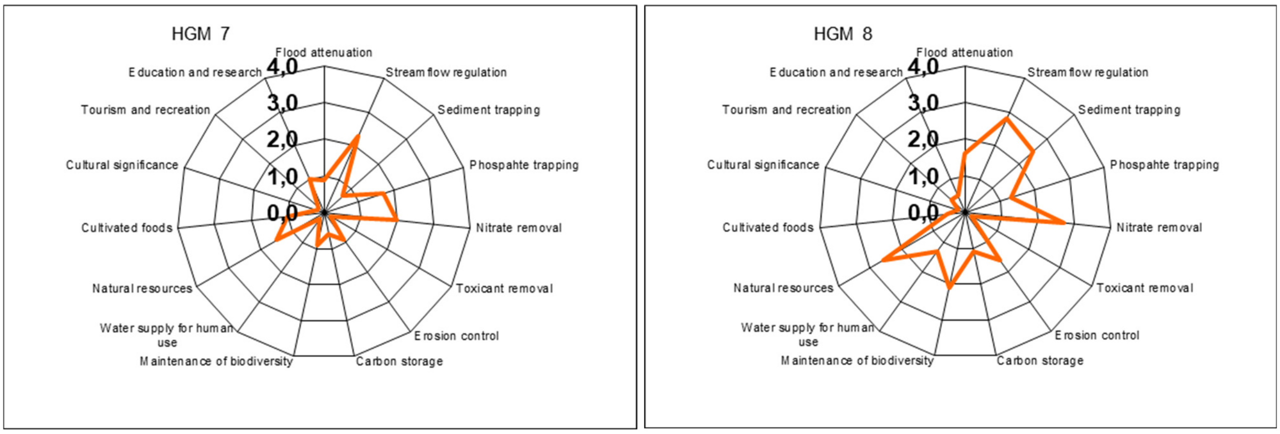


Figure 16: Radar diagrams depicting ecosystem services for HGM 7 and HGM 8 within the study area

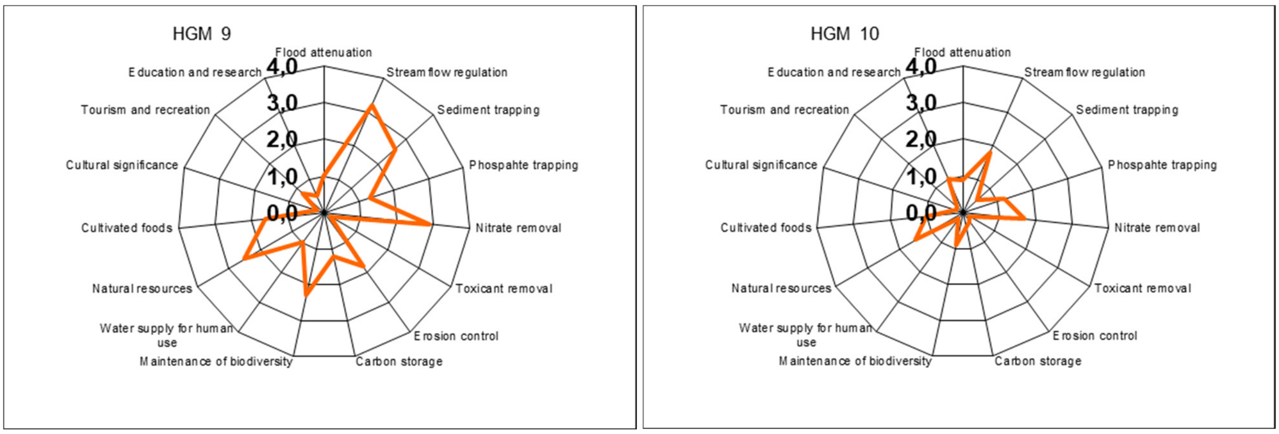


Figure 17: Radar diagrams depicting ecosystem services for HGM 9 and HGM 10 within the study area

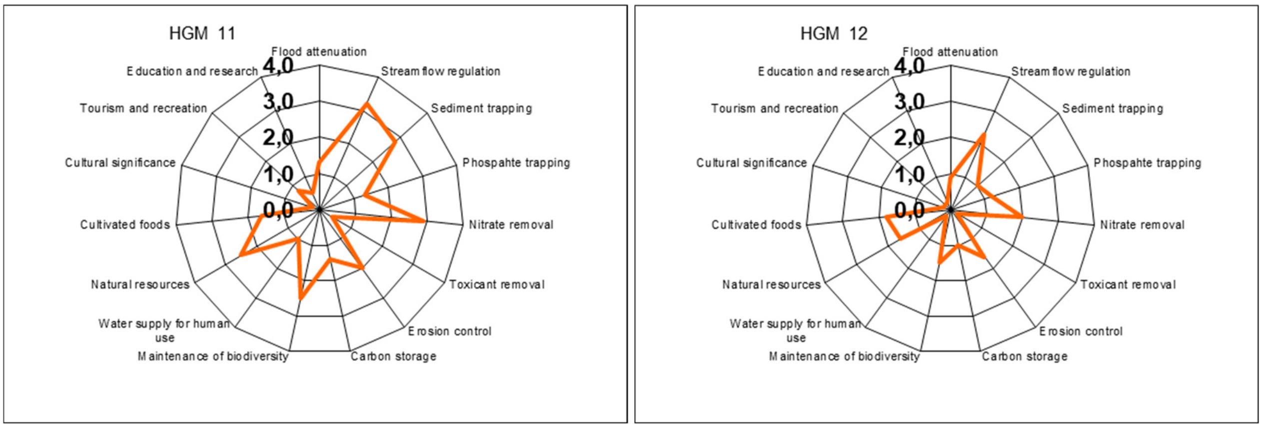


Figure 18: Radar diagrams depicting ecosystem services for HGM 11 and HGM 12

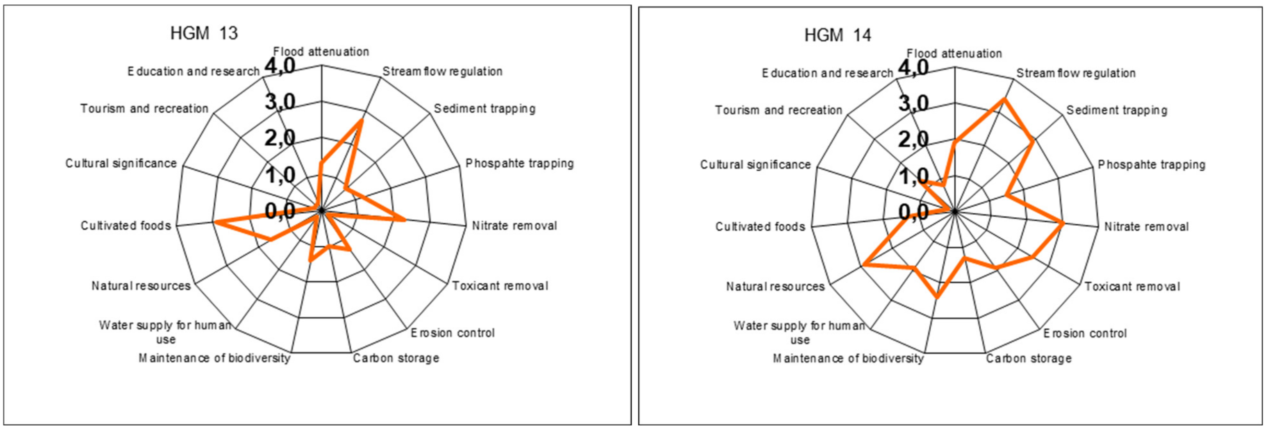


Figure 19: Radar diagrams depicting ecosystem services for HGM 13 and HGM 14

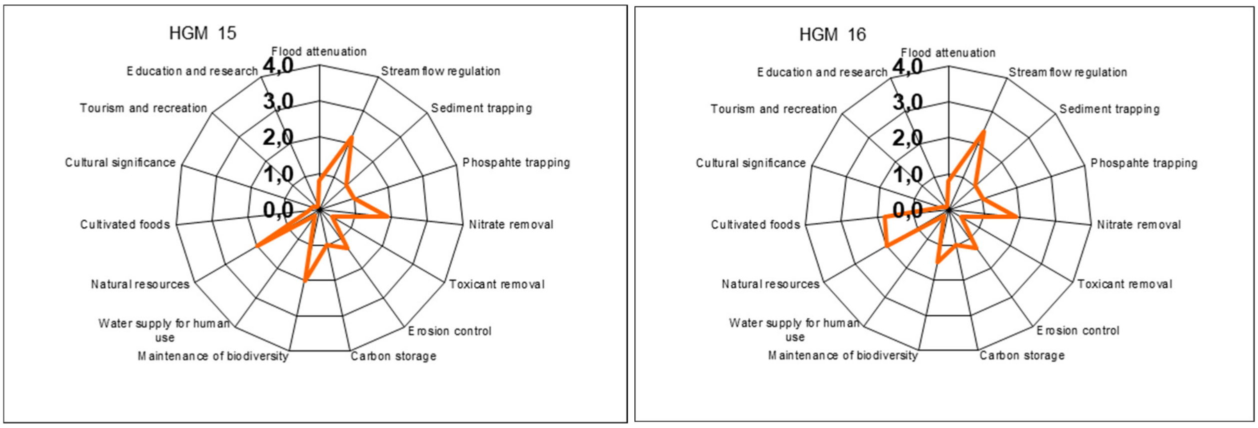
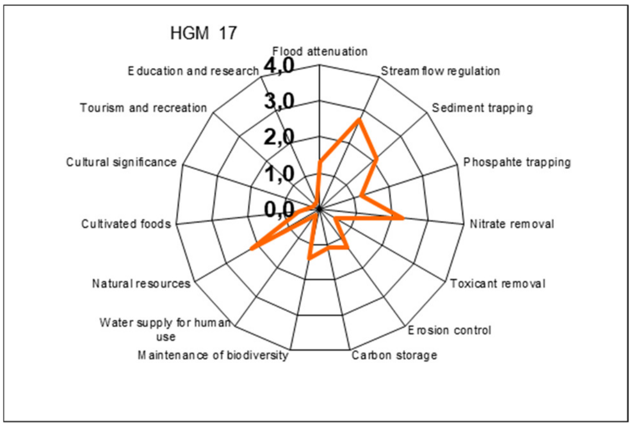


