TEN BOSCH - KOMATIPOORT
Wetland and Riparian Zone Identification and Assessment

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By:

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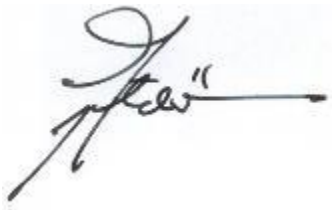
DECLARATION OF INDEPENDENCE

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 (Pty) Ltd was appointed by NuLeaf Planning & Environmental to conduct a wetland / riparian survey for a Basic Assessment Report (BAR) on the Ten Bosch - Komatipoort property north of the town Malelane. The landowner intends to establish a Nature Estate for Leisure Purposes and a Lodge.

The affected property, Portion 2 and Portion 3 Tenbosch 661 JU and erf 814, is situated within the Nkomazi Local Municipality, in the Ehlanzeni District Municipality, approximately 3 Km north of the town of Komatipoort. The Kruger National Park forms the northern and eastern boundaries of the property.

The study area lies on the south-eastern border of the Kruger National Park, about 1.5 km north of the town of Komatipoort, and about 3 km west of Mozambique. The N4 lies approximately 3.5 km to the south. It falls under the Ehlanzeni District Municipality, Nkomazi Local Municipality, Mpumalanga Province.

The study area forms part of the Tshokwane-Hlane Basalt Lowveld vegetation unit and land type Ea78. It falls within quaternary catchment X24H, which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area. The study area borders the perennial Crocodile River (PES of 'D') and also includes several non-perennial rivers.

According to the MBSP freshwater assessment, the study area falls within an ESA Important Sub-catchment as it is a Fish Support Area (FSA), as per NFEPA. This particular FSA supports the Tiger Fish (*Hydrocynus vittatus*), a fish species of conservation concern. According to the MBSP freshwater assessment, the study area is associated with one ESA wetland area and also includes two dams. The National Wetland Map 5 shows this ESA wetland area to be a riverine/ floodplain wetland (associated with the Crocodile River).

Water resources such as wetland areas with swamp forest characteristics and the riparian of the Crocodile River were identified. It should be noted that several ephemeral drainage lines were also encountered. In total, seven ephemeral drainage lines, two riparian zones and three palustrine wetlands were identified.

Site TB08 Riparian Index of Habitat Integrity (RIHI) is a C/D (61%). The major impacts include the increased flows (artificial canal feeding water to the dam), dam, road traversing riparian and the presence of exotic vegetation.

Site TB09 is a valley bottom wetland with no channel. The following disturbances in the catchment of the wetland were observed: sugarcane crops (31.2%) and management roads (10.6%). The untransformed area (58.2%) appears to be slightly overgrazed, although in a reasonable condition. Disturbances in the wetland include a dam (24%), road crossings (10.6%), and an artificial canal (0.5%). The untransformed portion of the wetland (68.1%) is in a reasonable good condition. The wetland can, therefore, be currently described as having a "C" PES Category. The wetlands ecosystem services do reflect some values in contributing to better water quality in the form of phosphate and nitrate trapping is an important function. The maintenance of biodiversity is one of its essential services. The wetland does not contribute significantly towards human services. The unique swamp forest habitat provides plenty of opportunity for bird watching, fishing and hiking. Tourism and recreation pose to be a potential service.

Site TB10 is a valley bottom wetland with no channel. The following disturbances in the catchment of the wetland were observed: sugarcane crops (34.7%), road crossings (9.6%), dwelling (2.4%), dumping (0.03%), etc. The untransformed area consists of 53.27% of the catchment and is in a reasonable condition. Impacts occur in the wetland: dam (5%) and

road and footpath crossing (14%). The untransformed area makes 81% of the wetland, and its condition is hindered by the presence of exotic and terrestrial species. . The wetland can, therefore, be currently described as having a “C” Category. Wet ecosystem services consist of phosphate and nitrate trapping and erosion control which contribute towards a better water quality. Its biodiversity service is also important due to the swamp forest habitat. People rarely rely on the wetland and rarely benefit directly from it. The tourism and recreation service came out high due to the fact that the site is close to a major tourism route and does have birding opportunities.

Site TB11 is a valley bottom wetland with a channel. The significant disturbance in the catchment is sugarcane crops with it making 93% of the surface area. The wetland has been altered by means of road crossings (11%) and an artificial channel (0.1%). The untransformed area (88.9%) dominated by trees and shrubs with scattered clumps of grass and sedges. The wetland has good forest cover with little sign of erosion. The wetland can, therefore, be currently described as having a “C” PES Category. The wetlands ecosystem services ad value in streamflow regulation, phosphate trapping and nitrate removal, all are contributing towards better water quality. The swamp forest provides a variety of habitat benefitting high biodiversity, adding value to the wetland uniqueness. Tourism and recreation came out reasonably high due to the swamp forest habitat providing an opportunity for birding and the fact that the wetland is in and adjacent to the town of Komatipoort.

Site Tb12 (Crocodile River) Riparian Index of Habitat Integrity (RIHI) is a C (62.3%), with the main impacts being flooded events, grazing and trampling (stunted trees and shrubs and the presence of a few exotic species.

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). A 15m buffer is proposed for the ephemeral systems to provide an opportunity for the systems to accommodate surface water flowing from its catchment basin. However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers, the following buffer widths for the denominated riparian zones and wetlands are as follows.

- TB08 (Riparian): 35 m
- TB09 (Wetland): 30 m
- TB10 (Wetland): 30 m
- TB11 (Wetland): 30 m
- TB12 (Riparian): 60 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.

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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.
Hydrophytic	Wetland plants, or hydrophytic "water loving" vegetation, are those plants which have adapted to growing in the low-oxygen (anaerobic) conditions associated with prolonged saturation or flooding. These plants have adapted to anaerobic soil conditions by evolving alternative methods of collecting oxygen such as the hypertrophied lenticels in the bark of speckled alder; the hollow stems of rush and grass species; and the air filled cells (aerenchyma) in the roots of cattails.
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

Wet-Earth Eco-Specs was appointed by NuLeaf Planning & Environmental to conduct a wetland / riparian survey for a Basic Assessment Report (BAR) on the Ten Bosch - Komatipoort property north of the town Malelane. The landowner intends to establish a Nature Estate for Leisure Purposes and a Lodge.

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The proposed development entails the creation of a Nature Estate with several chalets, residence and a safari lodge in a nature area, located north of Komatipoort town by the zoning of the development footprints within a nature area.

The National Environmental Management Act (NEMA) and the National Water Act legally requires determining the occurrence and extent of wetlands on the proposed development areas. The legislation is strict when it comes to any development close to or in wetland and/or riparian habitat. The planning of infrastructure needs to be sensitive towards these water resources, and impacts should be avoided and/or minimise.

2 Scope of work

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.

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;
- Precision 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 the 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 and Classification**

The National Water Act, Act 36 of 1998, defines wetlands as follows:

"*Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.*"

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.

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:

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 essential 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

[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.

Exotic vegetation has an impact on indigenous riparian vegetation. The impact is measured using the cover percentage of alien 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%.

To assess each of these factors for each impact, the following ranking scales will be used (Error! eference source not found.).

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**Error! Reference source not found.** and Table 4-5**Error! Reference source not found.**.

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)	The impact is significant; mitigation is critical to reducing 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)

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

The study area lies on the south-eastern border of the Kruger National Park, about 1.5 km north of the town of Komatipoort, and about 3 km west of Mozambique (Figure 5-1). The N4 lies approximately 3.5 km to the south. The study area falls under the Ehlanzeni District Municipality, Nkomazi Local Municipality, Mpumalanga Province.

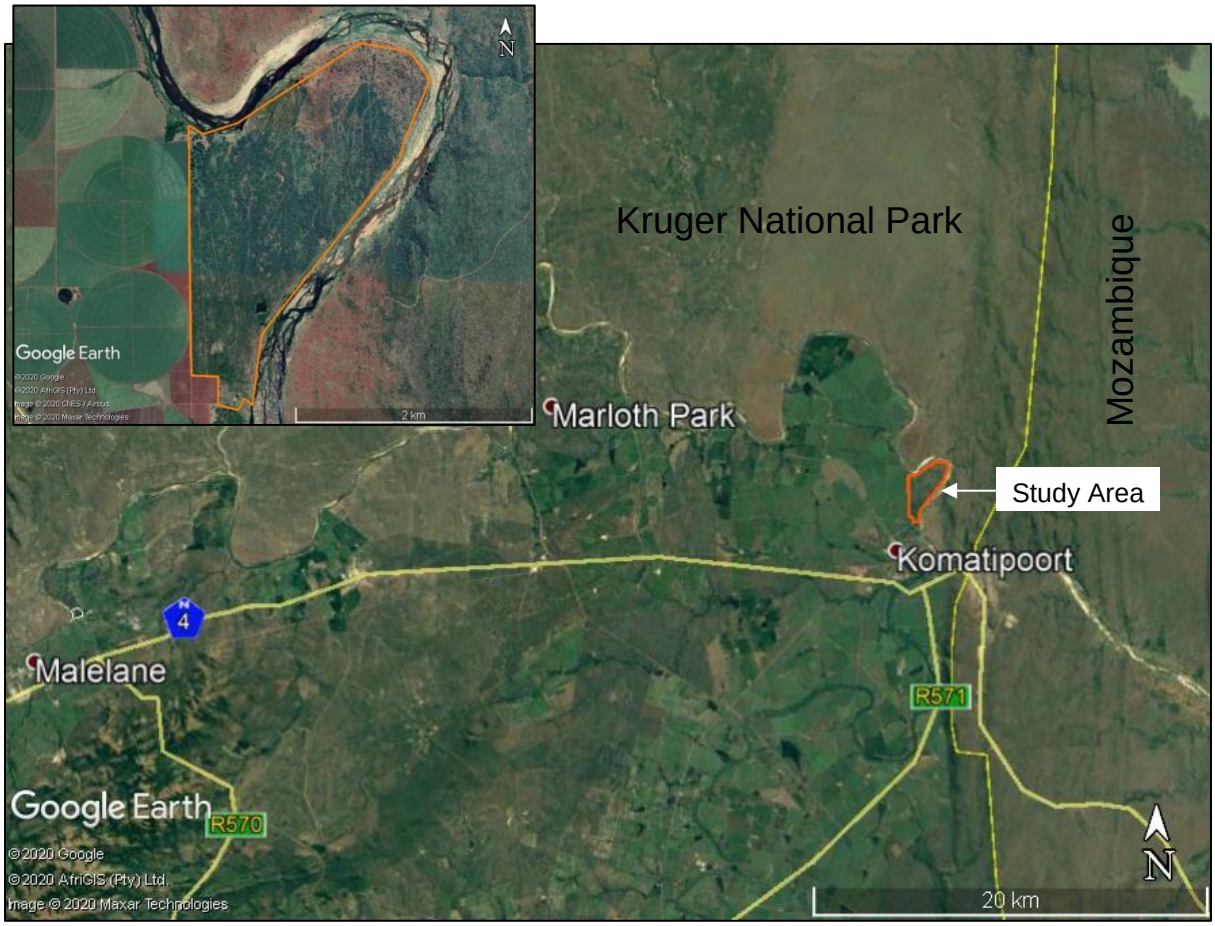


Figure 5-1: Google Earth image showing the study area in relation to the surrounding towns, roads and places of interest; the inset map shows the study area in greater detail

Land-use

According to the 2013/2014 land-cover data, the study area is entirely natural, although it borders on cultivated land to the west (Figure 5-2). The Kruger National Park lies to the north and east, while the land-use of the surrounding area to the west and south is predominantly cultivation, with some urban development also present (Figure 5-2). Some water and bare patches are also visible in the vicinity (Figure 5-2).

