PESTANA

Wetland and Riparian Zone Identification and Assessment

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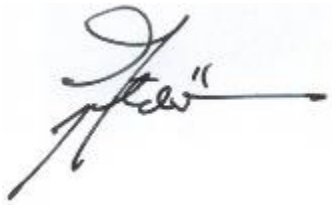
DECLARATION OF INDEPENDENCE

The specialist/s appointed in terms of the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended and the Environmental Impact Assessment Regulations, 2010:

I/We, Anton Linström declare that:

General declaration

- I/We act as the independent specialist/s in this application;
- 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;
- All the particulars furnished by me/us in this form are true and correct; and
- I/We realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.



Signature of Ecologist

Executive Summary

Wet-Earth Eco-Specs was appointed by NuLeaf Planning & Environmental to conduct a wetland / riparian survey for a Basic Assessment Report (BAR) on the Pestana property North East of the town Malelane. The land owner intends to expand the existing footprint of the Pestana Resort.

The following activities were conducted:

- Identification of wetlands and riparian areas;
- Delineation of wetlands and riparian areas;
- Classification of the wetlands;
- Characterisation of wetlands and riparian areas,
- PES and Wet Eco Service description of wetlands,
- PES evaluation of riparian areas,
- Buffer zone recommendations.
- Impact Assessment, and
- Mitigation measures.

The study area lies about 3 km north-east of the town of Malelane and about 2 km north-west of the N4, in Mpumalanga Province, and is situated on the border of the Kruger National Park. It falls under the Ehlanzeni District Municipality, Nkomazi Local Municipality. The study area falls within the Granite Lowveld vegetation unit and covers two land types (Ea75 & Fb168). It falls within quaternary catchment X24E, which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area.

A stream flow through the study area, while the perennial Crocodile River forms the western border of the study area. In this area the Crocodile River has a PES of 'D'. According to the MBSP freshwater assessment the study area falls within an ESA Important Sub-catchment, with some patches of Heavily Modified areas included. The sub-catchment is important as it is a Fish Support Area, supporting the Tiger Fish (*Hydrocynus vittatus*). The study area also overlaps with an MBSP CBA: Aquatic Species, which supports the Zambezi Siphonta dragonfly (*Neurogomphus zambeziensis*).

According to the MBSP, the study area borders on an ESA Wetland, while the latest wetland delineations (National Wetland Map 5) show that the study area includes a floodplain wetland and borders on a riverine wetland.

Four water courses were identified for the purpose of this study and can be described as riverine and wetland areas. There are riparian areas and a wetland. The delineated riparian areas are demarcated and indicated as PR1, PR3 and PR4. The wetland identified is demarcated as PR2.

Site PR1 Riparian Index of Habitat Integrity (RIHI) is a C (62.1%). The main impacts include the upstream road crossing, golf course (impacted corridor upstream of the study area), sugarcane factory upstream, and the presence of exotic vegetation.

Site PR2 is a wetland with artificial features. The wetland's catchment has been altered by agricultural activities, and the wetland itself has been transformed due to the building of a dam; this has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having an "E" PES Category. The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognisable. The wetlands ecosystem services do reflect some values in contributing towards better water quality in the form of sediment trapping, phosphate trapping, streamflow regulation, toxicant removal, and nitrate removal. The

wetland does not contribute significantly towards human services, as indicated by the score which shows that these services are low.

Site PR3 Riparian Index of Habitat Integrity (RIHI) is a D (55.9%). The main impacts are the road crossings, lodge footprint (extending into riparian areas, cover an area of 65% of the non-marginal zone), golf course (impacted corridor upstream of the study area), sugarcane factory upstream, felling of riparian vegetation, and the presence of exotic vegetation.

Site PR4 (Crocodile River) Riparian Index of Habitat Integrity (RIHI) is a C/D (59%), with the main impacts being flood events, grazing and trampling (stunted trees and shrubs), a tributary consisting of polluted water from industrial sugarcane factory and the presence of exotic species. The sugarcane factory pollute the water in the increase in sucrose and fructose that further benefit the microbe organisms which forms the basis of the food chain, thus the reason for an increase in diversity within this confluence.

The edge of the water resources (PR1 to PR4) in the study area have been delineated, with the starting point for delineation of the aquatic impact buffer zones for Rivers and streams, being on the outer edge of the active channel and from the outer edge of the delineated wetland area. A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows:

- PR1 : 25 m
- PR2 : 25 m
- PR3 : 25 m
- PR4 : 62 m

The proposed development can result in the increase of hardened surfaces and subsequent storm water runoff. Any hardening of surfaces will reduce the infiltration and ultimately reduce the yield of the seep zones they are feeding into the greater riparian areas systems.

The following is recommended:

- All activities should stay out of the 1:100 year flood line area;
- All activities should stay out of the riparian areas area and its recommended buffer zones;
- All storm water should be diverted to a point from where the water must be released in a controlled manner that will not initiate or enhance any erosion, the way storm water enters a natural waterway is important because high-energy flows can cause serious damage (especially to riparian zones); and
- Energy dissipaters and smaller permeable gabion-structures covered with reeds can be constructed at the effluent points of all stormwater.
- To cater for the present and the proposed developments in above mentioned riparian areas on site and off site mitigation is recommended to mitigate the negative effects thereof.

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GLOSSARY

Anaerobic	Without air.
Biodiversity	The variety of life: the different plants, animals and micro-organisms, their genes and the ecosystems which they form part of.
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.
Exotic	From another part of the world; foreign and/or alien.
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.
Gleyed soil	A material that has been or is subject to intense reduction as a result of prolonged saturation with water. Grey colours are due to an absence of iron compounds.
Hydro-geomorphic	Refers to the water source and geology forms.
Invasive	Any alien species of insect, animal, plant or pathogen, including its seeds, eggs, spores, or other biological material capable of propagating that species.
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.
Rivers and streams	This type of water resource is described as a channel (river, including the banks) in the National Wetland Classification System (SANBI, 2009). This is defined as *"an open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterises the hydrodynamic nature of these units."* According to the classification system, channels generally refer to rivers or streams (including those that have been canalised) that are subject to concentrated flow on a continuous basis or periodically during flooding. This definition is consistent with the NWA (Act No. 36 of 1998) which makes reference to (i) a river or spring and (ii) a natural channel in which water flows regularly or intermittently within the definition of a water resource. As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks which can be identified and delineated.
Riparian Zone	Area of land directly adjacent to the active channel of a river, which is influenced by river-induced or river-related processes.

Seep	A wetland area located on gently to steeply sloping land and dominated by the colluvial unidirectional movement of water and material down-slope. Water inputs are primarily via subsurface flows from an up-slope direction.
Soils	Dynamic natural body composed of mineral and organic materials (as well as living organisms) 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 has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.
Topographical maps	Detailed depiction of land features shown on a map.
Topography	Detailed description of land features.
Unchannelled valley bottom	Linear fluvial, net depositional valley bottom surfaces that 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

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

1 INTRODUCTION

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2 Scope of work

The following activities were conducted:

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- Buffer zone recommendations.
- Impact Assessment, and
- Mitigation measures.

3 Limitations of this investigation

The following limitations were placed on the wetland ecosystem and biodiversity study of this project:

- A single baseline assessment was conducted, thus limiting the amount of biota identified at the site;
- Accuracy of the maps, aquatic ecosystems, routes, and desktop assessments was limited to the current 1:50 000 topographical map series of South Africa;
- Accuracy of Global Positioning System (GPS) coordinates was limited to 15 m accuracy in the field;
- Delineations and related spatial data generated will be supplied in GIS (shapefile) format only and will be for conceptual planning only and not detailed design. If the client requires that data be accurate to detailed design level, this can be negotiated and budgeted for separately;
- This survey was conducted in the autumn season, which is not optimal: surveys of this nature should take place in the summer months;
- The assessment of the impact of past activities on the wetlands was based on professional judgment since no data (to our knowledge) exists before the developments that have already taken place on the site, to which the current status can be compared;
- Time and costs related to surveys have been calculated based on the proposed area (route) as indicated by the client;
- While every care is taken to ensure that the data presented is qualitatively adequate, inevitably conditions are never such that that is entirely possible. Under 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.

4 Methodology

4.1 Characterization of the flora

The area was traversed on foot, and all indications of plant species observed were recorded. Background literature surveys were also conducted to assess which species have been recorded in the general area.

4.2 Wetland Assessment

- **Wetland Delineation**

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, they are often not apparent, and the delineation should, therefore, be regarded as a human construct. However, the delineation is based on scientifically defensible criteria, thus providing a tool to facilitate decision-making regarding the assessment of the significance of impacts on wetlands that may be associated with the proposed development.

- **Wetland Classification**

Wetlands are described in terms of their position in the landscape, and the classification was done according to their hydro-geomorphic setting (Kotze *et al.*, 2004).

- **Wetland Integrity Assessments**
  - **Present Ecological State (PES)**

The following steps were followed, to assess the ecological status and associated impacts and threats posed to the wetland system:

- Describing the hydro-geomorphic setting of the wetland according to Kotze et al. (2008); and
- Assessing the overall health of the wetland at Level 1, using WET-Health[1] (Macfarlane et al., 2007).
  - **Ecosystem Services Supplied by the Wetland (Eco-Services)**

The assessment of the ecosystem services supplied by the identified wetland units was conducted according to the guidelines described by Kotze, *et al.* (2004). A Level 2 assessment was conducted, which examines, and rates natural and human services.

4.3 Riparian Vegetation Response Assessment Index (VEGRAI)

The assessment of the riparian vegetation was done according to Level 3: Riparian Vegetation Response Assessment Index (VEGRAI) (Kleynhans et al. 2007). According to this index, the following components were assessed:

[1] In order to improve the resolution of baseline data collection, information on impacts to vegetation and hydrology (water distribution and retention patterns) are captured at an impact unit level. This improves the accuracy of extent estimates and allows assumptions to be more clearly documented for future comparison.

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

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 on foot, and spot surveys contributed to a complete survey.

Zone determination

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

- Marginal zone: starts at the water's edge and extends a few meters up the bank, 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 were 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 were based on indigenous species density and percentage aerial cover.

Ecological Category

Field data was transferred to the VEGRAI Excel spreadsheet. 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 conditions 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 4-1).

Table 4-1. 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 habitat 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

4.4 Buffer Zone

The literature review revealed that international approaches used to determine required buffer zone widths varied considerably from simple one-size-fits-all approaches to others that rely on extensive site-specific information to inform buffer width requirements (Macfarlane, 2014). Three generic approaches were identified in the literature, and are briefly outlined below:

- Fixed-width: The fixed-width approach typically applies a standard buffer width to a particular water resource type. In some instances, a generic width is applied

regardless of any characteristics of the water resource. However, this approach is more typically applied to a class of wetland or river type, or a specific land use type/activity.

