



Proposed Shangoni Gate and associated Infrastructure, Kruger National Park, Limpopo Province

Wetland and Riparian Delineation & Functional Assessment
June 2016

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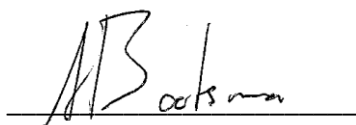
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2016.06.15

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Ecologist/Botanist

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EXECUTIVE SUMMARY

Envirovolution Consulting is facilitating the environmental authorization process for the proposed new Kruger National Park Shangoni Gate and associated infrastructure including a high water bridge, a reception / education building, a picnic site, a tented camp, a camping terrain, and a 50km road upgrade to connect the access gate with the H1-6 Road between Shingwedzi and Mopane Rest Camps

Limosella Consulting was appointed by Envirovolution Consulting to undertake the wetland and riparian delineation and functional assessment potentially affected by the proposed development. Fieldwork was conducted between the 18th and 21st of April 2016.

The proposed development falls within the Shingwedzi/Gyiani district in the Limpopo Province. The project comprises a new entrance gate, a high-water bridge over the Shingwedzi River, a new reception centre with education facilities, a picnic site, a camp site, a tented camp and a ca. 50 kilometer black-topped road routed parallel to the Shingwedzi River which connects with the H1-6 Road linking Shingwedzi and Mopane Rest camps. The new road will be an upgrade of a suitable portion of the gravelled S52 route to Bataleur camp and the graded Shangoni Ranger patrol track. To the east the upgraded road will again cross the Shingwedzi River as well as the Tshanga tributary across low water bridges. Most of the distance the upgraded road will be parallel to the Shingwedzi River and within the riparian area or the buffer area in numerous areas. Most of the the road will be north of the Shingwedzi River, and the section between the Shingwedzi Low Water bridge and the H1-6 will traverse through mopane veld south of the river. A short alignment has to be constructed to connect the western terminal end of the Shangoni Ranger patrol road with the reception centre. The upgraded road will be six meters wide with a one meter shoulder on each side.

The main watercourse likely to be affected by the proposed activities is the Shingwedzi River. This river is classified as a non-perennial river, ephemeral in nature. Non-perennial ephemeral rivers are defined as rivers that have no active water flow for between 3 – 6 months in a year. A large number of smaller non-perennial rivers are also likely to be impacted by the proposed activities. The majority of these smaller rivers are also classified as non-perennial rivers although they are more likely to be episodic in nature. Episodic rivers are defined as rivers without active water flow for 9 months of the year or more. Both Ephemeral Rivers and Episodic Rivers are further characterised by high variability and high unpredictability as is evident in the occasional flooding of the Shingwedzi River.



In the absence of dedicated hydrological, groundwater and geohydrological assessments, the current assessment finds that a minimum buffer of 100 m from the edge of the ephemeral river boundaries and a 50 m from the edge of the episodic river boundaries should be respected.

To minimise the expected potential impacts, site specific mitigation measures should be included in an Environmental Management Plan. Some important points are highlighted below:

- Lodges and other permanent structures should not be constructed on or near the river banks. Development should be confined to tented camps on timber platforms with inter-leading boardwalks
- Cognizance should be taken of recent flood impacts – not merely the flood levels but also silts deposits, scouring, vegetation damage, etc.
- Trails and other public access along the banks should be on boardwalks.
- Bridges should be designed in consultation with specialist river basin hydrologists.
- The development of the gate could be used to initiate opportunities for community education on water and river use.

The DWS 2014 risk assessment scores put the proposed development impacts into a **Medium** category for which authorization through a Water Use Licence application process may be required.



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1 INTRODUCTION

Envirovolution Consulting is facilitating the environmental authorization process for the proposed new Kruger National Park Shangoni Gate and associated infrastructure including a high water bridge, a reception / education building, a picnic site, a tented camp, a camping terrain, and a 50km road upgrade to connect the access gate with the H1-6 Road between Shingwedzi and Mopane Rest Camps

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1.1 Locality of the Study Site

The proposed development falls within the Shingwedzi/Gyiani district in the Limpopo Province. The project comprises a new entrance gate, a high-water bridge over the Shingwedzi River, a new reception centre with education facilities, a picnic site, a camp site, a tented camp and a ca. 50 kilometer black-topped road routed parallel to the Shingwedzi River which connects with the H1-6 Road linking Shingwedzi and Mopane Rest camps. The new road will be an upgrade of a suitable portion of the gravelled S52 route to Bataleur camp and the graded Shangoni Ranger patrol track. To the east the upgraded road will again cross the Shingwedzi River as well as the Tshanga tributary across low water bridges. Most of the distance the upgraded road will be parallel to the Shingwedzi River. Most of the the road will be north of the Shingwedzi River, and the section between the Shingwedzi Low Water bridge and the H1-6 will traverse through mopane veld south of the river. A short alignment has to be constructed to connect the western terminal end of the Shangoni Ranger patrol road with the reception centre. The upgraded road will be six meters wide with a one meter shoulder on each side. The location of these structures are listed in Table 1 and Figure 1 below.

Table 1: Coordinates for areas earmarked for infrastructure

FACILITY	COORDINATES
Gate preferred site	23°08'40.2"S 30°55'53.6" E
Shingwedzi bridge site	23°08'37.0"S 30°56'07.7" E
Reception preferred site	23°08'37.7"S 30°56'17.4" E
Western end new alignment	23°09'14.5"S 30°56'56.2" E
Eastern end new alignment	23°09'14.5"S 30°56'56.2" E
Picnic site original	23°10'30.09"S 31°1'22.48" E
Picnic site Alt 1	23°10'41.47"S 31°2'24.3" E
Camping site original	23°10'41.47"S 31°2'24.3" E
Camping site Alt 1	23°11'44.7"S 31°2'10.59" E
Tented camp original	23°11'35.81"S 31°1'36.71" E



FACILITY	COORDINATES
Tented camp Alt 1	23°11'05.09"S 31°1'19.6" E
Tented camp Alt 1	23°11'05.09"S 31°1'19.6" E
Shingwedzi crossing	23°12'32.9"S 31°14'0.1" E
S52 crossing Shingwedzi	23°12'32.9"S 31°14'0.1" E
S52 crossing Tshanga	23°12'28.1"S 31°14'18.1" E
H1-6 and S52 T-junction	23°10'46.0"S 31°19'20.9" E

1.2 Terms of Reference

The terms of reference for the current study were as follows:

- Delineate the watercourse(s) that could be impacted upon by the proposed development;
- Classify the watercourse(s) according to the system proposed in the national wetlands inventory if relevant,
- Undertake the functional assessment of wetland(s) or the Ecological category of Riparian areas based on VEGRAI and QHI that are likely to be affected;
- Recommend suitable buffer zones; and
- Assess the possible impact that the proposed structures are likely to have on the watercourses.



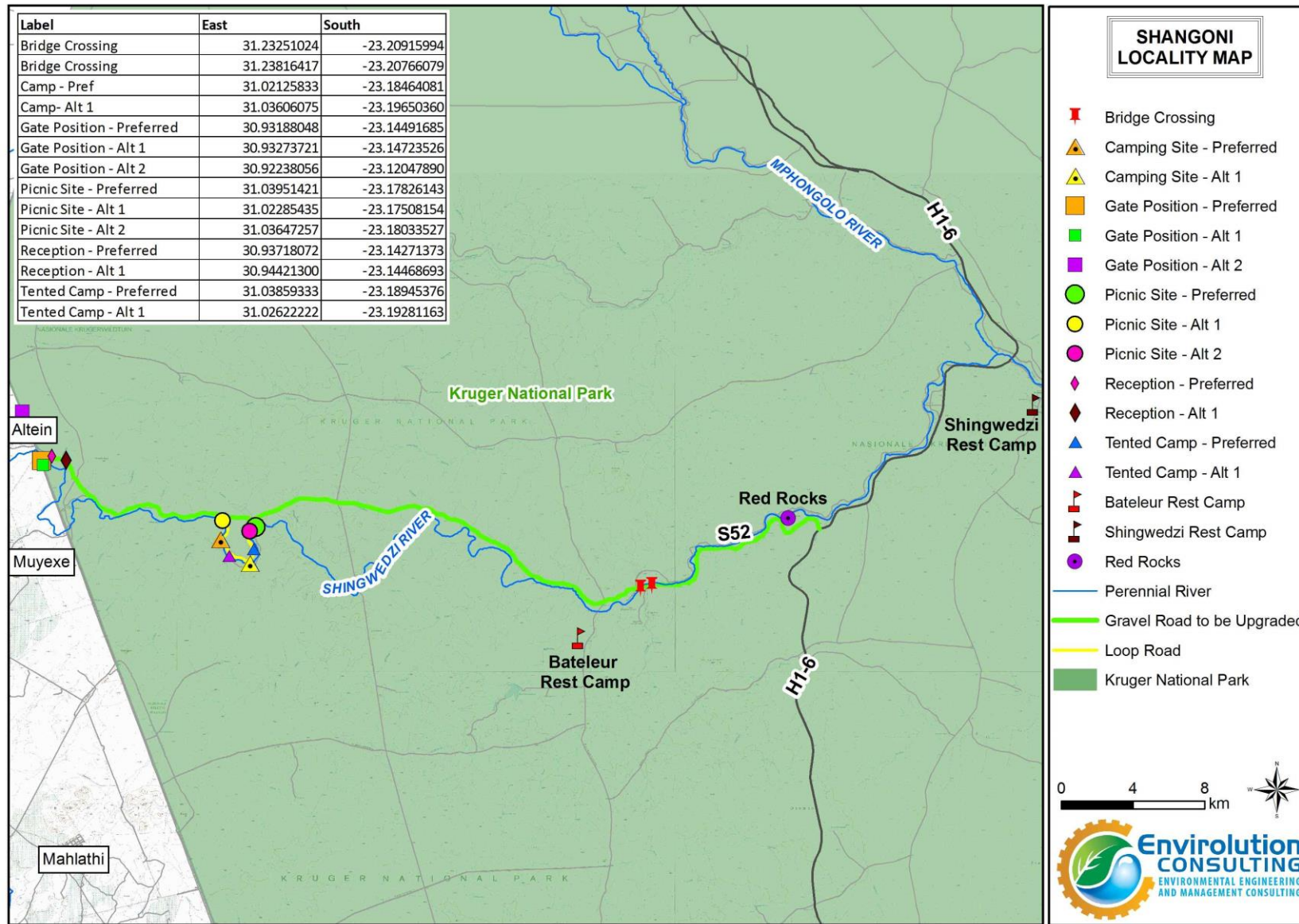


Figure 1: Location of the study site



1.3 Assumptions and Limitations

The Garmin Montana 650 used for wetland and riparian delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries. The scale at which maps and drawings are presented in the current report may become distorted should they be reproduced by for example photocopying and printing.

Furthermore, the assessment of wetlands and rivers is based on environmental indicators such as vegetation, that are subjected to seasonal variation as well as factors such as fire and drought. Although background information was gathered, the information provided in this report was mainly derived from what was observed on the study site at the time of the field survey. The study was done during the winter and temporary wetland areas especially in the case of seepage wetland could have been overlooked. It is thus suggested that the current findings be confirmed during a summer study after rain. A Red Data scan, fauna and flora, and aquatic assessments were not included in the current study. Description of the depth of the regional water table and geohydrological processes falls outside the scope of the current assessment.

It should be noted that the final lay-out plan was not available during the site visit and that the study took place in a particularly dry year and some wetland/riparian signatures could not have been present. It should also be noted that the study area is vast and the report is thus based on ground-truthing sample plots and desktop studies.

1.4 Definitions and Legal Framework

This section outlines the definitions, key legislative requirements and guiding principles of wetland studies and the Water Use Authorisation process.

The National Water Act, 1998 (Act No. 36 of 1998) [NWA] provides for Constitutional water demands including pollution prevention, ecological and resource conservation and sustainable utilisation. In terms of this Act, all water resources are the property of the State and are regulated by the Department of Water Affairs (DWA). The NWA sets out a range of water use related principles that are to be applied by DWA when taking decisions that significantly affect a water resource. The NWA defines a water resource as including a watercourse, surface water, estuary or aquifer. A watercourse includes a river or spring; a natural channel in which water flows regularly or intermittently; a wetland, lake, pan or dam, into which or from which water flows; any collection of water that the Minister may declare to be a watercourse; and were relevant its beds and banks.

The NWA defines a wetland as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.” In addition to water at or near the surface, other distinguishing indicators of wetlands include hydromorphic soils and vegetation adapted to or tolerant of saturated soils (DWA, 2005).

Riparian habitat often times perform the important ecological and hydrological functions, some similar to those performed by wetlands (DWA, 2005). Riparian habitat is also the accepted indicator used to delineate the extent of a river’s footprint (DWA, 2005). It is defined by the NWA as follows: “Riparian habitat includes the physical structure and associated vegetation of the areas associated with a



watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas”.

Water uses for which authorisation must be obtained from DWA are indicated in Section 21 of the NWA. Section 21 (c) and (i) is applicable to any activity related to a wetland:

Section 21(c): Impeding or diverting the flow of water in a watercourse; and

Section 21(i): Altering the bed, banks, course or characteristics of a watercourse.

Authorisations related to wetlands are regulated by Government Notices R.1198 and R.1199 of 18 December 2009. GN 1198 and 1199 of 2009 grants General Authorisation (GA) for the above water uses on certain conditions:

GN R.1198: Any activity in a wetland for the rehabilitation of a wetland for conservation purposes.

GN R.1199: Any activity more than 500 m from the boundary of a wetland.

These regulations also stipulate that these water uses must be registered with the responsible authority. Any activity that is not related to the rehabilitation of a wetland and which takes place within 500 m of a wetland are excluded from a GA under either of these regulations. Wetlands situated within 500 m of proposed activities should be regarded as sensitive features potentially affected by the proposed development (GN 1199). Such an activity requires a Water Use Licence (WUL) from the relevant authority.

In addition to the above, the proponent must also comply with the provisions of the following relevant national legislation, conventions and regulations applicable to wetlands and riparian zones:

- Convention on Wetlands of International Importance - the Ramsar Convention and the South African Wetlands Conservation Programme (SAWCP).
- National Environmental Management Act, 1998 (Act No. 107 of 1998) [NEMA].
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- National Environment Management Protected Areas Act, 2003 (Act No. 57 of 2003).
- Regulations GN R.982, R.983, R.984 and R.985 of 2014, promulgated under NEMA.
- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983).
- Regulations and Guidelines on Water Use under the NWA.
- South African Water Quality Guidelines under the NWA.
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 287 of 2002).

1.5 Description of the Receiving Environment

A review of available literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state.