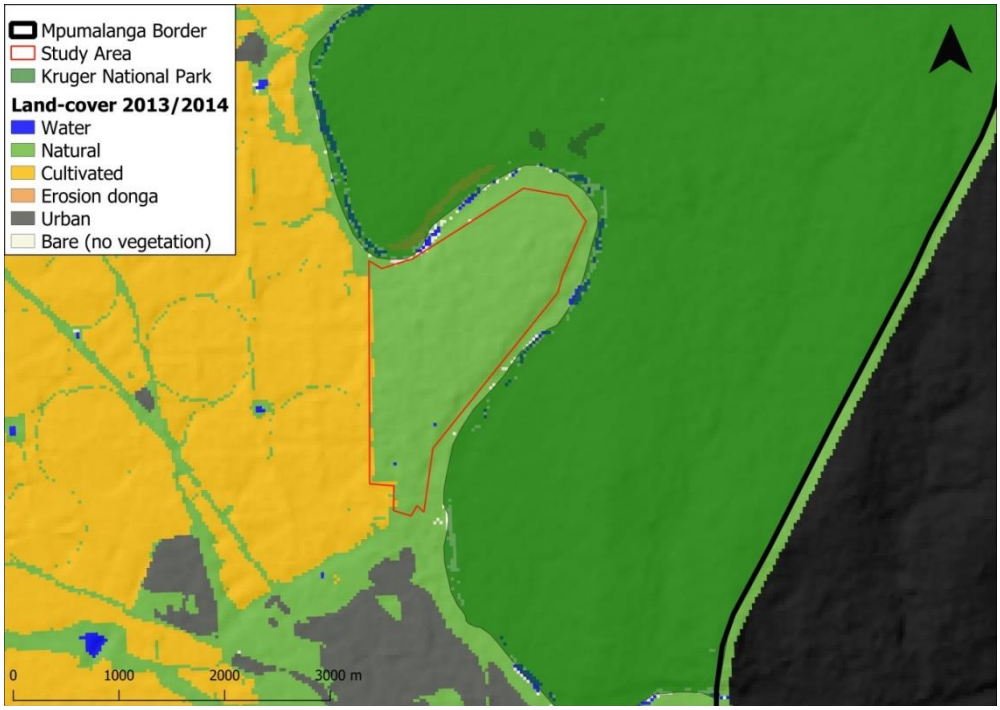


Figure 5-2: 2013/2014 land-cover data showing the different land-uses within and surrounding the study area

Vegetation Units

According to VEGMAP 2018 (SANBI 2006–2018), the study area falls within the Tshokwane-Hlane Basalt Lowveld (SVl 5) vegetation unit, and borders on the Northern Lebombo Bushveld (SVl 15) vegetation unit to the east (Figure 5-3). The following description applies to the unit as a whole and is taken from Mucina & Rutherford (2006).

Tshokwane-Hlane Basalt Lowveld has an altitude range of 180–400 m. It usually comprises fairly flat plains with open tree savanna, often dominated by tall *Sclerocarya birrea* and *Acacia nigrescens*, with a moderately developed shrub layer and a dense herbaceous layer. On some sloping areas with shallower soils, trees are stunted (e.g. *A. nigrescens*). It is a summer rainfall region with dry winters. The unit has a conservation target of 19%. About 64% is statutorily conserved mainly in the Kruger National Park, but also in the Mlawula Nature Reserve. In addition, over 3% is conserved mainly in the Hlane Game Sanctuary. About 17% is transformed, almost all by cultivation.

Mean monthly minimum and maximum temperatures at the study site itself are 9.4˚C and 32.8˚C in July and December respectively, while the annual average is 22.9˚C; the mean annual precipitation is 636 mm (WorldClim database, Hijmans *et al.*, 2005).

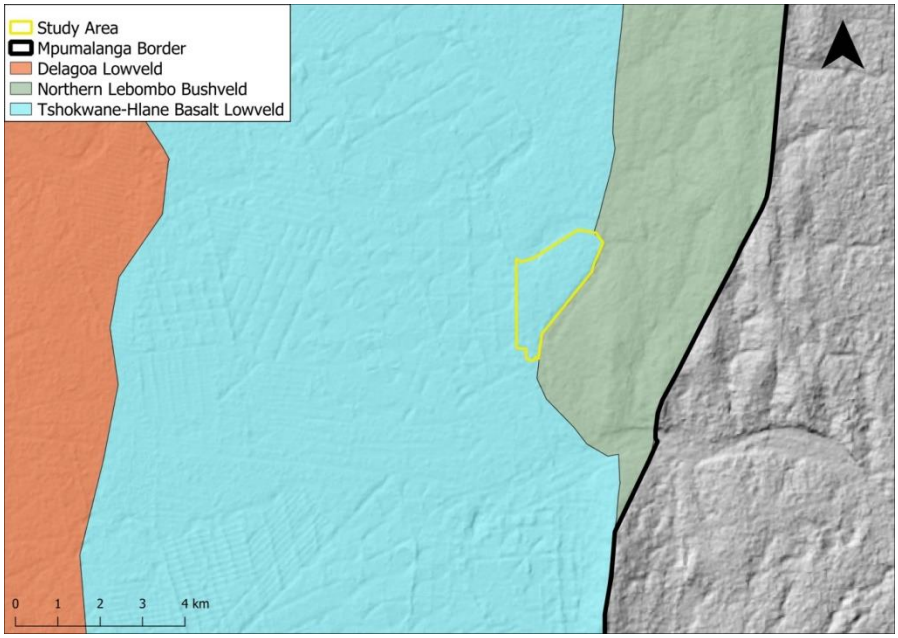


Figure 5-3: The position of the study area in relation to the surrounding vegetation units

Land Types

The study area falls within land type Ea78 (Figure 5-4). The geology is described as: “Basalt of the Letaba Formation, Karoo Sequence”, while the soils are described as: “One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated” (Land Type Survey Staff, 1972–2006).

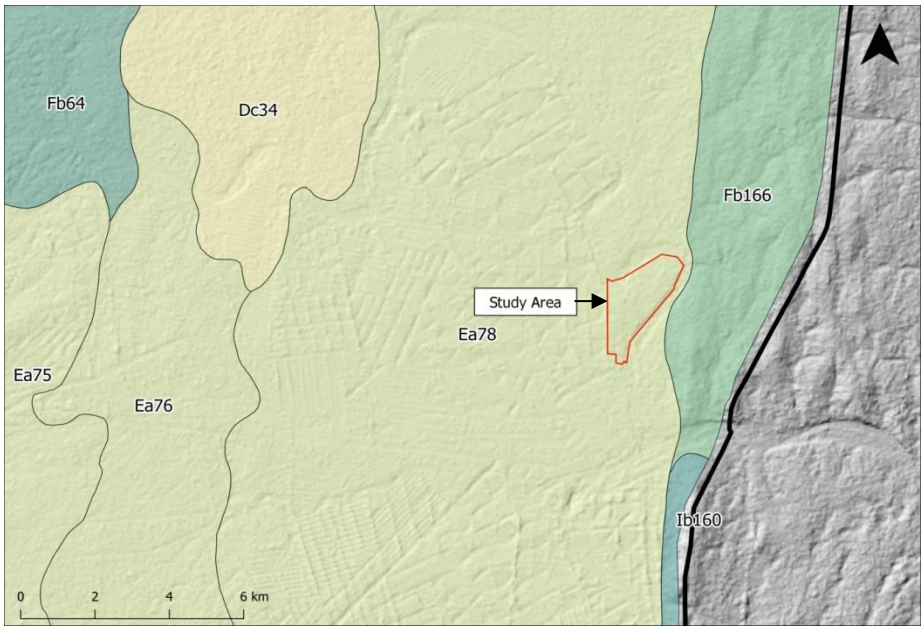


Figure 5-4: Study area in relation to the land types in the vicinity

Freshwater Desktop Assessment

This desktop assessment is based on a combination of the following:

- The Mpumalanga Biodiversity Sector Plan (MBSP) freshwater assessment (MTPA, 2014), together with the NFEPA project (National Freshwater Ecosystem Priority Areas; Nel *et al.*, 2011). 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 but was improved for Mpumalanga (Lötter, 2015). The NFEPA project identifies FEPAs (Freshwater Ecosystem Priority Areas), which are rivers, wetlands and estuaries that need to remain in a good condition to conserve freshwater ecosystems and protect water resources for human use (Nel *et al.*, 2011).

- The new National Wetland Map 5 (Van Deventer *et al.*, 2018), together with the wetland probability map for Mpumalanga (i.e. modelled wetlands; Dr Nacelle Collins; FS DESTEA). The National Wetland Map 5 and wetland probability maps show the most recent mapped and modelled wetlands for South Africa.
- The 2014 Present Ecological State (PES) for South African rivers (Department of Water and Sanitation [DWS], 2014). The PES assessment used six categories to describe the state of rivers, ranging from 'A' (natural) to 'F' (critically modified); DWS, 2014.

The study area falls within quaternary catchment X24H, which forms part of the Crocodile Sub-water Management Area, Inkomati Water Management Area (Figure 5-5).

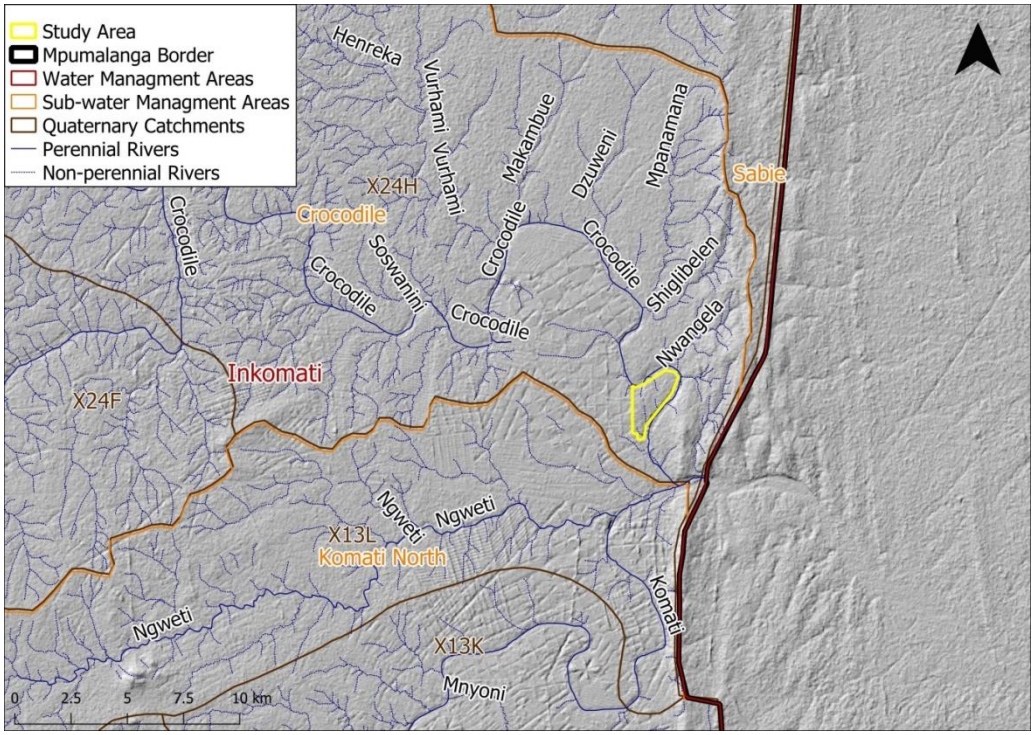


Figure 5-5: The study area in relation to water management areas, sub-water management areas, quaternary catchments and rivers

The study area borders the perennial Crocodile River and also includes several non-perennial rivers (Figure 5-6). 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 (Figure 5-6; Table 5-1). 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.