- Modified fixed-width: In this approach, a matrix of factors is typically used to categorize wetlands and / land-uses with category-specific standard buffer widths being applied to the resource. These widths may, however, be modified based on relevant on-site factors where more detailed information is available.
- Variable-width: This approach usually requires the development of a detailed formula and methodology for considering site-specific factors such as wetland type, adjacent land-use, vegetation, soils, wildlife habitats, slope, desired function and other special site-specific characteristics to calculate buffer widths.

While each approach has several advantages and disadvantages, the modified fixed-width approach was regarded as most appropriate for the South African context. This was principally due to the need to develop a tool that could be applied across different levels (i.e. desktop and site-based), while maintaining a level of predictability and consistency between approaches. The method outlined in this document, therefore, proposes highly conservative buffer widths based on generic relationships for broad-scale assessments but allows these to be modified based on more detailed site-level information. Resultant buffers, therefore, range from highly conservative, fixed-widths for different land-uses at a desktop level, to buffers that are modified based on a more thorough understanding of the water resource and specific site characteristics (Macfarlane, 2014).

4.4.1 Impact Assessment and Mitigation

To assess the impacts of the proposed project on the aquatic ecosystems, the following components were included:

- The identification of the main areas of the 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;
- 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). The following criteria have been proposed by the Department of Environmental Affairs for the description of the magnitude and significance of impact (DEAT, 2002):

This section of the report describes and evaluates the potential impact of the development on the receiving wetland environment. The significance of the impact was determined using the criteria given in Table 4-2 following the rating contained.

Table 4-2: 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 affected 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	The function or process of the affected environment is disturbed to the extent that 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, after which it will be entirely negated.
(L)ong term	The impact will continue 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 after that.
(P)ermanent	This is the only class of impact that will be non-transitory. Mitigation either by human-made or natural processes will not occur in such a way or in such a time that the impact is considered 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 neighboring farms, the transport routes and the adjoining towns.
(N)ational	The impact could affect the whole 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)improbable	The possibility of the impact occurring is nil, due either to the circumstances, design or experience. The chance of this impact occurring is defined as0%.
(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 for mitigation must therefore be made. The chance of this impact occurring is defined as 50%.
(H)ighly Likely	It is most likely that the impact 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 will be used (**Table 4-3**).

Table 4-3: 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 4-4 and Table 4-5.

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 Impact 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 4-4: 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 that 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 that 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 as contemplated in Table 4-5.

Table 4-5: 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.

5 RESULTS AND DISCUSSION

5.1 Study Area

Location

The study area lies about 3 km north-east of the town of Malelane and about 2 km north-west of the N4, in Mpumalanga Province, and is situated on the border of the Kruger National Park (Figure 5-1). It falls within the Ehlanzeni District Municipality, Nkomazi Local Municipality, and is located on the farm Riverside 173 JU.

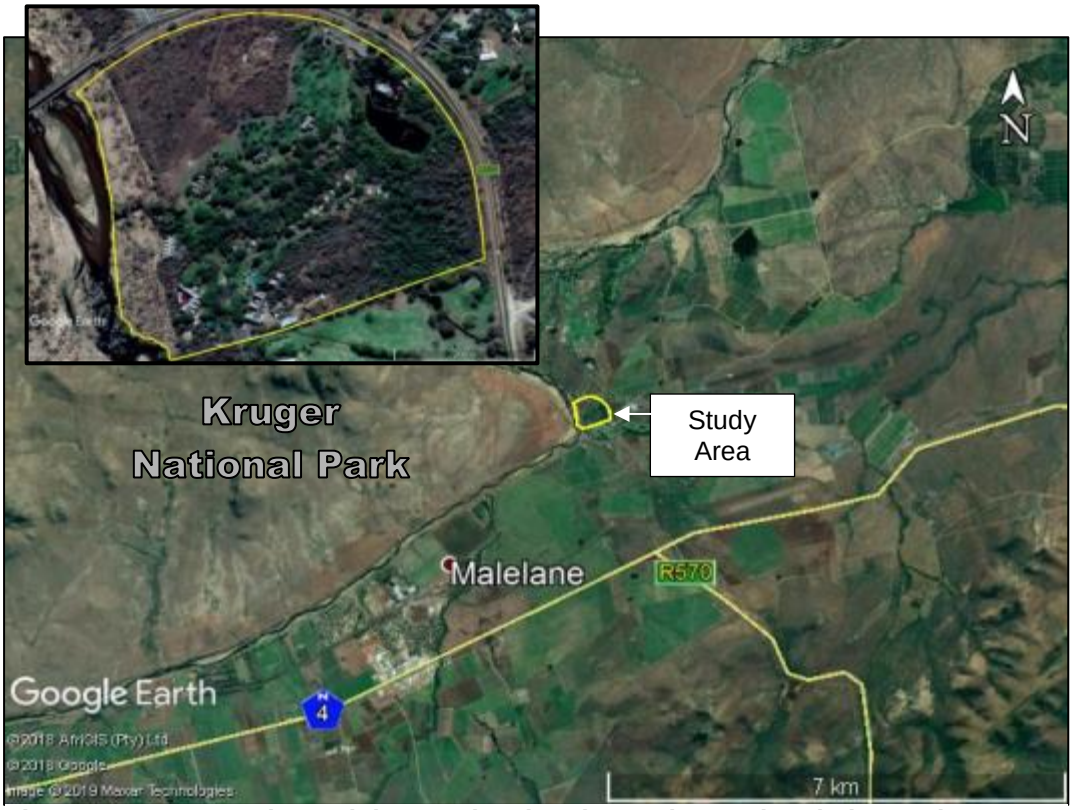

Figure 5-1: Google Earth image showing the study area in relation to the surrounding towns, roads and the Kruger National Park; the inset map shows the study area in greater detail

Land-use

According to the 2013/2014 land-cover data, the study area is almost all-natural, with some water and bare patches, as well as some urban development (Figure 5-2). Urban development and cultivation make up the predominant land-use in the surrounding area (Figure 5-2).

Figure 5-2: 2013/2014 Land-cover data showing the different land-uses within and surrounding the study area

Vegetation Units

According to Mucina & Rutherford (2006), the study area falls within the Granite Lowveld (SVl 3) vegetation unit (Figure 5-3). The following description applies to the unit as a whole and is taken from Mucina & Rutherford (2006).

Granite Lowveld has an altitude range of 250–700 m. The vegetation ranges from tall shrublands with few trees to moderately dense low woodland on the deep sandy uplands with *Terminalia sericea*, *Combretum zeyheri* and *C. apiculatum*, and ground layer including *Pogonarthria squarrosa*, *Tricholaena monachne* and *Eragrostis rigidior*. In the bottomlands, vegetation ranges from dense thicket to open savanna, with *Acacia nigrescens*, *Dichrostachys cinerea* and *Grewia bicolor* in the woody layer. The dense herbaceous layer contains the dominant *Digitaria eriantha*, *Panicum maximum* and *Aristida congesta* on fine-textured soils, while brackish bottomlands support *Sporobolus nitens*, *Urochloa mosambicensis* and *Chloris virgata*. At seep lines, where convex topography changes to concave, a dense fringe of *Terminalia sericea* occurs, with *Eragrostis gummiflua* in the undergrowth.

It is a summer rainfall region with dry winters and is generally frost-free. Granite Lowveld has a conservation target of 19%. Some 17% is statutorily conserved in the Kruger National Park. About the same amount is conserved in private reserves. More than 20% is already transformed, mainly by cultivation and by settlement development. Erosion is very low to moderate.

Mean monthly minimum, and maximum temperatures at the study site itself are 8.3˚C and 30.9˚C in July and February respectively, while the annual average is 21.7˚C; the mean annual precipitation is 708 mm (WorldClim database, Hijmans *et al.*, 2005).

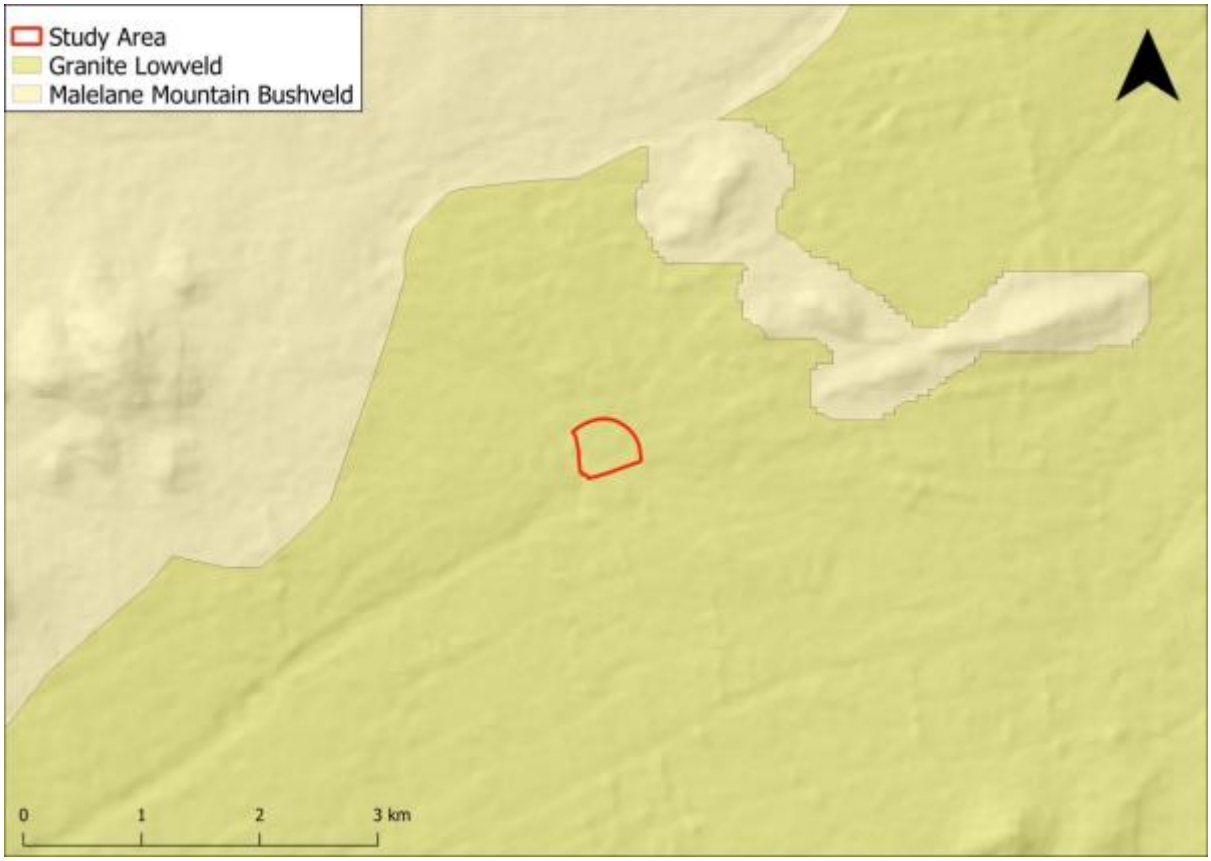

Figure 5-3: The position of the study area in relation to the surrounding vegetation units

Land Types

The study area covers two land types, as per Table 5-1 (Figure 5-4).