Hydrology

The study area falls into the second Water Management Area (WMA), Levuvu and Lethaba. The eastern section of the site in which the new gate and reception infrastructure is located, falls in Quarternary Catchment B90F. The eastern section falls in Quarternary Catchment B90G. The mean annual precipitation (MAP) value for the study site is 681mm (per annum) and the mean annual transpiration (MAT) is 1329



(Macfarlane *et al*, 2013). The ratio of MAT to MAP is thus 0.5 which means that, in this catchment, the precipitation rate is lower than the evaporation rate. Consequently, wetlands and rivers in this area are sensitive to changes in regional hydrology, particularly where their catchment becomes transformed and the water available to sustain them becomes redirected. The catchment of the Shingwedzi River is relatively small comprising of approximately 5300 km², the Shingwedzi sub-catchment has a natural MAR of 90 and an ecological reserve of 14 million m³ a-1 (Fouché & Vlok, 2012; DWAF 2004a). The Shingwedzi River is located in one of the drier sub-catchments of the South African component of the Limpopo River Catchment (Fouché & Vlok, 2012).

The Shingwedzi River (which originates near the town of Malamulele) is a dominant feature of the study site (Figure 2). It arises about 40 km to the North West near Thohoyandou. It is along this river that the road upgrades will occur and the picnic site and rest camp constructed. This river flows from west to east. It confluences with the Tshange River downstream from the Bateleur Bushveld Camp and later drains into the Olifants River which in turn drains into the Limpopo River which drains into the Indian Ocean. No major tributaries enter the Shingwedzi upstream from the KNP and there are no dams. The catchment of the Shingwedzi River is well populated with village settlements with no significant industrial development other than scattered mines, most of which are no longer operational (Shangoni Gate Pre-feasibility Study, 2013).

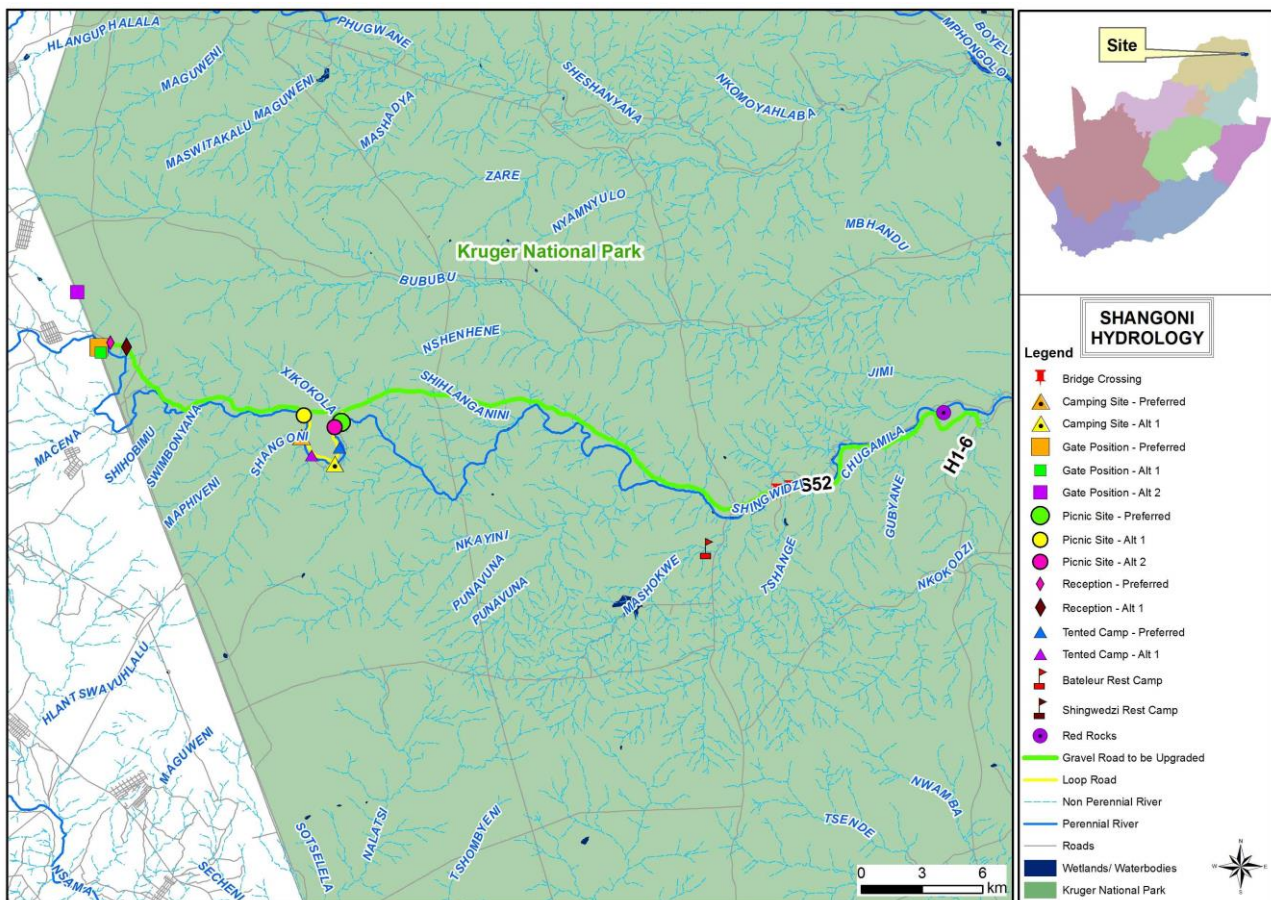


Figure 2: Regional hydrology.



Geology and Soil

The study site lies on the north-eastern edge of the Kaapvaal Craton. The underlying geology is Archaean granite and gneiss with infolded greenstone belts (including the Giyani Greenstone Belt) of the Barberton Supergroup. Younger dolerite dykes of mixed migmatic and granitoid composition traverse the region along north-westerly strike-lines spaced at intervals of between 200m and half a kilometre. They determine a network of temporary drainage lines draining towards the Shingwedzi River (Shangoni Gate Pre-feasibility Study, 2013). Figure 3 and Table 2 below presents the soil types relative to the proposed development.

Table 2: Soil types associated with the proposed infrastructure.

Soil Type (ARC, 2013)	Description	Relevance to wetlands
Ae316	Red-yellow apedal, freely drained soils; red, high base status, > 300 mm deep. The westernmost section of the study site earmarked for the westernmost section of the new road alignment.	None
Fb357	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in upland soils but generally present in low-lying soils. Occurs along the western section of the site where the proposed gate and reception area are located as well as a section of the new alignment.	The Glenrosa soil form is described as a potential seasonal to temporary wetland soil (DWA, 2005). This soil form is characterised by a surface horizon which is maintained by biological activity and underlying rock or saprolite. Saprolite refers to a horizon of weathering rock which still has distinct affinities with the parent rock (Fey, 2005).
Fa397	Glenrosa and/or Mispah forms (other soils may occur), lime rare or absent in the entire landscape. This is the dominant soil class which stretches along the largest part of the alignment for the upgrade of the two spoor road as well as the picnic sites and camps.	The Glenrosa soil form is described as a potential seasonal to temporary wetland soil (DWA, 2005). This soil form is characterised by a surface horizon which is maintained by biological activity and underlying rock or saprolite. Saprolite refers to a horizon of weathering rock which still has distinct affinities with the parent rock (Fey, 2005).
Ea164	One or more of: vertic, melanic, red structured diagnostic horizons, undifferentiated. A section of the alignment for the upgrade of the two spoor road falls in this class	High clay content of soil may result in some water trapped on the surface and supporting hydrophytic species during the wet season.
Ia112	Miscellaneous land classes, undifferentiated deep deposits. The existing public road falls in this class.	Unknown.



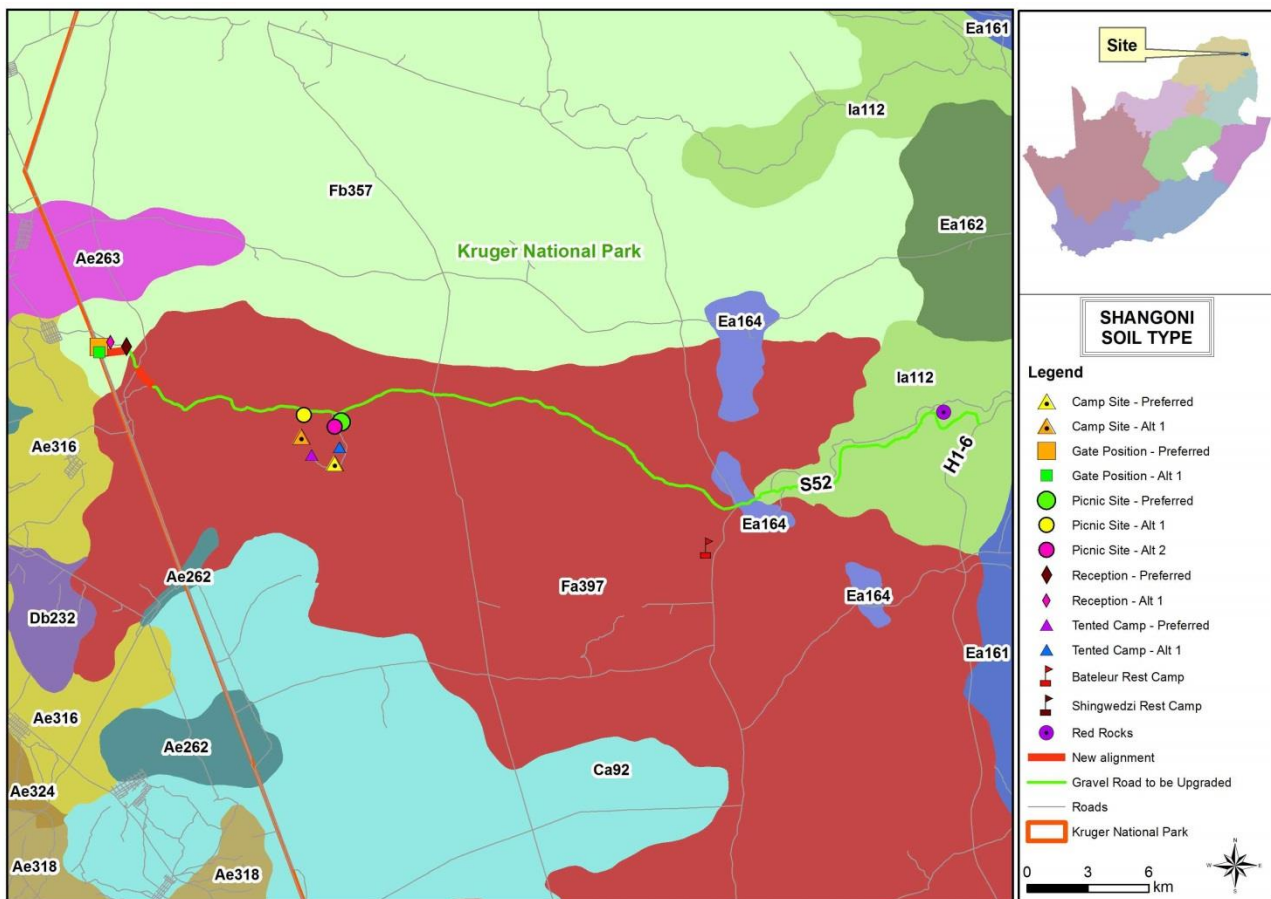


Figure 3: Soil types associated with the proposed pipelines.

Vegetation

Eight different Mopane Bushveld vegetation units are recognized by Mucina and Rutherford (2006). Collectively these are described as an ‘ecoregion’ which is the dominate vegetation assemblage on the plains of the northern KNP from Elephants Rest Camp northwards.

Lowveld Rugged Mopaneveld occurs at the westernmost tip of the new alignment linking to the proposed new gate. The new gate and reception areas are associated with Makuleke Sandy Bushveld. The main portion of the site, relevant to the two spoor track to be upgraded falls in the Tsende Mopaneveld vegetation unit. A section of Mopane Gabbro Shrubland crosses a section of the two spoor track and the existing road falls in the vegetation unit Subtropical Alluvial Vegetation (Mucina and Rutherford, 2006).

Details of the species composition and conservation status of the vegetation affected by the proposed activities are discussed in detail in a separate vegetation assessment.

2 METHODOLOGY

The delineation method documented by the Department of Water affairs and Forestry in their document “Updated manual for identification and delineation of wetlands and riparian areas” (DWAF, 2008), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2009) as well as the Classification System for



Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems (Ollis *et al*, 2013) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held Garmin Montana 650 was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary watercourse boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey.

2.1 Wetland and Riparian Delineation

Wetlands are delineated based on scientifically sound methods, and utilizes a tool from the Department of Water Affairs and Forestry named 'A practical field procedure for identification and delineation of wetlands and riparian areas' (DWAf, 2008).