According to the MBSP freshwater assessment, the study area is associated with one ESA wetland area, and also includes two dams (Figure 5-6; Table 5-1). The latest wetland delineations, as per the National Wetland Map 5, can be seen in Figure 5-7. This map is very similar to the MBSP map in Figure 5-6, and shows that the ESA wetland area is a riverine/ floodplain wetland (associated with the Crocodile River). The wetland probability map shows no modelled wetlands within the study area (Figure 5-7).

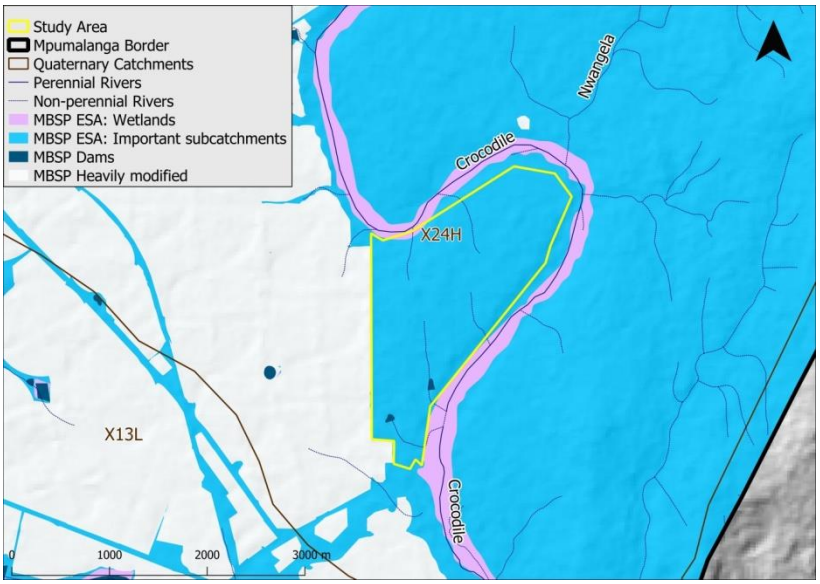


Figure 5-6: The study area in relation to rivers and the MBSP freshwater assessment; ESA = Ecological Support Area

Table 5-1: Descriptions of the relevant map categories for the MBSP freshwater assessment, as well as the desired management objectives for each main category, taken from MTPA (2014).

Map Category	Description	Desired Management Objectives	Sub-category	Description
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.	Maintain in a functional, near-natural state, but some habitat loss is acceptable. A greater range of land-uses over wider areas is appropriate, subject to an authorisation process that ensures the underlying biodiversity objectives are not compromised.	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.	Such areas offer the most flexibility regarding potential land-uses, but these should be managed in a biodiversity-sensitive manner, aiming to maximise ecological functionality and authorisation is still required for high-impact land-uses.	Heavily Modified: Dams	Artificial water bodies that have impacted on wetland or river ecosystems. These areas may still have a recharge effect on wetlands, groundwater and river systems and may support river- or water-dependent fauna and flora, such as water birds and wetland vegetation.

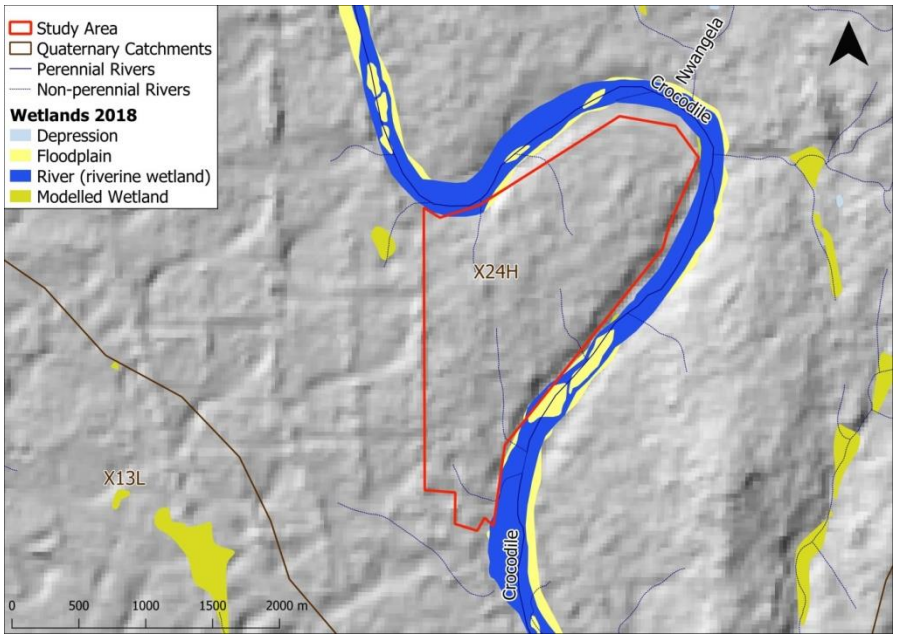


Figure 5-7: The study area in relation to rivers and the 2018 wetland delineations as per the National Wetland Map 5 (with hydrogeomorphic classification) and the wetland probability map for Mpumalanga (modelled wetlands)

5.2 Wetland and Riparian Identification and Delineation

To cover a representative area of the wetlands and riparian zones in the study area, several transect surveys were necessary. Water resources, such as wetland areas with swamp forest characteristics, and the riparian of the Crocodile River, were identified. It should be noted that several ephemeral drainage lines were also encountered.

The riparian areas and wetlands identified were delineated according to the guidelines for delineation, set out by the Department of Water Affairs and Forestry (DWAF) (DWAF, 2005). Seven ephemeral drainage lines, two riparian zones and three palustrine wetlands were identified; please refer to (Figure 5-8). For the purpose of this document, the dry drainage lines and water sources are numbered, please refer to Figure 5-9.