Figure 20: Radar diagrams depicting ecosystem services for HGM 15 and HGM 16



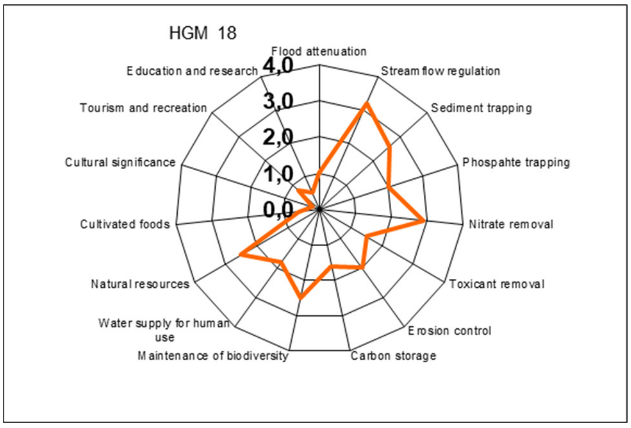
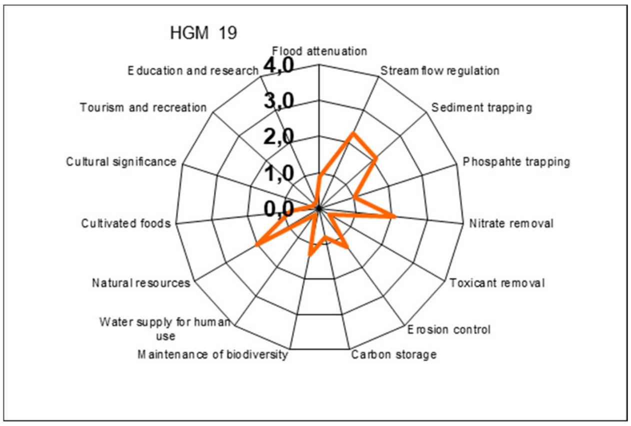


Figure 21: Radar diagrams depicting ecosystem services for HGM 17 and HGM 18



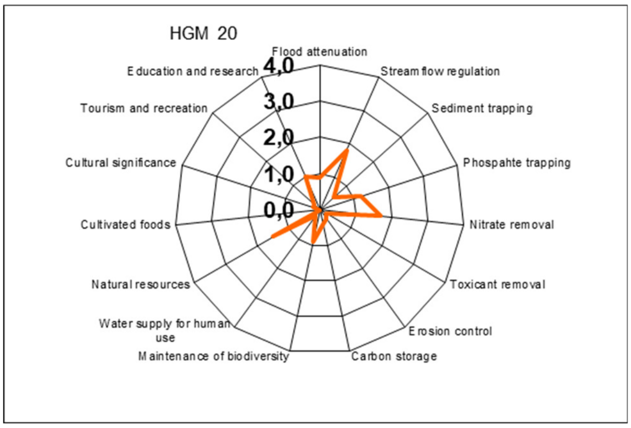
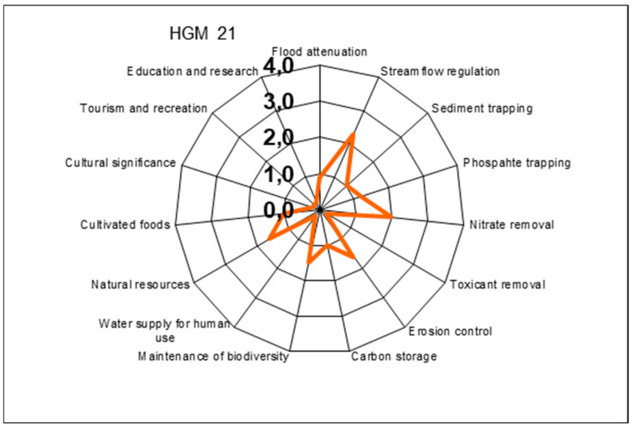


Figure 22: Radar diagrams depicting ecosystem services for HGM 19 and HGM 20



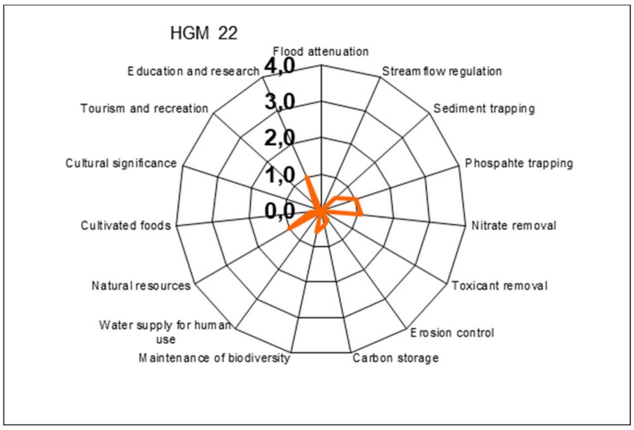


Figure 23: Radar diagrams depicting ecosystem services for HGM 21 and HGM 22

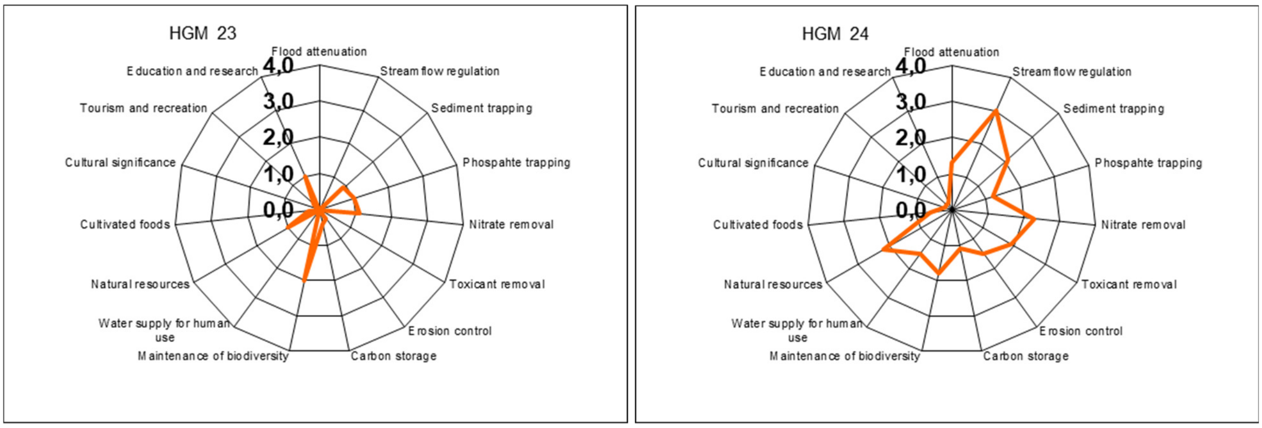


Figure 24: Radar diagrams depicting ecosystem services for HGM 23 and HGM 24

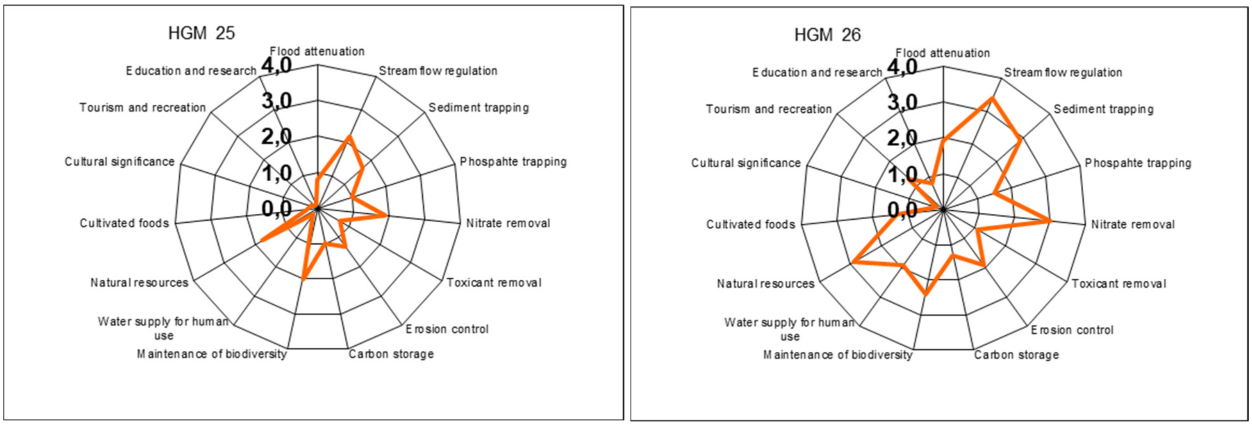


Figure 25: Radar diagrams depicting ecosystem services for HGM 25 and HGM 26

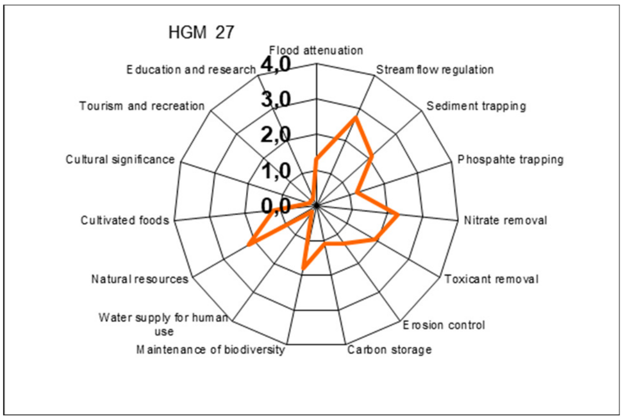


Figure 26: Radar diagrams depicting ecosystem services for HGM 27

PES scores obtained for the hydrology module indicated that water inputs (derived from the wetlands' respective catchments) and water retention and distribution patterns within most hillslope seepages within the study area have been moderately to largely modified. Within several seepages, large sections of the wetlands temporary zonation have been incorporated into maize production (especially on free draining Avalon and Pinedene soil forms). In some wetlands the conversion has been severe, for example more than 70% of HGM 13 has been converted to maize and soyabean production. Seepages have also been manipulated with large machinery to achieve greater maize productivity through modern contouring and micro-topography optimisation techniques which affected the local hydrology and functioning of the seepage wetlands. Contouring and draining is typically designed to reduce moisture regimes within the seepage wetlands. Such practices can have severe impacts on the geomorphology of affected wetlands, thereby greatly reducing the wetlands water retention capacity and ability to provide various other functions. Further, where preferential flow paths from maize fields enter seepages with a lower gradient, sediment deposition tends to occur, causing changes to the vegetation composition and geomorphology. Historic farming-related infrastructure developments such as the construction of farm dams were also noted to have caused site-specific impacts on the hydrology, geomorphology and vegetation. In addition, HGM 22 and HGM 23, have been seriously impacted through opencast mining with a considerable portion of the wetlands and their connectivity to the downstream watercourse sterilised through opencast mining.