Wetlands are identified based on one or more of the following characteristic attributes (DWAf, 2008) (Figures 4 & Figure 5):

- The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur (Figure 4 and Figure 5 and Figure 6);
- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

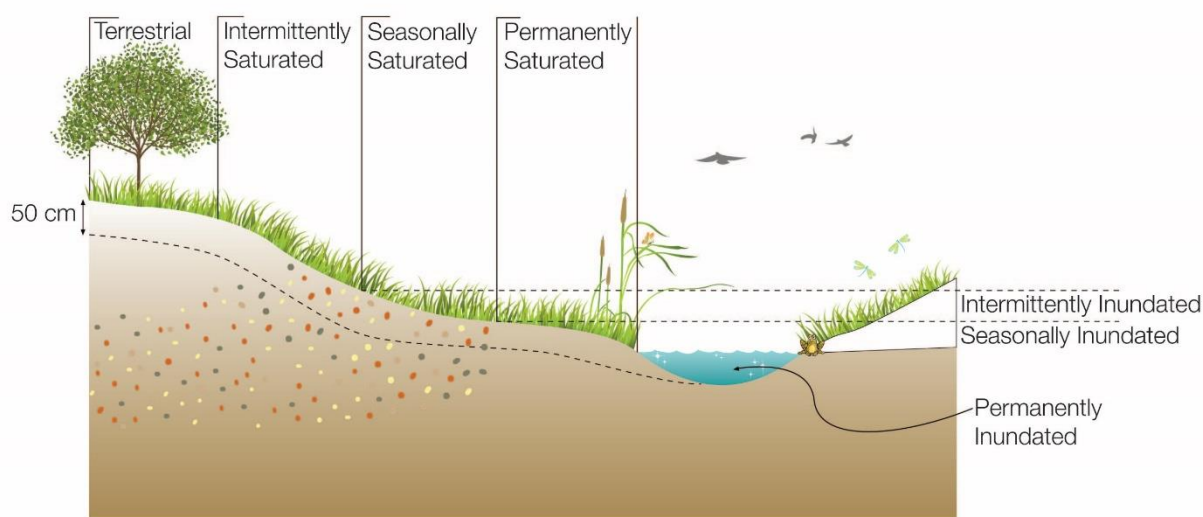


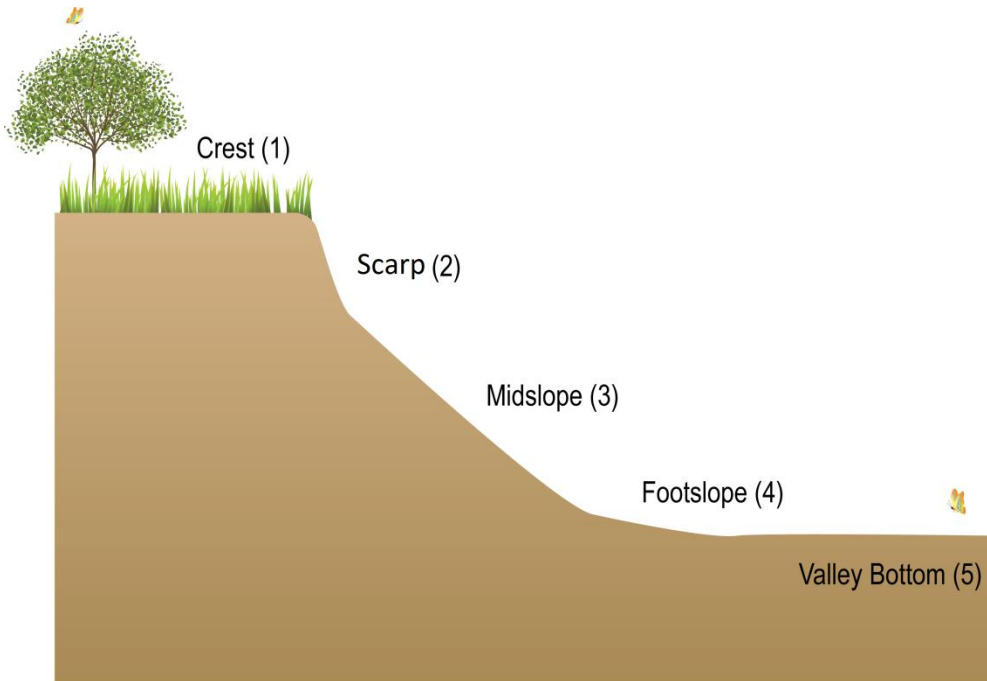
Figure 4: Typical cross section of a wetland (Ollis, 2013)

The Terrain Unit Indicator

The terrain unit indicator (Figure 7) is an important guide for identifying the parts of the landscape where wetlands might possibly occur. Some wetlands occur on slopes higher up in the catchment where groundwater discharge is taking place through seeps. An area with soil wetness and/or vegetation



indicators, but not displaying any of the topographical indicators should therefore not be excluded from being classified as a wetland. The type of wetland which occurs on a specific topographical area in the landscape is described using the Hydrogeomorphic classification which separates wetlands into ‘HGM’ units. The classification of Ollis, *et al.* (2013) is used, where wetlands are classified on Level 4 as either Rivers, Floodplain wetlands, Valley-bottom wetlands, Depressions, Seeps, or Flats (Figure 6).



Wetlands qualify as a (unit 5) or units 1(5), 3(5), 4(5)

Figure 5. Terrain units (DWAF, 2005).

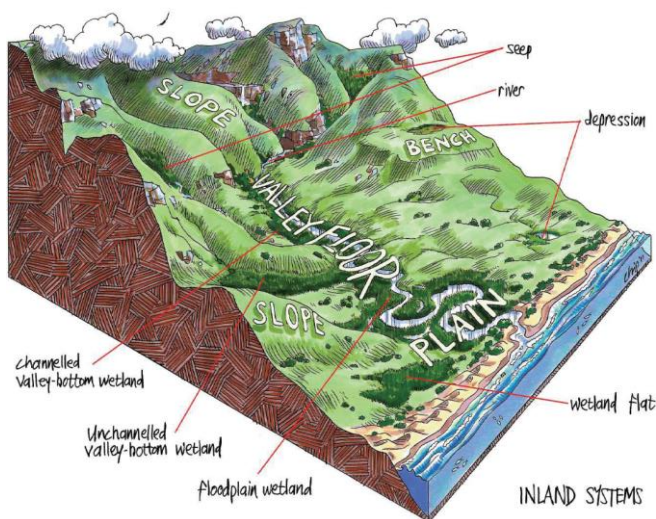


Figure 6: Wetland Units based on hydrogeomorphic types (Ollis *et al.* 2013)



Riparian Indicators

Riparian habitat is classified primarily by identifying riparian vegetation along the edge of the macro stream channel. The macro stream channel is defined as the outer bank of a compound channel and should not be confused with the active river bank. The macro channel bank often represents a dramatic change in the energy with which water passes through the system. Rich alluvial soils deposit nutrients making the riparian area a highly productive zone. This causes a very distinct change in vegetation structure and composition along the edges of the riparian area (DWAF, 2008). The marginal zone includes the area from the water level at low flow, to those features that are hydrologically activated for the greater part of the Year (WRC Report No TT 333/08 April, 2008). The non-marginal zone is the combination of the upper and lower zones (Figure 7).

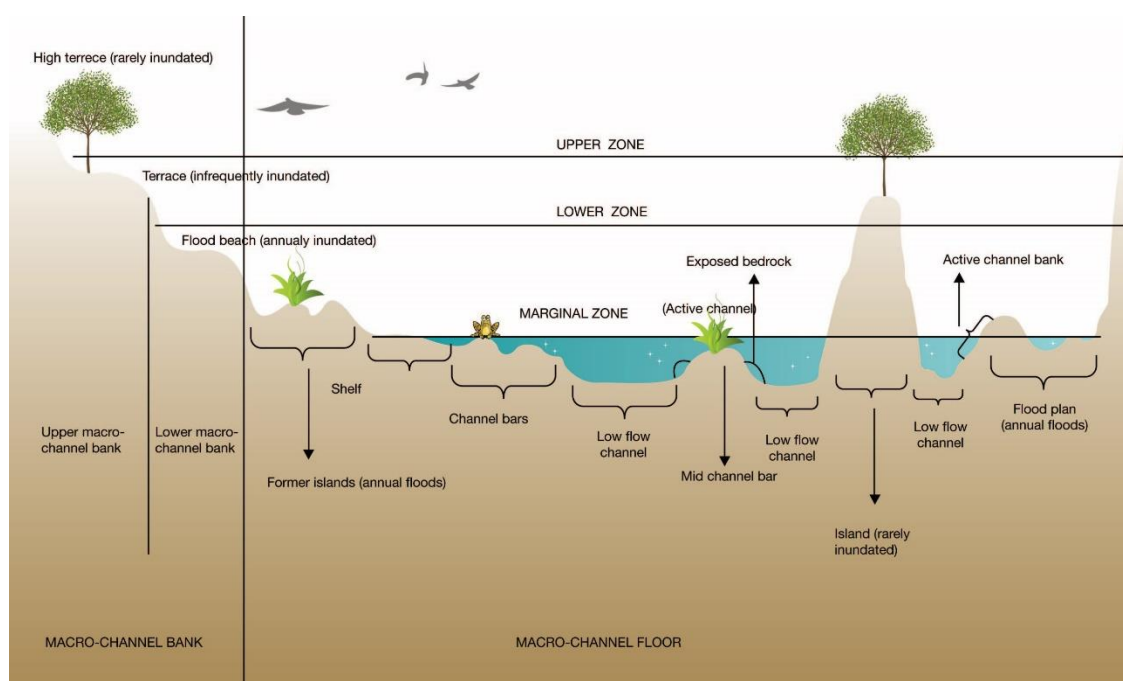


Figure 7: Schematic diagram illustrating an example of where the 3 zones would be placed relative to geomorphic diversity (Kleynhans et al, 2007)

The vegetation of riparian areas is divided into three zones, the marginal zone, lower non-marginal zone and the upper non-marginal zone (Table 3). The different zones have different vegetation growth.

Table 3: Description of riparian vegetation zones (Kleynhans et al, 2007).

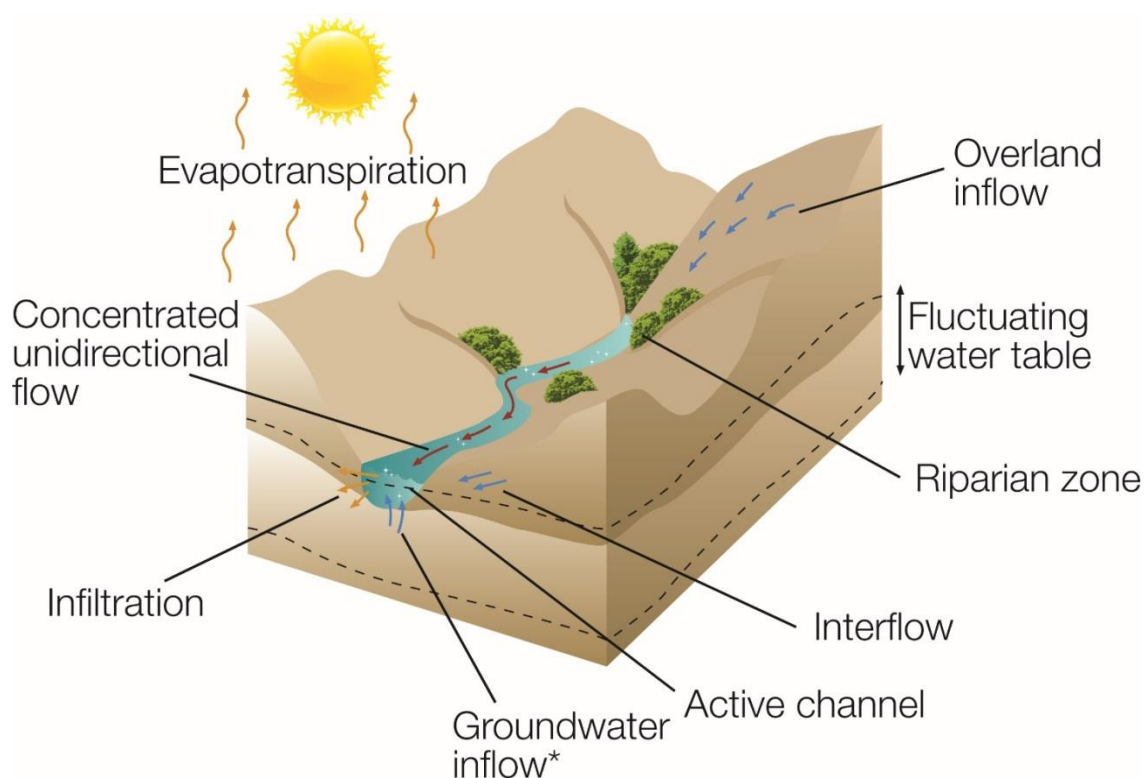
	Marginal	(Non-marginal) Lower	(Non-marginal) Upper
Alternative descriptions	Active features Wet bank	Seasonal features Wet bank	Ephemeral features Dry bank
Extends from	Water level at low flow	Marginal zone	Lower zone
Extends to	Geomorphic features / substrates that are hydrologically activated	Usually a marked increase in lateral	Usually a marked decrease in lateral



	Marginal	(Non-marginal) Lower	(Non-marginal) Upper
	(inundated or moistened) for the Greater part of the year.	Elevation.	elevation
Characterized by	See above ; Moist substrates next to water's edge; water loving- species usually vigorous due to near permanent access to soil moisture	Geomorphic features that are hydrologically activated (inundated or moistened) on a Seasonal basis. May have different species than marginal zone	Geomorphic features that are hydrological activated (inundated or moistened) on an Ephemeral basis. Presence of riparian and terrestrial species Terrestrial species with increased stature

Riparian Area:

A riparian area can be defined as a linear fluvial, eroded landform which carries channelized flow on a permanent, seasonal or ephemeral/episodic basis. The river channel flows within a confined valley (gorge) or within an incised macro-channel. The “river” includes both the active channel (the portion which carries the water) as well as the riparian zone (Figure 8) (Kotze, 1999).



RIVER

* Not always present

Figure 8: A schematic representation of the processes characteristic of a river area (Ollis et al, 2013).



Riparian areas can be grouped into different categories based on their inundation period per year. Perennial rivers are rivers with continuous surface water flow, intermittent rivers are rivers where surface flow disappears but some surface flow remains, temporary rivers are rivers where surface flow disappears for most of the channel (Figure 9). Two types of temporary rivers are recognized, namely “ephemeral” rivers that flow for less time than they are dry and support a series of pools in parts of the channel, and “episodic” rivers that only flow in response to extreme rainfall events, usually high in their catchments (Seaman *et al*, 2010). The main river associated with the proposed activities is the Shingwedzi River and its tributaries. The Shingwedzi River is classified as an ephemeral non-perennial riparian area while the majority of its tributaries are classified as episodic non-perennial rivers. The remaining watercourses likely to be impacted by the proposed activities are also non-perennial rivers.

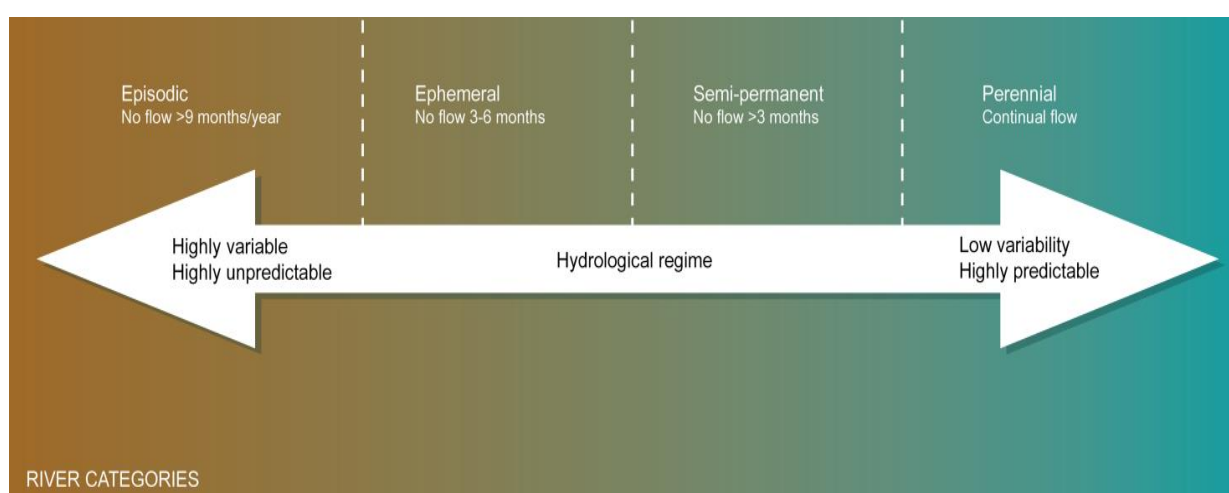


Figure 9: The four categories associated with rivers and the hydrological continuum. Dashed lines indicate that boundaries are not fixed (Seaman *et al*, 2010).