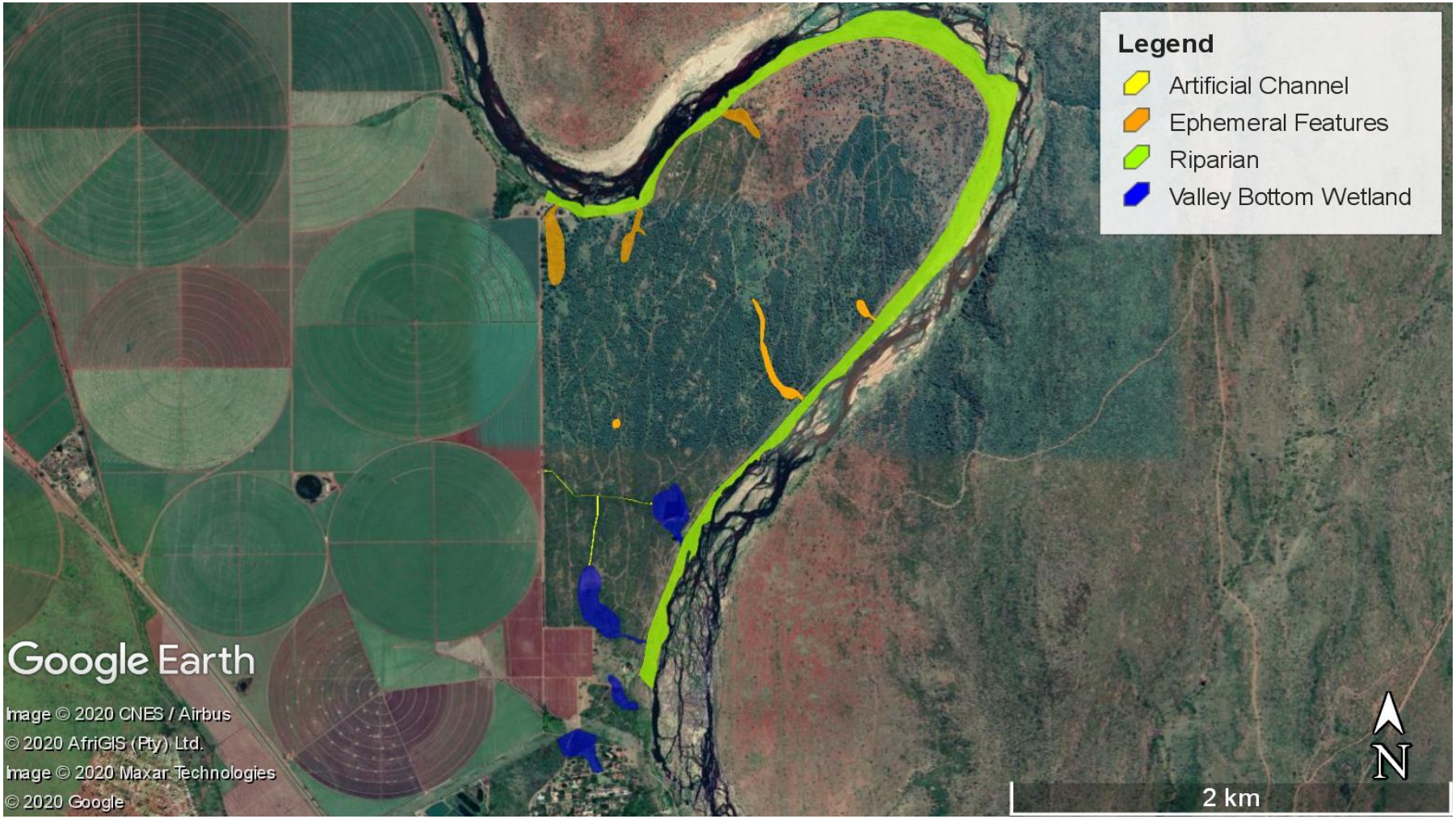


Figure 5-8: Identified riparian and wetland areas for the purpose of this study

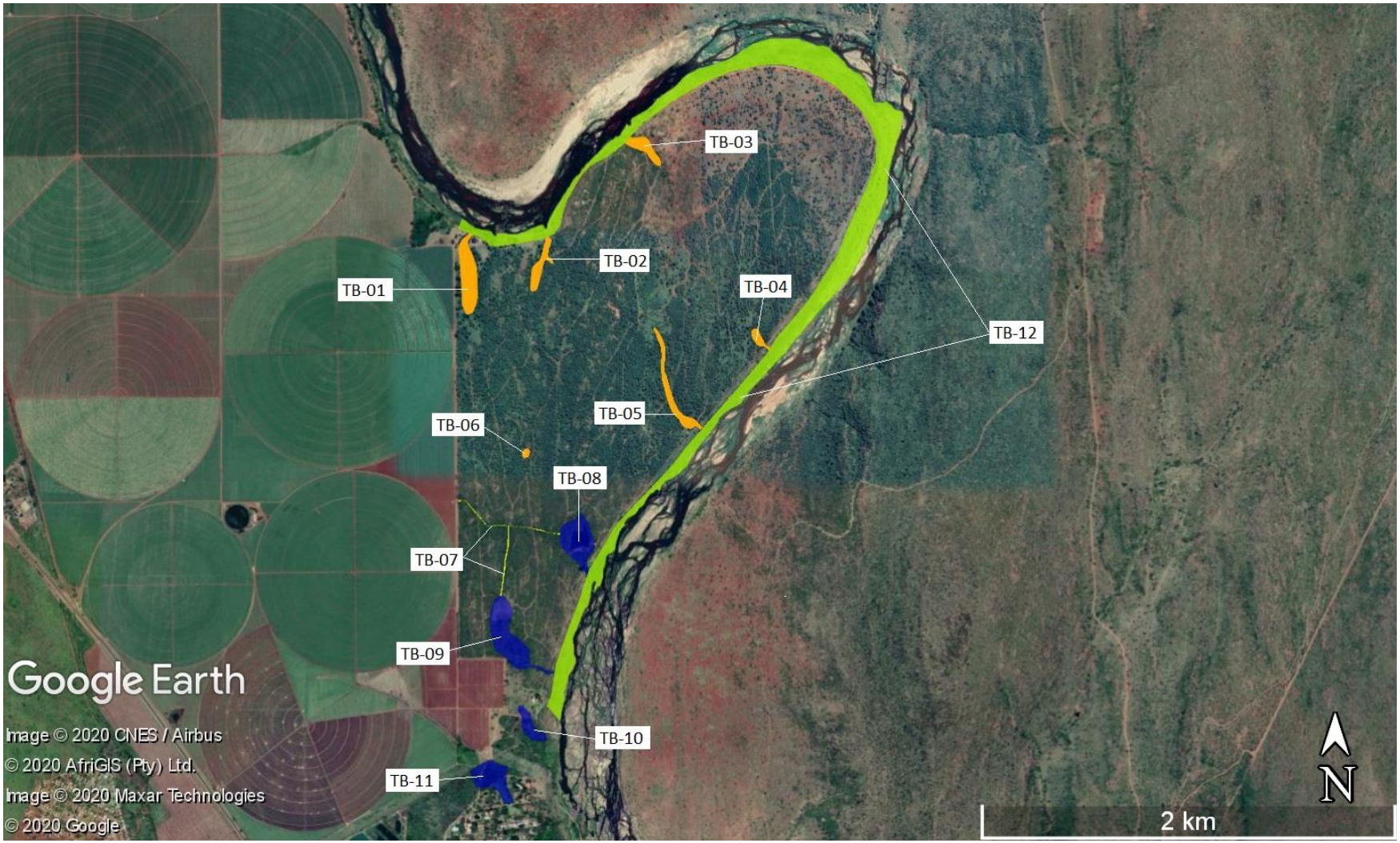


Figure 5-9: Demarcation of the watercourses encountered during the study

5.2.1 Ephemeral Features: TB 1-6

A total of seven ephemeral drainage lines were encountered during the fieldwork (Table 5-2). Please refer to Figure 5-9 for the location of these features. Streamflow begins when water is added to the surface from rainfall and groundwater. Drainage systems develop in such a way as to efficiently move water off the land. Streamflow begins as moving sheet wash which is a thin surface layer of water. The water moves down the steepest slope and starts to erode the surface by creating small rill channels. As the rills coalesce, deepen, and cut down into channels, larger channels form. Drainage systems which only have occasional water flowing through them are called ephemeral systems, or dry washes. They are above the water table and occur in dry climates with low volumes of rainfall, and high evaporation rates. They flow mostly during rare flash floods.

These systems do not qualify as wetlands or riparian areas; however, they are deemed to be necessary for the following reasons:

- To accommodate surface water flowing from its catchment basin
- The condition of these systems will determine how efficiently the water is moved towards more significant watercourses downstream
- Its integrity also adds to the quality of water conveyed to the downstream systems
- To act as corridors between terrestrial and the aquatic environment

Table 5-2: Dry ephemeral features encountered during study

Nr.	Type	Location	Description
TB01	Ephemeral drainage	25°24'00.82 S 31°57'23.55 E	The drainage forms part of a recreational area. The catchment consists mainly of sugar cane cultivation and bushveld. The drainage line's elevation is shallow at first but gets steeper as it drains towards the Crocodile River. Impacts: • Dumping of garden refuse • Head-cut erosion as a result of high flows during rain events • Infrastructure footprint extends into the drainage area • Road crossing • Vegetation clearing, impacting the roughness coefficient of the system • Exotic vegetation
The following species occur: *Tabernaeamontana elegans* *Sclerocarya birrea* *Acacia xanthophloea* *Trichilia emetica* *Diospyros mespiliformis* *Gymnosporia senegalensis* *Phyllanthhus reticulatus* *Philenoptera violacea* *Panicum maximum* *Cynodon dactylon* *Melinis repens* *Urochloa mosambicensis* *Berchemia zeyhgeri* *Lantana camara** *Melia azedarach**			

Upstream portion managed for recreational activities

The incised downstream area, before it drains into the Crocodile River

Nr.	Type	Location	Description
TB02	Ephemeral drainage	25°24'02.57 S 31°57'37.33 E	This feature is dry with a steep gradient. The upstream portion is rocky with a meandering channel. It is expected that high energy flows do occur during rain events. Impacts: • Dam in the downstream portion
The vegetation cover consist of the following species: *Rhoicissus tridentata*			

Euclea natalensis *Dichrostachus cinerea* *Ficus sycomorus* *Grewia hexamita* *Philanoptera violaceae* *Diospyros mepiliformes* *Grewia vilosa* *Maclura africana* *Panicum maximum* *Pogonarthria squarrosa* *Urochloa mosambicensis* *Hyperthelia dissoluta* *Heteropogon contortus*	• Road crossing • Trampling and grazing around the edge of the dam footprint

Dry terrestrial-like upstream portion, with eroded channel

Dam footprint in drainage line

Nr.	Type	Location	Description
TB03	Ephemeral drainage	25°23'44.47 S 31°57'52.46 E	This drainage line does have good vegetation cover in its upstream portion. This is the only drainage line in which there is water, in the dam portion. The reason for this is that water is pumped from the Crocodile River (see photo), to provide drinking water for the game in the enclosed study area.

Dominant species:
Acacia robusta
A. nigrescens
Rhoicissus tridentata
Ziziphus mucronata
Diospyros mespiliformis
Maclura africana
Combretum imberbe
Euclea natalensis

Schoenoplectus sp.

Leersia hexandra
Brachiaria serrata
Cynodon dactylon
Setaria sphacelata
Tragus berteronianus

Impacts:
- Road crossings, upstream and downstream
- The dam and its footprint impact on the hydrology of the system
- Overgrazing and trampling occur along the edge of the dam footprint

Dry dam showing overgrazing and trampling

Upstream portion with good vegetation cover

Nr.	Type	Location	Description
TB04	Ephemeral drainage	25°24'16.10 S 31°58'15.41 E	The drainage line is small and is situated close to the footprint of the dam. Good vegetation cover exists adjacent to the dam.

Dominant species:
Strichnos madagascariensis
Diospyros mespiliformis
Dalbergia melanoxylon
Acacia nigrescens
A. robusta

Impacts:
- Road crossing
- Dam
- Overgrazing and trampling along the edge of the dam footprint

Panicum maximum
Digitaria eriantha
Melinis repens
Pogonarthria squarrosa
Hyperthelia dissoluta

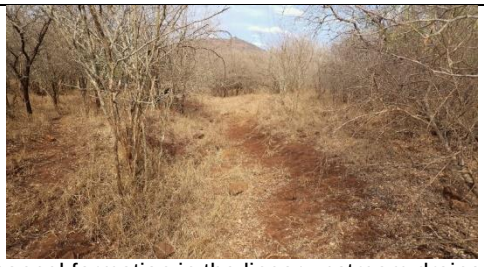
Dry dam basin with upstream drainage visible

Nr.	Type	Location	Description
TB05	Ephemeral drainage	25°24'28.55 S 31°58'03.41 E	This linear drainage line is narrow, with good vegetation cover, and water is conveyed in a controlled manner with little erosion visible. Impacts: • Road crossing • Dam • Overgrazing and trampling along the edge of the dam footprint • Surface erosion in the upstream portion (the result of flows during rain events)

Dominant species:
Euclea natalensis
Combretum imberbe
Dichrostachys cinerea
Grewia hexamita
Lippia javaqnica
Searsia pentheri

Panicum maximum
Cynodon dactylon
Digitaria eriantha
Aristida congesta
Heteropogon contortusw
Pogonarthia squarrosa

Dam at the lower end of drainage



Channel formation in the linear upstream drainage

Nr.	Type	Location	Description
TB06	Ephemeral Pan	25°24'33.20 S 31°57'34.36 E	An ephemeral pan feature was found with an indication of wetness. A dyke occurs which acts as a barrier resulting in the damming water in the upstream portion. Impacts: • Road crossing • Trampling and grazing

Dominant species
Urochloa mosambicensis
Cynodon dactylon

Pan feature, developed due to the rocky dyke formation damming up water in the upstream portion during the rainy season

5.2.2 Artificial Canal: TB07

Nr.	Type	Location	Description
TB07	Canal	25°24'44.50 S 31°57'31.22 E	An artificial canal has been constructed to provide water to two dams. The water is released from a water pump within the sugarcane cultivation area. Based on the vegetation setting, it appears that this canal is old and has been operating for many years. The vegetation, in and adjacent to the canal, comprises typical facultative riparian species. The canal is manually maintained, and in so doing the vegetation and soil surface is damaged. Although artificial, this feature hosts several interesting and diverse habitats.
Dominant species: *Acacia nigrescens* *Ziziphus mucronata* *Syzigium guineense* *Bridelia micrancha* *Phyllanthus reticulatus* *Phylenoptera violacea* *Peltiforum africanum* *Ficus sycomorus* *Diospyros mespiliformis* *Sida dregei* *Ischaemum polystachyum* *Hyperthelia dissoluta* *Panicum maximum* *Setaria sphacelata* *Phragmites mauritianus* *Indigofera tristoides*			

Vegetation cleared to make way for the artificial canal

Disturbed habitat due to the maintenance of the artificial canal

5.2.3 Site TB08 Riparian

SITE DESCRIPTION

This site is located at 25°24'49.99 S, 31°57'44.13 E. The riparian zone extends upstream from above the dam, and downstream, where it joins the Crocodile River (Figure 5-10 and Figure 5-11).

Dam in upstream portion of riparian area

Figure 5-10: View of Site TB08 Riparian Area

Figure 5-11: Google image of the delineated TB08 Riparian Area

Marginal zone (**Figure 5-12**)**:**
The presence of a dam, road crossings and channel undercutting has resulted in a somewhat disturbed environment. The dam contributes to the fact that a large portion of this zone is drowned and deprived of vegetation cover. The rest of the zone has sporadic cover and is dominated by woody species, with some grasses and sedges. The substrate consists of soil, with rocky features occurring in places. The dominant tree species are: *Diospyros mespiliformis, Ficus sycomorus, Maclura africanum*, *Kraussia floribunda, and Trichilia emetica.* Other species that occur in this zone: *Phragmites mauritianus, Cyperus sexangularis, Panicum maximum, Commelina bengalensis,* etc. Around the rim of the dam, *Typha capensis, Schoenoplectus sp., Leersia hexandra, Potamogeton schweinfurthii, Ludwigia adscendens*, etc. occurs. Exotic vegetation, such as *Melia azedarach, Lantana camara, Tagetes minuta*, etc. are also present.

Non-marginal zone (**Figure 5-12**)**:**
This zone has a steep gradient towards the marginal zone and is mostly covered by shrubs and trees. The substrate consists mainly of soil material with rocky habitat in places. The groundcover consists mainly of leaf litter and other moribund material. The following woody species occur: *Diospyros mespiliformis, Kraussia floribunda, Cordia africana, Afzelia quineensis, Bridelia micrantha, Acacia xanthophloea, Acacia nigrescens, Philenoptera*

violacea, Phyllanthus reticulatus, Ficus sycomorus, Maclura africanum, Euclea natalensis, Sclerocarya birrea subsp. *caffra, Grewia flavescens, Bridelia cathartica, Gymnosporia buxifolia, Dichrostachys cinerea* and *Gymnanthemum coloratum*, etc. Understory plants such as: *Vernonia colorata, 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 conditions for the components are 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 dam, 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. Without the dam, surface erosion and exotic vegetation, more indigenous species are expected. Better vegetation cover and abundance is expected. Species such as *Ficus sycomorus, F. sur, Acacia sieberiana, Maclura africanum, Gymnosporia buxifolia,* etc. could also occur in greater abundance.	2.5

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a C/D (61%). The main impacts are the road crossings, a dam that destroyed a large portion of the original riparian area, and the presence of exotic vegetation (Figure 5-13). Due to the influence of the dam, less alluvial material is released to the downstream areas which has resulted in the degradation of the riverbank, referred to as bed-armouring. The result of this can be seen in some bank collapse and under-cutting. The road crossing contributes to preferential flows which eventually contribute to the surface erosion in the non-marginal zone (Figure 5-13).

