**May 2016**

# Baseline wetland delineation and assessment for the proposed De Roodepoort Colliery, Mpumalanga


***Prepared by:***

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***Submitted to:***


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| **Report Title**: | Baseline wetland delineation and assessment for the proposed De Roodepoort Colliery, Mpumalanga |
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| **Client**: | Limosella Consulting |
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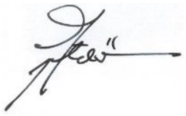
# Declaration

We, Anton Linström and Lulu van Rooyen, declare that -

- I/We act as independent specialists;
- I/We do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2010;
- I/We will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I/We declare that there are no circumstances that may compromise my/our objectivity in performing such work;
- I/We have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I/We will comply with the Act, regulations and all other applicable legislation;
- I/We have no, and will not engage in, conflicting interests in the undertaking of the activity;

- I/We undertake to disclose to the applicant and the competent authority all material information in my/our possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself/ourselves for submission to the competent authority; and
- All the particulars furnished by me/us in this form are true and correct



Signature of specialists

Date: 08 May 2016

# EXECUTIVE SUMMARY

***INTRODUCTION***

*The specialists were approached to conduct a wetland delineation and assessment for the proposed De Roodepoort Colliery outside Ermelo, Mpumalanga. The De Roodepoort mine will be an underground mine. Mining will be undertaken by means of underground board and pillar methods, which will be accessed via a boxcut. No surface disturbance is expected to occur on the remaining farm portions with the exception of ventilation shafts.*

***LEGISLATIVE STATURE OF WETLANDS***

*This study is required as part of the EIA requirements. All water courses are protected by law and no development is allowed to negatively impact on wetlands and river vegetation. Authoritative legislation that lists impacts and activities on wetlands that requires authorisation include the:*

- *Conservation of Agriculture Resources Act, 1983 (Act No. 43 of 1983);*
- *Environment Conservation Act, 1989 (Act No. 73 of 1989);*
- *National Water Act, 1998 (Act No. 36 of 1998);*
- *National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended; and*
- *National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004).*

*If any encroachment into wetlands takes place, or within the 500m boundary of a wetland, a Water Use License will be required from Department of Water Affairs (DWA) under Section 21 of the National Water Act (Act 36 of 1998).*

***SCOPE OF WORK***

- *Identify, classify, and assess the integrity of the wetland areas;*
- *Delineate a buffer area around the wetlands;*
- *Determine the Present Ecological State (PES) of the wetland units and riparian;*
- *Determine the Ecological Importance and Sensitivity (EIS) of the wetland units; and*
- *Impact assessment and mitigation measures.*

***LIMITATIONS OF THIS INVESTIGATION***

*The following was assumed for the purposes of this project:*

- *The information supplied by the client was correct at the time that fieldwork commenced.*
- *The study area covers the mining right area, and those areas to be mined fall well within this area. Delineation of wetlands within the 500m radius from the edge of the proposed mining area following GN1199 of the NWA might require additional mapping if located on the edge of the mining right area.*

*The following limitations affected the study:*

- *A single baseline assessment was conducted.*
- *Accuracy of the maps, aquatic ecosystems, routes and desktop assessments were made using the current 1:50 000 topographical map series of South Africa and Google Earth.*
- *Delineations and related spatial data generated will be supplied in kml/kmz format.*
- *Accuracy of Global Positioning System (GPS) coordinates was limited to 15 m accuracy in the field.*
- *Wetland and riparian zone reference points were identified during a desktop study and verified during the field visit. Some representative transects in each wetland unit on site was surveyed. However, it was relied on satellite and Google Earth imagery to aid the delineation of especially the seep wetland boundaries (the verified field delineation being a benchmark for image interpolation), due to budget constraints limiting time in field.*
- *The north-western section of the site (Portion 8) was delineated by means of a desktop study.*
- *Every effort was made to delineate wetland boundaries as accurately as possible within the project constraints. However, it is suggested that a more detailed wetland delineation and assessment is conducted around the proposed infrastructure location (with the assistance of a land surveyor with*

*accurate GPS equipment), in order to determine the precise boundaries of and impacts to the wetlands in the immediate vicinity of the proposed infrastructure.*

***THE STUDY AREA***

*The study area falls within the Gert Sibande District Municipality, Nsukaligwa Local Municipality, Mpumalanga Province, and is situated approximately 5.5 km west of the town of Ermelo. It falls within two vegetation units: Soweto Highveld Grassland and Amersfoort Highveld Clay Grassland. The study area is essentially made up of three land types: Ea20, Ea23 and Ca3. According to the MBSP terrestrial assessment, the study area includes large areas classified as 'CBA Irreplaceable' and 'CBA Optimal' as well as several 'ESA local corridors' and a few 'Other Natural Areas'; there are also large portions classified as 'Heavily Modified' with some 'Moderately Modified: Old lands'. The study area falls within quaternary catchment C11F, which forms part of the Upstream Vaal Dam Sub-water Management Area, Upper Vaal Water Management Area. According to the MBSP freshwater assessment, there are no wetlands within the study area and very few in the immediate vicinity. The MBSP has classified the study area as 'Heavily Modified', as well as 'Other Natural Areas'; there are also a few dams within and just outside of the study area. According to the NFEPA river classification, the study area falls within an Upstream Management Area. Several non-perennial rivers run through the study area, including the Klein-Xspruit. According to the new MHWet data layer, there is an extensive wetland system within the study area, incorporating several hydro-geomorphic wetland types, namely: floodplain wetland, channelled valley bottom wetland and seep. These wetlands have a condition of A, B, or C. All the wetlands within the study area are wetland FEPAs.*

***METHODOLOGY***

- *Wetland areas were identified, classified, and preliminarily delineated during a desktop assessment.*
- *Field verification points were set out during the desktop assessment. It was ensured that at least one representative transect were placed in each wetland system on site to verify wetland conditions.*
- *The site visit was conducted during 7 – 9 March and 6 – 8 April 2016.*
- *The results of the field verification were interpolated for the study area during a post-site visit desktop assessment. The wetland systems were divided into HGM units, delineated and mapped using Google Earth Pro and QGIS 2.0.1.*
- *The PES (Wet-Health) and EIS were determined of the wetland systems on site. A Level 1 Wet-Health was applied.*

***Wetland Identification and classification***

*The wetlands were delineated by making use of the Terrain unit indicator, the Soil wetness indicator and the vegetation indicator. Wetlands were classified according to its HGM setting. Rivers with riparian areas can be described as those areas with "Vegetation which is found in close proximity to rivers in a clearly defined riparian zone and which dependant on the river for a number of functions. It displays structural, compositional and functional characteristics which are clearly distinct from the fringing terrestrial vegetation and is distributed according to clear inundation and other functional gradients."*

*The mapping of the wetlands was done in Google Earth and QGIS 2.0.1. 1:50 000 topographic maps and GPS points were used to supplement. The main drainage systems on site were mapped.*

***Wetland Integrity Assessments***

*Three tools were utilized to determine ecological health, sensitivity, and status namely the Riparian Vegetation Response Assessment Index (VEGRAI) (for the riparian areas on site) (Kleynhans 2006); the WET-Health tool Level 1 (Macfarlane et al. 2007); and the Ecological Importance and Sensitivity (Kleynhans 2007).*

***RESULTS AND DISCUSSION***

*Wetland Identification and Classification*

*Approximately 140 points were sampled in the study area. Four palustrine wetland types including riparian areas were identified: Riparian areas, Valley bottom wetlands with a channel, Valley bottom wetlands without a channel, Hillslope seeps (feeding a water course), and Isolated hillslope seeps (not feeding a water course).*

*The* ***Terrain unit indicator:*** *Most of the large systems occurred in the valley bottoms. However, a large amount of seep zones were identified in the study site, which had no association with a specific terrain unit. These were identified with the soil- and vegetation indicators.*

*The* ***Soil Form indicator*** *was not used in this study.*

*The* ***Soil wetness indicator:*** *The wetland soils encountered during the survey varied widely, but in most cases there were clear signs of wetness within 500 mm of the surface.*

*The* ***vegetation indicator*** *was a very important indicator during this study, except in cases where the vegetation has been altered (old/current agricultural fields) or completely removed (erosion); in which cases more was relied on other indicators. The wetlands comprise mainly of herbaceous vegetation with grasses in the temporary wet zones (wet to damp grass meadow) which grades into a narrow grass/sedge dominated seasonal wet zone and then into the dominant permanent wet zone. The average height of the vegetation in the wetlands areas is 0.3m with diagnostic species such as grasses:* Leersia hexandra, Themeda triandra, Setaria sphacelata, Diheteropogon amplectens, Cynodon dactylon, Sporobolus africanus, and Eragrostis curvula*. The forbs observed included* Alisma plantago-aquatica, Albuca setose, Hypoxis acuminate, *and* Striga bilabiata. *Other species occurring are* Eulophia welwitschii, Argyrolobium harveyanum, Trifolium africanum *var* lydenburgense, Hewittia sublobata, Acalypha angustata, Aponogeton junceus, Stoebe vulgaris, Senecio coronatus, Berkheya radula, Haplocarpha scaposa, Sutera aurantiaca, Verbena venosa, Striga bilabiata, Mimulus gracilis, Drimiopsis burkei, Ledebouria ovatifolia, Ledebouria cooperi, Pycnostachys reticulate, Triflorum pratense, Senecio erubescens, Pelargonium luridum, Helichrysum rugulosum, Commelina bengalensis, *etc. Shrubs occur sporadic in the study area and included* Protasparagus laricinus *and* Rhus pyroides*. Two species,* Aloe ecklonis *and* Crinum cf. bulbispermum *are protected in terms of the regulations of the Mpumalanga Nature conservation Act 10 of 1998.*

*Exotic species identified are* Bidens pilosa, Verbena bonariensis, Bromus cathartica, Pennisetum clandestinum, Paspalum urvillei, Tragopogon dubius, Oxalis obliquifolia, Persicaria decipiens, Persicaria senegalensis, Myriophyllum aquaticum, Gleditsia triacanthos, Salix babylonica, Pyracantha angustifolia*, etc.*

***Buffer Zones***

*A width of 100 m is recommended for the wetlands in the study area.*

***Other sensitive species and habitats***

*The sandstone ridges present in the study area are deemed to be sensitive wetland habitat, due to the extensive associated seep areas. It is therefore proposed that all the delineated ridges are conserved alongside the wetland systems.*

***Wetland Integrity Assessments***

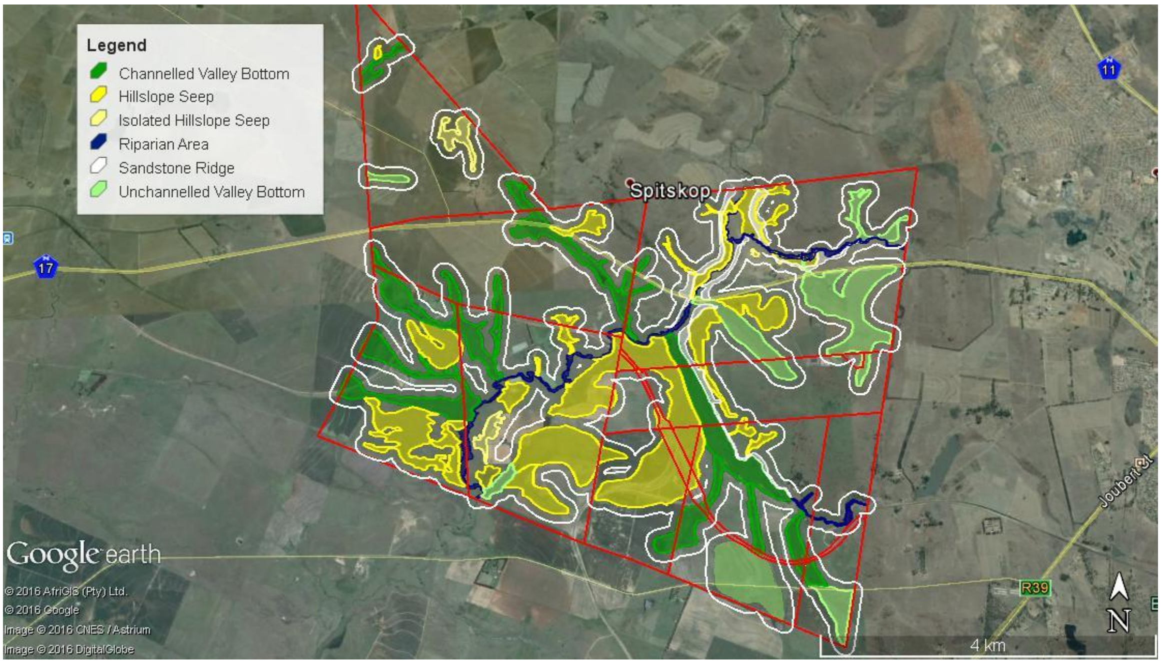
*1. VEGRAI*

*A total of 4 sites have been selected for VEGRAI assessments, which are representative of the riparian areas in the study area.*

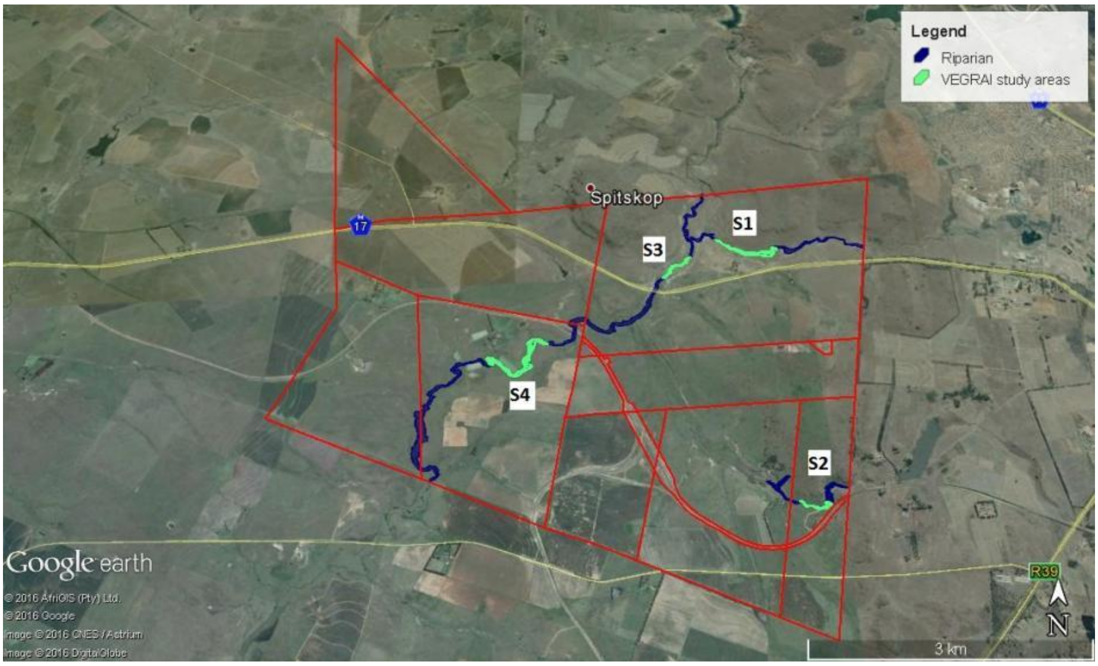
*Site 1: The Riparian Index of Habitat Integrity (RIHI) is a C/D (58%) with the main impacts being scouring of the marginal zone. Exotic trees, water quality and water flow modifications due to road crossings and a sewage plant upstream. The PES trend is negative. To determine the PES EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence rating are included in the EcoStatus assessment index. The EcoStatus EC is a C/D (58%).*

*<u>Site 2:</u> The Riparian Index of Habitat Integrity (RIHI) is a B/C (78.4%) with the main impacts being erosion and overgrazing. Water quantity and water flow modifications due to dam in upstream portion of the river. The PES trend is stable. The EcoStatus EC is a B/C (78.4%).*

*<u>Site 3:</u> The Riparian Index of Habitat Integrity (RIHI) is a C (64.2%) with the main impacts being overgrazing. Exotic hydrophytes and trees, water quality and water flow modifications due to dams upstream and a sewage plant. The PES trend is stable. The EcoStatus EC is a C (64.2%).*




***Wetland delineation with a 100 m buffer zone (white line). Shaded polygons: Blue = Riparian; light green = Unchannelled Valley Bottom; dark green = Channelled Valley Bottom; dark yellow = Hillslope seep connected to a channel; light yellow = Hillslope seep not connected to a channel; White = sandstone ridges.***



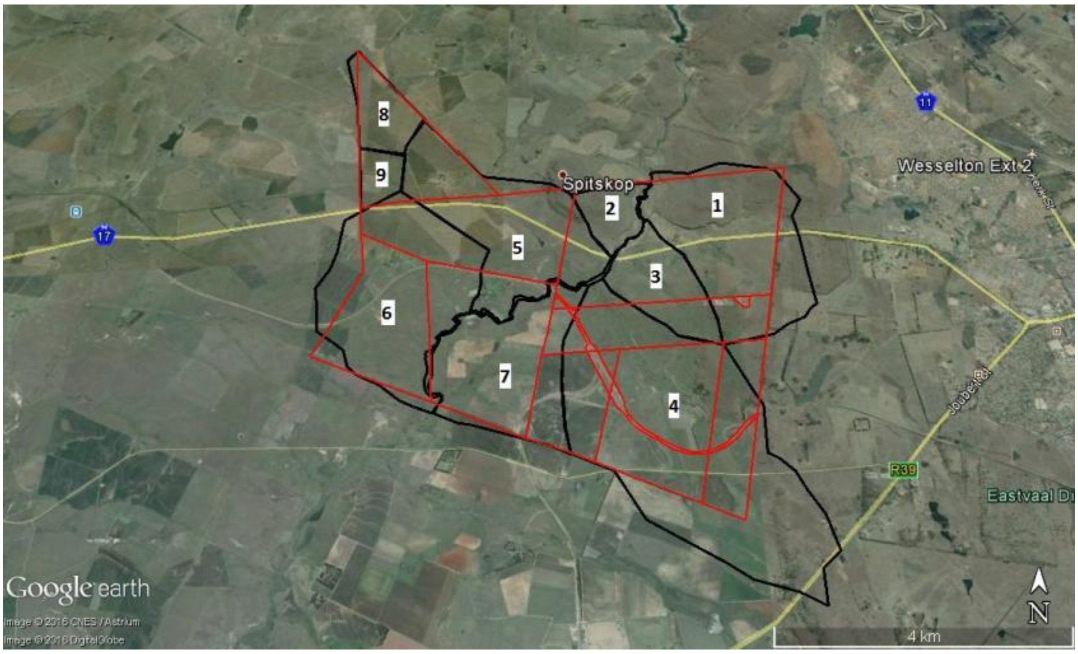

**Google image indicating the location of the VEGRAI assessment sites in the study area.**

*<u>Site 4:</u> The Riparian Index of Habitat Integrity (RIHI) is a C (63.6%) with the main impacts being overgrazing. Exotic hydrophytes and trees, water quality and water flow modifications due to dams upstream and a sewage plant. The PES trend is stable. The EcoStatus EC is a C (63.6%).*

*<u>2. Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessments</u>*

*Due to the size of the area a Level 1 assessment was applied. The study area was divided into nine catchment areas, based on 5 m contours. All the HGM wetland units present in each of the catchments were assessed.*

*Disturbances such as dumping, old farm roads, power line crossings, grazing, trampling, water abstraction, alien invasive vegetation species, erosion, etc., were taken account in determining the PES and EIS of the wetland units. In general the biggest impact to the wetlands in the study area is erosion, although the magnitude hereof varies. Other impacts include dams, invasive plant species, infrastructure, and overgrazing and dumping. Pollution is a serious problem in the riparian areas.*




**Map illustrating the assigned catchment areas for the Wet-Health assessments.**

*The results of the WET-Health assessments are indicated per catchment, and are separated into the various indicator components. The EIS assessments are indicated per HGM unit in each catchment. These results are also separated into the various indicator components.*

*The overall Present Ecological State of the wetlands in the study area is regarded as a **"C: Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact".** The geomorphology of these wetlands is mostly intact, while the vegetation component is the most modified. The absence of major infrastructure, large dams, and year-round irrigation sustains the hydrological function of the wetlands in the study area. The vegetation is mostly affected due to the removal of natural communities through the establishment of dams, the presence of erosion channels and gullies, and agricultural activities within the wetland boundary.*

*The overall Ecological Importance & Sensitivity of the wetlands in the study area is regarded as **"C: Moderate. The wetlands are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of the wetlands are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers"**. It is the opinion of the specialist that this is an underestimation of the overall EIS score, as the low importance and sensitivity is ascribed as a result of low direct human benefits.*

***IMPACT ASSESSMENT AND MITIGATION***

***Wetlands affected by the proposed infrastructure***

*The boxcut, plant, and associated mine infrastructure will be located in a section in the study area where relatively few wetland systems are present. The wetlands to be intersected are:*

- *A Channelled Valley Bottom wetland system by the Discard dump*
- *A Hillslope Seep area by the boxcut hards stockpile and the conveyor decline*
- *buffer area of a Channelled Valley Bottom wetland system by the pollution control dam*
- *buffer area between the Riparian area and a Hillslope Seep zone by the eastern ventilation shaft*

*Firstly it is recommended that the above-mentioned infrastructure (especially the Discard dump and the boxcut hards stockpile) be moved out of the wetland areas. It is however accepted that it might not be possible to move the conveyor decline and the eastern ventilation shaft. Depending on the incline of the conveyor decline it is possible that the infrastructure might be located below the seep area and therefore not impact (impede or divert flow) the seep zone, but this will have to be confirmed by a geohydrologist.*


***A more detailed illustration of the proposed aboveground mining infrastructure (indicated by the black lines) in relation to the delineated wetlands (as per the legend). The 100 m buffer is indicated by the white lines and the contours by the orange lines.***

*According to the project information as supplied by the client no surface disturbance is expected to occur on the remaining farm portions; with the exception of ventilation shafts. It is recommended that these ventilation shafts not be located within the 100 m buffer areas surrounding the wetlands. It is beyond the scope of this study to determine the possible effect of underground mining operations (during operational phases as well as during decommission phase) on the surface flow within the wetland systems. This will have to be determined by a qualified geohydrologist.*

*A Water Use License will have to be applied for since the infrastructure occurs within 500 m of wetland systems. A full set of expected impacts and mitigation measures are detailed in the report.*

***Impact Assessment and mitigation measures***

*Because the extent of the mining operation is not finalised, the impact assessment before mitigation in this document is based on the worst case scenario where the development would cause extensive damage or* *degradation to the aquatic ecosystems in the study area. The impact assessment after mitigation is based on the scenario where the client implements the mitigation measures recommended by this report and the Environmental Assessment Practitioner.*

*Water quality impacts*

*Fluctuations in the in situ water quality parameters (pH, Electrical Conductivity (EC), Total Dissolved Solids, Dissolved Oxygen, and temperature) may occur. These will have impacts on the wetlands' ecosystem, biotic communities and vegetation.*

1. *Dust generation and transportation due to the clearing of vegetation prior to construction, the construction phase, and the decommission and closure phase, which will settle on the wetland habitats, leading to:*
   - *Reduced photosynthesis and transpiration in flora;*
   - *An increase in fine-particulate sediments into the water;*
   - *A decrease in visibility and light penetration;*
   - *An increase in potential EC and TDS;*
   - *Fluctuation changes in the pH values; as well as*
   - *Fluctuations in the surface water quality monitoring parameters.*
2. *Increased soil sediment loads via surface water runoff into the adjacent wetlands via the clearing of vegetation prior to construction, the construction activities, the removal of topsoil, and the Discard dump can lead to:*
   - *Reduced photosynthesis and transpiration in the in-stream aquatic vegetation;*
   - *An increase in fine-particulate sediments into the water;*
   - *A decrease in visibility and light penetration;*
   - *An increase in potential EC and TDS;*
   - *Fluctuation changes in the pH values; as well as*
   - *Fluctuations in the surface water quality monitoring parameters.*
3. *Pollutants entering the wetland systems due to runoff from the Discard dump, pollution control dam, and boxcuts hards stockpile, accidental pollution or illegal disposal and dumping of construction material such as cement or oil will affect the water quality and influence its functionality and the persistence of vegetation.*

*Hydrological impacts*

1. *Construction activities*
   - *Clearing/removal of natural vegetation. Wetland vegetation stabilizes soil and therefore prevents erosion. They also play a role in the purification of water, attenuation of floods, and groundwater recharge.*
   - *Compaction of soils. Construction activities may compact soils from heavy equipment access which could inhibit seed germination, reduce water infiltration, inhibit root establishment, and result in bare soil exposure.*
2. *Operational phase*
   - *An increase in infrastructure is usually accompanied by an increase of hardened surfaces. Hardened surface can significantly increase the speed of water entering a wetland system. If the wetland system in question is then also impacted by activities causing bare and compacted soil surfaces, the increased velocity of water flow will result in erosion in the wetland.*

*Geomorphological impacts*

1. *Exposure to erosion that will erode into the wetland systems. Removal of vegetation against slopes and soil compaction expose soils to erosion during rainfall events. Erosion removes the top soil layer, thereby preventing establishment of vegetation.*

2. *Increased soil sediment loads via surface water runoff into the adjacent wetlands via the clearing of vegetation prior to construction, the construction activities, the removal of topsoil, and the Mine residue dump can lead to:*
    - *Reduced photosynthesis and transpiration in the in-stream aquatic vegetation;*
    - *An increase in fine-particulate sediments into the water;*
    - *A decrease in visibility and light penetration;*
    - *An increase in potential EC and TDS;*
    - *Fluctuation changes in the pH values;*
    - *Reduction of water storage capacity;*
    - *Elimination of natural vegetation;*
    - *Destruction of habitat; as well as*
    - *Fluctuations in the surface water quality monitoring parameters.*
3. *Bank disturbances, resulting in increased sediment input from erosion (if infrastructure is not removed from the wetlands and the buffers)*
4. *Cumulative impact from existing surrounding historic activities, human settlement, farming activities, as well as the proposed development project, leading to;*
    - *Increased erosion, flooding, sedimentation and bank instability;*
    - *Fluctuations in in situ water quality parameters; and*
    - *Fluctuations in surface water monitoring parameters.*

*Habitat impacts*

1. *Habitat loss or alteration during construction*
    - *Removal/destruction of wetland ecosystem habitat;*
    - *Vegetation removal;*
    - *Wetland edge disturbances; and*
    - *Drainage pattern changes.*
2. *Dust that enters the wetland can have the following impact:*
    - *Decreased visibility due to clouding of water column;*
    - *Decreased light penetration;*
    - *Siltation of fine sediment substrates, gravel substrates and inter-substrate spaces; and*
    - *Decrease in habitat availability.*
3. *Soil sediment loads entering the wetland ecosystems via surface water runoff as well as downstream wetland ecosystems, leading to:*
    - *An increase in fine-particulate sediments into the water;*
    - *A decrease in visibility;*
    - *A decrease in light penetration;*
    - *Increased siltation; and*
    - *Decreased habitat availability.*
4. *Cumulative impact from existing surrounding historic activities, human settlement, farming activities, as well as the proposed project, leading to;*
    - *Increased erosion, flooding, sedimentation and bank instability;*
    - *Fluctuations in in situ water quality parameters; and*
    - *Fluctuations in surface water monitoring parameters.*

*Biotic changes*

1. *Changes to the Riparian and marginal vegetation community structure of the wetland ecosystems may take place due to the likelihood that the following may occur as a result of the abovementioned impacts:*

- *Fluctuations in water chemistry may impact on the ability of vegetation species to survive;*
- *Toxicity of water may be lethal to sensitive vegetation;*
- *Increased possibility for microbial growth and algal blooms;*
- *Sedimentation of marginal vegetation habitats; and*
- *Exotic riparian vegetation encroachment.*

2. *Invasion by alien invasive vegetation and/or pioneer species. During construction vegetation will be removed and soil disturbed, which is conducive of the establishment of alien invasive plant seeds and/or pioneer plant species.*

***Mitigation measures***

*The impact assessment of the proposed development resulted in the impact being medium if no mitigation is implemented. With the proposed mitigation the impact was rated as low. The construction activities should apply methods and management practices that minimise and avoid the following impacts:*

- *Loss and disturbance of vegetation and habitat within the mining footprint;*
- *Soil compaction and increased risk of sediment transport and soil erosion during construction and routine maintenance in the operational phase;*
- *Flow modification due to concentrating flows, and storm water runoff from the foot print surfaces. This can lead to erosion and channel incision and change in the in-stream habitat;*
- *Water quality deterioration due to chemical spills during the construction and operational phases, and*
- *Wetland habitat fragmentation.*

*To maintain the integrity of the wetlands of concern, the following is recommended:*

- *Minimize the removal of/damage to vegetation in riparian and wetland areas;*
- *The construction of roads and road servitudes (disturbance zones) in or adjacent to the wetland/riparian zone is to be managed and strictly controlled to minimize damage to wetlands;*
- *Operation & storage of equipment in the riparian and wetland zones to be prevented;*
- *Wetlands disturbed during construction should be re-vegetated using site-appropriate indigenous vegetation and/or seed mixes;*
- *Alien vegetation should not be allowed to colonize the disturbed wetland areas;*
- *Rehabilitation of disturbed wetland habitat should commence immediately after construction;*
- *No construction camps should be allowed in or within 50 m of the wetlands;*
- *No stockpile areas should be located in or within 50 m of the wetlands;*
- *Construction should preferably take place during the low flow/winter months;*
- *Stockpiling of soil and the construction camps must be stored clearly away from the wetland;*
- *During the construction and operation phases erosion and siltation measures should be implemented;*
- *Slope/bank stabilization measures should be implemented where necessary;*
- *Erosion should be minimised;*
- *Debris and sediment trapping, as well as energy dissipation control structures, should be put in place;*
- *Turbidity, sedimentation and chemical changes to the composition of the water must be limited; and*
- *Where vegetation removal has occurred adjacent to the new roads, monitoring should take place to ensure successful re-establishment of natural vegetation. Alien vegetation should be removed from these disturbed areas.*