2.2 Wetland Classification and Delineation

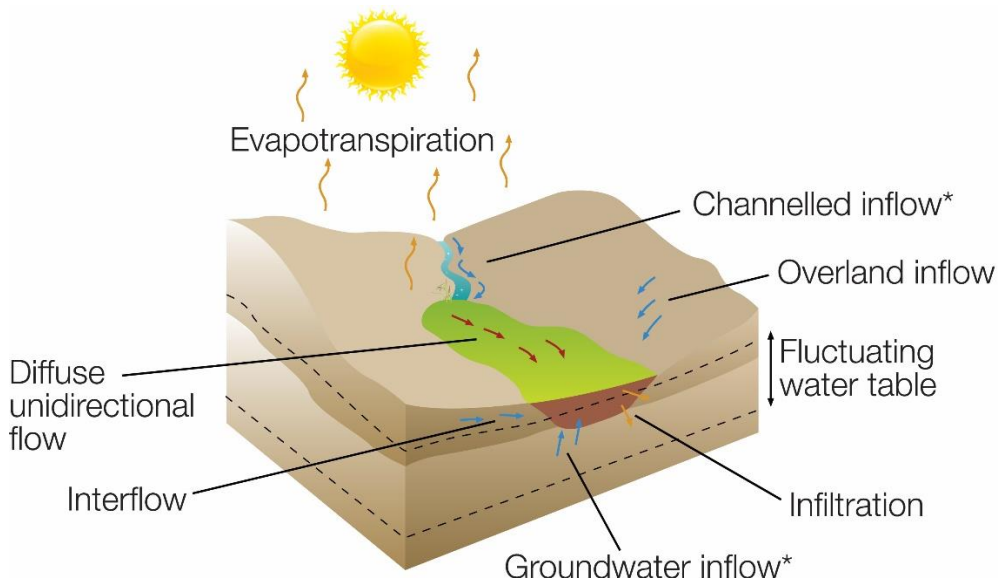
The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (SANBI, 2009). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in SANBI (2009). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. In general HGM units encompass three key elements (Kotze *et al*, 2005):

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



Unchanneled valley bottom wetland:

Unchannelled valley bottom wetlands are described as a linear fluvial, net depositional valley bottom surfaces which do not have a channel. The valley floor is a depositional environment composed of fluvial or colluvial deposited sediment. These systems tend to be found in the upper catchment areas, or at tributary junctions where the sediment from the tributary smothers the main drainage line (Figure 10) (Kotze, 1999).



UNCHANNELLED VALLEY-BOTTOM WETLAND * Not always present

Figure 10: A schematic representation of the processes characteristic of unchannelled valley bottom wetlands (Ollis et al, 2013).

The possibility of difficult wetland area exists on study areas and is summarised below including what approach to be taken in the case of a difficult wetland area (Table 4).

Table 4: List of types of sites that are difficult to delineate (Jobs, 2009).

Type of "difficult site"	Approach
Some or all, wetland indicators are present but is a non-natural wetland (e.g some dams, road islands)	<ul style="list-style-type: none"> • Decide on the relative permanence of the change and whether the area can now be said to be functioning as a wetland. • Time field observations during the wet season, when natural hydrology is at its peak, to help to differentiate between naturally-occurring versus human-induced wetland. • Decide appropriate policy/management i.e. can certain land uses be allowed due to "low" wetland functional value, or does the wetland perform key functions despite being artificial.
Indicators of soil wetness are present but no longer a functioning	<ul style="list-style-type: none"> • Look for evidence of ditches, canals, dikes, berms, or subsurface drainage tiles.



wetland (e.g. wetland has been drained)	<ul style="list-style-type: none"> Decide whether or not the area is currently functioning as a wetland.
Indicators of soil wetness are present but no longer a functioning wetland (e.g. relic / historical wetland)	<ul style="list-style-type: none"> Decide whether indicators were formed in the distant past when conditions were wetter than the area today. Obtain the assistance of an experienced soil scientist.
Some, or all, wetland indicators are absent at certain times of year (e.g. annual vegetation or seasonal saturation)	<ul style="list-style-type: none"> Thoroughly document soil and landscape conditions, develop rationale for considering the area to be a wetland. Recommend that the site be revisited in the wet season.
Some, or all, wetland indicators are absent due to human disturbance (e.g. vegetation has been cleared, wetland has been ploughed or filled)	<ul style="list-style-type: none"> Thoroughly document landscape conditions and any remnant vegetation, soil, hydrology indicators, develop rationale for considering the area to be wetland. Certain cases (illegal fill) may justify that the fill be removed and the wetland rehabilitated.

2.3 Buffer Zones

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAf, 2005). A development has several impacts on the surrounding environment and on a wetland. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is therefore often characteristic of transformed catchments. The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. A brief description of each of the functions and associated services is outlined in Table 5 below.

Table 5: Generic functions of buffer zones relevant to the study site (adapted from Macfarlane *et al*, 2010)

Primary Role	Buffer Functions
Maintaining basic aquatic processes, services and values.	<ul style="list-style-type: none"> Groundwater recharge: Seasonal flooding into wetland areas allows infiltration to the water table and replenishment of groundwater. This groundwater will often discharge during the dry season providing the base flow for streams, rivers, and wetlands.
Reducing impacts from upstream activities and adjoining land uses	<ul style="list-style-type: none"> Sediment removal: Surface roughness provided by vegetation, or litter, reduces the velocity of overland flow, enhancing settling of particles. Buffer zones can therefore act as effective sediment traps, removing sediment from runoff water



Primary Role	Buffer Functions
	<p>from adjoining lands thus reducing the sediment load of surface waters.</p> <ul style="list-style-type: none"> • Removal of toxics: Buffer zones can remove toxic pollutants, such hydrocarbons that would otherwise affect the quality of water resources and thus their suitability for aquatic biota and for human use. • Nutrient removal: Wetland vegetation and vegetation in terrestrial buffer zones may significantly reduce the amount of nutrients (N & P), entering a water body reducing the potential for excessive outbreaks of microalgae that can have an adverse effect on both freshwater and estuarine environments. • Removal of pathogens: By slowing water contaminated with faecal material, buffer zones encourage deposition of pathogens, which soon die when exposed to the elements.

Despite limitations, buffer zones are well suited to perform functions such as sediment trapping, erosion control and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of land uses / activities planned adjacent to water resources. These must however be considered in conjunction with other mitigation measures.

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWA, 2005). A development has several impacts on the surrounding environment and on a wetland. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site. An increased volume of stormwater runoff, peak discharges, and frequency and severity of flooding is therefore often characteristic of transformed catchments.

Local government policies require that protective buffer zones be calculated from the outer edge of the temporary zone of a wetland, or edge of the riparian habitat (CoCT, 2008; GDACE, 2009). The buffer zone identified in this report serves to highlight an ecologically sensitive area in which activities should be conducted with this sensitivity in mind.

New buffer tools have been developed and been published as “Preliminary Guideline for the Determination of Buffer Zones for Rivers, Wetlands and Estuaries. Consolidated Report” by the WRC (Macfarlane *et al* 2015). This new buffer tools aims to calculate the best suited buffer for each wetland or section of a wetland based on numerous on-site observations. The resulting buffer area can thus have large differences depending on the current state of the wetland as well as the nature of the proposed development. Developments with a high risk factor such as mining are likely to have a larger buffer area compared to a residential development with a lower risk factor. The minimum accepted buffer for low risk developments are however 15 meters from the edge of the wetland (Macfarlane, *et al* 2015) as opposed to the generic recommendation of 30 m for wetlands inside the urban edge and 50 m outside the urban edge (GDARD, 2012). For this proposed development a buffer of 100 m for the ephemeral rivers (Including the Shingwedzi River) and a 50 m buffer for the episodic rivers are suggested due to the high variability and unpredictability of the river systems and the frequency of floods especially with regards to the Shingwedzi River. However,



floodlines should also be consulted and certain developments should be avoided in the buffer zone or the floodlines, whichever is the greatest.

Figure 11 below shows a graphic representation of the setback of the buffer zone from the delineated riparian edge

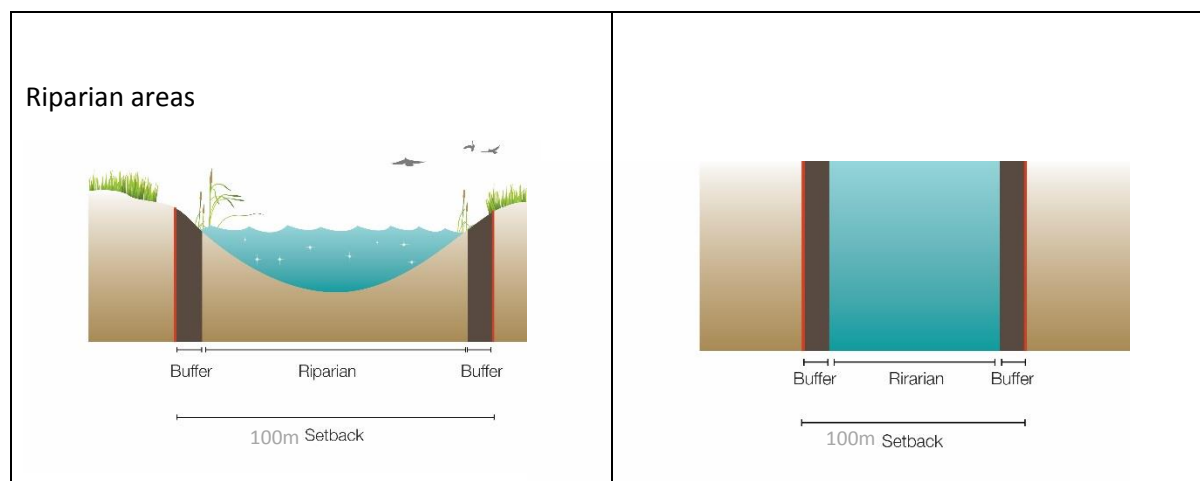


Figure 11: A representation of the buffer zone setback for the riparian area discussed in this report

2.4 Wetland Functionality, Status and Sensitivity

Wetland functionality is defined as a measure of the deviation of wetland structure and function from its natural reference condition. The natural reference condition is based on a theoretical undisturbed state extrapolated from an understanding of undisturbed regional vegetation and hydrological conditions. In the current assessment the hydrological, geomorphological and vegetation integrity was assessed for the wetland unit associated with the study site, to provide a Present Ecological Status (PES) score (Macfarlane *et al*, 2007) and an Environmental Importance and Sensitivity category (EIS) (DWAf, 1999). The impacts observed for the affected wetlands on the study site are summarised for each wetland under section 3.2. These impacts are based on evidence observed during the field survey and land-use changes visible on aerial imagery.

The allocations of scores in the functional and integrity assessment are subjective and are thus vulnerable to the interpretation of the specialist. Collection of empirical data is precluded at this level of investigation due to project constraints including time and budget. Water quality values, species richness and abundance indices, surface and groundwater volumes, amongst others, should ideally be used rather than a subjective scoring system such as is presented here.

The functional assessment methodologies presented below take into consideration subjective recorded impacts to determine the scores attributed to each functional Hydrogeomorphic (HGM) wetland unit. The aspect of wetland functionality and integrity that are predominantly addressed include hydrological and geomorphological function (subjective observations) and the integrity of the biodiversity component (mainly based on the theoretical intactness of natural vegetation) as directed by the assessment methodology.



2.4.1 Present Ecological Status (PES) – WET-Health

A summary of the three components of the WET-Health namely Hydrological; Geomorphological and Vegetation Health assessment for the wetlands found on site is described in Table 6. A Level 1 assessment was used in this report. Level 1 assessment is used in situations where limited time and/or resources are available.

Table 6: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2007)

Description	Impact Score Range	PES Score	Summary
Unmodified, natural.	0.0.9	A	Very High
Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1-1.9	B	High
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	2-3.9	C	Moderate
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	4-5.9	D	Moderate
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6-7.9	E	Low
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8.10	F	Very Low

A summary of the change class, description and symbols used to evaluate wetland health are summarised in Table 7.

Table 7: Trajectory class, change scores and symbols used to evaluate Trajectory of Change to wetland health (Macfarlane *et al*, 2007)

Change Class	Description	Symbol
Improve	Condition is likely to improve over the over the next 5 years	(↑)
Remain stable	Condition is likely to remain stable over the next 5 years	(→)
Slowly deteriorate	Condition is likely to deteriorate slightly over the next 5 years	(↓)



Change Class	Description	Symbol
Rapidly deteriorate	Substantial deterioration of condition is expected over the next 5 years	(↓↓)

2.4.2 Ecological Importance and Sensitivity (EIS)

The Ecological Importance and Sensitivity (EIS) score forms part of a larger assessment called the Wetland Importance and Sensitivity scoring system which also addresses hydrological importance and direct human benefits relevant to a HGM unit. Both PES and EIS form part of a larger reserve determination process documented by the Department of Water and Sanitation.

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity such as species diversity and abundance.
- Ecological functions including groundwater recharge, provision of specialised habitat and dispersal corridors.
- Basic human needs including subsistence farming and water use.

The Ecological importance is based on the ability of the wetland to preform indirect benefits (Table 8) as well as direct benefits (Table 9)

Table 8: Indirect Benefits provided by wetland habitats (Macfarlane *et al*, 2007).

Regulating & supporting benefits	Flood attenuation		The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream	
	Streamflow regulation		Sustaining streamflow during low flow periods	
	Water Quality Enhancement	Sediment trapping		The trapping and retention in the wetland of sediment carried by runoff waters
		Phosphate assimilation		Removal by the wetland of phosphates carried by runoff waters, thereby enhancing water quality
		Nitrate assimilation		Removal by the wetland of nitrates carried by runoff waters, thereby enhancing water quality



		Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters, thereby enhancing water quality
		Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
	Carbon storage		The trapping of carbon by the wetland, principally as soil organic matter

Table 9: Direct human benefits associated with wetland habitats (Macfarlane *et al*, 2007).

