WETLAND AND RIPARIAN ASSESSMENT

Remainder of Bultfontein 107 JR

Disturbed area at the riparian zone at site. Patches of the indigenous reed *Phragmites mauritianus* are visible in the picture.
Photo: R.F. Terblanche

FEBRUARY 2023

COMPILED BY:

Reinier F. Terblanche

(M.Sc, *Cum Laude*; Pr.Sci.Nat, Reg. No. 400244/05)

I) SPECIALIST EXPERTISE

SYNOPTIC CV: REINIER. F. TERBLANCHE

Reinier is an ecologist and in particular a habitat specialist with an exceptional combination of botanical and zoological expertise which he keeps fostering, updating and improving. He is busy with a PhD for which he registered at the Department of Conservation Ecology at the University of Stellenbosch. The PhD research focuses on the landscape ecology of selected terrestrial and wetland butterflies in South Africa. Reinier's experience includes being a lecturer in ecology and zoology at the North West University, Potchefstroom Campus (1998-2008). Reinier collaborates with a number of institutes, organizations and universities on animal, plant and habitat research.

Qualifications:

Qualification	**Main subject matter**	**University**
M.Sc *Cum Laude,* **1998:** Botany: Ecology	Quantitative study of invertebrate assemblages and plant assemblages of rangelands in grasslands.	North-West University, Potchefstroom
B.Sc Honns *Cum Laude,* **1992** Botany: Taxonomy	Distinctions in all subjects: Plant Anatomy, Taxonomy, Modern Systematics, System Modelling, Plant Ecology, Taxonomy Project, Statistics Attendance Course.	North-West University, Potchefstroom
B.Sc Botany, Zoology	Main subjects: Botany, Zoology.	North-West University, Potchefstroom
Higher Education Diploma, 1990	Numerous subjects aimed at holistic training of teachers.	North-West University, Potchefstroom

In research Reinier specializes in conservation biology, threatened butterfly species, vegetation dynamics and ant assemblages at terrestrial and wetland butterfly habitats as well as enhancing quantitative studies on butterflies of Africa. He has published extensively in the fields of taxonomy, biogeography and ecology in popular journals, peer-reviewed scientific journals and as co-author and co-editor of books (see 10 examples beneath).

Reinier practices as an ecological consultant and has been registered as a Professional Natural Scientist by SACNASP since 2005: Reg. No. 400244/05. His experience in consultation includes: Flora and fauna habitat surveys, Threatened species assessments, Riparian vegetation index surveys, Compilation of Ecological Management Plans, Biodiversity Action Plans and Status quo of biodiversity for Environmental Management Frameworks, Wetland Assessments, Management of Rare Wetland Species.

Recent activities/ awards: Best Poster Award at Oppenheimer De Beers Group Research Conference 2015, Johannesburg. One of the co-authors of Guidelines for Standardised Global Butterfly Monitoring, 2015, Group on Earth Observations Biodiversity Observation Network, Leipzig, Germany (UNEP-WCMC), GEO BON Technical Series 1. Awarded the prestigious Torben Larsen Memorial Tankard in October 2017; one is awarded annually to the person responsible for the most outstanding written account on Afrotropical Lepidoptera. Lectured as Conservationist-in-Residence in the Wildlife Conservation Programme of the African Leadership University, Kigali, Rwanda, 9-23 February 2019. Reinier won a photographic competition which resulted his photograph of the Critically Endangered *Erikssonia edgei* (Waterberg Copper) being on the front cover of the Synthesis Report of the National Biodiversity Assessment (2018) prepared by SANBI.

EXPERIENCE

Lecturer: Zoology 1998-2008	**Main subject matter and level**	**Organization**
Lectured subjects	- 3rd year level Ecology, Plantparasitology - 2nd year level Ethology - *Master's degree* Evolutionary Ethology, Systematics in Practice, Morphology and Taxonomy of Insect Pests, Wetlands.	North-West University, Potchefstroom and University of South Africa
Co-promoter	PhD: Edge, D.A. 2005. Ecological factors that influence the survival of the Brenton Blue butterfly	North-West University, Potchefstroom
Study leader/ assistant study leader	Six MSc students, One BSc Honn student: Various quantitative biodiversity studies (terrestrial and aquatic).	North-West University, Potchefstroom
Teacher 1994-1998	Biology and Science, Secondary School	Afrikaans Hoër Seunskool, Pretoria
Owned Anthene Ecological CC 2008 – present	- Flora and Fauna habitat surveys - Highly specialized ecological surveys - Riparian vegetation index surveys - Ecological Management Plans - Biodiversity Action Plans - Biodiversity section of Environmental Management Frameworks - Wetland assessments	Private Closed Corporation that has been subcontracted by many companies
Herbarium assistant 1988-1991	- Part-time assistant at the A.P. Goossens herbarium, Botany Department, North-West University, 1988, 1989, 1990 and 1991 (as a student).	North-West University, Potchefstroom

10 EXAMPLES OF PUBLICATIONS OF WHICH R.F. TERBLANCHE IS AUTHOR/ CO-AUTHOR

(Three books, two chapters in books and five articles are listed here as examples)

1. HENNING, G.A., **TERBLANCHE, R.F.** & BALL, J.B. (eds) **2009.** *South African Red Data Book: butterflies*. *SANBI Biodiversity Series* 13. South African National Biodiversity Institute, Pretoria. 158p. ISBN 978-1-919976-51-8
2. MECENERO, S., BALL, J.B., EDGE, D.A., HAMER, M.L., HENNING, G.A., KRÜGER, M, PRINGLE, E.L., **TERBLANCHE, R.F.** & WILLIAMS, M.C. (eds). 2013. *Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and atlas.* Saftronics (Pty) Ltd., Johannesburg & Animal Demography Unit, Cape Town.
3. VAN SWAAY, C., REGAN, E., LING, M., BOZHINOVSKA, E., FERNANDEZ, M., MARINI-FILHO, O.J., HUERTAS, B., PHON, C.-K., KŐRÖSI, A., MEERMAN, J., PE'ER, G., UEHARA-PRADO, M., SÁFIÁN, S., SAM, L., SHUEY, J., TARON, D., **TERBLANCHE, R.F**. & UNDERHILL, L. 2015. Guidelines for Standardised Global Butterfly Monitoring. Group on Earth Observations Biodiversity Observation Network, Leipzig, Germany. GEO BON Technical Series 1.
4. **TERBLANCHE, R.F.** & HENNING, G.A. **2009.** *A framework for conservation management of South African butterflies in practice.* In: Henning, G.A., Terblanche, R.F. & Ball, J.B. (eds). *South African Red Data Book: Butterflies. SANBI Biodiversity Series 13.* South African National Biodiversity Institute, Pretoria. p. 68 – 71.
5. EDGE, D.A., **TERBLANCHE, R.F**., HENNING, G.A., MECENERO, S. & NAVARRO, R.A. 2013. Butterfly conservation in southern Africa: Analysis of the Red List and threats. In: Mecenero, S., Ball, J.B., Edge, D.A., Hamer, M.L., Henning, G.A., Krüger, M., Pringle, E.L., Terblanche, R.F. & Williams, M.C. (eds). *Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas.* pp. 13-33. Saftronics (Pty) Ltd., Johannesburg & Animal Demography Unit, Cape Town.
6. **TERBLANCHE, R.F.**, SMITH, G.F. & THEUNISSEN, J.D. **1993.** Did Scott typify names in *Haworthia* (Asphodelaceae: Alooideae)? *Taxon* **42**(1): 91–95. (International Journal of Plant Taxonomy).
7. **TERBLANCHE, R.F.**, MORGENTHAL, T.L. & CILLIERS, S.S. **2003.** The vegetation of three localities of the threatened butterfly species *Chrysoritis aureus* (Lepidoptera: Lycaenidae). *Koedoe* **46**(1): 73-90.
8. EDGE, D.A., CILLIERS, S.S. & **TERBLANCHE, R.F. 2008**. Vegetation associated with the occurrence of the Brenton blue butterfly. *South African Journal of Science* **104**: 505 - 510.
9. GARDINER, A.J. & **TERBLANCHE, R.F. 2010.** Taxonomy, biology, biogeography, evolution and conservation of the genus *Erikssonia* Trimen (Lepidoptera: Lycaenidae) *African Entomology* **18**(1): 171-191.
10. **TERBLANCHE, R.F.** 2016. *Acraea trimeni* Aurivillius, [1899], *Acraea stenobea* Wallengren, 1860 and *Acraea neobule* Doubleday, [1847] on host-plant *Adenia repanda* (Burch.) Engl. at Tswalu Kalahari Reserve, South Africa. *Metamorphosis* 27: 92-102.

* A detailed CV with more complete publication list is available.

II) SPECIALIST DECLARATION

I, Reinier F. Terblanche, as the appointed independent specialist, in terms of the 2014 EIA Regulations (as amended), hereby declare that I:

- I act as the independent specialist in this application;
- I perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- regard the information contained in this report as it relates to my specialist input/study to be true and correct, and do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 (as amended) and any specific environmental management Act;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I have no vested interest in the proposed activity proceeding;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- I have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- all the particulars furnished by me in this specialist input/study are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Name of Specialist: Reinier F. Terblanche

Signature of the specialist

Date: 20 February 2023

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1 INTRODUCTION

A wetland and riparian assessment are required for proposed developments at the Remainder of Bultfontein 107 JR which is located east of Soshanguwe in the Gauteng Province (elswhere referred to as the site). If wetlands would be present at the site the assessment further focuses on the hydro-geomorphic setting, an estimate of the properties of the wetlands, an assessment of the functional aspects of wetlands and an impact assessment to wetlands, should the development be approved. If riparian zones would be present an indication of the active channel and riparian zone is given.

1.1 Wetlands in South Africa

Wetlands are defined by the National Water Act (Act 36 of 1998) as:
"land which is transitional between terrestrial and aquatic ecosystems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil".

According to *A practical field procedure for identification and delineation of wetlands and riparian areas* (DWAF 2005) wetlands must have one or more of the following attributes:

- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation
- The presence, at least occasionally, of water loving plants (hydrophytes)
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil

Wetlands, according to the definition of DWAF (2005) are at the interface of aquatic systems and the terrestrial environment. As such the characteristics of the surface water or near surface water in space and time at this interface between the terrestrial and aquatic environment are fundamental to understand the functioning of a particular wetland. At the higher elevations of South Africa surface water at wetlands are characterised by considerable contrasts between seasons and periodic precipitation events. Generally accepted definitions of wetlands which focus on the wetland attributes of soil and vegetation are therefore useful because of its consistency despite seasonal fluctuations.

The Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013) includes wetland ecosystems defined by the National Water Act (Act 36 of 1998) as well as those “wetland sytems” defined by the Ramsar Convention. The broader definition of wetlands, according to the Ramsar Convention is that wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water to the depth of which at low tide does not exceed six metres (cited by Ramsar Convention Secretariat 2011). This Ramsar definition of “wetlands” overlaps broadly with the definition of aquatic systems according to the South African system of classifying wetlands and other aquatic ecosystems. In South Africa an aquatic ecosystem is an ecosystem that is permanently or periodically inundated by flowing or standing water, or which has soils that are permanently or periodically saturated within 0.5 m of the soil surface (Ollis *et al*., 2013). Therefore an important consideration of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013) is that a wetland (narrow definition according to water act and not Ramsar definition) is taken to be a unique type of aquatic system.

1.2 Importance of wetlands

The importance of wetlands for human well-being and the conservation of biodiversity are recognised world-wide. Ecosystem services which directly or indirectly benefit human well-being are of particular importance when wetlands are considered. Wetlands play a major role to enhance supporting services such as nutrient cycling and primary production, which in turn is the basis for other ecosystem services. Wetlands are very important to regulating services such as maintaining water flow and water quality by processing water and regulating water run-off, provisioning services such as providing freshwater, cultural services such as appreciating the landscape and biodiversity. Overall wetlands play a major role in the sustainability of land use from socio-economic and biodiversity conservation perspectives. The setting and function of wetlands at each site should therefore be evaluated to inform land use management.

Wetland vegetation is of significant importance for wetlands to play a role in valuable ecosystem services. Vegetation plays an important role in natural wetland ecosystems. It holds soil together and slows down the flow of water, reducing the risk of erosion and promoting sediment deposition. Plants are the source of organic material in wetland soils, and form the organic soil in peat wetlands. Vegetation also has an impact on the quality of surface and subsurface water as it (1) provides

organic soil matter required by microbes in order to assimilate nutrients and toxicants (2) provides habitat for the microbes in the soil immediately surrounding the roots, and (3) contributes through direct uptake of nutrients and toxicants and incorporation of these into plant tissues (Sieben *et al.* 2009).

1.3 Aims and objectives of the survey

A survey to investigate key elements of habitats on the site, relevant to the conservation of wetlands is conducted. The importance and significance of the site with special emphasis on the current status of biodiversity and ecological services of the wetland are evaluated. Literature investigations are integrated with field observations to identify potential ecological impacts that could occur as a result of the development and to make recommendations to reduce or minimise impacts, should the development be approved.

The objectives of the wetland habitat assessment are to provide:

- An indication of the existence of wetlands at the site and if so:
- An identification of major aspects of the hydro-geomorphic setting and terrain unit at which the wetland occur;
- An estimate of the size and roughness of the wetland
- An indication of the hydric soils at the site;
- An indication of erodability;
- An indication of the presence or absence of peat at the site;
- An outline of hydrological drivers that support the existence and character of the wetland;
- An assessment of the possible presence or absence of threatened or localised plant species, vertebrates and invertebrates of the region, at the site;
- A description of the functions provided by the wetland at the site;
- An interpretation of the priority of the wetland for local communities in the area;
- An interpretation of the priority of the wetland to biodiversity at the site;

2 STUDY AREA

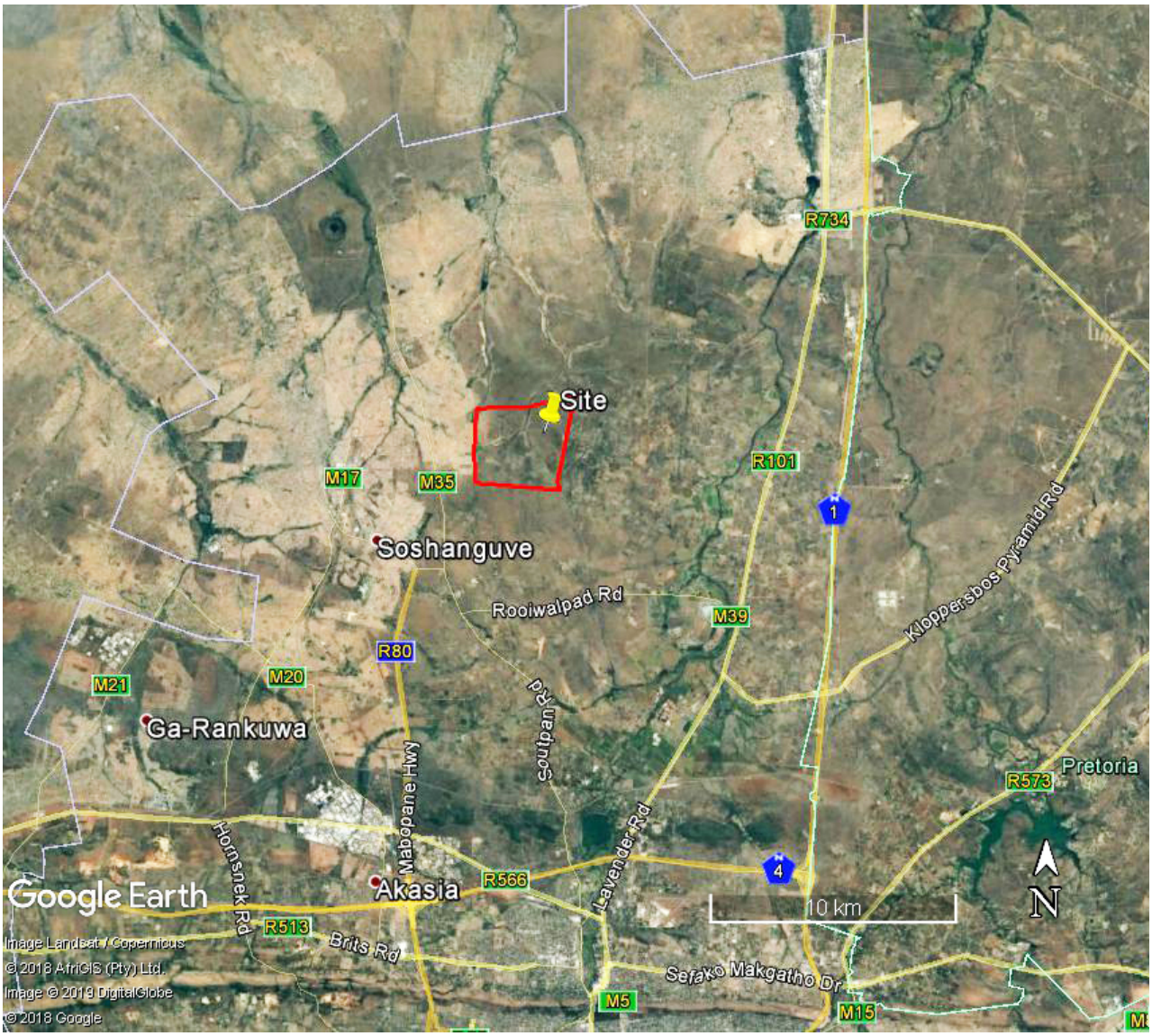

Figure 1 Map with indication of the location of the site (Yellow marker).

Map information were analysed and depicted on Google images with the aid of Google Earth Pro (US Dept. of State Geographer, MapLink/ Tele Atlas, Google, 2019).

The site is at proposed Bultfontein 107 east of Soshanguwe in the Gauteng Province. The site is situated at the Savanna Biome (Mucina & Rutherford 2006). Savanna Biome at the site is represented by the Central Sandy Bushveld vegetation type (Mucina & Rutherford 2006) of which an outline follows.

SVcb 12 Central Sandy Bushveld

Distribution of Central Sandy Bushveld in South Africa: Limpopo, Mpumalanga, Gauteng and North West Provinces: Undulating terrain occurs mainly in a broad arc south of the Springbokvlakte from the Pilanesberg in the west through Hammanskraal and Groblersdal to GaMasemola in the east. A generally narrow irregular band along the north-western edge of the Springbokvlakte (including Modimolle) extending into a series of valleys and lower-altitude areas within the Waterberg including the upper Mokolo River Valley near Vaalwater, the corridor between Rankins Pass and the Doorndraai Dam, and the lowlands from the Mabula area to south of the Hoekberge. Some isolated sandy rises are found on the Springbokvlakte. Altitude about 850 – 1450 m.

Vegetation and Landscape Features: Low undulating areas, sometimes between mountains, and sandy plains and catenas supporting tall, deciduous *Terminalia sericea* and *Burkea africana* woodland on deep sandy soils (with the former often dominant on the lower slopes of sandy catenas) and low, broad-leaved woodland on shallow rocky gravelly soils. Species of *Acacia*, *Ziziphus* and *Euclea* are found on flats and lower slopes on eutrophic sands and some less sandy soils. *Acacia tortilis* may dominate some areas along valleys. Grass-dominated herbaceous layer with relatively low basal cover on dystrophic sands (Mucina & Rutherford, 2006).

Geology & Soils: The large southern and eastern parts of this area are underlain by granite of the Lebowa Granite Suite and some granophyre of the Rashoop Granophyre Suite (both Bushveld Complex, Vaalian). In the north, the sedimentary rocks of the Waterberg Group (Mokolian Erathem) are most important. Specifically, sandstone, conglomerate and siltstone of the Alma Formation and sandstone, siltstone and shale of the Vaalwater formation. Well-drained, deep Hutton or Clovelly soils often with a catenary sequence from Hutton at the top to Clovelly on the lower slopes; shallow, skeletal Glenrosa soils also occur. Land types mainly Bb, Fa, Ba, Bd and Ac (Mucina & Rutherford, 2006).

Climate: Summer rainfall with very dry winters. Effectively three seasons, namely a cool dry season from May to mid-August, a hot dry season form mid-August to about October and a hot wet season form about November to April. Mean annual precipitation from about 500 mm to 700 mm. Frost fairly infrequent (Mucina & Rutherford, 2006).

Important taxa: Tall Trees: *Acacia burkei*, *Acacia robusta, Sclerocarya birrea* subsp. *caffra.* Small Trees: *Burkea africana, Combretum apiculatum, Combretum zeyheri, Terminalia sericea, Ochna pulchra, Peltophorum africanum, Searsia [Rhus] leptodictya.* Tall Shrubs: *Combretum hereroense, Grewia bicolor, Grewia monticola, Strychnos pungens.* Low Shrubs: *Agathisanthemum bojeri, Indigofera filipes, Felicia fascicularis, Gnidia sericocephala.* Geoxyllic Suffrutex: *Dichapetalum cymosum*. Woody Climber: *Asparagus buchananii.* Graminoids: *Brachiaria nigropedata, Eragrostis pallens, Eragrostis rigidior, Hyperthelia dissoluta, Panicum maximum, Perotis patens, Anthephora pubescens, Aristida scabrivalvis* subsp. *scabrivalvis, Brachiaria serrata, Elionurus muticus, Eragrostis nindensis, Loudetia simplex, Schmidtia pappophoroides, Themeda triandra, Trachypogon spicatus*. Herbs: *Dicerocaryum senecioides, Barleria macrostegia, Blepharis integrifolia, Crabbea angustifolia, Evolvus alsinoides, Geigeria burkei, Hermannia lancifolia, Indigofera daleoides, Justica anagalloides, Kyphocarpa angustifolia, Lophiocarpus tenuissimus, Waltheria indica, Xerophyta humilis.* Geophytic Herb: *Hypoxis hemerocallidea.* Succulent Herb: *Aloe greatheadii* var. *davyana.*

Note: Not necessarily all of the above plant species are present at the site.