Vegetation composition changes of the hillslope seepage wetlands was one of the main drivers of the Present Ecological State category obtained for most of these wetlands. Due to the nature of historic and current land uses within the catchment, species composition within the wetlands is expected to have changed relative to the perceived natural condition of the wetlands. This is most evident in the seepage which are utilised for the planting of pasture grasses (*Eragrostis* spp.) to facilitate grazing of cattle where maize cultivation was not deemed suitable. While this does contribute to basal cover within these areas, such practices decrease the natural diversity and abundance of species associated with the temporary and seasonal seepage areas. Wetter portions within seepages for example sections from HGM 10 were also ploughed historically against contour in order to decrease the moisture regime within the seepage wetland.

Surface roughness within the wetlands have also been reduced as a result of heavy grazing regimes. Further, invasive alien vegetation included *Campuloclinium macrocephalum* (Pom-pom weed), especially in disturbed areas as well as clumps of *Populus* sp. located close to homesteads in most instances.

PES scores obtained for HGM 5 through to HGM 27 are indicated in Table 5.

Table 5: Wet-Health scores for HGM 5 to HGM 27

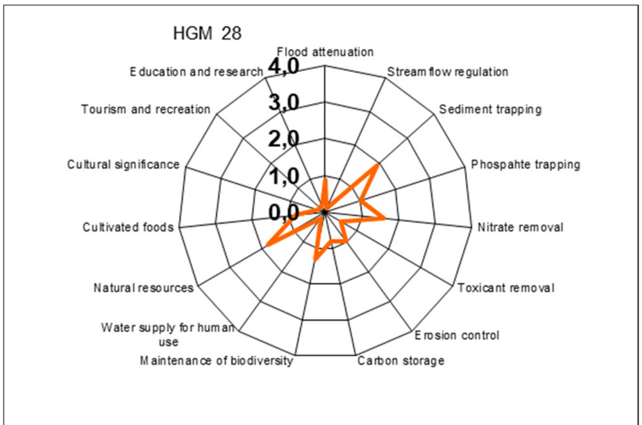
HGM Unit	Hydrology	Geomorphology	Vegetation	PES category
HGM 5	2.5	2.5	8.5	**D (4.2)**
HGM 6	3.0	2.5	6.5	**C (3.9)**
HGM 7	3.5	2.5	6.6	**D (4.1)**
HGM 8	3.0	2.5	7.0	**D (4.0)**
HGM 9	3.0	2.0	8.1	**D (4.2)**
HGM 10	3.5	3.0	9.0	**D (4.9)**
HGM 11	3.0	2.0	7.5	**D (4.0)**
HGM 12	3.0	2.5	8.6	**D (4.5)**
HGM 13	3.5	3.0	8.8	**D (5.3)**
HGM 14	2.5	2.0	5.0	**C (3.1)**
HGM 15	3.0	2.5	7.0	**D (4.0)**
HGM 16	4.0	3.5	7.2	**D (4.7)**
HGM 17	3.0	2.5	7.0	**D (4.0)**

HGM 18	3.0	2.5	6.5	**C (3.9)**
HGM 19	3.5	3.0	8.1	**D (4.7)**
HGM 20	4.5	4.0	7.2	**D (5.1)**
HGM 21	3.5	2.5	7.0	**D (4.2)**
HGM 22	7.5	7.5	9.8	**F (8.1)**
HGM 23	7.5	7.5	9.5	**F (8.0)**
HGM 24	2.5	2.0	5.6	**C (3.2)**
HGM 25	3.0	2.5	6.0	**C (3.7)**
HGM 26	2.5	2.0	5.9	**C (3.3)**
HGM 27	4.5	3.5	7.4	**D (5.0)**

3.4.3 Depression Wetlands (Pans)

The depression wetlands (pans), received its highest ecosystem services scores for sediment trapping, erosion control and maintenance of biodiversity (Figure 8). However, if the pans are hydrologically connected to surrounding wetlands through subsurface flows, it could likely perform other beneficial functions such as stream flow regulation and nitrate removal.

Depressions can receive both surface and subsurface flows, which accumulate in the depression owing to a generally impervious underlying layer which prevents the water draining away (Kotze *et al*., 2005). Some nitrate removal could be expected through diffuse subsurface flows, especially where pans are associated with lateral and hillslope seepages. Pans capture runoff because of their inward draining nature, and thus they reduce the volume of surface water which would otherwise reach the stream system during storm events (Kotze *et al*., 2005). This also adds to the erosion control benefits performed by these wetlands. In addition, several waterfowl species were noticed to utilise the pans during the site visit especially the more permanent pans. Pans are also heavily utilised for grazing purposes within the study area while some sections of especially their temporary zonation have been converted to crop production.