***CONCLUSIONS***

*Four types of palustrine wetland were identified, which included riparian areas, isolated Hillslope Seeps, Hillslope Seeps connected to a water course, Channelled Valley Bottom wetlands, and Unchannelled Valley*

*Bottom wetlands. The wetland indicators recommended by DWAF (2005) was used during field verification, and supported the delineations contained in this report. A 100 m buffer was applied to the delineated wetlands.*

*The riparian vegetation response assessment (VEGRAI), WET-Health Level 1 (PES tool), and Ecological Importance and Sensitivity were conducted to assess the current state of the wetlands on site. The Klein-Drinkwater has an average PES Ecostatus of C, the riparian tributary in the northern section of the site flowing from east to west has a PES Ecostatus of C, and the riparian tributary in the south-eastern portion of the site has a PES Ecostatus of B/C. The WET-Health assessment indicated that the PES of the wetlands in the study area is regarded as a* ***"C: Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact".*** *The overall EIS of the wetlands in the study area is regarded as* ***"C: Moderate. The wetlands are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of the wetlands are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers".*** *It is the opinion of the specialist that this is an underestimation of the overall EIS score, as the low importance and sensitivity is ascribed as a result of low direct human benefits.*

*There are two different sets of impacts envisaged for the mining activities: the local impacts caused by the proposed infrastructure, and the impacts caused by the underground operations. The mine infrastructure will intersect the following wetlands:*

- *A Channelled Valley Bottom wetland system by the Discard dump*
- *A Hillslope Seep area by the boxcut hards stockpile and the conveyor decline*
- *buffer area of a Channelled Valley Bottom wetland system by the pollution control dam*
- *buffer area between the Riparian area and a Hillslope Seep zone by the eastern ventilation shaft*

*It is beyond the scope of this study to determine the possible effect of underground mining operations on the surface flow within the wetland systems. This will have to be determined by a qualified geohydrologist. For the impacts caused by the mining infrastructure, a detailed set of impact evaluation and mitigation measures is contained within the report.*

*It is recommended that the above-mentioned infrastructure be moved out of the wetland areas. Depending on the incline of the conveyor decline it is possible that the infrastructure might be located below the seep area and therefore not impact (impede or divert flow) the seep zone, but this will have to be confirmed by a geohydrologist.*

***RECOMMENDATIONS***

*It is recommended that:*

- *The infrastructure dissecting the wetlands and buffers is moved out of the wetland areas.*
- *The ventilation shafts located in the rest of the study are not to be located within the 100 m buffer areas surrounding the wetlands.*
- *The geohydrological study investigate the impact of the underground mining operations on the surface flow within the wetland systems.*
- *A detailed field verification is done to confirm the wetland boundary around the proposed infrastructure.*

# TABLE OF CONTENTS

**EXECUTIVE SUMMARY** ..... **4**

**TABLE OF CONTENTS** ..... **14**

**TABLE OF FIGURES** ..... **15**

**TABLE OF TABLES** ..... **16**

**GLOSSARY** ..... **18**

**ABBREVIATIONS** ..... **19**

**1 INTRODUCTION** ..... **20**

**2 LEGISLATIVE STATURE OF WETLANDS** ..... **20**

**3 SCOPE OF WORK** ..... **21**

**4 LIMITATIONS OF THIS INVESTIGATION** ..... **21**

**5 THE STUDY AREA** ..... **22**

5.1 Climate ..... 23

5.2 Topography, Geology, Soils, and Land types ..... 23

5.3 Quaternary Catchments, Wetlands and Rivers ..... 24

5.4 Vegetation ..... 27

5.5 Mpumalanga Biodiversity Sector Plan (Terrestrial Assessment) ..... 28

**6 METHODOLOGY** ..... **29**

6.1 Wetland Identification ..... 29

6.2 Wetland Classification ..... 31

6.3 Mapping ..... 31

6.4 Wetland Integrity Assessments ..... 32

6.4.1 Riparian Vegetation Response Assessment Index (VEGRAI) (for riparian areas) ..... 32

6.4.2 Wet-Health ..... 34

6.4.3 Ecological Importance and Sensitivity ..... 35

6.5 Impacts to the wetlands on site ..... 36

6.6 Buffer zones ..... 40

**7 RESULTS AND DISCUSSION** ..... **43**

7.1 Wetland Identification and Classification ..... 43

7.2 Buffer Zones ..... 52

7.3 Other sensitive species and habitats ..... 52

7.4 Wetland Integrity Assessments ..... 55

7.4.1 Riparian Vegetation Response Assessment Index (VEGRAI) ..... 55

7.4.2 Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessments ... 79

**8 IMPACT ASSESSMENT AND MITIGATION ... 86**

8.1 Wetlands affected by the proposed infrastructure ... 86

8.2 Wetlands affected by the underground mining activities ... 88

8.3 Impact Assessment and mitigation measures ... 89

8.3.1 Water quality impacts ... 89

8.3.2 Hydrological impacts ... 94

8.3.3 Geomorphological impacts ... 96

8.3.4 Habitat impacts ... 99

8.3.5 Biotic changes ... 105

8.4 Mitigation measures ... 109

**9 CONCLUSIONS ... 110**

**10 RECOMMENDATIONS ... 111**

**11 REFERENCES AND FURTHER READING ... 112**

# TABLE OF FIGURES

Figure 1. Location of the study area. ... 22

Figure 2. 2010 land cover data (which only indicates transformed areas) showing the different land uses within and surrounding the study area. The light grey areas indicate untransformed (natural) areas. ... 23

Figure 3. Study area in relation to the land types in the vicinity. ... 24

Figure 4. Map showing the study area in relation to quaternary catchments, rivers and the MBSP freshwater assessment; CBA = Critical Biodiversity Area, ESA = Ecological Support Area. ... 25

Figure 5. The study area in relation to the rivers and the NFEPA river classification, as well as the MHWet data layer. ... 26

Figure 6. The study area in relation to the MHWet data layer showing wetland condition and FEPA status of the wetlands within the study area. ... 26

Figure 7. The position of the study area in relation to the surrounding vegetation units. ... 27

Figure 8. Study area in relation to the MBSP terrestrial assessment; CBA = Critical Biodiversity Area; ESA = Ecological Support Area. ... 29

Figure 9. Terrain units ... 30

Figure 10. Map to indicate the amount and position of the survey points. ... 43

Figure 11. Wetlands identified and delineated on the various properties in the study area (as indicated by the red polygons). ... 44

Figure 12. Typical wetland types encountered on site. ... 46

Figure 13. Soils found on site. ... 47

Figure 14: Visuals of some of the vegetation species encountered during the field survey. ... 52

Figure 15. An example of a 'pocket wetland', which extends from above the ridges to the river below (not seen in the photo). ... 52

Figure 16. Wetland delineation with a 100 m buffer zone (white line). Shaded polygons: Blue = Riparian; light green = Unchannelled Valley Bottom; dark green = Channelled Valley Bottom; dark yellow = Hillslope seep connected to a channel; light yellow = Hillslope seep not connected to a channel; White = sandstone ridges. .......... 54

Figure 17. Google image indicating the location of the VEGRAI assessment sites in the study area. .......... 55

Figure 18. Google image of the location of the focus area of the VEGRAI assessment area .......... 56

Figure 19. Panoramic view of the selected VEGRAI study area. .......... 56

Figure 20. Photos of selected VEGRAI site. .......... 57

Figure 21. Visuals of riparian vegetation found in the study area. .......... 59

Figure 22: Some visuals within the bigger riparian zone. .......... 60

Figure 23. Google image of the location of the focus area of the VEGRAI assessment area. .......... 62

Figure 24. Panoramic view of the selected VEGRAI study area. .......... 62

Figure 25. Photos of selected VEGRAI site. .......... 63

Figure 26: Visual of the farm dam upstream of the VEGRAI study site. .......... 65

Figure 27. Google image of the location of the focus area of the VEGRAI assessment area S3. .......... 67

Figure 28. Panoramic view of the selected VEGRAI study area S3. .......... 67

Figure 29. Photos of selected VEGRAI site. .......... 68

Figure 30: Visuals of riparian vegetation found in the study area. .......... 70

Figure 31. Some visuals within the bigger riparian zone. .......... 71

Figure 32. Google image of the location of the focus area of the VEGRAI assessment area S4. .......... 73

Figure 33. Visual of the selected VEGRAI study area S4. .......... 74

Figure 34. Photos of selected VEGRAI site. .......... 75

Figure 35. Some visuals within the bigger riparian zone. .......... 77

Figure 36. Map illustrating the assigned catchment areas for the Wet-Health assessments. .......... 79

Figure 37. A few examples of impacts encountered on site. .......... 81

Figure 38. The mining infrastructure layout. .......... 87

Figure 39. The proposed aboveground mining infrastructure in relation to the delineated wetlands and the 100 m buffer (as indicated by white lines). .......... 87

Figure 40. A more detailed illustration of the proposed aboveground mining infrastructure (indicated by the black lines) in relation to the delineated wetlands (as per the legend). The 100 m buffer is indicated by the white lines and the contours by the orange lines. .......... 88

Figure 41. The extent of the underground mining activities (indicated by the orange polygon). .......... 89

# TABLE OF TABLES

Table 1. A description of the geology and soils of the three land types associated with the study area (Land Type Survey Staff, 1972–2006). .......... 23

Table 2. Summary of relevant map categories for MBSP terrestrial assessment, taken from MTPA (2014). .......... 28

Table 3. Criteria for distinguishing different soil saturation zones and hydric vegetation within a wetland (from Kotze *et al*. 1994). .......... 31

Table 4. Generic ecological categories for EcoStatus components (modified from Kleynhans 1996 & Kleynhans 1999) .......... 34

Table 5. Combined Present Ecological State Categories. 35
Table 6. Determinants of ecological importance and sensitivity (DWAF 1999). 36
Table 7. Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF 1999). 36
Table 8. Criteria for Assessment of Impacts. 37
Table 9. Assessment Criteria: Ranking Scales. 39
Table 10: Significance Rating Scales without mitigation. 40
Table 11: Significance Rating Scales with mitigation. 40
Table 12: Wetland vegetation species found in the different wetland types in the study area. 48
Table 13. Site advantages and disadvantages. 58
Table 14: Reference conditions. 58
Table 15. Causes and sources. 60
Table 16. PES Trend. 61
Table 17. EcoStatus. 61
Table 18. Site advantages and disadvantages. 64
Table 19. Reference conditions. 64
Table 20: Causes and sources. 65
Table 21: Trend. 66
Table 22: EcoStatus. 66
Table 23. Site advantages and disadvantages. 69
Table 24. Reference conditions. 69
Table 25. Causes and sources. 71
Table 26. Trend. 72
Table 27. EcoStatus. 73
Table 28. Site advantages and disadvantages. 76
Table 29. Reference conditions. 76
Table 30. Causes and sources. 78
Table 31. Trend. 78
Table 32: EcoStatus. 79
Table 33. Location of and impacts present in the various HGM units. 80
Table 34. Present Ecological State of wetlands in the study area. 82
Table 35. Ecological Importance & Sensitivity of the wetlands in the study area. 83
Table 36. Significance and possible mitigation measures of water quality impacts. 91
Table 37. Significance and possible mitigation measures of hydrological impacts. 95
Table 38. Significance and possible mitigation measures of geomorphological impacts. 97
Table 39. Significance and possible mitigation measures of habitat impacts. 100
Table 40. Significance and possible mitigation measures of biotic impacts. 105

## GLOSSARY

| | |
|---|---|
| Anaerobic | Without air. |
| Biodiversity | The variety of life: the different plants, animals and micro-organisms, their genes and the ecosystems of which they are a part. |
| Catchment | Area from which rainfall flows into river. |
| Connectivity | In this context, referring to either the upstream-downstream or lateral (between the channel and the adjacent floodplain) connectivity of a drainage line. Upstream-downstream connectivity is an important consideration for the movement of sediment as well as migratory aquatic biota. Lateral connectivity is important for the floodplain species dependent on the wetting and nutrients associated with overbank flooding. |
| Geology | The study of the composition, structure, physical properties, dynamics, and history of Earth materials, and the Processes by which they are formed, moved, and changed. |
| Hydro-geomorphic | Refers to the water source and geology forms. |
| Invasive | Any species of insects, animals, plants and pathogens, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem. |
| Palustrine | Relating to a system of inland non-tidal wetlands characterized by the presence of trees, shrubs and emergent vegetation. |
| Pedology | The branch of soil science that treats soils and all their properties as natural phenomena. |
| Seep | A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows |
| Soils | Dynamic natural body composed of mineral and organic materials as well as living forms in which plants grow. It can also be described as the collection of natural bodies occupying parts of the earth's surface that supports plants and that have properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time. |
| Topography | Detailed description of land features. |
| Unchannelled valley bottom | Linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas. |

## Abbreviations

| | |
|---|---|
| PES | Present Ecological Status |
| EIS | Ecological Importance and Sensitivity |
| HGM | Hydrogeomorphic |
| EMC | Ecological Management Class |
| VEGRAI | Vegetation response assessment index |
| EIA | Environmental Impact Assessment |
| NEMA | National Environmental Management Act |
| MBSP | Mpumalanga Biodiversity Sector Plan |
| MHWet | Mpumalanga Highveld Wetland GIS spatial layer |
| MPRDA | Mineral and Petroleum Resources Development Act |
| DWA(F) | Department of Water Affairs (and Forestry, i.e. prior to 2009) |
| FEPA | Freshwater Ecosystem Priority Area |
| GIS | Geographic Information System |
| SANBI | South African National Biodiversity Institute |
| NWA | National Water Act (Act No. 36 of 1998) |
| TDS | Total Dissolved Solids |
| SBM | Significance before mitigation |
| SAM | Significance after mitigation |

# 1 INTRODUCTION

The specialists were approached by Limosella Consulting to conduct a wetland delineation, and assessment for the proposed De Roodepoort Colliery outside Ermelo, Mpumalanga.

According the information supplied by Cabanga Environmental the De Roodepoort mine will be an underground mine on the following properties : De Roodepoort 435 IS (Portions: RE, RE1, RE2, 3, RE4, 5, RE6, RE7, 8, RE9, 10, 11, 12, 13, 14). Mining will be undertaken by means of underground board and pillar methods. The underground will be accessed via a boxcut. The boxcut, plant and associated mine infrastructure will be located on portion RE 0 of the Farm De Roodepoort 435 IS. No surface disturbance is expected to occur on the remaining farm portions with the exception of ventilation shafts. Coal will be transferred from the underground to surface by means of a conveyor belt, whereby it will be sent to the plant area for processing (crushing, screening and washing). Mine residue from the plant will be disposed of onto an integrated disposal dump. The plant will run 24/7.

The C Seam depth ranges from 95 m below surface in the north-west and reaches depths of up to 160 m at the deepest point on the property. The C Lower Seam is separated from the C Upper Seam by sandstone and shale parting ranging in thickness between 200 mm and 1000 mm. Locally the coal seams occur within the Vryheid Formation of the Ecca Group, of which the Pietermaritzburg and Vryheid Formations are found in the Ermelo Coalfield. The Ermelo Coalfield stretches from Carolina to Standerton and Wakkerstroom in the Mpumalanga Province. Coal qualities in mineable seams are generally good.

The viability of the mine is dependent on:

- The upgrading of the existing access road from the coal processing plant to the N17 main road.
- The upgrading of the existing intersection onto the N17.
- The availability of a total maximum electricity demand of 10.
- The availability of process water – The total average annual water demand for the underground works, surface works and processing area is estimated to be 276,5 Ml for the underground workings, 65,9Ml for the processing plant (this is make water only). It is expected that this will initially be sourced from rainwater and a borehole to start with, and then from the underground workings.
- The availability of potable water. Approximately 6Ml of potable water required per annum (based on 70l per person) will be sourced from boreholes.
- A portable/modular sewage treatment plant will be installed on site for the treatment of sewage.
- A maximum of 80 $m^3$ fuel storage is required.

# 2 LEGISLATIVE STATURE OF WETLANDS

This study is required as part of the Environmental Impact Assessment (EIA) requirements as stipulated in the National Environmental Management Act (NEMA) and the Mineral and Petroleum Resources Development Act (MPRDA). All water courses (wetlands, rivers, and their riparian areas) are protected by law and no development is allowed to negatively impact on wetlands and river vegetation. Authoritative legislation that lists impacts and activities on wetlands that requires authorisation include the:

- Conservation of Agriculture Resources Act, 1983 (Act No. 43 of 1983);

- Environment Conservation Act, 1989 (Act No. 73 of 1989);
- National Water Act, 1998 (Act No. 36 of 1998);
- National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended; and
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004).

If any encroachment into wetlands takes place, or within the 500m boundary of a wetland, a Water Use License will be required from Department of Water Affairs (DWA) under Section 21 of the National Water Act (Act 36 of 1998).

# 3 SCOPE OF WORK

This study will:

- Identify, classify, and assess the integrity of the wetland area;
- Delineate a buffer area around the wetlands;
- Determine the Present Ecological State (PES) of the wetland units and riparian;
- Determine the Ecological Importance and Sensitivity (EIS) of the wetland units; and
- Impact assessment and mitigation measures.

# 4 LIMITATIONS OF THIS INVESTIGATION

The following was assumed for the purposes of this project:

- The information supplied by the client was correct at the time that fieldwork commenced.
- The study area covers the mining right area, and those areas to be mined falls well within this area. Delineation of wetlands within the 500m radius from the edge of the proposed mining area following GN1199 of the NWA might require additional mapping if located on the edge of the mining right area.

The following limitations affected the study:

- A single baseline assessment was conducted.
- Accuracy of the maps, aquatic ecosystems, routes and desktop assessments were made using the current 1:50 000 topographical map series of South Africa and Google Earth.
- Delineations and related spatial data generated will be supplied in kml/kmz format. Using this format is not advisable for detailed design, only for conceptual planning purposes.
- Accuracy of Global Positioning System (GPS) coordinates was limited to 15 m accuracy in the field.
- Whilst every care is taken in ensuring that the data presented is qualitatively adequate, inevitably conditions are never such that that is possible. In the circumstances it must be pointed out that the nature of the vegetation, the time of year, human intervention and the like limit the veracity of the material presented.
- Wetland and riparian zone reference points were identified during a desktop study and verified during the field visit. Some representative transects in each wetland unit on site was surveyed. However, it was relied on satellite and Google Earth imagery to aid the delineation of especially the seep wetland boundaries (the verified field delineation being a benchmark for image interpolation), due to budget constraints limiting time in field.
- The north-western section of the site (Portion 8) was delineated by means of a desktop study.

- Please note that the terms of reference and the budget supplied did not allow for delineation and assessment on a very detailed scale. Although it was done as precise as possible, with the aim to get at least one transect in each wetland system, it is recommended that a more detailed wetland delineation and assessment is conducted around the proposed infrastructure location, in order to determine the precise boundaries of and impacts to the wetlands in the immediate vicinity of the proposed infrastructure.

# 5 THE STUDY AREA

The study area covers the majority of the farm De Roodepoort 435 IS. It falls within the Gert Sibande District Municipality, Nsukaligwa Local Municipality, Mpumalanga Province, and is situated approximately 5.5 km west of the town of Ermelo. The N17 runs through the study area and the R39 lies to the south-east (Figure 1).The land uses within the study area, as per the 2010 land cover data, comprise mainly cultivation/old lands with some mining, afforestation, urban development, dams and an erosion donga; there are also large natural areas (Figure 1).

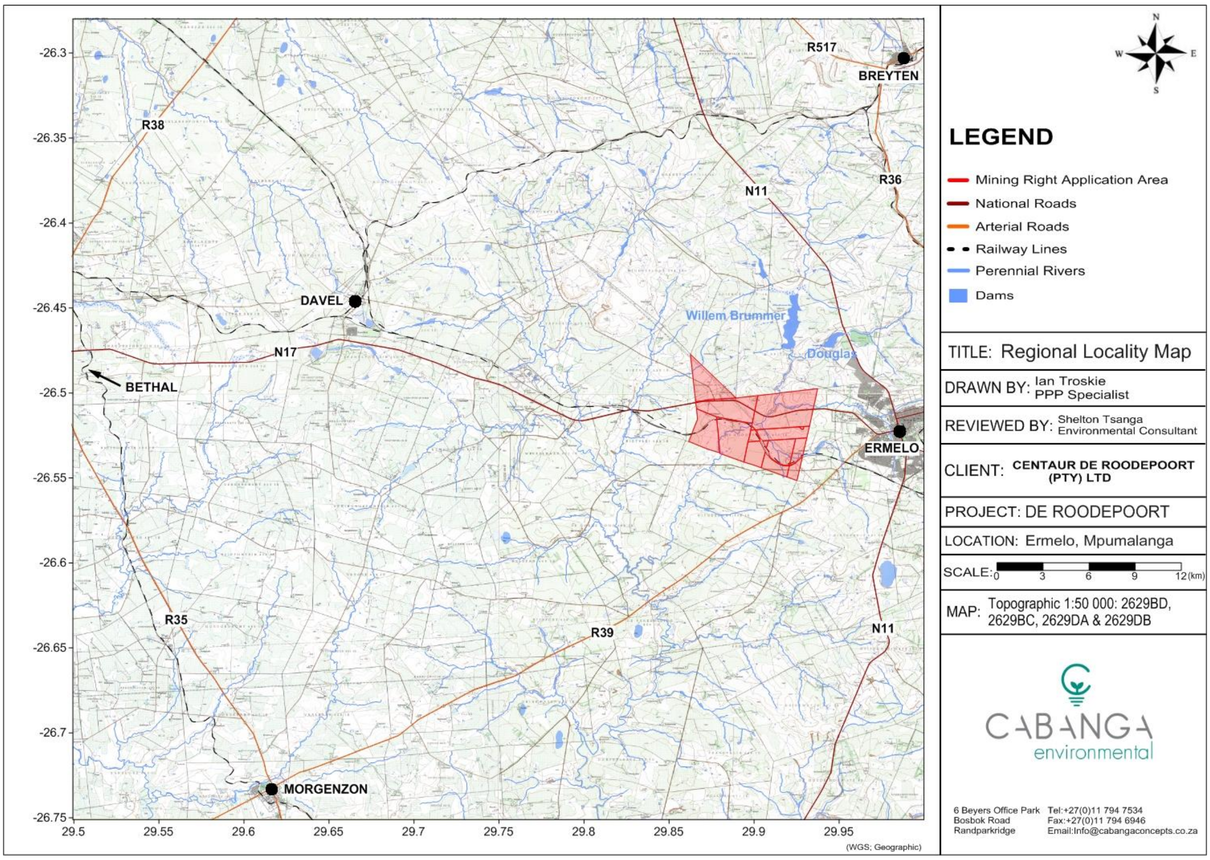



**Figure 1. Location of the study area.**

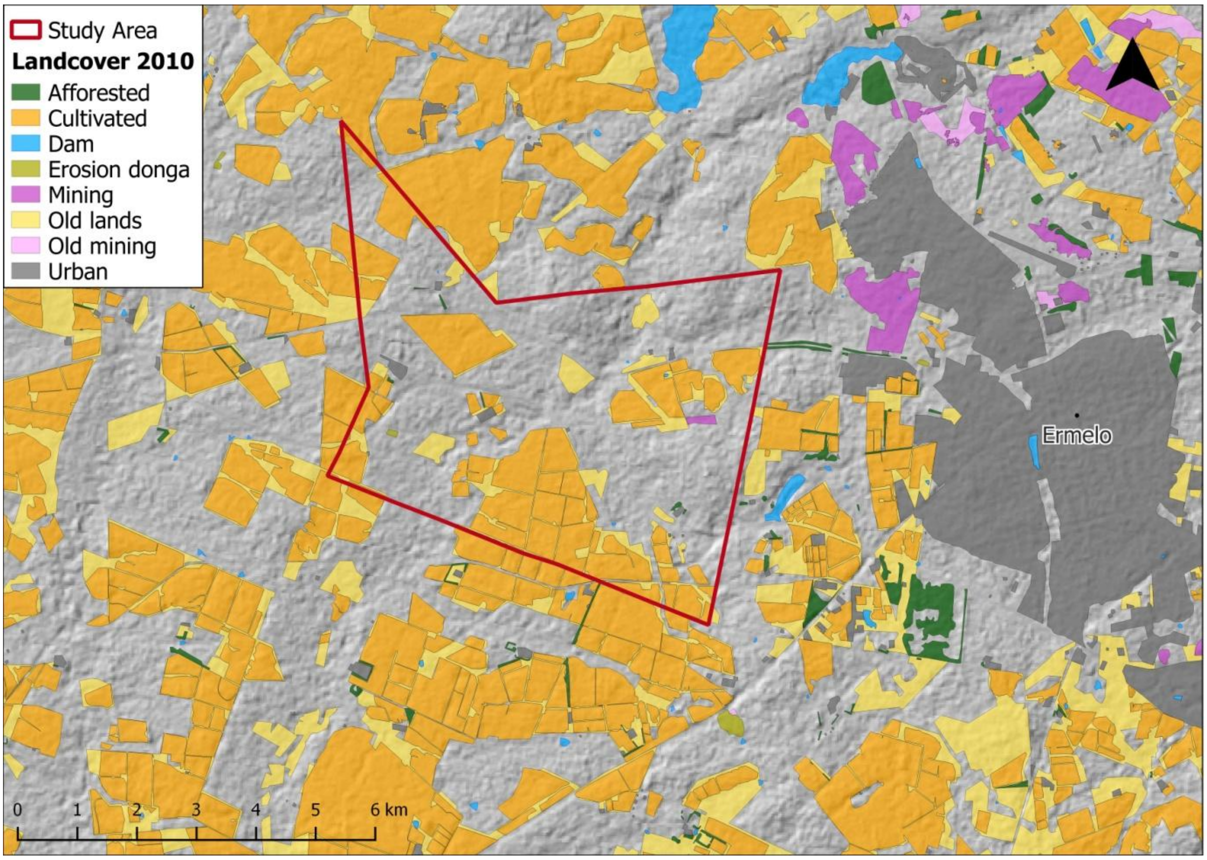


**Figure 2. 2010 land cover data (which only indicates transformed areas) showing the different land uses within and surrounding the study area. The light grey areas indicate untransformed (natural) areas.**

## 5.1 Climate

The study area is located within the summer rainfall region of South Africa. Mean monthly minimum and maximum temperatures at the study site are 0.4˚C and 25.3˚C in June/July and January respectively, while the annual average is 15.0˚C. The mean annual precipitation is 731 mm (WorldClim database, Hijmans *et al*., 2005), mainly in the form of summer thunderstorms, and severe frost in the winter.

## 5.2 Topography, Geology, Soils, and Land types

The site is characterized by undulating topography with rivers and valleys incising the landscape. The study area is essentially made up of three land types: Ea20, Ea23 and Ca3 (Figure 3). The geology and soils of these land types are described in **Table 1**.

**Table 1. A description of the geology and soils of the three land types associated with the study area (Land Type Survey Staff, 1972–2006).**

| Land type | Geology | Soil description |
|---|---|---|
| Ea20 | Dolerite; sandstone, grit and shale of the Ecca Group, Karoo Sequence. | One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated |
| Ea23 | Dolerite; sandstone, grit and shale of the Ecca Group, Karoo Sequence. | One or more of: vertic, melanic, red structured diagnostic horizons, |

| | | |
|---|---|---|
| | | undifferentiated |
| Ca3 | Shale, shaly sandstone, grit, sandstone and conglomerate of the Ecca group; dolerite. | Plinthic catena: undifferentiated, upland duplex and/or margalitic soils common |

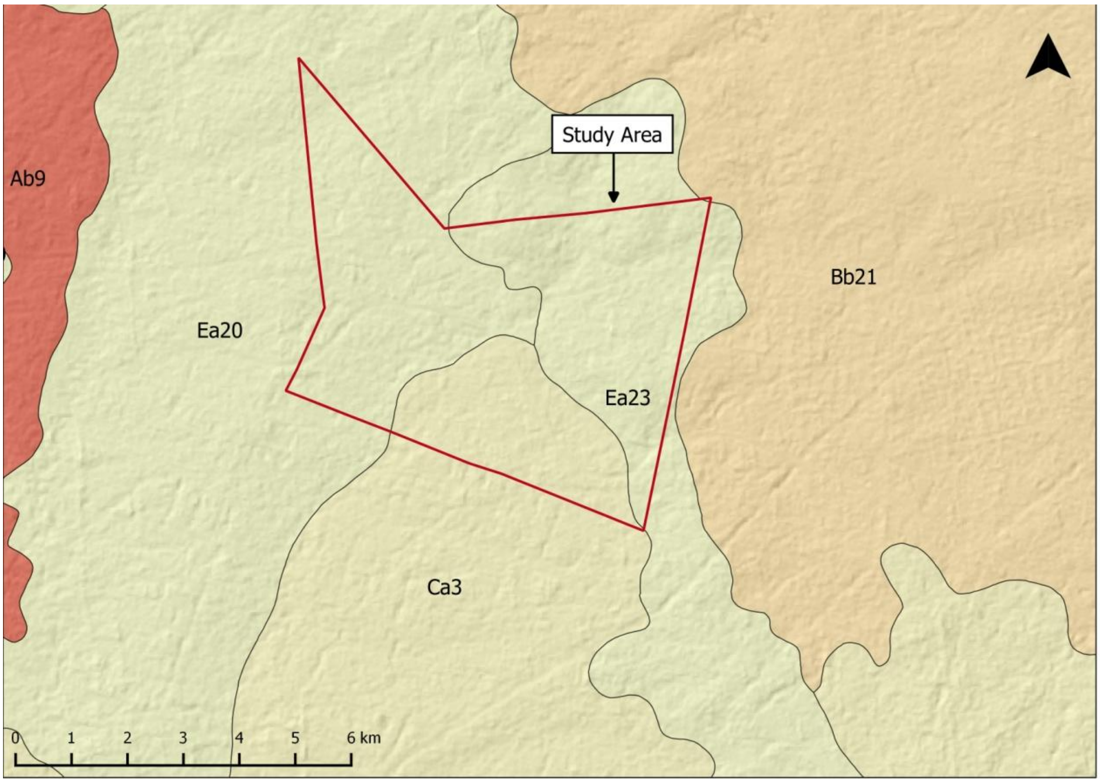


**Figure 3. Study area in relation to the land types in the vicinity.**

## 5.3 Quaternary Catchments, Wetlands and Rivers

This desktop assessment is based on a combination of the MBSP freshwater assessment, the NFEPA project (National Freshwater Ecosystem Priority Areas) and the new Mpumalanga Highveld Wetlands (MHWet) dataset. The MBSP freshwater assessment relied heavily on the NFEPA project but was improved for Mpumalanga (Lötter 2015). The NFEPA project identifies FEPAs (Freshwater Ecosystem Priority Areas), which are rivers, wetlands and estuaries that need to remain in a good condition to conserve freshwater ecosystems and protect water resources for human use (Nel *et al*. 2011). In 2015, a project was undertaken to improve the NFEPA wetland data for the Mpumalanga Highveld region, which resulted in an updated spatial dataset (MHWet) for the wetlands of the Mpumalanga Highveld (Mbona *et al*. 2015).