Table 5-1: A description of the soils and geology of the two land types associated with the study area (Land Type Survey Staff, 1972–2006)

Land type	Soil Description	Geology
Ea75	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated.	Predominantly mafic and ultramafic lavas and schists with banded ironstone and chert of the Tjakastad Formation (Onverwacht Group); some mafic to felsic sediments and schists of the Moodies Group (Barberton Sequence).
Fb168	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in upland soils but generally present in low-lying soils.	Potassic gneiss, migmatite, biotite granite and biotite-trondhjemite gneiss; all of Swazian age.

Figure 5-4: Study area in relation to the land types in the vicinity

Freshwater Desktop Assessment

This desktop assessment is based on a combination of the Mpumalanga Biodiversity Sector Plan (MBSP) freshwater assessment (MTPA, 2014), the 2014 PES (Present Ecological State) for South African rivers (Department of Water and Sanitation [DWS], 2014), the new National Wetland Map 5 (Van Deventer *et al.*, 2018) and the wetland probability map for Mpumalanga (i.e. modelled wetlands; Dr Nacelle Collins; FS DESTEA). The MBSP identifies terrestrial and freshwater areas that are important for conserving biodiversity pattern and ecological processes (MTPA, 2014). The MBSP freshwater assessment relied heavily on the NFEPA project (National Freshwater Ecosystem Priority Areas) 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 good condition to conserve freshwater ecosystems and protect water resources for human use (Nel *et al.*, 2011). The PES assessment used six categories to describe the state of rivers, ranging from 'A' (natural) to 'F' (critically modified); DWS, 2014. The National Wetland Map 5 and wetland probability maps show the most recent mapped and modelled wetlands for South Africa.

The study area falls within quaternary catchment X24E (Figure 5-5), which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area.

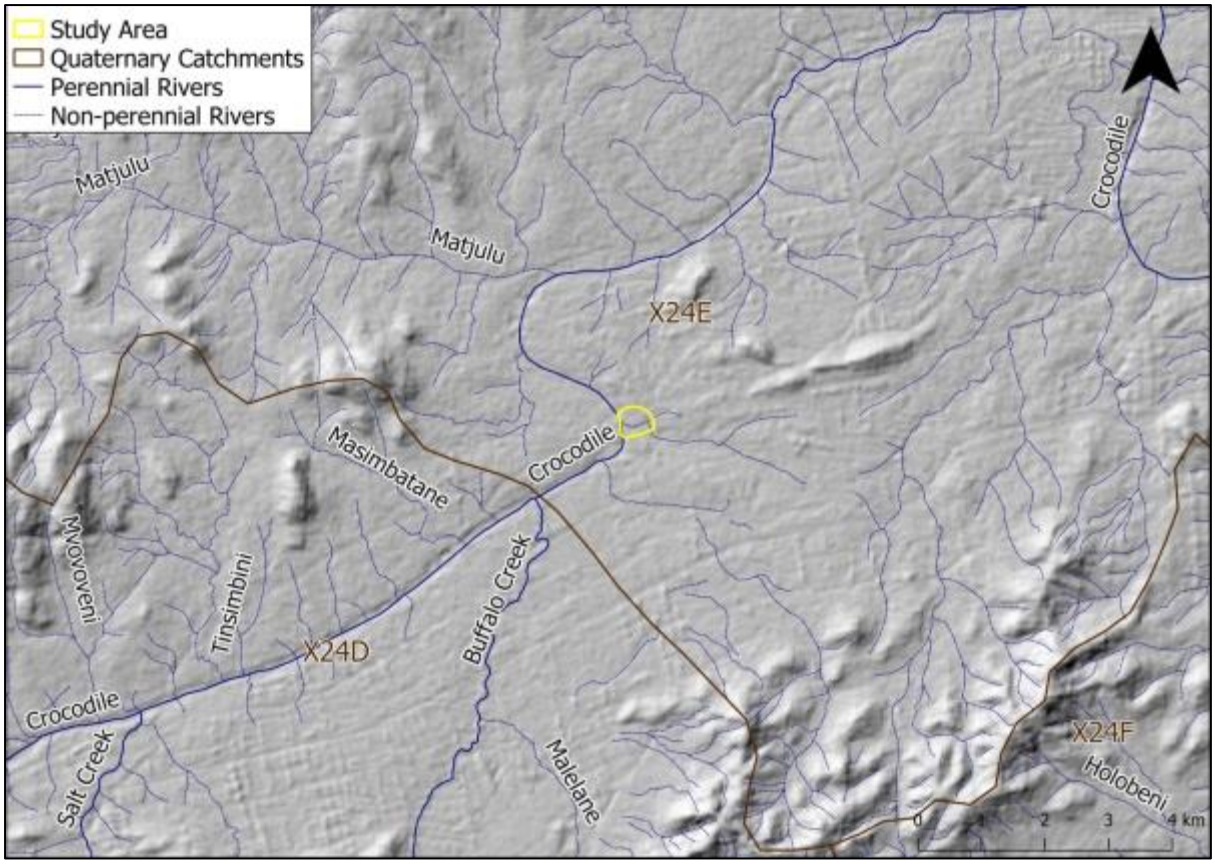

Figure 5-5: The study area in relation to quaternary catchments and rivers

Some non-perennial rivers flow through the study area, while the perennial Crocodile River forms the western border of the study area (Figure 5-5 and Figure 5-6; see also Google Earth inset map in Figure 5-1). According to the 2014 PES for South African rivers, the section of the Crocodile River flowing through this sub-catchment has a PES of 'D' (i.e. "Largely modified. A large loss of natural habitat, biota, and basic ecosystem functions has occurred.").

According to the MBSP freshwater assessment the study area falls within an Ecological Support Area (ESA) Important Sub-catchment, with some patches of Heavily Modified areas included (Figure 5-6; Table 5-2). The sub-catchment is important as it is a Fish Support Area (FSA), as per NFEPA. FSAs are fish sanctuaries that are in a lower than A or B ecological condition. Fish sanctuaries, which include both river FEPAs and FSAs, are rivers and their associated sub-catchments that are essential for protecting threatened and near-threatened fish; consequently, there should be no further deterioration in the condition of the associated rivers (Nel *et al.*, 2011). This particular FSA supports the Tiger Fish (*Hydrocynus vittatus*), a fish species of conservation concern. The study area also overlaps with an MBSP Critical Biodiversity Area (CBA): Aquatic Species (Figure 5-6; Table 5-2). This CBA supports the Zambezi Siphonta dragonfly (*Neurogomphus zambeziensis*), listed by the Mpumalanga Tourism and Parks Agency provincial assessment as Vulnerable.

According to the MBSP, the study area borders on an ESA Wetland (Figure 5-6; Table 5-2). The latest wetland delineations, as per the National Wetland Map 5, can be seen in Figure 5-7. According to this map, the study area includes a floodplain wetland and borders on a riverine wetland (Figure 5-7). The wetland probability map showed no modelled wetlands for this area.

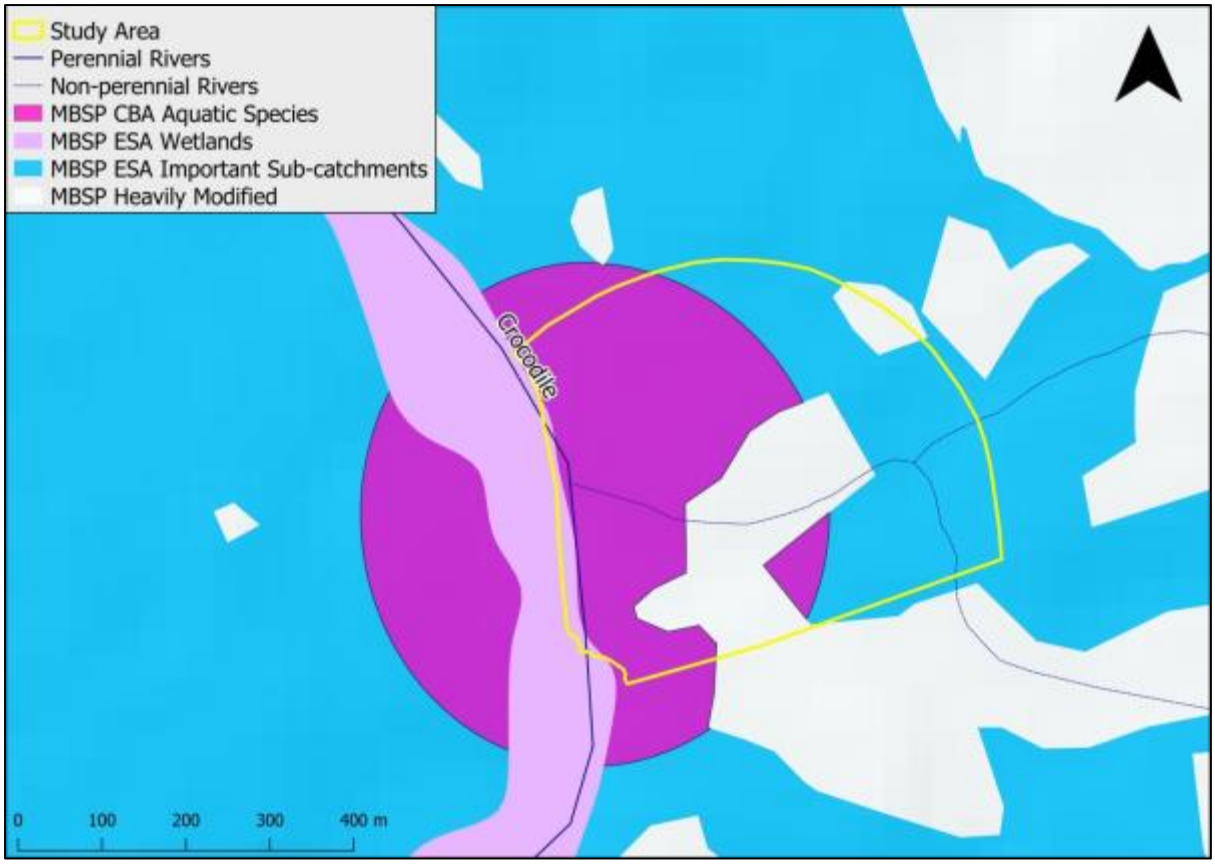

Figure 5-6: The study area in relation to rivers and the MBSP freshwater assessment; CBA = Critical Biodiversity Area, ESA = Ecological Support Area