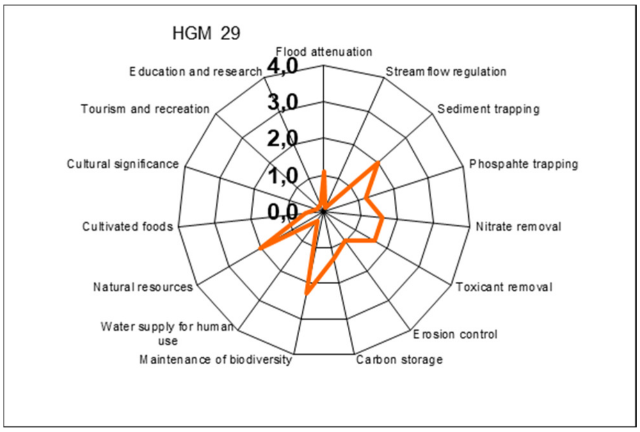


Figure 27: Radar diagrams depicting ecosystem services for HGM 28 and HGM 29

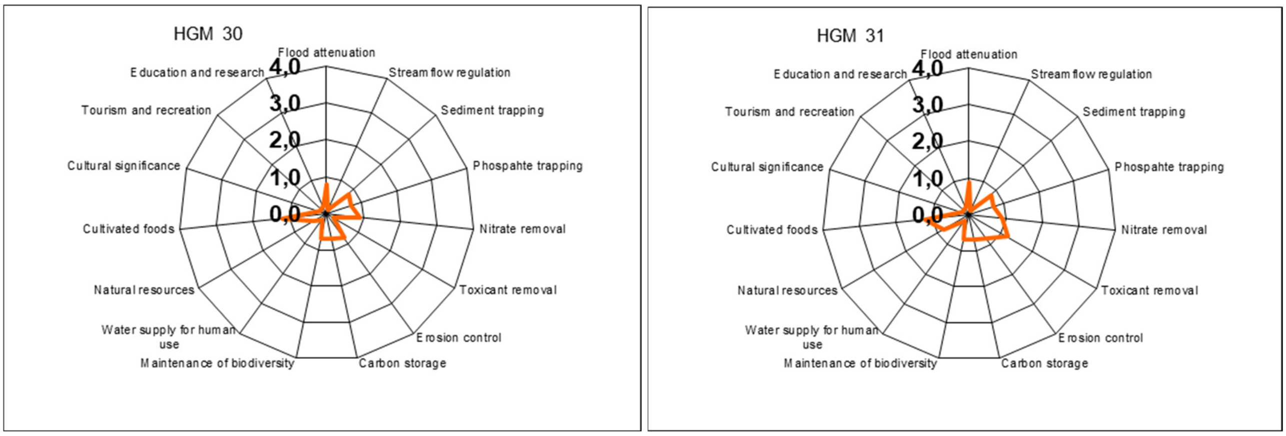


Figure 28: Radar diagrams depicting ecosystem services for HGM 30 and HGM 31

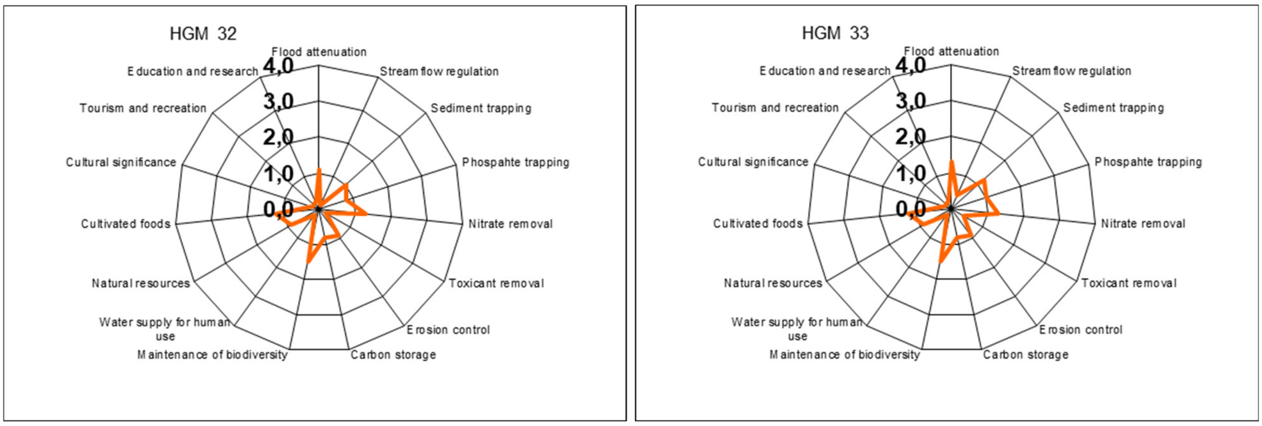


Figure 29: Radar diagrams depicting ecosystem services for HGM 32 and HGM 33

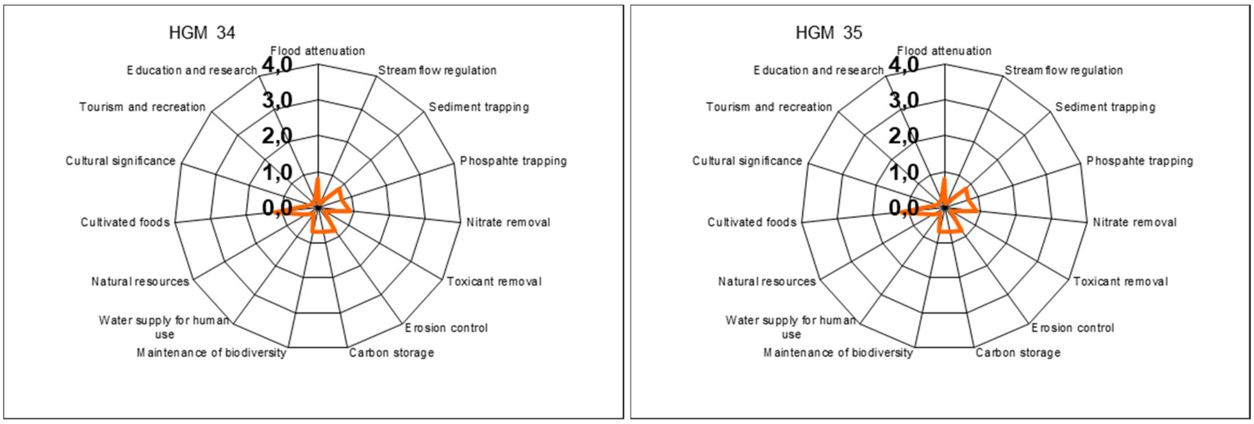
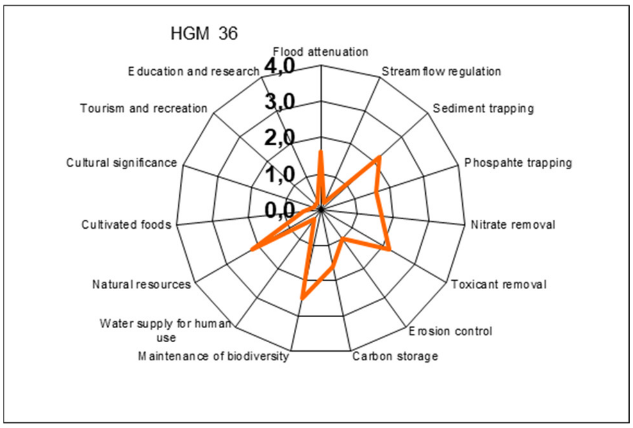


Figure 30: Radar diagrams depicting ecosystem services for HGM 34 and HGM 35



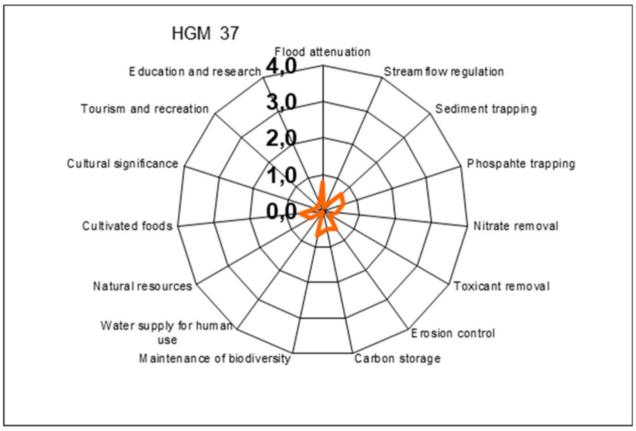


Figure 31: Radar diagrams depicting ecosystem services for HGM 36 and HGM 37

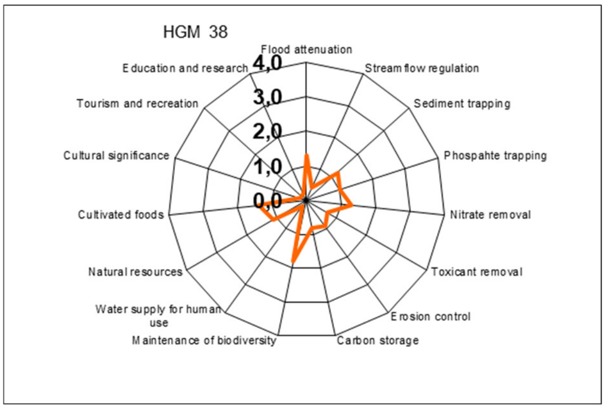


Figure 32: Radar diagram depicting ecosystem services for HGM 38

From a hydrological perspective, the largest impact on the pans within the study area were changes in land use through agriculture. Maize production occupies a large portion of the pan's catchments and has also infringed on the temporary zones of most of the pans. It would be anticipated that maize production resulted in changes to surface roughness and thereby impacted on water quality through changes in surface run-off characteristics and sediment transport.

It should however be noted that, according to the Macfarlane *et al.* (2009), the Wet-Health approach is applicable for the assessment of the Present Ecological State for all wetland types. However, for the assessment of wetlands not connected to a drainage network (such as endorheic pans), the geomorphology module could be excluded from the assessment, thus focussing on hydrology and vegetation for the determination of Present Ecological State (Macfarlane *et al.,* 2009). However, in the hydrology module, the scoring of "modification of existing channels" for evaluating changes to water distribution and retention patters within a wetland, and the scoring of "reduced floodpeaks" as a criterion in the evaluation of changes to water input characteristics from the catchment are not relevant for systems that do not form an intrinsic part of a drainage network (Ollis and Malan, 2014). In reality, this method is therefore most appropriate for the assessment of floodplain and valley-bottom wetlands (channelled and unchannelled), and (to a lesser degree) hillslope seeps connected to a drainage network, while it is not particularly well suited to the assessment of depressions (especially endorheic pans), wetland flats, or seeps that are not integrally connected to a watercourse (Ollis and Malan, 2014). As such, the application of the Wet-Health approach for the purpose of determining the PES of depression wetlands should be interpreted with caution.

Some of the supporting hillslope seepages as wella sthe pans themeselves have been largely impacted in several instances through agriculture and especially precision farming techniques as well as road infrastructure and invasive vegetation in a few instances, negatively affecting the drivers of these wetlands. PES and associated wetland functionality for wetlands were therefore reduced as a result of these anthropogenic impacts, with the wetlands scoring a PES Category C or D, representing moderately and mostly largely modified systems (Table 6).

Table 6: PES scores obtained for HGM 28 to HGM 38

HGM unit	Hydrology	Geomorphology	Vegetation	PES category
HGM 28	3.5	2.5	7.8	**D (4.3)**
HGM 29	2.5	2.0	5.0	**C (3.1)**
HGM 30	3.5	3.0	8.0	**D (4.5)**
HGM 31	3.0	3.0	6.4	**D (4.0)**
HGM 32	2.5	2.5	7.8	**D (4.0)**
HGM 33	4.5	4.0	7.2	**D (5.1)**
HGM 34	3.5	3.0	8.0	**D (4.6)**
HGM 35	3.5	3.0	9.0	**D (4.9)**
HGM 36	2.5	2.0	5.6	**C (3.2)**
HGM 37	3.5	3.0	8.5	**D (4.6)**
HGM 38	2.5	2.5	8.5	**D (4.2)**

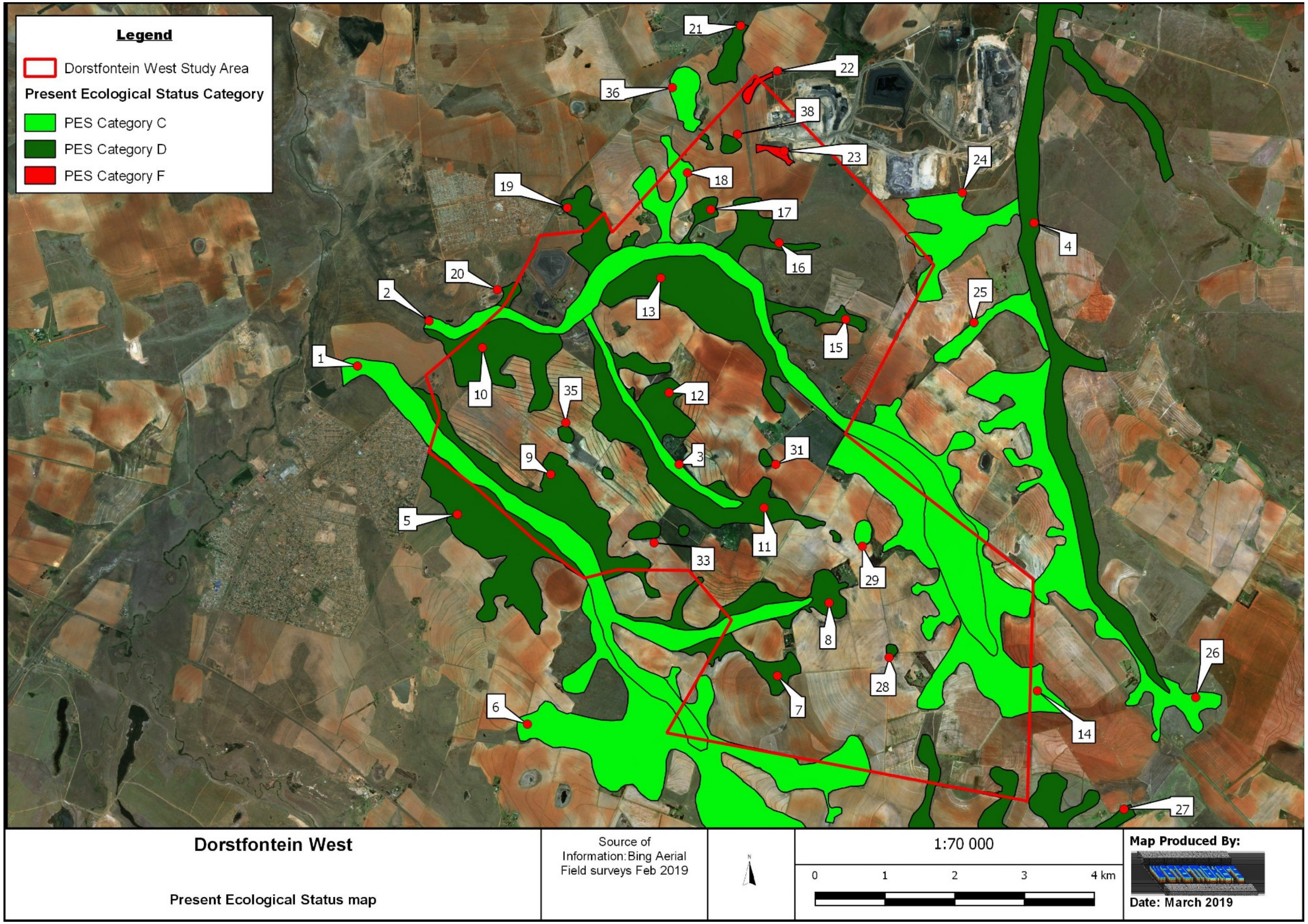


Figure 33: Present Ecological Status for wetlands within the study area and within 500m

3.5 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.