The study area falls within quaternary catchment C11F and lies close to the border of C11G, which both form part of the Upstream Vaal Dam Sub-water Management Area, Upper Vaal Water Management Area (Figure 4). The MBSP has classified the study area as 'Heavily Modified', as well as 'Other Natural Areas' (Figure 4; see Table 2 for definitions). There are a few dams within and just outside of the study area (Figure 4), which are artificial water bodies that have impacted on wetland or river ecosystems; these areas may still have a recharge effect on wetlands, groundwater and river systems and may support river- or water-dependent fauna and flora (MTPA 2014).

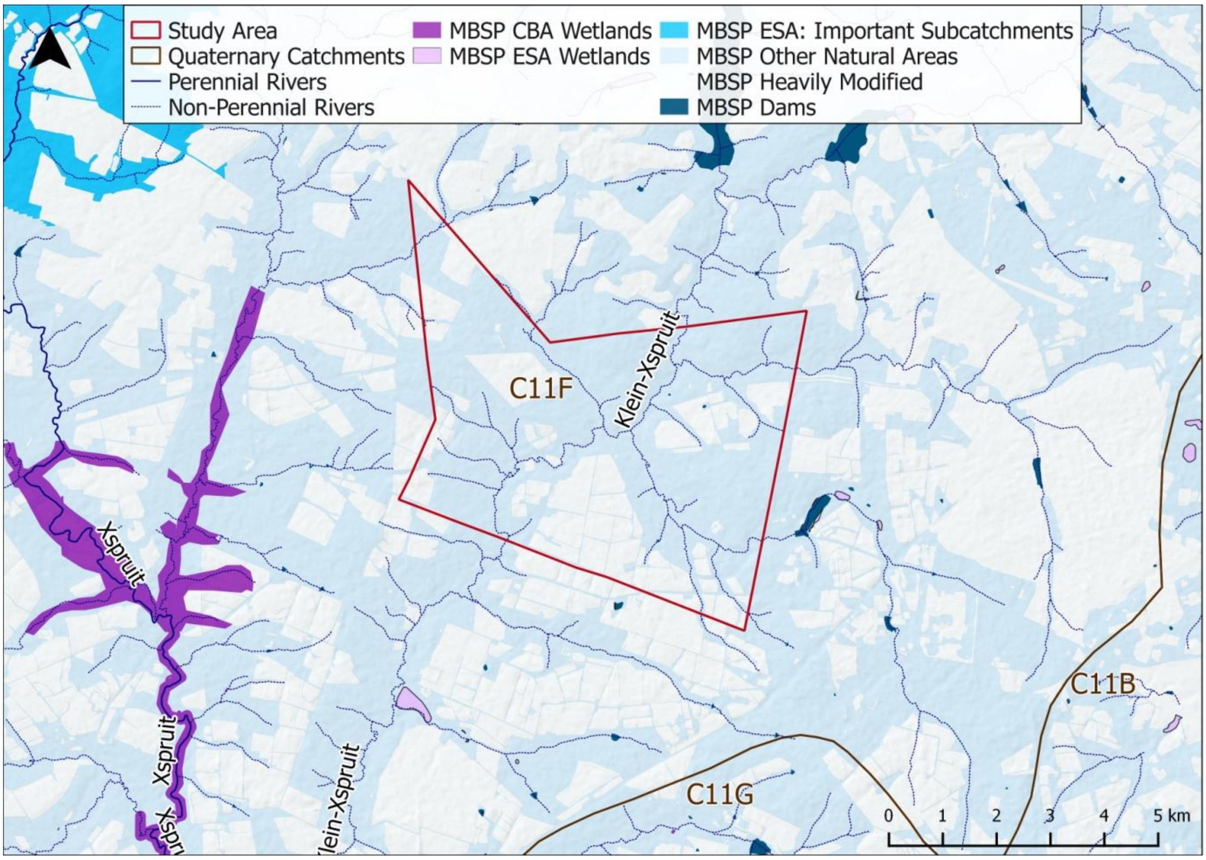



**Figure 4. Map showing the study area in relation to quaternary catchments, rivers and the MBSP freshwater assessment; CBA = Critical Biodiversity Area, ESA = Ecological Support Area.**

According to the NFEPA river classification, the study area falls within an Upstream Management Area (Figure 5). Upstream Management Areas are sub-quaternary catchments where human activities need to be managed to prevent degradation of downstream river FEPAs and Fish Support Areas (Nel et al. 2011). Several non-perennial rivers run through the study area, including the Klein-Xspruit (also known as the Klein-Drinkwater) (Figure 5).

According to the new MHWet data layer, there is an extensive wetland system within the study area, incorporating several hydro-geomorphic wetland types, namely: floodplain wetland, channelled valley bottom wetland and seep (Figure 5). These wetlands have a condition of AB (i.e. 'good' — minimum percentage natural land cover is ≥ 75%) or C (i.e. 'moderately modified' — minimum percentage natural land cover is 25–75%) (Figure 6). Almost all the wetlands within the study area are wetland FEPAs (Figure 6).

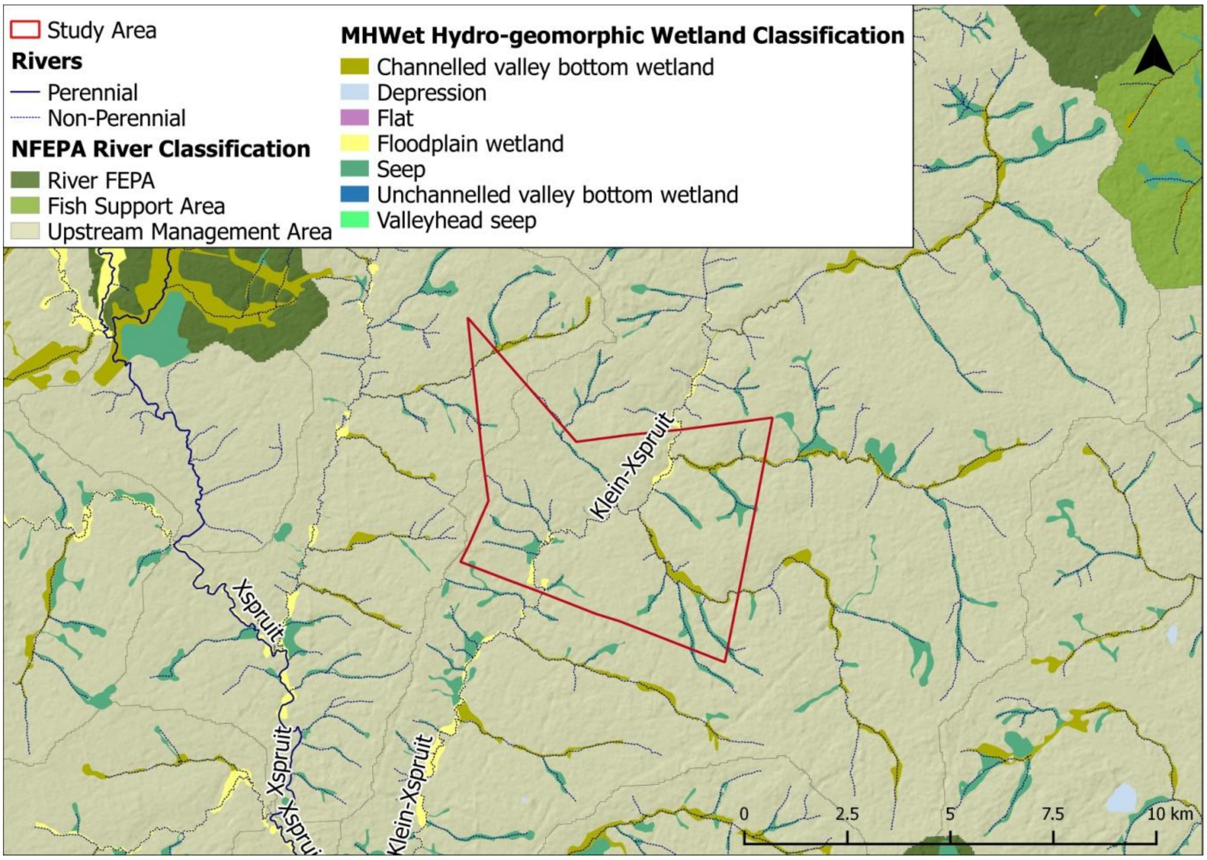



**Figure 5. The study area in relation to the rivers and the NFEPA river classification, as well as the MHWet data layer.**

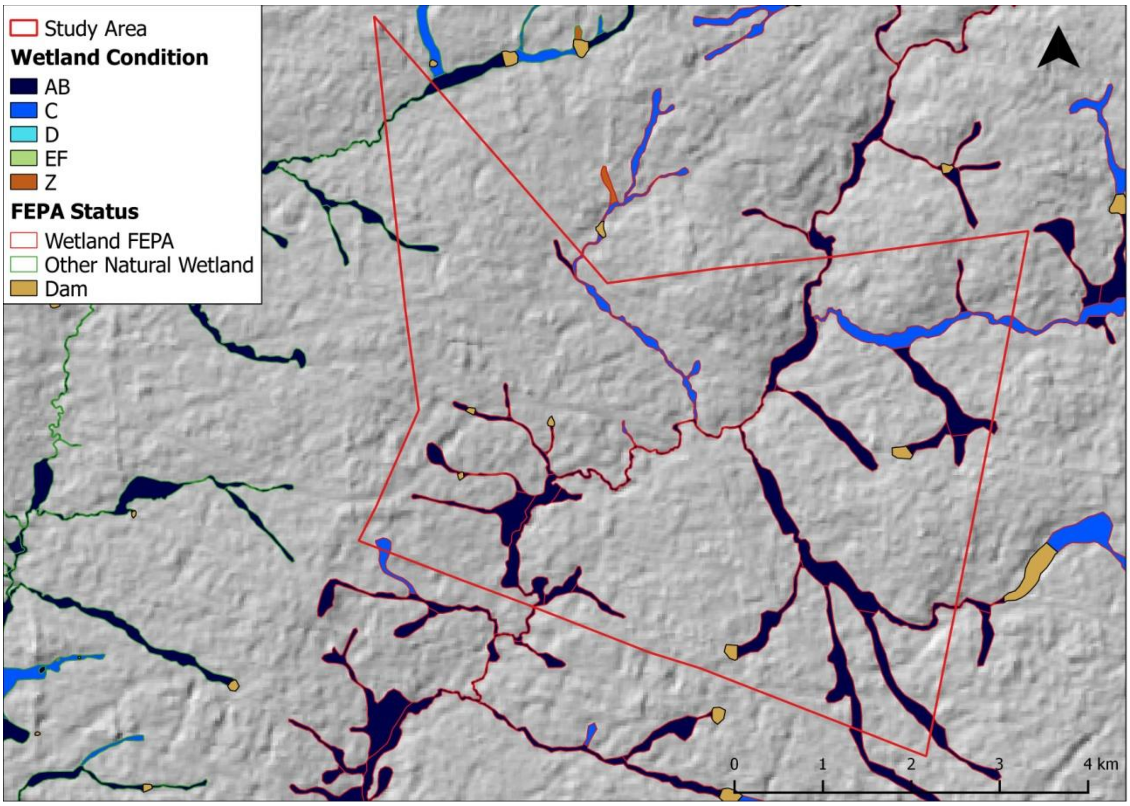



**Figure 6. The study area in relation to the MHWet data layer showing wetland condition and FEPA status of the wetlands within the study area.**

## 5.4 Vegetation

According to Mucina & Rutherford (2006), the study area covers two vegetation units: Soweto Highveld Grassland (Gm8) and Amersfoort Highveld Clay Grassland (Gm13) (**Figure 7**).

The Soweto Highveld Grassland has an altitude range of 1 420 – 1 760 m with a gently to moderately undulating landscape supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus, Eragrostis racemosa, Heteropogon contortus* and *Tristachya leucothrix*. In undisturbed places, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover. The Soweto Highveld Grassland vegetation unit is considered to be Endangered with a conservation target of 24%, and only a handful of patches are statutorily conserved (Waldrift, Krugersdorp, Leeuwkuil, Suikerbosrand, Rolfe's Pan Nature Reserves) or privately conserved (Johanna Jacobs, Tweefontein, Gert Jacobs, Nikolaas and Avalon Nature Reserves, Heidelberg Natural Heritage Site). Almost half of the area has already been transformed by cultivation, urban sprawl, mining and building of road infrastructure, and some areas have been flooded by dams.

The Amersfoort Highveld Clay Grassland vegetation unit has an altitude range of 1 580 – 1 860 m and is comprised of undulating grassland plains, with small scattered patches of dolerite outcrops in areas. The vegetation is comprised of a short closed grassland cover, largely dominated by a dense *Themeda triandra* sward, which is often severely grazed to form a short lawn. This unit is considered to be Vulnerable with a conservation target of 27% but none is protected. About 25% of the unit is transformed, predominantly by cultivation (22%); the area is not suited to afforestation. Silver and black wattle (*Acacia* species), as well as *Salix babylonica*, invade drainage areas.

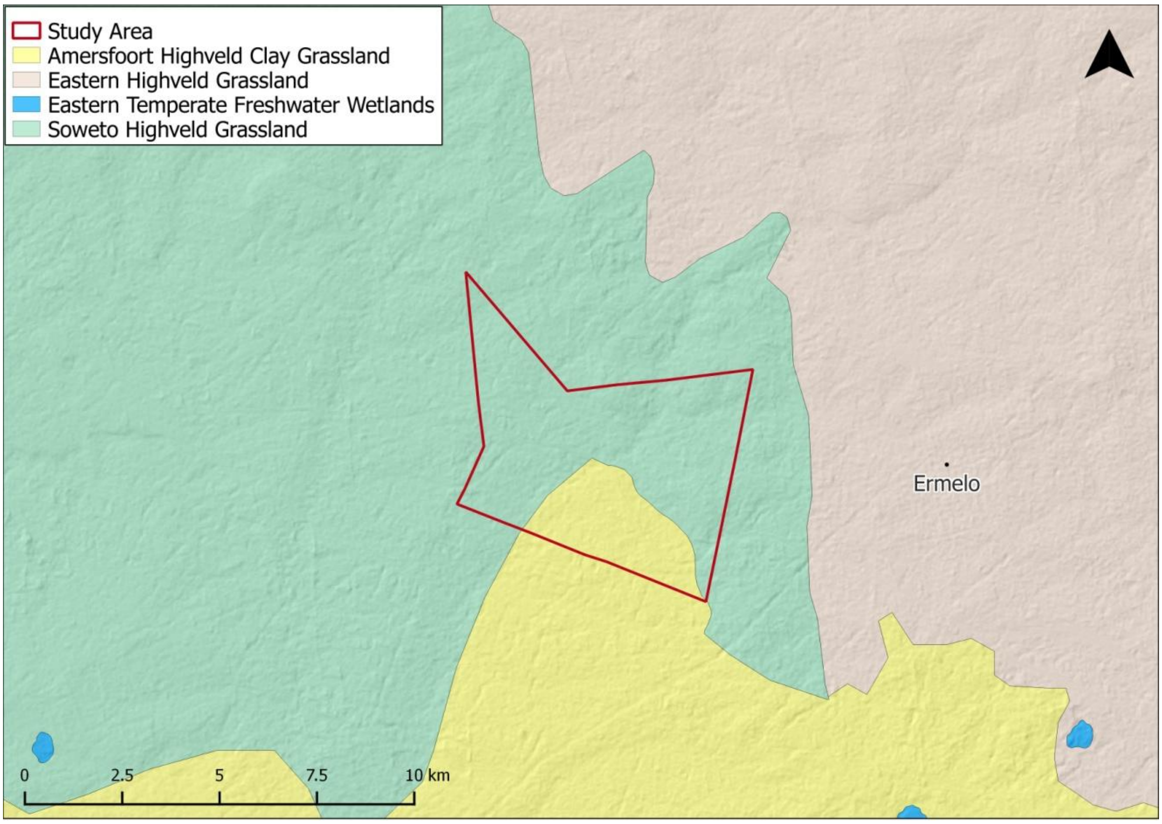



**Figure 7. The position of the study area in relation to the surrounding vegetation units.**

## 5.5 Mpumalanga Biodiversity Sector Plan (Terrestrial Assessment)

The Mpumalanga Biodiversity Sector Plan (MBSP) identifies terrestrial and freshwater areas that are important for conserving biodiversity pattern and ecological processes (MTPA, 2014). According to the MBSP (terrestrial assessment), the study area includes large areas classified as 'CBA Irreplaceable' and 'CBA Optimal', as well as several 'ESA local corridors' and a few 'Other Natural Areas'; there are also large portions classified as 'Heavily Modified' with some 'Moderately Modified: Old lands' (Figure 8). Definitions of these categories can be found in Table 2.

**Table 2. Summary of relevant map categories for MBSP terrestrial assessment, taken from MTPA (2014).**

| Map Category | Description | Sub-category | Description |
|---|---|---|---|
| **Critical Biodiversity Areas (CBA)** | All areas required to meet biodiversity pattern and process targets; Critically Endangered ecosystems, critical linkages (corridor pinch-points) to maintain connectivity; CBAs are areas of high biodiversity value that must be maintained in a natural state. | CBA: Irreplaceable | This category includes: (1) Areas required to meet targets and with irreplaceability values of more than 80%; (2) Critical linkages or pinch-points in the landscape that must remain natural; (3) Critically Endangered Ecosystems. |
| | | CBA: Optimal | The CBA Optimal Areas are the areas optimally located to meet both the various biodiversity targets and other criteria defined in the analysis. Although these areas are not 'irreplaceable' they are the most efficient land configuration to meet all biodiversity targets and design criteria. |
| **Ecological Support Areas (ESA)** | Areas that are not essential for meeting targets, but that play an important role in supporting the functioning of CBAs and that deliver important ecosystem services | ESA: Landscape Corridor | The best option to support landscape-scale ecological processes, especially allowing for adaptation to the impacts of climate change. |
| | | ESA: Local Corridor | Finer-scale alternative pathways that build resilience into the corridor network by ensuring connectivity between climate change focal areas, reducing reliance on single landscape-scale corridors. |
| **Other Natural Areas (ONA)** | Areas that have not been identified as a priority in the current systematic biodiversity plan but retain most of their natural character and perform a range of biodiversity and ecological infrastructural functions. | | |
| **Moderately or Heavily Modified Areas** | Areas in which significant or complete loss of natural habitat and ecological function has taken place due to activities such as ploughing, hardening of surfaces, open-cast mining, cultivation and so on. | Heavily Modified | All areas currently modified to such an extent that any valuable biodiversity and ecological functions have been lost. |
| | | Moderately Modified: Old lands | Old cultivated lands that have been allowed to recover, and support some natural vegetation. Although biodiversity pattern and ecological functioning may have been |

| | | | |
|---|---|---|---|
| | | | compromised, the areas may still play a role in supporting biodiversity and providing ecosystem services. |

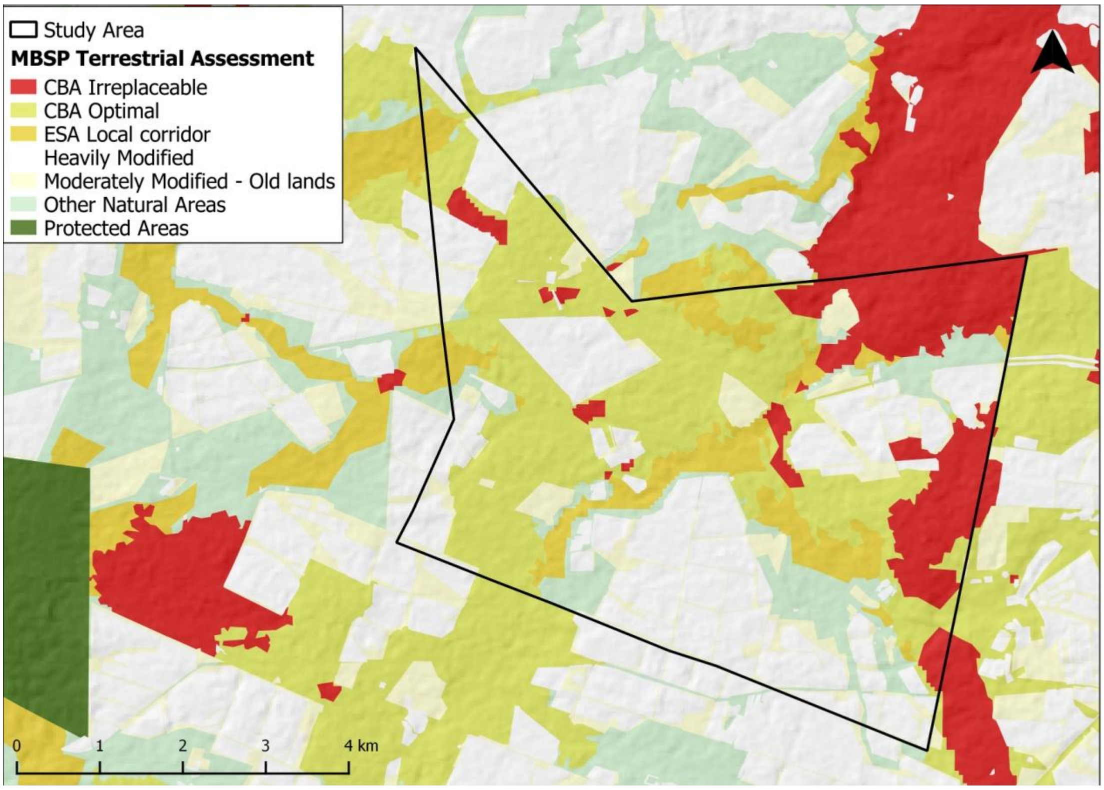



**Figure 8. Study area in relation to the MBSP terrestrial assessment; CBA = Critical Biodiversity Area; ESA = Ecological Support Area.**

# 6 METHODOLOGY

- Wetland areas were identified, classified, and preliminarily delineated during a desktop assessment using Google Earth and 1:50 000 topographic maps.
- Field verification points were set out during the desktop assessment. It was ensured that at least one representative transect were placed in each wetland system on site to verify wetland conditions. Wetlands encountered on site that were missed during the desktop survey were included in the delineation.
- The site visit was conducted during 7 – 9 March and 6 – 8 April 2016.
- The results of the field verification were interpolated for the study area during a post-site visit desktop assessment. The wetland systems were divided into HGM units, delineated and mapped using Google Earth Pro and QGIS 2.0.1.
- The PES (Wet-Health) and EIS were determined of the wetland systems on site. Only a Level 1 Wet-Health was applied.

## 6.1 Wetland Identification

The wetland delineation was conducted according to the Guidelines set out by the Department of Water Affairs and Forestry (DWAF 2005). Due to the transitional nature of wetland boundaries, these boundaries are often not clearly apparent and the delineations should therefore be regarded as of human construct. However, the delineations are based on scientifically defensible criteria that aims to provide a tool to facilitate the decision making process regarding the assessment of the significance of impacts on wetlands that may be associated with proposed developments.

According to DWAF (2005) the following general principals should be applied as the basis to undertake wetland delineation:

> "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 under normal circumstances supports or would support vegetation typically adapted to life in saturated soil "(Water Act 36 of 1998 In DWAF 2005).

A wetland can be defined in terms of hydrology (flooded or saturated soils), plants (adapted to saturated soils) and soil (saturated). Due to the variable nature of South Africa's climate the direct presence of water is often an unreliable indicator of wetland conditions. Prolonged saturation of soil has a characteristic effect on soil morphology, affecting soil matrix chroma and mottling in particular.

The wetlands were delineated by making use of the following wetland indicators (DWAF 2005):

- **Terrain unit indicator** helps identifying those parts of the landscape where wetlands are most likely to occur. Wetlands occupy characteristic positions in the landscape and can occur on the following terrain units: crest, midslope, footslope and valley bottom (Figure 9).
- The **Soil Form indicator** identifies the soil forms, as defined by the Soil Classification Working group (1991), which are associated with prolonged and frequent saturation.
- **Soil wetness indicator** identifies the morphological signatures developed in the soil profile as a result of prolonged and frequent saturation. Notes were taken on soil chroma to a depth of 50 cm and this was related to hydrological conditions in terms of the criteria for distinguishing different soil saturation zones within a wetland (Table 3) (Kotze *et al.* 1994).
- The **vegetation indicator** identifies hydrophytic vegetation associated with frequently saturated soils (Table 3).

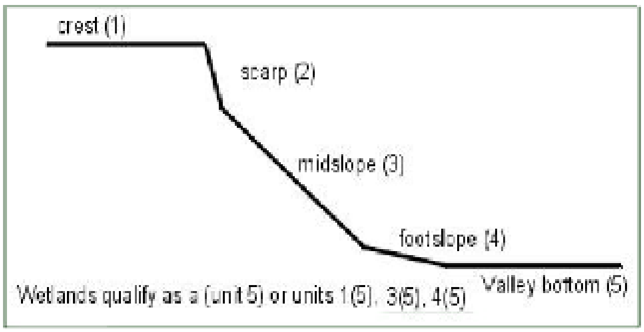



**Figure 9. Terrain units**

**Table 3. Criteria for distinguishing different soil saturation zones and hydric vegetation within a wetland (from Kotze *et al*. 1994)**

| SOIL | DEGREE OF WETNESS | | |
|---|---|---|---|
| | Temporary | Seasonal | Permanent/Semi-permanent |
| Soil depth 0-20cm | Matrix brown to greyish brown (chroma 0-3, usually 1 or 2). Few/no mottles. Nonsulphudic. | Matrix brownish grey to grey (chroma 0-2). Many mottles. Sometimes sulphuric. | Matrix grey (chroma 0-1). Few/no mottles. Often sulphuric. |
| Soil depth 20-40cm | Matrix greyish brown (chroma 0-2, usually 1). Few/many mottles. | Matrix brownish grey to grey (chroma 0-1). Many mottles. | Matrix grey (chroma 0-1). No/few mottles. |
| **VEGETATION** | | | |
| If herbaceous: | Predominantly grass species; mixture of species, which occur extensively in non-wetland areas, and hydrophytic plant species, which are restricted largely to wetland areas. | Hydrophytic sedge and grass species which are restricted to wetland areas, usually <1m tall. | Dominated by: (1) emergent plants, including reeds (*Phragmites* sp.), sedges and bulrushes (*Typha* sp.), usually >1m tall (marsh); or (2) floating or submerged aquatic plants. |

## 6.2 Wetland Classification

Wetlands are described in terms of their position in the landscape, and the classification was done according to its hydrogeomorphic setting (Figure 9) (Ollis 2013).

Rivers with riparian areas can be described as those areas with "Vegetation which is found in close proximity to rivers in a clearly defined riparian zone and which dependant on the river for a number of functions. It displays structural, compositional and functional characteristics which are clearly distinct from the fringing terrestrial vegetation and is distributed according to clear inundation and other functional gradients."

## 6.3 Mapping

The mapping of the wetlands was done in Google Earth and QGIS 2.0.1. 1:50 000 topographic maps and GPS points supplemented the mapping.

A first estimation of the extent of wet soils can be made during a desktop study from imagery, largely based on differences in vegetation and topography, indicating differences in species composition or more vigorous growth. This delineation needs to be verified during field sampling making use of soil samples and vegetation line transects and spot checks in between transects. Field verification in this study consisted of line transect surveys through the wetlands. In each line transect survey soils and vegetation was used to assess the edge of the wetland. It is important to note that according to the wetland definition used in the South African National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practice the soil wetness indicator tends to be the most important, and the other three indicators are used in the confirmatory role (DWAF 2005).

Mapping was done in the following manner:

1. The main drainage systems on site (valley bottom wetlands, seeps, and riparian areas) were mapped.
2. Within the valley bottom systems the water source might change from one type of wetland system to another more than once (i.e. from a seep to an unchannelled valley-bottom, to a riparian area, etc.). The wetland classification was done by indicating the various HGM units. Only in some cases where a seep area was strongly associated with a valley-bottom/riparian area was the seep included in the valley-bottom/riparian area, for simplification's sake.
3. A 100 m buffer was added, as per (Macfarlane *et al*. 2009).

## 6.4 Wetland Integrity Assessments

Three tools were utilized to determine ecological health, sensitivity, and status of wetlands and riparian areas, namely the:

- Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans *et al.* 2007) (for the riparian areas on site)
- WET-Health tool Level 1 (Macfarlane *et al*. 2008)
- Ecological importance and sensitivity (DWAF 1999)

### 6.4.1 Riparian Vegetation Response Assessment Index (VEGRAI) (for riparian areas)

The assessment of the riparian vegetation was done according to the Level 3: Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans *et al*. 2007). According to this index, the following components were assessed (with site advantages and disadvantages describing the accessibility, zones, biotic factors, and impacts):

*Site extent determination*

Flow, geomorphology, substrata, elevation, vegetation structure and species diversity, as well as the importance of these, were recorded, as they play an important role in determining riparian vegetation distribution. General characteristics were described.