Table 5-2: Descriptions of the relevant map categories for the MBSP freshwater 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; CBAs are areas of high biodiversity value that should be maintained in a natural or near-natural state.	CBA: Aquatic Species	Areas considered critical for meeting the habitat requirements for selected aquatic invertebrate species (dragonflies, damselflies, crabs). These species are known to occur only at one or a few localities and are at high risk of extinction if their habitat is lost.
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: Wetlands	All non-FEPA wetlands. Although not classed as FEPAs, these wetlands support the hydrological functioning of rivers, water tables and freshwater biodiversity, as well as providing a host of ecosystem services through the ecological infrastructure that they provide.
		ESA: Important Sub-catchments	Sub-catchments that either contain river FEPAs and/or Fish Support Areas.
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, building of dams, 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.

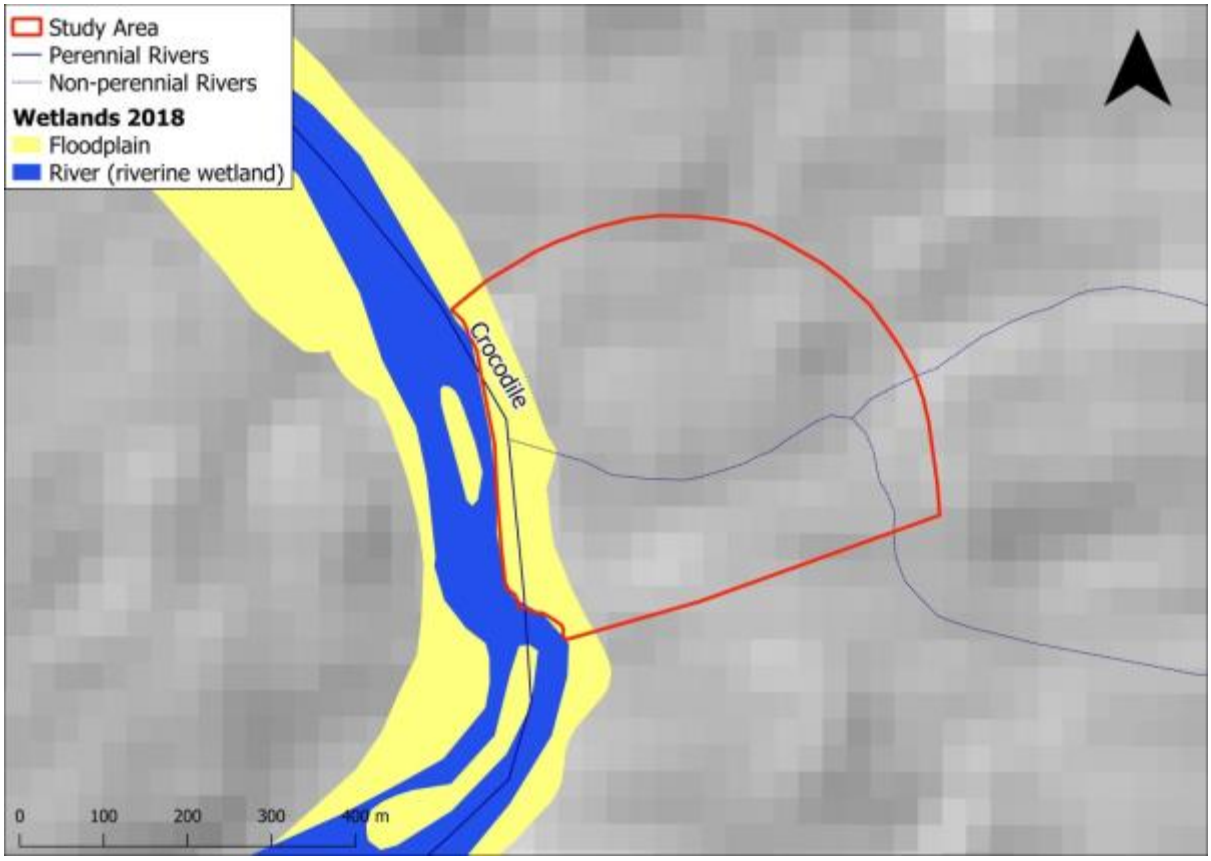

Figure 5-7: The study area in relation to rivers and the 2018 wetland delineations as per the National Wetland Map 5 (with hydrogeomorphic classification)

5.2 Wetland and Riparian Identification and Delineation

To cover a representative area of the wetlands and riparian zones in the study area, several surveys were necessary. It should be noted that only the riparian areas in the study area were identified and surveyed.

The riparian areas identified were delineated following the guidelines for delineating the boundaries of a wetland, set out by the Department of Water Affairs and Forestry (DWAF) (DWAF, 2005). These delineated riparian areas are demarcated and indicated as per the map is shown in Figure 5-8**Error! Reference source not found.**.

Figure 5-8: Delineated watercourses within the Pestana Study Area

5.3 Wetland and Riparian Characterization and Integrity Study

In order to cover a representative area of the wetlands and riparian zones in the study area, several transect surveys were necessary. The riparian areas and wetland identified were delineated following the guidelines for delineating the boundaries set out by the then Department of Water Affairs and Forestry (DWAF, 2005).

Four watercourses were identified and can be described as riverine and a wetland. The wetland area is mostly covered by a dam and leakage taking place that resulted in inundated wetland area downstream thereof. Wetland areas occur around the dam and upstream of the road crossing. The delineated wetland and riparian areas are demarcated and indicated as per the map in Figure 5-9.

Figure 5-9: Identified Riparian areas for the purpose of this study

5.3.1 Site PR1 (Riparian)

Site Description

This site is located at 25°27'43.77" S, 31°52'25.21" E. The riparian zone extends upstream from the edge of the property and downstream where it reaches the guesthouses (Figure 5-10 and Figure 5-11).

Dam in upstream portion of riparian area

Figure 5-10: Visuals of Site PR1 Riparian

Figure 5-11: Google image of the delineated PR1 Riparian within the study area

Marginal zone (**Error! Reference source not found.**)**:**
The existence of a golf course and industrial activity upstream has resulted in a somewhat disturbed environment, with a large portion of this zone being deprived of some vegetation cover. This zone has patchy vegetation coverage and is dominated by woody species, grasses, and sedges. The substrate consists of soil with rocky features in places. The dominant tree species are *Diospyros mespiliformis, Ficus sycomorus, Syzygium guineense,* and *Trichilia emetica.* The fern *Pteris vittata* also occurs. Other species that occur in this zone include: *Phragmites* australis, *Cyperus sexangularis*, *Panicum maximum, Commelina bengalensis,* etc. Exotic vegetation, such as *Melia azedarach, Tecoma stans, Tagetes minuta,* etc. occur.

Non-marginal zone (**Error! Reference source not found.**)**:**
This zone is reasonably wide and is mostly covered by shrubs and trees. The substrate consists mainly of soil material and rocky habitat in places. The ground cover consists mainly of leaf litter and other moribund material. The following woody species occur: *Bridelia micrantha, Acacia xanthophloea, Philenoptera violacea, Phyllanthus reticulatus, Ficus sycomorus, Syzygium cordatum, Celtis africana, Sclerocarya birrea* subsp*. caffra*, *Grewia flavescens, Bridelia cathartica, Phyllanthus reticulatus, Gymnosporia senegalensis and Gymnanthemum coloratum,* etc. Understory plants such as *Setaria megaphylla, Hypoestes forskaolii,* and *Panicum maximum* occur. The exotics, *Melia azedarach* and *Chromolaena odorata* are dominant in places within this zone. Other exotics found include: *Solanum mauritianum, Lantana camara, Ageratum conyzoides,* etc.

View of the marginal zone

View of the non-marginal zone

Figure 5-12: Photos of selected VEGRAI site

Reference Condition

The reference condition for the components is summarised in Table 5-3.

Table 5-3: Reference conditions

Component	Reference conditions	Confidence
Riparian vegetation	**Marginal zone:** Woody and sedge-dominated state with pockets of grass. Sedges such as *Cyperus dives, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. could occur. Without the influence of the upstream golf course and industrial site, and riverbank undercutting, a more woody- and sedge vegetated state, with better species composition, cover and abundance is expected **Non-marginal zone:** A more tree, shrub and grass-dominated state is expected, especially along the edges of the macro-channel. In the absence of the exotic vegetation, more indigenous species would be expected. Species such as *Ficus sycomorus*, *F. sur, Acacia sieberiana, Ziziphus mucronata*, *Gymnosporia buxifolia*, etc. could also occur in greater abundance.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) for PR1 is a C (62.1%). The main impacts include the upstream road crossing, golf course (impacted corridor upstream of the study area), sugarcane factory upstream, and the presence of exotic vegetation (**Error! Reference source not found.**). The water quality is further degraded by the sugarcane factory and the golf course adjacent to the riparian area. The sugarcane factory can pollute the water in the increase in sucrose and fructose that further benefit the microbe organisms which forms the basis of the food chain, thus the reason for an increase in diversity within this system. Due to the influence of the factory site, a continuous high-flow pattern is experienced through the riparian area, less alluvial material is thus available to the riparian zone, which has resulted in the degradation of the riverbank, referred to as bed-armouring. The result of this can be seen in bank collapse and under-cutting of the bank, which is taking place (Figure 5-13).

The exotic, *Chromolaena odorata*, is smothering potential riparian vegetation habitat

The exotic tree, *Melia azedarach*, growing in abundance within the non-marginal zone of the riparian macro channel

Bank collapse and under-cutting

Figure 5-13: Activities that contribute towards the degradation of the PR1 riparian zone's integrity

PES causes and sources

The PES for the components, as well as the reasons for the PES, are summarised in Table 5-4.