Dam in the upstream portion of the riparian area

Erosion in the riparian area

Road contributing towards preferential flows

Figure 5-13: Activities that contribute towards the degradation of the TB08 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

	PES	Conf.	Source	Cause	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	C/D	2.8	Increased flows	Increased base flow due to added water being conveyed via the artificial canal to the dam.	Non-Flow related NF	2.9
			Dam, habitat destruction	It was constructed in the macro channel.		
			Exotic invasion	*Melia azedarach, Lantana camara* and non-woody weeds such as *Verbena bonariensis*, *Tagetes minuta*, etc. No eradication programme in place.		
			Water quality	Water can be slightly enriched coming from the sugarcane cultivation, etc.		
			Road traversing area	Restricted hydrology and results in preferential flows	Flow related F	

	PES	Conf.	Source	Cause	F[1]/NF[2] Flow related Non-Flow related	Conf.
			Road traversing area	Surface erosion in non-marginal zone		
			Water quantity	Dam upstream.		

[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/D	Stable	C/D	The presence of the road crossings and the extent of the dam area will always have an impact on the habitat availability and integrity of this site. The presence of exotic vegetation species impacts on the vegetation composition, cover and abundance. If these impacts are not managed, their impact will stay 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 5-6). The EcoStatus EC is a C/D (61%).

Table 5-6: EcoStatus

RIPARIAN VEGETATION	EC %	Confidence
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	61.0	2.9
ECOSTATUS		C/D

5.2.4 Site TB9: Valley Bottom Wetland (Unchannelled)

Site Description

This site is located at 25°25'03.40 S, 31°57'31.93 E, close to the entrance of the property. The wetland extends up- and downstream of the dam, where it then joins the Crocodile River (Figure 5-14). The wetland is characterised by vegetation conducive to wet conditions. Facultative tree species occur in large numbers with the presence of obligate and facultative herbs, sedges and graminoids.

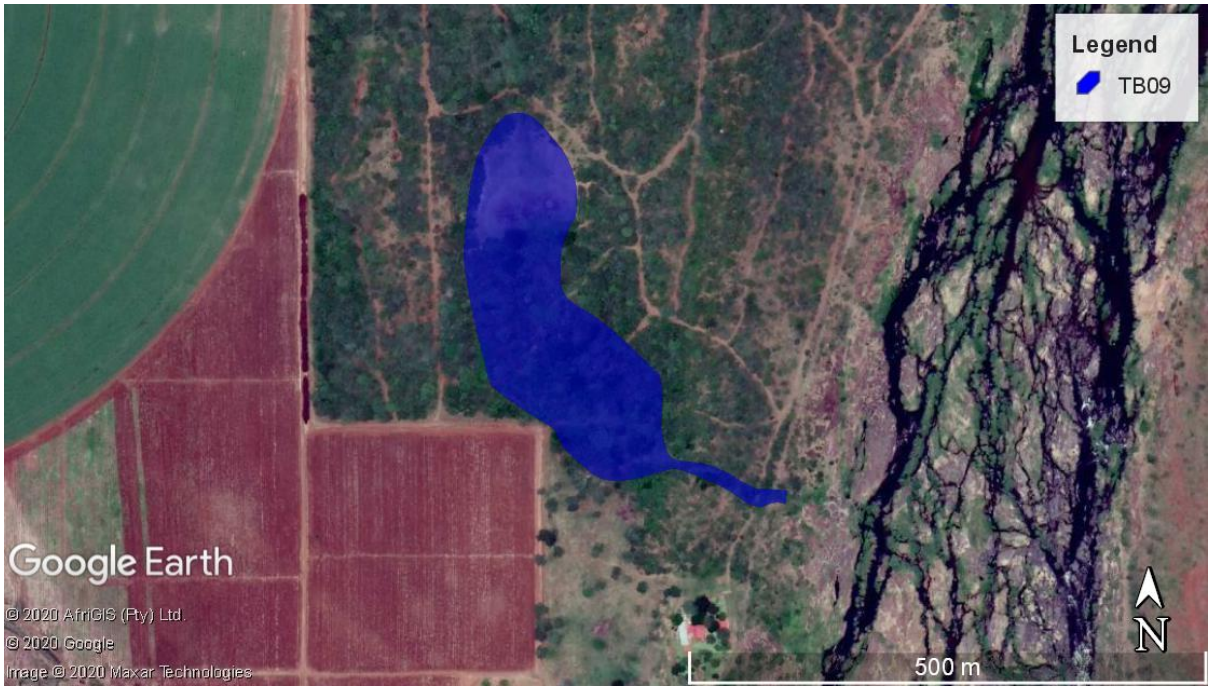


Figure 5-14: Google Earth image of wetland TB09

Figure 5-15: Visual indicating the wetland habitat dominated by woody species and lush vegetation

Impacts to the wetland's integrity

To determine the integrity and the condition of the site, the direct and indirect disturbances, etc. were taken into account. The following disturbances were observed in the wetland's catchment: sugarcane crops (31.2%) and management roads (10.6%). The untransformed area (58.2%) appears to be slightly overgrazed, although still in a reasonable condition (Figure 5-16).

Disturbances in the wetland include a dam (24%), road crossings (10.6%), and an artificial canal (0.5%). The untransformed wetland area (68.1%) is in good condition with lush vegetation cover, but some signs of trampling and grazing. Although, the dam is having a major impact on the wetland, the water that is leaking from the dam does contribute towards the wetness in the wetland and its associated lush vegetation. The dam itself has good vegetation cover along its edges with reeds, grasses, and sedges. The substrate consists of soil (high organic) with rocky features in places (Figure 5-17).

The dominant tree species are *Diospyros mespiliformis*, *Ficus sycomorus, Vachellia xanthophloea, Syzygium guineense, Maclura africanum, Cordia africanum, Kraussii floribunda, Cissus quadrangularis and Trichilia emetica.* The following herbs, grass and sedge species occur in this zone: *Gomphocarpus fruticosus, Phragmites* australis, *Typha capensis, Cyperus dives, Panicum maximum, Cyperus sexangularis*, etc. Exotic vegetation, such as *Chromolaena odorata*, *Melia azedarach, Arundo donax, Verbena bonariensis, Tagetes minuta, Ricinus communis, Lantana camara*, *Azolla filiculoides*, etc. are also present.

Panoramic view of the dam constructed in the wetland

Road crossing resulting in the destruction of wetland habitat

Canal in wetland resulting in preferential flows

The exotic red water fern (*Azolla filiculoides*)

Paraffin weed (*Chromolaena odorata*)

Figure 5-16: Activities in wetland areas that can be detrimental to wetland integrity

Figure 5-17: Map indicating the location of the different impacts in the wetland

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 Table 5-7 below. The hydrology of the wetland can be categorised as moderately modified (a "C" PES Category), where the change in ecological processes and loss of natural habitat have resulted in a moderate 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, although contributing towards an assorted range of wetland habitat.

The wetland's catchment is dominated by sugarcane crops (31.2%) and roads (10.6%). The natural hydrology is impacted by an increase in flows and a change in flood patterns. An artificial canal transfers water to two dams, of which this dam is one of them. The untransformed catchment area (58.2%) is in a reasonably good condition, although there are signs of overgrazing and trampling.

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	**3.8**
Changes to water input characteristics	**1.0**
Combined Hydrology Impact Score	**3.5**
PES Category	**C**

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 'moderately modified' class, as reflected by a "C" PES category.

Geomorphology

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

Assessment of impacts

Current impacts to the geomorphological integrity are limited to the dam and road crossings. Given these impacts, the current geomorphic integrity is considered to be moderately

changed, with a loss of natural habitat. The wetland is rated as having a “C” Category classification for Geomorphology.

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	0.0
4. Loss of organic matter	All non-floodplain HGMs with organic material	1.0
Combined Impact Score based on a sum of the three highest scores		**3.6**
PES Category		**C**

Vegetation

Due to changes in hydrology and flow patterns – as a result of the 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 ‘moderately modified’, and loss of wetland/natural habitat and biota has occurred. The disturbed wetland reflects a “C” Category. Further details of this assessment are provided below.

Table 5-9 summarises the impacts to the wetland vegetation disturbance units. The direct impacts to vegetation habitat include the dam and road crossings.

Table 5-9: Assessment of impact on wetland vegetation

No.	Disturbance Class	Extent (%)	Intensity (0 - 10)	Magnitude of impact
1	Dam	24	8	1.9
2	Artificial canal	0.5	2	0.01
3	Roads	7.4	4	0.3
5	Untransformed area	68.1	2	1.4
			Overall weighted impact score	**3.6**
			PES Category	**C**

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, and the presence of road crossings; this has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having a “C” Category (Table 5-10). There has been a change in ecosystem processes and a loss of natural habitat and biota has occurred, but the natural habitat features remain predominantly intact.

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
VB	4	3.5	0	3.6	0	3.6	0
PES Categories		**C**	→	**C**	→	**C**	→
Wetland Impact Score		**3.54**					
Wetland PES		**C**					

Ecosystem Services supplied by the wetland

This unchannelled valley bottom wetland is connected to the Crocodile River. Its ecosystem services (both natural and human) are reflected in the radar chart below (Figure 5-18).

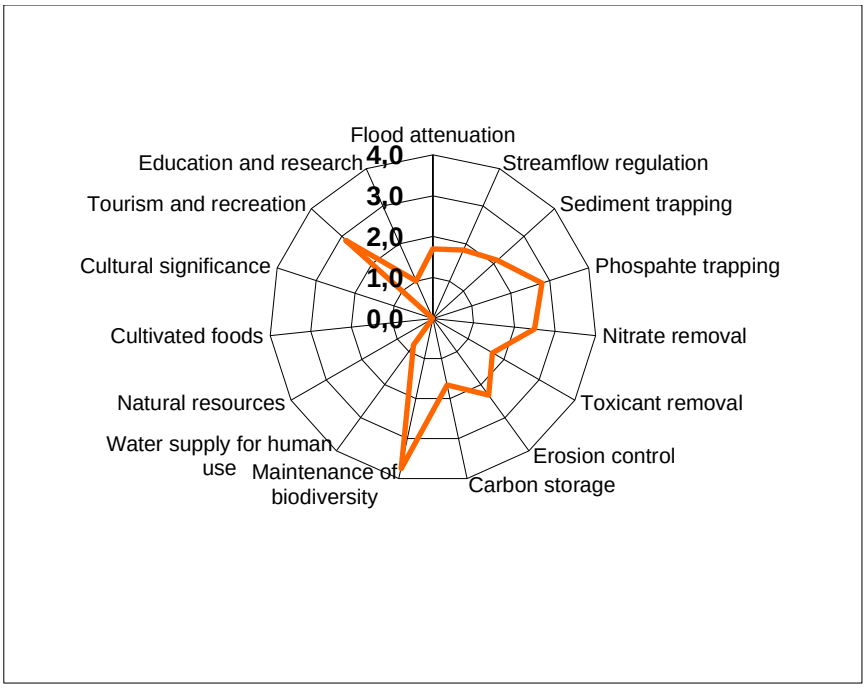


Figure 5-18: Wetland Eco-Services results

Natural Services

The wetland achieved a moderate total (Table 5-11) within a disturbed environment, indicating that the wetland has lost some habitat. The score of 15.4 reflects that the wetland is 'moderately modified'.

