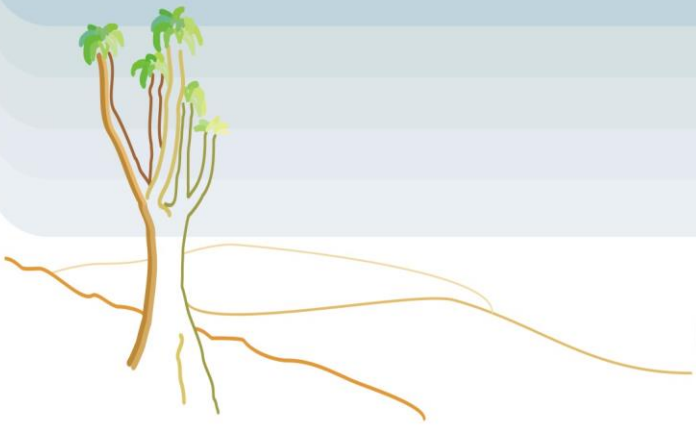

DPR
Ecologists & Environmental Services

Report on the ecological and wetland assessment for the proposed establishment of irrigated cropfields adjacent to the Vaal River near the town of Riverton, Northern Cape Province.

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DECLARATION OF INDEPENDENCE

DPR Ecologists and Environmental Services is an independent company and has no financial, personal or other interest in the proposed project, apart from fair remuneration for work performed in the delivery of ecological services. There are no circumstances that compromise the objectivity of the study.

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Executive Summary

The site consists mostly of natural vegetation though it is clear that a crop field including centre-pivot was present at some time. Therefore, the vegetation on the site, although indigenous, must be of secondary establishment. Notable impacts on the site include the previous clearing of vegetation which has caused significant alteration to the vegetation structure and species composition, soil surface disturbance along the north eastern portion of the site due to alluvial diamond mining operations and linear tranches/canals associated with these mined areas.

The proposed agricultural crop fields will be situated to the north west of the small town of Riverton. The site currently consists of natural vegetation but it is clear that the site was historically also utilised for crop production. The extent of the site is approximately 70 hectares. It is also situated on the eastern bank of the Vaal River which will be utilised to irrigate the crops (Map 1).

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures. Riparian vegetation associated with the Vaal River consists of Highveld Alluvial Vegetation (Aza 5), also listed as being of Least Concern (LC) but does not form part of the proposed site. Furthermore, the natural vegetation type on the site has been transformed and consequently the conservation value is relatively low.

From the description of the vegetation structure and species composition on the site it should be clear that the natural vegetation type has been transformed and that the site is currently still in a pioneer stage and still undergoing succession. From the study of aerial imagery (Google Earth 2005 – 2018) it can clearly be seen how and where the natural vegetation was transformed (Figure 1 – 3). Given time it is possible that the vegetation will be able to re-establish a similar structure and species composition to that of the natural vegetation type in the area.

From the survey of the site it is clear that although it is dominated by natural, indigenous vegetation this is of secondary nature and the natural vegetation type on the site has been completely transformed. The vegetation is in a pioneer stage of succession progressing toward a climax condition. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. The Vaal River, located adjacent to the site, is however highly sensitive and may be affected by the proposed development. It will be discussed in the following sections.

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial

basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

The wetland conditions associated with the Vaal River can be characterised as a channel wetland system (SANBI 2009).

The largest impact on the site itself is considered historical alluvial diamond mining and centre-pivot irrigation which has had a high impact on the site. Consequently almost the entire site consist of indigenous vegetation but which are of secondary establishment and transformed from the natural vegetation type. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

A Risk Assessment for the proposed construction of irrigated cropfields in close proximity to the Vaal River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). The clearing of vegetation and establishment of irrigated cropfields in close proximity to the river is anticipated to have a moderate risk and although the river is not included in the site footprint runoff is still likely to have a significant impact on the river. It is difficult to mitigate irrigation but it is recommended that good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers.

The Vaal River and associated riparian zone should be treated as a no-go area and no construction activities, material or waste should occur or be placed in this area. It is likely an abstraction point will be constructed but impacts associated with this should be kept to a minimum. In order to establish a suitable buffer for the river the Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems (2014) was utilised (Appendix F). By using the above tools a suitable buffer was determined at 26 meters for the Vaal River (Map 1). This buffer should be applied from the edge of the riparian zone.

The impact significance has been determined and it is clear that the impacts before mitigation will vary from low to moderate with the impact on the Vaal River and increased infestation by exotics being the most notable as moderate impacts. Although mitigation from irrigated cropfields are not easily applied it is anticipated that some of the impacts can be decreased to some extent by applying good farming practises including the preservation of the topsoil and responsible use of chemicals including fertilisers. Maintaining the adequate buffer from the edge of the riparian zone of the Vaal River will also decrease the impact on it.

Table of contents

Ecological and wetland assessment.

1. INTRODUCTION

1.1 Background

Natural vegetation is an important component of ecosystems. Some of the vegetation units in a region can be more sensitive than others, usually as a result of a variety of environmental factors and species composition. These units are often associated with water bodies, water transferring bodies or moisture sinks. These systems are always connected to each other through a complex pattern. Degradation of a link in this larger system, e.g. tributary, pan, wetland, usually leads to the degradation of the larger system. Therefore, degradation of such a water related system should be prevented.

Though vegetation may seem to be uniform and low in diversity it may still contain species that are rare and endangered. The occurrence of such a species may render the development unviable. Should such a species be encountered the development should be moved to another location or cease altogether.

South Africa has a large amount of endemic species and in terms of plant diversity ranks third in the world. This has the result that many of the species are rare, highly localised and consequently endangered. It is our duty to protect our diverse natural resources.

South Africa's water resources have become a major concern in recent times. As a water scarce country, we need to manage our water resources sustainably in order to maintain a viable resource for the community as well as to preserve the biodiversity of the system. Thus, it should be clear that we need to protect our water resources so that we may be able to utilise this renewable resource sustainably. Areas that are regarded as crucial to maintain healthy water resources include wetlands, streams as well as the overall catchment of a river system.

Development of agricultural cropfields are necessary to feed an ever-growing population. This promotes food security and contributes to the economy. Areas used for intensive agricultural activities are often degraded due to the clearing of the natural vegetation required for crop cultivation. Though this may often be the case portions of remaining natural vegetation may still consist of sensitive habitats such as watercourses, wetlands or rare vegetation types that need to be conserved. These areas may also contain endangered fauna and flora.

The proposed agricultural cropfields will be situated to the north west of the small town of Riverton. The site currently consists of natural vegetation but it is clear that the site was historically also utilised for crop production. Consequently the vegetation is of secondary establishment and differs significantly from the primary natural vegetation. The extent of the site is approximately 70 hectares. It is also situated on the eastern bank of the Vaal River which will be utilised to irrigate the crops (Map 1).

A site visit was conducted on 15 August 2018. The entire footprint of the agricultural development was surveyed over the period of one day. The site survey was conducted during winter which is not optimal in terms of plant identification although it was still possible to determine a reasonably accurate plant species composition

For the above reasons it is necessary to conduct an ecological and wetland assessment of an area proposed for development.

The report together with its recommendations and mitigation measures should be used to minimise the impact of the proposed development.

1.2 The value of biodiversity

The diversity of life forms and their interaction with each other and the environment has made Earth a uniquely habitable place for humans. Biodiversity sustains human livelihoods and life itself. Although our dependence on biodiversity has become less tangible and apparent, it remains critically important.

The balancing of atmospheric gases through photosynthesis and carbon sequestration is reliant on biodiversity, while an estimated 40% of the global economy is based on biological products and processes.

Biodiversity is the basis of innumerable environmental services that keep us and the natural environment alive. These services range from the provision of clean water and watershed services to the recycling of nutrients and pollution. These ecosystem services include:

- Soil formation and maintenance of soil fertility.
- Primary production through photosynthesis as the supportive foundation for all life.
- Provision of food, fuel and fibre.
- Provision of shelter and building materials.
- Regulation of water flows and the maintenance of water quality.
- Regulation and purification of atmospheric gases.
- Moderation of climate and weather.
- Detoxification and decomposition of wastes.
- Pollination of plants, including many crops.
- Control of pests and diseases.
- Maintenance of genetic resources.

2. SCOPE AND LIMITATIONS

- To evaluate the present state of the vegetation and ecological functioning of the area proposed for the agricultural development.
- To identify possible negative impacts that could be caused by the proposed clearing of vegetation and establishment of an agricultural development.
- Identify and delineate wetland and riparian areas associated with the Vaal River along the western border of the site.
- Determine the Present Ecological State (PES) and Ecological Importance & Sensitivity (EIS) for the Vaal River in the study area.
- Conduct a risk assessment and determine the likelihood that watercourses and wetlands will be adversely affected by the development.

2.1 Vegetation

Aspects of the vegetation that will be assessed include:

- The vegetation types of the region with their relevance to the proposed site.
- The overall status of the vegetation on site.
- Species composition with the emphasis on dominant-, rare- and endangered species.

The amount of disturbance present on the site assessed according to:

- The amount of grazing impacts.
- Disturbance caused by human impacts.
- Other disturbances.

2.2 Fauna

Aspects of the fauna that will be assessed include:

- A basic survey of the fauna occurring in the region using visual observations of species as well as evidence of their occurrence in the region (burrows, excavations, animal tracks, etc.).
- The overall condition of the habitat.

2.3 Wetlands and watercourses

Aspects of the wetlands that will be assessed include:

- Identification and delineation of watercourses including rivers, streams, pans and wetlands.
- Describe condition and status of watercourses and importance relative to the larger system.
- Conduct habitat integrity assessment of perennial systems to inform the condition and status of watercourses.

2.4 Limitations

Due to the season of the survey several bulbs, seasonal herbs and subterranean succulents may have been overlooked as leaves and flowers may be absent due to their seasonal or deciduous nature.
Although a comprehensive survey of the site was done it is still likely that several species were overlooked.
Smaller drainage lines may have been overlooked where a distinct channel or riparian vegetation is absent.
Some animal species may not have been observed as a result of their nocturnal and/or shy habits.

3. METHODOLOGY

3.1 Several literature works were used for additional information.

Vegetation:
Red Data List (Raymondo *et al.* 2009)
Vegetation types (Mucina & Rutherford 2006)
Field guides used for species identification (Adams 1976, Bromilow 1995, 2010, Coates-Palgrave 2002, Gerber *et al* 2004, Gibbs-Russell *et al* 1990, Manning 2009, Roberts & Fourie 1975, Shearing & Van Heerden 2008, Van Ginkel *et al* 2011, Van Oudtshoorn 2004, Van Rooyen 2001, Van Wyk & Malan 1998, Van Wyk & Van Wyk 1997).

Terrestrial fauna:
Field guides for species identification (Smithers 1986a).

Wetland methodology, delineation and identification:
Department of Water Affairs and Forestry 2004, 2005, 2008, Collins 2006, Duthie 1999, Gerber *et al* 2004, Kleynhans 2000, Marnewecke & Kotze 1999, Macfarlane *at el* 2014, Nel *et al* 2011, SANBI 2009, Van Ginkel *et al* 2011.

3.2 Survey

The site was assessed by means of transects and sample plots.

Noted species include rare and dominant species.
The broad vegetation types present on the site were determined.
The state of the environment was assessed in terms of condition, grazing impacts, disturbance by humans, erosion and presence of invader and exotic species.

Animal species were also noted as well as the probability of other species occurring on or near the site according to their distribution areas and habitat requirements.
The state of the habitat was also assessed.

All rivers, streams, pans and wetlands were identified and surveyed where it occurred in the study area.