*Site delineation*

In order to cover a representative area of the riparian zone in the study area, several transect surveys were necessary. Areas in between these transects were also traversed by foot, and spot surveys contributed to a more complete survey.

*Zone determination*

The following zones within the riparian vegetation were identified for Level 3 assessments and were assessed at each site:

- Marginal zone: starts at the water's edge and extends a few meters up the banks along a lateral gradient.

- Non-Marginal zone: Starts at the end of the marginal zone and extends away from the river to a point where there is a significant decrease in lateral slope or where vegetation species composition changes from riparian to non-riparian vegetation species.

*Species list*

Key/dominant/easily identifiable vegetation species were listed and indicated as woody or non-*woody* species and the zones where they occur were recorded.

*Land use and impact evaluation*

The surrounding and upstream land uses that could have an impact on the site were identified. Vegetation removal, changes to water quality and changes to water quantity were the three impacts that were considered for intensity and extent. The impacts were assessed on a scale from 0–5 (where 0 = no impact and 5 = extreme impact).

*Exotic vegetation and invasion*

Exotic vegetation has an impact on indigenous riparian vegetation. The impact is measured using the cover percentage of exotic species. A list of exotic species and the zones in which they are found was recorded at each of the sites.

*Reference condition reconstruction*

Reference conditions can be reconstructed in one of two ways:

- By using an unaffected river in the same eco-region to reconstruct the reference state, or
- By eliminating impacts to reconstruct the reference conditions.

*Response metrics rating*

For Level 3 VEGRAI assessments, only abundance and cover were rated. Using the guideline illustrations provided by the index, the abundance and cover for woody and non-woody species were rated separately for each of the zones. The abundance and cover rating was based on indigenous species density and percentage aerial cover.

*Ecological Category*

Field data were transferred to the VEGRAI Excel spreadsheet. The Ecological Category was calculated from the results obtained.

*Metric groups and the calculation of the Ecological Category*

The following procedure was followed to integrate the condition of metric groups and to provide an estimated Ecological Category for the riparian vegetation:

- The degree to which a metric group has changed from the natural state is subtracted from 100 to provide the degree to which the metric group is still intact.
- Each metric group (vegetation zone) is ranked and weighted according to its relative importance to the functioning of the river under natural conditions (cf. above). The focus is on the in-stream aspect of the river in particular.
- These weights are summed and the weight for each metric group is expressed as a proportion of this total.

- This proportional weight is multiplied by the percentage of the metric group in a natural condition and summed for all metric groups. This provides an integrated value that relates to the Ecological Category for the riparian vegetation that ranges from A to F (Table 4).

**Table 4. Generic ecological categories for EcoStatus components (modified from Kleynhans 1996 & Kleynhans 1999)**

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

### 6.4.2 Wet-Health

Wetland health is defined as a measure of the similarity of a wetland to a natural reference condition. The state of a wetland is a measure of the extent to which human impacts have caused the wetland to differ from the natural reference condition. The WET-Health tool assists in assessing the health or integrity of wetlands by looking at the deviation of wetland structure and function from the wetland's natural reference condition. The tool uses indicators based on three main components namely Geomorphology, Hydrology and Vegetation. The resulting score places the wetland into a Health Category for each component. At the end of each assessment an overall health score is given using the following equation and categories (Table 5) (Macfarlane *et al.* 2008):

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

**Table 5. Combined Present Ecological State Categories.**

| Description | Combined impact score | PES Category |
|---|---|---|
| Unmodified, natural | 0-0.9 | A |
| Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place. | 1-1.9 | B |
| Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact | 2-3.9 | C |
| Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred. | 4-5.9 | D |
| The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable. | 6-7.9 | E |
| Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota. | 8-10 | F |

A Level 1 assessment was done for this project. A Level 1 assessment is primarily a desktop evaluation with limited field verification, and is designed for use when many wetlands need to be assessed over a broad geographical area. The study area was divided into catchments, which was used to broadly assess the wetlands.

### 6.4.3 Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity (EIS) assessment was conducted according to the guidelines as discussed by DWAF (1999). Here DWAF defines "ecological importance" of a water resource as an expression of its importance to the maintenance of ecological diversity and function on local and wider scales. "Ecological sensitivity", according to DWAF (1999), refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred.

In the method outlined by DWAF a series of determinants for EIS are assessed for the wetlands on a scale of 0 to 4 (Table 6), where 0 indicates no importance and 4 indicates very high importance. The median of the determinants is used to determine the EIS of the wetland unit (Table 7).

**Table 6. Determinants of ecological importance and sensitivity (DWAF 1999).**

| Determinant |
|---|
| **Primary determinants** |
| Rare and endangered species |
| Species/taxon richness |
| Diversity of Habitat types or features |
| Migration route/breeding and feeding site for wetland species |
| Sensitivity to changes in the natural hydrological regime |
| Sensitivity to water quality changes |
| Flood storage, energy dissipation and particulate/element removal |
| **Modifying determinants** |
| Protected status |
| Ecological integrity |

**Table 7. Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF 1999).**

| Range of Median | EIS Category | Category Description |
|---|---|---|
| **>3 and <=4** | **Very High** | Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers. |
| **>2 and <=3** | **High** | Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water in major rivers. |
| **>1 and <=2** | **Moderate** | Wetlands that are to be considered ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers. |
| **>0 and <=1** | **Low/ Marginal** | Wetlands that is not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers. |

## 6.5 Impacts to the wetlands on site

A list of all the activities currently impacting on the wetland systems were compiled during the field visit, and is discussed as part of the results, as part of the Wet-Health (PES) assessment as well as the overall impact assessment.

In order to assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of impact associated with the proposed project,
- The assessment of the impacts of the proposed project on the aquatic ecosystems;
- The recommendation of mitigation and management measures to deal with significant impacts; and
- The identification of aspects which may require further study.

The impacts of the proposed project were assessed in terms of impact significance and recommended mitigation measures. The determination of significant impacts relates to the degree of change in the environmental resource measured against some standard or threshold (DEAT 2002). This requires a definition of the magnitude, prevalence, duration, frequency and likelihood of potential change (DEAT, 2002). Criteria have been proposed by the Department of Environmental Affairs for the description of the magnitude and significance of impacts (DEAT 2002). The significance of the impacts was determined using the criteria given in Table 8 in accordance with the rating as contained in Table 9.

**Table 8. Criteria for Assessment of Impacts.**

| | |
|---|---|
| **Severity (Magnitude)** | |
| The severity of the impact is considered by examining whether the impact is destructive or benign, whether it destroys the impacted environment, alters its functioning, or slightly alters the environment itself. The intensity is rated as | |
| (I)nsignificant | The impact alters the affected environment in such a way that the natural processes or functions are not affected. |
| (M)oderate | The affected environment is altered, but functions and processes continue, albeit in a modified way. |
| (V)ery High | Function or process of the affected environment is disturbed to the extent where it temporarily or permanently ceases. |
| **Duration** | |
| The lifetime of the impact that is measured in relation to the lifetime of the proposed development. | |
| (T)emporary | The impact will either disappear with mitigation or will be mitigated through a natural process in a period shorter than that of the construction phase. |
| (S)hort term | The impact will be relevant through to the end of a construction phase (1.5–2 years). |
| (M)edium term | The impact will last up to the end of the development phases, where after it will be entirely negated. |
| (L)ong term | The impact will continue or last for the entire operational lifetime i.e. exceed 30 years of the development, but will be mitigated by direct human action or by natural processes thereafter. |
| (P)ermanent | This is the only class of impact that will be non-transitory. Mitigation either by man or natural process will not occur in such a way or in such a time span that the impact is transient. |

| | |
|---|---|
| **Spatial scale** | |
| Classification of the physical and spatial scale of the impact | |
| (F)ootprint | The impacted area extends only as far as the activity, such as the footprint occurring within the total site area. |
| (S)ite | The impact could affect the whole, or a significant portion of, the site. |
| (R)egional | The impact could affect the area including the neighbouring farms, the transport routes and the adjoining towns. |
| (N)ational | The impact could have an effect that expands throughout the country (South Africa). |
| (I)nternational | Where the impact has international ramifications that extend beyond the boundaries of South Africa. |
| **Probability** | |
| This describes the likelihood of the impacts actually occurring. The impact may occur for any length of time during the life cycle of the activity, and not at any given time. The classes are rated as follows: | |
| (I)mprobable | The possibility of the impact occurring is none, due either to the circumstances, design or experience. The chance of this impact occurring is zero (0 %). |
| (P)ossible | The possibility of the impact occurring is very low, due either to the circumstances, design or experience. The chance of this impact occurring is defined as 25%. |
| (L)ikely | There is a possibility that the impact will occur to the extent that provisions must therefore be made. The chance of this impact occurring is defined as 50%. |
| (H)ighly Likely | It is most likely that the impacts will occur at some stage of the development. Plans must be drawn up before carrying out the activity. The chance of this impact occurring is defined as 75%. |
| (D)efinite | The impact will take place regardless of any prevention plans, and only mitigation actions or contingency plans to contain the effect can be relied on. The chance of this impact occurring is defined as 100%. |

In order to assess each of these factors for each impact, the following ranking scales were used (Table 9).

**Table 9. Assessment Criteria: Ranking Scales.**

| PROBABILITY | | MAGNITUDE | |
|---|---|---|---|
| Description / Meaning | Score | Description / Meaning | Score |
| Definite/don't know | 5 | Very high/don't know | 10 |
| Highly likely | 4 | High | 8 |
| Likely | 3 | Moderate | 6 |
| Possible | 2 | Low | 4 |
| Improbable | 1 | Insignificant | 2 |
| **DURATION** | | **SPATIAL SCALE** | |
| Description / Meaning | Score | Description / Meaning | Score |
| Permanent | 5 | International | 5 |
| Long Term | 4 | National | 4 |
| Medium Term | 3 | Regional | 3 |
| Short term | 2 | Local | 2 |
| Temporary | 1 | Footprint | 1/0 |

Details of the significance of the various impacts identified are presented in Table 10 and Table 11.

### Determination of Significance – With Mitigation

Determination of significance refers to the foreseeable significance of the impact after the successful implementation of the necessary mitigation measures. The Significance Rating (SR) is determined as follows:

**Equation 1:**

**Significance Rating (SR) = (Extent + Intensity + Duration) x Probability**

### Identifying the Potential Impacts without Mitigation Measures (WOM)

Following the assignment of the necessary weights to the respective aspects, criteria are summed and multiplied by their assigned probabilities, resulting in a value for each impact (prior to the implementation of mitigation measures). Significance without mitigation is rated on the following scale:

**Table 10: Significance Rating Scales without mitigation.**

| | | |
|---|---|---|
| SR < 30 | Low (L) | Impacts with little real effect and which should not have an influence on or require modification of the project design or alternative mitigation. No mitigation is required. |
| 30 < SR < 60 | Medium (M) | Where it could have an influence on the decision unless it is mitigated. An impact or benefit which is sufficiently important to require management. Of moderate significance - could influence the decisions about the project if left unmanaged. |
| SR > 60 | High (H) | Impact is significant, mitigation is critical to reduce impact or risk. Resulting impact could influence the decision depending on the possible mitigation. An impact which could influence the decision about whether or not to proceed with the project. |

**Identifying the Potential Impacts with Mitigation Measures (WM)**

In order to gain a comprehensive understanding of the overall significance of the impact, after implementation of the mitigation measures, it will be necessary to re-evaluate the impact. Significance with mitigation is rated on the following scale:

**Table 11: Significance Rating Scales with mitigation.**

| | | |
|---|---|---|
| SR < 30 | Low (L) | The impact is mitigated to the point where it is of limited importance. |
| 30 < SR < 60 | Medium (M) | Notwithstanding the successful implementation of the mitigation measures to reduce the negative impacts to acceptable levels, the negative impact will remain of significance. However, taken within the overall context of the project, the persistent impact does not constitute a fatal flaw. |
| SR > 60 | High (H) | The impact is of major importance. Mitigation of the impact is not possible on a cost-effective basis. The impact is regarded as high importance and taken within the overall context of the project, is regarded as a fatal flaw. An impact regarded as high significance after mitigation could render the entire development option or entire project proposal unacceptable. |

## 6.6 Buffer zones

'Buffer zones are strips of undeveloped, typically vegetated land (composed in many cases of riparian habitat or terrestrial plant communities) which separate development or adjacent land uses from aquatic ecosystems (rivers and wetlands).' For the protection of the aquatic resource in the study area it is essential that buffer zones are adequately defined. In establishing buffer zones it is essential to define the primary purpose for establishing buffers, which will guide the development of an appropriate approach. The primary purposes for this study are to:

1. Reduce the impacts of adjacent land uses on water resource quality. At a broad level, this would be used to flag potential constraints to development to inform regional planning initiatives. The primary application is likely to inform site-specific planning of new

developments / land use change. It may also be applied as "Best-practice" guidelines to inform land management (e.g. certification schemes).

2. Sustaining or improving the ability of the water resources to provide goods and services to society. This recognizes the importance of aquatic resources and that adequate protection of these resources is required to ensure that levels of benefits are not jeopardized for current or future generations.
3. Providing protection of and providing habitat for aquatic and semi-aquatic species.

Buffer width is regularly cited as one of the most important attributes affecting the functioning of aquatic buffers, regardless of the site properties or intended protection characteristics of the buffer. To assess and apply the width of any buffer it is important to understand the role that buffer zones do play in protecting aquatic resources with associated biota and in mitigating impacts from anthropogenic activities. Thus, the proposed buffer serves to provide a summary of a wide range of buffer functions and values including (Macfarlane *et al*. 2009):

- Sediment removal;
- Nutrient removal;
- Toxin removal;
- Control of microclimate and water temperature;
- Provision of habitat for wildlife;
- Screening of adjacent disturbances;
- Habitat connectivity;
- Channel stability and flood attenuation;
- Groundwater recharge; and
- Aesthetic appeal.

Indications are that wetlands are mainly depended of groundwater and this can be described as one of the main drivers of the wetland's existence. Valley Bottom wetlands can be dependent on ground and surface water. Anthropogenic impacts (agriculture, roads, infrastructure development, etc.) occur in and around the wetlands, emphasizing the already increased effect from the wetlands' catchment. To support the wetlands' integrity in a potentially disturbed environment, and with any futuristic development, a wetland buffer will be a necessity.

The wetland and/or aquatic buffer zones are typically defined from the edge of the identified wetland and/or aquatic resource, extending outward, ending at the interface with another land use. Buffers would therefore typically be applied from the delineated edge of a wetland and/or river. Thus, the recommended buffers should be implemented from the edge of the wetland and/or aquatic habitat and not from the middle or channel of the valley bottom wetland systems.

Although corridors created by buffer zones enable short distance or regional movements, they also play a role in sustaining long distance migrations. Many birds, for example Little Bitterns, Common Sandpiper and Greenshanks, use riparian vegetation (in buffers) as migratory routes (Cowan 1995). This is likely to be particularly important in semi-arid and urban areas, which are major obstacles in a bird's migration route. In such areas, buffer zones may provide the only suitable pathway through these obstacles along which these species can travel (Biohabitats Inc., 2007 in MacFarlane *et al*. 2009).

The main structural factor influencing the ability of a buffer zone to maintain habitat connectivity and use as a wildlife corridor is its continuity. Indeed, if buffers lie in fragmented strips they will be less effective in allowing wildlife movement than buffers that are well connected in the landscape (Fischer *et al*. 2000 in MacFarlane *et al.* 2009). Barriers that effectively obstruct movement, such as roads and development impinging on waterways would therefore reduce the effectiveness of buffers by blocking the movement of some species (Kent 2000 in MacFarlane *et al*. 2009). Here, it is worth noting that even small obstructions may act as barriers for some species. The presence of alien trees, for example, is enough to obstruct the movement of some dragonfly and butterfly species (Samways & Taylor 2004 in MacFarlane *et al.* 2009). This highlights the importance of behavioral aspects in assessing the usefulness of corridors for different species.

The width of corridors is also an important consideration as it influences most of the aspects that affect the functionality of the corridor. Indeed, maximizing width is regarded as one of the most effective options to increase the effectiveness of corridors for wildlife conservation (Bennet 1998, 2003 in MacFarlane *et al*. 2009). Benefits of wider buffer widths include:

- Reduction in edge effects, which can be most effectively minimized by increasing the width or size of corridors;
- Incorporation of large areas of significant wildlife habitat with potentially greater diversity of habitats that are likely to act as a useful link for a wider variety of species and;
- Increasing the likelihood of the corridor providing appropriate requirements for species sensitive to disturbances, requiring large amounts of space or having specialized feeding and habitat requirements (Bennet 1998, 2003; Fischer *et al*. 2000 in MacFarlane *et al*. 2009).

Several approaches exist in determining buffer widths and the one used in this case is the Fixed Width Methodology. The Fixed Width approach applies a standard buffer width to a resource and typically prohibits any land use within this zone. In this case a generic width is applied regardless of any characteristic of the water resource and/or any biotic requirements. However, no single-size buffer can protect all functions unless it is extremely large.

This Fixed Width approach has a number of benefits, providing predictability and is generally easy to apply and administer. The disadvantage of this 'one size fits all' (or at least all in one class) method is that it leads to some buffers being too small to sufficiently protect wetland functioning and some being larger than necessary. With time, this may reduce public and political support for the buffer program. Frustrated landowners can point to the buffers that are larger than necessary, while environmentalists can complain about buffers that are too small to protect wetland functioning (Granger *et al*., 2005 in MacFarlane *et al*., 2009). From a scientific perspective, it is also difficult to determine a generic width, as no single size buffer has been shown to protect all wetlands adequately unless this width was very large.

One way to address site-specific factors while using Fixed Width approaches is to have different widths based on the type of adjacent land use. Buffer regulation could therefore require larger buffer widths for land uses with intense impacts and smaller buffer widths for low impacts from adjacent land uses. This strategy can also be combined with a wetland rating system to provide a more scientific and defensible methodology.

For the study area, it is likely that a buffer of >50 m may adequately fulfill a number of functions and values such as promoting bank stability and affecting stream microclimate. A larger buffer may, however, be necessary in order to adequately cater for biotic requirements.

A decrease in the buffer width from 50 m to 30 m will have an impact on the buffer's ability to fulfill functions such as flood attenuation, general wildlife habitat, connectivity, habitat for semi-aquatic species, etc.

## 7 RESULTS AND DISCUSSION

## 7.1 Wetland Identification and Classification

Approximately 140 points were sampled in the study area (Figure 10). A list with all the surveyed points as well as the soil characteristics and impacts are given in Addendum A.

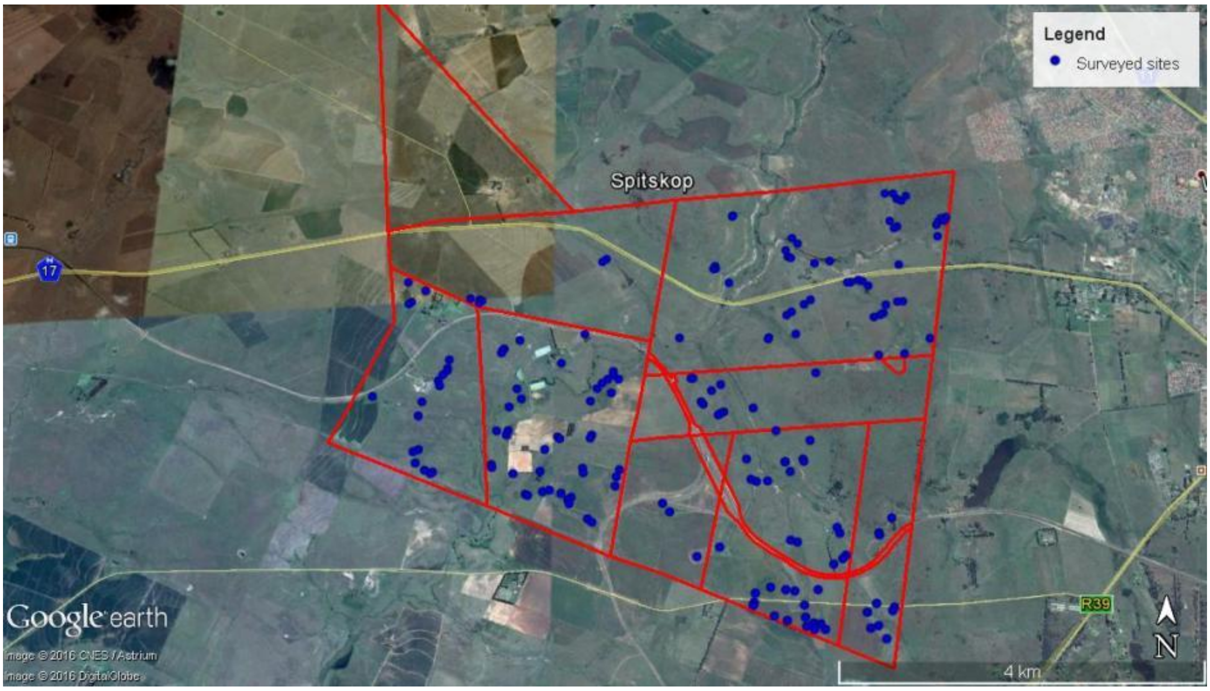



**Figure 10. Map to indicate the amount and position of the survey points.**

Based on hydro-geomorphic setting four palustrine wetland types as well as riparian areas were identified in the study area (Ollis *et al*. 2013) (Figure 11, Figure 12):

- Riparian area
- Valley bottom wetlands with a channel,
- Valley bottom wetlands without a channel,
- Hillslope seep (feeding a water course), and
- Isolated hillslope seep (not feeding a water course).

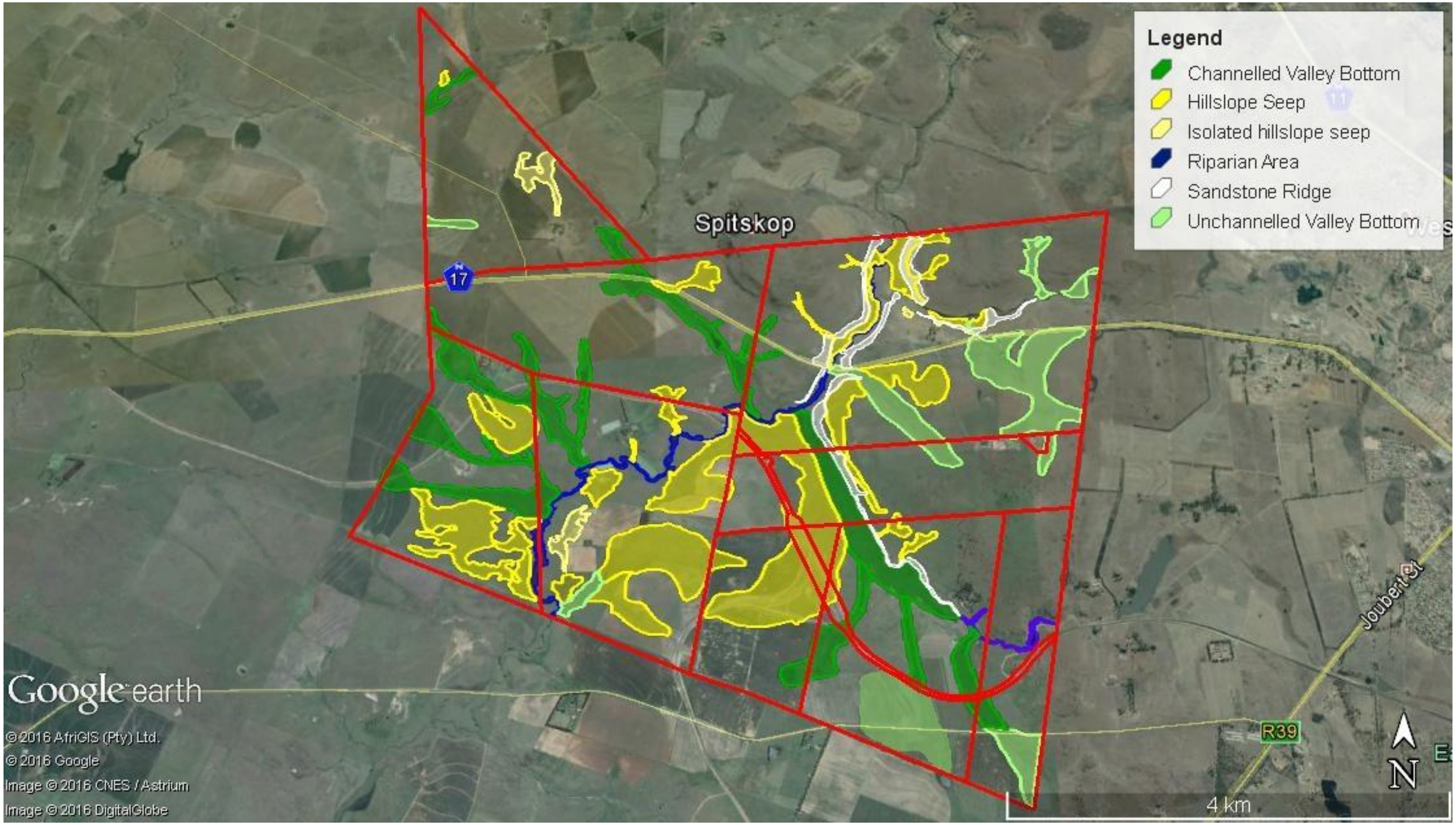



**Figure 11. Wetlands identified and delineated on the various properties in the study area (as indicated by the red polygons).**


(a) Riparian area (with associated seep zones)


(b) Isolated hillslope seep


(c) Hillslope seep area on vertic soil. The plant species in the photo, *Berkheya rigida*, is strongly associated with seep areas on vertic soil.

(d) Unchannelled Valley-Bottom wetland.

(e) Channelled Valley-Bottom wetland.

(f) Typical appearance of hillslope seep areas on vertic soils.

**Figure 12. Typical wetland types encountered on site.**

In accordance with the guidelines for delineating wetlands (DWAF 2005) the wetlands identified in the study area was delineated, both in the field and with a desktop study.

The **Terrain unit indicator** proved useful during this study. Most of the large systems occurred in the valley bottoms. However, a large amount of seep zones were identified in the study site, which had no association with a specific terrain unit. These were identified with the soil- and vegetation indicators.

The **Soil Form indicator** was not used in this study and should be incorporated once a land capability study has been commissioned.

The **Soil wetness indicator** was used successfully in this study to identify the boundaries of the wetland systems (Figure 13). The wetland soils encountered during the survey did have signs of wetness within 500 mm of the surface. Seasonally-, and temporarily wet zones were identified.

<u>Non-wetland soil</u> encountered were either red apedal or slightly structured profiles; Brown Orthic A on red or yellow-brown apedal B profiles; or slightly structured shallow soil on bedrock or saprolitic material (often at 200 mm). Clay often increased with depth. No signs of wetness were recorded in these sites.

Permanently wet soil encountered were a very dark vertic soil, high in clay content; sometimes underlain by a gray clay layer with calcium carbonate concretions. These profiles always occurred in valley bottom wetlands.

Seasonally wet soil encountered generally has red and/or orange mottles of various sizes and degrees of clarity in high organic, brown, structured or unstructured profiles. Often the profiles have grey colours. In some cases soil profiles are underlain by highly mottled saprolitic material with manganese concretions. Mottles are usually present between 0 – 350 mm. In some cases red mottles in a red matrix is encountered within the top 100 mm. In one of the isolated seep areas ferricrete was encountered on the soil surface. Vertic soil profiles were often encountered, in all wetland types, all over the study site. Calcium carbonate concretions were often encountered in these profiles, and erosion was evident wherever vertic soils were encountered.

Temporary wet soil, from which the edge of the wetlands were delineated, were found to be usually a brown, red, or yellow-brown profile of various textures and degrees of structure; sometimes of a shallow soil. Sporadic mottles (red, orange, black) (if present) were usually at depths deeper than 350 mm. Clay often increased with profile depth. Manganese concretions were sporadically encountered. Saprolitic material, sometimes with signs of wetness, was present at 400 - 500 mm in a few cases. Vertic horizons were also present here, but not as dark or as sticky as in the seasonally wet soils.

(a) Non-wetland soil.

(b) Seasonally wet soil from a hillslope seep feeding a water course in a maize field.

(d) Permanently wet, dark, vertic soil from A horizon (0 – 350 mm) overlying a grey clay C horizon with calcium carbonate concretions (350 – 600 mm).

(c) Temporarily wet soil from a hillslope seep feeding a water course.

**Figure 13. Soils found on site.**

The **vegetation indicator** was a very important indicator during this study, except in cases where the vegetation has been altered (old/current agricultural fields) or completely removed (erosion); in which cases more was relied on other indicators (Table 12).

Various wetland types occur throughout the study area and in these wetlands a variety of habitats occur. A diversity of wetland dependant species occur within these different habitat types (Table 12). A general description of the most dominant species is defined, with lists of species encountered during the once off field trip (Table 12).

The wetlands comprises mainly of herbaceous vegetation with grasses in the temporary wet zones (wet to damp grass meadow) which grades into a narrow grass/sedge dominated seasonal wet zone and then into the dominant permanent wet zone. The average height of the vegetation in the wetlands areas is 0.3m with diagnostic species such as grasses: *Leersia hexandra*, *Themeda triandra, Setaria sphacelata, Diheteropogon amplectens, Cynodon dactylon, Sporobolus africanus,* and *Eragrostis curvula.* The forbs observed included *Alisma plantago-aquatica, Albuca setose, Hypoxis acuminate,* and *Striga bilabiata.* Other species occurring are *Eulophia welwitschii*, *Argyrolobium harveyanum*, *Trifolium africanum* var *lydenburgense*, *Hewittia sublobata*, *Acalypha angustata*, *Aponogeton junceus*, *Stoebe vulgaris, Senecio coronatus, Berkheya radula, Haplocarpha scaposa, Sutera aurantiaca, Verbena venosa, Striga bilabiata, Mimulus gracilis, Drimiopsis burkei, Ledebouria ovatifolia, Ledebouria cooperi, Pycnostachys reticulate, Triflorum pratense, Senecio erubescens, Pelargonium luridum, Helichrysum rugulosum, Commelina bengalensis,* etc. Shrubs occur sporadic in the study area and included *Protasparagus laricinus* and *Rhus pyroides*. Two species, *Aloe ecklonis* and *Crinum* cf. *bulbispermum* are protected in terms of the regulations of the Mpumalanga Nature conservation Act 10 of 1998.