Subsistence benefits	Water for human use	The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
	Harvestable resources	The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
	Cultivated foods	Areas in the wetland used for the cultivation of foods
Cultural benefits	Cultural heritage	Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants
	Tourism and recreation	Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
	Education and research	Sites of value in the wetland for education or research

The Ecological Importance and Sensitivity of the wetlands are described in the results section. Explanations of the scores are given in Table 10.

Table 10: Environmental Importance and Sensitivity rating scale used for the estimation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating	Recommended Ecological Management Class
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and ≤4	A
High Wetlands that are considered to be ecologically important and sensitive. The	>2 and ≤3	B



Ecological Importance and Sensitivity Categories	Rating	Recommended Ecological Management Class
biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers		
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2	C
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1	D

2.4.3 Present Ecological Category (EC): Riparian

In the current study, the Ecological Category of the riparian areas was assessed using a level 3 VEGRAI (Riparian Vegetation Response Assessment Index) (Kleynhans *et al*, 2007). Table 11 below provides a description of each EC category.

Table 11: Generic ecological categories for EcoStatus components (modified from Kleynhans, 1996 & Kleynhans, 1999)

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



ECOLOGICAL CATEGORY	DESCRIPTION	SCORE (% OF TOTAL)
	the basic ecosystem functions have been destroyed and the changes are irreversible	

2.4.4 Quick Habitat Integrity Model

To accommodate a less-detailed process, a desktop habitat integrity assessment (using the Quick Habitat Integrity model) that allows for a coarse assessment was developed. This assessment rates the habitat according to a scale of 0 (close to natural) to 5 (critically modified) according to the following metrics (Seaman *et al*, 2010):

- Bed modification.
- Flow modification.
- Introduced Instream biota.
- Inundation.
- Riparian / bank condition.
- Water quality modification.

2.5 Impact Assessments

2.5.1 NEMA (2014) Impact Ratings

As required by the 2014 NEMA regulations, impact assessment should provide quantified scores indicating the expected impact, including the cumulative impact of a proposed activity. This assessment follows the format presented below:

The impact assessment score below are calculated using the following parameters:

- Direct, indirect and cumulative impacts of the issues identified through the specialist study, as well as all other issues must be assessed in terms of the following criteria:
 - The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
 - The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
 - The **duration**, wherein it will be indicated whether:
 - The lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
 - The lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
 - Medium-term (5–15 years) – assigned a score of 3;
 - Long term (> 15 years) - assigned a score of 4; or
 - Permanent - assigned a score of 5;



- The consequences (magnitude), quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The probability of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- The significance, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- The status, which will be described as either positive, negative or neutral.
- The degree to which the impact can be reversed.
- The degree to which the impact may cause irreplaceable loss of resources.
- The degree to which the impact can be mitigated.

The **significance** is calculated by combining the criteria in the following formula:

- $S=(E+D+M)P$
- S = Significance weighting
- E = Extent
- D = Duration
- M = Magnitude
- P = Probability

The **significance weightings** for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated),
- > 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).

2.5.2 DWS (2014) Impact Register and Risk Assessment

Section 21(c) and (i) water uses (Impeding or diverting low and/or impacts to the bed and banks of watercourses) are non-consumptive and their impacts more difficult to detect and manage. They are also generally difficult to clearly quantify. However, if left undetected these impacts can significantly change various attributes and characteristics of a watercourse, and water resources, especially if left unmanaged and uncontrolled.

Risk-based management has value in providing an indication of the potential for delegating certain categories of water use “risks” to DWS regional offices (RO) or Catchment Management Agencies (CMA).



Risk categories obtained through this assessment serve as a guideline to establish the appropriate channel of authorisation of these water uses

The DWS has therefore developed a risk assessment matrix to assist in quantifying expected impacts. The scores obtained in this assessment are useful in evaluating how the proposed activities should be authorised.

The formula used to derive a risk score is as follows:

RISK = CONSEQUENCE x LIKELIHOOD

CONSEQUENCE = SEVERITY + SPATIAL SCALE + DURATION

LIKELIHOOD = FREQUENCY OF THE ACTIVITY + FREQUENCY OF THE IMPACT + LEGAL ISSUES + DETECTION

Table 12 below provides a description of the classes into which scores are sorted, and their implication for authorization.

Table 12: An extract from DWS (2014) indicating the risk scores and classes as well as the implication for the appropriate authorization process

RATING	CLASS	MANAGEMENT DESCRIPTION	AUTHORISATION	DELEGATION
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Wetlands are excluded.	GA	Regional Head
56 – 169	(M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input. Wetlands are excluded.	WUL	Regional Head
170 – 300	(H) High Risk	Always involves wetlands. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.	WUL	Director General

3 RESULTS

3.1 Wetland Classification and Delineation

The rivers recorded on the study site ranges from 1st order rivers to 4th order rivers, such as the Shingwedzi River. The Strahler stream order of rivers is where the headwaters of a stream is given an order of 1 and the confluence of two 1st order streams assigns the downstream section an order of 2. Downstream of two 2nd order streams a third order stream is located and so forth (Figure 12). The stream order of a stream is an important in the river continuum concept which can be explained as a “model used to determine the biotic community expected in a stream based on the size of the stream itself. As water travels from headwater streams toward the mouths of big rivers, the width, depth, and velocity of the waterways gradually increase. The amount of water they discharge also increases. These physical characteristics dictate the types of aquatic organisms that can inhabit a stream” (Wheeling Jesuit University, 2003).



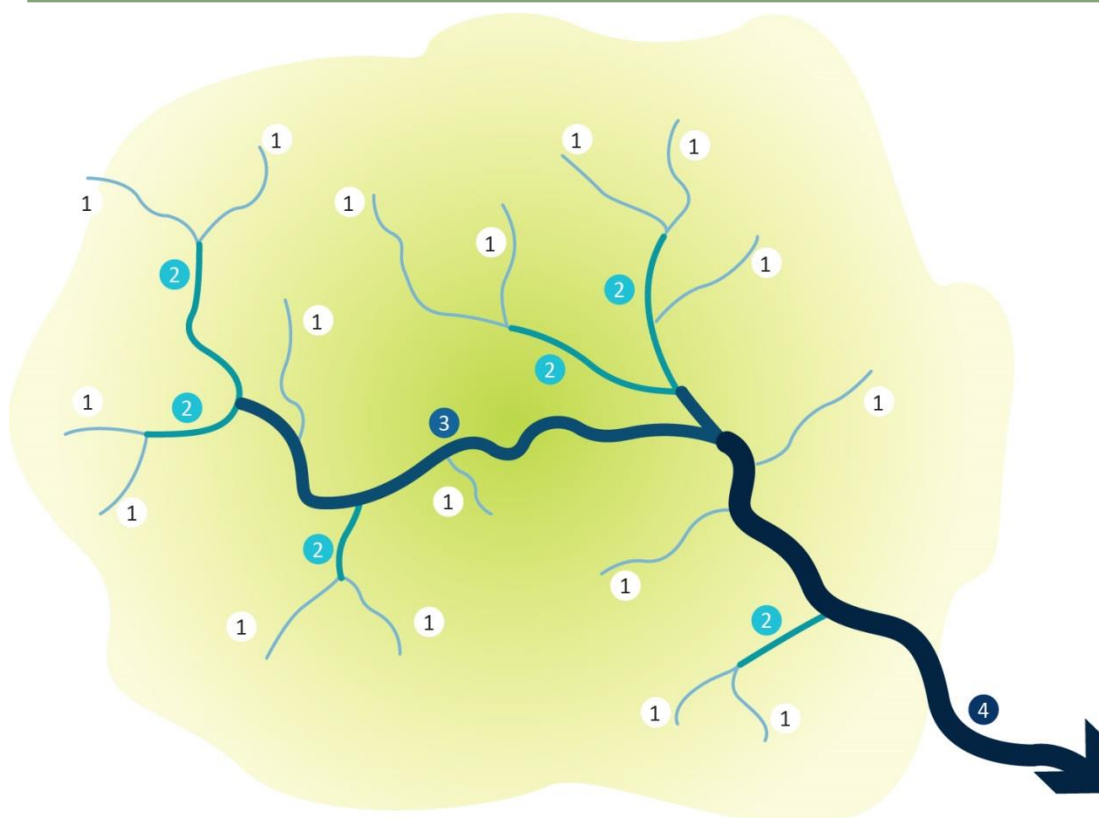


Figure 12: A visual explanation of Strahler stream order.

The main river that is likely to be impacted by the proposed activities is the Shingwedzi River. The Shingwedzi River is a long meandering ephemeral non-perennial river that runs parallel to the proposed road for long sections and is also adjacent to the various proposed new camps. The Shingwedzi River is classified as a fourth order river and numerous lower order rivers are likely to be impacted by the proposed road construction. There are an estimated 52 episodic streams and 9 ephemeral rivers that either are directly within the development footprint or within 500 m of the development footprint. In this instance the lower stream orders are usually episodic and only have water flow during rainfall events and the higher stream orders have a higher perennial water flow. Another important feature of the Shingwedzi River are small pools of water which remain in the river bed during dry months. These pools are essential for the numerous wildlife species in the park and care should be taken to ensure water from lower stream orders are able to flow freely, without artificial barriers, into the higher order rivers to ensure regular water entering the system during rainfall events.

The banks of the Shingwedzi River is composed of highly erodible alluvial soil banks of between 20 m – 30 m high with an active channel of between 15 m – 30 m wide often with a mid-channel bar. The macro-channel is up to 60 m wide in some sections. The banks and terraces are dominated by rich riparian vegetation with large trees that stabilises the banks. It should also be noted that the riparian vegetation is classified as critically endangered (Shangoni Gate Pre-feasibility Study, 2013).



Furthermore, some dams/drinking holes were recorded on the study site although none directly within any proposed activity.

The rivers are grouped into either ephemeral or episodic and are classified up to level 6 according to the SANBI guidelines (Ollis *et al*, 2013) and summarised in the tables below (Table 13 - 15) and indicated in Figure 13 and Figure 14.

Table 13: Level 1- 4 classification of the watercourses recorded on the study site (adapted from Ollis *et al*, 2013).

Level 1: System Type	Level 2: Regional Setting	Level 3: Landscape Setting	Level 4: HGM Unit		
System	DWA Ecoregion	Landscape Unit	Level 4A: Watercourse Type	Level 4B: Longitudinal zonation	Level 4C: Inflow drainage
Inland	Lowveld	Valley Floor	Ephemeral Rivers	Lowland River	Riparian Zone
			Episodic Rivers	Lowland River	Active Channel

Table 14: Level 5 classification of the watercourses recorded on the study site (adapted from Ollis *et al*, 2013).

Level 5: Hydroperiod and depth of inundation		
Level 5A	Proportional Rating (0-6) for wetlands on site	
Inundation Period		
	Ephemeral Rivers (Including the Shingwedzi River)	Episodic Rivers
Permanently Inundated	2	0
Seasonally Inundated	6	5
Intermittently Inundated	5	6
Never/Rarely Inundated	1	3
Unknown		
Level 5A	Proportional Rating (0-6) for wetlands on site	



Level5: Hydroperiod and depth of inundation		
Saturartion periodicity (within 50 cm of the soil surface)		
Permanently Inandated	2	0
Seasonally Inandated	5	2
Intermittently Inandated	1	1
Never/Rarely Inandated	1	1
Unknown		
Level 5C: Inundation depth-class		
	n/a	



Table 15: Level 6 classification of the watercourse recorded on the study site (adapted from Ollis *et al*, 2013).

Component	Dominant categories for selected descriptors (Level 6)							
	Natural vs Artificial		Substratum Type	Vegetation Cover, Form and Status				
	6A: NATural vs Artificial	6B: Artificial Categories	6A: Primary Categories	6A: Vegetation Cover	6B: Primary Vegetation Cover	Detailed Vegetation From		6E: Vegetation Status
6C: Herbaceous Vegetation						6D: Forest Vegetation		
Ephemeral Rivers	Natural	n/a	Sand/Bedrock	Vegetated	Woody	Reeds & Sedges	Riparian Vegetation	Indigenous
Episodic Rivers	Natural	n/a	Sand/Bedrock	Vegetated	Woody	Grasses	Terrestrial Vegetation	Indigenous



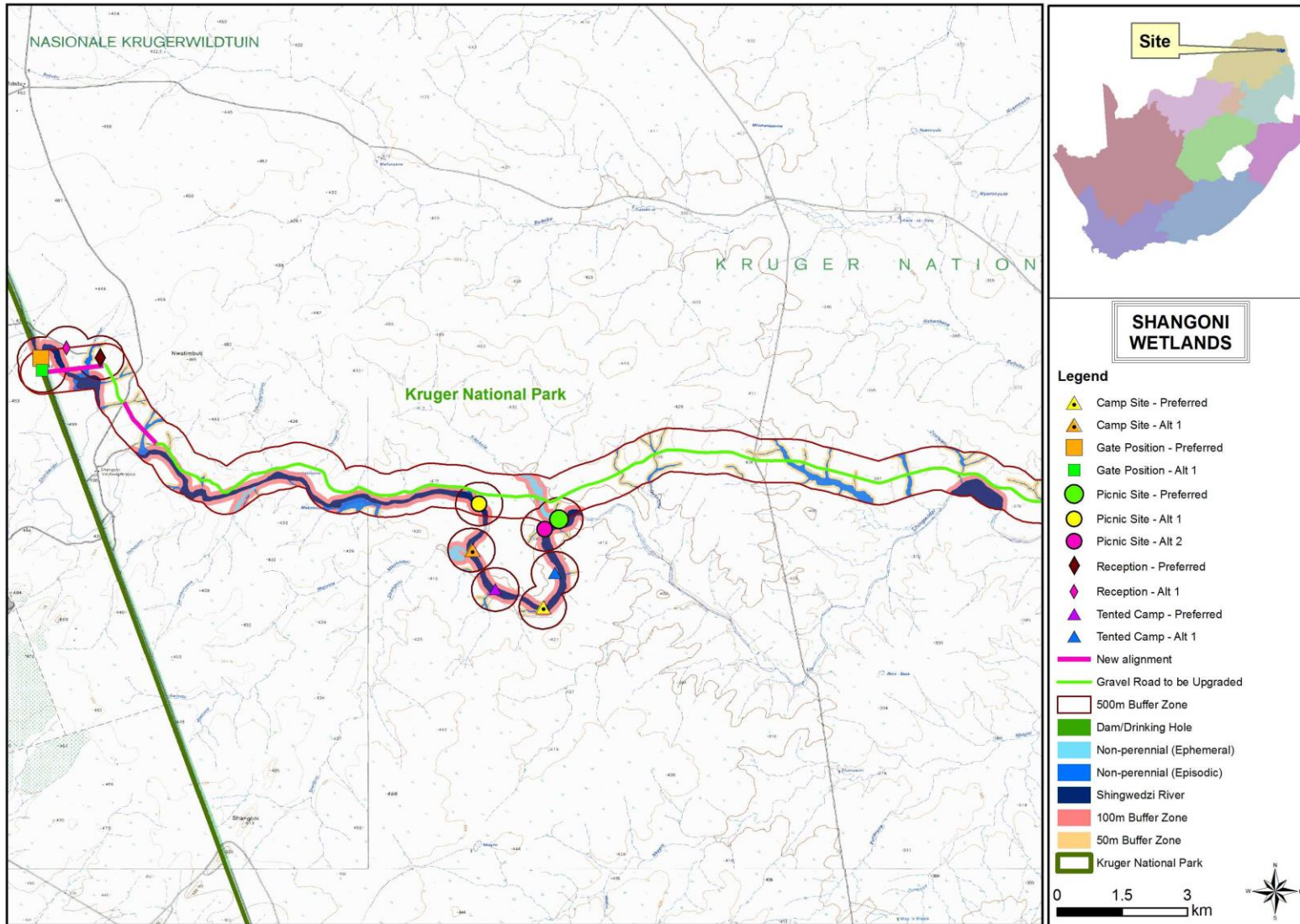


Figure 13: Watercourse sensitivity areas delineated together with associated buffer zones (Section 1).