These systems were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix B & C).
The following guidelines and frameworks were used to determine and delineate the rivers, streams, pans and wetlands in the study area:

- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.
- Marnewecke & Kotze 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

The following guidelines and frameworks were used to determine the sensitivity or importance of these identified watercourses in the study area:

- Nel *et al.* (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

- Government of South Africa. 2008. National Protected Area Expansion Strategy for South Africa 2008: Priorities for expanding the protected area network for ecological sustainability and climate change adaptation. Government of South Africa, Pretoria.

- Duthie, A. 1999. Appendix W5: IER (floodplain and wetlands) determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

These guidelines provide the characteristics which can be utilised to determine if a wetland or watercourse is present and also aids in determining the boundary of these systems.

A Risk Assessment will be conducted for the agricultural operations in the study area in accordance with the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use.

3.3 Criteria used to assess sites

Several criteria were used to assess the site and determine the overall status of the environment.

Vegetation characteristics
Characteristics of the vegetation in its current state. The diversity of species, sensitivity of habitats and importance of the ecology as a whole.

Habitat diversity and species richness: normally a function of locality, habitat diversity and climatic conditions.
Scoring: Wide variety of species occupying a variety of niches – 1, Variety of species occupying a single nich – 2, Single species dominance over a large area containing a low diversity of species – 3.

Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species on a proposed site plays a large role on the feasibility of a development. Depending on the status and provincial conservation policy, presence of a Red Data species can potentially be a fatal flaw.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely – 3.

Ecological function: All plant communities play a role in the ecosystem. The ecological importance of all areas though, can vary significantly e.g. wetlands, drainage lines, ecotones, etc.
Scoring: Ecological function critical for greater system – 1, Ecological function of medium importance – 2, No special ecological function (system will not fail if absent) – 3.

Degree of rarity/conservation value:
Scoring: Very rare and/or in pristine condition – 1, Fair to good condition and/or relatively rare – 2, Not rare, degraded and/or poorly conserved – 3.

Vegetation condition
The sites are compared to a benchmark site in a good to excellent condition. Vegetation management practises (e.g. grazing regime, fire, management, etc.) can have a marked impact on the condition of the vegetation.

Percentage ground cover: Ground cover is under normal and natural conditions a function of climate and biophysical characteristics. Under poor grazing management, ground cover is one of the first signs of vegetation degradation.
Scoring: Good to excellent – 1, Fair – 2, Poor – 3.

Vegetation structure: This is the ratio between tree, shrub, sub-shrubs and grass layers. The ratio could be affected by grazing and browsing by animals.
Scoring: All layers still intact and showing specimens of all age classes – 1, Sub-shrubs and/or grass layers highly grazed while tree layer still fairly intact (bush partly opened up) – 2, Mono-layered structure often dominated by a few unpalatable species (presence of barren patches notable) – 3.

Infestation with exotic weeds and invader plants or encroachers:
Scoring: No or very slight infestation levels by weeds and invaders – 1, Medium infestation by one or more species – 2, Several weed and invader species present and high occurrence of one or more species – 3.

Degree of grazing/browsing impact:
Scoring: No or very slight notable signs of browsing and/or grazing – 1, Some browse lines evident, shrubs shows signs of browsing, grass layer grazed though still intact – 2, Clear browse line on trees, shrubs heavily pruned and grass layer almost absent – 3.

Signs of erosion: The formation of erosion scars can often give an indication of the severity and/or duration of vegetation degradation.
Scoring: No or very little signs of soil erosion – 1, Small erosion gullies present and/or evidence of slight sheet erosion – 2, Gully erosion well developed (medium to large dongas) and/or sheet erosion removed the topsoil over large areas – 3.

Faunal characteristics
Presence of rare and endangered species: The actual occurrence or potential occurrence of rare or endangered species on a proposed site plays a large role on the feasibility of a development. Depending on the status and provincial conservation policy, presence of a Red Data species or very unique and sensitive habitats can potentially be a fatal flaw.
Scoring: Occurrence actual or highly likely – 1, Occurrence possible – 2, Occurrence highly unlikely.

3.4 Biodiversity sensitivity rating (BSR)

The total scores for the criteria above were used to determine the biodiversity sensitivity ranking for the sites. On a scale of 0 – 30, six different classes are described to assess the suitability of the sites to be developed. The different classes are described in the table below:

Table 1: Biodiversity sensitivity ranking

BSR	BSR general floral description	Floral score equating to BSR class
Ideal (5)	Vegetation is totally transformed or in a highly degraded state, generally has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area has lost its inherent ecological function. The area has no conservation value and potential for successful rehabilitation is very low. The site is ideal for the proposed development.	29 – 30
Preferred (4)	Vegetation is in an advanced state of degradation, has a low level of species diversity, no species of concern and/or has a high level of invasive plants. The area's ecological function is seriously hampered, has a very low conservation value and the potential for successful rehabilitation is low. The area is preferred for the proposed development.	26 – 28
Acceptable (3)	Vegetation is notably degraded, has a medium level of species diversity although no species of concern are present. Invasive plants are present but are still controllable. The area's ecological function is still intact but may be hampered by the current levels of degradation. Successful rehabilitation of the area is possible. The conservation value is regarded as low. The area is acceptable for the proposed development.	21 – 25
Not preferred (2)	The area is in a good condition although signs of disturbance are present. Species diversity is high and species of concern may be present. The ecological function is intact and very little rehabilitation is needed. The area is of medium conservation importance. The area is not preferred for the proposed development.	11 – 20
Sensitive (1)	The vegetation is in a pristine or near pristine condition. Very little signs of disturbance other than those needed for successful management are present. The species diversity is very high with several species of concern known to be present. Ecological functioning is intact and the conservation importance is high. The area is regarded as sensitive and not suitable for the proposed development.	0 - 10

4. ECOLOGICAL OVERVIEW OF THE SITE

4.1 Overview of ecology and vegetation types (Mucina & Ruterford 2006)

Refer to the list of species encountered on the site in Appendix B.

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures. Riparian vegetation associated with the Vaal River consists of Highveld Alluvial Vegetation (Aza 5), also listed as being of Least Concern (LC) but does not form part of the proposed site.

The site consists mostly of natural vegetation though it is clear that a crop field including centre-pivot was present at some time. By looking at the current vegetation this must have been several years ago. Therefore, the vegetation on the site, although indigenous, must be of secondary establishment. Vegetation may either be of primary establishment, i.e. it is the natural occurring vegetation type which has never been altered by anthropogenic activities. Or it may be of secondary establishment, i.e. the naturally occurring vegetation has at some stage been cleared by human activity and a natural, though not necessarily representative of the natural vegetation type, vegetation layer has re-established.

Notable impacts on the site include the previous clearing of vegetation which has caused significant alteration to the vegetation structure and species composition, soil surface disturbance along the north eastern portion of the site due to alluvial diamond mining operations and linear tranches/canals associated with these mined areas. Other smaller impacts include a small building on the banks of the Vaal River, an overhead power line and a few small dirt tracks. Impacts associated with the river will be discussed under the wetland assessment in following sections.

The proposed agricultural crop fields will be situated to the north west of the small town of Riverton. The site currently consists of natural vegetation but it is clear that the site was historically also utilised for crop production. Consequently the vegetation is of secondary establishment and differs significantly from the primary natural vegetation. The extent of the site is approximately 70 hectares. It is also situated on the eastern bank of the Vaal River which will be utilised to irrigate the crops (Map 1). The dominant vegetation structure on the site consists of a dense grass layer with a few scattered shrubs and trees which indicates a modification of the natural vegetation structure and riparian thicket dominating along the banks of the Vaal River and considered natural for this area.

The topography of the site is rather uniform and consists of a plain, gently sloping toward the west and the Vaal River (Map 1). Significant portions of the topography on the site has been transformed by previous alluvial diamond mining activities and it is also likely that the historical centre-pivot visible on aerial images has required some levelling of the topography. The topography along the Vaal River seems to remain intact and consists of a steep bank containing a prominent riparian thicket. The elevation of the site varies from 1112 m along the north eastern border and decreases to 1105 along the south western border. This also indicates the gentle though definite slope of the site.

The geology of the area us underlain by the Prince Albert Formation forming part of the Ecca Group within the Karoo Supergroup and is dominated by dark-grey mudrock.

The region has an approximate mean annual rainfall of 280 mm with most rainfall occurring mainly during summer. This is considered a relatively low rainfall and causes the area to form part of the more arid parts of South Africa. The occurrence of wetlands are therefore not common, however, due to the proximity to the Vaal River the area adjacent to the river contains wetland conditions associated with the marginal zone of the river. The average maximum temperature ranges from 18˚C in June to 32˚C in January.

As mentioned previously the dominant vegetation structure on the site consists of a dense grass layer. Over the majority of the site the dominant grass species include *Eragrostis lehmanniana, Enneapogon cenchroides, Cynodon dactylon* and *Chloris virgata*. These are all pioneer species commonly found on old crop fields as is the case at the site. They therefore indicate a degraded and transformed grass layer. Scattered clumps of the climax grass, *Schmidtia pappophoroides*, also occur and indicate that the vegetation is still in the process of succession. Scattered shrubs are mostly represented by *Lucium cinerium*, also an indicator of a pioneer vegetation layer. Several exotic weeds including *Datura ferox, Salsola kali* and *Argemone ochroleuca* also indicates a disturbed vegetation layer. The site is located within the Savannah Biome and as such should contain a well-developed grass layer but also with a prominent tree/shrub layer (Map 2). This layer is absent on the site and therefore indicates that the natural vegetation type on the site has been transformed to a large degree. This is most likely due to the historical ploughing for the centre-pivot cultivation. Toward the north east and outside the footprint of the historical centre-pivot the site has been affected by previous mining activities and here the natural vegetation type has also been transformed to a large degree. The grass layer remains similar to that given above although exotic weeds and dwarf shrubs become more prominent. Additional grass species observed in this area included *Eragrostis echinchloidea, Panicum coloratum* and *Aristida congesta*. The dwarf shrub species noted include *Chrysocoma ciliata* and *Pentzia incana*. These are natural to the increased calcrete and gravel content in this portion of the site. Additional exotic weed species in this area and which confirm a degraded vegetation layer include *Tagetes minuta, Verbena bonariensis* and *Schkuhria pinata*. The exotic and highly invasive tree, *Prosopis* glandulosa was also observed as scattered specimens. The pioneer, indigenous shrub, *Laggera decurrens*, also indicates a pioneer vegetation layer still in the process of succession. A small specimen of *Senagalia melifera* was observed and indictive of succession towards a climax and natural vegetation structure. In this portion of the site a series of longitudinal trenches/canals/excavations are also present. These are clearly of artificial excavation and may be associated with previous mining activities. They indicate a higher moisture regime and it is highly likely that they collect surface runoff. The vegetation in these areas are highly transformed as can be expected. Dominant vegetation includes a small sedge, *Cyperus sp.* and herbs including *Selago densiflora, Arctotis arctotoides, Cullen tomentosum* and *Atriplex semibaccatta*. Exotic weeds similar to those species in the surroundings are also common. The exotic tree species, *Tamarix chinensis*, is also common in these excavations and are often found where surface water accumulates. Stands of reeds, *Phragmites australis*, also confirm the accumulation of surface runoff. These trenches/canals/excavations are however considered as totally artificial and does not represent watercourses or wetlands and also do not perform any significant function, either natural or artificial.

From the description of the vegetation structure and species composition on the site it should be clear that the natural vegetation type has been transformed and that the site is currently still

in a pioneer stage and still undergoing succession. Given time it is possible that the vegetation will be able to re-establish a similar structure and species composition to that of the natural vegetation type in the area.

From the study of aerial imagery (Google Earth 2005 – 2018) it can clearly be seen how and where the natural vegetation was transformed. The earliest available aerial image dating from 2005 indicates that the site was at that time actively cultivated and two centre-pivot irrigation areas are present (Figure 1). In 2007 (Figure 2) cultivation was ceased but it is clear that a large portion of the north east of the site was then subjected to excavation for alluvial diamond mining. This was apparently ceased some time before 2010 (Figure 3) and the site consequently left to re-vegetate itself through succession.