The wetland's catchment has been affected by agricultural activities–sugarcane crops and cultivation – an artificial water canal providing water to the dam, road crossings, and 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 phosphate and nitrate trapping, is an essential function. The maintenance of biodiversity is another of its important services.

Table 5-11: Natural services results of wetland		
Ecosystem Services	**Score**	**Conf.**
Flood attenuation	1,7	3,3
Streamflow regulation	1,8	4,0
Sediment trapping	2,1	3,6
Phosphate trapping	2,8	3,8
Nitrate removal	2,5	4,0
Toxicant removal	1,7	3,8
Erosion control	2,3	3,4
Carbon storage	1,7	4,0
Maintenance of biodiversity	3,8	3,8
Total	20.4	
Class	Moderate	

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). The unique swamp forest habitat provides plenty of opportunity for birdwatching, fishing and hiking. Tourism and recreation have the potential to be an important service. 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	2,9	4,0
Education and research	1,0	3,8
Total	4.7	
Score	Very Low	

5.2.5 Site TB10: Unchannelled Valley Bottom Wetland

Site Description

This site is located at 25°25’16.35 S, 31°57’31.93 E. The wetland extends upstream of the earthern dam, to where it flows into the Crocodile River (Figure 5-19). The wetland is characterised by vegetation conducive to wet conditions. Facultative tree species occur in large numbers, and obligate and facultative herbs, sedges and graminoids are present (Figure 5-20).

Figure 5-19: Google Earth image of wetland TB10

Figure 5-20: Image of the habitat reflecting wet conditions with hydrophytic vegetation

Impacts to wetland's integrity

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 within the wetland's catchment were observed: sugarcane crops (34.7%), road crossings (9.6%), dwelling (2.4%), dumping (0.03%), etc. The untransformed area comprises 53.27% of the catchment and is in a reasonable condition (some mowing occurs, bush encroachment, etc.).

The following impacts occur within the wetland: a dam (5%), and road and footpath crossings (14%). The untransformed area makes up 81% of the wetland, and its condition is hindered by the presence of exotic and terrestrial species (Figure 5-16). The substrate consists of soil with rocky features in places.

The dominant tree species are *Ficus sycomorus, Syzygium guineense, Trichilia emetica, Diospyros mespiliformis*, *Vachellia xanthophloea, Syzygium guineense, Maclura africanum, Cordia africanum, Kraussii floribunda, Cissus quadrangularis,* etc. 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, Passiflora suberosa, Verbena bonariensis, Tagetes minuta, Convolvulus farinosus, Ricinus communis, Datura strumarium, Lantana camara*, etc. are also present.

Road crossing wetland area

Exotic vegetation (*Convolvulus farinosus*)

Dam and water effluent point into the wetland

Footpath and fence crossing, note exotic vegetation

Figure 5-21: Activities in wetland areas that can be detrimental to wetland integrity

Figure 5-22: Google Earth image indicating the position of the impacts

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 Table 5-13. The hydrology of the wetland can be categorised as 'moderately modified' (a "C" PES Category), where a moderate change in ecological processes and loss of natural habitat has taken place, but the natural habitat remains predominantly intact. The wetland's catchment is dominated by sugarcane crops, with road crossings and a dwelling, resulting in an increase in peak flows due to a decrease in the roughness of the vegetation and hardening of surfaces.

Table 5-13: 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	**3.5**
Changes to water input characteristics	**1.0**
Combined Hydrology Impact Score	**3.5**
PES Category	**C**

Geomorphology

The level of impacts and threats to the geomorphological integrity of the wetland are presented below.

Assessment of impacts

Current impacts on geomorphological integrity are limited to the landscaping of developed areas within the wetland and an increase in water runoff (pipe releasing water in the wetland). Given the impacts, the current geomorphic integrity is considered to be moderately changed, with the natural habitat remaining predominantly intact. The wetland is rated as having a "C" Category classification for Geomorphology. Impacts such as the dam and the road and foot/fence crossing contribute towards the degradation of geomorphological integrity.

Table 5-14: 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	0.8
Indicator-based component		
2. Erosion features	All non-floodplain HGMs	0.0

Impact type	Applicability to HGM type	Magnitude of impact
3. Depositional features	All non-floodplain HGMs	1.5
4. Loss of organic matter	All non-floodplain HGMs with organic material	0.0
Combined Impact Score based on a sum of the three highest scores		**2.3**
PES Category		**C**

Vegetation

Due to changes in hydrology and flow patterns – as a result of the roads, dam, extensive exotic infestation and terrestrialisation – 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 to wetland vegetation disturbance units.

Table 5-15: Assessment of impact on wetland vegetation

No.	Disturbance Class	Extent (%)	Intensity (0 - 10)	Magnitude of impact
1	Dam	5	8	0.4
2	Road crossing	14	7	0.98
3	Untransformed area	81	6	4.05
			Overall weighted impact score	**5.4**
			PES Category	**D**

Summary

The wetland's catchment has been altered by agricultural activities, and the wetland itself has been transformed due to the dam, road crossings, exotic vegetation; which has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having a "C" Category (Table 5-16). There have been changes to the ecosystem processes and a loss of natural habitat has occurred, but some natural wetland habitat remains predominantly intact.

Table 5-16: 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
Valley Bottom	1	3.5	0	2.3	0	5.4	-1
PES Categories		**C**	→	**C**	→	**D**	↓
Wetland Impact Score		**3.71**					
Wetland PES		**C**					

Ecosystem Services supplied by the wetland

This valley bottom wetland is connected to the Crocodile River. Its ecosystem services (both natural and human) are reflected in the radar chart below (Figure 5-23).

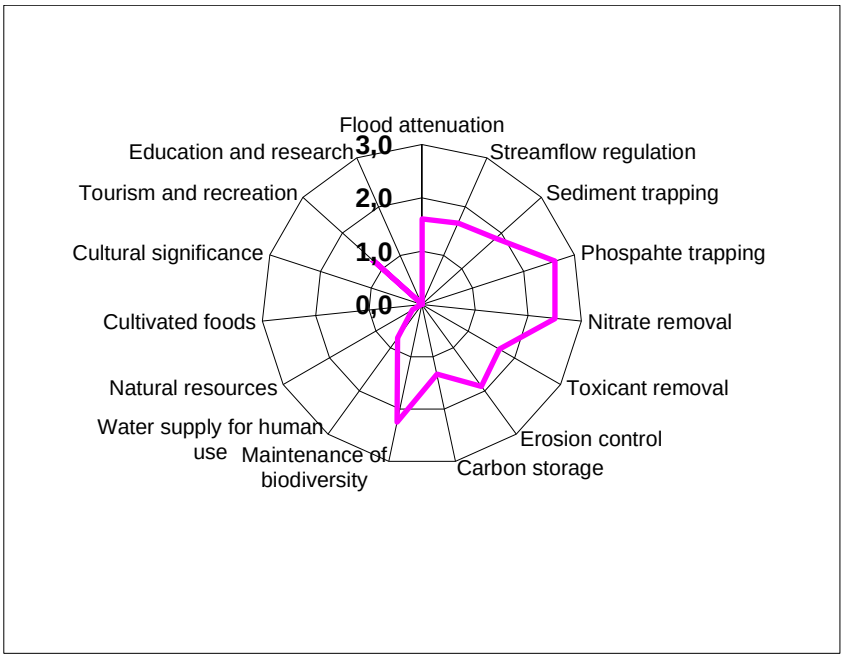


Figure 5-23: Wetland Eco-Services results

Natural Services

The wetland achieved a low total (Table 5-17) within a disturbed environment, indicating that the wetland has lost various functions. The score of 17.4 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 road crossings. The wetland is impacted by a small dam, road crossings and the presence of exotic vegetation, etc. This affects the wetland's ability to perform certain natural services. Although the wetland rates 'low', it has services that are essential, such as phosphate and nitrate trapping and erosion control which contribute towards improved water quality. Its biodiversity service is also important due to the swamp forest tree-dominated area.

Table 5-17: Natural services results of wetland

Ecosystem Services	Score	Conf.
Flood attenuation	1,6	2,9
Streamflow regulation	1,7	3,8
Sediment trapping	1,9	2,7
Phosphate trapping	2,6	3,5
Nitrate removal	2,5	3,5
Toxicant removal	1,7	3,0
Erosion control	1,9	3,0
Carbon storage	1,3	3,3
Maintenance of biodiversity	2,3	3,4
Total	17.4	
Score	Low	

Human Services

The wetland does not contribute significantly towards human services, as indicated by the score, which shows that these services are very low (Table 5-18). People rarely rely on this wetland and rarely benefit directly from it. The tourism and recreation service came out high due to the fact that the site is close to a major tourism route and does have birding opportunities.

Table 5-18: Human services results for wetland

Ecosystem Services	Score	Conf.
Water supply for human use	0,8	3,5
Natural resources	0,2	3,8
Cultivated foods	0,0	4,0
Cultural significance	0,0	3,0
Tourism and recreation	1,3	3,8
Education and research	0,0	3,5
Total	2.3	
Score	Very Low	

5.2.6 Site TB11: Valley Bottom Wetland

Site Description

This site is located at 25°25'24.07 S, 31°57'29.20 E. The wetland extends upstream from the road and downstream to the third road crossing, close to the Komatipoort municipal area (Figure 5-24**)**. This wetland reflects many characteristics of a swamp forest. A swamp forest is a wetland ecosystem characterised by mineral soils with poor drainage, and tree-dominated vegetation (Figure 5-25).

Figure 5-24: Google Earth image of wetland TB11

Figure 5-25: Visuals of the typical wetland habitat found in a swamp forest

The substrate consists of wetland soils with hydric characteristics. No detailed soil classifications were completed. This is, however, not the primary determinant for it being a wetland or not.

Baseline soil information was used to confirm wetland and terrestrial properties within the wetland. The soils in the wetland showed signs of wetness within 50 cm of the surface and displayed typical hydromorphic characteristics varying between temporarily, seasonally and permanently wet profiles. The permanently wet soils varied from a dark, highly organic soil to that of a grey colour. In some areas gleyed soils occurred as a result of prolonged saturation with water; the grey colour is due to the absence of iron compounds. Seasonally wet soils display mottling due to localisation of iron oxides. The soils outside the wetland area are typical terrestrial soils with a uniform red colour, indicating good aeration (Figure 5-26).

Terrestrial soil

Hydric wetland soil

Figure 5-26: Photos indicating the different hydric features of the soil found in the wetland

The dominant tree species are *Vachellia xanthophloea, Ficus sycomorus* and *Trichilia emetica.* The following species also occur in this zone: *Phragmites* australis, *Typha capensis, Cyperus dives, Cyperus sexangularis*, *Phyllanthus reticulatus, Rauvolfia caffra, Indigofera* spp. etc. Exotic vegetation, such as *Syzygium cumini, Schefflera arboricola, Melia azedarach, Psidium guava, Arundo donax, Colocasia esculenta, Verbena bonariensis, Passiflora subpeltata, Withania somnifera, Tagetes minuta, Ricinus communis, Lantana camara*, etc. are also present.

Impacts to wetland's integrity

To determine the integrity of the wetland, and the condition of the site, the direct and indirect disturbances, etc. were taken into account. The primary disturbance in the catchment is sugarcane crops comprising 93% of the surface area. The wetland has been altered by road crossings (11%) and an artificial canal (0.1%). The untransformed area (88.9%) is dominated by trees and shrubs, with scattered clumps of grass and sedges. The wetland has good forest cover with little sign of erosion.