Exotic species identified are *Bidens pilosa, Verbena bonariensis, Bromus cathartica, Pennisetum clandestinum, Paspalum urvillei, Tragopogon dubius, Oxalis obliquifolia, Persicaria decipiens, Persicaria senegalensis, Myriophyllum aquaticum, Gleditsia triacanthos, Salix babylonica, Pyracantha angustifolia,* etc.

**Table 12: Wetland vegetation species found in the different wetland types in the study area.**

| Species | Riparian | Hillslope Seep (Connected & Not Connected) | Valley Bottom with Channel | Valley Bottom with no channel |
|---|---|---|---|---|
| *Acalypha angustata* | | | x | |
| *Argyrolobium harveyanum* | | | x | |
| *Aristida congestus* | | x | | |
| *Arundinella nepalensis* | | x | | |
| *Berkheya radula* | x | | x | |
| *Berkheya rigida* | x | x | | |
| *Berula erecta* | x | | x | |
| *Bulbostylis hispidula* | | x | | x |
| *Chenopodium album* | | x | | |
| *Cladium mariscus* | x | | | x |
| *Cymbopogon plurinodis* | | | x | |

| Species | Riparian | Hillslope Seep (Connected & Not Connected) | Valley Bottom with Channel | Valley Bottom with no channel |
|---|---|---|---|---|
| *Cynodon dactylon* | x | x | x | x |
| *Cyperus semitrifidus* | | | x | |
| *Dianthus basuticus* | | | x | |
| *Eleusine coracana* | x | x | | |
| *Eragrostis curvula* | | | x | |
| *Eragrostis plana* | x | x | x | x |
| *Eulophia welwitschii* | | | x | |
| *Haplocarpha lyrata* | | | x | |
| *Haplocarpha scaposa* | | x | | |
| *Helichrysum aureonitens* | x | x | x | x |
| *Hewittia sublobata* | x | | | |
| *Hypoxis* spp. | | | | x |
| *Imperata cylindrica* | | x | | |
| *Juncus effuses* | x | | | x |
| *Juncus oxycarpus* | x | | | |
| *Leersia hexandra* | x | | x | x |
| *Lobelia flaccid* | | | x | |
| *Mentos aquatica* | | x | x | x |
| *Oxalis obliquifolia* | | | x | |
| *Oxalis* spp | | x | | |
| *Pachycarpus schinzianus* | | | x | |
| *Paspalum distichum* | x | | x | |
| *Paspalum huillensis* | | x | x | x |
| *Pennisetum thunbergii* | x | | | |
| *Persicaria lapathifolia* | | | x | |
| *Protasparagus laricinus* | x | | | |
| *Ranunculus meyeri* | x | | x | |
| *Schoenoplectus brachycerus* | x | | x | |
| *Seersia dentata* | x | | | |
| *Seersia pyroides* | x | | | |

| Species | Riparian | Hillslope Seep (Connected & Not Connected) | Valley Bottom with Channel | Valley Bottom with no channel |
|---|---|---|---|---|
| *Sporobolus africanus* | x | x | x | x |
| *Stoebe vulgaris* | | x | | x |
| *Trichoneura grandiglumis* | x | x | | |
| *Typha capensis* | x | | x | |
| *Xyris capensis* | | x | x | x |

*Argyrolobium harveyanum*

*Bromus catharticus*

*Eulophia welwitschii*

*Trifolium africanum var lydenburgense*

*Oxalis obliquifolia*

*Walafrida densiflora*

*Hewittia sublobata*

*Myriophyllum aquaticum*

*Aponogeton junceus*

*Helichrysum aureonitens*

*Persicaria lapathifolia*

*Centella asiatica*

*Juncus exertus* (L) & *Juncus punctorius* (R)

*Juncus rigidus*

*Senecio coronatus*

*Leersia hexandra*

*Helichrysum setosum*

*Setaria sphacelata*

*Calamagrostis huttonii*

*Aster squamata*

*Cyperus esculentus*

*Berkheya rigida*

*Pycreus polystachyos*

*Haplocarpha scaposa*

**Figure 14: Visuals of some of the vegetation species encountered during the field survey.**

## 7.2 Buffer Zones

In assessing a range of buffer widths, a width of 100 m is recommended for the wetlands in the study area (Figure 16). This 100 m width should cater for most buffer functions as mentioned in Section 6.6 (MacFarlane *et al*. 2009).

## 7.3 Other sensitive species and habitats

Sandstone ridges are common in especially the eastern portions of the site, where they are exposed on steep slopes close to valley bottom wetland systems. Often these sandstone ridges have extensive associated seep areas (Figure 11), where water either accumulate above the ridge, siphon through the ridge by means of cracks, or get expelled from the soil just below the ridge. These seep areas are often expressed as 'pockets' of wetlands above, on, or below the sandstone ridges, but can also appear as one large seep area from the ridge down to the valley-bottom wetland system. Figure 15 depicts an example of one of these 'pocket wetlands' in between the sandstone ridge outcrops. This specific seep extends through the ridge, down the slope where it dominates the whole toe parallel to the ridge, to the river below. Due to the numerous resulting seeps of various sizes, as well as the high diversity that these sandstone ridge-seep areas usually host, the ridges are deemed highly sensitive. It is therefore proposed that all the delineated ridges are conserved alongside the wetland systems.

**Figure 15. An example of a 'pocket wetland', which extends from above the ridges to the river below (not seen in the photo).**

Please note that although a detail biodiversity survey was not part of the scope of this project, the specialists feel it imperative to mention that several dams, open water areas in wetlands and rivers, dense wetland vegetation, shallow muddy areas, etc. provided habitat to various water and wetland related birds. During fieldwork several **Marsh Owls** were flushed from dense vegetation habitat, which is the habitat in which they prefer to build nests. The **Denham's Bustard** was also encountered in and close to some seep wetlands. Its International Conservation Status is that of Near –Threatened and its Red Data Status is that of vulnerable. The fringes of wetland areas with denser grass cover may still provide good, undisturbed habitat for species such as rodents, Cape Clawless Otter, Water Mongoose and Serval. Signs of the presence of animals such as Aardvark, Porcupine, Yellow mongoose, and others were recorded during the field survey.

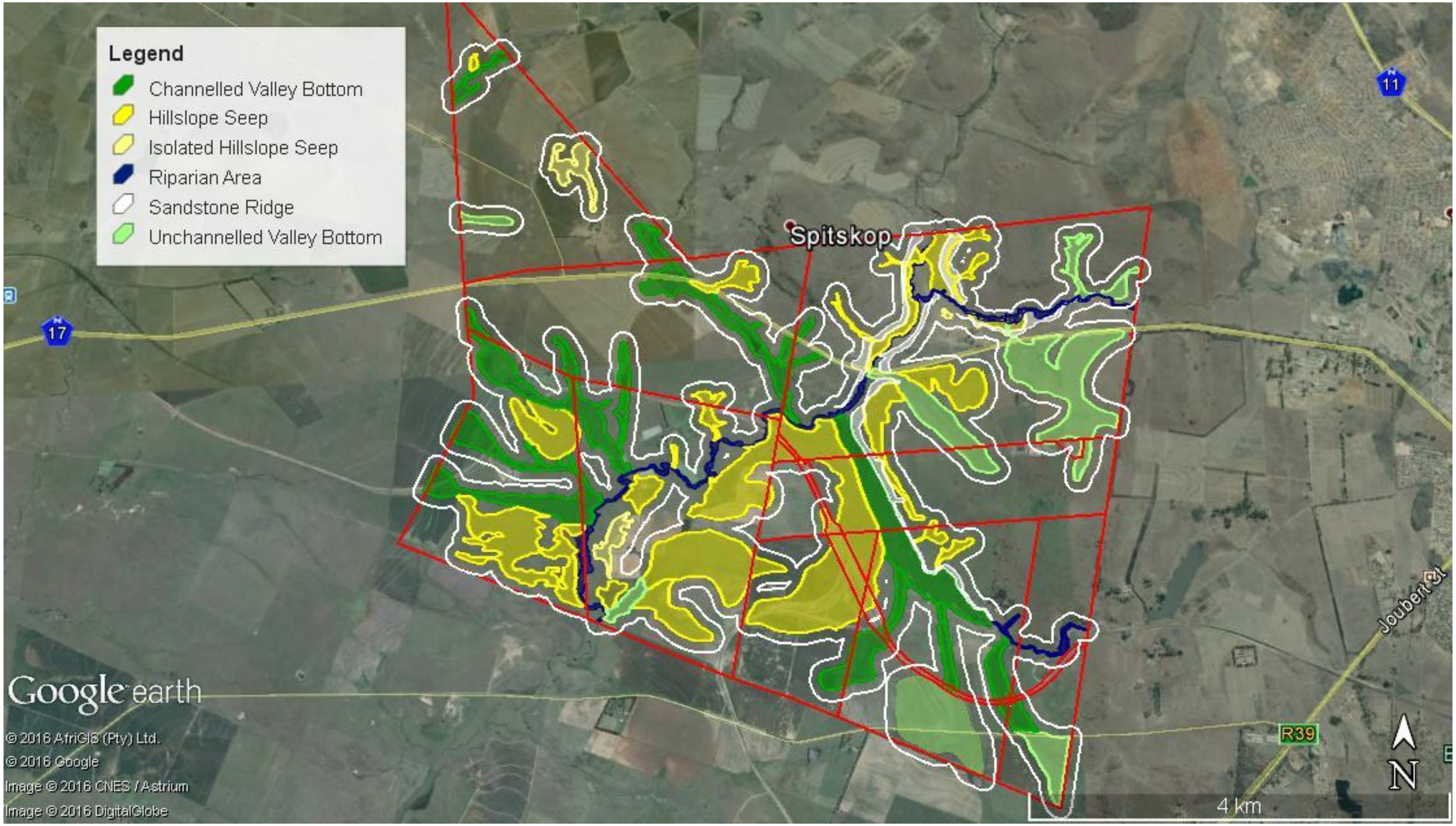



**Figure 16. Wetland delineation with a 100 m buffer zone (white line). Shaded polygons: Blue = Riparian; light green = Unchannelled Valley Bottom; dark green = Channelled Valley Bottom; dark yellow = Hillslope seep connected to a channel; light yellow = Hillslope seep not connected to a channel; White = sandstone ridges.**

## 7.4 Wetland Integrity Assessments

### 7.4.1 Riparian Vegetation Response Assessment Index (VEGRAI)

This index was applied to the riparian areas in the study area. A total of 4 sites have been selected for VEGRAI assessments, these sites will be representative of the riparian areas in the study area (Figure 17).

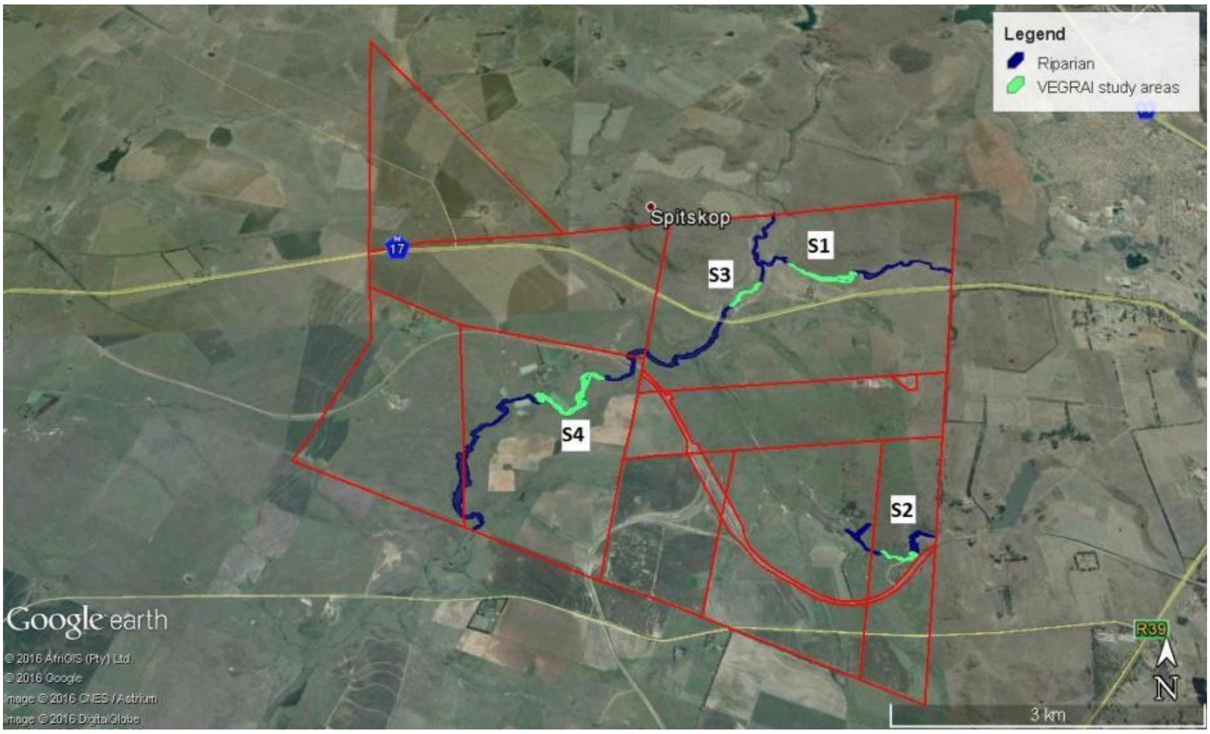



**Figure 17. Google image indicating the location of the VEGRAI assessment sites in the study area.**

**Site 1**

The site assessed covers approximately 800 m from GPS point 26°30'24.39"S / 29°54'58.13"E upstream to 26°30'30.51"S / 29°55'25.08"E. This area forms part of the delineated riparian zone as visualised in the Google Earth photo in Figure 18.

In Figure 19 a panoramic view of the site is visualised and the sandstone formations and exotic Poplar infestation can be seen.


**Figure 18. Google image of the location of the focus area of the VEGRAI assessment area**

**Figure 19. Panoramic view of the selected VEGRAI study area.**

- Marginal zone (Figure 20):

Various sedges & grasses occur. The river meanders around a sand rock face and open grassland area. In places vegetation occurs sporadically where habitat is available. Habitat availability is determined by rocky substrate in the channel and/or bank collapse and bank undercutting. Substrate consists of sandstone bedrock or soil. Exotic species that occur are tree species such as *Salix babylonica*, *Populus x. canescens* and *Gleditsia triacanthos*. Other pioneer species such as *Pennisetum clandestinum, Paspalum urvillei, Cirsium vulgare, Verbena bonariensis, Tagetes minuta*, *Persicaria lapathifolia*, etc. occur. Besides exotics, water quality and refuge is an issue. Common indigenous species are *Gomphocarpus physocarpus, Cyperus fastigiatus, Cynodon dactylon, Pennisetum macrourum, Leersia hexandra, Juncus effusus, Diospyros lycioides, Schoenoplectus sp., Imperata cylindrica, Setaria sphacelata*, etc.

- Non-marginal zone (Figure 20):

Grass and herb dominated state. Some individual woody species occur, such as *Diospyros lycioides*. Both banks have got reasonable cover and abundance of herbs and grasses. Indigenous species are: *Leersia hexandra, Juncus rigidus, Senecio coronatus, Kyllinga alata, Setaria sphacelata, Cyperus esculentus, Cephalaria zeyheriana, Berkheya radula*, etc. Some exotic pioneers occur such as *Cirsium vulgare, Verbena bonariensis, Paspalum urvillei,* etc. Exotic trees dominate some areas of the riparian with species *Populus x. canescens, Pyracantha angustifolia, Gleditsia triacanthos*, etc.  Bank substrate consists of soil material with various sandstone dykes crossing the study area.

View of the marginal zone

View of the non-marginal zone

**Figure 20. Photos of selected VEGRAI site.**

Site advantages and disadvantages:

Advantages and disadvantages are presented for this site in Table 13.

**Table 13. Site advantages and disadvantages.**

| Component | Advantages | Disadvantages | Conf |
|---|---|---|---|
| **Riparian vegetation** | • Easy accessible<br>• Zones with relatively good vegetation cover<br>• Clear hydro-geomorphological zones | • Grazing and trampling<br>• Road crossing<br>• Exotic species<br>• Localized impacts<br>• Terrestrialization<br>• Erosion (scouring and collapse)<br>• Steep banks | 3 |

Reference conditions:

The reference conditions for the components are summarized in Table 14.

**Table 14: Reference conditions.**

| Component | Reference conditions | Conf |
|---|---|---|
| **Riparian vegetation** | **Marginal zone:**<br>Grass and sedge dominated state with pockets of reeds. Less erosion in the form of bank undercutting and scouring would occur and therefore providing good habitat. Individual and or clumps of woody species such as *Salix mucronata* and *Diospyros lycioides*. With the absence of bank scouring, grass and sedge dominance with some reeds would provide more cover abundance that may result in a better species composition. Vegetation roughness coefficient would be higher in the presence of good grazing management.<br>**Non-marginal zone:**<br>Grass, herb and sedge dominated state. It is expected that more woody species would occur such as *Diospyros lycioides, Ziziphus mucronata*, etc. More indigenous grass and herb cover and abundance should occur. Without impacts the response metrics would have been better on all accounts. Roughness coefficient should be more if a better grazing management plan is implemented. | 3 |

- Riparian vegetation:

Riparian vegetation species expected to occur under reference conditions include the following (Figure 21):

*Themeda triandra, Eragrostis curvula, Setaria sphacelata, Arundinella nepalensis, Sporobolus africanus, Pennisetum macrourum, Persicaria senegalensis, Paspalum distichum, Phragmites australis, Kyllinga melanosperma, Schoenoplectus brachyceras, Searsia leptodictya, Commelina benghalensis, Ziziphus mucronata*, etc.

Exotic species: *Bidens pilosa, Salix babylonica, Populus x canescens, Cosmos bipinnatus, Flaveria bidentis, Tagetes minuta, Zinnia peruviana*, etc.

*Pennisetum macrourum*

*Cyperus fastigiatus*

**Figure 21. Visuals of riparian vegetation found in the study area.**

## Present Ecological State

Riparian vegetation (C/D EC, 58%)

The Riparian Index of Habitat Integrity (RIHI) is a C/D (58%) with the main impacts being scouring of the marginal zone. Exotic trees, water quality and water flow modifications due to road crossings and a sewage plant (Figure 22) upstream.

*Populus x canescens* in riparian zone

Refuse in riparian

Refuse and exotic vegetation

Bank collapse and scouring

**Figure 22: Some visuals within the bigger riparian zone.**

## PES causes and sources

The PES for the components as well as the reasons for the PES is summarized in Table 15.

**Table 15. Causes and sources.**

| | PES | Conf | Causes | Sources | F[1]/NF[2] Flow related Non-Flow related | Conf |
|---|---|---|---|---|---|---|
| Rip veg | C/D | 2.9 | Trampling and overgrazing in places | Lack of proper management. | Non-Flow related NF | 2.9 |
| | | | Water quality | Ermelo town, sewage plant, and mining occur upstream | | |
| | | | Exotic invasion | *Salix babylonica*, *Populus x. canescens* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication programmes in place. | | |
| | | | Road crossing | Impacting on hydrology of system | Flow related F | |
| | | | Bank collapse and scouring | Flooding, little vegetation cover and deepening of channel | | |
| | | | Water quantity | Water flow modifications as a consequence of sewage plant, mining and dams upstream | | |

1 Flow related 2 Non Flow related

## PES trends

An estimate was made as to whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarized in Table 16.

**Table 16. PES Trend.**

| | PES | Trend | Trend PES | Reasons | Conf |
|---|---|---|---|---|---|
| Rip veg | C/D | Negative | D | The presence of mining, management roads adjacent to riparian zone, and road crossing will always have an impact on the habitat availability and integrity of this site. Cattle tracks, local burning regimes and the presence of exotic vegetation species impact on the vegetation composition, cover and abundance. Mining, sewage plant and dams upstream impact affecting water flow, etc. If these impacts can be managed it will have a positive effect on the integrity of the system. It is unlikely that this will happen and it is predicted that the current EC will change to that of a D. | 2.9 |

## PES EcoStatus

To determine the PES EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence rating are included in the EcoStatus assessment index (Table 17). The EcoStatus EC is a C/D (58%).

**Table 17. EcoStatus.**

| RIPARIAN VEGETATION | EC % | EC | |
|---|---|---|---|
| RIPARIAN VEGETATION ECOLOGICAL CATEGORY | 58 | C/D | |
| ECOSTATUS | Confidence rating | | Modified weights |
| Confidence rating for riparian vegetation zone information | 2.9 | | 130.0 |
| ECOSTATUS | EC | | C/D |

**Site 2:**

The site assessed covers approximately 800 m from GPS point 26°30’24.39”S / 29°54’58.13”E upstream to 26°30’30.51”S / 29°55’25.08”E. This area forms part of the delineated riparian zone as visualised in the Google Earth photo in Figure 23.


**Figure 23. Google image of the location of the focus area of the VEGRAI assessment area.**

In Figure 24 a panoramic view of the site is visualised with the sandstone dykes in the foreground.

**Figure 24. Panoramic view of the selected VEGRAI study area.**

- Marginal zone (Figure 25):

This marginal zone is sedge & grass dominant. The river meanders around sand rock dykes and open grassland area. In places vegetation occurs sporadically where habitat is available. Habitat availability is determined by rocky substrate in the channel and/or bank collapse and bank undercutting. Substrate consists of sandstone bedrock or soil. Exotic species that occur are pioneer species such as *Centella asiatica, Paspalum urvillei, Cirsium vulgare, Verbena bonariensis, Tagetes minuta, Persicaria lapathifolia*, etc. occur. Water quantity and availability is an issue due to a dam just upstream of the site. Common indigenous species are *Cyperus compressus, Kyllinga alata, Pycreus nitidus, Leersia hexandra, Juncus effusus, Diospyros lycioides, Schoenoplectus brachyceras sp., Imperata cylindrica, Setaria sphacelata*, etc.

- Non-marginal zone (Figure 25):

Grass and herb dominated state. Some individual woody species occur, such as *Diospyros lycioides* and *Searsia dentata*. Both banks has got reasonable cover and abundance of herbs and grasses there where habitat is available. Indigenous species are: *Leersia hexandra, Fuirena pubescens, Cyperus compressus, Juncus rigidus, Senecio coronatus, Heteropogon amplectens, Themeda triandra, Setaria sphacelata, Cyperus esculentus, Berkheya radula, Crinum bulbispermum*, etc. Some exotic pioneers occur such as *Cirsium vulgare, Verbena bonariensis, Paspalum urvillei*, etc. Indications of terrestrialization is taking place with species such as *Elionurus muticus, Melinus repens*, etc. occurring. Bank substrate consists of soil material with various sandstone dykes crossing the study area.

View of the marginal zone

View of the non-marginal zone

**Figure 25. Photos of selected VEGRAI site.**

**Site advantages and disadvantages:**

Advantages and disadvantages are presented for this site in Table 13.

**Table 18. Site advantages and disadvantages.**

| Component | Advantages | Disadvantages | Conf |
|---|---|---|---|
| **Riparian vegetation** | • Easy accessible<br>• Zones with relatively good vegetation cover<br>• Clear hydro-geomorphological zones | • Grazing and trampling<br>• Road crossing<br>• Dam upstream<br>• Terrestrialization<br>• Erosion (scouring and collapse)<br>• Road adjacent to riparian | 3 |

## Reference conditions:

The reference conditions for the components are summarized in Table 14.

**Table 19. Reference conditions.**

| Component | Reference conditions | Conf |
|---|---|---|
| **Riparian vegetation** | **Marginal zone:**<br>Grass and sedge dominated state. Less erosion in the form of bank undercutting and scouring provide good habitat. Better cover and abundance may result in a better species composition. Good grazing management will provide a better vegetation roughness coefficient.<br>**Non-marginal zone:**<br>Grass, herb and sedge dominated state. It is expected that more woody species would occur such as *Diospyros lycioides, Ziziphus mucronata, Seersia dentata*, etc. More indigenous grass and herb cover and abundance is expected to occur. Without impacts such as grazing and trampling and the dam upstream the response metrics should have been better on all accounts. Roughness coefficient should be more if a better grazing management plan is implemented. | 3 |

- Riparian vegetation:

Riparian vegetation species *expected to occur under reference conditions include the following:*

*Common indigenous species are Cyperus compressus, Kyllinga alata, Pycreus nitidus, Leersia hexandra, Juncus effusus, Diospyros lycioides, Protasparagus setaceus, Schoenoplectus brachyceras sp., Imperata cylindrica, Setaria sphacelata, Crinum bulbispermum, Diospyros lycioides, Seersia dentata*, etc.

Exotic species: *Bidens pilosa, Centella asiatica, Paspalum urvillei, Cosmos bipinnatus, Zinnia peruviana, Cirsium vulgare, Verbena bonariensis, Tagetes minutes, Persicaria lapathifolia*, etc.

## Present Ecological State

Riparian vegetation (B/C EC, 78.4%)

The Riparian Index of Habitat Integrity (RIHI) is a B/C (78.4%) with the main impacts being erosion and overgrazing. Water quantity and water flow modifications due to dam in upstream portion of the river (Figure 26).

**Figure 26: Visual of the farm dam upstream of the VEGRAI study site.**

## PES causes and sources

The PES for the components as well as the reasons for the PES is summarized in Table 20.

**Table 20: Causes and sources.**

| | PES | Conf | Causes | Sources | F[1]/NF[2]<br>Flow related<br>Non-Flow related | Conf |
|---|---|---|---|---|---|---|
| Rip veg | B/C | 3 | Trampling and overgrazing in places | Lack of proper management. | Non-Flow related<br>NF | 2.9 |
| | | | Road adjacent to river | Impacting on hydrology of system | Flow related<br>F | |
| | | | Bank collapse and scouring | Dam upstream influencing hydrology of the system | | |
| | | | Water quantity | Water flow modifications as a consequence of a dam upstream | | |

1 Flow related 2 Non Flow related

## PES TREND

An estimate was made as to whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarized in Table 21.

**Table 21: Trend.**

| | PES | Trend | Trend PES | Reasons | Conf |
|---|---|---|---|---|---|
| Rip veg | B/C | Stable | B/C | The presence of grazing, road adjacent to riparian zone, and dam will always have an impact on the habitat availability and integrity of this site. If these impacts can be managed it will have a positive effect on the integrity of the system. It is unlikely that this will happen and it is predicted that the current EC will not change. | 3 |

### PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence rating are included in the EcoStatus assessment index (Table 22). The EcoStatus EC is a B/C (78.4%).

**Table 22: EcoStatus.**

| RIPARIAN VEGETATION | EC % | EC | |
|---|---|---|---|
| **RIPARIAN VEGETATION ECOLOGICAL CATEGORY** | **78.4** | **C/D** | |
| **ECOSTATUS** | **Confidence rating** | | **Modified weights** |
| Confidence rating for riparian vegetation zone information | 3 | | 140.0 |
| **ECOSTATUS** | **EC** | | **B/C** |

## Site 3

The site assessed covers approximately 800 m from GPS point 26°30’42.69”S / 29°54’32.98”E upstream to 26°30’29.55”S / 29°54’46.64”E. This area forms part of the delineated riparian zone as visualised in the Google Earth photo in Figure 27.

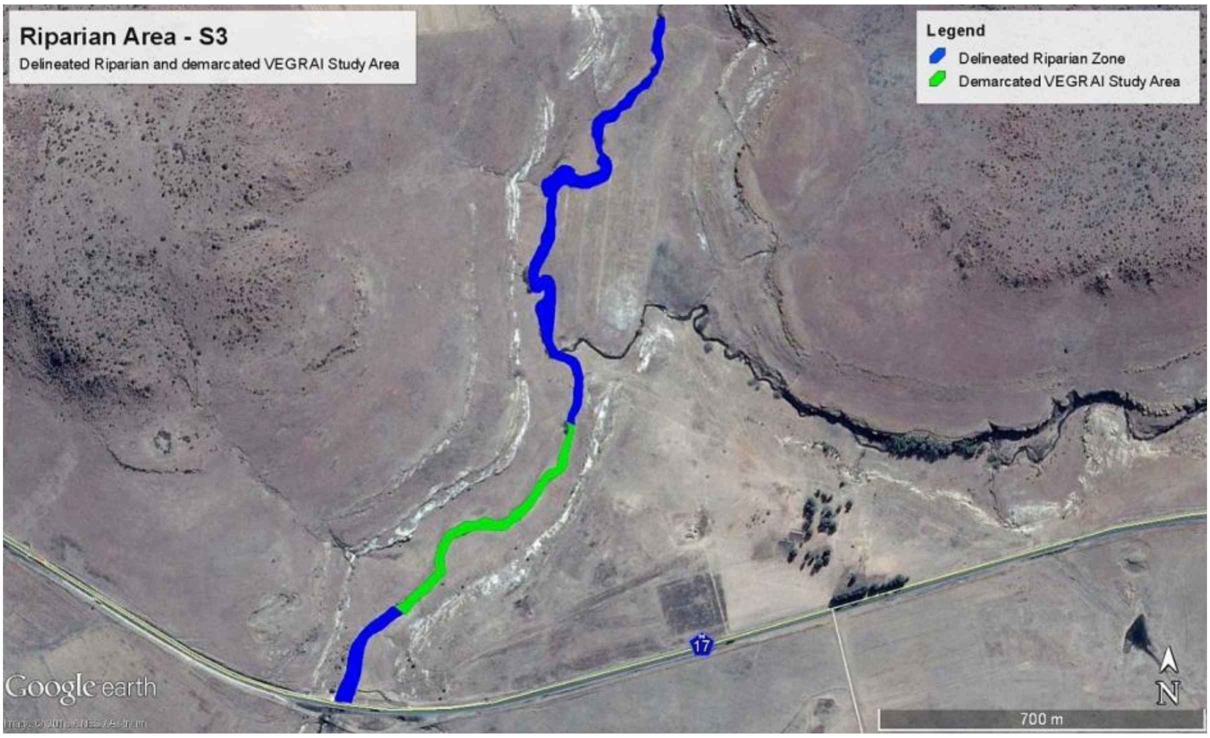



**Figure 27. Google image of the location of the focus area of the VEGRAI assessment area S3.**

In Figure 28 a panoramic view of the site is visualised and the sandstone formations and the river can be seen.