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). Ecological Importance and Sensitivity results for wetlands identified to be associated with the study area are listed in Table 7.

Table 7: Ecological Importance and Sensitivity scores for wetland complexes

Wetland	Parameter	Rating (0 -4)	Confidence (1 – 5)
HGM 1	Ecological Importance & Sensitivity	Moderate (2.6)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.3)	Moderate (2.0)
HGM 2	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.5)	Moderate (2.0)
HGM 3	Ecological Importance & Sensitivity	Moderate (2.1)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.3)	Moderate (2.0)
HGM 4	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	High (3.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.5)	Moderate (2.0)
HGM 5	Ecological Importance & Sensitivity	Low (1.6)	Low (1.2)

	Hydrological / Functional Importance	Moderate (2.1)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 6	Ecological Importance & Sensitivity	Moderate (2.0)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.9)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.4)	Moderate (2.0)
HGM 7	Ecological Importance & Sensitivity	Low (1.8)	Low (1.2)
	Hydrological / Functional Importance	Low (1.9)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.1)	Moderate (2.0)
HGM 8	Ecological Importance & Sensitivity	Moderate (2.1)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 9	Ecological Importance & Sensitivity	Moderate (2.0)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.4)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 10	Ecological Importance & Sensitivity	Low (1.2)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 11	Ecological Importance & Sensitivity	Moderate (2.1)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 12	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)
	Hydrological / Functional Importance	Low (1.9)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 13	Ecological Importance & Sensitivity	Low (1.4)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.1)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.3)	Moderate (2.0)
HGM 14	Ecological Importance & Sensitivity	Moderate (2.7)	Low (1.2)

	Hydrological / Functional Importance	Moderate (2.8)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.6)	Moderate (2.0)
HGM 15	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)
	Hydrological / Functional Importance	Low (1.9)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 16	Ecological Importance & Sensitivity	Low (1.7)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.1)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 17	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 18	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.9)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.4)	Moderate (2.0)
HGM 19	Ecological Importance & Sensitivity	Low (1.3)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 20	Ecological Importance & Sensitivity	Low (1.2)	Low (1.2)
	Hydrological / Functional Importance	Low (1.4)	Moderate (2.0)
	Direct Human Benefits	Low (1.1)	Moderate (2.0)
HGM 21	Ecological Importance & Sensitivity	Low (1.9)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.1)	Moderate (2.0)
HGM 22	Ecological Importance & Sensitivity	Very Low (0.3)	Low (1.2)
	Hydrological / Functional Importance	Very Low (0.3)	Moderate (2.0)
	Direct Human Benefits	Very Low (0.5)	Moderate (2.0)
HGM 23	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)

	Hydrological / Functional Importance	Very Low (0.2)	Moderate (2.0)
	Direct Human Benefits	Very Low (0.3)	Moderate (2.0)
HGM 24	Ecological Importance & Sensitivity	Moderate (2.5)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.6)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.4)	Moderate (2.0)
HGM 25	Ecological Importance & Sensitivity	Low (1.8)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.1)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.1)	Moderate (2.0)
HGM 26	Ecological Importance & Sensitivity	Moderate (2.6)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.5)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.4)	Moderate (2.0)
HGM 27	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.2)	Moderate (2.0)
HGM 28	Ecological Importance & Sensitivity	Low (1.5)	Low (1.2)
	Hydrological / Functional Importance	Low (1.5)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 29	Ecological Importance & Sensitivity	High (3.0)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 30	Ecological Importance & Sensitivity	Low (1.3)	Low (1.2)
	Hydrological / Functional Importance	Low (1.2)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 31	Ecological Importance & Sensitivity	Low (1.9)	Low (1.2)
	Hydrological / Functional Importance	Low (1.9)	Moderate (2.0)
	Direct Human Benefits	Low (1.9)	Moderate (2.0)
HGM 32	Ecological Importance & Sensitivity	Low (1.7)	Low (1.2)

	Hydrological / Functional Importance	Low (1.8)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 33	Ecological Importance & Sensitivity	Low (1.5)	Low (1.2)
	Hydrological / Functional Importance	Low (1.6)	Moderate (2.0)
	Direct Human Benefits	Low (1.9)	Moderate (2.0)
HGM 34	Ecological Importance & Sensitivity	Low (1.1)	Low (1.2)
	Hydrological / Functional Importance	Low (1.3)	Moderate (2.0)
	Direct Human Benefits	Low (1.8)	Moderate (2.0)
HGM 35	Ecological Importance & Sensitivity	Low (1.2)	Low (1.2)
	Hydrological / Functional Importance	Low (1.4)	Moderate (2.0)
	Direct Human Benefits	Low (1.3)	Moderate (2.0)
HGM 36	Ecological Importance & Sensitivity	High (3.2)	Low (1.2)
	Hydrological / Functional Importance	Moderate (2.0)	Moderate (2.0)
	Direct Human Benefits	Moderate (2.0)	Moderate (2.0)
HGM 37	Ecological Importance & Sensitivity	Very Low (0.8)	Low (1.2)
	Hydrological / Functional Importance	Very Low (0.7)	Moderate (2.1)
	Direct Human Benefits	Low (1.5)	Moderate (2.0)
HGM 38	Ecological Importance & Sensitivity	Moderate (2.0)	Low (1.2)
	Hydrological / Functional Importance	Low (1.8)	Moderate (2.1)
	Direct Human Benefits	Low (1.89	Moderate (2.0)

The valley bottom wetlands, HGM 1, HGM 2, HGM 3 and HGM 4 were regarded as having a high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment, more specifically the Olifants River.

The moderate Ecological Importance and Sensitivity assigned too many of the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing and fodder production which reduced the perceived biodiversity observed. However, as usual, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetlands (pans) in general received low scores for their Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and often incorporation into productions areas. However, HGM 29 and HGM 36 which were relatively large pans were considered intact from a hydrological and geomorphological perspective with a high Ecological Importance and Sensitivity assigned to them due to the perceived biodiversity associated with them.

4. ASSESSMENT OF IMPACTS

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the impacts caused by the proposed activities and to provide a description of potential mitigation required so as to limit the perceived impacts on the natural environment.

4.1 Impact Assessment Methodology

The environmental impacts are assessed with mitigation measures (WMM) and without mitigation measures (WOMM) and the results presented in impact tables which summarise the assessment. Mitigation and management actions are also recommended with the aim of enhancing positive impacts and minimising negative impacts.

In order to assess these impacts, the proposed development has been divided into two project phases, namely the construction and operational phase. The criteria against which these activities were assessed are discussed below.

Nature of the Impact
This is an appraisal of the type of effect the project would have on the environment. This description includes what would be affected and how and whether the impact is expected to be positive or negative.

Extent of the Impact
A description of whether the impact will be local, limited to the study area and its immediate surroundings, regional, or on a national scale.

Duration of the Impact
This provides an indication of whether the lifespan of the impact would be short term (0-5 years), medium term (6-10 years), long term (>10 years) or permanent.

Intensity
This indicates the degree to which the impact would change the conditions or quality of the environment. This was qualified as low, medium or high.

Probability of Occurrence
This describes the probability of the impact actually occurring. This is rated as improbable (low likelihood), probable (distinct possibility), highly probable (most likely) or definite (impact will occur regardless of any prevention measures).

Degree of Confidence
This describes the degree of confidence for the predicted impact based on the available information and level of knowledge and expertise. It has been divided into low, medium or high.

The following risk assessment was used to determine the significance of impacts:

Significance = (Magnitude + Duration + Scale) x Probability

The maximum potential value for significance of an impact is 100 points. Environmental impacts can thus be rated as high, medium or low significance on the following basis:

- High environmental significance 60 – 100 points
- Medium environmental significance 30 – 59 points
- Low environmental significance 0 – 29 points

Table 9 illustrates the scale used to determine the overall ranking.

Table 8: Scale used to determine significance ranking

Magnitude (M)		**Duration (D)**	
Description	**Numerical value**	**Description**	**Numerical value**
Very high	10	Permanent	5
High	8	Long-term (ceases at end of operation)	4
Moderate	6	Medium-term	5-15 years
Low	4	Short-term	0 – 5 years
Minor	2	Immediate	1
Scale (S)		**Probability (P)**	
Description	**Numerical value**	**Description**	**Numerical value**
International	5	Definite (or unknown)	5
National	4	High	4
Regional	3	Medium	3
Local	2	Low	2
Site	1	Improbable	1
None	0	None	0

4.2 Impact Assessment

Possible impacts and their sources associated with the proposed activities are provided in Table 10 (operational phase, including the expansion of the mine) and Table 11 (decommissioning phase). Some of the impacts are relevant during more than one phase and has therefore only been described once under the initial phase. The mine extension will likely include a new conveyor route and extension of the existing discard dump (Figure 9).

Table 9: Possible additional impacts arising during the construction and operational phase

Possible impact	Source of impact
Destruction of wetlands	Destruction of hydric soils, hydrophytic vegetation and changes to hillslope hydrology.
Sedimentation of wetland and increased erosion	Runoff from construction activities associated with clearing of natural vegetation and earthworks related activities
Pollution of water resources	Mobilisation of sediments, excavations removal and disturbances to vegetation, mobilisation of sulphur, hydrocarbon and pyrite compounds. Contamination of recharge, interflow and responsive zones. Discharge of polluted water. Lack of clean and dirty water separation

Altered hydrologic regime	Destruction of hydric soils, hydrophytic vegetation and changes to hillslope hydropedological characteristics

Table 10: Potential impacts during the Decommissioning Phase of the proposed project

Possible Risks	**Source of the Risk**
Loss of wetland function	Pollution from decant. Poor rehabilitation.
Decreased downstream water quality	Pollution from decant Poor rehabilitation.