One of two roads traversing wetland habitat

Wood cutting

Dumped garden refuse

Artificial canal in wetland habitat

Extensive exotic vegetation (*Passiflora subpeltata*)

Figure 5-27: Activities in wetland areas that can be detrimental to wetland integrity

Figure 5-28: Google Earth map indicating the location of impacts

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 Table 5-19**Table 5-7** below. The hydrology of the wetland can be categorised as 'largely modified' (a "D" PES Category), where a large change in the hydrological processes has taken place. From the assessment, it is clear that the catchment is extensively modified by sugarcane agriculture, having a significant impact on the water input characteristics. The artificial canal, road crossings and exotic vegetation also contribute to an altered hydrology.

Table 5-19: 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	**2.9**
Changes to Water Input characteristics	**2.0**
Combined Hydrology Impact Score	**4.0**
PES Category	**D**

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 'largely modified' class, as reflected by a "D" PES category.

Geomorphology

The level of impacts and threats to the geomorphological integrity of the wetland are presented in Table 5-20 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 "C" Category classification for Geomorphology. Impacts such as the road crossings and the increased runoff from the upstream sugarcane and artificial canal contribute towards the degradation of geomorphological integrity.

Table 5-20: 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	3.0
Indicator-based component		
2. Erosion features	All non-floodplain HGMs	0.0
3. Depositional features	All non-floodplain HGMs	0.9
4. Loss of organic matter	All non-floodplain HGMs with organic material	0.0
Combined Impact Score based on a sum of the three highest scores		**3.9**
PES Category		**C**

Vegetation

Due to changes in hydrology and flow patterns – as a result of the road crossings, sugarcane crops and cultivation in the catchment – and the construction of an artificial canal, indications are that directional changes in wetland vegetation have occurred. The current state of vegetation is regarded as 'moderately modified', and loss of wetland/natural habitat and biota has occurred, but the natural habitat remains predominantly intact. The disturbed wetland reflects a "C" Category. Further details of this assessment are provided below.

Table 5-21 summarises the impacts to wetland vegetation disturbance units. The direct effects on vegetation habitat include invasive exotic vegetation, road crossings, artificial canal, R570 road crossing, hardening of surfaces, etc.

Table 5-21: Assessment of impact on wetland vegetation

No.	Disturbance Class	Extent (%)	Intensity (0 - 10)	Magnitude of impact
1	Artificial canal	0.1	8	0.01
2	Road crossings	11	5	0.55
3	Untransformed area	88.9	2	1.78
Overall weighted impact score				**2.3**
PES Category				**C**

Summary

The wetland's catchment has been altered by agricultural activities, and the wetland itself has been transformed due to road crossings, exotic vegetation, and an artificial canal; which has resulted in changes to the three components of wetland health assessed. The wetland can, therefore, be currently described as having a "C" Category (Table 5-22). The change in ecosystem processes and loss of natural habitat and biota is moderate, with the natural habitat remaining predominantly intact.

Table 5-22: 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	2	4.0	0	3.9	0	2.3	0
PES Categories		**D**	→	**C**	→	**C**	→
Wetland Impact Score		**3.5**					
Wetland PES		**C**					

Ecosystem Services supplied by the wetland

This valley bottom wetland, with a channel, is connected to a watercourse, the Crocodile River. Its ecosystem services (both natural and human) are reflected in the radar chart below (Figure 5-29).

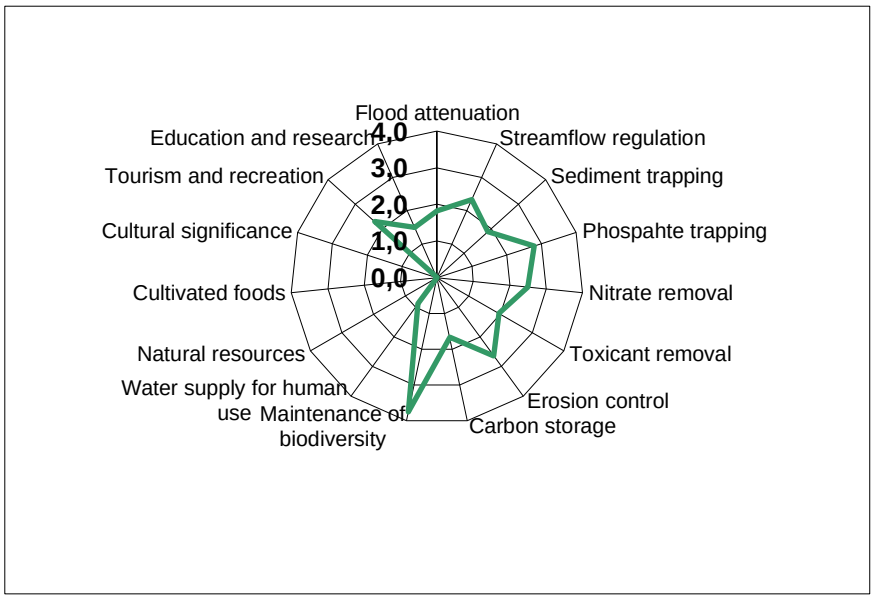


Figure 5-29: Wetland Eco-Services results

Natural Services

The wetland achieved a moderate total (Table 5-23) with some loss of natural habitat. The score of 21.3 reflects that the wetland is 'moderately modified'.

The wetland's catchment has been severely affected by sugarcane crops and cultivation. Road crossings, an artificial canal and the presence of exotic and terrestrial vegetation contribute to a moderate score. This affects the wetland's ability to perform certain natural services. Services that stand out and add value to the wetland's presence are streamflow regulation, phosphate trapping and nitrate removal, which all contribute towards improved water quality. The swamp forest provides a variety of habitat for high biodiversity, thus adding to the wetland's uniqueness.

Table 5-23: Natural services results of wetland

Ecosystem Services	Score	Conf.
Flood attenuation	1,8	3,7
Streamflow regulation	2,3	4,0
Sediment trapping	1,9	2,5
Phosphate trapping	2,8	3,5
Nitrate removal	2,5	4,0
Toxicant removal	2,0	3,0
Erosion control	2,6	3,4
Carbon storage	1,7	4,0
Maintenance of biodiversity	3,8	3,6
Total	21.3	
Score	Moderate	

Human Services

The wetland does not contribute significantly towards human services, as indicated by the score, which shows that these services are low (Table 5-24). Tourism and recreation came

out reasonably high due to the swamp forest habitat providing an opportunity for birding and the fact that the wetland is adjacent to the town of Komatipoort.

Table 5-24: Human services results for wetland		
Ecosystem Services	**Score**	**Conf.**
Water supply for human use	0,9	3,7
Natural resources	0,0	4,0
Cultivated foods	0,0	4,0
Cultural significance	0,0	4,0
Tourism and recreation	2,3	4,0
Education and research	1,5	3,0
Total	4.7	
Score	Low	

5.2.7 Site TB12 Riparian (Crocodile River)

Site Description

The Crocodile River site is located at 25°23'59.36" S, 31°58'31.48" E. A panoramic view of the study area can be seen in Figure 5-30. Figure 5-31 is a Google aerial photo indicating the extent of this riparian zone.

Figure 5-30: Panoramic view of the riparian area TB12

Figure 5-31: Google image of the delineated riparian zone, TB12, in the study area

Marginal zone: (Figure 5-32)
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, Leersia hexandra, 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 *Flaveria bidentis, Ricinus communis, Centella asiatica, Sesbania bispinosa, Sesbania punicea*, etc. are also present.

Non-marginal zone: (Figure 5-32)
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 and browsing. It appears that the woody species are trying to recover after past flood events. The substrate consists mainly of alluvial material and rocky dykes crossing the riverine area. The following woody species are dominant: *Euclea natalensis, 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 *Senna didymobotrya, Conyza bonariensis, Melia azedarach, Solanum mauritianum, Lantana camara, Parthenium hysterophorus, Sesbania punicea*, etc. were also found.

View of the marginal zone

View of the non-marginal zone

Figure 5-32: Photos of selected VEGRAI site

REFERENCE CONDITIONS

The reference conditions for the components are summarised in Table 5-25.

Table 5-25: Reference conditions

Component	Reference conditions	Conf
Riparian vegetation	**Marginal zone:** Grasses and sedge dominate, with pockets of reeds. Little to no woody species are 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 is expected. **Non-marginal zone:** It is expected that grass would dominate, with scattered trees and shrubs, in this zone. Species such as *Ficus sycomorus, F. sur, Trichilia emetica, Nuxia oppositifolia, Ziziphus mucronata, Diospyros mespiliformis, Gymnosporia senegalensis,* etc. could occur in greater abundance. 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 resulting in a denser riparian vegetation habitat.	3

PRESENT ECOLOGICAL STATE

Riparian vegetation

The Riparian Index of Habitat Integrity (RIHI) is a C (62.3%), with the main impacts being flooding events, grazing and trampling (stunted trees and shrubs), and the presence of exotic species (Figure 5-33).

The exotic *Eichhornia crassipes* (Water hyacinth)

Grazing and trampling

Figure 5-33: 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 5-26.

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 5-26: Causes and sources

	PES	Conf.	Sources	Causes	F[1]/NF[2] Flow related Non-Flow related	Conf.
Rip. Veg.	C	2.9	Infrastructure	Disturbance to the riparian footprint	Non-Flow related NF	2.9
			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		

	PES	Conf.	Sources	Causes	F[1]/NF[2] Flow related Non-Flow related	Conf.
			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 5-27.

Table 5-27: Trend

	PES	Trend	Trend PES	Reasons	Conf.
Rip. Veg.	C	Stable	C	Grazing and trampling, flood events, etc. will always have an impact on the habitat availability and integrity of this site. The presence of exotic vegetation species will not change if no management plan is implemented to eradicate these alien species. This continues to have an impact on vegetation composition, cover, and abundance. It is unlikely that these impacts will improve and therefore, the current situation should 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 5-28). The EcoStatus EC is a C (62.3%).

Table 5-28: EcoStatus

RIPARIAN VEGETATION	EC %	Confidence
RIPARIAN VEGETATION ECOLOGICAL CATEGORY	62.3	2.9
ECOSTATUS		C

5.3 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.

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 and associated water channels, town development footprint, roads, bush clearing, sugarcane lands, 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 20-30m 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 (T01-04) 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 5-34 (Macfarlane *et al.,* 2014). For the wetland buffer, the starting point is from the edge of the wetland.

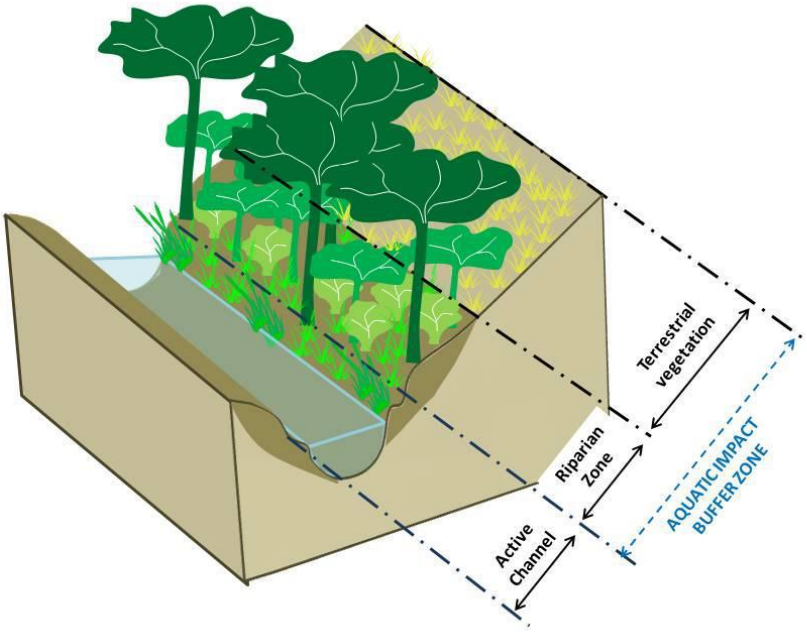


Figure 5-34: Schematic diagram indicating the boundary of the active channel and riparian habitat, and the areas potentially included in an aquatic impact buffer zone.