CAUSE: A stressor that occurs at an intensity, duration, and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 5-4: Causes and sources

Entity	PES	Conf.	Sources	Causes	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	C	3.3	Water quality	Sugarcane factory, golf course, farming activities, etc. with many upstream points and non-point source pollution occurring	Non-Flow related NF	3.3
			Golf course	Extends into riparian areas upstream of the study area and contributes towards the degraded water quality		
			Sugar cane factory	Enriched water quality		
			Exotic invasion	*Melia azedarach, Chromolaena odorata* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication programme in place		
			Road traversing area	Restricted hydrology confined to culverts	Flow related F	
			Water quantity	Higher flows throughout the year due to water discharged by the sugar cane factory		

[1] Flow related [2] Non Flow related

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e., whether the quality and quantity are stable, or still changing). The results are summarised in Table 5-5.

Table 5-5: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	C	Stable	C	The presence of the sugar cane factory, road crossing, and the golf course will always have an impact on the habitat and integrity of this site. The presence of exotic vegetation impacts on the vegetation composition cover and abundance and it is unlikely that a management and control plan will be initiated. If these impacts are not managed it is expected that their impact will remain the same.	3

PES ECOSTATUS

To determine the Eco-Status, the Vegetation Response Assessment Index (VEGRAI) EC and confidence are included in the Eco-Status assessment index (

Table 5-6). The Eco-Status EC is a C (62.1%).

Table 5-6: EcoStatus

RIPARIAN VEGETATION	EC %	ECO-STATUS	CONFIDENCE RATING
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**62.1**	**C**	
Confidence rating for riparian vegetation zone information			**3.3**

5.3.2 Site PR2 Wetland

Site Description

This site is located at 25°23'09.51 S, 31°53'31.57 E. The wetland extends upstream from the edge of the R570 road and downstream where it joins riparian PR3 (Figure 5-14**)**.

Figure 5-14: Google Earth image of wetland PR2

Impacts on the integrity of the wetland

To determine the integrity of the wetland, and the condition of the site, the direct and indirect disturbances, etc. were taken into account. The following disturbances in the catchment of the wetland were observed: sugarcane crops, management roads, the R570 road crossing with culverts, fences, pipelines, earthworks (embankment from cultivation activities), alien and terrestrial invasive vegetation species, etc. (Figure 5-15). 74.4% of the wetland has been altered.

The presence of a dam indicates a disturbed environment with the result that a large portion of this zone is dominated by reeds, grasses, and sedges. The section downstream of the dam is dominated by trees and scattered clumps of grass and sedge. The substrate consists of soil with rocky features occurring in places.

The dominant tree species are *Ficus sycomorus, Syzygium guineense,* and *Trichilia emetica.* The following grass and sedge species occur in this zone: *Phragmites* australis, *Typha capensis, Cyperus dives, Cyperus sexangularis*, etc. Exotic vegetation, such as *Melia azedarach, Tecoma stans, Arundo donax, Verbena bonariensis, Tagetes minuta, Ricinus communis, Lantana camara*, etc. occur.

Panoramic view of the dam constructed in the wetland

Aerial photo indicating the extent of the dam

Figure 5-15: Activities in wetland areas that can be detrimental to wetland integrity

Present Ecological State (PES)

Assessment of ecological status (Wet-Health – Level 1)

The wetland ecological status is assessed by considering impacts to wetland hydrology, geomorphology, and vegetation. A summary of the findings is outlined below.

Hydrology

Assessment of impacts

The level of impacts and threats to the wetland hydrology are presented in **Error! Reference source not found.** Table 5-7 below. The hydrology of the wetland can be categorised as critically modified (an "F" PES Category), where the change in ecological processes and loss of natural habitat have resulted in a complete modification of the wetland. From the assessment, it is clear that the dam covers most of the wetland area, modifying the habitat, impeding/drowning wetland habitat and resulting in an artificial environment. Overflows and leakage from the dam have resulted in a very wet environment downstream of the dam wall that is expected to be different from the natural hydrology regime.

The catchment of the wetland is dominated by sugar cane crops, and the R570 road crossing also restricts the natural hydrology via two culverts, resulting in point releases into the wetland area.

Table 5-7: Calculation of combined hydrology impact score based on joint consideration of catchment and wetland impacts

Impact Type	Magnitude of impact
Changes to water distribution & retention patterns	**11.7**
Changes to Water Input characteristics	**5.0**
Combined Hydrology Impact Score	**9.5**
PES Category	**F**

Based on a combined understanding of catchment-related impacts and impacts within the wetland, the current hydrological state is regarded as falling just within the critically modified class, as reflected by an "F" PES category.

Geomorphology

The level of impacts and threats to the geomorphological integrity of the wetland are presented in Table 5-8-10 below.

Assessment of impacts

Current impacts on geomorphological integrity are limited to the landscaping of developed areas. Given these impacts, the current geomorphic integrity is considered to be degraded, with a loss of natural habitat. The wetland is rated as having a "D" Category classification for Geomorphology. Impacts such as the dam and the R570 road crossing contribute towards the degradation of geomorphological integrity.

Table 5-8: Assessment of impact on the geomorphology of the wetland

Impact type	Applicability to HGM type	Magnitude of impact
Diagnostic component		
1. Increased runoff	Non-floodplain HGMs	2.4
Indicator-based component		
2. Erosion features	All non-floodplain HGMs	0.2
3. Depositional features	All non-floodplain HGMs	0.6
4. Loss of organic matter	All non-floodplain HGMs with organic material	1.0

Impact type	Applicability to HGM type	Magnitude of impact
Combined Impact Score based on a sum of the three highest scores		**4.9**
PES Category		**D**

Vegetation

Due to changes in hydrology and flow patterns, as a result of the R570 crossing and sugarcane crops and cultivation in the catchment; and the construction of the dam, indications are that directional changes in wetland vegetation have occurred. The current state of vegetation is regarded as largely modified, and loss of wetland/natural habitat and biota has occurred. The disturbed wetland reflects a "D" Category. Further details of this assessment are provided below.

Table **5-9** summarises the impacts of wetland vegetation disturbance units. The primary impacts to vegetation habitat include invasive exotic vegetation, the dam, earthworks, R570 road crossing, hardening of surfaces, etc.

Table 5-9: Assessment of impact on wetland vegetation

No.	Disturbance Class	Extent (%)	Intensity (0 - 10)	Magnitude of impact
1	Dam	59	8	4.7
2	Seepage below dam	9.4	5	0.5
3	Bare surface area	6	2	0.1
5	Untransformed area	25.6	2	0.5
			Overall weighted impact score	**5.8**
			PES Category	**D**

Summary

The wetland's catchment has been altered by agricultural activities, and the wetland itself has been transformed due to the building of a dam; this has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having an "E" Category (Table 5-10). The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognisable.

Table 5-10: Summary of present wetland health based on the Wet-Health assessment

Wetland	Ha	Hydrology		Geomorphology		Vegetation	
		Impact Score	Change Score	Impact Score	Change Score	Impact Score	Change Score
HS	8	9.0	0	5.7	0	8.8	0
PES Categories		**F**	→	**D**	→	**F**	→
Wetland Impact Score		**8.0**					
Wetland PES		**E**					

Ecosystem Services supplied by the wetland

This hillslope seep wetland is connected to a watercourse (an unknown tributary to the Crocodile River). Its ecosystem services (both natural and human) are reflected in the radar chart below (Figure 5-16-16).

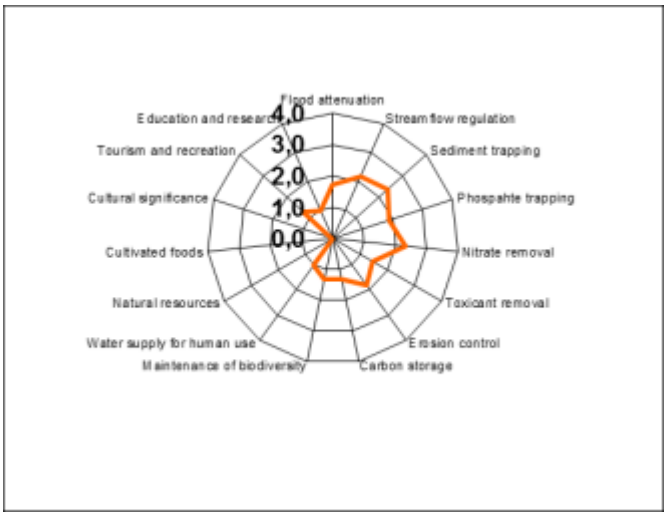

Figure 5-16: Wetland Eco-Services results

Natural Services

The wetland achieved a low total (Table 5-11) within a disturbed environment, indicating that the wetland has lost various functions. The score of 15.4 reflects that the wetland is largely modified. A large loss of natural habitat and basic ecosystem functions has occurred.

The wetland's catchment has been affected by agricultural activities, with sugarcane crops and cultivation, and the R570 road crossing, as well as a network of management roads, the construction of a dam in the wetland, etc. This affects the wetland's ability to perform certain natural services. Services, such as contributing towards better water quality in the form of sediment trapping, phosphate trapping, streamflow regulation, toxicant removal, and nitrate removal have been degraded.

Table 5-11: Natural services results of wetland

Ecosystem Services	Score	Conf.
Flood attenuation	1,8	3,6
Streamflow regulation	2,0	4,0
Sediment trapping	2,4	3,7
Phosphate trapping	2,2	3,9
Nitrate removal	1,7	4,0
Toxicant removal	1,3	3,9
Erosion control	1,5	3,4
Carbon storage	1,0	4,0
Maintenance of biodiversity	1,4	3,8
Total	15.4	
Score	Low	

Human Services

The wetland does not contribute significantly towards human services, as indicated by the score, which shows that these services are low (Table 5-12). People rarely rely on the wetland and rarely benefit directly from it.

Table 5-12: Human services results for wetland

Ecosystem Services	Score	Conf.
Water supply for human use	0,8	3,7
Natural resources	0,0	4,0
Cultivated foods	0,0	4,0
Cultural significance	0,0	4,0
Tourism and recreation	1,3	4,0
Education and research	1,0	3,8
Total	3.1	
Score	Low	

5.3.3 Site PR3 Riparian

Site Description

This site is located at 25°27’42.91” S, 31°32’18.31” E. The riparian zone extends upstream from the edge of the guesthouses and downstream to where it joins the Crocodile River (Figure 5-10 and Error! Reference source not found.).