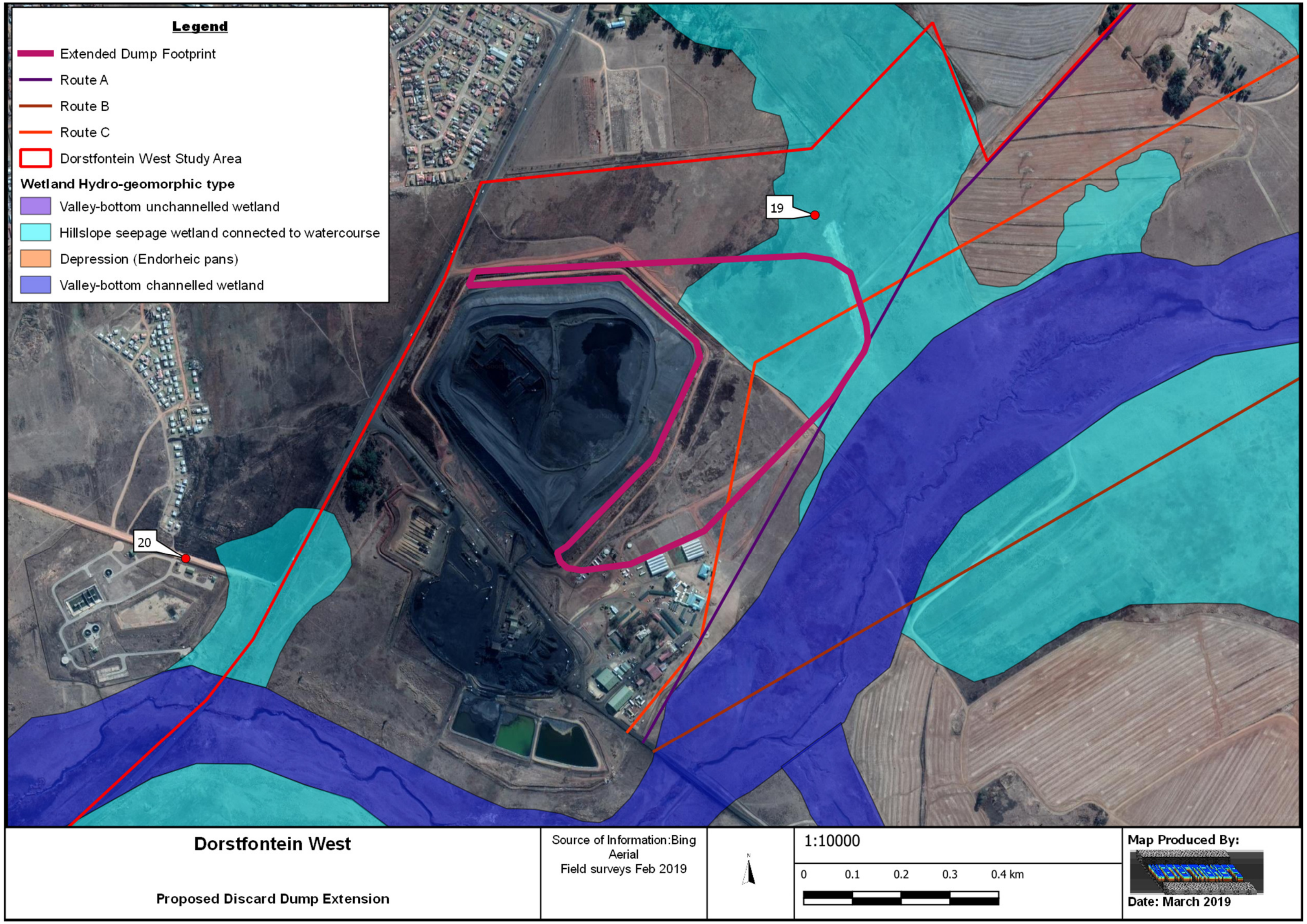


Figure 34: Proposed discard dump extension in purple

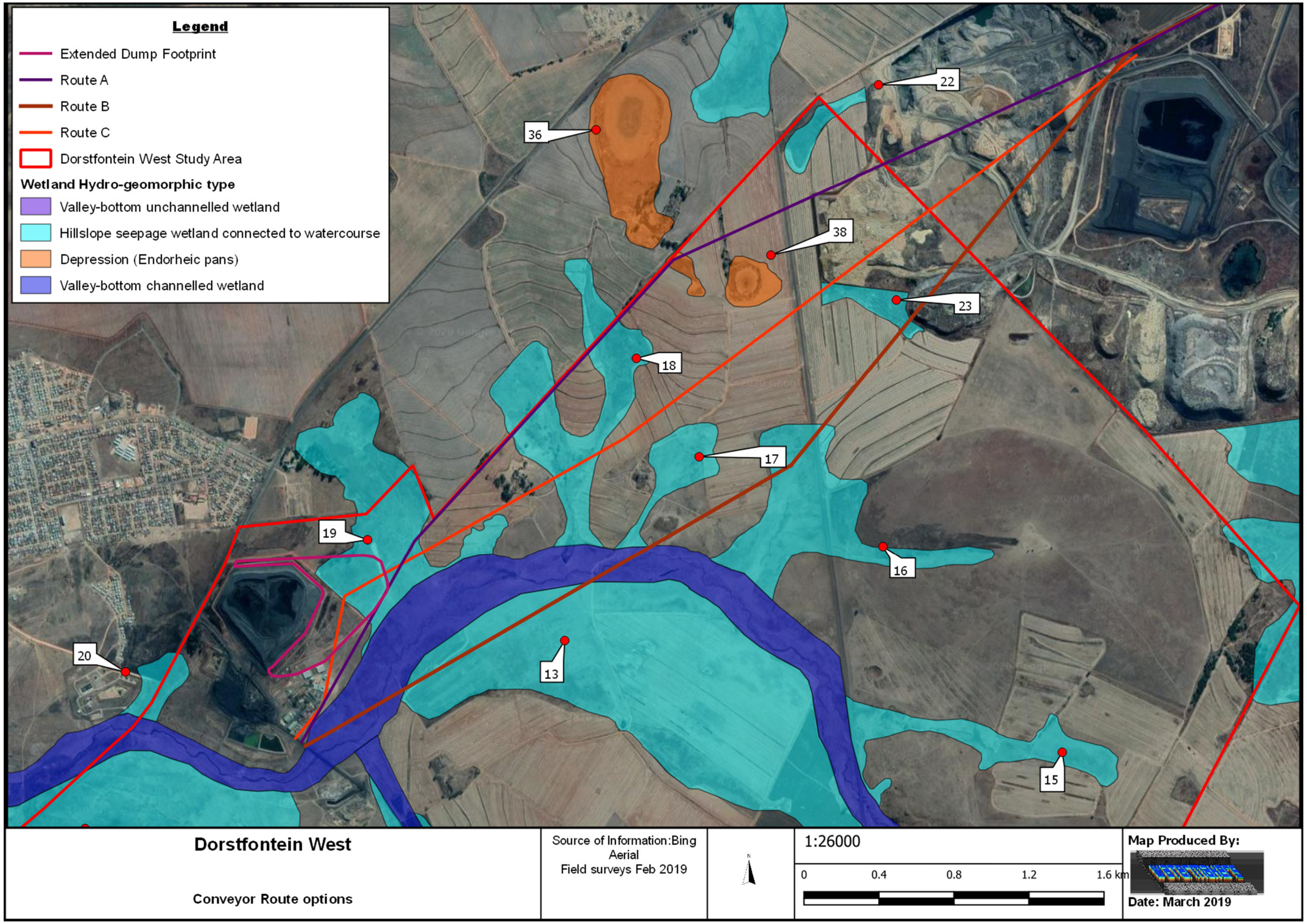


Figure 35: Proposed conveyor route options.

Construction and Operational Phase

Destruction and degradation of wetlands

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without mitigation measures	Regional (3)	Permanent (5)	High (8)	Definite (5)	High (80)	High
With mitigation measures	Local (2)	Medium term (3)	Moderate (6)	Medium (3)	Medium (33)	Low

Description of Impact

The footprint of new infrastructure and the expansion of the mine could infringe on or destroy wetland habitats. Further, the removal of natural vegetation and hydric soils will lead to the degradation of the surrounding wetland areas through the initiation of erosion processes and increased runoff of sediment into watercourses particularly during times of high rainfall.

As per the current proposed lay-out for the extension of the discard dump, a portion (8,4ha) of HGM 19 will be sterilised as a result of the proposed extension footprint. The sterilisation off wetland habitat represents a loss of 4,45 healthy wetland hectare equivalents which will have to be mitigated for. It is important to note that it is especially the recharge and interflow soils and associated hydropedological flow paths that could likely interact with the discard dumps that is of concern which could represent further potential loss of wetland habitat. The likely interacting hydropedological flowpaths associated with the local hillslopes will likely mobilise sulphites, pirites and various metals from the discard facility and be transported to the valley-bottom wetlands via hillslope seepage processes. In order to effectively predict and mitigate potential impacts on wetlands within the study, a hydropedological assessment including hillslope classification, flow quantification and modelling is highly recommended.

Two conveyor routes, Route A and Route B have been proposed, both routes will have some form of impact on wetlands due to the linear nature of the conveyor belt. Route A traverses HGM 18 higher up in in the catchment which contain significant seasonal and large permanent wetland zones. These seasonally and permanent wet areas will make the construction of the route demanding and likely result in a significant impact on HGM 19. Route B traverses the valley-bottom wetland (HGM 2) with high Hydrological and Functional Importance twice, diagonally for more than a kilometre in total, which could result in large negative long term impacts. The construction cost would also likely be significant in order for the conveyor to clear floodlines through engineering solutions. Crossing the wetlands diagonally is also not wanted as such linear development typically result in unnatural and concentrated flow paths which increases the risk of erosion and structure failure. Route C was also proposed initially which signifies the least amount of impact and shortest distance with much narrower and perpendicular wetland crossings. However, Route C is no longer deemed feasible due to planned future opencast mining within the route footprint, which leaves Route A as the option with the least potential impact from a wetland perspective, although site specific mitigation measures will have to be designed.