Figure 1: Aerial view of the proposed site (Google Earth 2005). Although a portion of the imagery is not yet available it is clear that two centre-pivot irrigation fields dominate the site and has cleared the natural vegetation.

Figure 2: Aerial view of the proposed site (Google Earth 2007). The centre-pivot footprints are clearly visible but it is evident that cultivation is not taking place anymore. A large mining scar is clearly visible in the northern corner of the site.

Figure 3: Aerial view of the proposed site (Google Earth 2010). It is clear that both irrigation and mining has ceased and the site left to re-vegetate itself.

From the survey of the site it is clear that although it is dominated by natural, indigenous vegetation this is of secondary nature and the natural vegetation type on the site has been completely transformed. The vegetation is in a pioneer stage of succession progressing toward a climax condition. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. The Vaal River,

located adjacent to the site, is however highly sensitive and may be affected by the proposed development. It will be discussed in the following sections.

4.2 Overview of terrestrial fauna (actual & possible)

Tracks and signs of mammals are present on the site but notably diminished from the natural condition. Due to the largely transformed vegetation type on the site and its isolation from larger areas of natural vegetation by surrounding cropfields. Extensive centre-pivot irrigation surround the site and has resulted in the clearance of natural vegetation. Mammal species which are rare and endangered are often habitat specific and sensitive to habitat change. It is therefore considered unlikely that such species would occur on the site.

Numerous small burrows occur on the site and is most likely those of small rodents. These burrows are most likely those of the Multimammate Mouse (*Mastomys coucha*) and the Striped Mouse (*Rhabdomys pumilio*). According to Avenant (2000) where extensive disturbance of grassland occur these species dominate. It has also been shown that these rodent species can be used as indicators of grassland degradation (Avenant & Cavallini 2007, MacFadyen *et al.* 2012). In light of the transformed and pioneer condition of the grassland on the site this is considered the most likely occupants of the small burrows.

A few larger burrows, still of a small mammals, was also identified though seems to be unoccupied at this time.

The Vaal River will contain a much more substantial mammal population and with a more natural species assemblage. Surrounding vegetation transformation by centre-pivot irrigation will influence the mammal population along the river to some extent as a result of the transformation of surrounding habitat. Nonetheless, watercourses are able to sustain a higher bio-load which in turn supports a larger mammal population and it is likely that the mammal population along the river will be substantial. The river will however not form part of the site and because the vegetation on the site is already transformed from the natural vegetation type the impact should remain low.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. However, as discussed, the available habitat is already transformed and mammal population would be much diminished from the natural condition. In addition, agricultural cropfields are still able to sustain a diminished and generalist mammal population. Therefore, the resulting impact of clearing the vegetation for agriculture cannot be considered to have a high impact on the mammal population.

It is also considered likely that several mammal species were overlooked during the survey but owing to the transformed condition of the site and surrounding centre-pivot irrigation areas it is considered highly unlikely that any rare or endangered species would occur on the site.

In order to ensure no direct impact on the mammals on the site occur the hunting, capturing or trapping of mammals on the site should be strictly prohibited.

List of some Red Data terrestrial mammals that could occur in the region:

South African Hedgehog	*Atelerix frontalis*
Aardwolf	*Proteles cristatus*
African Wild Cat	*Felis lybica*
Small-Spotted Cat	*Felis nigripes*
Bat-Eared Fox	*Otocyon megalotis*
Striped Weasel	*Poecilogale albinucha*

It is considered unlikely that any of these species would occur on the site due to the transformed and degraded nature of the available habitat on the site.

4.3 Wetland Assessment

The Vaal River occurring to the west of the site will be discussed below (Map 1).

The term watercourse refers to a river, stream, wetland or pan. The National Water Act (NWA, 1998) includes rivers, streams, pans and wetlands in the definition of the term watercourse. This definition follows:

Watercourse means:

- A river or spring.
- A natural channel in which water flows regularly or intermittently.
- A wetland, lake or dam into which water flows.
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

The classification of stream orders from 1 to 3 can be illustrated by means of the Strahler 1952 classification:

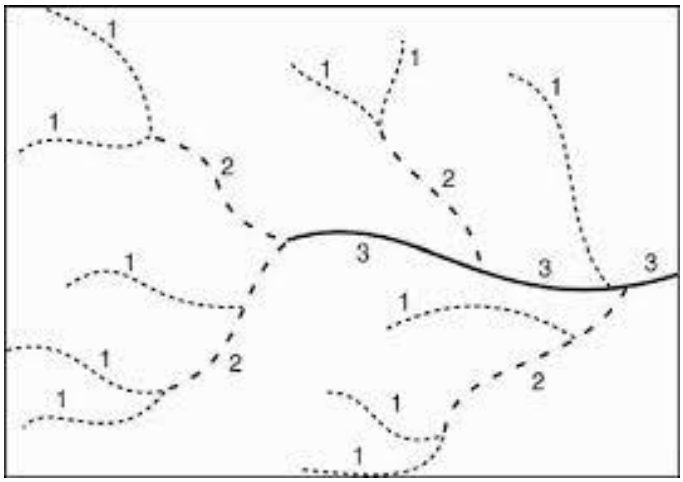


Figure 4: The classification of stream orders from 1 to 3 (Strahler 1952)

Riparian habitat is an accepted indicator of watercourses used to delineate the extent of wetlands, rivers, streams and pans (Department of Water Affairs and Forestry 2005).

The Vaal River and its associated wetland conditions were delineated by use of topography (land form and drainage pattern) and riparian vegetation with limited soil sampling (Appendix C). The following guidelines and frameworks were used to determine and delineate the watercourses and wetlands in the study area:

- Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.
- Marnewecke & Kotze 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

The upper zone contains a minimal grey matrix, no mottles and is not considered as being a wetland area. However, the marginal and lower zone of the Vaal River contains distinctive wetland soil indicators. The banks (Lower Zone) shows indications of a seasonal zone of wetness whilst the Marginal Zone shows soil characters of a permanent zone of wetness. The Vaal River and its banks are clearly defined and easily identifiable. The boundary of the floodplain is not easily identified due to previous transformation by centre-pivot irrigation although the riparian zone is still clearly defined.

4.3.1 Classification of wetland systems

The wetland conditions identified along the Vaal River can be classified into a specific wetland type.

The wetland conditions associated with the Vaal River can be characterised as a channel wetland system (SANBI 2009):

"An open conduit with clearly defined margins that (i) continuously or periodically contains flowing water, or (ii) forms a connecting link between two water bodies. Dominant water sources include concentrated surface flow from upstream channels and tributaries, diffuse surface flow or interflow, and/or groundwater flow. Water moves through the system as concentrated flow and usually exits as such but can exit as diffuse surface flow because of a sudden change in gradient. Unidirectional channel-contained horizontal flow characterises the hydrodynamic nature of these units. Note that, for purposes of the classification system, channels generally refer to rivers or streams (including those that have been canalised) that are subject to concentrated flow on a continuous basis or periodically during flooding, as opposed to being characterised by diffuse flow (see unchannelled valley-bottom wetland). As a result of the erosive forces associated with concentrated flow, channels characteristically have relatively obvious active channel banks. An active channel is a channel that is inundated at sufficiently regular intervals to maintain channel form and keep the channel free of established terrestrial

vegetation. These channels are typically filled to capacity during bankfull discharge (i.e. during the annual flood, except for intermittent rivers that do not flood annually)."

This accurately describes the wetland conditions along the Vaal River (Map 1). Here the wetland conditions are most prominent along the main channel and decrease in distance from the channel.

4.3.2 Description of the Vaal River

The Vaal River was surveyed by two separate locations along the section adjacent to the site. Both locations were very similar in terms of geomorphology, vegetation structure and species composition.

Obligate wetland vegetation was also used to determine the presence of wetland conditions. Obligate wetland species are confined to wetlands and are only able to occur in wetlands. They are therefore reliable indicators of wetland conditions. Field observations over time as well as the following sources were used to determine FW and OW species:

- Marnewecke, G. & Kotze, D. 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

- DWAF. 2008. Updated manual for the identification and delineation of wetlands and riparian areas, prepared by M.Rountree, A.L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

River systems can be divided into different riparian zones within the lateral section of the system. These zones are as follows:

The marginal zone is the lowest zone and is always present in river systems while the other two zones may not always be present. The zone is situated from the water level at low flow, if present, up to the features that are hydrologically activated for the most of the year (Figure 5). The marginal zone within the Vaal River as it occurs within the study area is well defined and easily identifiable by the presence of a dense reedbed (*Phragmites australis*) which is inundated on an annual basis. This is also a listed obligate wetland species. The reedbed is so dense that it almost excludes all other vegetation with a few scattered herbs and exotic weeds occurring. These include the indigenous herb, *Arctotis arctotoides,* and exotic weeds, *Xanthium spinosum* and *Bidens bipinnata*. The width of the marginal zone in the study area is relatively narrow and uniform along the stretch adjacent to the site. The section of Vaal River in close proximity to the site has a length of approximately 400 meters and the areas in closest proximity is approximately 60 meters from the marginal zone of the river. These marginal zones also constitute perennial wetland areas. The marginal zone is largely natural although the dominant reedbeds may indicate a high nutrient content caused by agricultural activities or upstream impacts.

The lower zone is characterised by seasonal features and extends from the marginal zone up to an area of marked elevation. This area may be accompanied by a change in species distribution patterns. The lower zone consists of geomorphic features that are activated on a

seasonal basis (Figure 5). The lower zone along the Vaal River is clearly defined and is easily visible and rather uniform within the study area. The majority of the lower zone is exceedingly steep with a sudden increase in slope over a short distance where after it levels off into the upper zone. The boundary between these zones are relatively easy to discern. The lower zone is inundated infrequently and only during larger flooding events. The riparian vegetation in this zone is dominated by a low shrub and grass layer and the absence of larger trees. Low shrubs include *Lycium cinerium, Diospyros lycioides, Asparagus larcinus* and *Lycium hirsutum*. *Enneapogon cenchroides* is the dominant grass in the lower zone with *Setaria verticillata* common under shrubs. The exotic weeds *Bidens bipinnata* and *Salsola kali* is also common. This vegetation structure can also be explained by the flooding of the lower zone. Large-scale flooding has a disturbance effect whereby vegetation is removed and allows for vegetation to re-establish through an ongoing cycle which is well known in river systems. Trees are also being affected most by flooding due to their increased volume presented to floods. Grasses, sedges and low shrubs are much better adapted to flooding and able to withstand being uprooted to a much better degree. As a result the marginal and lower zones contain almost no trees whereas the upper zone is dominated by trees. The lower zone is largely natural and the geomorphology intact. However, the abundance of pioneer species and exotic weeds do indicate moderate levels of disturbance, most likely as a result of adjacent agricultural activities and upstream impacts.

The upper zone is characterised by ephemeral features as well as the presence of both riparian and terrestrial species. The zone extends from the lower zone to the riparian corridor. The upper zone contains geomorphic features that are hydrologically activated on an ephemeral basis (Figure 5). The upper zone of the Vaal River is clearly visible as a decrease in slope and an increase in the woodland component. The tree species are able to attain height and age due to the deep root systems still able to access the higher moisture levels and as flood disturbance in the upper zone is much less the trees are allowed to grow old without being removed by flood damage. The riparian tree species within the upper zone is dominated by *Vachellia karroo* (Sweetthorn), *Ziziphus mucronata* (Buffalo Thorn), *Searsia lancea* (Karree), *Combretum erythrophyllum* (River Bushwillow) and *Diospyros lycioides* (Bluebush) which then also indicate the border of the upper zone. The understorey also contains a dense but low shrub and climber layer dominated by *Lycium cineriumm, L. hirsutum, Clematis brachiata, Asparagus larcinus* and *Gymnosporia buxiifolia*. The dense shade caused by trees and shrubs cause the establishment of shade loving species including the grass, *Setaria verticillata* and herbs, *Dicliptera leistneri* and *Atriplex semibaccatta*. Exotic weeds are also abundant and include *Bidens bipinnata, Datura ferox, Tagetes minuta, Achyranthes aspera* and *Sphaeralcea bonariensis*. The upper zone is mostly natural and the geomorphology intact though it is clear that some disturbance from adjacent land uses causes disturbance of the vegetation layer.