Due to the buffer zone's position adjacent to water bodies, riparian buffer zones 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 cases, 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). A 15m buffer is proposed for the ephemeral systems to provide an opportunity for the systems to accommodate surface water flowing from its catchment basin. However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers and wetlands, the following buffer widths for the denominated riparian zones and wetlands are proposed as follows (Figure 5-35, Figure 5-36 and Figure 5-37):

- TB01-07 (Ephemeral): 15 m
- TB08 (Riparian): 35 m
- TB09 (Wetland): 20 m
- TB10 (Wetland): 20 m
- TB11 (Wetland): 20 m
- TB12 (Riparian): 60 m

Figure 5-35: Delineation of the TB08 aquatic requirement, and the setback requirement as the buffer edge

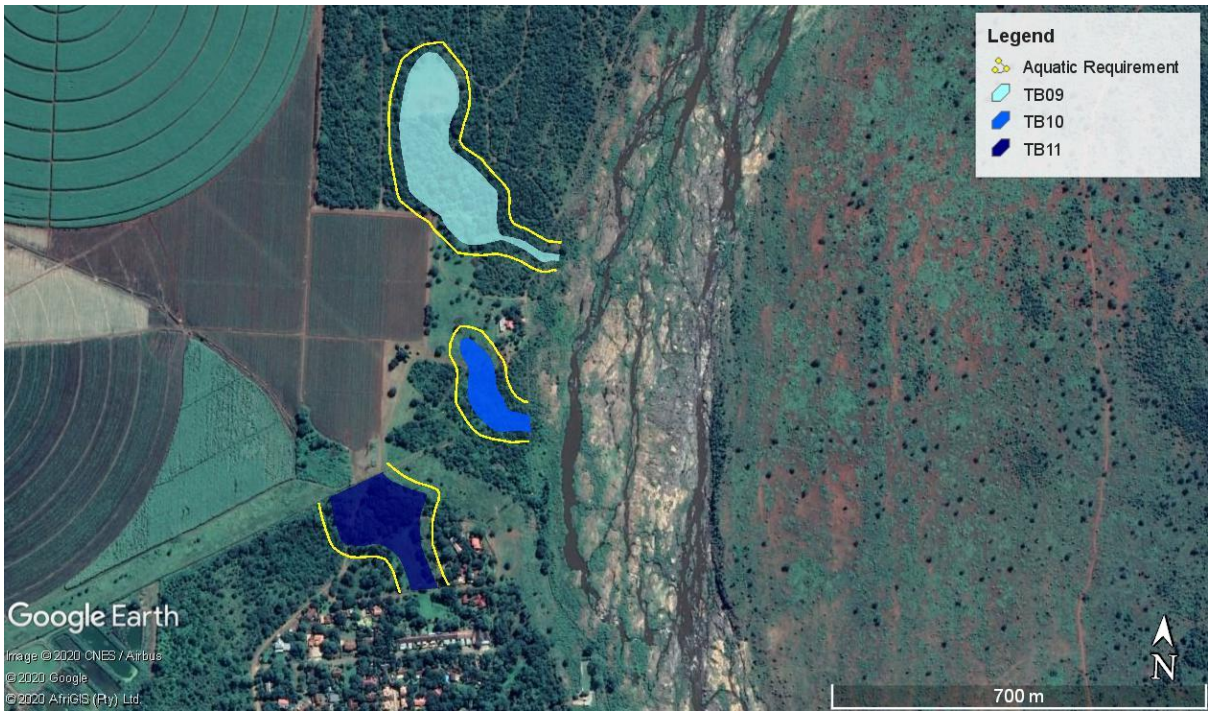


Figure 5-36: Delineation of the Wetlands TB09, TB10 and TB11 and the recommended aquatic buffer

Figure 5-37: Delineation of the TB12-Riparian site's riparian zone and the aquatic requirement as the buffer edge

6 Impact assessment and Mitigation

Any development in a natural system will impact 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 river and/or wetland's 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.

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 for the presence of threatened or protected species is thus limited. Therefor, 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 riparian and wetland areas that host certain wetland services.

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

- Change in hydrology characteristics,
- Destruction of riparian and/or wetland areas that leads to habitat (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 and wetland habitat downstream
- Change in water quality

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

- Run-off water into the riparian and/or wetland must be controlled by making use of energy dissipaters
- Remove all dumped and refuse material from the riparian and/or wetland area
- Remove invasive alien vegetation to establish and recreate riparian and/or wetland 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 wetlands and riparian habitat, care should be taken to construct adequate numbers of large culverts to accommodate the natural hydrology of the system. However, culverts and/or stormwater pipes can initiate erosion capable of destroying wetland and 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 phases. These willimpact 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 water resource:

- Dust generation and transportation due to the clearing of vegetation before construction, the construction phase, and the decommission and closure phases, 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 water resource 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.

Cumulative impacts from existing surrounding activities, as well as the proposed development project, leads 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 along the edge of a riparian and/or wetland area, 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 destabilisation, 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 impacts 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 ecosystems 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 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 minimise 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 stormwater run-off from the road surfaces. This can lead to erosion and channel incision, and changes to 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 and/or wetland 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. This would 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 and/or wetland areas;
- Create the recommended buffer around riparian areas (likely, a buffer of <20m may adequately fulfil 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);
- Minimise the removal/damage to vegetation in riparian and/or wetland areas;
- The construction of pathways (disturbance zones) in or adjacent to the riparian and/or wetland areas is to be closely managed and strictly controlled to minimise damage to riparian and/or wetland areas;
- Operation and storage of equipment in the riparian and/or wetland areas to be prevented;
- If the riparian and/or wetland areas are disturbed during construction it should be re-vegetated using site-appropriate indigenous vegetation and/or seed mixes;
- Alien vegetation should not be allowed to colonise the disturbed riparian and/or wetland areas;
- Rehabilitation of disturbed riparian and/or wetland areas habitat should commence immediately after construction is completed;
- No construction camps should be allowed in or within 20m of riparian and/or wetland areas;
- No stockpile areas should be located in or within 20m of riparian and/or wetland areas;

- Construction should preferably take place during the low flow/winter months in order to minimise the risk of sediment and debris being washed into riparian and/or wetland areas;
- Stockpiling of soil and of supplies for the construction camps must take place well away (at least 20m where possible) from the edge of riparian and/or wetland areas to prevent soil being washed into its habitat;
- During the construction and operational phases, erosion and siltation measures should be implemented (e.g., the use of temporary silt traps downstream of construction areas);
- Slope/bank stabilisation measures should be implemented, where necessary, to prevent erosion during the operational phase;
- Debris and sediment trapping, as well as energy dissipation control structures, should be put in place where stormwater may enter riparian and/or wetland 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

The perennial Crocodile River forms the northern and eastern border of the study area. In this area, the Crocodile River has a riparian PES of 'C.' According to the MBSP freshwater assessment, the study area falls within an ESA Important Sub-catchment as it is a Fish Support Area (FSA), as per NFEPA. This particular FSA supports the Tiger Fish (*Hydrocynus vittatus*), a fish species of conservation concern. According to the MBSP freshwater assessment, the study area is associated with one ESA wetland area and also includes two dams. The National Wetland Map 5 shows this ESA wetland area to be a riverine/ floodplain wetland (associated with the Crocodile River).

Water resources, such as wetland areas with swamp forest characteristics, and the riparian of the Crocodile River were identified. It should be noted that several ephemeral drainage lines were also identified. In total, seven ephemeral drainage lines, two riparian zones and three palustrine wetlands were identified.

Site TB08 Riparian Index of Habitat Integrity (RIHI) is a C/D (61%). The major impacts include the increased flows (artificial canal feeding water to the dam), dam, road traversing riparian and the presence of exotic vegetation.

Site TB09 is a valley bottom wetland with no channel. The following disturbances in the catchment were observed: sugarcane crops (31.2%) and management roads (10.6%). The untransformed area (58.2%) appears to be slightly overgrazed, although in a reasonable condition. Disturbances in the wetland include a dam (24%), road crossings (10.6%), and an artificial canal (0.5%). The untransformed portion of the wetland (68.1%) is in a reasonably good condition. The wetland can, therefore, be currently described as having a "C" PES Category. The wetland's ecosystem services do reflect some value in contributing to improved water quality in the form of phosphate and nitrate trapping, an important function. The maintenance of biodiversity is another of its important services. The wetland does not contribute significantly towards human services. The unique swamp forest habitat provides plenty of opportunity for birdwatching, fishing and hiking. Tourism and recreation present a potential service.

Site TB10 is a valley bottom wetland with no channel. The following disturbances within the wetland's catchment were observed: sugarcane crops (34.7%), road crossings (9.6%), a dwelling (2.4%), dumping (0.03%), etc. The untransformed area comprises 53.27% of the catchment and is in a reasonable condition. Impacts in the wetland include: a dam (5%) and road and footpath crossing (14%). The untransformed area comprises 81% of the wetland and its condition is hampered by the presence of exotic and terrestrial species. . The wetland can, therefore, be currently described as having a "C" Category. Wet ecosystem services consist of phosphate and nitrate trapping and erosion control which contribute towards improved water quality. Its biodiversity service is also important due to the swamp forest habitat. People rarely rely on this wetland and rarely benefit directly from it. The tourism and recreation service ranked highly due to the site being close to a major tourism route with the potential of birding opportunities.

Site TB11 is a valley bottom wetland with a channel. The major disturbance within the catchment is sugarcane crops, covering about 93% of the surface area. The wetland has been altered by road crossings (11%) and an artificial canal (0.1%). The untransformed area (88.9%) is dominated by trees and shrubs with scattered clumps of grass and sedges. The wetland has good forest cover with few signs of erosion. The wetland can, therefore, be currently described as having a "C" PES Category. The wetland's ecosystem services add value in terms of streamflow regulation, phosphate trapping and nitrate removal, and all contribute towards improved water quality. The swamp forest provides various habitats,

increasing the biodiversity, and adding to the wetland's uniqueness. Tourism and recreation ranked reasonably high due to the swamp forest habitat providing an opportunity for birding, and the fact that the wetland is in close proximity to the town of Komatipoort.

Site Tb12 (Crocodile River) Riparian Index of Habitat Integrity (RIHI) is a C (62.3%), with the main impacts being flood events, extensive grazing and trampling (stunted trees and shrubs) and the presence of exotic species.

A buffer width of 30m is recommended by the Mpumalanga Tourism and Parks Agency (2006) and a 100m buffer according to the MBSP (2014). A 15m buffer is proposed for the ephemeral systems to provide an opportunity for the systems to accommodate surface water flowing from its catchment basin. However, according to the Preliminary guidelines for the Determination of Buffer Zones for rivers, the following buffer widths for the denominated riparian zones and wetlands are as follows.

- TB01-06 & 07 (Ephemeral and canal): 15 m
- TB08 (Riparian): 35 m
- TB09 (Wetland): 30 m
- TB10 (Wetland): 30 m
- TB11 (Wetland): 30 m
- TB12 (Riparian): 60 m

The proposed development could increase hardened surfaces and subsequent stormwater runoff. Any hardening of surfaces will reduce the infiltration and ultimately reduce the yield of the seep zones that feed into the greater riparian area's 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 the 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 severe 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.

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