Mitigation Measures

- The outcome of the hydropedological assessment should determine the best option and final designs of the discard facility extension in terms of mitigation measures in base preparation and clean and dirty water separation design in order to prevent recharge and or interflow interaction between the discard facility and the vadose zone. A clean water cut-off trench, informed by the hydropedological study must be designed and installed on the northern side of the existing and extended discard dump footprint in order to prevent more clean water from being polluted within the vadose zone. The water must be routed and delivered to the unaffected eastern section of HGM 19 via a diffuse release intervention also to be designed in conjunction with the information obtained from the hydropedological study.
- A wetland mitigation and rehabilitation plan will have to be designed to compensate for a minimum loss of of 4,45 healthy hectare wetland equivalents (the final multiplication factor to be determined in conjunction with DWS)
- All soils, especially wetland soils within the footprint of the discard facility must be appropriately separated and stored. A soil management program must be implemented before construction are initiated in order to secure all wetland soils in situ as these will be utilised for mitigating wetland loss through the wetland mitigation and rehabilitation plan.
- For the conveyor routing, Route A should only be constructed during the winter months. A special works program must be implemented which ensures that a wetland specialist is part of the design and construction team (to minimise impacts on wetland habitat) and that the wetland monitoring program makes provision for increased monitoring intensity for the conveyor route specifically. The construction process must be supervised and signed off by a wetland specialist.
- Avoid mining activities in the wetland areas identified as far as possible through proper planning, demarcation and appropriate environmental training. It is recommended that the layout plan be revisited and optimised to take cognisance of the potentially directly affected HGM units and avoid them as far as possible by keeping the construction footprint as small as practically possible;
- Lay-out designs should incorporate wetland sensitive designs e.g. appropriate watercourse crossings that do not concentrate flows or impact on subsurface interflow. A wetland specialist must be appointed to guide engineers for the detailed designs;
- Management has the responsibility to inform members of staff of the need to be vigilant against any practice that will have a harmful effect on wetlands;
- Any proclaimed weed or alien species that germinate during the operational period shall be cleared by hand before flowering;
- The re-release of clean water from clean and dirty water separation infrastructure must be diffused and not reach wetland habitat as concentrated flows where it will have serious negative impacts on especially the valley bottom wetlands. The stormwater plan must include adequate attenuation facilities to ensure that peak flows do not cause negative impacts on wetlands. More specifically as a guideline, stormwater release structures must be designed to be released diffusely, mimicking seepage wetlands. All designs should be approved by an appropriately qualified wetland specialist;
- The design of drainage systems must ensure there is no contamination, eutrophication or increased erosion of the wetland areas. Drainage systems should be maintained regularly in order to minimize the runoff of harmful chemical substances into the wetland areas;

- The construction of surface stormwater drainage systems during the operational phase must be done in a manner that would protect the quality and quantity of the downstream system;
- Caution must be taken to ensure building materials are not dumped or stored within the proximity of the delineated wetlands;
- Emergency plans must be in place in case of spillages into wetland systems.
- 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;
- Erosion control of all banks must take place so as to reduce erosion and sedimentation into wetland areas;
- Littering and contamination of water sources during mining activities must be mitigated by effective camp management;
- All construction materials including fuels and oil should be stored in a demarcated area that is contained within a bunded impermeable surface to avoid spread of any contamination (outside of wetlands); and
- Where impacts could not effectively be mitigated or in instances where mitigation measures failed, a wetland off-set mitigation approach should be followed as a last resort. Appropriate wetlands studies should be conducted in order to facilitate such a process.

Sedimentation of wetlands and increased erosion

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**	**Confidence**
Without mitigation measures	Regional (3)	Medium-term (3)	High (8)	Definite (5)	High (70)	High
With mitigation measures	Local (2)	Short-term (2)	Moderate (6)	Moderate (3)	Medium (30)	Moderate

<u>Description of Impact</u>

The clearing of natural vegetation and the stripping of topsoil will result in increased runoff of sediment from the site into watercourses associated with the study area. This is particularly so during times of high rainfall and high winds. Water flowing down trenches and access roads, as well as movement of vehicles and personnel, could cause additional erosion processes and sediment to accumulate within the wetland areas. The potential siltation of the wetland system would alter geomorphologic functioning, the movement of water through the system (hydrological functioning) as well as having an impact on water quality within the resource. In addition, hardened surfaces and bare areas are likely to increase surface run off velocities and peak flows received by wetlands. Further, the installation of clean and dirty water separation infrastructure could cause concentrated flows from reaching the wetland and initiate erosion processes, or add to the present erosion problems.

<u>Mitigation Measures</u>

- A phased planned approach must be taken when construction is initiated. Areas must only be stripped directly prior to construction and only expose soils to erosion for the minimum period necessary. Where possible, re-vegetation of areas must be implemented as soon as possible;
- An effective stormwater and clean and dirty water separation system (that includes serviceable sedimentation basins) must be designed and approved by a wetland specialist as part of the WUL. Erosion control and stormwater infrastructure must form the basis of the initial construction activities, prior to production related construction activities;
- Topsoil and subsoil must be stockpiled separately in low heaps;
- Stockpile any topsoil or any overburden material at least 40m outside of the outer boundary of wetlands;
- Erosion must not be allowed to develop on a large scale before effecting repairs;
- A wetland monitoring program should be initiated before the start of the construction phase. The Environmental Control Officer should be briefed by a wetland specialist on specific monitoring issues. An inspection of clean and dirty water separation infrastructure and stormwater infrastructure needs to take place after each large rain event. Appropriate mitigation needs to be implemented after consultation with relevant specialist if any problems are detected;
- Make use of existing roads and tracks where feasible rather than creating new routes through vegetated areas;
- Vegetation and soil must be retained in position for as long as and wherever possible, and only removed immediately ahead of construction / earthworks in that area (DWAF, 2005). Topographical profiling and revegetation must take place as soon as a section is completed;
- Runoff from roads must be managed to avoid erosion and pollution problems;
- All areas susceptible to erosion must be protected (e.g. silt screens, sandbags, swales, haybales etc.) and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and or work areas;
- Areas exposed to erosion due to construction should be vegetated with appropriate species naturally occurring in the area; and
- Surface water or storm water must not be allowed to concentrate, or flow down cut or fill slopes without erosion protection measures being put in place.

Pollution of water resources

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**	**Confidence**
Without mitigation measures	Regional (3)	Long-term (4)	High (8)	High (4)	High (60)	High
With mitigation measures	Local (2)	Short-term (2)	High (8)	Moderate (3)	Medium (42)	Low

Description of Impact

Hydrocarbon-based fuels or lubricants spilled from construction vehicles, construction materials that are not properly stockpiled, and litter deposited by construction workers may be washed into the surface water bodies. Coal and coal discard spillages, the mobilisation of sediments, excavations, removal and disturbances to vegetation, mobilisation of sulphur, hydrocarbon and or pyrite compounds could have various negative impacts on wetlands and their associated functionality.

Should appropriate toilet facilities not be provided for construction workers at the construction crew camps, the potential exists for surface water resources and surroundings to be contaminated by raw sewage. The utilisation of the water courses for disposal of water used for washing will decrease the abundance and diversity of aquatic macro-invertebrates inhabiting the section of the wetlands and freshwater ecosystems downstream. Contaminated runoff from concrete mixing and sediment release as well as hydrocarbon spillages may lead to the infiltration of pollutants into recharge, interflow or responsive soils with potential negative impacts on freshwater ecosystems downstream.

Mitigation Measures

- For the conveyor route, a special works program must be implemented which ensures that a wetland specialist is part of the design and construction team (to minimise impacts on wetland habitat) and that the wetland monitoring program makes provision for increased monitoring intensity for the conveyor route specifically.
- An emergency response plan must be implemented to clean and remediate any coal spillages as soon as they happen in order to prevent carbonaceous and harmful derivative materials from being washed into watercourses through either surface or hydropedological pathways. Particular care must be taken within the design to ensure that watercourse (wetlands) crossings are the least vulnerable areas for spillages and that emergency response plans rank and regard wetland areas as priority sections.
- Construction vehicles are to be maintained in good working order so as to reduce the probability of leakage of fuels and lubricants;
- Emergency plans and infrastructure to deal with spillages (especially hydro-carbon spillages) must be in place, this should include mobile response units to deal with spillages in the field;
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas;
- Storage of potentially hazardous materials should be above any 100-year flood line, or as agreed with the Environmental Control Officer. These materials include fuel, oil, cement, bitumen etc.;
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils;
- All construction materials liable to spillage are to be stored in appropriate structures with impermeable flooring;
- Portable septic toilets are to be provided and maintained for construction crews. Maintenance must include their removal without sewage spillage;
- Under no circumstances may ablutions occur outside of the provided facilities;

- No uncontrolled discharges from the construction crew camps to any surface water resources shall be permitted. Any discharge points need to be approved by the relevant authority;
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water Affairs must be informed immediately;
- Store all litter carefully so it cannot be washed or blown into any of the water courses within the study area;
- Provide bins for construction workers and staff at appropriate locations, particularly where food is consumed;
- The construction site should be cleaned daily and litter removed; and
- Conduct ongoing staff awareness programs so as to reinforce the need to avoid littering.

Altered hydrological regime

	Scale	Duration	Magnitude	Probability of occurrence	Significance	Confidence
Without mitigation measures	Regional (3)	Permanent (5)	High (8)	High (4)	High (64)	Medium
With mitigation measures	Local (2)	Long-term (4)	Moderate (4)	Medium (3)	Medium (30)	Low

<u>Description of impact</u>

The establishment and or extension of a discard facility will cause reduction of recharge areas and or impact significantly on interflow soils and or cause the destruction of responsive soils within effected wetland areas themselves which would result in significant changes to the hydrological regime of the local hillslope hydropedology. As mentioned previously, the outcome of the hydropedological assessment should determine the best mitigation designs for the discard facility extension including base preparation, clean and dirty water separation design (including clean water cut-off trench on the northern side of the facility as well as diffuse release intervention) in order to prevent recharge and or interflow interaction between the discard facility and the vadose zone. Mitigation design should always attempt to mimic the local hillslopes natural hydropedological regimes through applying appropriate attenuation and diffused, slow release mechanisms downstream of the discard facilities (clean water).