3 METHODS

A desktop study comprised not only an initial phase, but also it was used throughout the study to accommodate and integrate all the data that become available during the field observations.

A survey consisted of visits by R.F. Terblanche during June 2019, July 2019 and January 2023 to note key elements of habitats on the site, relevant to the conservation of wetlands and riparian zones.

Classification of any inland wetland systems that could be present at the site is according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*.,

2013). One of the major advantages of the Classification System for South Africa (Ollis *et al*., 2013) is that the functional aspects of wetlands are the focal point of the classification. Wetlands are very dynamic systems and their functionality weighs high against rapid changes in their appearance, as could be seen from wetland butterfly studies (Terblanche *In prep*). In this document the main guideline for the delineation and identification of wetlands where present is the practical field procedure for identification and delineation of wetlands by DWAF (2005).

The following sections highlight the materials and methods applicable to different aspects that were observed.

3.1 Classification of wetlands (SANBI: Ollis *et al*., 2013)

3.1.1 System, regional setting and landscape unit (Levels 1, 2 and 3)

Three broad types of Inlands Systems are dealt with in the Classification System namely rivers, open waterbodies and wetlands. These Inland Systems are then classified according to a six-tiered structure that includes six levels.

At the systems level (Level 1) of wetland classification, a distinction is made between Marine, Estuarine and Inland ecosystems using the level of connectivity to the open ocean as discriminator of the biophysical character of each (Ollis *et al*., 2013). Inland wetland systems are aquatic ecosystems with no no existing connection to the ocean (i.e. characterised by the complete absence of marine exchange and/ or tidal influence (Ollis *et al*., 2013). In this case if any wetland is present it obviously qualifies as an Inland wetland system.

At Level 2 the regional setting is a spatial framework that is preferred by the investigator to allow for gaining an understanding of the broad ecological context within which an aquatic system occurs (Ollis *et al*., 2013). A regional setting can be identified according to the DWA ecoregion classification of Kleynhans *et al.* (2005).

A distinction is made between four landscape units at Level 3 of the Classification System for Inland Systems on the basis of the landscape setting (i.e. topographical position) (Ollis *et al*., 2013). Four landscape units are recognized: slope, valley floor, plain and bench.

3.1.2 Hydrogeomorphic units (Level 4)

Seven primary hydrogeomorphic (HGM) units are recognised for Inland Systems at Level 4A of the Classification System for Wetlands and other Aquatic Ecosystems in South Africa, on the basis of hydrology and geomorphology (Ollis *et al*., 2013). These are a River, Channeled valley-bottom wetland, Unchannelled valley-bottom wetland, Floodplain wetland, Depression, Seep and Wetland flat.

3.1.3 Hydrological regime (Level 5)

While the hydrogeomorphic unit (HGM) is influenced by the source of water and how it moves into, through and out of an Inland System, the hydrological regime (as catergorised by the Classification System) describes the behaviour fo the water within the system and, for wetlands, in the underlying soil (Ollis *et al.,* 2013). Together with the hydrogeomorphology the hydrological regime are used to describe the wetland as a functional unit (Ollis *et al.*, 2013). In the case of Inland wetlands which are classified as rivers, perenniality is an important characteristic to describe the hydrological regime. For Inland Systems other than rivers, five categories relating to the frequency and duration of inundation have been provided: Permanently inundated, Seasonally inundated, Intermittently inundated, Never inundated/ rarely inundated and unknown (Ollis *et al*., 2013). Period of saturation within the upper 0.5 m of the soil is a very important discriminator that also links to the wetland delineation system of DWAF (2005). The following categories for saturation of wetland soils are recognised: Permanently saturated, Seasonally saturated, Intermittently saturated and unknown. These categories of period of saturation correspond to the permanent, seasonal and temporary zones of wetlands respectively.

3.1.4 Wetland descriptors (Level 6)

At Level 6 several “descriptors” are included for the structural/ chemical/ biological characterisation of Inland Systems (Ollis *et al.,* 2013). These descriptors are non-hierarchical to one another and can be applied in any order depending on the purpose of a study and the availability of information. Descriptors include natural vs. artificial, salinity, substratum type, pH, geology and vegetation cover (Ollis *et al*., 2013). Various definitions are given for the descriptors which are likely to increase the consistency and use of the system.

3.2 Delineation of wetland

Together with terrain unit, indirect indicators of prolonged saturation by water: wetland plants (hydrophytes) and wetland (hydromorphic) soils are identified and used to delineate the wetland (DWAF 2005). Three zones, which may not all three be present in all wetlands, namely the permanent zone of wetness, the seasonal zone and the temporary zone are identified. The temporary zone is the outer zone and is saturated for only a short period of the year that is sufficient, under normal circumstances, for the formation of hydromorphic soils and the growth of wetland vegetation (DWAF 2005). Hydromorphic soils must display signs of wetness within 50cm of the soil to qualify as wetland soil that can support hydrophytic vegetation. Grid references and altitudes are taken on site with a GPS Garmin E-trex 20 ® instrument. Map information are analysed and depicted on Google images with the aid of Google Earth Pro (US Dept. of State Geographer, MapLink/ Tele Atlas, Google, 2012).

3.3 Vegetation at and near wetland

Though vegetation is a key component of the wetland definition in the Water Act, using vegetation as a primary indicator requires undisturbed conditions and expert knowledge (DWAF 2005). Modern wetland classification systems in South Africa therefore place more emphasis on the soil wetness indicators. It remains however, that plant assemblages undergo distinct changes in species composition from the centre of a wetland to the edge, and into adjacent terrestrial areas (DWAF 2005). This change in species composition of vegetation provides valuable clues for determining the wetland boundary and wetness zones (DWAF 2005).

Apart from botanical aspects which are integrated into the description of a wetland it is imperative to note the existence or not of threatened plant species or other plant species of conservation concern, such as near-threatened, data deficient or declining species at a wetland. Floristic composition is therefore also considered during the wetland assessment. Voucher specimens of plant species are only taken where the taxonomy is in doubt or where the plant specimens are of significant relevance for invertebrate conservation. Field guides such as those by Germishuizen (2003), Manning (2003), Manning (2009), Van Oudtshoorn (1999), Van Wyk (2000), Van Wyk & Malan (1998) and Van Wyk & Van Wyk (1997) were used to confirm the taxonomy of the species.

Works on specific plant groups (often genera) such as those by Goldblatt (1986), Goldblatt & Manning (1998), Jacobsen (1983), McMurtry, Grobler, Grobler & Burns (2008), Smit (2008), Van Jaarsveld (2006) and Van Wyk & Smith (2003) were also consulted to confirm the identification of species. An important source of identifications of plant species for the wetland survey is Van Ginkel, Glen, Gordon-Gray, Cilliers, Muasya & Van Deventer (2011). In this case no plant specimens were needed to be collected as voucher specimens or to be send to a herbarium for identification. For the most recent treatise of scientific plant names and broad distributions, Germishuizen, Meyer & Steenkamp (2006) or Raimondo *et al*. (2009) or updated lists on SANBI websites are followed to compile the lists of species.

3.4 Fauna at and near wetland

Species composition of fauna is not used in wetland characterization and assessments. However, it is important to note species that favour wetlands and especially whether threatened animal species are present at a wetland or not.

Mammals are noted as sight records by day. For the identification of species and observation of diagnostic characteristics Smithers (1986), Skinner & Chimimba (2005), Cillié, Oberprieler and Joubert (2004) and Apps (2000) are consulted. Sites are been walked, covering as many habitats as possible. Signs of the presence of mammal species, such as calls of animals, animal tracks (spoor), burrows, runways, nests and faeces are recorded. Walker (1996), Stuart & Stuart (2000) and Liebenberg (1990) are consulted for additional information and for the identification of spoor and signs. Trapping is only done if necessary. Habitat characteristics are also surveyed to note potential occurrences of mammals. Many mammals can be identified from field sightings but, with a few exceptions bats, rodents and shrews can only be reliably identified in the hand, and even then some species needs examination of skulls, or even chromosomes (Apps, 2000).

Birds are noted as sight records, mainly with the aid of binoculars (10x30). Nearby bird calls of which the observer was sure of the identity were also recorded. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques Ryan (2001) is followed. For information on identification, biogeography and ecology Barnes (2000), Hockey, Dean & Ryan, P.G. (2005), Cillié, Oberprieler & Joubert (2004), Tarboton & Erasmus (1998) and Chittenden (2007) are consulted. Ringing of birds falls beyond the scope of this survey. Sites are

walked, covering as many habitats as possible. Signs of the presence of bird species such as spoor and nests are additionally been recorded. Habitat characteristics are surveyed to note potential occurrences of birds.

Reptiles are noted as sight records in the field. Binoculars (10x30) can also be used for identifying reptiles of which some are wary. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques, Branch (1998), Marais (2004), Alexander & Marais (2007) and Cillié, Oberprieler and Joubert (2004) are followed. Sites are walked, covering as many habitats as possible. Smaller reptiles are sometimes collected for identification, but this practice was not necessary in the case of this study. Habitat characteristics are surveyed to note potential occurrences of reptiles.

Frogs and toads are noted as sight records in the field or by their calls. For practical skills of noting diagnostic characteristics, the identification of species and observation techniques Carruthers (2001), Du Preez (1996), Conradie, Du Preez, Smith & Weldon (2006) and the recent complete guide by Du Preez & Carruthers (2009) are consulted. CD's with frog calls by Carruthers (2001) and Du Preez & Carruthers (2009) are used to identify species by their calls when applicable. Sites are walked, covering as many habitats as possible. Smaller frogs are often collected by pitfall traps put out for epigeal invertebrates (on the soil), but this practice falls beyond the scope of this survey. Habitat characteristics are also surveyed to note potential occurrences of amphibians.