Dam in upstream portion of riparian area

Figure 5-17: Visuals of Site PR3 Riparian

Figure 5-18: Google image of the delineated PR3 Riparian within the study area

Marginal zone (**Error! Reference source not found.**)**:**
The presence of a dam upstream, a golf course and industrial site within its catchment and the guesthouse development footprint within the non-marginal zone has resulted in the degradation of the marginal zone's integrity. The dominant tree species are *Ficus sycomorus, F. sur, Diospyros mespiliformis, Combretum microphyllum, Syzygium cordatum,* and *Trichilia emetica.* The following grass and sedge species occur, although in low numbers in this zone: *Cyperus sexangularis*, *Pteris vittata*, etc. Exotic vegetation, such as: *Caryota urens*, *Melia azedarach, Tecoma stans, Tagetes minuta, Ricinus communis, Lantana camara*, etc. occur.

Non-marginal zone (**Error! Reference source not found.**)**:**
This zone is dominated by trees, with a few shrubs. The undergrowth has been reduced to garden-like features: mowed grass cover and large areas with no cover, for the purpose of the premises. The substrate consists mainly of soil material and rocky habitat in places. The banks are reasonably steep in places. The following woody species occur: *Philenoptera violacea, Ficus sycomorus, Syzygium cordatum, Celtis africana, Sclerocarya birrea* subsp*. caffra*, *Bridelia cathartica, Grewia flavescens, Bridelia cathartica, Combretum erythrophyllum, Diospyros mespiliformis, Gymnosporia senegalensis, and Gymnanthemum coloratum,* etc. Understory plants such as: *Setaria megaphylla, Hypoestes forskaolii, Cucumis zeyheri*, *Cynodon dactylon*, and *Panicum maximum* occur. Some exotic vegetation such as *Melia azedarach, Bougainvillea spectabilis, Solanum mauritianum, Bidens pilosa, Lantana camara, Ageratum conyzoides,* etc. were also found.

View of the marginal zone (note the sparse vegetation cover)

View of the non-marginal zone (note removal of undercover)

Figure 5-19: Photos of selected VEGRAI site

Reference Condition

The reference condition for the components are summarised in Table 5-3.

Table 5-13: Reference conditions

Component	Reference conditions	Confidence
Riparian vegetation	**Marginal zone:** Tree and sedge-dominated state with pockets of grass is expected, as per reference conditions. Sedges such as *Cyperus dives, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. could occur. Without the habitat destruction caused by the upstream activities and the footprint of the lodge, and riverbank undercutting, a more woody- and shrub vegetated state, with better species composition and abundance is expected	3

	Non-marginal zone: A more tree, shrub, and grass-dominated state is expected. More trees and shrubs are expected, especially along the edges of the macro-channel. Species such as *Ficus sycomorus*, *F. sur, Acacia sieberiana, Ziziphus mucronata, Gymnosporia buxifolia*, etc. could also occur. With less mowing and cutting of undergrowth, more grass cover and abundance is expected.	

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a D (55.9%). The main impacts are the road crossings, lodge footprint (extending into riparian areas, cover an area of 65% of the non-marginal zone), felling of riparian vegetation, and the presence of exotic vegetation (Figure 5-13). Water quality is further degraded as a result of upstream activities such as a dam, industrial site (sugarcane factory) and a golf course. Due to the influence of the dam and other mentioned activities, less alluvial material is released to the downstream areas, which have resulted in the degradation of the riverbank, referred to as bed-armouring. The constant high flows increased the size of the active channel and have had a bearing on the integrity of the non-marginal zone as well. The result of this can be seen in bank collapse and under-cutting of the bank which is taking place. There is also vegetation clearing in the riparian areas' which reduces the vegetation roughness coefficient (Figure 5-13).

Footprint of the lodge extend into the non-marginal zone

Road crossing bisects riparian area

Remnant infrastructure and the felling of riparian trees

Figure 5-20: Activities that contribute towards the degradation of the PR3 riparian zone's integrity

PES causes and sources

The PES for the components, as well as the reasons for the PES are summarised in Table 5-4.

CAUSE: A stressor that occurs at an intensity, duration, and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 5-14: Causes and sources

Entity	PES	Conf.	Sources	Causes	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	D	2.9	Sugarcane factory, golf course, farming activities, etc.	Decrease in water quality with many upstream point and non-point source pollution occurring	Non-Flow related NF	2.9
			Golf course	Extends into riparian areas upstream of the study area and contributes towards the degraded water quality		
			The footprint of the lodge	Intrusion into the non-marginal zone impacting on the available habitat		
			Exotic invasion	*Melia azedarach, Lantana camara, Tecoma stans, Caryota urens* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication programme in place		
			Road traversing area	Restricted hydrology confined to culverts	Flow related F	
			Sugarcane factory	Higher flows throughout the year due to water releases from the sugarcane factory.		

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e., whether the quality and quantity are stable, or still changing). The results are summarised in Table 5-5.

Table 5-15: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	D	Stable	D	The presence of the sugarcane factory, golf course, road crossing and the extent of the dam area will always have an impact on the habitat availability and integrity of this site. Felling of indigenous vegetation and the presence of exotic vegetation species impacts on the vegetation composition, cover, and abundance. If these impacts are not managed it is expected that their effect will remain the same.	2.9

PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence are included in the EcoStatus assessment index (

Table 5-16). The EcoStatus EC is a D (55.9%).

Table 5-16: EcoStatus

RIPARIAN VEGETATION	EC %	ECO-STATUS	CONFIDENCE RATING
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**55.9**	**D**	
Confidence rating for riparian vegetation zone information			**2.9**

5.3.4 Site PR4 Riparian (Crocodile River)

SITE DESCRIPTION

The Crocodile River site is located at 25°27'43.05" S, 31°32'11.06" E. A panoramic view of the study area can be seen in Figure 5-21. Figure 5-22 is a Google aerial photo indicating the extent of this riparian zone.

Figure 5-21: Panoramic view of the riparian area PR4

Figure 5-22: Google image of the delineated riparian zone, PR4, in the study area

Marginal zone: (Figure 5-23)
The dominant vegetation consists of grass and sedges. The substrate consists mainly of alluvial soils. The following grass and sedge species occur: *Cynodon dactylon, Panicum maximum, Sporobolus africanus, Commelina diffusa subsp. scandens, Phragmites australis, Cyperus sexangularis, Schoenoplectus brachyceras,* etc. Exotic vegetation such as the macrophyte, *Eichhornia crassipes* occurs in places along the edge of the active channel. Other exotic species such as *Ricinus communis, Centella asiatica, Sesbania bispinosa, Sesbania punicea*, etc. occur. This riparian area is situated at the outflow point of a small tributary consisting of water coming from a sugarcane factory and a golf course upstream. It is expected that the water will be high in nutrients and a higher temperature than the norm. This results in a higher occurrence and diversity of animals (crocodiles, hippopotamus, elephant, etc.) at its confluence with the Crocodile River. The increase in mammal activity results in trampling and overgrazing.

Non-marginal zone: (Figure 5-23)
The dominant vegetation consists of grass and scattered shrub species. Grazing and trampling have resulted in bare soil surface areas and trees being stunted due to continuous grazing. It appears that the woody species are trying to recover after flood events in the past. The substrate consists mainly of alluvial material and rocky dykes crossing the riverine area.

The following woody species are dominant: *Combretum imberbe, Dichrostachys cinerea, Gymnosporia senegalensis, Ziziphus mucronata, Acacia nigrescens, Philenoptera violacea, Phyllanthus reticulatus, Peltophorum africanum, Pluchea dioscoridis,* etc. Grass species such as *Sporobolus africanus, Cynodon dactylon, Setaria sphacelata, Panicum deustum and Panicum maximum occur. Cyperus sexangularis and Schoenoplectus* spp. are the dominant sedges. Some exotic vegetation such as *Melia azedarach, Solanum mauritianum, Lantana camara, Parthenium hysterophorus, Sesbania punicea*, etc. were also found.

This riparian area is situated at the outflow point of a small tributary (as mentioned above) consisting of water from a sugarcane factory and a golf course upstream. As previously mentioned, it is expected that the water will be high in nutrients and a higher temperature than the norm. This has resulted in a higher occurrence and diversity of animals (crocodiles, hippopotamus, elephant, etc.) at its confluence with the Crocodile River resulting in trampling and overgrazing of this zone.

View of the marginal zone

View of the non-marginal zone

Figure 5-23: Photos of selected VEGRAI site

REFERENCE CONDITIONS

The reference conditions for the components are summarised in

Table 5-17.

Table 5-17: Reference conditions

Component	Reference conditions	Conf
Riparian vegetation	**Marginal zone:** Grass and sedge dominated state with pockets of reeds. Little to no woody species is expected in this alluvial system. Sedges such as *Cyperus dives*, *Cyperus sexangularis, Schoenoplectus brachyceras,* etc. could occur in abundance. The hydrophyte *Ludwigia adscendens* could also occur. Grasses such as *Sporobolus africanus, Leersia hexandra, Panicum deustum, Ischaemum fasciculatum,* etc. could occur. More grass cover and greater abundance are expected. **Non-marginal zone:** It is expected that grass would dominate with scattered trees and shrubsin this zone. Species such as *Ficus sycomorus, F. sur, Trichilia emetica, Nuxia oppositifolia, Ziziphus mucronata, Diospyros mespiliformis, Gymnosporia senegalensis,* etc. could occur more abundantly. Graminoids such as *Bothriochloa insculpta, Panicum maximum, Setaria sphacelata, Sporobolus africanus*, etc. are expected to occur in greater numbers. Indications are that with time, more trees and shrubs should recover that could result in denser riparian vegetation habitat.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a C/D (59%), with the main impacts flooding events, extensive grazing and trampling (stunted trees and shrubs), a tributary consisting of polluted water from industrial sugarcane factory and the presence of exotic species (Figure 5-24). The influx of enriched waters attracts higher animal numbers than would have been the case in similar natural conditions.

The exotic *Eichhornia crassipes* (Water hyacinth)

Grazing and trampling

From this photo the overgrazed area of the riparian zone is obvious

Tributary releasing enriched water from the sugarcane factory into the Crocodile river

Figure 5-24: Impacts identified in the Crocodile River Riparian zone

PES causes and sources

The PES for the components, as well as the reasons for the PES are summarised in Table 5-18.

CAUSE: A stressor that occurs at an intensity, duration, and frequency of exposure that results in a change in the ecological conditions.
SOURCE: A source is the origin of a stressor. It is an entity or action that releases or imposes a stressor on the water body (EPA, 2000).