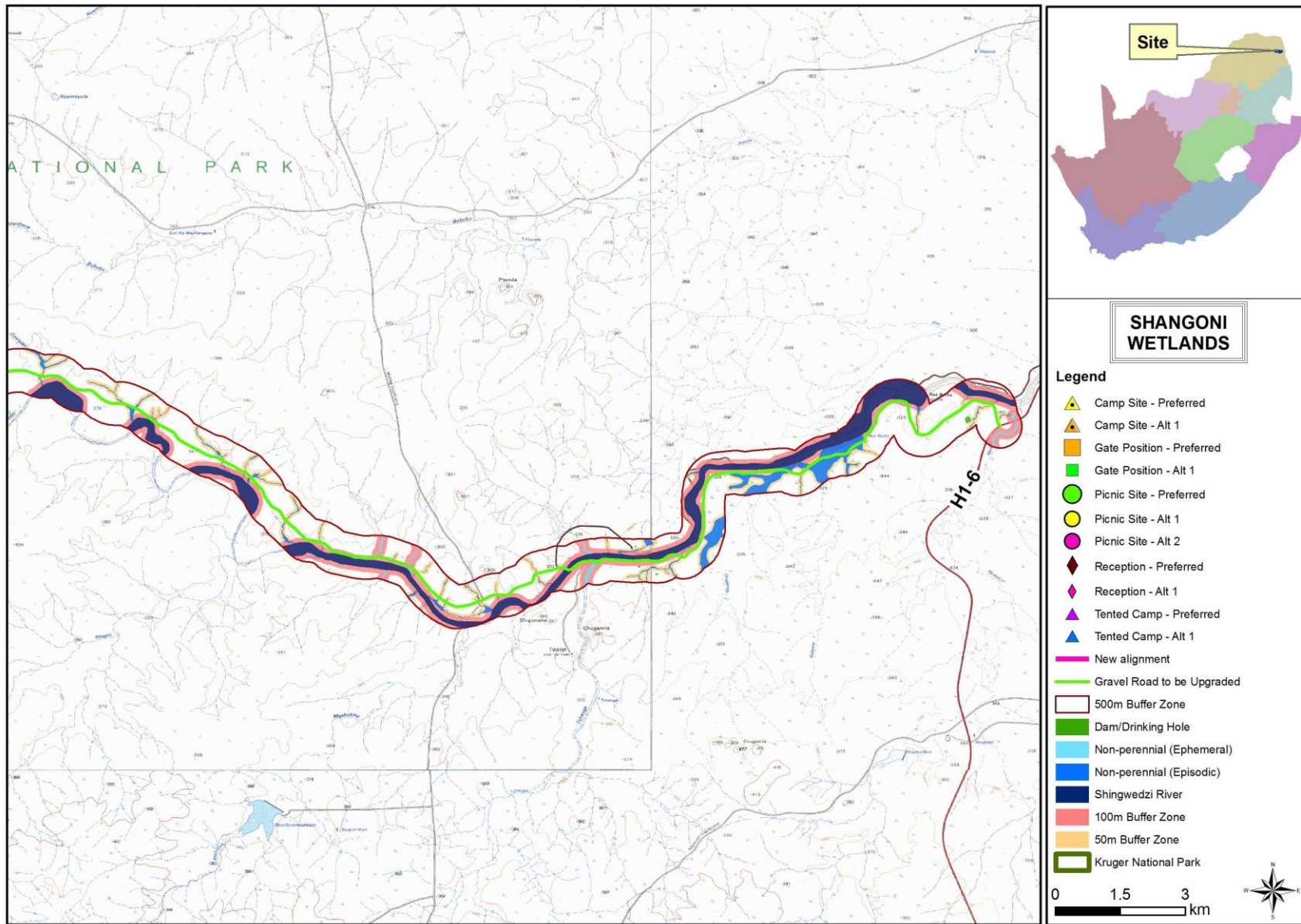


Figure 14: Watercourse sensitivity areas delineated together with associated buffer zones (Section 2).



Both the episodic and ephemeral rivers associated with the study site are characterised by sandy alluvial deposits although some sections of the ephemeral rivers were characterised by large areas of bedrock. Alluvial deposits were also evident near the confluence of the ephemeral rivers indicating high flood peaks at these areas. Furthermore, the ephemeral rivers were characterised by large woody vegetation with short herbaceous vegetation cover with some reeds, and sedges located on the upper macro channel bank while the episodic rivers were characterised by terrestrial vegetation growth albeit slightly more robust growth than the surroundings and a short to medium grass layer. The differentiation of the terrestrial areas and the episodic stream are difficult to distinguish (Figure 15)



Figure 15: General characteristics of the ephemeral and episodic rivers associated with the study area including sandy alluvial deposits, bedrock and the vegetation components of the different systems.



Riparian Vegetation Response Assessment Index (VEGRAI) & Quick Habitat Integrity (QHI)

The biggest current impact associated with the study area and the river in this sub-catchment (DWAF, 2004b), is phosphates from diffuse sources including agricultural run-off and domestic waste-water from the informal settlements. Furthermore, several abandoned mines are located in the catchment some of which have dysfunctional slimes dams that are severely degraded and the run-off could potentially enter the river systems during rain fall events (Fouché & Vlok, 2012)

Although the Kruger National Park was established in 1926 and is therefore not greatly impacted by anthropogenic activities, the presence of some artificial dams such as the Kannidood Dam near the Shingwedzi Rest Camp and the Sirheni Dam near the Sirheni Rest camp has had an impact on the natural flow regime of the river. The majority of the study area can only be accessed by private ranger roads not accessible to the general public and is therefore less impacted than other main roads within the park. Currently the low water bridges located on the smaller episodic streams is inadequate to allow uninterrupted flow of water and has led to erosion at numerous areas. Cognisance should be taken of the extreme flow fluctuations of the rivers in this catchment resulting in regular flooding often exceeding the flood lines up to 200 m and more. Such floods could have devastating impacts on infrastructure located within the flood range. Some impacts recorded within the watercourses are shown in the figures below (Figure 16)



Figure 16: Figures indicating erosion associated with the rivers and the low water bridges.

Riparian Vegetation Response Assessment Index (VEGRAI) and the Quick Habitat Integrity (QHI) assessment was done to determine the Ecological Category (EC) on sections of the Shingwedzi River and random smaller episodic rivers (Table 16-18).



Table 16: Results Ecosystem Services provided by the Shingwedzi and other ephemeral rivers of the study area (Kleynhans *et al*, 2008).

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	80.0	22.9	2.5	2.0	40.0
NON MARGINAL	85.7	61.2	2.5	1.0	100.0
2.0					140.0
LEVEL 3 VEGRAI (%)				84.1	
VEGRAI EC				B	
AVERAGE CONFIDENCE				2.5	

Table 17: Results Ecosystem Services provided by the episodic rivers of the study area (Kleynhans *et al*, 2008).

LEVEL 3 ASSESSMENT					
METRIC GROUP	CALCULATED RATING	WEIGHTED RATING	CONFIDENCE	RANK	% WEIGHT
MARGINAL	80.0	22.9	2.5	2.0	40.0
NON MARGINAL	80.0	57.1	2.5	1.0	100.0
2.0					140.0
LEVEL 3 VEGRAI (%)				80.0	
VEGRAI EC				B/C	
AVERAGE CONFIDENCE				2.5	

Table 18: QHI for the non-perennial and drainage areas on the study site (Seaman *et al*, 2010).

QUATERNARY CATCHMENT	RIVER	Bed modification (0-5)	Flow modification (0-5)	Inundation (0-5)	Riparian/Bank condition (0-5)	Water quality modification (0-5)	DESKTOP HABITAT INTEGRITY	INSTREAM EC%	INSTREAM EC	Vegetation Rating (0-5)	ECOSTATUS %	ECOSTATUS EC	CONFIDENCE (1-5)
B90F	Shingwedzi Ephemeral &	1	1	1	1	2	82.0	82.0	B /C	1	83.0	B	3:MODE RATE
B90G	Episodic Rivers	2	3	1	1	1	75.0	75.0	C	1	78.3	B /C	3:MODE RATE

3.2 Impacts and Mitigation

A development has several impacts on the surrounding environment and particularly on a watercourse. The development changes habitats, the ecological environment, infiltration rates, amount of runoff and runoff intensity of stormwater run-off, and therefore the hydrological regime of the site. Site specific mitigation measures should be included in an Environmental Management Plan and follow the General Rehabilitation and Monitoring Plan accompanying this report

The following potential impacts are listed in the Shangoni Gate Pre-feasibility Study (2013)

For the Bridge:

- Creation or exacerbation of water turbulence causing bank or channel scouring and erosion.
- Impedance of water velocity and debris causing backup and flooding.
- Ecological disturbance to aquatic and bank biodiversity.

For the visitor centre:

- The region is water-scarce.
- Visual impacts must be managed and kept to a minimum.
- The substrate is susceptible to erosion.
- Solid waste will accumulate and will need to be managed.



For the Tented camp and camping area:

- The habitat is critically endangered and susceptible to damage during construction and by visitors when occupied.
- Visual impacts must be managed and kept to a minimum.
- The substrate is highly friable and susceptible to erosion.
- Sewage treatment will need to be managed to avoid contamination of the river system.
- Solid waste will accumulate and will need to be managed.

For the Picnic sites:

- The habitat is critically endangered and susceptible to damage particularly by picnickers.
- The site offers opportunities for predators and other animals to be concealed and a danger to picnickers. Hyenas in particular may be attracted.
- The substrate is highly friable and susceptible to erosion.
- Sewage treatment will need to be managed to avoid contamination of the river system.
- Solid waste will accumulate and will need to be managed.

For the road upgrade:

- Borrow pits for road construction materials would damage the landscape of the Park.
- Large areas of indigenous vegetation would be removed or damaged along the verges of the road.
- Storm water runoff from the impervious surface would need to be managed.

The flowing mitigation measures are recommended in the Shangoni Gate Pre-feasibility Study (2013)

For the Bridge:

- Mitigation of the possible impacts will require engineering design in collaboration with river basin hydrologists and ecologists. In particular, the hydrological disturbance around anchor points in the river basin will need to be avoided.

For the visitor centre:

- Water-wise plumbing and landscaping.
- Aesthetic architectural design to accommodate visual impacts.
- The design of systems for the control of storm water runoff from hard surfaces (paving and roofs).
- Solid waste will need to be stored in a container out of sight and protected from scavengers. Waste should be removed from the site to a central facility or an approved municipal dump on a routine basis, e.g. once a week.

For the Tented camp and camping area:

- Careful siting of tents to minimise disturbance to trees.
- Construction of boardwalks for all pedestrian traffic.
- Good information and control of behaviour by contractors and visitors.
- Water-wise plumbing, sewage treatment and landscaping.



-
- Aesthetic architectural design to accommodate visual impacts.
 - Solid waste will need to be stored in a container out of sight and protected from scavengers. Waste should be removed from the site to a central facility or an approved municipal dump on a routine basis, e.g. once a week.

For the picnic site:

- Careful siting of picnic sites to minimise disturbance to trees.
- Construction of boardwalks for all pedestrian traffic.
- Good information and control of visitor behaviour, especially with regard to wild animals.
- Water-wise plumbing, sewage treatment and landscaping.
- Solid waste will need to be stored in a container out of sight and protected from scavengers. Waste should be removed from the site to a central facility or an approved municipal dump on a routine basis, e.g. once a week.

For the road upgrade:

- Road building material should be sourced from outside of the park wherever possible and borrow pits should be avoided.
- Only the minimum amount of vegetation should be removed to allow for the road alignment. Construction vehicles and machinery should not be driven outside of the road alignment footprint.
- Culverts and drainage systems must be constructed to specification standards that avoid concentrations of flow energy and erosion of drainage line banks. Protective gabions or other structured should be used to prevent turbulence and undercutting.

The following recommendation is recommended (Shangoni Gate Pre-feasibility Study, 2013)

- Lodges and other permanent structures should not be constructed on or near the river banks. Development should be confined to tented camps on timber platforms with inter-leading boardwalks
- Cognizance should be taken of recent flood impacts – not merely the flood levels but also silt deposits, scouring, vegetation damage, etc.
- Trails and other public access along the banks should be on boardwalks.
- Bridges should be designed in consultation with specialist river basin hydrologists.
- The development of the gate could be used to initiate opportunities for community education on water and river use.

The impacts relevant to the proposed activities are likely to include:

- Changing the quantity and fluctuation properties of the watercourse by for example restricting water flow. The sources of these impacts include the compaction of soil, the removal of vegetation, surface water redirection and construction of infrastructure.
- Changing the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount). Construction and operational activities will result in



earthworks and soil disturbance as well as the removal of natural vegetation. This could result in the loss of topsoil, sedimentation of the wetland and increase the turbidity of the water.

- The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity.
- Loss and disturbance of wetland/riparian habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.
- Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/rivers and a reduction in watercourse function as well as human and animal waste. Could possibly impact on groundwater.

Tables 19-23 below indicate the impact scores for the potential impacts relevant to the proposed activities.