Invertebrates of which enough information is available to be integrated into an assessment, such as butterflies, are recorded as sight records, photographic records or voucher specimens. Voucher specimens are mostly taken of those species of which the taxa warrant collecting due to taxonomic difficulties or in the cases where species can look similar in the veldt. Many butterflies use only one species or a limited number of plant species as host plants for their larvae. Myrmecophilous (ant-loving) butterflies such as the *Aloeides*, *Chrysoritis*, *Erikssonia, Lepidochrysops* and *Orachrysops* species (Lepidoptera: Lycaenidae), which live in association with a specific ant species, require a unique ecosystem for their survival (Deutschländer & Bredenkamp, 1999; Terblanche, Morghental & Cilliers, 2003; Edge, Cilliers & Terblanche, 2008; Gardiner & Terblanche, 2010). Known food plants of butterflies are therefore also recorded. Other invertebrate groups such as fruit chafer beetles and mygalomorph spiders are also investigated where relevant.

3.5 Present Ecological Status

Ecological status of wetlands are based on models such as the modified Habitat Integrity approach developed by Kleynhans (1996, 1999). Present ecological status PES methodology is then largely based on criteria for assessing the habitat integrity of floodplain wetlands and notes for allocating a score to attributes and rating the confidence level associated with each score (DWAF 1999). Such criteria are selected on the assumption that anthropogenic modification can generally be regarded as the primary causes of degradation of the ecological integrity of a wetland (see DWAF 1999). This is done by using Table W4-1 given by DWAF (1999):

- Score each attribute according to the guidelines provided in the footnote.
- Calculate a mean score for Table W4-1 using the individual scores for all attributes.
- Provide a confidence rating for each score according to the guidelines provided in the footnote to indicate the areas of uncertainty in the determination.

Table W4-2 provides guidelines for the determination of the Present Ecological Status Class (PESC), based on the mean score determined for Table W4-1. If any of the attributes scores < 2 (i.e., it is considered to be seriously or critically modified) this score and not the mean should be taken into consideration. This approach is based on the assumption that extensive degradation of any of the wetland attributes may determine the Present Ecological Status Category (PESC). In any case, the mean on which the assessment of the PESC is based should be regarded as a guideline and should also be tested against the opinion of local experts (DWAF 1999).

Biological integrity is not directly estimated through this approach though in some systems or parts of systems, information on biological integrity is available. In such cases, the information on biological integrity can be used as a check of the PES Category determination. The mean is used to relate the ecological state of the wetland to a particular PES Category (Table W4-2) (DWAF 1999).

3.6 Ecological Importance and Sensitivity

The assessment of the ecological importance and sensitivity is according to DWAF (1999) which in turn is adapted from Kleynhans (1996) and Kelynhans (1999). "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) DWAF (1999).

In the method outlined here, a series of determinants for EIS according to Table W5-1 of DWAF (1999) are assessed on a scale of 0 to 4, where 0 indicates no importance and 4 indicates very high importance. The method is used as a guideline for the professional judgement of individuals familiar with an area and its wetlands. The assessors must substantiate and document their judgement as far as possible for future reference and revision (DWAF 1999).

3.7 Limitations

Wetlands or riparian zones are very dynamic systems and owing to time constraints a glimpse of conditions at wetlands are taken, even though the hydrogeomorphological setting, soil wetness characteristics and established vegetation constitute some long-term features of a wetland. For each site visited, it should then be emphasized that surveys can by no means result in an exhaustive list of wetland plants and animals present on the site, because of the time constraint. A desktop study comprised not only an initial phase, but also it was used throughout the study to accommodate and integrate all the data that become available during the field observations.

The survey at the site was conducted during June 2019, July 2019 and January 2023 to note key elements of habitats on the site, relevant to the conservation of wetlands and riparian areas. The focus of the survey remains a habitat survey that concentrates on the hydrogeomorphological, hydrological and additional descriptors to classify and assess wetlands where present and to assess for the likelihood of occurrence or not of any wetland fauna and flora of particular conservation concern.

4 RESULTS AND DISCUSSION

4.1 Assessment of presence of wetlands at the site

Photo 1 Part of Dam 6 (which could also be regarded as a quarry) at the site.
Photo: R.F. Terblanche.

Photo 2 The largest dam, Dam 1, near the northern boundary of the site.
Photo: R.F. Terblanche.

Photo 3 Fringe of wetland vegetation at Dam 1 at the site.
Photo: R.F. Terblanche

Photo 4 A small dam, Dam 3 at the site. Note sparse vegetation at groundwall.
Photo: R.F. Terblanche.

Photo 5 Part of Dam 4 at the site.
Photo: R.F. Terblanche

Photo 6 Groundwall at Dam 4 at the site.
Photo: R.F. Terblanche.

Photo 7 Dam 6 at the site. Groundwalls with sparse vegetation are prone to be eroded.
Photo: R.F. Terblanche

Photo 8 Extensive informal dumping has increased in recent years at Dam 6, such as observed in January 2023.
Photo: R.F. Terblanche.

Photo 9 Some parts of the groundwalls at Dam 6 at the stie, are covered by rubble owing to informal dumping.
Photo: R.F. Terblanche

Photo 10 Distubed riparian zone at the site. A partch of indigenous *Phragmites mauritianus* (reed species) is noticeable in the picture.
Photo: R.F. Terblanche.

Photo 11 Exposed soil where the riparian zone has been modified or transformed at the site.
Photo: R.F. Terblanche

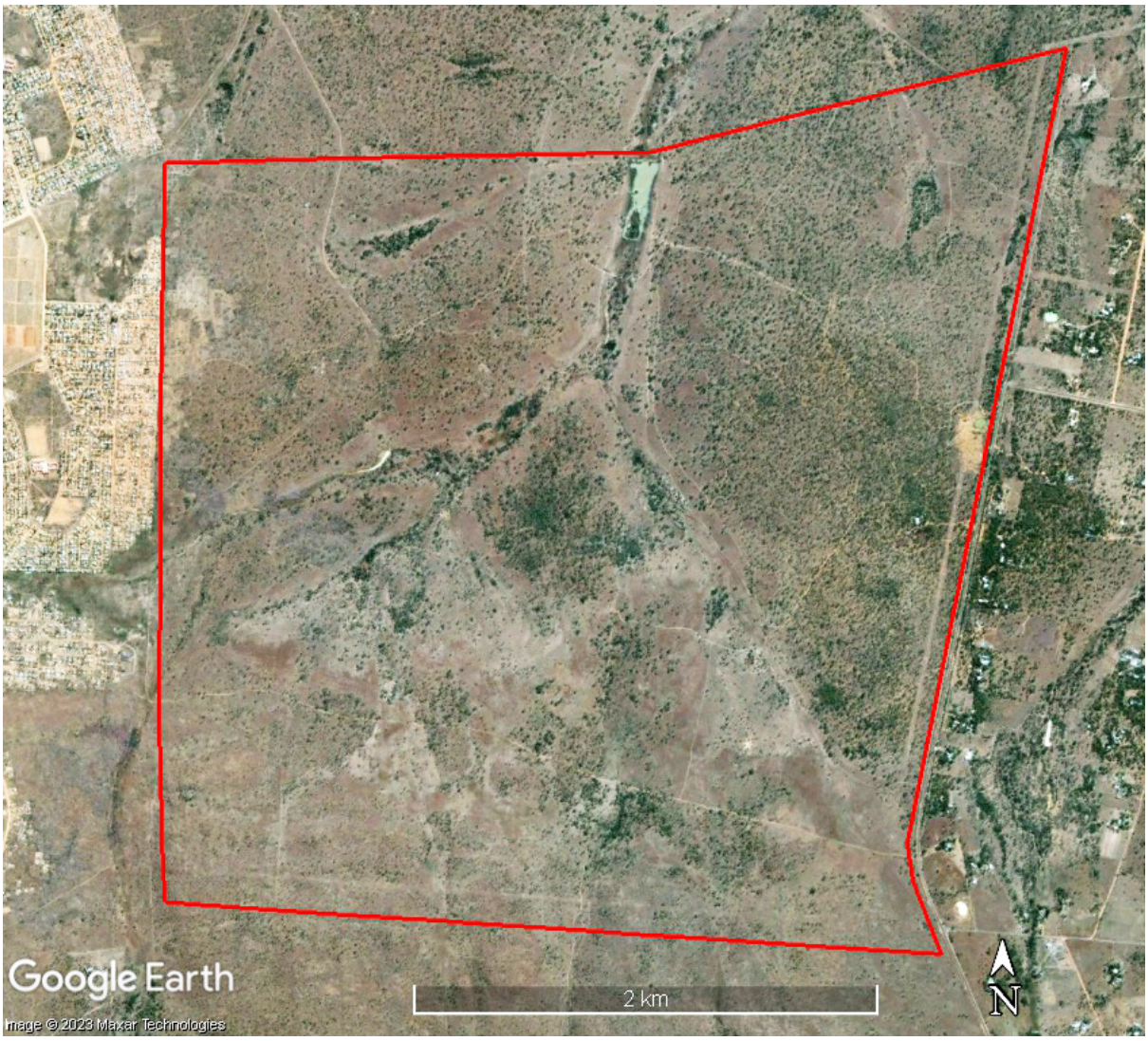

Figure 2 Google Earth Pro map of the study area for **June 2004**.