Table 5-18: Causes and sources

	PES	Conf.	Sources	Causes	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	C/D	3.1	Bridge crossing downstream	Confines hydrology during high flood events	Non-Flow related NF	3.1
			Grazing and trampling	Exposes bare soil areas, decreases roughness coefficient, impacts on vegetation cover, etc.		
			Exotic infestation	*Melia azedarach, Lantana camara,* and non-woody weeds, such as *Ageratum houstonianum, Verbena bonariensis*, *Centella asiatica*, etc.		
			Flood events	Flood events can be extreme due to the mismanagement of the catchment-related activities	Flow related F	
			Water quality	Sugarcane factory, housing developments, etc. with point and non-point source pollution occurring		
			Water quantity	Water abstraction points at various points along the river. Many of the tributaries have in-stream dams for irrigation purposes.		

[1] Flow related [2] Non Flow related

PES TREND

An estimate was made of whether the components are responding to the main drivers (i.e., whether the quality and quantity are stable or still changing). The results are summarised in Table 5-19.

Table 5-19: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	C/D	Stable	C/D	Grazing pressure, flood events, a tributary with enriched waters, etc. will always have an impact on the habitat availability and integrity of this site. Grazing and trampling will always occur, and the presence of exotic vegetation species will not change. No management plan is in place to eradicate these exotic species. This continues to have an impact on the vegetation composition, cover, and abundance. It is unlikely that these impacts will improve and therefore the current situation should remain the same.	3.1

PES ECOSTATUS

To determine the EcoStatus, the Vegetation Response Assessment Index (VEGRAI) EC and confidence are included in the EcoStatus assessment index (Table 5-20). The EcoStatus EC is a C/D (57.9%).

Table 5-20: EcoStatus

RIPARIAN VEGETATION	EC %	ECO-STATUS	CONFIDENCE RATING
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	**59**	**C/D**	
Confidence rating for riparian vegetation zone information			**3.1**

5.4 Buffer Zone

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). The primary purpose for establishing buffers, in this case, would be to reduce the impact of adjacent land use on water quality and to provide habitat for aquatic and semi-aquatic species. The hydrology and the water quality of the riparian zones in the study area could change both during the construction period and after development.

In order to assess and apply the width of any buffer, it is important to understand the role that buffer zones play in protecting aquatic resources with their associated biota and in mitigating impacts from anthropogenic impacts. Thus, the proposed buffer will serve to provide a wide range of buffer functions and values including (Macfarlane, *et al.*, 2014):

- Sediment removal;
- Nutrient removal;
- Toxic 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.

Despite the range of functions potentially provided by buffer zones, they are far from being a ‘silver bullet’ that addresses all water resource-related problems. Indeed, buffers can do little to address some impacts such as hydrological changes caused by stream flow reduction activities (i.e. changes in flow brought about by abstractions or upstream impoundments). Buffer zones are also not the appropriate tool for mitigating against point-source discharges (e.g. sewage outflows), which can be more effectively managed by targeting these areas through specific source-directed controls. Contamination or use of groundwater is also not well addressed by buffer zones and requires complementary approaches such as controlling activities in sensitive groundwater zones (Macfarlane, *et al.*, 2014).

Anthropogenic impacts (dams, lodge footprint, roads, bush clearing, golf course, sugarcane factory, etc.) in and around these watercourses, emphasises the already increased impact from the larger catchment. To support the water courses’ integrity in an already disturbed environment and with the proposed development still to come, an aquatic buffer will be a necessity. However, it should be noted that an aquatic surface buffer of 20-30 m is highly unlikely to protect catchment-related hydrology support such as groundwater recharge. Therefore, the identification of mitigation and management measures of the proposed development in the greater catchment should compensate for the possible loss of catchment support.

The edge of the water resources (P01-04) in the study area has been delineated, with the starting point for delineation of the aquatic impact buffer zones for rivers, being on the outer edge of the active channel as visualised in Figure 5-25 (Macfarlane *et al.,* 2014). For the wetland, the buffer the starting point is from the edge of the wetland.

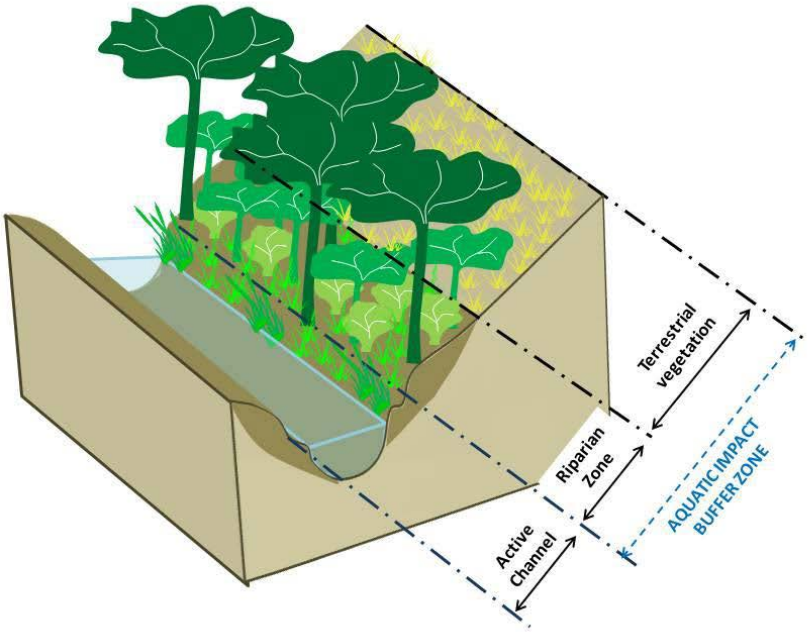

Figure 5-25: Schematic diagram indicating the boundary of the active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone.

Due to their position adjacent to water bodies, buffer zones associated with streams and rivers will typically incorporate riparian habitat. Riparian habitat, as defined by the NWA, includes the physical structure and associated vegetation of the areas linked to a watercourse. These areas are commonly characterised by alluvial soils (deposited by the current river system), and are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with composition and physical structure distinct from those of adjacent land areas. However, the riparian zone is not the only vegetation type that lies in the buffer zone as the zone may also incorporate stream banks and terrestrial habitats depending on the width of the aquatic impact buffer zone applied. There may however be instances in which the riparian zone extends beyond the aquatic impact buffer zone. In such instances, setback requirements include the full extent of the riparian zone and any additional requirements that may apply to manage this area.

A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows (Figure 5-26, Figure 5-27 and Figure 5-28):

- PR1 : 25 m
- PR2 : 25 m
- PR3 : 25 m
- PR4 : 70 m

Figure 5-26: Delineation of the PR1-Riparian site's active channel edge, aquatic requirement, riparian edge and then the final setback requirement

Figure 5-27: Delineation of the PR2-Wetland site's with setback requirement


Legend
Aquatic Requirement
PR3 Riparian Area
Setback Requirement
SR3 Active Channel
Google Earth
N
100 m

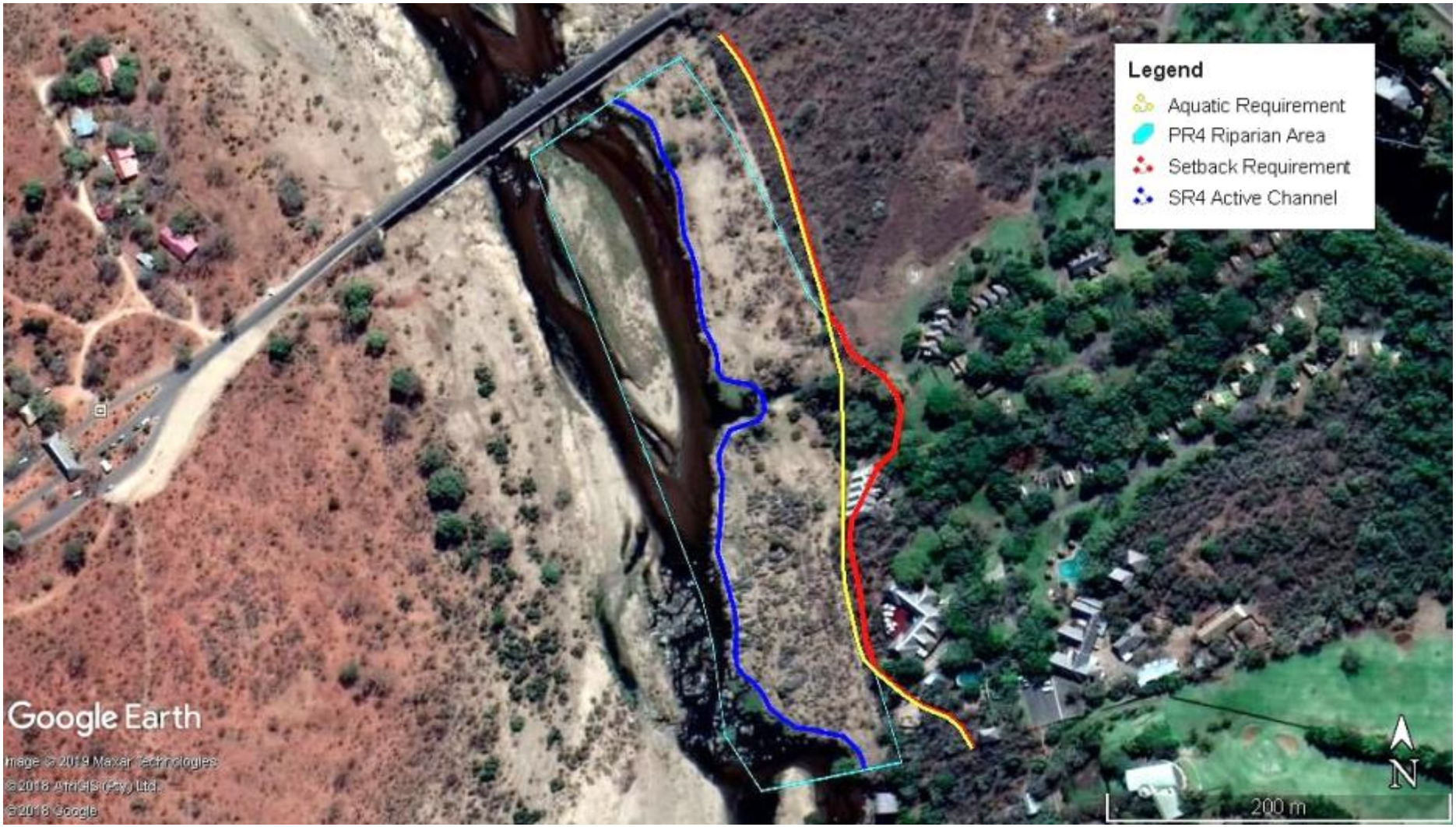

Figure 5-28: Delineation of the T03-Riparian site's active channel edge, aquatic requirement, riparian edge and then the final setback requirement

6 Impact assessment and Mitigation

Any development in a natural system will have an impact on the environment, usually with adverse effects. From a technical, conceptual, or philosophical perspective, the focus of an 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 water flow through decreasing or increasing can only have an influence upon almost every aspect of the wetland's and/or ecological functioning (Davies & Day, 1998).