**Figure 28. Panoramic view of the selected VEGRAI study area S3.**

- Marginal zone (Figure 29):

This marginal zone is sedge & forb dominant. The river meanders through a valley bottom area in between sand rock formations. This zone is well covered with vegetation and little erosion has been encountered. Substrate consists of sandstone bedrock and/or soil. Indigenous species are *Phragmites australis, Cyperus compressus, Kyllinga alata, Pycreus nitidus, Leersia hexandra, Juncus effusus, Schoenoplectus brachyceras, Imperata cylindrica, Setaria sphacelata*, etc. Exotic species that occur are species such as *Centella asiatica, Paspalum urvillei, Cirsium vulgare, Verbena bonariensis, Tagetes minuta, Myriophyllum aquaticum, Lemna gibba, Veronica Anagallis-aquatica*, etc. occur. Water quantity and quality is an issue due to a dam upstream of the study area.

- Non-marginal zone (Figure 29):

Grass and herb dominated state. Some individual woody species occur, such as *Diospyros lycioides, Searsia lanceolata* and *Searsia dentata*. Both banks have good cover and little to no erosion was observed. High flow channels occur which is also well covered with vegetation. Indigenous species such as *Miscanthus junceus, Paspalum distichum, Cyperus compressus, Cynodon dactylon, Senecio coronatus, Heteropogon amplectens, Themeda triandra, Setaria sphacelata, Cyperus esculentus, Crinum bulbispermum*, etc., occur. There are some exotic pioneers occur such as *Cirsium vulgare, Verbena bonariensis, Paspalum urvillei*, etc. Bank substrate consists of soil material with sandstone.

View of the marginal zone

View of the non-marginal zone

**Figure 29. Photos of selected VEGRAI site.**

**Site advantages and disadvantages:**

Advantages and disadvantages are presented for this site in Table 23.

**Table 23. Site advantages and disadvantages.**

| Component | Advantages | Disadvantages | Conf |
|---|---|---|---|
| **Riparian vegetation** | • Easy accessible<br>• Zones with relatively good vegetation cover<br>• Clear hydro-geomorphological zones | • Grazing and trampling<br>• Exotic species<br>• Localized impacts<br>• Terrestrialization<br>• Erosion (scouring and collapse) | 3 |

**Reference conditions:**

The reference conditions for the components are summarized in Table 24.

**Table 24. Reference conditions.**

| Component | Reference conditions | Conf |
|---|---|---|
| **Riparian vegetation** | **Marginal zone:**<br>Grass and sedge dominated state. Less erosion in the form of bank undercutting and scouring should provide good habitat. Better cover and abundance may result in a better species composition. More indigenous species such as *Paspalum distichum* and perhaps more reed clumps. More woodies such as *Salix mucronata* and *Diospyros lycioides* is expected. Good grazing management will provide a better vegetation roughness coefficient.<br>**Non-marginal zone:**<br>Grass, herb and forb dominated state with scattered individual trees. With good grazing management a much better roughness coefficient is expected. A better grass and forb cover and abundance is expected if a proper fire management is implemented. Without impacts such as grazing and trampling and the dam upstream the response metrics should have been better on all accounts. | 3 |

- Riparian vegetation:

Riparian vegetation species expected to occur under reference conditions include the following (Figure 30):

*Themeda triandra, Eragrostis curvula, Setaria sphacelata, Arundinella nepalensis, Sporobolus africanus, Pennisetum macrourum, Persicaria senegalensis, Paspalum distichum, Berula erecta, Veronica anagallis-aquatica, Phragmites australis, Kyllinga melanosperma, Schoenoplectus brachyceras, Searsia leptodictya, Commelina benghalensis, Crinum bulbispermum,* etc.

Exotic species: *Bidens pilosa, Salix babylonica, Schinus terebinthifolius, Myriophyllum aquaticum, Lemna gibba, Cosmos bipinnatus, Tagetes minuta*, etc.

*Schinus terebinthifolius*

*Persicaria senegalensis* and *Phragmites australis*

*Myriophyllum aquaticum*

*Persicaria senegalensis*

**Figure 30: Visuals of riparian vegetation found in the study area.**

## Present Ecological State

Riparian vegetation (C EC, 64.2%)

The Riparian Index of Habitat Integrity (RIHI) is a C (64.2%) with the main impacts being overgrazing. Exotic hydrophytes and trees, water quality and water flow modifications due to dams upstream and a sewage plant (Figure 31).

No vegetation cover underneath *Salix babylonica* due to the effect of shading. Exposure to erosion is evident

Exotic *Lemma gibba* and *Myriophyllum aquaticum*

**Figure 31. Some visuals within the bigger riparian zone.**

## PES causes and sources

The PES for the components as well as the reasons for the PES is summarized in Table 25.

**Table 25. Causes and sources.**

| | PES | Conf | Causes | Sources | F[1]/NF[2] Flow related Non-Flow related | Conf |
|---|---|---|---|---|---|---|
| Rip veg | C | 3 | Trampling and overgrazing in places | Lack of proper management. | Non-Flow related NF | 3 |
| | | | Water quality | Ermelo town, sewage plant, and mining occur upstream | | |

| | PES | Conf | Causes | Sources | F[1]/NF[2] Flow related Non-Flow related | Conf |
|---|---|---|---|---|---|---|
| | | | Exotic invasion | *Salix babylonica* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, and hydrophytes such as *Myriophyllum aquaticum, Lemna gibba*, etc. No eradication programmes in place. | | |
| | | | Terrestrialisation | Dam upstream impacting on hydrology of system | Flow related F | |
| | | | Increase in exotic hydrophytes | Flooding, and enrichment of water due to sewage and mining upstream | | |
| | | | Water quantity | Water flow modifications as a consequence of sewage plant, mining and dams upstream | | |

1 Flow related 2 Non Flow related

**PES TREND**

An estimate was made as to whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarized in Table 26.

**Table 26. Trend.**

| | PES | Trend | Trend PES | Reasons | Conf |
|---|---|---|---|---|---|
| Rip veg | C | Stable | C | The presence of mining, sewage plant, dams, etc. will always have an impact on the habitat availability and integrity of this site. Cattle tracks, local burning regimes and the presence of exotic vegetation species impact on the vegetation composition, cover and abundance. If these impacts can be managed it will have a positive effect on the integrity of the system. It is unlikely that this will happen and it is predicted that the current EC-C will stay the same. | 3 |

**PES ECOSTATUS**

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence rating are included in the EcoStatus assessment index (Table 27). The EcoStatus EC is a C (64.2%).

**Table 27. EcoStatus.**

| RIPARIAN VEGETATION | EC % | EC | |
|---|---|---|---|
| **RIPARIAN VEGETATION ECOLOGICAL CATEGORY** | 64.2 | C | |
| **ECOSTATUS** | **Confidence rating** | | **Modified weights** |
| Confidence rating for riparian vegetation zone information | 3.0 | | 160.0 |
| **ECOSTATUS** | **EC** | | **C** |

### Site 4:

The site assessed covers approximately 1,218 m from GPS point 26°31'22.05"S / 29°53'13.96"E upstream to 26°31'12.74"S / 29°53'38.82"E. This area forms part of the delineated riparian zone as visualised in the Google Earth photo in Figure 32.

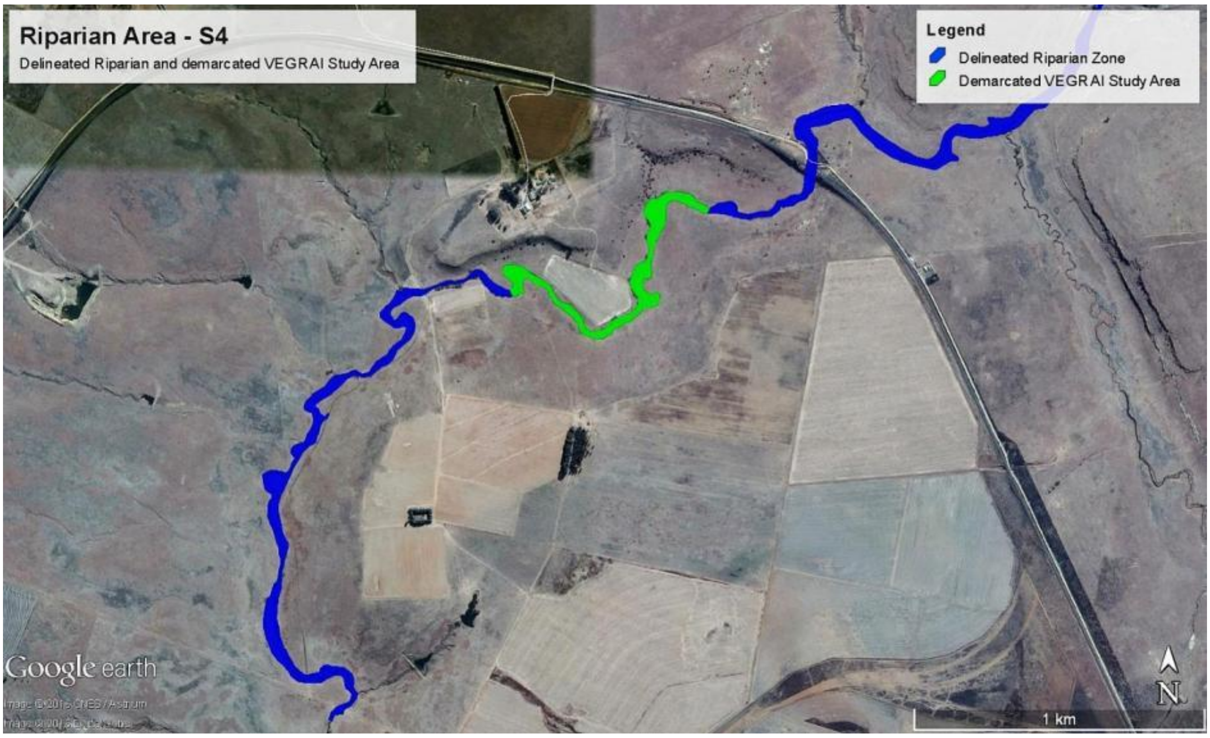



**Figure 32. Google image of the location of the focus area of the VEGRAI assessment area S4.**

In Figure 33 a photo of the site is visualised and the grassveld and the river channel can be seen.

**Figure 33. Visual of the selected VEGRAI study area S4.**

- Marginal zone (Figure 34):

This marginal zone is sedge & forb dominant. Several isolated *Salix babylonica*, tree clumps occur. The river meanders through a valley bottom area and is deeply incised. This zone is well covered with vegetation and bank slumping and undercutting have been encountered. Substrate consists of alluvial soil. Indigenous species are *Miscanthus junceus, Agrostis sp., Cyperus digitates, Gunnera perpensa, Plantago longissima, Persicaria senegalensis, Phragmites australis, Cyperus compressus, Pycreus nitidus, Leersia hexandra, Juncus effusus, Schoenoplectus brachyceras, Imperata cylindrica, Setaria sphacelata*, etc. Exotic species that occur are species such as *Centella asiatica, Paspalum urvillei, Cirsium vulgare, Verbena bonariensis, Tagetes minuta*, *Veronica Anagallis-aquatica*, etc. occur. Water quantity and quality is an issue due to a dam upstream of the study area.

- Non-marginal zone (Figure 34):

Grass and herb dominated state. Both banks are reasonably flat and do have good vegetation cover. Little to no erosion was observed, some high flow channels also occurs. Indigenous species such as *Miscanthus junceus, Cyperus digitates, Cyperus compressus, Cynodon dactylon, Senecio coronatus, Heteropogon amplectens, Themeda triandra, Setaria sphacelata, Cyperus esculentus, Crinum bulbispermum*, etc. occurs. Some exotic pioneers occur such as *Cirsium vulgare, Verbena bonariensis, Paspalum urville*i, etc. Bank substrate consists of soil material with sandstone.

View of the marginal zone with *Cyperus digitates* in the foreground

View of the non-marginal zone

**Figure 34. Photos of selected VEGRAI site.**

**Site advantages and disadvantages:**

Advantages and disadvantages are presented for this site in Table 28.

**Table 28. Site advantages and disadvantages.**

| Component | Advantages | Disadvantages | Conf |
|---|---|---|---|
| **Riparian vegetation** | • Easy accessible<br>• Zones with good vegetation cover<br>• Clear hydro-geomorphological zones | • Grazing and trampling<br>• Exotic species<br>• Localized impacts<br>• Terrestrialization<br>• Erosion (scouring and collapse) | 3 |

### Reference conditions:

The reference conditions for the components are summarized in Table 29.

**Table 29. Reference conditions.**

| Component | Reference conditions | Conf |
|---|---|---|
| **Riparian vegetation** | **Marginal zone:**<br>Grass and sedge dominated state. Less erosion in the form of bank undercutting and scouring should provide good habitat. Better cover and abundance may result in a better species composition. More indigenous species such as *Paspalum distichum* and perhaps more reed clumps can occur. More woodies such as *Salix mucronata* and *Diospyros lycioides* is expected. Good grazing management will provide a better vegetation roughness coefficient.<br>**Non-marginal zone:**<br>Grass, herb and forb dominated state with scattered individual trees. With good grazing management a much better roughness coefficient is expected. Good grass and forb cover and abundance is expected if a proper fire management is implemented. Without impacts such as grazing and trampling and the shading effect of *Salix babylonica* the response metrics should have been better on all accounts. | 3 |

- Riparian vegetation:

Riparian vegetation species expected to occur under reference conditions include the following:

*Pennisetum thunbergii, Pennisetum macrourum, Miscanthus junceus, Themeda triandra, Eragrostis curvula, Setaria sphacelata, Arundinella nepalensis, Sporobolus africanus, Persicaria senegalensis, Plantago longissima, Paspalum distichum, Berula erecta, Veronica anagallis-aquatica, Phragmites australis, Kyllinga melanosperma, Schoenoplectus brachyceras, Commelina benghalensis, Crinum bulbispermum*, etc.

Exotic species: *Pseudognaphalium luteo-album, Bidens pilosa, Salix babylonica, Verbena bonariensis, Veronica anagallis-aquatica, Bromus catharticus, Cosmos bipinnatus, Tagetes minuta*, etc.

### Present Ecological State

Riparian vegetation (C EC, 63.6%)

The Riparian Index of Habitat Integrity (RIHI) is a C (63.6%) with the main impacts being overgrazing. Exotic hydrophytes and trees, water quality and water flow modifications due to dams upstream and a sewage plant (Figure 35).

No vegetation cover underneath *Salix babylonica* due to the effect of shading. Exposure to erosion is evident

*Salix babylonica* growing in channel

Moribund material of a Salix banylonica tree

**Figure 35. Some visuals within the bigger riparian zone.**

## PES causes and sources

The PES for the components as well as the reasons for the PES is summarized in Table 30.

**Table 30. Causes and sources.**

| | PES | Conf | Causes | Sources | F[1]/NF[2] Flow related Non-Flow related | Conf |
|---|---|---|---|---|---|---|
| Rip veg | C | 3 | Trampling and overgrazing in places | Lack of proper management. | Non-Flow related NF | 3 |
| | | | Water quality | Ermelo town, sewage plant, and mining occur upstream. | | |
| | | | Exotic vegetation | *Salix babylonica* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta,* etc. No eradication programmes in place. | | |
| | | | Terrestrialisation | Dam upstream impacting on hydrology of system | Flow related F | |
| | | | Water quantity | Water flow modifications as a consequence of sewage plant, mining and dams upstream | | |

1 Flow related 2 Non Flow related

## PES TREND

An estimate was made as to whether the components are responding to the main drivers (i.e. whether the quality and quantity are stable or still changing). The results are summarized in Table 31.

**Table 31. Trend.**

| | PES | Trend | Trend PES | Reasons | Conf |
|---|---|---|---|---|---|
| Rip veg | C | Stable | C | The presence of mining, sewage plant, dams, etc. will always have an impact on the water quality and quantity. Cattle tracks, local burning regimes and the presence of exotic vegetation species impact on the vegetation composition, cover and abundance. If these impacts can be managed it will have a positive effect on the integrity of the system. It is unlikely that this will happen and it is predicted that the current EC-C will stay the same. | 3 |

## PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence rating are included in the EcoStatus assessment index (Table 32). The EcoStatus EC is a C (63.6%).

**Table 32: EcoStatus.**

| RIPARIAN VEGETATION | EC % | EC | |
|---|---|---|---|
| RIPARIAN VEGETATION ECOLOGICAL CATEGORY | 63.6 | C | |
| ECOSTATUS | Confidence rating | | Modified weights |
| Confidence rating for riparian vegetation zone information | 3.0 | | 150.0 |
| ECOSTATUS | EC | | C |

## 7.4.2 Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessments

Wet-Health (Macfarlane *et al.* 2007) is an accepted method to determine the Present Ecological State, by evaluating the deviation of wetland structure and function from the wetland's natural reference condition. Indirect and direct disturbances are taken into account. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. Both these assessments give scores with resulting Ecological Management Classes (EMC).

Due to the size of the area a Level 1 assessment was applied. The study area was divided into nine catchment areas, based on 5 m contours (**Figure 36**). All the HGM wetland units present in each of the catchments were assessed.

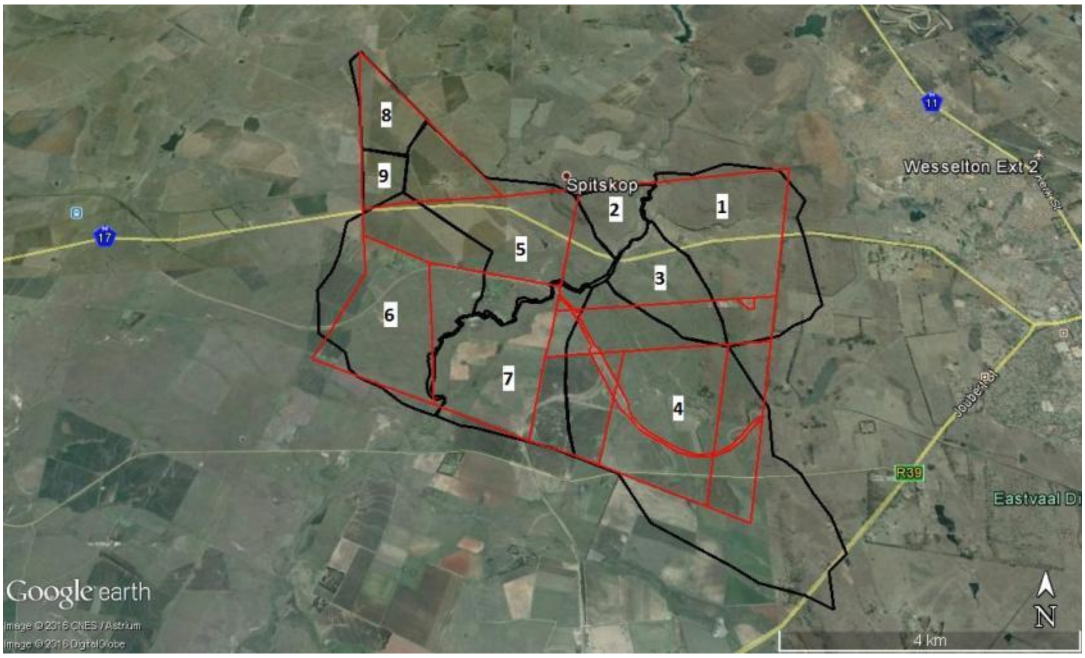



**Figure 36. Map illustrating the assigned catchment areas for the Wet-Health assessments.**

Disturbances such as dumping, old farm roads, power line crossings, grazing, trampling, water abstraction, alien invasive vegetation species, erosion, etc., were taken into account in determining the PES and EIS of the wetland units (Table 33). In general the biggest impact to the wetlands in the study area is erosion, although the magnitude hereof varies. Other impacts include dams, invasive plant species, infrastructure, and overgrazing and dumping. Pollution is a serious problem in the riparian areas. Figure 37 illustrates some of the impacts in the wetlands in the study area.

**Table 33. Location of and impacts present in the various HGM units.**

| Catchment | HGM unit | Extent (%) | Impacts in HGM unit |
|---|---|---|---|
| **Catchment 1** | Unchannelled valley bottom | 11 | Erosion, grazing |
| | Hillslope Seep | 19 | Erosion, grazing |
| | Unchannelled valley bottom | 65 | Dam, highway, erosion, quarry activities, old fields |
| | Hillslope Seep | 4 | Erosion |
| | Isolated hillslope seep | 1 | Sediment deposition, grazing |
| **Catchment 2** | Seep | 100 | Erosion |
| **Catchment 3** | Seep | 56 | Dam, highway, old fields |
| | Unchannelled valley bottom | 44 | Old fields, dam, highway |
| **Catchment 4** | Hillslope seep | 6 | Erosion, Infrastructure, Dumping |
| | Channelled valley bottom 1 | 20 | Invasive species, erosion, infrastructure |
| | Channelled valley bottom 2 | 16 | Erosion, dams, Infrastructure |
| | Unchannelled valley bottom 1 | 24 | Infrastructure, Invasive species |
| | Hillslope seep | 34 | Infrastructure |
| **Catchment 5** | Isolated hillslope seep | 18 | Invasive species, some infrastructure |
| | Channelled valley bottom | 61 | Erosion, Infrastructure, dam |
| | Hillslope Seep | 21 | Infrastructure, dam |
| **Catchment 6** | Hillslope seep | 44 | Erosion, Infrastructure |
| | Channelled valley bottom | 56 | Erosion, Infrastructure, dam, croplands |
| **Catchment 7** | Hillslope Seep | 83 | Dam, slight erosion |
| | Unchannelled valley bottom | 4 | Dam, erosion |
| | Hillslope Seep | 8 | Erosion, infrastructure |
| | Isolated hillslope seep | 5 | Croplands |
| **Catchment 8** | Channelled valley bottom | 100 | Erosion and gullies |
| **Catchment 9** | Unchannelled valley bottom | 100 | Infrastructure |

*Badly constructed road through a wetland*

*Hillslope seep being eroded*

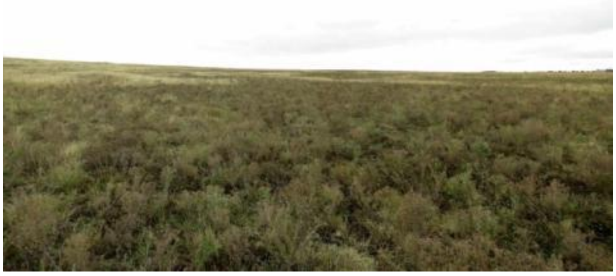
*Croplands in a hillslope seep*

*Dumping in a wetland*

*An unchannelled valley bottom wetland eroded unto bedrock*

*Railway infrastructure in the extensive seep in the southern portion of the site*

*Dam with extensive erosion and dumping*



*Seep dominated by pioneer plant species in an old field on an extensive seep area*

**Figure 37. A few examples of impacts encountered on site.**

The 'Trajectory of Change' component of the WET-Heath assessment is designed to indicate the direction of ecological status which an ecosystem might take under the proposed development. The trajectory of change was not included in this assessment. Rather the expected impacts of the proposed mining on the wetland systems on site are more directly explored in Section 8.

Table 34 indicates the result of the WET-Health assessment per catchment (Figure 36). The results are separated into the various indicator components namely hydrology, geomorphology and vegetation.

Table 35 indicates the results of the EIS assessment per HGM unit in each catchment. These results are separated into the various indicator components namely Ecological Importance & Sensitivity, Hydro-Functional Importance, and Direct Human Benefits.

**Table 34. Present Ecological State of wetlands in the study area.**

| | Hydrology | | Geomorphology | | Vegetation | | FINAL SCORE | |
|---|---|---|---|---|---|---|---|---|
| **Catchment 1** | 1.1 | B | 0.3 | A | 2.6 | **C** | **1.3** | **B** |
| **Catchment 2** | 0.0 | A | 0.3 | A | 0.8 | **A** | **0.4** | **A** |
| **Catchment 3** | 0.4 | A | 0.0 | A | 3.2 | **C** | **1.2** | **B** |
| **Catchment 4** | 3.7 | C | 0.9 | A | 4.4 | **D** | **3.0** | **C** |
| **Catchment 5** | 0.6 | A | 0.2 | A | 2.6 | **C** | **1.1** | **B** |
| **Catchment 6** | 1.1 | B | 0.5 | A | 5.1 | **D** | **2.2** | **C** |
| **Catchment 7** | 0.2 | A | 0.2 | A | 6.4 | **E** | **2.3** | **C** |
| **Catchment 8** | 6.0 | E | 0.8 | A | 5.6 | **D** | **4.1** | **D** |
| **Catchment 9** | 1.0 | B | 3.6 | C | 5.9 | **D** | **3.2** | **C** |
| **Average** | **1.6** | **B** | **0.8** | **A** | **4.1** | **D** | **2.2** | **C** |

**Table 35. Ecological Importance & Sensitivity of the wetlands in the study area.**

| Catchment | HGM unit | Ecological Importance & Sensitivity | Conf | Ecol. Man. Class | Hydro-Functional Importance | Conf | Ecol. Man. Cl | Direct Human Benefits | Conf | Ecol. Man. | FINAL EIS | Conf | Ecol. Man. Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Catchment 1** | Unchannelled valley bottom | 2.0 | 3.7 | B | 2.9 | 3.0 | B | 0.8 | 5.0 | D | **1.9** | **3.9** | **C** |
| | Hillslope Seep & Isolated seep | 3.7 | 3.8 | A | 1.3 | 3.5 | C | 0.5 | 5.0 | D | **1.8** | **4.1** | **C** |
| **Catchment 2** | Seep | 3.2 | 3.5 | A | 1.5 | 3.5 | C | 0.8 | 5.0 | D | **1.8** | **4.0** | **C** |
| **Catchment 3** | Seep | 2.7 | 3.5 | B | 1.1 | 3.5 | C | 0.5 | 5.0 | D | **1.4** | **4.0** | **C** |
| | Unchannelled valley bottom | 2.8 | 3.5 | B | 3.0 | 3.0 | A | 0.7 | 5.0 | D | **2.2** | **3.3** | **B** |
| **Catchment 4** | Hillslope seep | 2.2 | 3.5 | B | 1.1 | 4.0 | C | 0.7 | 5.0 | D | **1.3** | **4.1** | **C** |
| | Channelled valley bottom | 2.8 | 3.5 | B | 2.0 | 3.0 | B | 1.7 | 5.0 | C | **2.1** | **3.8** | **B** |
| | Unchannelled valley bottom | 3.0 | 3.9 | A | 3.1 | 3.5 | A | 0.5 | 4.5 | D | **2.2** | **4.0** | **B** |
| **Catchment 5** | Isolated hillslope seep | 2.0 | 4.0 | B | 1.0 | 4.0 | C | 0.7 | 5.0 | D | **1.2** | **3.8** | **C** |
| | Channelled valley bottom | 2.5 | 3.5 | B | 1.9 | 3.0 | C | 1.2 | 5.0 | C | **1.9** | **4.1** | **C** |
| | Hillslope Seep | 2.2 | 3.5 | B | 1.4 | 4.0 | C | 0.8 | 5.0 | D | **1.5** | **4.1** | **C** |
| **Catchment 6** | Hillslope seep | 2.4 | 3.5 | B | 1.0 | 4.0 | C | 0.3 | 5.0 | D | **1.2** | **4.2** | **C** |
| | Channelled valley bottom | 2.8 | 3.6 | B | 1.9 | 4.0 | C | 1.3 | 5.0 | C | **2.0** | **4.1** | **B** |
| **Catchment 7** | Hillslope Seep & Isolated seep | 2.8 | 3.3 | B | 1.0 | 4.0 | C | 0.9 | 5.0 | D | **1.6** | **4.1** | **C** |
| | Unchannelled valley bottom | 2.7 | 3.4 | B | 2.0 | 4.0 | B | 0.8 | 5.0 | D | **1.8** | **4.1** | **C** |
| **Catchment 8** | Channelled valley bottom | 1.6 | 3.4 | C | 1.8 | 4.0 | C | 0.7 | 5.0 | D | **1.1** | **3.9** | **C** |
| **Catchment 9** | Unchannelled valley bottom | 1.6 | 3.4 | C | 1.6 | 3.0 | C | 0.3 | 5.0 | D | **1.7** | **4.0** | **C** |
| **TOTAL** | | **2.5** | **3.6** | **B** | **1.7** | **3.6** | **C** | **0.8** | **5.0** | D | **1.6** | **4.0** | **C** |

The overall Present Ecological State of the wetlands in the study area is regarded as a **"C: Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact".** The geomorphology of these wetlands is mostly intact, while the vegetation component is the most modified. The absence of major infrastructure, large dams, and year-round irrigation sustains the hydrological function of the wetlands in the study area. The vegetation is mostly affected due to the removal of natural communities through the establishment of dams, the presence of erosion channels and gullies, and agricultural activities within the wetland boundary.