The floodplain of the Vaal River outside the upper zone is no longer discernible due to historical transformation for the centre-pivot irrigation though the vegetation structure and species composition do differ from the larger terrestrial portion of the site. The vegetation structure is dominated by a more open grass layer as compared to the upper zone, scattered shrubs and the absence of strictly riparian tree species. Dominant grasses include *Cynodon dactylon, Panicum coloratum, Enneapogon cenchroides, Eragrostis lehmanniana* and *Chloris virgata*. Shrubs and small trees include *Lycium cinerium, Vachellia karroo* and *Ziziphus mucronata*. Exotic weeds are abundant here and include *Bidens bipinnata, Tagetes minuta, Datura ferox, Salsola kali, Argemone ochroleuca* and *Xanthium spinosum*. The exotic tree species, *Tamarix chinensis* and *Melia azedarach* are also scattered. These exotic species also indicate the largely transformed nature of the floodplain. Due to the transformed nature of the floodplain it

was not possible to delineate it and delineation was only done for the wetland conditions associated with the river and the edge of the riparian zone.

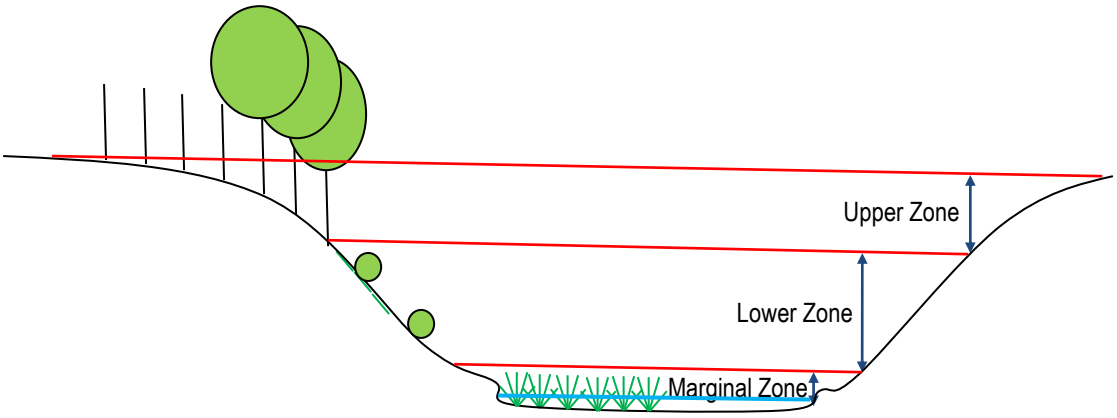


Figure 5: Illustration showing the different riparian zones of the of Vaal River in the study area. This is the situation over the entire length of the section in the study area. Note the narrow marginal zone and steep lower zone.

4.3.3 Condition and importance of the affected watercourses

An Index of Habitat Integrity (IHI) was conducted for the Vaal River for the section adjacent to the site (Appendix D). The IHI will be taken as representative of the Present Ecological State (PES) of this system.

Table 3 refers to the determination and categorisation of the Present Ecological State (PES; health or integrity) of various biophysical attributes of rivers relative to the natural or close to the natural reference condition. The purpose of the EcoClassification process is to gain insights and understanding into the causes and sources of the deviation of the PES of biophysical attributes from the reference condition. This provides the information needed to derive desirable and attainable future ecological objectives for the river (Kleynhans & Louw 2007).

Table 4 refers to the Ecological Importance and Sensitivity (EIS) of wetlands. "Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and Sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC).

Table 3: Ecological categories for Present Ecological Status (PES).

Ecolocial Category	Description
A	Unmodified, natural
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.
C	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominately unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem function has occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 4: Ecological importance and sensitivity categories.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very High Floodplains that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High Floodplains that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal Floodplains that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

The section of the Vaal River within the study area is considered to be Largely Modified by several impacts (Appendix D). The flood dynamics of the river has been altered to a large

degree by the construction of large dams upstream. Extensive centre-pivot irrigation in the surroundings and alluvial diamond mining on the banks and surrounding catchment in upstream areas will also contribute several significant impacts on the river.

Impacts on the Vaal River are many and several are considered as large impacts. Extensive alluvial diamond mining takes place in several areas upstream and downstream of the site. This occurs within the catchment as well as the riparian zone. This will undoubtedly contribute to the sediment load of the river. Historical mining is also evident on the site itself. The impact of historical mining has diminished to some extent as the environment rehabilitates itself although the change in topography and morphology is not rehabilitatable through succession of the environment itself. Centre-pivot irrigation is also extensive in the immediate surroundings and will undoubtedly have significant impacts as a result of fertiliser runoff and enrichment, pesticides and other impacts associated with commercial irrigation. Also coupled with this is abstraction from the river for irrigation and this will also influence the flow regime of the river. Adjacent and upstream areas are also utilised for domestic stock grazing which will have some impact on the sediment load of the river.

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix D). This is also due to the river being a large lowland river. The quaternary catchment of this area is C91E. The largest impact on the site itself is considered historical alluvial diamond mining and centre-pivot irrigation which has had a high impact on the site. Consequently almost the entire site consist of indigenous vegetation but which are of secondary establishment and transformed from the natural vegetation type. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified. This is largely due to the change in flooding regime and other significant upstream impacts as well as historical alluvial diamond mining within the study area.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

4.3.4 Risk Assessment

A Risk Assessment for the proposed construction of irrigated cropfields in close proximity to the Vaal River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). The clearance of vegetation and operation of an irrigated cropfiled adjacent to the river will likely affect it in terms of increased erosion, fertiliser, pesticide and herbicide runoff and this has been assessed within the risk assessment.

The clearing of vegetation and establishment of irrigated cropfields in close proximity to the river is anticipated to have a moderate risk and although the river is not included in the site

footprint runoff is still likely to have a significant impact on the river. It is difficult to mitigate irrigation but it is recommended that good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers.

Moderate Risks: Risk and impact on watercourses are notable and require mitigation measures on a higher level.

For the complete risk assessment please refer to Appendix E.

No.	Phases	Activity	Aspect	Impact	Risk Rating	Confidence level	Control measures
1	Mostly Operational Phase	Clearing of vegetation and establishment of irrigated crop fields.	Impacts associated with irrigation in close proximity to the Vaal River.	Initial clearance of vegetation will cause conditions susceptible to erosion and will most likely increase the sediment load in the river. Operation of irrigated cropfields will involve fertiliser, pesticide and herbicide runoff which impact the water quality of the river.	**M**	**4**	The impact that irrigation in close proximity to the river will have is associated with runoff generated on the cropfields and include increased sediment, fertiliser, pesticide and herbicide runoff. It is difficult to mitigate these impacts but good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers.

4.4 Buffer zone determination

As discussed, the proposed cropfileds will be situated in close proximity to the Vaal River. The Vaal River and associated riparian zone should be treated as a no-go area and no construction activities, material or waste should occur or be placed in this area. It is likely an abstraction point will be constructed but impacts associated with this should be kept to a minimum.

In order to establish a suitable buffer for the river the Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems (2014) was utilised (Appendix F). This determination was also done in conjunction with Macfarlane *et al* (2014). It should be noted that the buffers determined by this model only caters for impacts associated with diffuse-source surface runoff and will not take into account groundwater movement. By using the above tools a suitable buffer was determined at 26 meters for the Vaal River (Map 1). This buffer should be applied from the edge of the riparian zone.

5. ANTICIPATED IMPACTS

Anticipated impacts that the development will have is primarily concerned with the loss of habitat and species diversity but will also include impacts on the adjacent Vaal River.

The site consists of a grassland layer which is transformed from the natural vegetation type, dominated by pioneer species and currently in the process of succession. Consequently the species diversity is also relatively low. In addition, the vegetation type present on the site is currently listed as being of Least Concern (LC) and therefore does not have a high conservation value (Map 2). As a result the loss of habitat and species diversity can therefore not be considered as a high impact.

No protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site which has been transformed to a large degree.

The Vaal River is located adjacent to the site and will therefore not be affected directly by the development (Map 1). However, it is highly likely that indirect impacts associated with runoff from the site will affect it. The clearance of vegetation and operation of an irrigated cropfield adjacent to the river will likely affect it in terms of increased erosion, fertiliser, pesticide and herbicide runoff. It is difficult to mitigate irrigation but it is recommended that good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers. Furthermore, keeping a buffer zone of 26 meters from the edge of the riparian zone will minimise these impacts (Map 1). The required authorisations must also be lodged with the Department of Water and Sanitation (DWS) for the establishment of irrigated cropfields in close proximity to the river.

Agricultural crop production is often associated with an increase in exotic weeds. This is due to the clearance of the natural vegetation and mono-culture of a single crop. This also leaves the adjacent natural areas susceptible to infestation due to the edge-effect. This is difficult to mitigate although it is recommended that weed control on the cropfields and adjacent areas be implemented in line with general farming practises.

The most significant impact on mammals anticipated on the site itself is primarily concerned with the loss and fragmentation of available habitat. Transformation of the natural vegetation on the site will result in a decrease in the population size as available habitat decreases. However, as discussed, the available habitat is already transformed and mammal population would be much diminished from the natural condition. In addition, agricultural cropfields are still able to sustain a diminished and generalist mammal population. Therefore, the resulting impact of clearing the vegetation for agriculture cannot be considered to have a high impact on the mammal population. In order to ensure no direct impact on the mammals on the site occur the hunting, capturing or trapping of mammals on the site should be strictly prohibited.

The impact significance has been determined and it is clear that the impacts before mitigation will vary from low to moderate with the impact on the Vaal River and increased infestation by exotics being the most notable as moderate impacts. Although mitigation from irrigated cropfields are not easily applied it is anticipated that some of the impacts can be decreased to some extent by applying good farming practises including the preservation of the topsoil and responsible use of chemicals including fertilisers. Maintaining the adequate buffer from the edge of the riparian zone of the Vaal River will also decrease the impact on it.

Please refer to Appendix G for the impact methodology.

Significance of the impact:

Impact	Severity	Duration	Extent	Consequence	Probability	Frequency	Likelihood	Significance
Before Mitigation								
Loss of vegetation type and clearing of vegetation	2	4	2	2.6	4	3	3.5	9.1
Loss of protected species	1	5	2	2.6	1	1	1	2.6
Impact on watercourses	4	4	4	4	4	3	3.5	14
Infestation with weeds and invaders	3	4	3	3.3	4	3	3.5	11.5
Impact on Terrestrial fauna	2	4	2	2.6	3	3	3	7.8
After Mitigation								
Loss of vegetation type and clearing of vegetation	2	4	2	2.6	4	3	3.5	9.1
Loss of protected species	1	5	2	2.6	1	1	1	2.6
Impact on watercourses	3	4	3	3.3	4	3	3.5	11.5
Infestation with weeds and invaders	3	4	2	3	3	3	3	9
Impact on Terrestrial fauna	2	4	2	2.6	3	3	3	7.8

6. SITE SPECIFIC RESULTS

Habitat diversity and species richness:
The natural vegetation type on the site has largely been transformed and is consequently rather uniform with a low diversity of habitats. As a result the species diversity is also low.

Presence of rare and endangered species:
No protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site which has been transformed to a large degree.