Current South African legislation, as indicated at the beginning 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 and riparian that may have an impact on migration and ecosystem functioning.

This assessment was made after one visit to the study area. A single visit makes it difficult to identify and assess all habitat, associated species and/or species compositions. Further assessment on the presence of threatened or protected species is thus handicapped. Thus, for this assessment, the riparian and wetland areas should be regarded as sensitive from a biodiversity aspect.

6.1 Impacts

Based on evaluation tables (Table 4-2 and Table 4-3), the impact magnitude and significance of the development will depend on where it will take place. If the footprint extends into the riparian and/or wetland areas, the impact can be significant due to the loss of a riparian and wetlands (and habitat) that is host to certain wetland services.

The most significant impact of development in watercourse areas can have the following effects:

- Destruction of riparian and/or wetland that leads to habitat loss (and biodiversity loss)
- Initiation of erosion (increased flow volumes due to hardened surfaces)
- Increase in sediment due to the construction of buildings that can smother riparian habitat downstream
- Change in water quality.

Only some of the negative impacts of development in a riparian and/or wetland can be mitigated by controlling flow-rates utilizing the following:

- Some erosion is already evident in the area, and storm-water run-off into the riparian area should make use of energy dissipaters
- Remove all dumped and refuse material in the riparian area
- Remove invasive alien vegetation to establish and recreate riparian habitat
- Stay clear of the 1:100 flood lines and buffer zones.

Because roads and/or pathways can be one of the biggest destroyers of riparian areas, care should be taken to construct adequate numbers of large culverts to cover the area of a riparian area. However, culverts and/or storm-water pipes can initiate erosion capable of destroying riparian areas; therefore sufficient numbers of energy dissipaters should be put in place.

Most of the impacts identified relate to water quality, wetland habitat and biotic components:

Water quality impacts

Fluctuations in the *in situ* water quality parameters (pH, Electrical Conductivity (EC), TDS, DO, and temperature) may occur during the construction phase, the operational phase as well as during the decommissioning and closure phase. These will have impacts on the riparian and/or wetland's ecosystem, biotic communities, and vegetation.

Water quality may be adversely affected since the following proposed activities will impact the riparian area:

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

Increased soil sediment loads via surface water run-off into the adjacent riparian areas owing to the clearing of vegetation before construction, the construction activities and the removal of topsoil, can lead to:

- Reduced photosynthesis and transpiration in the in-stream aquatic macrophytes;
- An increase in fine-particulate sediments in the water;
- A decrease in visibility and light penetration;
- An increase in potential EC and TDS;
- Fluctuations 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.

Habitat disturbances, resulting in increased sediment input from erosion; and

Cumulative impact from existing surrounding 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 biodiversity parameters.

Habitat impacts

The habitat may be affected because the following proposed activities may impact the riparian areas:

Habitat loss or alteration

If construction is going to take place in or on the edge of a riparian and/or wetland, the largest impact is expected to occur during this period. The following activities can have an impact:

- Removal/destruction of riparian 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.

Dust that enters the riparian and/or riparian area can have the following impact:

- Decreased visibility due to clouding of the water column;
- Decreased light penetration;
- Siltation of fine sediment substrates, gravel substrates and inter-substrate spaces; and
- The decrease in habitat availability.

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

Soil sediment loads entering the riparian ecosystems via surface water will lead to:

- An increase in fine-particulate sediments in 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.

Cumulative impact from existing surrounding activities as well as the proposed project, will lead to:

- Increased erosion, flooding, sedimentation and bank instability;
- Fluctuations in *in situ* water quality parameters; and
- Fluctuations in biodiversity parameters.

Biotic changes

Vegetation

Changes to the vegetation community structure of the riparian and/or wetland ecosystem may take place due to the likelihood that the following may occur as a result of the above-mentioned impacts:

- Fluctuations in water chemistry may directly impact on the ability of certain plant 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.

6.2 Mitigation

The construction, operation, and maintenance of this development have the potential to cause some environmental damage to the physical, biological and chemical components of riparian and/or wetland ecosystems. The construction activities should, therefore, apply methods and management practices that minimize and avoid the following impacts:

- Loss and disturbance of vegetation and habitat within its 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 run-off from the road 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 operation phases, and
- Riparian and/or wetland habitat fragmentation.

Riparian and/or wetlands, in particular, can be very sensitive. This is due to the fact that wetlands are low energy drainage lines in the landscape that are generally dependent on locally high water tables. These locally high water tables create the hydrological conditions of near-surface soil saturation that allows riparian areas 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 further erosion and donga formation. That could result in a degradation of the environmental resource, as well as effectively draining the riparian areas through a lowering of the local water table and subsequent desiccation of the riparian areas. Eroded riparian areas are very difficult to rehabilitate to reference conditions because both the water and soil required to support the riparian areas would then need to be reinstated.

To maintain the integrity of the riparian areas concerned, the following actions are recommended:

- Plan and develop outside riparian areas;
- Create the recommended buffer around riparian areas (likely, a buffer of <20 m may adequately fulfill several functions and values such as biotic movement, protecting the edge of the riparian areas, and some water quality functions, etc.) (MacFarlane, Dickens, & Von Hase, 2009);
- Minimize the removal/damage to vegetation in riparian areas;
- The construction of pathways (disturbance zones) in or adjacent to the riparian areas is to be closely managed and strictly controlled to minimize damage to riparian areas;
- Operation and storage of equipment in the riparian areas to be prevented;
- If the riparian areas is disturbed during construction it should be re-vegetated using site-appropriate indigenous vegetation and/or seed mixes;
- Alien vegetation should not be allowed to colonize the disturbed riparian areas;
- Rehabilitation of disturbed riparian areas habitat should commence immediately after construction is completed;
- No construction camps should be allowed in or within 20 m of riparian areas;
- No stockpile areas should be located in or within 20 m of riparian areas;
- Construction should preferably take place during the low flow/winter months in order to minimize the risk of sediment and debris being washed into riparian areas;
- Stockpiling of soil and of supplies for the construction camps must take place clearly away (at least 20 m where possible) from the edge of riparian areas to prevent soil being washed into the habitat of the riparian area;

- During the construction and operation phases erosion and siltation measures should be implemented (e.g., the use of temporary silt traps downstream of construction areas);
- Slope/bank stabilization measures should be implemented where necessary to prevent erosion during the operation;
- Debris and sediment trapping, as well as energy dissipation control structures, should be put in place where storm-water may enter riparian areas;
- Turbidity, sedimentation and chemical changes to the composition of the water must be limited; and
- Where vegetation removal has occurred adjacent to the pathways, 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 successful re-vegetation by indigenous species.

7 Conclusion

There is a stream that flows through the study area, while the perennial Crocodile River forms the western border of the study area. In this area the Crocodile River has an aquatic PES of 'D.' According to the MBSP freshwater assessment the study area falls within an ESA Important Sub-catchment, with some patches of Heavily Modified areas included. The sub-catchment is important as it is a Fish Support Area, supporting the Tiger Fish (*Hydrocynus vittatus*). The study area also overlaps with an MBSP CBA: Aquatic Species, which supports the Zambezi Siphonta dragonfly (*Neurogomphus zambeziensis*).

Four watercourses were identified and can be described as riverine and wetland areas. There are riparian areas and a wetland. The delineated riparian areas are demarcated and indicated as PR1, PR3, and PR4. The wetland identified is demarcated as PR2.

Site PR1 Riparian Index of Habitat Integrity (RIHI) is a C (62.1%). The main impacts include the upstream road crossing, golf course (impacted corridor upstream of the study area), sugarcane factory upstream, and the presence of exotic vegetation.

Site PR2 is a wetland with artificial features. The wetland's catchment has been altered by agricultural activities, and the wetland itself has been transformed due to the building of a dam; this has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having an "E" PES Category. The change in ecosystem processes and loss of natural habitat and biota is great, but some remaining natural habitat features are still recognisable. The wetlands ecosystem services do reflect some values in contributing to better water quality in the form of sediment trapping, phosphate trapping, streamflow regulation, toxicant removal, and nitrate removal. The wetland does not contribute significantly towards human services, as indicated by the score which shows that these services are low

Site PR3 Riparian Index of Habitat Integrity (RIHI) is a D (55.9%). The main impacts are the road crossings, lodge footprint (extending into riparian areas, cover an area of 65% of the non-marginal zone), golf course (impacted corridor upstream of the study area), sugarcane factory upstream, felling of riparian vegetation, and the presence of exotic vegetation.

Site PR4 (Crocodile River) Riparian Index of Habitat Integrity (RIHI) is a C/D (59%), with the main impacts being flooded events, extensive grazing and trampling (stunted trees and shrubs), a tributary consisting of polluted water from industrial sugarcane factory and the presence of exotic species. The sugarcane factory pollutes the water in the increase in sucrose and fructose that further benefit the microbe organisms which forms the basis of the food chain, thus the reason for an increase in diversity within this system.

The edge of the water resources (PR1 to PR4) in the study area has been delineated, with the starting point for delineation of the aquatic impact buffer zones for Rivers and streams, being on the outer edge of the active channel. A buffer width of 30 m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers the following buffer widths for the denominated riparian zones are as follows:

- PR1 : 25 m
- PR2 : 25 m
- PR3 : 25 m
- PR4 : 62 m

The proposed development can increase hardened surfaces and subsequent stormwater runoff. Any hardening of surfaces will reduce the infiltration and ultimately reduce the yield of the seep zones they are feeding into the greater riparian areas systems.

The following is recommended:

- All activities should stay out of the 1: 100-year flood line area;
- All activities should stay out of the riparian areas area and its recommended buffer zones;
- All stormwater should be diverted to a point from where the water must be released in a controlled manner that will not initiate or enhance any erosion, and the way stormwater enters a natural waterway is important because high-energy flows can cause serious damage (especially to riparian zones); and
- Energy dissipaters and smaller permeable gabion-structures covered with reeds can be constructed at the effluent points of all stormwater.
- To cater to the present and the proposed developments in above mentioned riparian areas on-site and off-site mitigation are recommended to mitigate the negative effects thereof.

8 REFERENCES

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