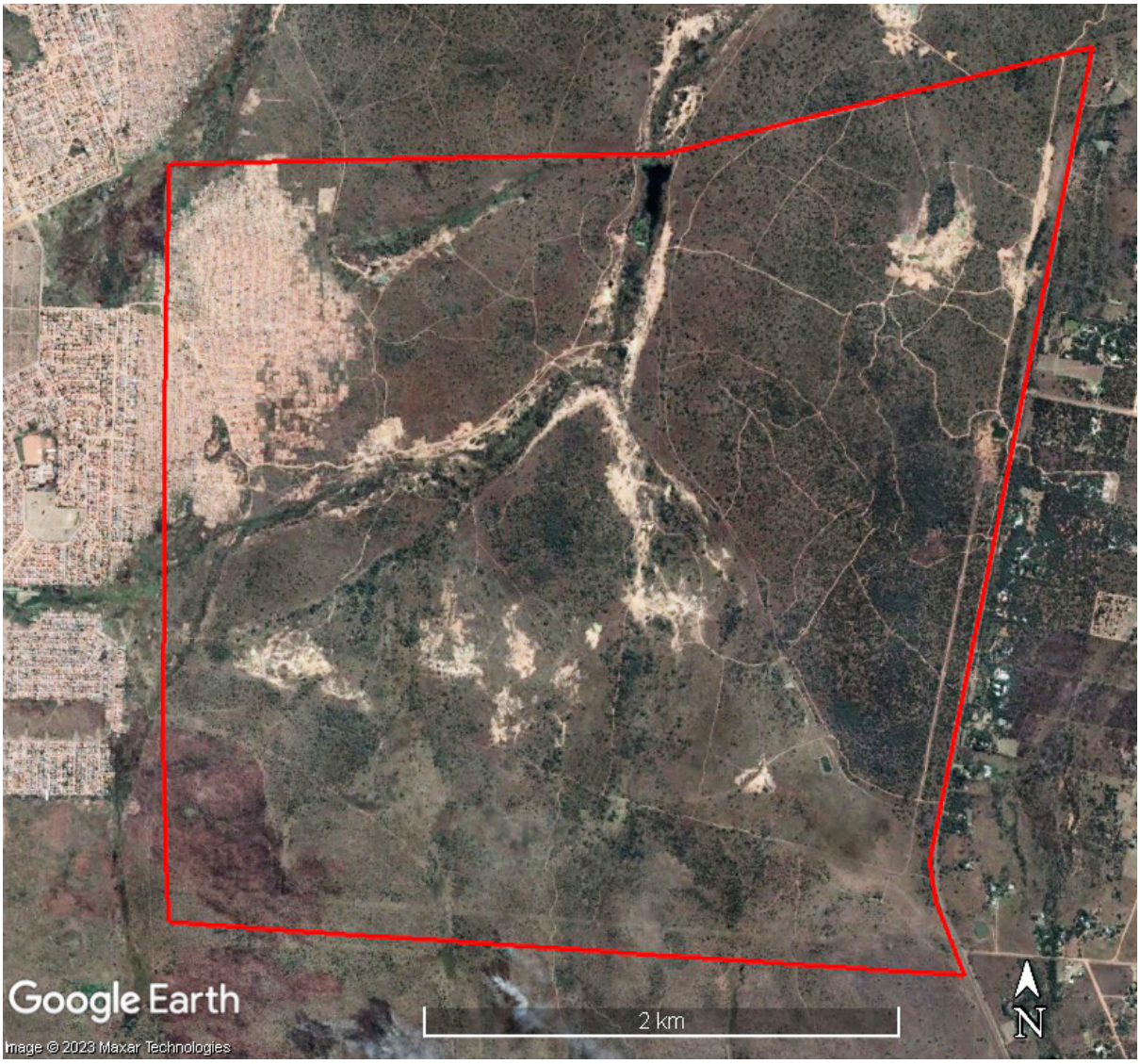

Figure 3 Google Earth Pro map of the study area for **February 2023**. Informal residential areas are spreading increasingly into the norheastern parts of the site. Extensive excavations and groundworks are taking place at many parts of the site including at the active channels and riparian zones.

Figure 4 Google Earth Pro map of a central-western part of the site where excavations and transformation of ecosystems at the site have been extensive. Grid reference coordinates are given as a reference point. The catchment and hydrological regime are transformed at a very large scale at many parts of the site, including riparian zones.

Figure 5 Google Earth Pro map of a central-eastern part of the site where excavations and transformation of ecosystems at the site have been extensive. Grid reference coordinates are given as a reference point. The catchment and hydrological regime at the site are transformed at a very large scale at many parts of the site.

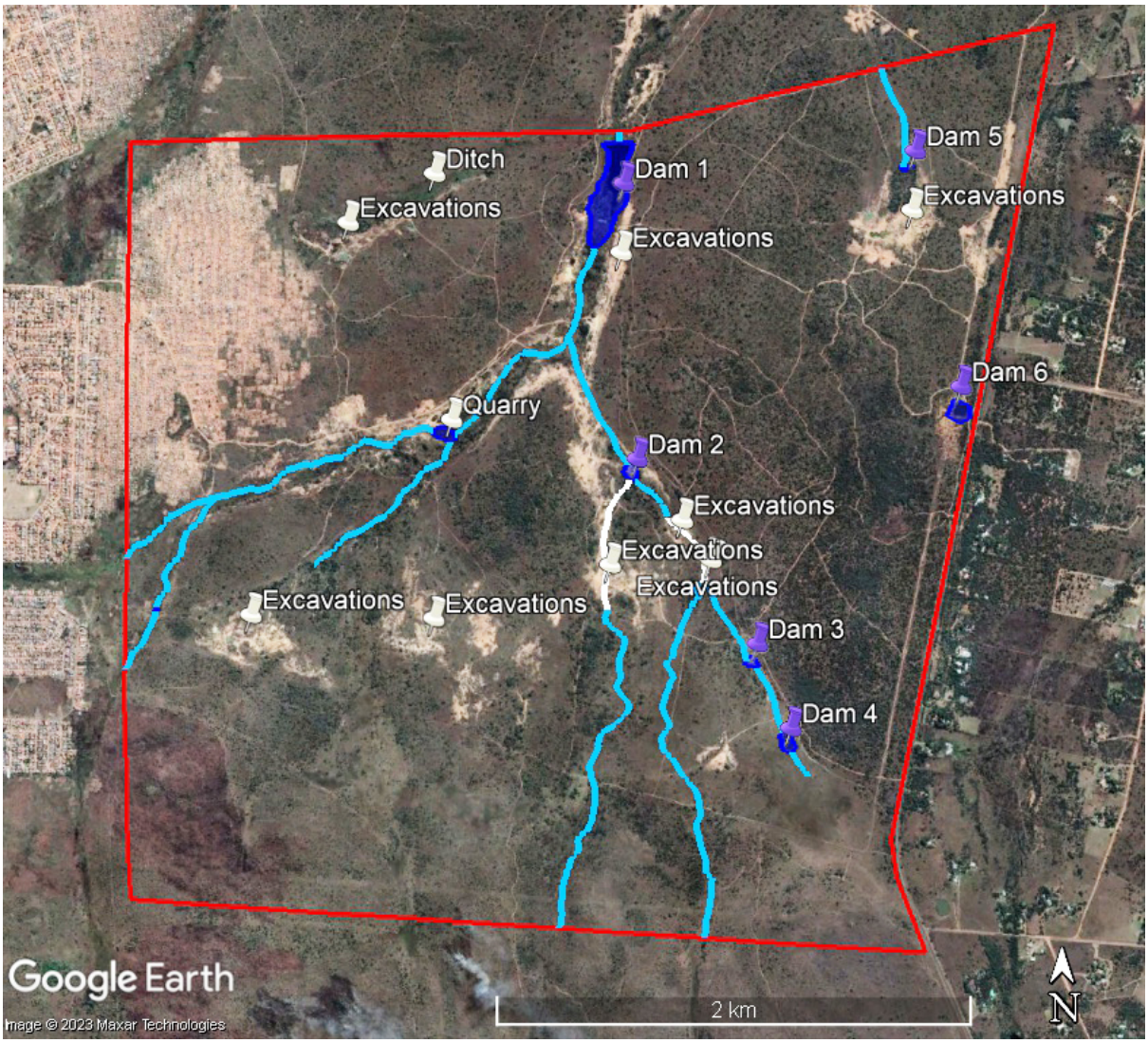

Figure 6 Indication of non-perennial rivers (active channels, riparian zones), dams and excavations at the site.

	Light blue outline	Route of active channel at the site
	Dark blue outline and shading	Artificial waterbodies (excavated or with groundwall)
	Green outline and shading	Riparian zone

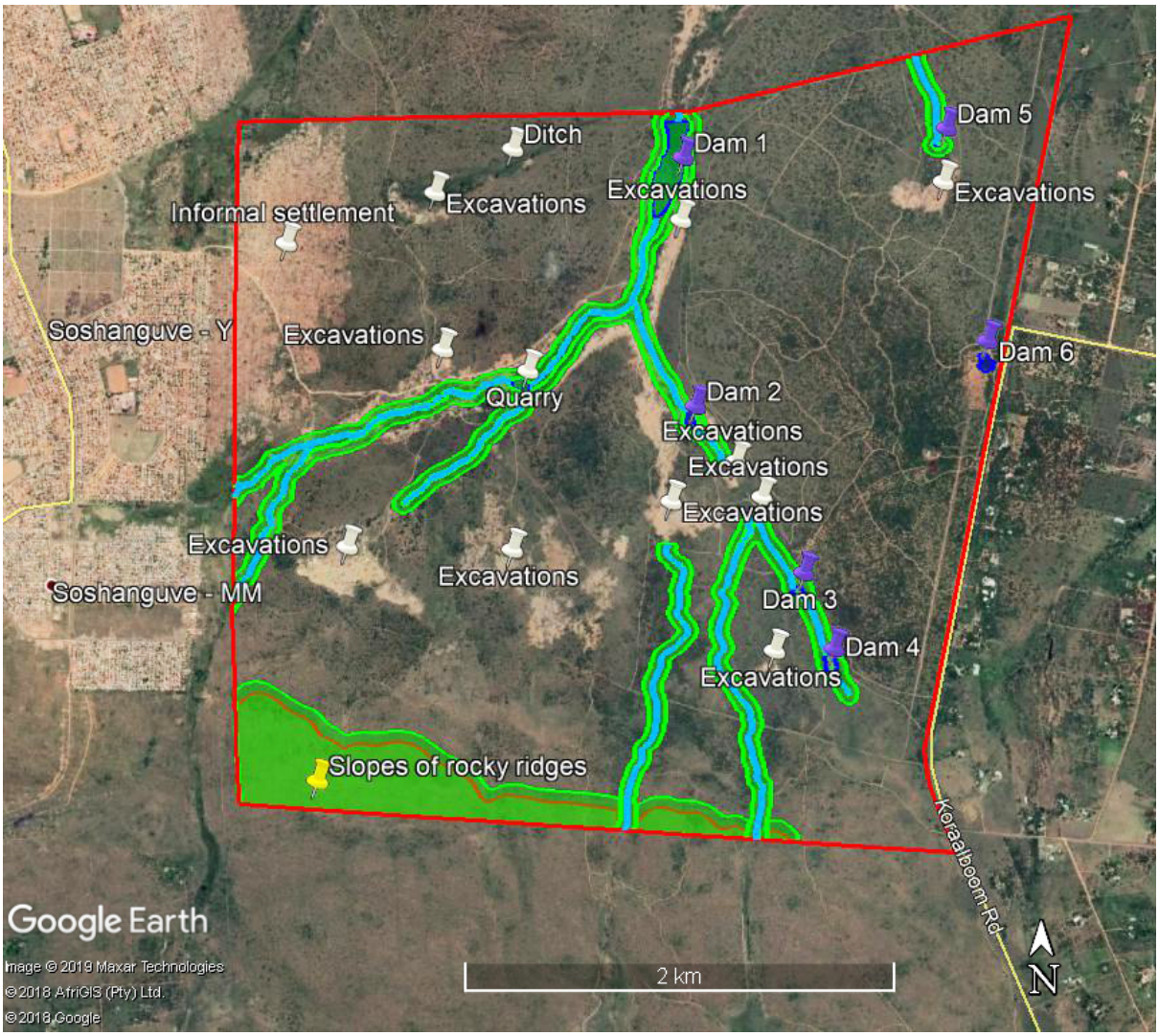

Figure 7 Indication of non-perennial rivers (active channels, riparian zones), dams and excavations at the site. Rocky slopes that enter the southwestern parts of the site are also depicted. An indication is also given of the buffer zones of the riparian areas as well as where the slopes of rocky ridges enter the site.