Ecological function:
The ecological function of the site has been altered to a significant degree. The site functions as habitat for a variety of fauna, supports a specific vegetation type and also functions as part of the catchment of the adjacent Vaal River. However, the vegetation type on the site has been transformed to a large degree and the resultant habitat provided to fauna is also altered and unable to sustain the natural population. Its functioning as part of the catchment of the river is still intact but altered to some extent due to the alteration of the topography and consequently the runoff patterns. This function is however also still considered as important to the adjacent Vaal River.

Degree of rarity/conservation value:
According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures. Riparian vegetation associated with the Vaal River consists of Highveld Alluvial Vegetation (Aza 5), also listed as being of Least Concern (LC) but does not form part of the proposed site. Furthermore, the natural vegetation type on the site has been transformed and consequently the conservation value is relatively low.

Although degraded the Vaal River still plays a vital role in water transport and is therefore considered to have a high conservation value. Although it does not form part of the site any impacts on it should still kept to a minimum.

Percentage ground cover:
The percentage vegetation cover is moderate and dominated by a dense grass layer.

Vegetation structure:
The vegetation structure on the site is modified to large extent in comparison to the natural condition. The site is situated within the Savannah Biome and as such should contain a well-developed grass layer but also with a prominent tree/shrub layer. This layer is absent on the site and therefore indicates that the natural vegetation type on the site has been transformed to a large degree.

Infestation with exotic weeds and invader plants:
Numerous exotic weeds occur on the site and may become quite abundant in some areas.

Degree of grazing/browsing impact:
Grazing by domestic stock is considered as moderate.

Signs of erosion:
Signs of erosion is not highly prominent but a moderate level of erosion is considered to be present.

Terrestrial animals:
Tracks and signs of mammals are present on the site but notably diminished from the natural condition. Due to the largely transformed vegetation type on the site and its isolation from larger areas of natural vegetation by surrounding cropfields. Extensive centre-pivot irrigation surround the site and has resulted in the clearance of natural vegetation. Mammal species which are rare and endangered are often habitat specific and sensitive to habitat change. It is therefore considered unlikely that such species would occur on the site.

Table 2: Biodiversity Sensitivity Rating for the proposed agricultural development.

	Low (3)	Medium (2)	High (1)
Vegetation characteristics			
Habitat diversity & Species richness	3		
Presence of rare and endangered species	3		
Ecological function		2	
Uniqueness/conservation value		2	
Vegetation condition			
Percentage ground cover		2	
Vegetation structure	3		
Infestation with exotic weeds and invader plants or encroachers	3		
Degree of grazing/browsing impact		2	
Signs of erosion		2	
Terrestrial animal characteristics			
Presence of rare and endangered species	3		
Sub total	15	10	0
Total		25	

7. BIODIVERSITY SENSITIVITY RATING (BSR) INTERPRETATION

Table 3: Interpretation of Biodiversity Sensitivity Rating.

Site	Score	Site Preference Rating	Value
agricultural development	25	Acceptable	3

8. DISCUSSION AND CONCLUSION

The site proposed for the agricultural irrigated cropfields development has been rated as being acceptable for this development. This is mostly as a result of the already transformed nature of the natural vegetation type occurring on the site.

The site consists mostly of natural vegetation though it is clear that a crop field including centre-pivot was present at some time. Therefore, the vegetation on the site, although indigenous, must be of secondary establishment.

Notable impacts on the site include the previous clearing of vegetation which has caused significant alteration to the vegetation structure and species composition, soil surface disturbance along the north eastern portion of the site due to alluvial diamond mining operations and linear tranches/canals associated with these mined areas.

The proposed agricultural crop fields will be situated to the north west of the small town of Riverton. The site currently consists of natural vegetation but it is clear that the site was historically also utilised for crop production. The extent of the site is approximately 70 hectares. It is also situated on the eastern bank of the Vaal River which will be utilised to irrigate the crops (Map 1). The dominant vegetation structure on the site consists of a dense grass layer with a few scattered shrubs and trees which indicates a modification of the natural vegetation structure and riparian thicket dominating along the banks of the Vaal River and considered natural for this area.

According to Mucina & Rutherford (2006) the area consists of Kimberley Thornveld (SVk 4). This vegetation type is currently listed as being of Least Concern (LC) under the National List of Threatened Ecosystems (Notice 1477 of 2009) (National Environmental Management Biodiversity Act, 2004) (Map 2). The vegetation type is not currently subjected to any pronounced transformation pressures. Riparian vegetation associated with the Vaal River consists of Highveld Alluvial Vegetation (Aza 5), also listed as being of Least Concern (LC) but does not form part of the proposed site. Furthermore, the natural vegetation type on the site has been transformed and consequently the conservation value is relatively low.

From the description of the vegetation structure and species composition on the site it should be clear that the natural vegetation type has been transformed and that the site is currently still in a pioneer stage and still undergoing succession. From the study of aerial imagery (Google Earth 2005 – 2018) it can clearly be seen how and where the natural vegetation was transformed (Figure 1 – 3). Given time it is possible that the vegetation will be able to re-establish a similar structure and species composition to that of the natural vegetation type in the area.

From the survey of the site it is clear that although it is dominated by natural, indigenous vegetation this is of secondary nature and the natural vegetation type on the site has been completely transformed. The vegetation is in a pioneer stage of succession progressing toward a climax condition. As a consequence the conservation value of the ecology on the site is relatively low. The habitat and species diversity is consequently also very low. Furthermore, being dominated by pioneer species no protected, rare or endangered species could be identified on the site. Such species are often adapted to specialised habitats in good conditions and it is therefore highly unlikely that such a species would occur on the site. The Vaal River,

located adjacent to the site, is however highly sensitive and may be affected by the proposed development. It will be discussed in the following sections.

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to determine the border and also to confirm the presence of wetland soils along the banks of the Vaal River (Appendix C). Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils. The soil samples taken along the banks of the Vaal River are clearly indicative of wetland conditions on a perennial basis (Map 1). The marginal and lower zones of the Vaal River contain distinctive wetland soil indicators. The Marginal Zone shows soil characters of a permanent zone of wetness.

The upper zone contains a minimal grey matrix, no mottles and is not considered as being a wetland area. However, the marginal and lower zone of the Vaal River contains distinctive wetland soil indicators. The banks (Lower Zone) shows indications of a seasonal zone of wetness whilst the Marginal Zone shows soil characters of a permanent zone of wetness. The Vaal River and its banks are clearly defined and easily identifiable. The boundary of the floodplain is not easily identified due to previous transformation by centre-pivot irrigation although the riparian zone is still clearly defined. Due to the transformed nature of the floodplain it was not possible to delineate and delineation was only done for the wetland conditions associated with the river and the edge of the riparian zone.

The wetland conditions associated with the Vaal River can be characterised as a channel wetland system (SANBI 2009).

The Vaal River and its associated floodplains are considered a fifth order watercourse (Appendix D). The quaternary catchment of this area is C91E. The largest impact on the site itself is considered historical alluvial diamond mining and centre-pivot irrigation which has had a high impact on the site. Consequently almost the entire site consist of indigenous vegetation but which are of secondary establishment and transformed from the natural vegetation type. This will undoubtedly also have an impact on the ecological functioning of the Vaal River. Upstream impacts are also numerous and cause alteration in the functioning of the river. The most prominent impacts are the upstream alluvial diamond mining and construction of containment dams which alter the flooding regime and the functioning and habitat of the river and its floodplains. An Index of Habitat Integrity (IHI) was conducted along the Vaal River within the study area (Appendix D). The results of the IHI indicated that the Vaal River has an Instream IHI of category C/D: Moderately to Largely Modified and Riparian IHI of category D: Largely Modified. This is largely due to the change in flooding regime and other significant upstream impacts as well as historical alluvial diamond mining within the study area.

The EI&S of the floodplains associated with the Vaal River has been rated as being Moderate: Floodplains that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains are not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.

A Risk Assessment for the proposed construction of irrigated cropfields in close proximity to the Vaal River has been undertaken according to the Department of Water & Sanitation's requirements for risk assessment and the provisional Risk Assessment Matrix for Section 21(c) & (i) water use (Appendix E). The clearing of vegetation and establishment of irrigated cropfields in close proximity to the river is anticipated to have a moderate risk and although the

river is not included in the site footprint runoff is still likely to have a significant impact on the river. It is difficult to mitigate irrigation but it is recommended that good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers.

The Vaal River and associated riparian zone should be treated as a no-go area and no construction activities, material or waste should occur or be placed in this area. It is likely an abstraction point will be constructed but impacts associated with this should be kept to a minimum. In order to establish a suitable buffer for the river the Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems (2014) was utilised (Appendix F). It should be noted that the buffers determined by this model only caters for impacts associated with diffuse-source surface runoff and will not take into account groundwater movement. By using the above tools a suitable buffer was determined at 26 meters for the Vaal River (Map 1). This buffer should be applied from the edge of the riparian zone.

The impact significance has been determined and it is clear that the impacts before mitigation will vary from low to moderate with the impact on the Vaal River and increased infestation by exotics being the most notable as moderate impacts. Although mitigation from irrigated cropfields are not easily applied it is anticipated that some of the impacts can be decreased to some extent by applying good farming practises including the preservation of the topsoil and responsible use of chemicals including fertilisers. Maintaining the adequate buffer from the edge of the riparian zone of the Vaal River will also decrease the impact on it.

9. REFERENCES

Adams, J. 1976. Wild flowers of the Northern Cape. The Department of Nature and Environmental Conservation of the Provincial Administration of the Cape of Good Hope, Cape Town.

Avenant, N.L. 2000. Small mammal community characteristics as indicators of ecological disturbance in the Willem Pretorius Nature Reserve, Free State, South Africa. *South African Journal of Wildlife Reserves* 30(1): 26-33.

Bromilow, C. 1995. Problem Plants of South Africa. Briza Publications CC, Cape Town.

Bromilow, C. 2010. Problem plants and alien weeds of South Africa. Briza Publications CC, Cape Town.

Coates-Palgrave, M. 2002. Keith Coates-Palgrave Trees of Southern Africa, edn 3, imp. 4. Random House Struik (Pty.) Ltd, Cape Town.

Collins, N.B. 2005. Wetlands: The basics and some more. Free State Department of Tourism, Environmental and Economic Affairs.

Conservation of Agricultural Resources Act, 1983 (ACT No. 43 OF 1983) Department of Agriculture.

Department of Water Affairs and Forestry. 2005. A practical field procedure for identification and delineation of wetlands and riparian areas. Edition 1. Department of Water Affairs and Forestry, Pretoria.

Duthie, A. 1999. Appendix W5: IER (floodplain and wetlands) determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

DWAF. 2008. Updated manual for the identification and delineation of wetlands and riparian areas, prepared by M.Rountree, A.L. Batchelor, J. MacKenzie and D. Hoare. Stream Flow Reduction Activities, Department of Water Affairs and Forestry, Pretoria, South Africa.

Gerber, A., Cilliers, C.J., Van Ginkel, C. & Glen, R. 2004. Easy identification of aquatic plants. Department of Water Affairs, Pretoria.

Government of South Africa. 2008. National Protected Area Expansion Strategy for South Africa 2008: Priorities for expanding the protected area network for ecological sustainability and climate change adaptation. Government of South Africa, Pretoria.

Germishuizen, G. & Meyer, N.L. (eds) 2003. Plants of Southern Africa: an annotated checklist. *Strelitzia* 14. National Botanical Institute, Pretoria.

Gerber, A., Cilliers, C.J., Van Ginkel, C. & Glen, R. 2004. Easy identification of aquatic plants. Department of Water Affairs, Pretoria.

Gibbs Russell, G.E., Watson, L., Koekemoer, M., Smook, L., Barker, N.P., Anderson, H.M. & Dallwitz, M.J. 1990. Grasses of Southern Africa. Memoirs of the Botanical Survey of South Africa No. 58. Botanical Research Institute, South Africa.