Table 19: Changes in water flow regime impact ratings

Nature: Changing the quantity and fluctuation properties of the watercourse by for example restricting water flow.		
ACTIVITY: The sources of this impacts include the compaction of soil, the removal of vegetation, surfacewater redirection of water during construction activities		
	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Highly probable (4)	Probable (3)
Duration	Long term (4)	Short term (3)
Extent	Regional (4)	Limited to Local Area (2)
Magnitude	High (8)	Moderate (6)
Significance	64 (high)	33 (medium)
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Probable (3)
Duration	Long term (5)	Medium term (3)
Extent	Regional (4)	Limited to the site (2)
Magnitude	Moderate (6)	Low (4)
Significance	45 (medium)	27 (low)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	



Mitigation:

- Construction affecting watercourses must be restricted to the dryer winter months.
- A temporary fence or demarcation must be erected around No-Go Areas outside the proposed works area prior to any construction taking place as part of the contractor planning phase when compiling work method statements to prevent access to the adjacent portions of the watercourse.
- Effective stormwater management should be a priority during both construction and operational phase. This should be monitored as part of the EMP. High energy stormwater input into the watercourses should be prevented at all cost. Changes to natural flow of water (surface water as well as water flowing within the soil profile) should be taken into account.
- Impeding water flow during construction

Cumulative impacts: Construction activities may result in cumulative impact to the water courses within the local catchments and beyond. It is very important that protective measures should be put into place and monitored. A rehabilitation plan should be put into action should any degradation be observed as a result from stormwater or sediment input.

Residual Risks: Impacts to the flow characteristics of this watercourse are likely to be permanent unless rehabilitated.

Table 20: Changes in sediment entering and exiting the system impact ratings

Nature: Changes in sediment entering and exiting the system.		
Activity: Changing the amount of sediment entering water resource and associated change in turbidity (increasing or decreasing the amount). Construction and operational activities will result in earthworks and soil disturbance as well as the removal of natural vegetation. This could result in the loss of topsoil, sedimentation of the watercourse and increase the turbidity of the water. Possible sources of the impacts include:		
<ul style="list-style-type: none"> • Earthwork activities during construction • Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil. • Disturbance of soil surface • Disturbance of slopes through creation of roads and tracks adjacent to the watercourse • Erosion (e.g. gully formation, bank collapse) 		
	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Definite (5)	Probable (3)
Duration	Medium-term (3)	Medium-term (3)
Extent	Regional (4)	Regional (4)
Magnitude	High (8)	Low (4)
Significance	75 (high)	33 (moderate)
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Probable (3)	Improbable (2)
Duration	Medium-term (3)	Permanent (4)
Extent	Regional (4)	Limited to the local area (2)
Magnitude	Low (4)	Low (4)



Significance	33 (moderate)	20 (low)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation:		
<ul style="list-style-type: none"> • Consider the various methods and equipment available and select whichever method(s) that will have the least impact on watercourses. • Water may seep into trenching and earthworks. It is likely that water will be contaminated within these earthworks and should thus be cleaned or dissipated into a structure that allows for additional sediment input and slows down the velocity of the water thus reducing the risk of erosion. Effective sediment traps should be installed. • Construction in and around watercourses must be restricted to the dryer winter months where possible. • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area (DWAF, 2005). • Remove only the vegetation where essential for construction and do not allow any disturbance to the adjoining natural vegetation cover. • Rehabilitation plans must be submitted and approved for rehabilitation of damage during construction and that plan must be implemented immediately upon completion of construction. • Cordon off areas that are under rehabilitation as no-go areas using danger tape and steel droppers. If necessary, these areas should be fenced off to prevent vehicular, pedestrian and livestock access. • During the construction phase measures must be put in place to control the flow of excess water so that it does not impact on the surface vegetation. • Protect all areas susceptible to erosion and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas. • Runoff from the construction area must be managed to avoid erosion and pollution problems. • Implementation of best management practices • Source-directed controls • Buffer zones to trap sediments • Monitoring should be done to ensure that sediment pollution is timeously dressed 		
Cumulative impacts: Expected to be high. Should mitigation measure not be implemented and changes made to the bed or banks of watercourse unstable channel conditions may result causing erosion, meandering, increased potential for flooding and movement of bed material, which will result in property damage adjacent to and downstream of the site. Reversing this process is unlikely and should be prevented in the first place.		
Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.		

Table 21: Introduction and spread of alien vegetation impact ratings.

Nature: Introduction and spread of alien vegetation.
Activity: The moving of soil and vegetation resulting in opportunistic invasions after disturbance and the introduction of seed in building materials and on vehicles. Invasions of alien plants can impact on hydrology, by reducing the quantity of water entering a watercourse, and outcompete natural vegetation, decreasing the natural biodiversity. Once in a system alien invasive plants can spread through the catchment. If allowed to seed before control measures are implemented alien plants can



easily colonise and impact on downstream users.		
	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Definite (4)	Probable (3)
Duration	Medium-term (4)	Medium-term (2)
Extent	Limited to Local Area (4)	Limited to Local Area (4)
Magnitude	High (8)	Low (4)
Significance	64 (high)	30 (low)
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Highly probable (2)	Improbable (1)
Duration	Permanent (4)	Permanent (3)
Extent	Limited to Local Area (2)	Limited to the Site (1)
Magnitude	High (6)	Low (4)
Significance	24 (low)	8 (low)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
<p>Mitigation:</p> <ul style="list-style-type: none"> • Weed control • Retain vegetation and soil in position for as long as possible, removing it immediately ahead of construction / earthworks in that area and returning it where possible afterwards. • Monitor the establishment of alien invasive species within the areas affected by the construction and maintenance and take immediate corrective action where invasive species are observed to establish. • Rehabilitate or revegetate disturbed areas 		
<p>Cumulative impacts: Expected to be moderate to high. Construction areas within the watercourses along the proposed road upgrade can experience an increased invasion if mitigation is not implemented or implemented correctly. Regular monitoring should be implemented during construction, rehabilitation including for a period after rehabilitation is completed.</p>		
<p>Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.</p>		

Table 22: Loss and disturbance of watercourse habitat and fringe vegetation impact ratings.

Nature: Loss and disturbance of watercourse habitat and fringe vegetation impact ratings.		
Activity: Direct development within watercourse areas. Loss and disturbance of watercourse habitat and fringe vegetation due to direct development on the watercourse as well as changes in management, fire regime and habitat fragmentation.		
	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Definite (4)	Definite (4)
Duration	Medium-term (4)	Medium-term (2)



Extent	Limited to Local Area (4)	Limited to Local Area (4)
Magnitude	High (8)	High (6)
Significance	64 (high)	48 (moderate)
Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Definite (4)	Probable (3)
Duration	Medium-term (2)	Medium-term (3)
Extent	Limited to Local Area (4)	Regional (4)
Magnitude	High (6)	Low (4)
Significance	48 (moderate)	33 (moderate)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation:		
<ul style="list-style-type: none"> Where construction occurs in the demarcated watercourse and buffer, extra precautions should be implemented to so as to minimise watercourse loss. Other than approved and authorized structure, no other development or maintenance infrastructure is allowed within the delineated watercourse or associated buffer zones. Demarcate the watercourse areas and buffer zones to limit disturbance, clearly mark these areas as no-go areas Weed control in buffer zone Monitor rehabilitation and the occurrence of erosion twice during the rainy season for at least two years and take immediate corrective action where needed. Monitor the establishment of alien invasive species within the areas affected by the construction and take immediate corrective action where invasive species are observed to establish Operational activities should not take place within watercourses or buffer zones, nor should edge effects impact on these areas Operational activities should not impact on rehabilitated or naturally vegetated areas 		
Cumulative impacts: Expected to be moderate. May result in a high degree of irreplaceable loss of resources.		
Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.		

Table 23: Changes in water quality due to foreign materials and increased nutrients impact ratings.

Nature: Changes in water quality due to foreign materials and increased nutrients impact ratings.		
Activity: Construction and operational activities may result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles and the disposal of sewage resulting in the loss of sensitive biota in the wetlands/riparian areas and a reduction in watercourse function as well as human and animal waste.		
	Without mitigation	With mitigation
CONSTRUCTION PHASE		
Probability	Definite (4)	Definite (4)
Duration	Medium-term (4)	Medium-term (2)
Extent	Limited to Local Area (4)	Limited to Local Area (4)
Magnitude	High (8)	High (6)
Significance	64 (high)	48 (moderate)



Status (positive or negative)	Negative	Negative
OPERATIONAL PHASE		
Probability	Definite (4)	Definite (4)
Duration	Medium-term (4)	Medium-term (2)
Extent	Limited to Local Area (4)	Limited to Local Area (4)
Magnitude	High (8)	High (6)
Significance	64 (high)	48 (moderate)
Status (positive or negative)	Negative	Negative
Reversibility	Low	Moderate
Irreplaceable loss of resources?	Low	Low
Can impacts be mitigated?	Yes	
Mitigation:		
<ul style="list-style-type: none"> • Provision of adequate sanitation facilities located outside of the watercourse or its associated buffer zone. • Implementation of appropriate stormwater management around the excavation to prevent the ingress of run-off into the excavation and to prevent contaminated runoff into the watercourse. • Provision of adequate sanitation facilities located outside of the watercourse area or its associated buffer zone • The development footprint must be fenced off from the watercourses and no related impacts may be allowed into the watercourse e.g. water runoff from cleaning of equipment, vehicle access etc. • After construction, the land must be cleared of rubbish, surplus materials, and equipment, and all parts of the land shall be left in a condition as close as possible to that prior to use. • Maintenance of construction vehicles / equipment should not take place within the watercourse or watercourse buffer. • Control of waste discharges • Maintenance of buffer zones to trap sediments with associated toxins • Ensure that no operational activities impact on the watercourse or buffer area. This includes edge effects. • Control of waste discharges and do not allow dirty water from operational activities to enter the watercourse • Ensure that no operational activities impact on the watercourse or buffer area. This includes edge effects. • Control of waste discharges and do not allow dirty water from operational activities to enter the watercourse • Regular independent water quality monitoring should form part of operational procedures in order to identify pollution • Treatment of pollution identified should be prioritized accordingly. 		
Cumulative impacts: Expected to be moderate. Once in the system it may take many years for some toxins to be eradicated.		
Residual Risks: Expected to be limited provided that the mitigation measures are implemented correctly and effective rehabilitation of the site is undertaken where necessary.		



In addition to the impact ratings a risk assessment was completed establish and quantify the 'uncertainty of the outcome' associated with a particular section 21(c) or (i) water use as specified in DWS (2014). The Risk Matrix spreadsheet presented in Table 24 below shows that the expected risk score falls within the Medium to High risk category which refers to risk and impact on watercourses that are notable and require mitigation measures on a higher level, which costs more and require specialist input. Activities which fall within this category should be authorised through a Water Use Licence.

It is important to note that this risk assessment was completed without input of a method statement describing how the proposed roads and camps are likely to be constructed. This information may change the scores obtained in this assessment.

Table 24: DWS (2014) risk assessment matrix for the proposed activities

Activity	Aspect	Impact	Flow Regime	Physico &	Habitat	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of	Frequency of	Legal Issues	Detection	Likelihood	Significance	Risk Rating
																	Moderate
Clearing of vegetation in close proximity to or in a watercourse	Creating Access roads for infrastructure	Impact posed by Damage to bank. Loss of biodiversity & habitat; impeding the flow of the watercourse to	4	3	3	3	3.25	2	4	9.25	1	2	5	2	10	92.5	Moderate
	Maintenance and repair of existing access roads.		2	3	2	2	2.25	2	2	6.25	3	3	1	2	9	56.25	Low
	Vegetation maintenance within watercourses (Reeds, etc.)		2	2	4	2	2.5	2	2	6.5	3	3	1	2	9	58.5	Low
	Creating Safety Clearances		2	2	3	2	2.25	2	2	6.25	3	3	1	2	9	56.25	Low



gates		Siltation; Compaction of soil / rutting Impact on bird/animal species	3	4	3	2	3	2	8	1	4	5	1	11	88	Moderat a
Casting of foundations for poles	Delivery of material		2	2	2	2	2	2	6	1	3	5	1	10	60	Moderat a
*Construction of Roads (Should consider for internal roads- to be defined)	Drainage patterns change due to road levels. Installation of culverts/pipes for stream crossings, Cutting/reshapi ng of river banks , Construction of a low level bridge Denuding the area Creating a platform for Infrastructure	Impeding the flow of water. Damage to banks. Siltation of water course. Erosion of water course.	5	4	4	4	4.25	3	4	11.25	5	5	1	16	180	High



		Moderate				Moderate				Moderate				Moderate			
Erosion Control	Donga Repair and filling for protection of infrastructure.	Altering of banks. Impeding the flow. Changing the water course. Siltation & sedimentation	66	69	72	69	121	121	121	121	121	121	121	121	121	121	
			12	12	12	12	11	11	11	11	11	11	11	11	11	11	
			2	2	2	2	1	1	1	1	1	1	1	1	1	1	
			5	5	5	5	5	5	5	5	5	5	5	5	5	5	
	4		4	4	4	4	4	4	4	4	4	4	4	4	4		
	1		1	1	1	1	1	1	1	1	1	1	1	1	1		
	5.5		5.75	6	5.75	11	11	11	11	11	11	11	11	11	11		
	3.5		3.75	4	3.75	4	4	4	4	4	4	4	4	4	4		
	2		2	2	2	3	3	3	3	3	3	3	3	3	3		
	3		4	4	4	4	4	4	4	4	4	4	4	4	4		
	3		3	3	3	4	4	4	4	4	4	4	4	4	4		
	4		4	4	4	3	3	3	3	3	3	3	3	3	3		
4	4	5	4	5	5	5	5	5	5	5	5	5	5				
Storm Water Management	Creating diversions in existing water courses	Impeding and change the flow. Altering the bank / impeding the flow. Siltation & sedimentation	5	5	5	5	5	5	5	5	5	5	5	5	5		
Putting in berm	5		5	5	5	5	5	5	5	5	5	5	5	5			
Construction of drainage channels	5		5	5	5	5	5	5	5	5	5	5	5	5			



4 CONCLUSION

The proposed development falls within the Shingwedzi/Gyiani district in the Limpopo Province. The project comprises a new entrance gate, a high-water bridge over the Shingwedzi River, a new reception centre with education facilities, a picnic site, a camp site, a tented camp and a ca. 50 kilometer black-topped road routed parallel to the Shingwedzi River which connects with the H1-6 Road linking Shingwedzi and Mopane Rest camps. The new road will be an upgrade of a suitable portion of the gravelled S52 route to Bataleur camp and the graded Shangoni Ranger patrol track. To the east the upgraded road will again cross the Shingwedzi River as well as the Tshanga tributary across low water bridges. Most of the distance the upgraded road will be parallel to the Shingwedzi River and within the riparian area or the buffer area in numerous areas. Most of the the road will be north of the Shingwedzi River, and the section between the Shingwedzi Low Water bridge and the H1-6 will traverse through mopane veld south of the river. A short alignment has to be constructed to connect the western terminal end of the Shangoni Ranger patrol road with the reception centre. The upgraded road will be six meters wide with a one meter shoulder on each side.