The overall Ecological Importance & Sensitivity of the wetlands in the study area is regarded as **"C: Moderate. The wetlands are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of the wetlands are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers"**. It is the opinion of the specialist that this is an underestimation of the overall EIS score, as the low importance and sensitivity is ascribed as a result of low direct human benefits.

**<u>Catchments 1 – 3 & 5</u>**

The wetlands in catchment 1 – 3 and 5, which constitutes the northern portions of the study area, are still relatively intact due to little infrastructure and only a few dams.

These wetlands in these catchments collectively obtained either an **<u>Unmodified</u>**, or a **<u>Small</u>** impact category in the Present Ecological State (PES) assessment, which indicate that the habitat varies between natural to largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place. Despite widely occurring erosion features, the geomorphology is deemed **"Unmodified".** Due to increases runoff from croplands, numerous dams and erosion channels, the hydrology component varies between "**Natural**" and **"Largely natural with few modifications."** The vegetation in the wetlands in the study area is the worst affected and is "**Largely modified"**. This is mostly a result of removal of natural vegetation. Despite this there are still large areas with primary grassland in especially the extensive seep areas.

The overall EIS of the wetlands in this catchment is **<u>Moderate.</u>** The wetlands are considered ecologically important and sensitive on a provincial or local scale. The biodiversity is not so sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers. The C-ecological management class is mostly a result of the low direct human benefits gained from the system. The Ecological- and Hydro-functional Importance of these wetlands varies between **<u>High</u>** and **<u>Very High,</u>** and is deemed more sensitive for the same reasons as mentioned with the PES.

**<u>Catchments 4, 6 & 7</u>**

The wetlands in catchments 4, 6, 7, and 9, which constitute the southern portions of the study area, are somewhat more impacted upon, mostly due to an increase of dams, the large railway- and other infrastructure and an increase in wetlands affected by erosion. There also more active agricultural fields often located in the extensive seep areas in the southern portion of the study area.

These wetlands in these catchments collectively obtained a **<u>Moderate</u>** impact category in the Present Ecological State (PES) assessment, which indicate that although the habitat underwent a moderate change in ecosystem processes and loss of natural habitats, the natural habitat remains predominantly intact. The geomorphology component of the WET-Health assessment was shown to be the most intact, while the vegetation component is the most modified. Despite widely occurring erosion features, the geomorphology is deemed **"Unmodified".** Due to increases runoff from croplands, numerous dams and erosion channels, the hydrology component varies between **"Unmodified"** and "**Moderately modified".** In this portion of the study area there are more dams, infrastructure and active agricultural activities. This also results in the vegetation in the wetlands being the worst affected and regarded as **"Largely modified"**. Natural vegetation is removed through the establishment of dams, the presence of erosion channels and gullies, and agricultural activities within the wetland boundary.

The collective EIS of the wetlands are considered to be **High** in Catchment 4 (i.e. ecologically important and sensitive, with the biodiversity being sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers), and **Moderate** in Catchments 6 and 7 (ecologically important and sensitive on a lesser scale, with less sensitive biodiversity. They play a small role in moderating the quantity and quality of water of major rivers.)
Catchment 4 has a higher Hydro-functional importance than Catchments 6 and 7 (considered to be **"Moderate")**, while all the catchments are regarded as having a "**High"** sensitivity to changes to the biodiversity, and "**Low"** direct human benefits.

**Catchments 8 & 9**

Catchment 8 and 9 which occurs in the north-western portion of the site scores slightly lower in most aspects of the PES and EIS. This is probably due to a smaller wetland size in relation to the catchment size, as well as the significant presence of erosion gullies in the wetlands.

The PES assessment of the wetland system in Catchment 8 regards the change in the wetland as **Large**. A large change in ecosystem processes and loss of natural habitat and biota and has occurred. This is due to the hydrology component being significantly affected by erosion, which is regarded as "**Serious"**. However, it is the opinion of the specialist that this is an overestimation of the severity of the impact on the hydrology, especially in relation to the other wetland systems in the study area also impacted by erosion.

The PES assessment of the wetland system in Catchment 9 regards the change in the wetland as **Moderate,** with the hydrological function being largely natural with only a few modifications, the geomorphology being moderately modified, and the vegetation being largely modified. The geomorphology component is affected by a road that runs longitudinally right through the middle of the wetland, therefore carrying floodwaters unattenuated downstream.

The collective EIS in both catchment 8 and 9 is **Moderate,** with the wetlands being ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands are not usually sensitive to flow and habitat modifications, and they play a small role in moderating the quantity and quality of water of major rivers. The wetlands in both these catchments are affected by erosion and infrastructure.

# 8 IMPACT ASSESSMENT AND MITIGATION

Any development in a natural system will impact on the environment, usually with adverse effects. From a technical, conceptual or philosophical perspective the focus of impact assessment ultimately narrows down to a judgment on whether the predicted impacts are significant or not (DEAT 2002). Alterations of the natural variation of flow by river or channel regulation through decreasing or increasing the flows can have a profound influence upon almost every aspect of the floodplain's and/or wetland's ecological functioning (Davies & Day, 1998).

Current South African legislation, as indicated at the outset of this report, requires that the necessary aquatic ecosystem impact assessment be conducted and mitigation measures assessed, so as to reduce or prevent the degradation of aquatic habitats and biotic populations due to alterations in the wetland that may impact on migration and ecosystem functioning. This assessment was done after a single wet season field survey. A single visit makes it difficult to assess the wetland systems' response under different environmental conditions such as different seasons. However, all the wetlands should, from a biodiversity and hydrology aspect, be regarded as sensitive.

There are two different sets of impacts envisaged for the mining activities:

- The local impacts caused by the proposed infrastructure (Catchment 5)
- The impacts caused by the underground operations (Whole site)

## 8.1 Wetlands affected by the proposed infrastructure

The boxcut, plant, and associated mine infrastructure will be located on portion RE 0 of the Farm De Roodepoort 435 IS (**Figure 38**), in a section in the study area were relatively few wetland systems are present (**Figure 39**). Figure 40 indicates that the wetlands to be intersected are:

- A <u>Channelled Valley Bottom</u> wetland system by the <u>Mine residue dump</u>
- A <u>Hillslope Seep</u> area by the <u>boxcut hards stockpile</u> and the <u>conveyor decline</u>
- buffer area of a <u>Channelled Valley Bottom</u> wetland system by the <u>pollution control dam</u>
- buffer area between the <u>Riparian area and a Hillslope Seep</u> zone by the <u>eastern ventilation shaft</u>

Firstly it is recommended that the above-mentioned infrastructure (*especially* the Mine residue dump and the boxcut hards stockpile) be moved out of the wetland areas. It is however accepted that it might not be possible to move the conveyor decline and the eastern ventilation shaft. Depending on the incline of the conveyor decline it is possible that the infrastructure might be located below the seep area and therefore not impact (impede or divert flow) the seep zone, but this will have to be confirmed by a geohydrologist.

A Water Use License will have to be applied for since the infrastructure occurs within 500 m of wetland systems.

For a full set of expected impacts and mitigation measures refer to Section 8.3.

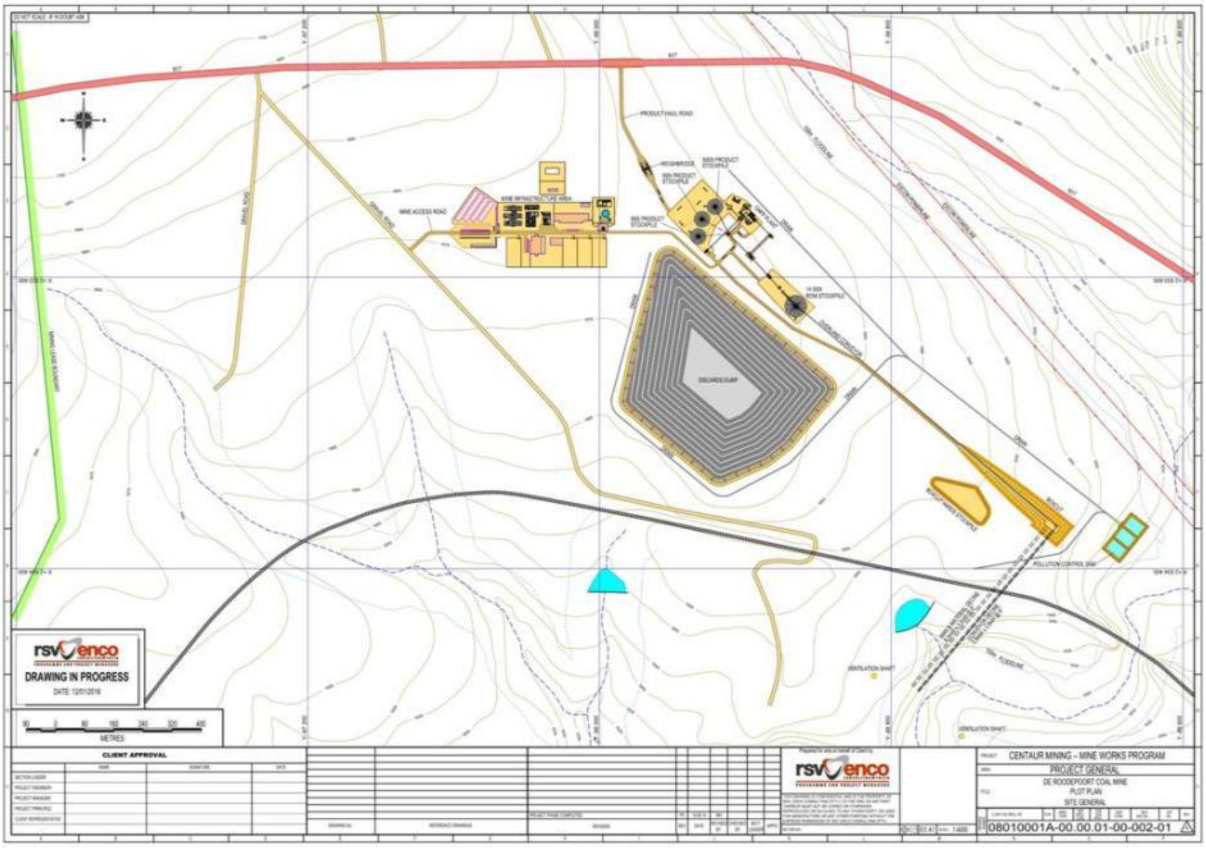



**Figure 38. The mining infrastructure layout.**

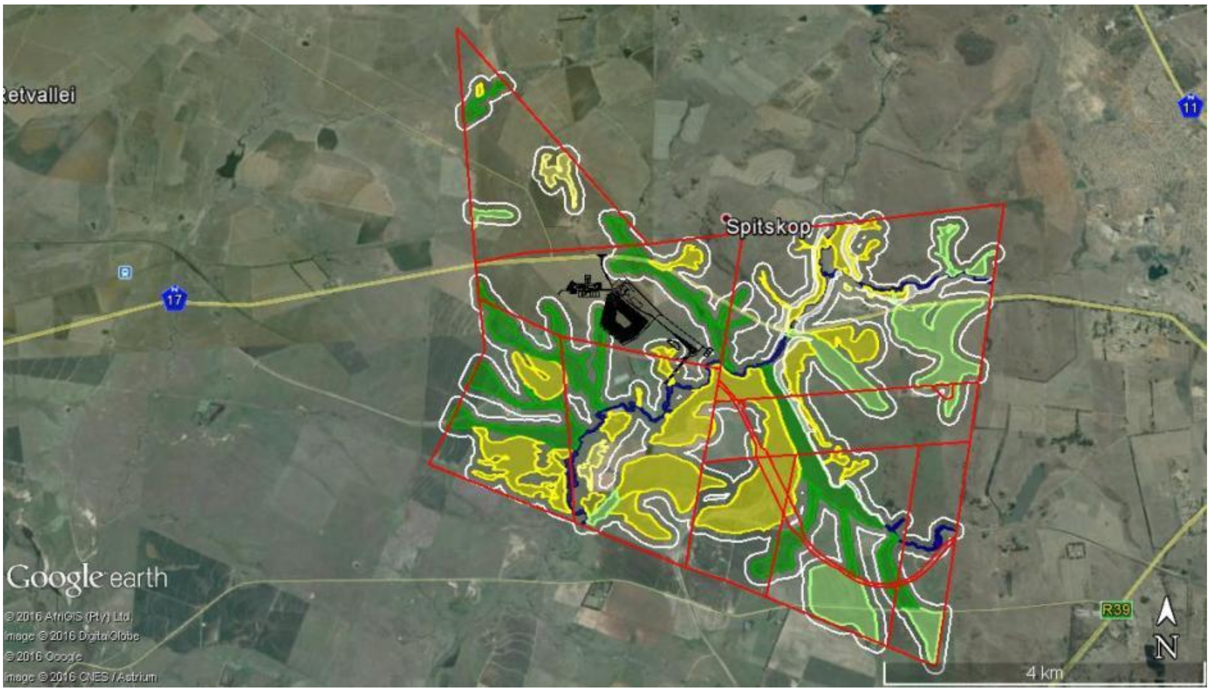



**Figure 39. The proposed aboveground mining infrastructure in relation to the delineated wetlands and the 100 m buffer (as indicated by white lines).**


**Figure 40. A more detailed illustration of the proposed aboveground mining infrastructure (indicated by the black lines) in relation to the delineated wetlands (as per the legend). The 100 m buffer is indicated by the white lines and the contours by the orange lines.**

## 8.2 Wetlands affected by the underground mining activities

According to the project information as supplied by the client no surface disturbance is expected to occur on the remaining farm portions (these include RE1, RE2, 3, RE4, 5, RE6, RE7, 8, RE9, 10, 11, 12, 13, 14 of De Roodepoort 435 IS); with the exception of ventilation shafts. It is recommended that these ventilation shafts not be located within the 100 m buffer areas surrounding the wetlands.

It is beyond the scope of this study to determine the possible effect of underground mining operations (during operational phases as well as during decommission phase) on the surface flow within the wetland systems. This will have to be determined by a qualified geohydrologist.

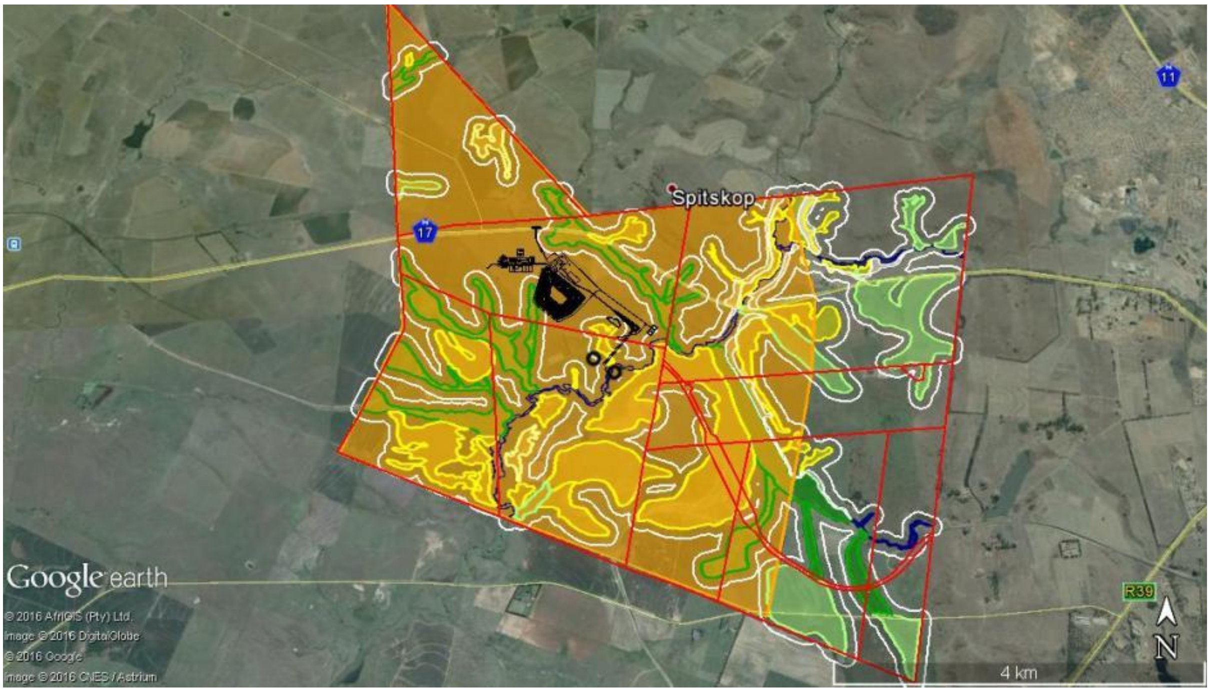



**Figure 41. The extent of the underground mining activities (indicated by the orange polygon).**

## 8.3 Impact Assessment and mitigation measures

Because the extent of the mining operation is not finalised, the impact assessment before mitigation in this document is based on the worst case scenario where the development would cause extensive damage or degradation to the aquatic ecosystems in the study area. The impact assessment after mitigation is based on the scenario where the client implements the mitigation measures recommended by this report and the Environmental Assessment Practitioner.

Most of the impacts identified relate to water quality, water flow, sediment, and habitat destruction. These impacts are all applicable to the aboveground mining infrastructure, and not with the underground mining operations.

### 8.3.1 Water quality impacts

Fluctuations in the *in situ* water quality parameters (pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and temperature) may occur during the construction phase, the operational phase, as well as during the decommissioning and closure phase of this project. These will have impacts on the wetlands' ecosystem, biotic communities and vegetation.

The impacts on the water quality may occur due to the fact that the following proposed activities will impact on the wetlands:

1. Dust generation and transportation due to the clearing of vegetation prior to construction, the construction phase, and the decommission and closure phase, which will settle on the wetland habitats, leading to:
    - Reduced photosynthesis and transpiration in flora;
    - An increase in fine-particulate sediments into the water;
    - A decrease in visibility and light penetration;
    - An increase in potential EC and TDS;

- Fluctuation changes in the pH values; as well as
- Fluctuations in the surface water quality monitoring parameters.

This impact will be greatly increased during the drier months of April through to September.

2. Increased soil sediment loads via surface water runoff into the adjacent wetlands via the clearing of vegetation prior to construction, the construction activities, the removal of topsoil, and the Mine residue dump can lead to:
   - Reduced photosynthesis and transpiration in the in-stream aquatic vegetation;
   - An increase in fine-particulate sediments into the water;
   - A decrease in visibility and light penetration;
   - An increase in potential EC and TDS;
   - Fluctuation changes in the pH values; as well as
   - Fluctuations in the surface water quality monitoring parameters.

This impact will be greatly increased in the wet months of October to March and during high flow events.

3. Pollutants entering the wetland systems due to runoff from the Mine residue dump, pollution control dam, and boxcuts hards stockpile, accidental pollution or illegal disposal and dumping of construction material such as cement or oil will affect the water quality and influence its functionality and the persistence of vegetation. This impact will be greatly increased in the wet months of October to March and during high flow events.

**Table 36. Significance and possible mitigation measures of water quality impacts.**

| Impacts | Significance Score | | | | | | Discussion | Possible mitigation measures |
|---|---|---|---|---|---|---|---|---|
| | Mag | D | SS | P | Total | Signif | | |
| Dust generation and transportation | SBM | | | | | | Clearing of vegetation, construction activities, the mining operations and storage of coal and stockpiles will generate dust that may settle on or enter wetland ecosystems, thus impacting water quality, especially during the drier months from April to September. | **None** - impacts to the water quality will be greatest, with further impacts on the wetland habitats and wetland biota; **Avoidance** - N/A; **Minimization** - treatment of roads within the project area, avoid large-scale vegetation clearing, and maintain buffer zones; include misters at mine residue facility, **Rectification** - natural re-vegetation of exposed areas in consultation with an ecologist; **Reduction** - wetting of dirt roads with water on a daily basis or sealing with dust sealant, include misters at mine residue facility, wetting of soil and coal stockpiles and cleared areas during the drier months, placing speed limits on all dirt roads (maximum 20 km/hr), use of wind buffering structures around exposed mining sites or open strip areas. **Compensation** - N/A |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | SAM | | | | | | | |
| | 6 | 3 | 2 | 4 | **44** | **Medium** | | |
| Increased soil sediment loads and coal sediments | SBM | | | | | | Clearing of vegetation prior to construction, construction activities and removal of topsoil, during the mining operation processes will generate sediment that may enter wetland ecosystems, especially during the wet months from October to March. | **None** - impacts to the water quality and habitat will be the greatest, with further impacts on the wetland biota; **Avoidance** - N/A; **Minimization** - clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; create an adequate buffer zone (100 m) around wetland ecosystems - in consultation with the wetland ecologist, and prevent any activities within this buffer zone, construct silt traps, runoff storage dams and water clarification treatment plants; **Rectification** – re-vegetate all cleared land as quickly as possible, clean up any sediment spills or contamination immediately; **Reduction** - monitor sediment loads and water quality and metals concentrations in wetland ecosystems; **Compensation** - N/A. |
| | 10 | 4 | 2 | 5 | **80** | **High** | | |
| | SAM | | | | | | | |
| | 6 | 3 | 2 | 4 | **44** | **Medium** | | |
| Loss of wetland's | SBM | | | | | | Groundwater and surface water recharge into the wetland | **None** - impacts to the water quality and water yield will be greatest, with further impacts on the wetland habitats and biota; **Avoidance** - |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| catchment water yield adjacent to the footprint of the mining operation | 6 | 4 | 1 | 3 | **33** | **Medium** | ecosystems can be reduced due to the mining activities, leading to impacts on water yield, drainage patterns, dilution factor and water quality. | Mine outside the catchment divide; **Minimization** -, clearing of land kept to a minimum, proposed mining activities managed properly and rehabilitated correctly, prevent indiscriminate groundwater or surface water usage; **Rectification** – Adhere to buffer zone recommendations and minimization recommendations; **Reduction** - land not used for mining should not be cleared and all mining footprint areas should be rehabilitated immediately, long term monitoring of rehabilitated areas and downstream aquatic and wetland ecosystems, to mitigate any long term impacts; **Compensation** - N/A |
| | **SAM** | | | | | | | |
| | 4 | 1 | 1 | 2 | **12** | **Low** | | |
| Increased suspended solid concentrations (not including dust generation) | **SBM** | | | | | | Sedimentation is the tendency for particles of various sizes in suspension that settles out. Increase in suspended solid concentrations at sites already characterised by high concentrations, which may lead to further wetland habitat and water quality impacts. | **None** - impacts to the wetland habitat and water quality will be greatest, with further impacts on the aquatic biota; **Avoidance** - prevention of contaminated water entering the wetland ecosystem; **Minimization** - containment of groundwater and surface water and the purification treatment thereof before release into the wetland ecosystems, protection and rehabilitation of impacted wetland vegetation, **Rectification** - initiate immediate clean up of any spills or contamination; **Reduction** - monitoring of water quality and metals; **Compensation** - N/A |
| | 10 | 4 | 2 | 5 | **80** | **High** | | |
| | **SAM** | | | | | | | |
| | 6 | 3 | 2 | 4 | **44** | **Medium** | | |
| Contamination of groundwater resources | **SBM** | | | | | | Contamination of seepage, and spring, eye and fountain water source zones of the wetlands leading to water quality impacts such as toxicity and metal contamination (possible Acid Mine Drainage). | **None** - impacts to the water quality and wetland biota will be greatest, with further impacts on the wetland habitats; **Avoidance** - prevention of groundwater seepage, prevent aquifer contamination; **Minimization** - mining areas should be sealed off and decanting effluent should be controlled and treated before release into the environment; **Rectification** - clean up any spills immediately, **Reduction** - avoid contaminated water transfer and seepage, monitor water of the boreholes, springs, eyes and fountain source zones; monitor groundwater recharge locations and seepage areas throughout the project area; **Compensation** - N/A |
| | 10 | 4 | 3 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |
| | 4 | 3 | 2 | 2 | **18** | **Low** | | |
| Oil from | **SBM** | | | | | | Oil from generators and vehicles may | **None** - impacts to the water quality will be greatest, with further |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| generators and vehicles | 6 | 3 | 2 | 3 | **33** | **Medium** | enter the wetland ecosystem and lead to contamination of the water and habitat. | impacts on the wetland habitats and biota; **Avoidance** - prevent any oils from entering the wetland ecosystem; **Minimization** - vehicles and generators must be kept away from the wetlands, all equipment must be properly maintained; **Rectification** - any spill should be cleaned up immediately, spills should be contained, parking lots and fuel storage areas should be correctly bermed and storm water management systems constructed for protection from surface water runoff; **Reduction** - vehicles activity near the aquatic ecosystems should be kept to a minimum; **Compensation** - N/A |
| | **SAM** | | | | | | | |
| | 4 | 3 | 1 | 3 | **24** | **Low** | | |
| Cumulative impacts | **SBM** | | | | | | Cumulative impact from existing agriculture impacts, surrounding mining activities as well as the proposed project, leading to; increased erosion, sedimentation fluctuations in situ water quality parameters; and fluctuations in surface water monitoring parameters. | **None** - impacts to the water quality and wetland habitat will be greatest, with further impacts on the wetland biota; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, rehabilitate all cleared areas progressively and immediately upon completion of activity, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; create an adequate buffer zone around the edge of wetland ecosystems - in consultation with the wetland ecologist, and prevent any activities within this buffer zone, construction of silt traps, runoff storage dams and water clarification treatment; combine management plans of mining and agriculture to achieve an improve environmental integrity; **Rectification** - rehabilitate and clean up any spills or disturbances to the wetland ecosystems; **Reduction** - monitor the water quality of the project area on a quarterly basis; **Compensation** - N/A |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |
| | 4 | 3 | 2 | 3 | **27** | **Low** | | |

### 8.3.2 Hydrological impacts

Hydrological impacts may occur during the following activities:

1. Construction activities
    - Clearing/removal of natural vegetation**.** Wetland vegetation stabilizes soil and therefore prevents erosion. They also play a role in the purification of water, attenuation of floods, and groundwater recharge.
    - Compaction of soils. Construction activities may compact soils from heavy equipment access which could inhibit seed germination, reduce water infiltration, inhibit root establishment, and result in bare soil exposure. Soil exposure and compaction can increase water runoff during rainy events and induce/worsen erosion.
2. Operational phase
    - An increase in infrastructure is usually accompanied by an increase of hardened surfaces. Hardened surface can significantly increase the speed of water entering a wetland system. If the wetland system in question is then also impacted by activities causing bare and compacted soil surfaces, the increased velocity of water flow will result in erosion in the wetland.

**Table 37. Significance and possible mitigation measures of hydrological impacts.**

| Impacts | Significance Score | | | | | | Discussion | Possible mitigation measures |
|---|---|---|---|---|---|---|---|---|
| | Mag | D | SS | P | Total | Signif | | |
| Loss of wetland's catchment water yield adjacent to the footprint of the mining operation | SBM | | | | | | Groundwater and surface water recharge into the wetland ecosystems can be reduced due to the mining activities, leading to impacts on water yield, drainage patterns, dilution factor and water quality. | **None** - impacts to the water quality and water yield will be greatest, with further impacts on the wetland habitats and biota; **Avoidance** - Mine outside the catchment divide; **Minimization** - mine selected portions of the catchment area, clearing of land kept to a minimum, proposed mining activities managed properly and rehabilitated correctly, prevent indiscriminate groundwater or surface water usage; **Rectification** – provide stormwater and grey water plan to prevent polluted water to flow into wetland areas; **Reduction** - land not used for mining should not be cleared, and where it cannot be avoided should be rehabilitated immediately, long term monitoring of rehabilitated areas and downstream aquatic and wetland ecosystems, to mitigate any long term impacts; **Compensation** - N/A |
| | 10 | 5 | 3 | 5 | **90** | **High** | | |
| | SAM | | | | | | | |
| | 8 | 5 | 2 | 5 | **75** | **High** | | |
| Clearing/removal of natural vegetation and compaction of soil | SBM | | | | | | Wetland vegetation stabilizes soil and therefore prevents erosion. They also play a role in the purification of water, attenuation of floods, and groundwater recharge. Construction activities may compact soils from heavy equipment access which could inhibit seed germination, reduce water infiltration, inhibit root establishment, and result in bare soil exposure. Soil exposure and compaction can increase water runoff during rainy events and induce/worsen erosion. | **None** - impacts to the water yield and secondary effects will be greatest; **Avoidance** - N/A; **Minimization** - implement good construction practices, rehabilitate all cleared areas progressively and immediately upon completion of activity, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; prevent any activities within the buffer zone, construction of silt traps, runoff storage dams and water clarification treatment; **Rectification** - rehabilitate all bare areas; **Reduction** - monitor the establishment of vegetation and implement an invasive plant eradication programme; **Compensation** - N/A |
| | 10 | 5 | 1 | 5 | **80** | **High** | | |
| | SAM | | | | | | | |
| | 4 | 3 | 1 | 3 | **24** | **Low** | | |

### 8.3.3 Geomorphological impacts

Geomorphological impacts as a result of the construction phase include:

1. Exposure to erosion that will erode into the wetland systems. Removal of vegetation against slopes and soil compaction expose soils to erosion during rainfall events. Erosion removes the top soil layer, thereby preventing establishment of vegetation. Eroded areas are likely to be colonised by alien invasive and pioneer plants, or in severe cases, no vegetation will establish causing high velocity runoff during rainfall events and continuous erosion into wetland systems.
2. Increased soil sediment loads via surface water runoff into the adjacent wetlands via the clearing of vegetation prior to construction, the construction activities, the removal of topsoil, and the Discards dump can lead to:
   - Reduced photosynthesis and transpiration in the in-stream aquatic vegetation;
   - An increase in fine-particulate sediments into the water;
   - A decrease in visibility and light penetration;
   - An increase in potential EC and TDS;
   - Fluctuation changes in the pH values;
   - Reduction of water storage capacity;
   - Elimination of natural vegetation;
   - Destruction of habitat; as well as
   - Fluctuations in the surface water quality monitoring parameters.