Light blue outline	Route of active channel at the site
Dark blue outline and shading	Artificial waterbodies (excavated or with groundwall)
Green outline and shading	Buffer Zone

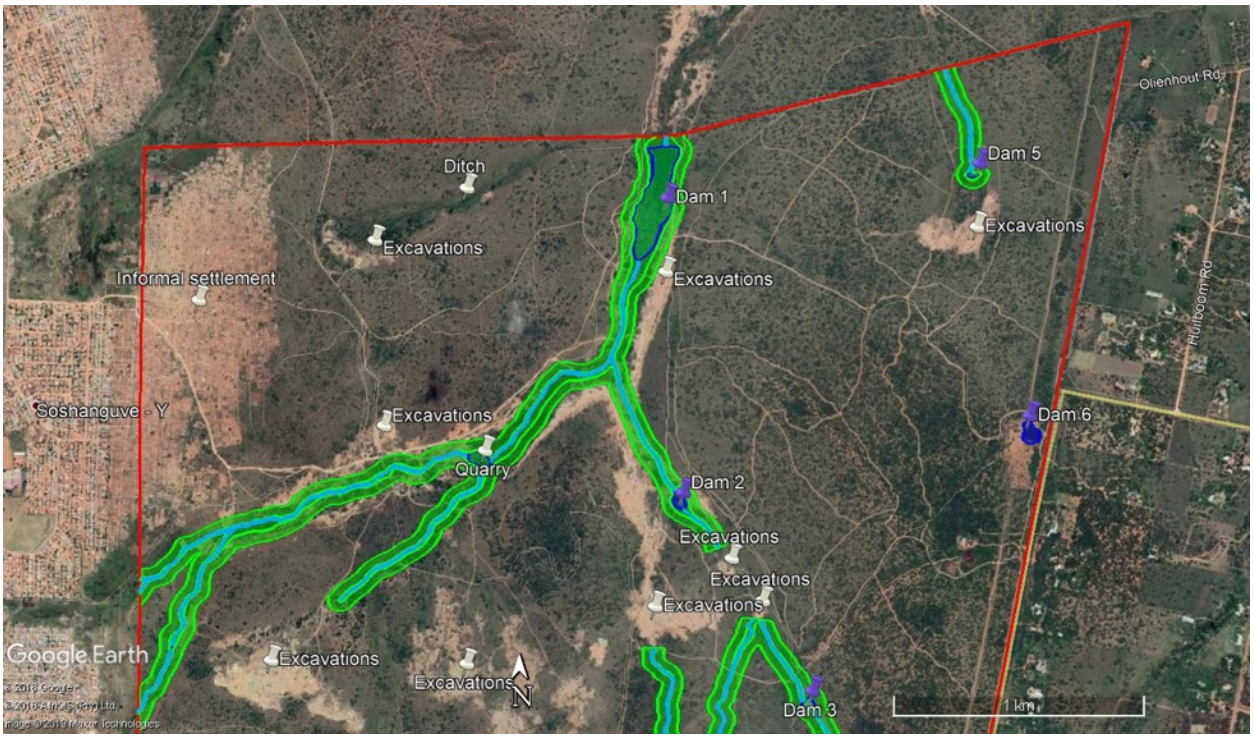

Figure 8 Indication of non-perennial rivers (active channels, riparian zones), dams and excavations at the northern parts of the site. An indication is also given of the buffer zones of the riparian areas.

Light blue outline	Route of active channel at the site
Dark blue outline and shading	Artificial waterbodies (excavated or with groundwall)
Green outline and shading	Buffer Zone

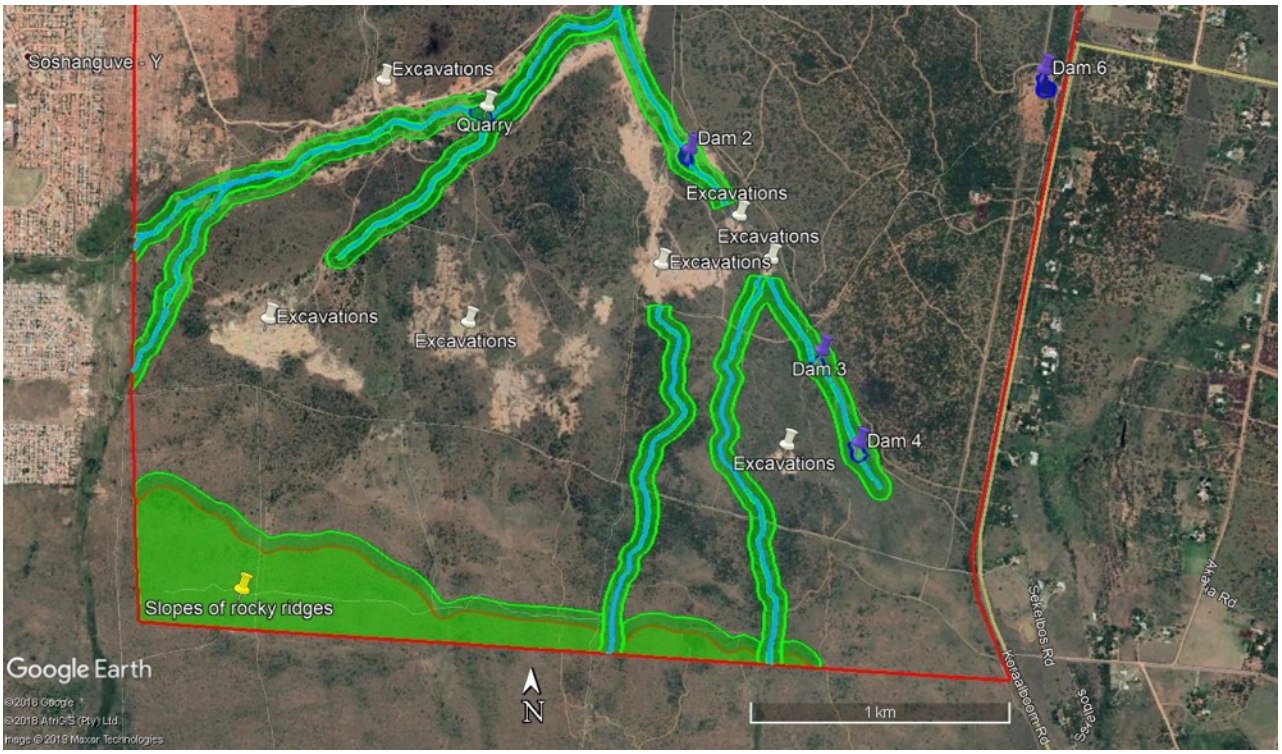

Figure 9 Indication of non-perennial rivers (active channels, riparian zones), dams and excavations at the southern parts of the site. Rocky slopes that enter the southwestern parts of the site are also depicted. An indication is also given of the buffer zones of the riparian areas as well as where the slopes of rocky ridges enter the site.

Light blue outline	Route of active channel at the site
Dark blue outline and shading	Artificial waterbodies (excavated or with groundwall)
Green outline and shading	Buffer Zone

4.2 Absence of wetlands

No wetlands appear to be present at the site.

Wetlands such as floodplain wetlands, channelled valley-bottom wetlands, unchannelled valley-bottom wetlands, depressions, seeps and wetland flats appear to be absent at the site. In conclusion no wetlands are found at the site.

4.3 Presence of non-perennial rivers and artificial waterbodies (dams)

Non-perennial rivers, with their active channels and riparian zones, are present at the site. Artificial waterbodies, mostly in-channel dams, with groundwalls, are also present at the site. Water gathers at numerous excavations at the site (Figures 2,3,4 and 5). An assessment of the present ecological state (PES) and ecological importance and sensitivity (EIS) follows. The watercourses have been grouped together where the PES and EIS are similar or part of one unit.

4.2.1 Non-perennial rivers (with active channel and riparian zones) and in-channel dams, at the site

Non-perennial rivers (tributaries of the Tshwane-river system) with small in-channel dams (Dam 2, Dam 3, Dam 4 and Dam 5) are present at the site. These non-perennial rivers consist of active channels and riparian zones that have been transformed or modified at many areas along the watercourses.

Riparian zones have distinctive characteristic vegetation which is often visibly distinct from the surrounding vegetation. It is often clearly adapted to different levels of frequency and inundation and distributed accordingly within the broad riparian zone. The more water loving or mesic species are therefore located close to the river channel, while species which are less dependent on water are located further away. It is the ability of species to tolerate different levels of inundation, the need for excessive water availability, or the need for close river proximity for growth, propagation, temperature control and nutrient enrichment which clearly determinate the structural, compositional and functional characteristics of riparian zones (Kemper, 2001).

The riparian zones at the tributaries at the site are modified and transformed to a very large scale. Extensive removal of vegetation and soils and numerous excavations are present. At some parts the active channel and riparian zone of the tributaries are difficult to follow and the connectivity broken up. Patches of vegetation along the riparian zones contain the indigenous reed *Phragmites mauritianus.* Other wetland plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae).

Present ecological status (PES) of the non-perennial rivers at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.2 and Table 4.3). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the is Category C which is Moderate and refers to watercourses 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 (Table 4.4 and Table 4.5).

Table 4.1 Classification and outline of characteristics of **non-perennial rivers (tributaries of the Tshwane-river system) and their small in-channel dams at the site**, according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013).

CHARACTERISTIC TYPE WETLAND DISCRIMINATORS AND DESCRIPTORS	**DESCRIPTION**
System (level 1)	Inland watercourse
Regional setting (level 2)	Bushveld Basin (Kleynhans *et. al.*, 2005)
Landscape unit (level 3)	Plain
Hydrogeomorphic unit (level 4)	River (non-perennial)
Hydrological regime (Level 5)	Concentrated unidirectional flow of water at the active channel. Waterflow is seasonal (non-perennial).
Additional descriptors (Levels 5,6)	The riparian zones at the tributaries at the northern parts of the site are modified and transformed to a very large scale. Extensive removal of vegetation and soils and numerous excavations are present. At some parts the active channel and riparian zone of the tributaries are difficult to follow and the connectivity broken up. Patches of vegetation along the riparian zones contain the indigenous reed *Phragmites mauritianus.* Other wetland

	plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae).