Google Earth V 7.3.2.5491. 2005-2010. Kilmorey, South Africa. S 28.492963°, E 24.654224°°. Eye alt. 2.93 km. Digital Globe 2018. http://www.earth.google.com (August 2018).

Kleynhans, C.J. 2000. Desktop estimates of the ecological importance and sensitivity categories (EISC), default ecological management classes (DEMC), present ecological status categories (PESC), present attainable ecological management classes (present AEMC), and best attainable ecological management class (best AEMC) for quaternary catchments in South Africa. DWAF report, Institute for Water Quality Studies, Pretoria, South Africa.

Kleynhans, C.J. & Louw, M.D. 2007. Module A: EcoClassification and EcoStatus determination in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 329/08.

Kleynhans, C.J., Louw, M.D. & Graham, M. 2008. Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical Manual). Joint Water Research Commission and Department of Water Affaris and Forestry Report. WRC Report No. TT 377-08.

MacFadyen, D.N., Avenant, N.L., Van Der Merwe, M. & Bredenkamp, G.J. 2012. The influence of fire on rodent abundance at the N'washitshumbe enclosure site, Kruger National Park, South Africa. *African Zoology* 47(1): 138-146.

Macfarlane, D.M., Bredin, I.P., Adams, J.B., Zungu, M.M., Bate, G.C. and Dickens, C.W.S. (2014). Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries. Final Consolidated Report. WRC Report No TT 610/14, Water Research Commission, Pretoria.

Manning, J. 2009. Field Guide to Wild Flowers. Struik Nature, Cape Town.

Marnewecke, G. & Kotze, D. 1999. Appendix W6: Guidelines for delineation of wetland boundary and wetland zones. In: MacKay (Ed.), H. Resource directed measures for protection of water resources: wetland ecosystems. Department of Water Affairs and Forestry, Pretoria.

Mucina, L. & Rutherford, M.C. (eds.) 2006. The Vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19.South African National Biodiversity Institute, Pretoria.

National Environmental Management: Biodiversity Act (10/2004): National list of ecosystems that are threatened and in need of protection. Government Notice 1002 of 2011, Department of Environmental Affairs.

National Water Act (Act No. 36 of 1998). Republic of South Africa.

Nel, J.L., Murray, K.M., Maherry, A.M., Petersen, C.P., Roux, D.J., Driver, A., Hill, L., Van Deventer, H., Funke, N., Swartz, E.R., Smith-Adao, L.B., Mbona, N., Downsborough, L. and

Nienaber, S. (2011). Technical Report for the National Freshwater Ecosystem Priority Areas project. WRC Report No. K5/1801.

Raymondo, D. Van Staden, L. Foden, W. Victor, J.E. Helme, N.A. Turner, R.C. Kamundi, D.A. Manyama, P.A. (eds.) 2009. Red List of South African Plants. *Strelitzia* 25. South African National Biodiversity Institute, Pretoria.

Roberts, B.R. & Fourie, J.H. 1975. Common grasses of the Northern Cape. Northern Cape Livestock Co-Operative Limited, Vryburg.

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).

Shearing, D. & Van Heerden, K. 2008. Karoo: South African wild flower guide 6. Botanical Society of South Africa, Cape Town.

Smithers, R.H.N. 1986a. Land Mammals of Southern Africa. Macmillan, Johannesburg.

Smithers, R.H.N. 1986b. South African Red Data Book - Terrestrial Mammals. *South African National Scientific Programmes Report No. 125.* A report for the Committee for Nature Conservation Research National Programme for Ecosystem Research.

Van Ginkel, C.E., Glen, R.P., Gordon-Grey, K.D., Cilliers, C.J., Musaya, M. & Van Deventer, P.P. 2011. Easy Identification of some South African Wetland Plants. WRC Report No. TT 479/10.

Van Oudtshoorn, F. 2004. Gids tot Grasse van Suider-Afrika. Briza Publications, Pretoria.

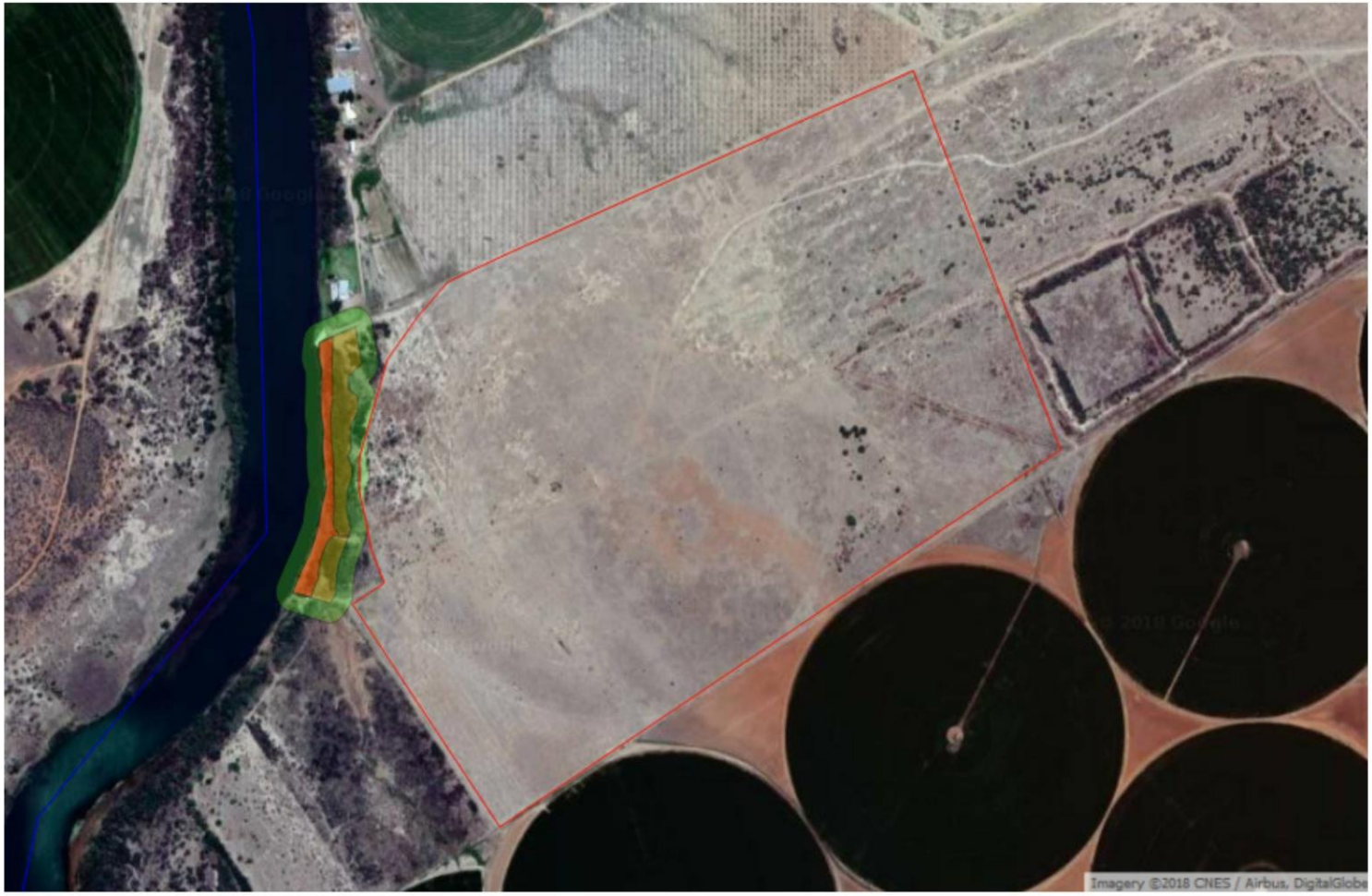
Van Rooyen, N. 2001. Flowering plants of the Kalahari dunes. Ekotrust CC, Lynnwood.

Van Wyk, B. & Malan, S. 1998. Field guide to the wild flowers of the Highveld. Struik Publishers, Cape Town.

Van Wyk, B. & Van Wyk, P. 1997. Field guide to trees of Southern Africa. Struik Publishers, Cape Town.

Annexure A: Maps and Site photos

Wetland delineation for the proposed establishment of irrigated cropfields adjacent to the Vaal River near the town of Riverton, Northern Cape Province.



Preparred for:
Turn 180 Environmental Consultants
Suite 221, Private Bag X01
Brandhof
9324

Legend:

- Approximate site boundary (Study Area)
- Vaal River
- Wetland areas
- Riparian zone
- 26 m buffer

Map Information

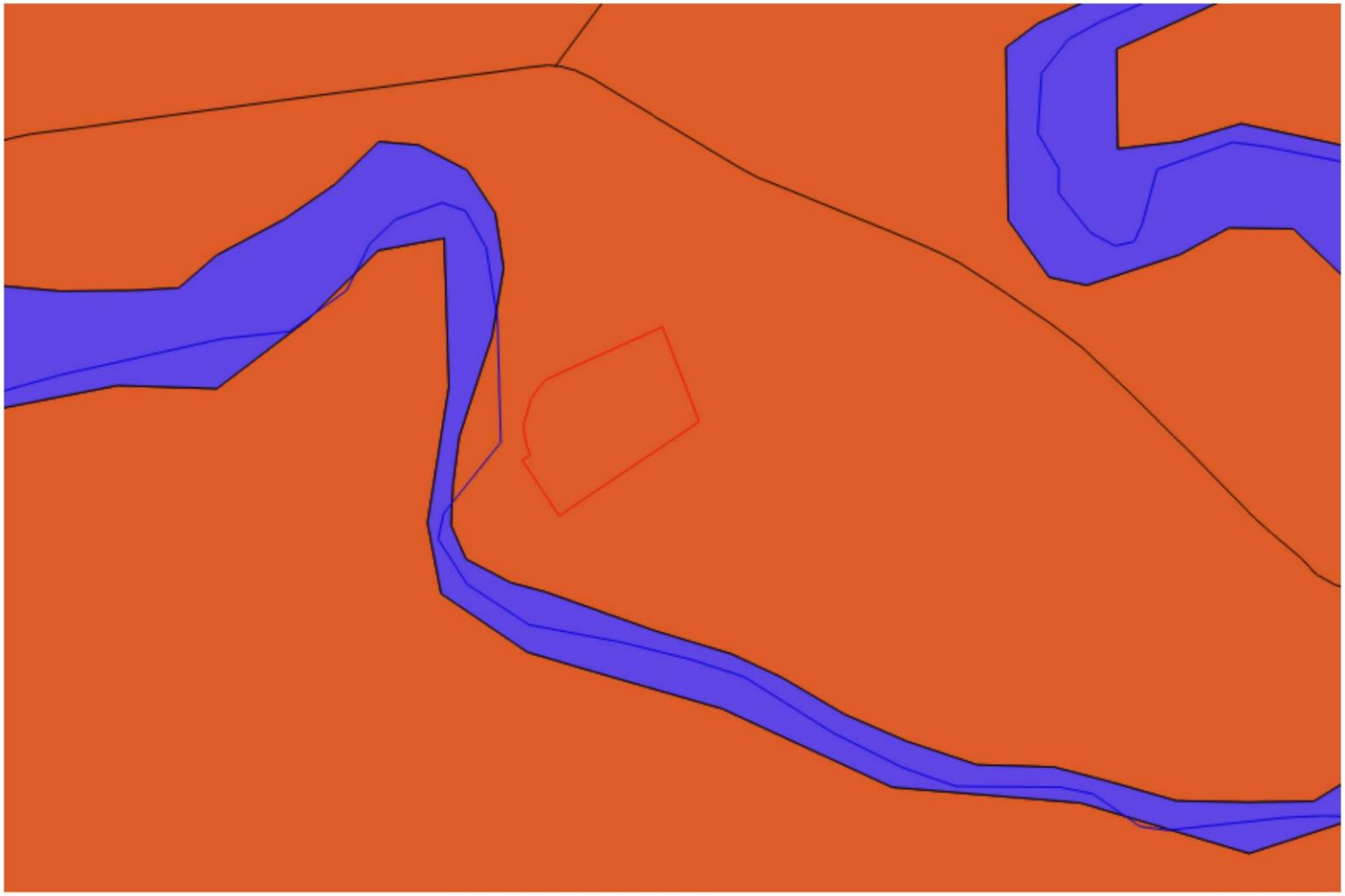
S 28.492963°
E 24.654224°

Spheroid: WGS 84
Scale: 1:10 000
Quantum GIS

DPR Ecologists
Contact Darius van Rensburg at:
darius@dprecologists.co.za
P.O. Box 12726, Brandhof, 9324
Tel: 083 410 0770

Map 1: Wetland delineation for the proposed establishment of irrigated cropfields adjacent to the Vaal River. The wetland conditions and riparian zone associated with the river and recommended buffer zone is indicated. Note extensive centre-pivot systems in surroundings.