This impact will be greatly increased in the wet months of October to March and during high flow events.

1. Bank disturbances, resulting in increased sediment input from erosion (if infrastructure is not removed from the wetlands and the buffers)
2. Cumulative impact from existing surrounding historic activities, human settlement, farming activities, as well as the proposed development project, leading to;
   - Increased erosion, flooding, sedimentation and bank instability;
   - Fluctuations in *in situ* water quality parameters; and
   - Fluctuations in surface water monitoring parameters.

**Table 38. Significance and possible mitigation measures of geomorphological impacts.**

| Impacts | Significance Score | | | | | | Discussion | Possible mitigation measures |
|---|---|---|---|---|---|---|---|---|
| | Mag | D | SS | P | Total | Signif | | |
| Increased soil sediment loads and coal sediments | SBM | | | | | | Clearing of vegetation prior to construction, construction activities and removal of topsoil, during the mining operation processes will generate sediment that may enter wetland ecosystems, especially during the wet months from October to March. | **None** - impacts to the geomorphology of the wetlands will be the greatest; **Avoidance** - N/A; **Minimization** - clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; maintain the buffer zone (100 m) around wetland ecosystems and prevent any activities within this buffer zone, construct silt traps, runoff storage dams and water clarification treatment plants; **Rectification** – re-vegetate all cleared land as quickly as possible, clean up any sediment spills or contamination immediately; **Reduction** - monitor sediment loads and water quality and metals concentrations in the wetland ecosystems; **Compensation** - N/A. |
| | 10 | 4 | 2 | 5 | **80** | **High** | | |
| | SAM | | | | | | | |
| | 6 | 3 | 2 | 4 | **44** | **Med** | | |
| Loss of wetland's catchment water yield adjacent to the footprint of the mining operation | SBM | | | | | | Groundwater and surface water recharge into the wetland ecosystems can be reduced due to the mining activities, leading to impacts on water yield, drainage patterns, dilution factor and water quality. | **None** - impacts to the geomorphology will be greatest; **Avoidance** - Mine outside the catchment divide; **Minimization** - mine selected portions of the catchment area, clearing of land kept to a minimum, proposed mining activities managed properly and rehabilitated correctly, prevent indiscriminate groundwater or surface water usage; **Rectification** - provide stormwater and grey water plan to prevent polluted water to flow into wetland areas; **Reduction** - land not used for mining in the footprint area should rehabilitated immediately, long term monitoring of rehabilitated areas and downstream aquatic and wetland ecosystems, to mitigate any long term impacts; **Compensation** - N/A |
| | 10 | 5 | 3 | 5 | **90** | **High** | | |
| | SAM | | | | | | | |
| | 8 | 5 | 2 | 5 | **75** | **High** | | |
| Cumulative impacts | SBM | | | | | | Cumulative impact from existing agriculture impacts, surrounding | **None** - impacts to the geomorphology of wetlands will be greatest; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **SAM** | | | | | | mining activities as well as the proposed project, leading to; increased erosion, flooding, sedimentation and bank instability; fluctuations in in situ water quality parameters; and fluctuations in surface water monitoring parameters. | procedures, rehabilitate all cleared areas progressively and immediately upon completion of activity, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; create an adequate buffer zone around the edge of wetland ecosystems - in consultation with the wetland ecologist, and prevent any activities within this buffer zone, construction of silt traps, runoff storage dams and water clarification treatment; combine management plans of mining and agriculture to achieve an improve environmental integrity; **Rectification** - rehabilitate and clean up any spills or disturbances to the wetland ecosystems; **Reduction** - monitor the water quality of the project area on a quarterly basis; **Compensation** - N/A |
| | 4 | 3 | 2 | 3 | **27** | **Low** | | |

### 8.3.4 Habitat impacts

Impacts on the habitat may occur due to the fact that the following proposed activities may impact the wetland:

1. Habitat loss or alteration during construction

If construction is going to take place in the wetland the largest impact is expected to occur during this period. The following proposed activities will have an impact:

- Removal/destruction of wetland ecosystem habitat;
- Vegetation removal;
- Wetland edge disturbances; and
- Drainage pattern changes.

These activities may result in possible destabilization, increased erosion potential and exotic vegetation encroachment.

2. Dust that enters the wetland can have the following impact:
   - Decreased visibility due to clouding of water column;
   - Decreased light penetration;
   - Siltation of fine sediment substrates, gravel substrates and inter-substrate spaces; and
   - Decrease in habitat availability.

This impact will be greatly increased during the drier months of April through to September.

3. Soil sediment loads entering the wetland ecosystems via surface water runoff as well as downstream wetland ecosystems, leading to:
   - An increase in fine-particulate sediments into the water;
   - A decrease in visibility;
   - A decrease in light penetration;
   - Increased siltation; and
   - Decreased habitat availability.

This impact will be greatly increased in the wet months of October to March and during flood events.

4. Cumulative impact from existing surrounding historic activities, human settlement, farming activities, as well as the proposed project, leading to;
   - Increased erosion, flooding, sedimentation and bank instability;
   - Fluctuations in *in situ* water quality parameters; and
   - Fluctuations in surface water monitoring parameters.

**Table 39. Significance and possible mitigation measures of habitat impacts.**

| Impacts | Significance Score | | | | | | Discussion | Possible mitigation measures |
|---|---|---|---|---|---|---|---|---|
| | Mag | D | SS | P | Total | Signif | | |
| Drainage pattern changes | SBM | | | | | | Groundwater and surface water recharge and drainage patterns into wetland ecosystems may be influenced by mining activities, leading to impacts on the catchment water yield and drainage patterns of the project area. This will impact on the wetlands within the surface infrastructure area. | **None** - impacts to the wetland habitat will be greatest, with further impacts on the water quality and wetland biota; **Avoidance** – locate infrastructure outside the proposed buffer zones; **Minimization** - clearing of land kept to a minimum, proposed mining activities managed properly and rehabilitated correctly, prevention of indiscriminate groundwater or surface water usage; **Rectification** – Rehabilitate surface areas as soon as possible; **Reduction** - land not used for mining or immediate construction should not be cleared and all mining areas should be rehabilitated immediately, map and monitor groundwater and surface water recharge points, and long term monitoring of rehabilitated areas and downstream aquatic and wetland ecosystems, to mitigate any long term impacts; **Compensation** - N/A. |
| | 10 | 5 | 2 | 5 | **85** | High | | |
| | SAM | | | | | | | |
| | 4 | 5 | 2 | 2 | **22** | Low | | |
| Dust generation and transportation | SBM | | | | | | Clearing of vegetation, construction activities and storage of coal and stockpiles will generated dust that may settle on or enter the wetland ecosystems, impacting on sedimentation and siltation of wetland and wetlands habitats and its water column, especially during the drier months from April to September. This will impact on the wetlands within the proposed surface infrastructure area. | **None** - possible impacts on open water in wetlands will be greatest, with further impacts on wetland habitat, its water quality and wetland biota; **Avoidance** - N/A; **Minimization** - treatment of road surface within the project area, avoid large-scale vegetation clearing, maintain buffer zones; **Rectification** - natural re-vegetation (make use of local indigenous vegetation) of exposed areas in consultation with the ecologist; **Reduction** - Wetting of dirt roads with water on a daily basis and/or sealing with dust sealant, wetting of soil- and coal stockpiles, and cleared areas during the drier months, placing speed limits on all dirt roads (maximum 20 km/hr), use of wind buffering structures around exposed mining sites or open strip areas. **Compensation** - N/A. |
| | 8 | 4 | 2 | 5 | **70** | High | | |
| | SAM | | | | | | | |
| | 6 | 3 | 1 | 4 | **40** | Medium | | |
| Increased soil | SBM | | | | | | Clearing of vegetation, removal | **None** - impacts to wetland habitats will be greatest, with further impacts |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| sediment loads and coal sediments | 10 | 5 | 2 | 5 | **85** | **High** | of topsoil and mining processes will increase the availability of sediments to wetland ecosystems especially during the wet months from October to March. An increase in sediment can smother wetland habitat that can lead to the loss of wetland functions. This will impact on the wetlands within the surface infrastructure area. | on the water quality and wetland biota; **Avoidance** - prevention of runoff from sites; **Minimization** - clear only areas necessary for immediate construction, storage of topsoils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish and maintain adequate buffer zone around the wetland ecosystem - in consultation with the wetland ecologist, and prevent any activities within this buffer zone, construct silt traps, runoff storage dams and water purification treatment plants; **Rectification** – re-vegetate all cleared land as quickly as possible, clean up any sediment spills or contamination immediately; **Reduction** - monitor sediment loads in the adjacent and downstream wetland ecosystems; **Compensation** - N/A. |
| | **SAM** | | | | | | | |
| | 4 | 3 | 2 | 4 | **36** | **Medium** | | |
| Dewatering of mine pits into wetland systems | **SBM** | | | | | | Contamination of the wetland ecosystems from mine water release and dewatering of mine pits, leading to habitat degradation. | **None** - impacts to wetland habitat will be greatest, with further impacts on the water quality and wetland biota; **Avoidance** - transfer mine water to storage dam for treatment or disposal instead of discharging or releasing into wetland ecosystems; **Minimization** - control release of treated mine water in sustainable manner - in consultation with ecologists; **Rectification** - rehabilitate any erosion or scouring immediately to prevent further impacts, rehabilitate strip mine areas and pits adequately; **Reduction** - habitat monitoring of the wetland ecosystems on a quarterly basis during operation and after closure phase; **Compensation** - N/A |
| | 10 | 5 | 3 | 5 | **90** | **High** | | |
| | **SAM** | | | | | | | |
| | 6 | 4 | 3 | 4 | **52** | **Medium** | | |
| Exotic vegetation encroachment | **SBM** | | | | | | Clearing of vegetation, construction activities, the mining operations will lead to impacts on stability promoting erosion that will result in exotic | **None** - impacts to wetland habitat will be greatest, with further impacts on the water quality and aquatic biota; **Avoidance** – implement exotic eradication management plan; **Minimization** - minimise and manage the amount of activity within the buffer zone of the wetlands and wetland ecosystems; implement exotic eradication management plan; |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | 4 | 3 | 2 | 4 | **36** | **Medium** | vegetation invasion and encroachment, with further impacts to wetland habitat such as habitat destruction, changes in the hydrological regime and the loss of wetland functions. This will impact on the wetlands within the surface infrastructure area. | **Rectification** - rehabilitate wetlands, wetlands and aquatic ecosystems on a continual basis during the operation phase of the project and during the closure phase and implement exotic vegetation removal actions; **Reduction** - monitor wetland ecosystems and mitigate any further impacts immediately, restrict any activities in the buffer zones. **Compensation** - N/A. |
| Cumulative impacts | **SBM** | | | | | | Cumulative impact from existing agriculture impacts, surrounding mining activities as well as the proposed project on wetlands can lead to; increased erosion, flooding, sedimentation; shifts in hydrological wet zones, habitat losses or alterations and habitat availability changes. This will impact on the wetlands within the proposed Surface infrastructure area. | **None** - impacts to wetlands will be greatest, with further impacts on the water quality and wetland biota; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, rehabilitate all cleared areas and strip mine pits progressively and immediately upon completion of activity, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland and wetlands ecosystems; create an adequate buffer zone around wetland and the catchment of wetlands ecosystems - in consultation with the wetland ecologist, and limit and manage any activities within this buffer zone, construction of silt traps, runoff storage dams and water clarification treatment, manage local cattle impacts on erosion; combine management plans of mining and agriculture to achieve an improve environmental integrity; **Rectification** - rehabilitate and clean-up any spills or disturbances immediately to the wetland ecosystems; **Reduction** - monitor the habitats of the wetland and aquatic ecosystems of the project area on a quarterly basis, during construction, operation and closure phases; **Compensation** - N/A. |
| | 10 | 5 | 3 | 5 | **90** | **High** | | |
| | **SAM** | | | | | | | |
| | 4 | 5 | 2 | 2 | **22** | **Low** | | |
| Loss or reduction of water bird habitat | **SBM** | | | | | | Impacts on wetlands as a result of sedimentation, siltation and flow reduction may result in certain wetland and wetlands habitats being lost or reduced (open water, grass/sedge, hydrophyte, sedge, etc); certain | **None** - impacts to the habitat availability will be greatest, with further impacts on the water quality and wetland biota; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, rehabilitate all cleared areas and strip mine pits progressively and immediately upon completion of activity, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 | 5 | 2 | 5 | **85** | **High** | habitats may be silted up or have sediment deposited over them (grass/sedge, sedge, etc), thus not being available for colonisation for certain water birds. Specialist water bird species such as certain ducks, waders, migratory species, etc. has specific habitat needs; if habitat is altered or destroyed these species can disappear. Generalist species such as Egyption Goose, Yellow Billed Ducks, Spurwing Goose can still make use of degraded wetlands. | seepage into the wetland and wetlands ecosystems; create an adequate buffer zone around wetland and the catchment of wetlands ecosystems - in consultation with the wetland ecologist, and limit and manage any activities within this buffer zone, construction of silt traps, runoff storage dams and water clarification treatment, manage local cattle impacts on erosion; **Rectification** - a new habitat equilibrium will result due to shifts in habitat availability, however, large-scale impacts to specific habitats must be rectified by rehabilitation of the altered or lost habitat in critical areas of the wetland ecosystems; **Reduction** - monitor the habitat availability of water birds within the project area on a bi-annual basis and mitigate any further impacts immediately, this should be done during the construction, operation and closure phases. Long term monitoring should also take place; **Compensation** - N/A. |
| | **SAM** | | | | | | | |
| | 4 | 5 | 2 | 2 | **22** | **Low** | | |
| Loss or reduction of small mammal habitats | **SBM** | | | | | | Loss or reduction of wetland habitats (open water, grass/sedge, sedge, hydrophyte, etc); can result in a decrease in small mammal | **None** - impacts to the habitat availability will be greatest, with further impacts on the water quality and wetland biota; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, rehabilitate all cleared areas, clear only areas necessary for immediate construction, storage of top-soils, |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 2 | 2 | **22** | **Low** | diversity and numbers. Specialist species has got specific habitat needs, if habitat is altered or destroyed these species will also disappear. Generalist species can still make use of degraded wetlands. | overburden and coal in a way to prevent erosion, runoff and seepage into the wetland and wetlands ecosystems; establish a adequate buffer zone around wetland and the catchment of wetlands ecosystems - in consultation with the ecologist, and limit and manage any activities within this buffer zone, construction of silt traps, runoff storage dams and water purification treatment; **Rectification** - a new habitat equilibrium will result due to shifts in habitat availability, however, large-scale impacts to specific habitats must be rectified by rehabilitation of the altered or lost habitat in critical areas of wetland ecosystems; **Reduction** - Monitor the habitat availability of small mammals within the project area on an annual basis and mitigate any further impacts immediately, this should be done during the construction, operation and closure phases. Long term monitoring should also take place. **Compensation** - N/A. |

### 8.3.5 Biotic changes

1. Changes to the Riparian and marginal vegetation community structure of the wetland ecosystems may take place due to the likelihood that the following may occur as a result of the abovementioned impacts:
    - Fluctuations in water chemistry may directly impact on the ability of certain vegetation species to survive;
    - Toxicity of water may be lethal to sensitive vegetation;
    - Increased possibility for microbial growth and algal blooms;
    - Sedimentation of marginal vegetation habitats; and
    - Exotic riparian vegetation encroachment.
2. Invasion by alien invasive vegetation and/or pioneer species. During construction vegetation will be removed and soil disturbed, which is conducive of the establishment of alien invasive plant seeds and/or pioneer plant species.

**Table 40. Significance and possible mitigation measures of biotic impacts.**

| Impacts | Significance Score | | | | | | Discussion | Possible mitigation measures |
|---|---|---|---|---|---|---|---|---|
| | Mag | D | SS | P | Total | Signif | | |
| Loss of species diversity | **SBM** | | | | | | Fluctuations in water chemistry, toxicity of water, microbial growth and algal blooms, sedimentation of wetland vegetation habitats, sedge/aquatic macrophytes, will result in a loss of sensitive vegetation species and or communities, thus impacting on the diversity of wetland vegetation species in the project area. This will impact on the wetlands in and adjacent to the | **None** - impacts to wetland marginal vegetation will be the greatest, with further impacts on the water quality and other wetland biota within the wetland ecosystem; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish an adequate buffer zone around wetlands - in consultation with a wetland ecologist, and limit and manage any activities within this buffer zone, construct silt traps, runoff storage dams and water treatment facilities; **Rectification** - identified impacts to specific habitats associated with the wetlands must be rectified by rehabilitation of the altered or lost habitat on a continual basis during the |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 6 | 4 | 2 | 4 | **48** | **Medium** | surface infrastructure area. | operation phase of the project and during the closure phase, threatened and/or unique species needs to be relocated and/or protected in a nursery for re-establishment, eradicate exotic vegetation on a continual basis, reintroduce local indigenous vegetation as part of the rehabilitation plan; **Reduction** - Monitor the habitat availability and species composition of the wetlands within the project area on a bi-annual basis and mitigate any further impacts immediately. This should be done during the construction, operation and closure phases and a long-term monitoring plan of the affected area; **Compensation** - N/A |
| Change in species abundance | **SBM** | | | | | | A loss of sensitive species or impacts to habitats may result in abundance changes, whereby numbers of individuals of certain species increase or decrease in response to the changes or impacts. This will impact on the wetlands within the proposed surface infrastructure area. | **None** - impacts to wetland marginal vegetation will be the greatest, with further impacts on the water quality and other wetland biota within the wetland ecosystem; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, clear only areas necessary for immediate construction, storage of topsoils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish an adequate buffer zone around wetlands - in consultation with a wetland ecologist, and limit and manage any activities within this buffer zone, construct silt traps, runoff storage dams and water treatment facilities; **Rectification** - identified impacts to specific habitats associated with the wetlands must be rectified by rehabilitation of the altered or lost habitat on a continual basis during the operation phase of the project and during the closure phase, threatened and/or unique species needs to be relocated and/or protected in a nursery for re-establishment, eradicate exotic vegetation on a continual basis, reintroduce local indigenous vegetation as part of the rehabilitation plan; **Reduction** - Monitor the habitat availability and species composition of the wetlands within the project area on a bi-annual basis and mitigate any further impacts immediately. This should be done during the construction, operation and closure phases and a long-term monitoring plan of the affected area; **Compensation** - N/A |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |
| | 8 | 4 | 2 | 4 | **56** | **Medium** | | |
| Shifts in community | **SBM** | | | | | | A loss of sensitive species and changes in species abundances will result in community structure | **None** - impacts to wetland marginal vegetation will be the greatest, with further impacts on the water quality and other wetland biota within the wetland ecosystem; **Avoidance** - N/A; **Minimization** - implement good |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| structure | 10 | 5 | 3 | 5 | **90** | **High** | changes to the wetland biota within the project area. This will impact on the wetlands within the surface infrastructure area. | construction practices, adhere to properly managed mining procedures, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish an adequate buffer zone around wetlands - in consultation with a wetland ecologist, and limit and manage any activities within this buffer zone, construct silt traps, runoff storage dams and water treatment facilities; **Rectification** - identified impacts to specific habitats associated with the wetlands must be rectified by rehabilitation of the altered or lost habitat on a continual basis during the operation phase of the project and during the closure phase, threatened and/or unique species needs to be relocated and/or protected in a nursery for re-establishment, eradicate exotic vegetation on a continual basis, reintroduce local indigenous vegetation as part of the rehabilitation plan; **Reduction** - Monitor the habitat availability and species composition of the wetlands within the project area on a bi-annual basis and mitigate any further impacts immediately. This should be done during the construction, operation and closure phases and a long-term monitoring plan of the affected area; **Compensation** - N/A |
| | **SAM** | | | | | | | |
| | 8 | 4 | 2 | 4 | **56** | **Medium** | | |
| Exotic species impacts | **SBM** | | | | | | Disturbances to the vegetation within the wetland ecosystems will result in the invasion and encroachment of exotic plant species. This impact can give rise to further habitat changes such as habitat loss and/or an increase in the erosion potential which will result in further impacts to the water quality and biota. This will impact on the wetlands within the | **None** - impacts to wetland marginal vegetation will be the greatest, with further impacts on the water quality and other wetland biota within the wetland ecosystem; **Avoidance** - N/A; **Minimization** - eradicate all alien invasive species on a continual basis in the catchment and wetland areas; implement good construction practices, adhere to properly managed mining procedures, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish an adequate buffer zone around wetlands - in consultation with a wetland ecologist, and limit and manage any activities within this buffer zone, construct silt traps, runoff storage dams and water treatment facilities; **Rectification** - eradicate all alien invasive species on a continual basis; identified impacts to specific |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 4 | 4 | 2 | 4 | **40** | **Medium** | surface infrastructure area. | habitats associated with the wetlands must be rectified by rehabilitation of the altered or lost habitat on a continual basis during the operation phase of the project and during the closure phase, reintroduce local indigenous vegetation as part of the rehabilitation plan; **Reduction** - Monitor the habitat availability and species composition of the wetlands within the project area on a bi-annual basis and mitigate any further impacts immediately. This should be done during the construction, operation and closure phases and a long-term monitoring plan of the affected area; eradicate all alien invasive species on a continual basis; **Compensation** - N/A; |
| Seed distribution and succession | **SBM** | | | | | | Water quality and habitat impacts may lead to reduced seed distribution, germination and plant succession in the wetland habitat. This will impact on the wetlands within the proposed surface infrastructure area. | **None** - impacts to wetland marginal vegetation will be the greatest, with further impacts on vegetation within the wetland ecosystem; **Avoidance** - N/A; **Minimization** - implement good construction practices, adhere to properly managed mining procedures, clear only areas necessary for immediate construction, storage of top soils, overburden and coal in a way to prevent erosion, runoff and seepage into the wetland ecosystems; establish an adequate buffer zone around wetlands - in consultation with a wetland ecologist, and limit and manage any activities within this buffer zone, construct silt traps, runoff storage dams and water treatment facilities; **Rectification** - identified impacts to specific habitats associated with the wetlands must be rectified by rehabilitation of the altered or lost habitat on a continual basis during the operation phase of the project and during the closure phase, threatened and/or unique species needs to be relocated and/or protected in a nursery for re-establishment, eradicate exotic vegetation on a continual basis, reintroduce local indigenous vegetation as part of the rehabilitation plan; **Reduction** - Monitor the habitat availability and species composition of the wetlands within the project area on a bi-annual basis and mitigate any further impacts immediately. This should be done during the construction, operation and closure phases and a long-term monitoring plan of the affected area; **Compensation** - N/A |
| | 10 | 5 | 2 | 5 | **85** | **High** | | |
| | **SAM** | | | | | | | |
| | 4 | 3 | 2 | 4 | **36** | **Medium** | | |

## 8.4 Mitigation measures

The impact assessment of the proposed development resulted in the impact being medium if no mitigation is implemented. With the proposed mitigation the impact was rated as low.

The construction, operation and maintenance of this mining development have the potential to cause serious environmental damage to the physical, biological and chemical components of the wetland ecosystem. The construction activities should therefore apply methods and management practices that minimise and avoid the following impacts:

- Loss and disturbance of vegetation and habitat within the infrastructure area;
- Soil compaction and increased risk of sediment transport and soil erosion during construction and routine maintenance in the operational phase;
- Flow modification due to concentrating flows, and storm water runoff from the foot print surfaces. This can lead to erosion and channel incision and change in the in-stream habitat;
- Water quality deterioration due to chemical spills during the construction and operational phases, and
- Wetland habitat fragmentation.

Wetlands in particular can be very sensitive. This is due to the fact that wetlands are low energy drainage lines in the landscape which are generally dependent on locally high water tables. These locally high water tables create the hydrological conditions of near-surface soil saturation which allows wetlands to develop.

Hardened surfaces and increased flow rates and volumes can lead to the creation of preferential flow paths and possible concentration of flows into channels, which may cause erosion and donga formation. That could result in a degradation of the environmental resource, as well as effectively draining the wetland through a lowering of the local water table and subsequent desiccation of the wetland. Eroded wetlands are very difficult to rehabilitate back to reference conditions due to the fact that both the water and soil needed to support the wetland would then need to be reinstated.

To maintain the integrity of the wetlands of concern, the following is recommended:

- Minimize the removal of/damage to vegetation in riparian and wetland areas;
- The construction of roads and road servitudes (disturbance zones) in or adjacent to the wetland/riparian zone is to be managed and strictly controlled to minimize damage to wetlands;
- Operation & storage of equipment in the riparian and wetland zones to be prevented;
- Wetlands disturbed during construction should be re-vegetated using site-appropriate indigenous vegetation and/or seed mixes;
- Alien vegetation should not be allowed to colonize the disturbed wetland areas;
- Rehabilitation of disturbed wetland habitat should commence immediately after construction is completed;
- No construction camps should be allowed in or within 50 m of the wetlands;
- No stockpile areas should be located in or within 50 m of the wetlands;
- Construction should preferably take place during the low flow/winter months in order to minimise the risk of sediment and debris being washed into wetlands;
- Stockpiling of soil and the construction camps must be stored clearly away (at least 100 m where possible) from the wetland to prevent soil being washed into the wetland;

- During the construction and operation phases erosion and siltation measures should be implemented (e.g. temporary silt traps downstream of construction areas should be employed);
- Slope/bank stabilization measures should be implemented where necessary, to prevent erosion during the operation;
- Erosion should be minimised by including frequent discharge points with energy dissipaters before discharging water into the wetland (where applicable);
- Debris and sediment trapping, as well as energy dissipation control structures, should be put in place where storm water enters the wetland;
- Turbidity, sedimentation and chemical changes to the composition of the water must be limited; and
- Where vegetation removal has occurred adjacent to the new roads, monitoring should take place to ensure successful re-establishment of natural vegetation. Alien vegetation should be removed from these disturbed areas on an ongoing basis to ensure the successful re-vegetation by indigenous species.

# 9 CONCLUSIONS

Approximately 140 points were sampled in the study area. Based on hydro-geomorphic (HGM) setting, four types of palustrine wetland were identified in the study area. This includes riparian areas, isolated Hillslope Seeps, Hillslope Seeps connected to a water course, Channelled Valley Bottom wetlands, and Unchannelled Valley Bottom wetlands. The wetland indicators recommended by DWAF (2005) was used during field verification, and supported the delineations contained in this report. A 100 m buffer was applied to the delineated wetlands, as per (MacFarlane et al. 2009).

The sandstone ridges present in the study area are deemed to be sensitive wetland habitat, due to the extensive associated seep areas. It is therefore proposed that all the delineated ridges are conserved alongside the wetland systems.

Three assessments were conducted to assess the current state of the wetlands on site: the riparian vegetation response assessment (VEGRAI), WET-Health Level 1 (PES tool), and Ecological Importance and Sensitivity. The results of the VEGRAI assessment indicated that the main river (Klein-Drinkwater) flowing through the site has an average PES Ecostatus of C, and is stable. The riparian tributary in the northern section of the site flowing from east to west where it enters the Klein Drinkwater River also has a PES Ecostatus of C, but has a negative trend. The riparian tributary in the south-eastern portion of the site has a PES Ecostatus of B/C and is stable.

The WET-Health assessment indicated that the present ecological state of the wetlands in the study area is regarded as a **"C: Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact".** The geomorphology of these wetlands is mostly intact, while the vegetation component is the most modified. The absence of major infrastructure, large dams, and year-round irrigation sustains the hydrological function of the wetlands in the study area. The vegetation is mostly affected due to the removal of natural communities through the establishment of dams, the presence of erosion channels and gullies, and agricultural activities within the wetland boundary.

The overall Ecological Importance & Sensitivity of the wetlands in the study area is regarded as **"C: Moderate. The wetlands are considered to be ecologically important and sensitive on a provincial**

**or local scale. The biodiversity of the wetlands are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers”**. It is the opinion of the specialist that this is an underestimation of the overall EIS score, as the low importance and sensitivity is ascribed as a result of low direct human benefits.

There are two different sets of impacts envisaged for the mining activities: the local impacts caused by the proposed infrastructure, and the impacts caused by the underground operations. The mine infrastructure will intersect the following wetlands:

- A Channelled Valley Bottom wetland system by the Mine residue dump
- A Hillslope Seep area by the boxcut hards stockpile and the conveyor decline
- buffer area of a Channelled Valley Bottom wetland system by the pollution control dam
- buffer area between the Riparian area and a Hillslope Seep zone by the eastern ventilation shaft

According to the project information as supplied by the client no surface disturbance is expected to occur on the remaining farm portions with the exception of ventilation shafts. It is recommended that these ventilation shafts not be located within the 100 m buffer areas surrounding the wetlands. It is beyond the scope of this study to determine the possible effect of underground mining operations (during operational phases as well as during decommission phase) on the surface flow within the wetland systems. This will have to be determined by a qualified geohydrologist. For the impacts caused by the mining infrastructure, a detailed set of impact evaluation and mitigation measures is contained within the report.

It is recommended that the above-mentioned infrastructure (especially the Mine residue dump and the boxcut hards stockpile) be moved out of the 100 m buffered wetland areas. Depending on the incline of the conveyor decline it is possible that the infrastructure might be located below the seep area and therefore not impact (impede or divert flow) the seep zone, but this will have to be confirmed by a geohydrologist.

Should the proposed mining be approved it is recommended that the wetlands areas around the infrastructure be confirmed with a detailed survey.

A Water Use License will have to be applied for since the infrastructure occurs within 500 m of wetland systems.

# 10 RECOMMENDATIONS

It is recommended that:

- The above-mentioned infrastructure (especially the Discard dump and the boxcut hards stockpile) be moved out of the 100 m buffered wetland areas.
- The ventilation shafts located in the rest of the study are not be located within the 100 m buffer areas surrounding the wetlands.
- The geohydrological study investigate the impact of the underground mining operations (during operational phases as well as during decommission phase) on the surface flow within the wetland systems.
- A detailed field verification is done to confirm the wetland boundary around the proposed infrastructure.

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