Further, the presence of hard impermeable surfaces associated with discard and conveyor route facilities such as roads, parking areas and roofs, will result in an increase in stormwater runoff volume and velocity. The increase of surface water runoff and the decrease of infiltration will result in an increase in erosion potential and sedimentation. Attenuation of surface water runoff and its subsequent diffused release are imperative to control erosion on site and not accentuate the problem. The development of a comprehensive surface runoff and stormwater management plan is therefore required, indicating how all surface runoff generated as a result of the development (new mining development and operational phase) will be managed (e.g. artificial wetlands / bio-retention / stormwater and flood retention ponds) prior to entering any natural drainage system or wetland. This plan should also indicate how surface runoff will be retained outside of any demarcated watercourses and subsequently released to simulate natural hydrological regimes.

Mitigation Measures

- Results of hydropedological investigation to be incorporated into the lay-out design in conjunction with a wetland specialist, including base preparation, clean and dirty water separation design (clean water cut-off trench on the northern side of the facility as well as diffuse release intervention);
- Implement an ecologically-sensitive stormwater management plan that includes not allowing stormwater to be discharged directly into the identified watercourse and drainage lines and seepage wetland areas.

6.2.2 Decommissioning phase

Loss of wetlands.

	Scale	**Duration**	**Magnitude**	**Probability of occurrence**	**Significance**
Without mitigation measures	Local (3)	Long term (4)	Moderate (6)	Definite (5)	High (65)
With mitigation measures	Local (3)	Long term (4)	Low (4)	Medium (3)	Medium (33)

Description of Impact

Surface facilities such as conveyor belt and discard facility could infringe and destroy wetland habitat and functions that overlap these areas, however there are opportunity to rehabilitate these wetlands status after proposed activities have ceased.

Mitigation Measures:

- Route and discard dump options should be chosen as per criteria in previous sections;
- Stockpile all wetlands soils to be impacted separately according to various soil horizons and not higher than 2,5m; and
- Where the above is not possible, it is recommended that a compensation mechanism or wetland offset approach be considered as there are many rehabilitation opportunities within the vicinity of the study area which can increase wetland functionality and support to the Olifants River downstream.

Decreased downstream water quality.

	Scale	Duration	Magnitude	Probability of occurrence	Significance
Without mitigation measures	Regional (3)	Long term (4)	Moderate (6)	Definite (5)	High (65)
With mitigation measures	Local (3)	Long term (4)	Low (4)	Medium (3)	Medium (33)

Description of Impact

Coal discard facilities after a number of years often emanate polluted seepage through hydropedological pathways to deliver pollutants into the downstream watercourses. If decant occur from the underground mining at topographical low points downstream following inundation it is likely to affect the ecology and wetlands within and downstream of the present study area. While it has been determined that oxidation reactions will generally decrease in flooded spoils and underground areas, all spoils above the final flooded or decant elevation will remain reactive for an extended period of time.

Mitigation Measures:

In addition to the above mitigation measures of geohydrological and hydropedological assessments mentioned in the Construction and Operational Phase, measures taken during the decommissioning phase will add value to minimising the future impacts associated with the proposed developments. Such measures include:

- An appropriate wetland and hillslope monitoring program must be implemented prior to the start of the construction phase;
- Appropriate wetland rehabilitation design and implementation must ensure that wetland functionality is restored;
- The re-release of clean water from clean and dirty water separation infrastructure must be diffused and not reach the wetland as concentrated flows where it will have serious negative impacts on the valley-bottom wetland soils. The stormwater plan must include adequate attenuation facilities to ensure that peak flows do not cause negative impacts on wetlands. More specifically as a guideline:
  - Post development flows for frequent, average every afternoon type storm event 6 mm over 2 hours, will not exceed pre development flows.
  - Post development velocities associated with the 1:5 year return event storm will be within 25% of predevelopment velocities.

5. CONCLUSION AND RECOMMENDATIONS

Thirty-eight separate hydro-geomorphic units (HGM), comprising four HGM types, namely unchannelled valley bottom wetlands, channelled valley bottom wetlands hillslope seepage wetlands connected to a watercourse and depressions (pans), were delineated and classified within the study area and within 500m surrounding the study area

Wetlands within the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increased biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes

Combined area weighted Wet-Health results indicated that the wetlands from the study area have been moderately to largely altered in most instances as a result of changes in water inputs (derived from its catchment) and water retention and distribution patterns within the wetlands units, as well as vegetation changes within the wetlands and surrounding catchments due to historic and current anthropogenic impacts.

The valley bottom wetlands, HGM 1, HGM 2, HGM 3 and HGM 4 were regarded as having a high Hydrological and Functional Importance as a result of the relatively intact nature and various important ecosystem services they provide. Direct human benefits were associated with the provision of natural resources as well as grazing opportunities afforded by most wetlands within the study area. Collectively, the valley bottom systems along with their supporting hillslope seepages, play an important role in contributing to good water quality and quantity to the downstream environment, more specifically the Olifants River.

The moderate Ecological Importance and Sensitivity assigned too many of the hillslope seepage wetland units can be attributed to the relatively intact hydrological and geomorphological nature associated with the wetlands and their associated catchments. Most seepages have been heavily utilised for especially grazing and fodder production which reduced the perceived biodiversity observed. However, as usual, further multiple seasonal biodiversity studies focused within wetland habitat would be required in order to increase the confidence levels with regards to the identification of species of conservation concern.

The depression wetlands (pans) in general received low scores for their Hydrological and Functional Importance as well as their Ecological Importance and Sensitivity as a result of several anthropogenically driven impacts and often incorporation into productions areas. However, HGM 29 and HGM 36 which were relatively large pans were considered intact from a hydrological and geomorphological perspective with a high Ecological Importance and Sensitivity assigned to them due to the perceived biodiversity associated with them

The impact assessment identified the destruction of wetland habitat, surface water pollution including sedimentation as well as increased erosion, altered hydrological regimes, loss of wetland functionality and decreased downstream water quality as the major 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:

- An appropriate wetland and hillslope monitoring program must be implemented prior to the start of the construction phase;
- Appropriate wetland rehabilitation design and implementation must ensure that wetland functionality is restored;
- The outcome of the hydropedological assessment should determine the best option and final designs of the discard facility extension in terms of mitigation measures in base preparation and clean and dirty water separation design in order to prevent recharge and or interflow interaction between the discard facility and the vadose zone. A clean water cut-off trench, informed by the hydropedological study must be designed and installed on the northern side of the existing and extended discard dump footprint in order to prevent more clean water from being polluted within the vadose zone. The water must be routed and delivered to the unaffected eastern section of HGM 19 via a diffuse release intervention also to be designed in conjunction with the information obtained from the hydropedological study.
- A wetland mitigation and rehabilitation plan will have to be designed to compensate for a minimum loss of of 4,45 healthy hectare wetland equivalents (the final multiplication factor to be determined in conjunction with DWS)
- All soils, especially wetland soils within the footprint of the discard facility must be appropriately separated and stored. A soil management program must be implemented before construction are initiated in order to secure all wetland soils in situ as these will be utilised for mitigating wetland loss through the wetland mitigation and rehabilitation plan.
- For the conveyor routing, Route A should only be constructed during the winter months. A special works program must be implemented which ensures that a wetland specialist is part of the design and construction team (to minimise impacts on wetland habitat) and that the wetland monitoring program makes provision for increased monitoring intensity for the conveyor route specifically. The construction process must be supervised and signed off by a wetland specialist.

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APPENDIX A – Methodology

Wetland Delineation

The report incorporated a desktop study, as well as field surveys, with site visits conducted during February 2019. 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; and
- 5m contour data.

A pre-survey wetland delineation was performed in order to assist the field survey. Identified wetland areas during the field survey were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These potential wetland 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). 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 (Figure 38).

Wetland Functionality

The methodology “Wet-EcoServices” (Kotze et al., 2008) was adapted and used to assess the different benefit values of the wetland units. A level one assessment, including a desktop study and a field assessment were performed to determine the wetland functional benefits between the different hydro-geomorphological types within the study area. Other documents and guidelines used are referenced accordingly. During the field survey, all possible wetlands and drainage lines identified from maps and aerial photos were visited on foot. Where feasible, cross sections were taken to determine the state and boundaries of the wetlands. Following the field survey, the data was submitted to a GIS program for compilation of the map sets. Subsequently the field survey and desktop survey data were combined within a project report.

In order to gauge the Present Ecological State of various wetlands within the study area, a Level 2 Wet-Health assessment was applied in order to assign ecological categories to certain wetlands. Wet-Health (Macfarlane et al., 2008) is a tool which guides the rapid assessment of a wetland's environmental condition based on a site visit. This involves scoring a number of attributes connected to the geomorphology, hydrology and vegetation, and devising an overall score which gives a rating of environmental condition.

Wet-Health is useful when making decisions regarding wetland rehabilitation, as it identifies whether the wetland is beyond repair, whether rehabilitation would be beneficial, or whether intervention is unnecessary, as the wetland's functionality is still intact. Through this method, the cause of any wetland degradation is also identified, and this facilitates effective remediation of wetland damage. There is wide scope for the application of Wet-Health as it can also be used in assessing the Present Ecological State of wetlands and thereby assist in determining the Ecological Reserve as laid out under the National Water Act. Wet-Health offers two levels of assessment, one more rapid than the other.

For the assessments, an impact and indicator system were used. The wetland is first categorized into the different hydrogeomorphic (HGM) units and their associated catchments, and these are then assessed individually in terms of their hydrological, geomorphologic and vegetation health by examining the extent, intensity and magnitude of impacts, of activities such as grazing or draining. The extent of the impact is measured by estimating the proportion the wetland that is affected. The intensity of the impact is determined by looking at the amount of alteration that occurs in the wetland due to various activities. The magnitude is then calculated as the combination of the intensity and the extent of the impact and is translated into an impact score. This is rated on a scale of 1 to 10, which can be translated into six health classes (A to F – compatible with the EcoStatus categories used by DWAF, Table 19). Threats to the wetland and its overall vulnerability can also be assessed and expressed as a likely Trajectory of Change.

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 12: Interpretation of scores for determining present ecological status (Kleynhans 1999)

Rating of Present Ecological State (Ecological Category)
CATEGORY A Score: 0-0.9; Unmodified, or approximates natural condition.
CATEGORY B Score: 1-1.9; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C Score: 2 – 3.9; Moderately modified, but with some loss of natural habitats.
CATEGORY D Score: 4 – 5.9; Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E Score: 6 -7.9; Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F Score: 8 - 10; Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean

Table 13: 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 14: 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.