General ecology map for the proposed establishment of irrigated cropfields adjacent to the Vaal River near the town of Riverton, Northern Cape Province.



Preparred for:
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Legend:

- Approximate site boundary (Study Area)
- Road network
- Vaal River
- Kimberley Thornveld
- Highveld Alluvial Vegetation
- Threatened Ecosystems

Map Information

S 28.492963°
E 24.654224°

Spheroid: WGS 84
Scale: 1:40 000
Quantum GIS

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Map 2: General ecology for the proposed establishment of irrigated cropfields adjacent to the Vaal River. The vegetation types in the area is indicated as well as any areas of Threatened Ecosystems.

Figure 1: View of the Vaal River adjacent to the western border of the site. Note the dense reedbed at the waters edge. The border is easily discernible by the present of a dense riparian tree layer (red).

Figure 2: View of the lower zone of the river. Note the dominant low shrub and grass layer. The upper zone is again clearly visible (red).

Figure 3: The floodplain of the river has clearly been affected by the previous crop cultivation. The border of the upper zone and floodplain is clearly visible (red).

Figure 4: View of the Vaal River adjacent to the north western corner of the site. The upper (red), Lower (yellow) and marginal (blue zones are indicated.

Figure 5: Another view of the floodplain. Transformation by previous crop cultivation is again prominent.

Figure 6: Panorama of the interior of the site. Note the dense grass layer with shrubs and trees largely absent.

Figure 7: Numerous burrows of small unidentified mammals were observed on the site.

Figure 8: View of the eastern corner of the site where scattered trees has become established (red).

Figure 9: Panorama of the eastern portion of the site. Disturbance here is higher as result of previous diamond mining activities.

Figure 10: View of the artificial trench/canal in the eastern portion of the site.

Figure 11: Another view of artificial excavations on the site, most likely associated with previous diamond mining activities.

Appendix B: Species list

Species indicated with an * are exotic.

Protected species are coloured orange and Red Listed species red.

Species	Growth form
**Achyranthes aspera*	Herb
**Argemone ochroleuca*	Herb
**Bidens bipinnata*	Herb
**Datura ferox*	Herb
**Prosopis glandulosa*	Tree
**Salsola kali*	Herb
**Schkuhria pinata*	Herb
**Tagetes minuta*	Herb
**Tamarix chinensis*	Tree
**Verbena bonariensis*	Herb
**Xanthium spinosum*	Herb
Arctotis arctotoides	Herb
Aristida congesta	Grass
Asparagus larcinus	Shrub
Atriplex semibaccatta	Herb
Chloris virgata	Grass
Chrysocoma ciliata	Dwarf shrub
Clematis brachiata	Climber
Combretum erythrophyllum	Tree
Cullen tomentosum	Herb
Cynodon dactylon	Grass
Cyperus sp.	Sedge
Dicliptera leistneri	Herb
Diospyros lycioides	Tree
Enneapogon cenchroides	Grass
Eragrostis echinochloidea	Grass
Eragrostis lehmanniana	Grass
Gymnosporia buxiifolia	Shrub
Laggera decurrens	Shrub
Lycium cinerium	Shrub
Lycium hirsutum	Shrub
Moraea pallida	Geophyte
Panicum coloratum	Grass
Pentzia incana	Dwarf shrub
Phragmites australis	Reed
Schmidtia kalahariensis	Grass
Searsia lancea	Tree
Selago densiflora	Herb
Senegalia melifera	Tree
Setaria verticillata	Grass

Vachellia karroo	Tree
Ziziphus mucronata	Tree

Appendix D: Soil Samples

Obligate wetland vegetation was utilised to determine the presence and border of wetlands. Soil samples were used to confirm the wetland conditions along the Vaal River. Soil samples were taken at approximately 10 meter intervals. Soil samples were investigated for the presence of anaerobic evidence which characterises wetland soils.

Within wetlands the hydrological regime differs due to the topography and landscape. For instance; a valley bottom wetland would have a main channel that is below the water table and consequently permanently saturated, i.e. permanent zone of wetness. As you move away from the main channel the wetland would become dependent on flooding in order to be saturated. As a result along this hydrological regime areas of permanent saturation, seasonal and temporary saturation would occur. At some point along this gradient the saturation of the soil would be insufficient to develop reduced soil conditions and therefore will not be considered as wetland.

Within wetland soils the pores between soil particles are filled with water instead of atmosphere. As a result available oxygen is consumed by microbes and plantroots and due to the slow rate of oxygen diffusion oxygen is depleted and biological activity continues in anaerobic conditions and this causes the soil to become reduced.

Reduction of wetland soils is a result of bacteria decomposing organic material. As bacteria in saturated soils deplete the dissolved oxygen they start to produce organic chemicals that reduce metals. In oxidised soils the metals in the soil give it a red, brown, yellow or orange colour. When these soils are saturated and metals reduced the soil attains a grey matrix characteristic of wetland soils.

Within this reduction taking place in the wetland soils there may be reduced matrix, redox depletions and redox concentrations. The reduced matrix is characterised by a low chroma and therefore a grey soil matrix. Redox depletions result in the grey bodies within the soil where metals have been stripped out. Redox concentrations result in mottles within the grey matrix with variable shape and are recognised as blotches or spots, red and yellow in colour.

Soil wetness indicator is used as the primary indicator of wetlands. The colour of various soil components are often the most diagnostic indicator of hydromorphic soils. Colours of these components are strongly influenced by the frequency and duration of soil saturation. Generally, the higher the duration and frequency of saturation in a soil profile, the more prominent grey colours become in the soil matrix.

Coloured mottles, another feature of hydromorphic soils, are usually absent in permanently saturated soils and are at their most prominent in seasonally saturated soils, becoming less abundant in temporarily saturated soils until they disappear altogether in dry soils (Collins 2005).

The following soil wetness indicators can be used to determine the permanent, seasonal and temporary wetness zones. The boundary of the wetland is defined as the outer edge of the temporary zone of wetness and is characterised by a minimal grey matrix (<10%), few high chroma mottles and short periods of saturation (less than three months per year). The seasonal zone of wetness is characterised by a grey matrix (>10%), many low chroma mottles and significant periods of wetness (at least three months per year). The permanent zone of wetness

is characterised by a prominent grey matrix, few to high chroma mottles, wetness all year round and sulphuric odour (rotten egg smell).

According to convention hydromorphic soil must display signs of wetness within 50 cm of the soil surface (DWAF 2005).

Table 1: Soil samples taken along a lateral transect of the Vaal River adjacent to the site (S 28.494296°, E 24.649590°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken in the lower zone of the river bank. A grey matrix (<10%) is clear and mottling is prominent indicating a seasonal zone of wetness. Wetland conditions are therefore clearly present.
	
Soil sample taken at the upper end of the lower zone of the river bank. A grey matrix is not clear and feint mottling may be present. This is taken as the border of wetland conditions.	Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.

	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.	Soil sample taken in the floodplain of the river. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.

Table 2: Soil samples taken along a lateral transect of the Vaal River adjacent to the site (S 28.491118°, E 24.650001°).

	
Soil sample taken in the marginal zone of the river. A prominent grey matrix (>10%) is clear and mottling is present indicating a permanent zone of wetness. Wetland conditions are therefore clearly present.	Soil sample taken in the lower zone of the river bank. A grey matrix (<10%) is clear and mottling is prominent indicating a seasonal zone of wetness. Wetland conditions are therefore clearly present.

	
Soil sample taken in the upper zone of the river bank. A grey matrix and mottling is clearly absent and wetland conditions are not present. A high silt content does indicate it still forming part of the floodplain.	

Table 3: Soil samples taken in the adjacent terrestrial environment (S 28.492963°, E 24.654224°).

	
Soil sample taken in the surrounding terrestrial area of the site. A grey matrix and mottling is clearly absent and wetland conditions are not present. Note the high sand content and absence of silt.	

Appendix D: Index of Habitat Integrity (IHI) Summary

For the complete IHI please contact the author of this report.

ASSESSMENT UNIT INFORMATION	
ASSESSMENT UNIT INFORMATION	
UPPER LATITUDE	S28.494296
UPPER LONGITUDE	E 24.649590
UPPER ALTITUDE	1104 m
LOWER LATITUDE	S 28.491118
LOWER LONGITUDE	E 24.650001
LOWER ALTITUDE	1102 m
SURVEY SITE (if applicable)	Vaal River Kilmorey
SITE LATITUDE (if applicable)	
SITE LONGITUDE (if applicable)	
SITE ALTITUDE (if applicable)	
WMA	Low er Vaal
QUATERNARY	C91E
ECOREGION 2	29_2
DATE	15/08/2018
RIVER	Vaal River
TRIBUTARY	
PERENNIAL (Y/N)	**Y**
GEOMORPH ZONE	**LOWLAND**
WIDTH (m)	**>15**

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY MODIFICATION	2.3	1.7
PHYSICO-CHEMICAL MODIFICATION	2.0	1.1
BED MODIFICATION	2.0	4.0
BANK MODIFICATION	2.3	3.0
CONNECTIVITTY MODIFICATION	2.0	4.0
INSTREAM IHI%	57.9	
CATEGORY	C/D	
CONFIDENCE	2.8	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% 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 / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

METRIC GROUP	RATING	CONFIDENCE
HYDROLOGY	2.85	3.00
BANK STRUCTURE MODIFICATION	2.50	4.00
CONNECTIVITY MODIFICATION	2.00	4.00
RIPARIAN HABITAT INTEGRITY (%)	49.91	
CATEGORY	D	
CONFIDENCE	3.67	

HABITAT INTEGRITY CATEGORY	DESCRIPTION	RATING (% 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 / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

	MRU
INSTREAM IHI	
Base Flows	-3.0
Zero Flows	1.0
Floods	-3.5
HYDROLOGY RATING	**2.3**
pH	2.0
Salts	2.5
Nutrients	2.0
Water Temperature	1.0
Water clarity	2.0
Oxygen	1.5
Toxics	2.0
PC RATING	**2.0**
Sediment	2.0
Benthic Growth	2.0
BED RATING	**2.0**
Marginal	2.5
Non-marginal	2.0
BANK RATING	**2.3**
Longitudinal Connectivity	2.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**2.0**
INSTREAM IHI %	**57.9**
INSTREAM IHI EC	**C/D**
INSTREAM CONFIDENCE	**2.8**

	MRU
RIPARIAN IHI	
Base Flows	-3.0
Zero Flows	-1.0
Moderate Floods	-3.0
Large Floods	-4.0
HYDROLOGY RATING	**2.8**
Substrate Exposure (marginal)	1.0
Substrate Exposure (non-marginal)	3.0
Invasive Alien Vegetation (marginal)	2.0
Invasive Alien Vegetation (non-marginal)	2.0
Erosion (marginal)	1.0
Erosion (non-marginal)	2.0
Physico-Chemical (marginal)	2.0
Physico-Chemical (non-marginal)	2.0
Marginal	2.0
Non-marginal	3.0
BANK STRUCTURE RATING	**2.5**
Longitudinal Connectivity	2.0
Lateral Connectivity	2.0
CONNECTIVITY RATING	**2.0**
RIPARIAN IHI %	**49.9**
RIPARIAN IHI EC	**D**
RIPARIAN CONFIDENCE	**3.7**

Appendix E: Risk Assessment Matrix

RISK MATRIX (Based on DWS 2015 publication: Section 21 c and I water use Risk Assessment Protocol)

Risk to be scored for construction and operational phases of the project. MUST BE COMPLETED BY SACNASP REGISTERED PROFESSIONAL MEMBER REGISTERED IN AN APPROPRIATE FIELD OF EXPERTISE

					Severity																
No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph+Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level	Control Measures
1	Mostly Operational Phase	Clearing of vegetation and establishment of irrigated crop fields.	Impacts associated with irrigation in close proximity to the Vaal River.	Initial clearance of vegetation will cause conditions susceptible to erosion and will most likely increase the sediment load in the river. Operation of irrigated cropfields will involve fertiliser, pesticide and herbicide runoff which impact the water quality of the river.	0	3	2	1	1.5	2	4	7.5	4	4	5	3	16	120	M	4	The impact that irrigation in close proximity to the river will have is associated with runoff generated on the cropfields and include increased sediment, fertiliser, pesticide and herbicide runoff. It is difficult to mitigate these impacts but good farming practises should in general be followed and include preservation of the topsoil and responsible use of chemicals including fertilisers.