Table 4.2 Scoresheet with criteria for assessing habitat integrity of **non-perennial rivers (tributaries of the Tshwane-river system) and their small in-channel dams at the site** according to DWAF (1999) such as adapted from Kleynhans (1996).

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	1	4
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	1	4
Water Quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	2	3
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	2	3
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	2	4
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or change wetland habitat directly or through changes in inundation patterns.	1	4
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	2	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	2	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	2	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	2	4
Overutilisation of biota	Overgrazing, over-fishing etc.	3	4
TOTAL **MEAN**		**20** **x = 1.8**	42 x = 3.8

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2;
seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 4.3 Interpretation of scores for determining present ecological status **(PES)** of the **non-perennial rivers (tributaries of the Tshwane-river system) and their small in-channel dam at the site** according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of watercourse is indicated in blue font.

Interpretation of Mean* of Scores for all Attributes: Rating of Present Ecological Status Category (PES Category)
WITHIN GENERALLY ACCEPTABLE RANGE
CATEGORY A >4; Unmodified, or approximates natural condition.
CATEGORY B >3 and <=4; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C >2 and <=3; moderately modified, but with some loss of natural habitats.
CATEGORY D =2; largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E **>0 and <2; seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.**
CATEGORY F 0; critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean.

Table 4.4 Scoresheet for determining ecological importance and sensitivity for floodplains of the **non-perennial rivers (tributaries of the Tshwane-river system) and their small in-channel dams at the site** (DWAF 1999, adapted from Kleynhans 1996, 1999).

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	2	3
3. Species/taxon Richness	3	3
4. Diversity of Habitat Types or Features	3	3
5. Migration route/breeding and feeding site for wetland species	2	3
6. Sensitivity to Changes in the Natural Hydrological Regime	2	3
7. Sensitivity to Water Quality Changes	2	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	1	4
10. Ecological Integrity	3	4
TOTAL	**19**	32
MEAN	**1.9**	3.2

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 4.5 Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF 1999, adapted from Kleynhans 1996, 1999). Ecological Importance and Sensitivity (EIS) of the **non-perennial rivers (tributaries of the Tshwane-river system) and their small in-channel dams at the site**.

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 which 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

4.2.2 In-channel dam, Dam 1 at the northern boundary of the site

An artificial waterbody, an in-channel dam, Dam 1, is present at the southern side of the northern boundary of the site. This dam is the largest of the dams at the site and could have possibly still be an important area for waterbirds though the disturbances at and near the dam increased extensively over the past decade. Its functioning as a recreational area that harbours a number of waterbirds and one which could be visited by bird enthusiasts and tourists are at present in doubt.

Extensive removal of vegetation and soils is present near Dam 1. Patches wetland plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae). Some indigenous trees also remained at the riparian zone.

Present ecological status (PES) of Dam 1 at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.7 and Table 4.8). Ecological Importance and Sensitivity (EIS) of Dam 1 at the site is Category C which is Moderate and refers to watercourses 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 (Table 4.9 and Table 4.10).

Table 4.6 Classification and outline of characteristics of **an artificial waterbody, the in-channel dam, Dam 1 at the site**, according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013).

CHARACTERISTIC TYPE WETLAND DISCRIMINATORS AND DESCRIPTORS	**DESCRIPTION**
System (level 1)	Inland watercourse
Regional setting (level 2)	Bushveld Basin (Kleynhans *et. al.*, 2005)
Landscape unit (level 3)	Plain
Hydrogeomorphic unit (level 4)	Artificial waterbody (Dam 1)
Hydrological regime (Level 5)	Concentrated unidirectional flow of water at from an active channel into the dam where some water is contained by a damwall.
Additional descriptors (Levels 5,6)	Extensive removal of vegetation and soils is present near Dam 1. Patches of wetland plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae). Some indigenous trees also remained as part of the riparian zone.

Table 4.7 Scoresheet with criteria for assessing habitat integrity of **an artificial waterbody, the in-channel dam, Dam 1 at the site** according to DWAF (1999) such as adapted from Kleynhans (1996).

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	1	4
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	1	4
Water Quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	2	3
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	1	3
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	2	4
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or change wetland habitat directly or through changes in inundation patterns.	1	4
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	1	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	2	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	2	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	2	4
Overutilisation of biota	Overgrazing, over-fishing etc.	3	4
TOTAL **MEAN**		**18** **x = 1.6**	42 x = 3.8

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2;
seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 4.8 Interpretation of scores for determining present ecological status **(PES)** of the **an artificial waterbody, the in-channel dam, Dam 1 at the site** according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of watercourse is indicated in blue font.

Interpretation of Mean* of Scores for all Attributes: Rating of Present Ecological Status Category (PES Category)
WITHIN GENERALLY ACCEPTABLE RANGE
CATEGORY A >4; Unmodified, or approximates natural condition.
CATEGORY B >3 and <=4; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C >2 and <=3; moderately modified, but with some loss of natural habitats.
CATEGORY D =2; largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E **>0 and <2; seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.**
CATEGORY F 0; critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean.

Table 4.9 Scoresheet for determining ecological importance and sensitivity for floodplains of an **artificial waterbody, the in-channel dam, Dam 1 at the site** (DWAF 1999, adapted from Kleynhans 1996, 1999).

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	1	3
3. Species/taxon Richness	2	3
4. Diversity of Habitat Types or Features	2	3
5. Migration route/breeding and feeding site for wetland species	2	3
6. Sensitivity to Changes in the Natural Hydrological Regime	2	3
7. Sensitivity to Water Quality Changes	2	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	1	4
10. Ecological Integrity	1	4
TOTAL	**15**	32
MEAN	**1.5**	3.2

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 4.10 Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF 1999, adapted from Kleynhans 1996, 1999). Ecological Importance and Sensitivity (EIS) of **an artificial waterbody, the in-channel dam, Dam 1 at the site**.

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 which 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

4.2.3 Artificial waterbody Dam 6 that possibly originated from a quarry

Dam 6 which could possibly be a quarry, is found at the eastern parts of the site. This dam is inherently transformed and modified. Riparian vegetation along the fringe of the dam is poorly developed. Many bare areas exist around the dam. Patches of a wetland plant species *Persicaria* species (Knot-weeds) are found at some places. Informal dumping has been occurring increasingly in recent years at Dam 6.

Present ecological status (PES) of Dam 6 is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.12 and Table 4.13). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the central- and northern parts of the site is Category D which is Low/Marginal and refers to watercourses 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 (Table 4.14 and Table 4.15).

Table 4.11 Classification and outline of characteristics of the **artificial waterbody that could possibly be the remains of a quarry, Dam 6**, at the site, according to the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al.*, 2013).

CHARACTERISTIC TYPE WETLAND DISCRIMINATORS AND DESCRIPTORS	**DESCRIPTION**
System (level 1)	Inland watercourse
Regional setting (level 2)	Bushveld Basin (Kleynhans *et. al.*, 2005)
Landscape unit (level 3)	Plain
Hydrogeomorphic unit (level 4)	Artificial waterbody (dam)
Hydrological regime (Level 5)	Water that gathers from rainfall events also via sheetflow.
Additional descriptors (Levels 5,6)	This dam is inherently transformed and modified. Riparian vegetation along the fringe of the dam is poorly developed. Patches of a wetland plant species *Persicaria* species (Knot-weeds) are found at some places. Many bare areas are present along the edge of the dam. Informal dumping has been occurring increasingly in recent years at Dam 6.

Table 4.12 Scoresheet with criteria for assessing habitat integrity of **artificial waterbody that could possibly be the remains of a quarry, Dam 6** according to DWAF (1999) such as adapted from Kleynhans (1996).

Criteria and attributes	**Relevance**	**Score**	**Confidence**
Hydrologic			
Flow modification	Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland.	1	4
Permanent inundation	Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota.	1	4
Water Quality			
Water quality modification	From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland.	2	3
Sediment load modification	Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats.	1	3
Hydraulic/Geomorphic			
Canalisation	Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage.	1	4
Topographic alteration	Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railway lines and other substrate disruptive activities which reduce or change wetland habitat directly or through changes in inundation patterns.	1	4
Biota			
Terrestrial encroachment	Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions.	1	4
Indigenous vegetation removal	Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion.	1	4
Invasive plant encroachment	Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading).	1	4
Alien fauna	Presence of alien fauna affecting faunal community structure.	2	4
Overutilisation of biota	Overgrazing, over-fishing etc.	2	4
TOTAL **MEAN**		**15** **x = 1.4**	42 x = 3.8

Scoring guidelines per attribute:
natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2;
seriously modified = 1; Critically modified = 0.
Relative confidence of score:
Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Table 4.13 Interpretation of scores for determining present ecological status **(PES)** of the **artificial waterbody that could possibly be the remains of a quarry, Dam 6** according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of watercourse is indicated in blue font.

Interpretation of Mean* of Scores for all Attributes: Rating of Present Ecological Status Category (PES Category)
WITHIN GENERALLY ACCEPTABLE RANGE
CATEGORY A >4; Unmodified, or approximates natural condition.
CATEGORY B >3 and <=4; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C >2 and <=3; moderately modified, but with some loss of natural habitats.
CATEGORY D =2; largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E **>0 and <2; seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.**
CATEGORY F 0; critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

* If any of the attributes are rated <2, then the lowest rating for the attribute should be taken as indicative of the PES category and not the mean.

Table 4.14 Scoresheet for determining ecological importance and sensitivity for floodplains of the **artificial waterbody that could possibly be the remains of a quarry, Dam 6** (DWAF 1999, adapted from Kleynhans 1996, 1999).

Determinant	Score	Confidence
PRIMARY DETERMINANTS		
1. Rare & Endangered Species	0	3
2. Populations of Unique Species	1	3
3. Species/taxon Richness	1	3
4. Diversity of Habitat Types or Features	1	3
5. Migration route/breeding and feeding site for wetland species	1	3
6. Sensitivity to Changes in the Natural Hydrological Regime	1	3
7. Sensitivity to Water Quality Changes	2	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	1	3
MODIFYING DETERMINANTS		
9. Protected Status	1	4
10. Ecological Integrity	1	4
TOTAL	**10**	32
MEAN	**1**	3.2

Score guideline Very high = 4; High = 3, Moderate = 2; Marginal/Low = 1; None = 0
Confidence rating Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1

Table 4.15 Ecological importance and sensitivity categories. Interpretation of median scores for biotic and habitat determinants (DWAF 1999, adapted from Kleynhans 1996, 1999). Ecological Importance and Sensitivity (EIS) of the **artificial waterbody that could possibly be the remains of a quarry, Dam 6 at the site.**

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 which 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

5 IMPACTS, MITIGATION AND RATING OF RISKS

5.1 Identification of potential impacts and risks

The potential impacts identified are:

Construction Phase

- Potential impact 1: Loss of riparian habitat owing to the removal of vegetation at the proposed footprint for development.
- Potential impact 2: Changes in flow regime.
- Potential impact 3: Exposure of soil leading to soil compaction and/ or erosion.
- Potential impact 4: Loss of sensitive wetland/ riparian species (Threatened, Near Threatened, Rare, Declining or Protected species) during the construction phase.
- Potential impact 5: Loss of riparian connectivity and conservation corridor networks in the landscape.
- Potential impact 6: Contamination of riparian soil during construction in particular by hydrocarbon spills.
- Potential impact 7: Contamination of habitat by littering and dumping of rubble/ construction material.