The main watercourse likely to be affected by the proposed activities is the Shingwedzi River. The Shingwedzi River is classified as a non-perennial river, ephemeral in nature. Non-perennial ephemeral rivers are defined as rivers that have no active water flow for between 3 – 6 months. A large number of smaller non-perennial rivers are also likely to be impacted by the proposed activities. The majority of these smaller rivers are also classified as non-perennial rivers although they are more likely to be episodic in nature. Episodic rivers are defined as rivers without active water flow for 9 months of the year or more. Both Ephemeral Rivers and Episodic Rivers are further characterised by high variability and high unpredictability as is evident in the occasional flooding of the Shingwedzi River.



Details pertaining to the watercourses are summarised in the table below:

	Wetland Type	Quaternary Catchment and WMA area	Linked to an important River System	Coordinates and Relation to study area	Riparian Vegetation Response Assessment Index (VEGRAI)	Quick Habitat Integrity (QHI)	Buffers	Is the watercourse likely to be impacted by the proposed activity
	Ephemeral Rivers & Shingwedzi River	B90F & B90G - Levuvu and Lethaba	Shingwedzi River	25°40'52.44"S and 27°48'3.26"E	B	B	100 m	Yes
	Episodic Rivers	B90F & B90G - Levuvu and Lethaba	Shingwedzi River	25°40'13.43"S and 27°51'12.02"E	B/C	B/C	50 m	Yes
Does the specialist support the proposed development	Yes, given that mitigation measures discussed in this report are effectively implemented as part of the EMP							
Major concerns	<p>Currently some of the culverts are inadequate.</p> <p>Culverts should be large enough to ensure they do not impede the flow of the water.</p> <p>Sedimentation should also be minimised.</p> <p>The flood peaks should be respected</p>							
Vegetation Type and Importance	The riparian vegetation is classified as endangered.							
CBA and other Important areas	Located in a protected area							



In the absence of dedicated hydrological, groundwater and geohydrological assessments the current assessment finds that a minimum buffer of 100 m from the edge of the Shingwedzi River boundaries should be respected and a 50 m for the remaining non-perennial episodic rivers.

The main concerns associated with the proposed activities include but are not limited to:

- Development within watercourse, thereby diverting or impeding flow
- Vehicles driving in / through the watercourse
- Lack of adequate rehabilitation resulting in invasion by invasive plants
- Earthwork activities when constructing
- Clearing of surface vegetation will expose the soils, which in rainy events would wash through the watercourse, causing sedimentation. In addition, indigenous vegetation communities are unlikely to colonise eroded soils successfully and seeds from proximate alien invasive trees can spread easily into these eroded soil.
- Disturbance of soil surface
- Disturbance of slopes through creation of roads and tracks adjacent to the watercourse
- Erosion (e.g. gully formation, bank collapse)
- Construction, operational and decommissioning activities will result in the discharge of solvents and other industrial chemicals, leakage of fuel/oil from vehicles resulting in the loss of sensitive biota in the riparian areas. Could possibly impact on groundwater

Mitigation measures discussed in this report should be adhered to in order to minimise potential impacts on the watercourses discussed in this report.

The DWS risk assessment scores put the proposed activities into a Medium category which may be needed to be authorized through a Water Use Licence application process.



REFERENCES

- Armstrong A. (2009). WET-Legal:Wetland rehabilitation and the law in South Africa. WRC Report TT 338/09. Water research Commission, Pretoria
- City of Cape Town (2008). Floodplain Management Policy, version 2.0 (draft for comment) City of Cape Town
- Department of Water Affairs (2008): Updated Manual for the Identification and Delineation of Wetlands and Riparian areas.
- Department of Water Affairs (2010). National Water Act, 1998 (Act No 36 of 1998) S21(c) & (i) Water Uses. Version: February 2010. Training Manual.
- Department of Water Affairs and Forestry (1999). Resource Directed Measures for Protection of Water Resources. Volume 4. Wetland Ecosystems Version 1.0. Pretoria
- Department of Water Affairs and Forestry (DWAf). (2004a). National Water Resource Strategy (1st Ed). Publication of the Department of Water Affairs and Forestry, Pretoria, South Africa.
- Department of Water Affairs and Forestry (DWAf). (2004b). Luvuvhu/Letaba Water. Management Area: Internal Strategic Perspective. Prepared by Goba Moahloli. Keeve Steyn (Pty) Ltd in association with Tlou and Matji, Golder Associates Africa. and BKS on behalf of the Directorate: National Water Resources Planning. DWAf. Report No. P WMA 02/000/00/0304.
- Department of Water Affairs and Forestry (2008). Updated Manual for the identification and delineation of wetlands and riparian areas. Department of Water affairs and Forestry. Pretoria. South Africa Second Edition. September 2008.
- Fouché P.S.O and W. Vlok (2012). The Vulnerability of the Shingwedzi River, a Non-Perennial River in a Water Stressed Rural Area of the Limpopo Province, South Africa, Water Pollution, Prof. Nuray Balkis (Ed.), ISBN: 978-953-307-962-2, InTech, Available from: <http://www.intechopen.com/books/water-pollution/thevulnerability-of-the-shingwedzi-river-a-non-perennial-river-in-a-water-stressed-rural-area-of-th>
- Gauteng Department of Agriculture Conservation & Environment (2002). Gauteng Agricultural Potential Atlas. Johannesburg
- Gauteng Department of Agriculture, Conservation & Environment (2012) GDARD Minimum Requirements for Biodiversity Assessments Version 3. Directorate Nature Conservation, Johannesburg.
- Gauteng Department of Agriculture and Rural Development, (2011): Gauteng Conservation Plan Version 3 ArcGIS Spatial data
- Job, N. (2009). Application of the Department of Water Affairs and Forestry (DWAf) Wetland Delineation Method to Wetland Soils of the Western Cape.



-
- Kotze D C, (1999): A system for supporting wetland management decisions. Ph.D. thesis. School of Applied Environmental Sciences, University of Natal, Pietermaritzburg.
- Kotze D.C., Marneweck, G.C., Batchelor, A.L., Lindley, D.S. and Collins, N.B. (2005). WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands
- Macfarlane D.M., Teixeira-Leite A., Goodman P., Bate G and Colvin C. (2010) Draft Report on the Development of a Method and Model for Buffer Zone Determination. Water Research Commission project K5/1789. The Institute of Natural Resources and its Associates
- Marneweck G C, and Batchelor A L, (2002). Wetland classification, mapping and inventory. In: PALMER R W, TURPIE J, MARNEWECK G C, and BATCHELOR A L. Ecological and economic evaluation of wetlands in the upper Olifants River Catchment, South Africa. WRC Report No. 1162/1/02. Water Research Commission, Pretoria
- Mucina L., & Rutherford M. C. (2006). Vegetation Map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. South African National Biodiversity Institute., Pretoria.
- Olis D., Snaddon K., Job., & Mbona N. (2013). Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. SANBI
- SANBI (2009). Further Development of a Proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).
- Seaman M.T., Avenant M.F., Watson M., King J., Armour J., Barker C.H., Dollar E., du Preez P.J., Hughes D., Rossouw L., & van Tonder G. (2010). Developing a Method for Determining the Environmental water Requirements for Ephemeral Systems. Water Research Commission, Pretoria, Report No. TT459/10.
- Schultze R.E. (1997). South African Atlas of Agrohydrology and Climatology. Water Research Commission, Pretoria, Report TT82/96



APPENDIX A: GLOSSARY OF TERMS

Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
Wetland:	<i>“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.”</i> (National Water Act; Act 36 of 1998).



Appendix B: Abbreviated Curriculum Vitae of participating specialists

Name: **ANTOINETTE BOOTSMA nee van Wyk**

ID Number: 7604250013088

Name of Firm: Limosella Consulting

Position: Director - Principal Specialist

SACNASP Status: Professional Natural Scientist # 400222-09 Botany and Ecology

EDUCATIONAL QUALIFICATIONS

- B. Sc (Botany & Zoology), University of South Africa (1997 - 2001)
 - B. Sc (Hons) Botany, University of Pretoria (2003-2005). Project Title: A phytosociological Assessment of the Wetland Pans of Lake Chrissie
 - Short course in wetland delineation, legislation and rehabilitation, University of Pretoria (2007)
 - Short course in wetland soils, Terrasoil Science (2009)
 - MSc Ecology, University of South Africa (2010 - ongoing). Project Title: Natural mechanisms of erosion prevention and stabilization in a Marakele peatland; implications for conservation management
-

PUBLICATIONS

- P.L. Grundling, A Lindstrom., M.L. Pretorius, A. Bootsma, N. Job, L. Delpont, S. Elshahawi, A.P Grootjans, A. Grundling, S. Mitchell. 2015. Investigation of Peatland Characteristics and Processes as well as Understanding of their Contribution to the South African Wetland Ecological Infrastructure Water Research Commission KSA 2: K5/2346
- A.P. Grootjans, A.J.M Jansen , A. Snijdewind, P.C. de Hullu, H. Joosten, A. Bootsma and P.L. Grundling. (In Press). In search of spring mires in Namibia: the Waterberg area revisited
- Haagner, A.S.H., van Wyk, A.A. & Wassenaar, T.D. 2006. *The biodiversity of herpetofauna of the Richards Bay Minerals leases*. CERU Technical Report 32. University of Pretoria.
- van Wyk, A.A., Wassenaar, T.D. 2006. *The biodiversity of epiphytic plants of the Richards Bay Minerals leases*. CERU Technical Report 33. University of Pretoria.
- Wassenaar, T.D., van Wyk, A.A., Haagner, A.S.H, & van Aarde, R.J.H. 2006. *Report on an Ecological Baseline Survey of Zulti South Lease for Richards Bay Minerals*. CERU Technical Report 29. University of Pretoria

KEY EXPERIENCE

The following projects provide an example of the application of wetland ecology on strategic as well as fine scale as well as its implementation into policies and guidelines. (This is not a complete list of projects completed, rather an extract to illustrate diversity);

- Wetland specialist input into the Open Space Management Framework for Linbro Park and Greater Bassonia, City of Johannesburg, 2015
- More than 250 fine scale wetland and ecological assessments in Gauteng, Mpumalanga, KwaZulu Natal, Limpopo and the Western Cape. 2007, ongoing.
- Scoping level assessment to inform a proposed railway line between Swaziland and Richards Bay. April 2013.
- Environmental Control Officer. Management of onsite audit of compliance during the construction of a pedestrian bridge in Zola Park, Soweto, Phase 1 Phase 2 and Phase 3. Commenced in 2010 - 2014.
- Fine scale wetland delineation and functional assessments in Lesotho and Kenya. 2008 and 2009;
- Analysis of wetland/riparian conditions potentially affected by 14 powerline rebuilds in Midrand, Gauteng, as well submission of a General Rehabilitation and Monitoring Plan. May 2013.
- Wetland specialist input into the Environmental Management Plan for the upgrade of the Firgrove Substation, Western Cape. April 2013
- An audit of the wetlands in the City of Johannesburg. Specialist studies as well as project management and integration of independent datasets into a final report. Commenced in August 2007
- Input into the wetland component of the Green Star SA rating system. April 2009;
- A strategic assessment of wetlands in Gauteng to inform the GDACE Regional Environmental Management Framework. June 2008.
- As assessment of wetlands in southern Mozambique. This involved a detailed analysis of the vegetation composition and sensitivity associated with wetlands and swamp forest in order to inform the development layout of a proposed resort. May 2008.
- An assessment of three wetlands in the Highlands of Lesotho. This involved a detailed assessment of the value of the study sites in terms of functionality and rehabilitation opportunities. Integration of the specialist reports socio economic, aquatic, terrestrial and wetland ecology studies into a final synthesis. May 2007.
- Ecological studies on a strategic scale to inform an Environmental Management Framework for the Emakazeni Municipality and an Integrated Environmental Management Program for the Emalahleni Municipality. May and June 2007

Name: **RUDI BEZUIDENHOUDT**

ID Number 880831 5038 081

Name of Firm: Limosella Consulting

Position: Wetland Specialist



SACNASP Status: Certified Natural Scientist SACNASP Reg. No. 500024/13

EDUCATIONAL QUALIFICATIONS

- BSc Hons (Environmental Science), University of South Africa (ongoing)
- B. Sc (Botany & Zoology), University of South Africa (2008 - 2012)
- Short course in Wetland Rehabilitation Principles, University of the Free State (2012)
- Short course in Tools for Wetland Assessment, Rhodes University (2011)
- Short course in Understanding Environmental Impact Assessment, WESSA (2011)
- Short course in SASS 5, Groundtruth (2012)
- Wetland Seminar, ARC-ISCW & IMCG (2011)
- Introduction to Wetlands Seminar, Gauteng Wetland Forum (2010)
- Biomimicry and Constructed Wetlands Workshop, Golder Associates & Water Research Commission (2011)

KEY EXPERIENCE

▶ **Assistant Wetland Specialist**

This entails all aspects of scientific investigation associated with a consultancy that focuses on wetland specialist investigations. This includes the following:

- Approximately 70 specialist investigations into wetland and riparian conditions on strategic, as well as fine scale levels in Gauteng, Limpopo, North-West Province Mpumalanga KwaZulu Natal, Western Cape, Eastern Cape & Northern Cape
- Ensuring the scientific integrity of wetland reports including peer review and publications.

▶ **Assistant – Wetland and Rehabilitation**

This entailed the management of wetland vegetation and rehabilitation related projects in terms of developing proposals, project management, technical investigation and quality control through the following:

▶ **Wetland Ecology**

Experience in the delineation and functional assessment of wetlands and riparian areas in order to advise proposed development layouts, project management, report writing and quality control.

▶ **Environmental Controlling Officer:**

Routine inspection of construction sites to ensure compliance with the City's environmental ordinances, the Environmental Management Program and other laws and by-laws associated with development at or near wetland or riparian areas.



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- Soweto Zola Park 2011-2014

MEMBERSHIPS IN SOCIETIES

- Botanical Society of South African
- SAWS (South African Wetland Society) Founding member
- SACNASP (Certified Natural Scientist)

EMPLOYMENT EXPERIENCE

Wetland Specialist – Limosella Consulting (September 2010 - Ongoing)

Technical Assistant – Afrigis (2008 – 2010)