Appendix F: Buffer Zone Tool for the Determination of Aquatic Impact Buffers and Additional Setback Requirements for Wetland Ecosystems (2014)

For the complete Buffer Report please contact the author of this report.

Name of Assessor	Darius	Project Details	Kilmorey Irrigation	Date of Assessment	23-Aug-18

Step 1: Define objectives and scope of assessment and determine the most appropriate level of assessment

Level of assessment	Site-based

Step 2: Map and categorize water resources in the study area

Approach used to delineate the wetland boundary?	Site-based delineation	Wetland type	Floodplain

Step 3: Refer to the DWA management objectives for mapped water resources or develop surrogate objectives

Present Ecological State	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
Ecological importance & sensitivity	Medium	Features that are considered to be ecologically important and sensitive at a local scale. The functioning and/or biodiversity of these features is not usually sensitive to anthropogenic disturbances. They typically play a small role in providing ecological services at the local scale.
Management Objective	Maintain	

Step 4: Assess the risks from proposed developments and define mitigation measures necessary for protecting mapped water resources in the study area

Assess threats of planned activities on water resources and determine desktop buffer requirements

Proposed development / activity	Sector	Agriculture	Agricultural-based land-use activities that range from the large-scale commercial production of crops and timber to small-scale subsistence crop farming and livestock rearing. May be associated with rural and/or urban contexts.
	Sub-Sector	Irrigated commercial cropland	The agricultural production of produce including crops, trees, seeds, fruit, vegetables or other plant material using conventional means of irrigation.

Climatic factors	MAP Class	0 - 400mm	Rainfall Intensity	Zone 3

Overall size	Size of the wetland relative to (as a percentage of) its catchment	Average slope of the wetland's catchment	The inherent runoff potential of the soil in the wetland's catchment	The extent to which the wetland (HGM) setting is generally characterized by sub-surface water input
0.5-5 ha	2-5%	6-8%	Moderate	Low (Floodplain)
Perimeter to area ratio	**Vulnerability of the HGM type to sediment accumulation**	**Vulnerability of the site to erosion given the site's slope and size**	**Extent of open water, particularly water that is naturally clear**	**Sensitivity of the vegetation to burial under sediment**
Low (<500 m per ha)	Floodplain wetland	Moderate (Vulnerability score :4-5)	Moderately High (7-9%)	Low (e.g. tall growing & fast colonizing)
Peat versus mineral soils	**Inherent level of nutrients in the landscape: is the wetland and its catchment underlain by sandstone?**	**Sensitivity of the vegetation to increased availability of nutrients**	**Sensitivity of the vegetation to toxic inputs, changes in acidity & salinization**	**Natural wetness regimes**
Mineral	No	Low (e.g. tall and dense vegetation with low natural diversity)	Low (e.g. low natural diversity)	Mix of permanently and seasonally saturated soils
Natural salinity levels	**Level of domestic use**	**Mean Annual Temperature**	Note: See the guideline document for further information on the rationale for indicator selection and how these attributes affect the sensitivity of wetlands to lateral inputs.	
Naturally low saline levels	Low	Zone 4 (18.2 - 19.5 Deg C)		

Buffer attributes	Buffer Segment 1	Buffer Segment 2	Buffer Segment 3	Buffer Segment 4
Slope of the buffer	Gentle (2.1 - 10%)			
Vegetation characteristics (Construction phase)	Very high: Very dense vegetation, with very high basal cover (e.g. vetiver grass filter strips).			
Vegetation characteristics (Operational phase)	Very high: Very dense vegetation, with very high basal cover (e.g. vetiver grass filter strips).			
Soil permeability	Low : Fine textured soils with low permeability (e.g. clay loam and clay).			
Topography of the buffer zone	Uniform topography: Smooth topography with no concentrated flow paths anticipated.			
Site-based aquatic impact buffer requirements (without additional mitigation measures)				
Construction Phase	26	Not Assessed	Not Assessed	Not Assessed
Operational Phase	26	Not Assessed	Not Assessed	Not Assessed
Final aquatic impact buffer requirements (including practical management considerations)				
Construction Phase	26	Not Assessed	Not Assessed	Not Assessed
Operational Phase	26	Not Assessed	Not Assessed	Not Assessed
Final aquatic impact buffer requirement	26	Not Assessed	Not Assessed	Not Assessed
Rationale for any increases in final buffer requirements				

Appendix G: Impact methodology

The environmental significance assessment methodology is based on the following determination:
Environmental Significance = Overall Consequence x Overall Likelihood

Determination of Consequence

Consequence analysis is a mixture of quantitative and qualitative information and the outcome can be positive or negative. Several factors can be used to determine consequence. For the purpose of determining the environmental significance in terms of consequence, the following factors were chosen: **Severity/Intensity, Duration and Extent/Spatial Scale.** Each factor is assigned a rating of 1 to 5, as described below and in tables 6, 7, 9 and 10.

Determination of Severity

Severity relates to the nature of the event, aspect or impact to the environment and describes how severe the aspects impact on the biophysical and socio-economic environment.
Table 7 will be used to obtain an overall rating for severity, taking into consideration the various criteria.

Table 7: Rating of severity

Type of criteria	**Rating**				
	1	**2**	**3**	**4**	**5**
Quantitative	0-20%	21-40%	41-60%	61-80%	81-100%
Qualitative	Insignificant / Non-harmful	Small / Potentially harmful	Significant / Harmful	Great / Very harmful	Disastrous Extremely harmful
Social/ Community response	Acceptable / I&AP satisfied	Slightly tolerable / Possible objections	Intolerable/ Sporadic complaints	Unacceptable / Widespread complaints	Totally unacceptable / Possible legal action
Irreversibility	Very low cost to mitigate/ High potential to mitigate impacts to level of insignificance / Easily reversible	Low cost to mitigate	Substantial cost to mitigate / Potential to mitigate impacts / Potential to reverse impact	High cost to mitigate	Prohibitive cost to mitigate / Little or no mechanism to mitigate impact Irreversible
Biophysical (Air quality, water quantity and quality, waste production, fauna and flora)	Insignificant change / deterioration or disturbance	Moderate change / deterioration or disturbance	Significant change / deterioration or disturbance	Very significant change / deterioration or disturbance	Disastrous change / deterioration or disturbance

Determination of Duration
Duration refers to the amount of time that the environment will be affected by the event, risk or impact, if no intervention e.g. remedial action takes place.

Table 8: Rating of Duration

Rating	Description
1: Low	Almost never / almost impossible
2: Low-Medium	Very seldom / highly unlikely
3: Medium	Infrequent / unlikely / seldom
4: Medium-High	Often / regularly / likely / possible
5: High	Daily / highly likely / definitely

Determination of Extent/Spatial Scale
Extent refer to the spatial influence of an impact be local (extending only as far as the activity, or will be limited to the site and its immediate surroundings), regional (will have an impact on the region), national (will have an impact on a national scale) or international (impact across international borders).

Table 9: Rating of Extent / Spatial Scale

Rating	Description
1: Low	Immediate, fully contained area
2: Low-Medium	Surrounding area
3: Medium	Within Business Unit area of responsibility
4: Medium-High	Within Mining Boundary area
5: High	Regional, National, International

Determination of Overall Consequence
Overall consequence is determined by adding the factors determined above and summarised below, and then dividing the sum by 4.

Table 10: Example of calculating Overall Consequence

Consequence	Rating
Severity	Example 4
Duration	Example 2
Extent	Example 4
SUBTOTAL	10
TOTAL CONSEQUENCE:(Subtotal divided by 4)	3.3

Likelihood
The determination of likelihood is a combination of Frequency and Probability. Each factor is assigned a rating of 1 to 5, as described below and in Table 11 and Table 12.

Determination of Frequency
Frequency refers to how often the specific activity, related to the event, aspect or impact, is undertaken.

Table 11: Rating of frequency

Rating	Description
1: Low	Once a year or once/more during operation/LOM
2: Low-Medium	Once/more in 6 Months
3: Medium	Once/more a Month
4: Medium-High	Once/more a Week
5: High	Daily

Determination of Probability
Probability refers to how often the activity/even or aspect has an impact on the environment.

Table 12: Rating of probability

Rating	Description
1: Low	Almost never / almost impossible
2: Low-Medium	Very seldom / highly unlikely
3: Medium	Infrequent / unlikely / seldom
4: Medium-High	Often / regularly / likely / possible
5: High	Daily / highly likely / definitely

Overall Likelihood
Overall likelihood is calculated by adding the factors determined above and summarised below, and then dividing the sum by 2.

Table 13: Example of calculating the overall likelihood

Consequence	Rating
Frequency	Example 4
Probability	Example 2
SUBTOTAL	6
TOTAL LIKELIHOOD (Subtotal divided by 2)	3

Determination of Overall Environmental Significance
The multiplication of overall consequence with overall likelihood will provide the environmental significance, which is a number that will then fall into a range of LOW, LOW-MEDIUM, MEDIUM, MEDIUM, MEDIUM-HIGH or HIGH, as shown in the table below.

Table 14: Determination of overall environmental significance

Significance or Risk	Low	Low-Moderate	Moderate	Moderate-High	High
Overall Consequence X Overall Likelihood	1 - 4.9	5 - 9.9	10 - 14.9	15 – 19.9	20 - 25

Qualitative description or magnitude of Environmental Significance
This description is qualitative and is an indication of the nature or magnitude of the Environmental Significance. It also guides the prioritisations and decision making process associated with this event, aspect or impact.

Table 15: Description of the environmental significance and the related action required.

Significance	Low	Low-Moderate	Moderate	Moderate-High	High
Impact Magnitude	Impact is of very low order and therefore likely to have very little real effect. Acceptable.	Impact is of low order and therefore likely to have little real effect. Acceptable.	Impact is real, and potentially substantial in relation to other impacts. Can pose a risk to the company	Impact is real and substantial in relation to other impacts. Pose a risk to the company. Unacceptable	Impact is of the highest order possible. Unacceptable. Fatal flaw.
Action Required	Maintain current management measures. Where possible improve.	Maintain current management measures. Implement monitoring and evaluate to determine potential increase in risk. Where possible improve	Implement monitoring. Investigate mitigation measures and improve management measures to reduce risk, where possible.	Improve management measures to reduce risk.	Implement significant mitigation measures or implement alternatives.