Operational Phase

- Potential impact 8: An increased infestation of exotic or alien invasive plant species owing to disturbances associated with the proposed development.
- Potential impact 9: Poor recovery of soils that were exposed and compacted during the construction phase.

5.2 Site specific considerations of risks and impacts

Large scale removal of vegetation and soils have taken place at the site. Note the Google Earth Pro Map comparison of the situation in 2004 compared to 2023 (Figure 2, Figure 3). While the ecological integrity of the active channels and riparian zones have been degraded at a large scale, these non-perennial rivers with their artificial waterbodies (dams) remain important corridors in the larger areas. The developer has considered the sensitive watercourse features and associated buffers recommended and has further ensured avoidance by considering 32 m buffers proposed in this report. This is considered to reduce the risk of impact to the sensitive features and is considered as an opportunity for further mitigation and reduction in the significance of the expected impact.

5.2.1 Riparian vegetation and habitat

Climate at the vegetation types of which site is part comprises summer rainfall with very dry winters. Mean annual precipitation from about 500 mm to 700 mm. The implications of the climate are that construction could take place at the non-perennial streams at a certain time of the year when there is a high probability that temporary diverting the stream would not be necessary. For much of the time the active channels could be dry.

Present ecological status (PES) of the non-perennial rivers at the site is CATEGORY E which means the watercourses are seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.2 and Table 4.3). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the is Category C which is Moderate and refers to watercourses 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 (Table 4.4 and Table 4.5).

Present ecological status (PES) of Dam 1 at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.7 and Table 4.8). Ecological Importance and Sensitivity (EIS) of Dam 1 at the site is Category C which is Moderate and refers to watercourses 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 (Table 4.9 and Table 4.10).

Present ecological status (PES) of Dam 6 is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.12 and Table 4.13). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the central- and northern parts of the site is Category D which is Low/Marginal and refers to watercourses 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 (Table 4.14 and Table 4.15).

5.2 2 Flow Regime

The non-perennial rivers at the site, with in-channel dams, their riparian zones and buffer zones, are likely to be impacted by the proposed development, but to a very limited extent by road- and bridge crossings. If the development is approved the construction should be planned in such a manner that surface flow function well while erosion is limited. There is no distinct indication that interflow plays an important role in the maintenance of the non-perennial rivers. The geomorphological setting and flow regime should be as similar as possible post development as to prior the development, if the development is approved. Loss of any wetland animal or plant species of particular conservation importance is not expected.

5.2.3 Likely absence of sensitive species

Loss of Threatened or Near Threatened wetland Plants, Mammals, Reptiles, Amphibians and Invertebrates at the proposed footprint appears to be unlikely.

5.2.4 Connectivity

The non-perennial rivers, with riparian zones and buffer zones, at the site are corridors of particular conservation importance. The non-perennial rivers and in-channel dams, with their riparian zones and buffer zones, are excluded from the development as far as practical. The area needed for

working and moving of construction vehicles, machinery and equipment to operate should be fenced off with appropriate material beyond which no activities should be allowed.

5.2.5 Pollution

Rubble or waste could lead to infiltration of unwanted pollutants into the soil. Spilling of petroleum fuels and unwanted chemicals onto the soils that infiltrate these soils could lead to pollution of soils and also impact on water quality when the stream flows. Rubble or waste that could accompany the construction effort, if the development is approved, should be removed during and after construction. Measures should be taken to avoid any spills and infiltration of petroleum fuels or any chemical pollutants into the soil during construction phase.

5.2.6 Alien invasive plant species

A rehabilitation plan which includes the combating of alien invasive plant species at the watercourses are essential. Infestation by alien invasive species could replace indigenous vegetation or potential areas where indigenous vegetation could recover. Once established combatting these alien invasive plant species may become very expensive in the long term, especially if species such as *Prosopis* (Mesquite) and *Melia azedarach* (Syringa Berry-tree) are allowed to establish. Continued monitoring and eradication of alien invasive plant species are imperative.

5.3 RISK RATING ASSESSMENT

Potential impacts, mitigations and site-specific considerations have been taken into account to arrive at risk ratings relevant to the site which follow.

The risk matrix is based on the DWS publication: Section 21 c and (i) water use Risk Assessment Protocol and Notice 509 of 2016 (Government Gazette No. 40229: 105-133; Republic of South Africa). Risk is determined after considering all listed control and/ or mitigation measures. Borderline low/ moderate risk scores can be manually adapted downwards up to a maximum of 25 points (from a score of 80) subject to listing of additional mitigation measures considered and listed in red font.

Construction is here interpreted in accordance with the definition provided in Notice 509 of 2016 (Government Gazette No. 40229, p.107) to mean “any works undertaken to initiate or establish impeding or diverting or modifying resource quality, for the first time, including vegetational removal, site preparation and ground levelling”.

Table 5.3.1 A summary of the phases, activities, aspects, impacts and mitigation measures for the proposed development at the site. This summary is part of the breakdown analyses to inform the risk matrix (based on Section 21 c and (i) water use Risk Assessment Protocol and Notice 509 of 2016 (Government Gazette No. 40229: 105-133; Republic of South Africa). The relevant mitigations are added to register the availability of practical solutions to minimize any negative impacts and because the residue following the mitigation is important in the risk assessment.

Phase	Activity	Aspect	Impact	Mitigation
Construction	Clearing of vegetation at and in close proximity of watercourse at proposed footprints for stream crossings via bridge structures.	Clearing of vegetation at proposed footprint in preparation for construction and during construction.	Loss of vegetation and riparian habitat.	Non-perennial rivers, with their riparian zones and 32 m buffer zones, are excluded from the development as far as practical. If the development is approved there will be small restricted parts of the non-perennial rivers and their buffer zone that will be impacted. Any such developments, if approved, should be restricted to a minimum and followed up by rehabilitation.
			Exposed soil at riparian zone; then soil prone to compaction or potential erosion.	Non-perennial rivers and in-channel dam, with their riparian zones and 32 m buffer zones, are excluded from the development as far as practical. If the development is approved there will be a part of the non-perennial river and its buffer zone that will be impacted. Any such developments, if approved, should be restricted to a minimum on which rehabilitation of vegetation should follow.
	Moving vehicles and working of equipment/ machinery at and in close proximity of watercourse.	Moving vehicles and working of machinery and equipment at bridge crossings and extra strip for manoeuvring.	Further loss of vegetation and riparian habitat.	Non-perennial rivers and in-channel dams, with their riparian zones and 32 m buffer zones, are excluded from the development as far as practical. If the development is approved there will be a part of the non-perennial river and its buffer zone that will be impacted. The footprint area with the area needed for

				moving of construction vehicles, machinery and equipment to operate should be fenced off with appropriate material beyond which no activities should be allowed.
			Further exposure and compaction of soils.	Non-perennial rivers and in-channel dams, with their riparian zones and 32 m buffer zones, are excluded from the development as far as practical. If the development is approved there will be a part of the non-perennial river and its buffer zone that will be impacted. The footprint area with the area needed for moving of construction vehicles, machinery and equipment to operate should be fenced off with appropriate material beyond which no activities should be allowed.
		Vehicles and machinery could leak which then result in spilling of hydrocarbons.	Pollution of soils by hydrocarbon and unwanted chemical spills.	Equipment to avoid any spills of fuels/ oils/ hydrocarbons should be available and at once implemented where necessary at the site. Regular inspections of machinery and equipment are essential to observe any leaks and should be serviced outside the proposed footprint.
	Generation of waste or building rubble materials at proposed footprint at watercourse.	Waste or building rubble are generated during the construction phase.	Potential contamination of the watercourse habitat by generated waste or building rubble.	Manage waste and take waste away to appropriate waste-disposal sites outside the watercourse.
	Clearing of vegetation at and in close proximity of access roads to construction site.	Creating access road(s) to construction area.	Loss of vegetation and habitat at and along access roads.	Existing access roads are used. Any alternative access roads, if approved, should be restricted to a minimum.
			Exposure and compaction of soils.	Existing access roads are used. Any alternative access roads, if approved, should be restricted to a minimum.

Operational	Establishment of alien invasive plant species at hitherto cleared areas.	Cleared areas where alien invasive plant species establish.	Alien invasive plant species infest hitherto cleared areas and occupy habitat which is then unavailable for indigenous species.	Continued monitoring and eradication of alien invasive plant species are imperative. A rehabilitation plan would be necessary which include the combating of alien invasive plant species.
	Poor recovery of soils that were exposed and compacted during the construction phase.	Compacted and exposed soils do not recover easily without rehabilitation.	Compacted and exposed soils are prone to further degradation and erosion.	Rehabilitation should take place which could include shallow ripping in appropriate direction and spacing. Mulch of indigenous widespread plant species or brushpacks of indigenous widespread species could also be included. Considerations such as too much ripping which could enhance erosion during high rainfall events should also be taken into account in the rehabilitation plan.

Table 5.3.2 Negative ratings of aspects for severity (flow regime, water quality, habitat, biota), spatial scale, duration and consequence. This table is part of a risk matrix (based on Section 21 c and (i) water use Risk Assessment Protocol and Notice 509 of 2016 (Government Gazette No. 40229: 105-133; Republic of South Africa).

		Severity							
Phase	**Aspect**	**Flow Regime**	**Water Quality**	**Habitat** Geomorph & Vegetation	**Biota**	**Severity**	**Spatial Scale**	**Duration**	**Consequence**
Construction	Clearing of vegetation at proposed footprint in preparation for construction and during construction.	1	1	2	2	**1,5**	1	2	**4,5**
	Moving vehicles and working of machinery and equipment at bridge crossings and extra strip for manoeuvring.	1	1	2	2	**1,5**	1	2	**4,5**
	Vehicles and machinery could leak which then result in spilling of hydrocarbons.	1	2	1	2	**1,5**	1	2	**4,5**

	Waste or building rubble are generated during the construction phase.	2	2	2	2	**2**	1	2	**5**
	Creating access road(s) to construction area.	1	1	1	1	**1**	1	1	**3**
Operational	Cleared areas where alien invasive plant species establish.	1	1	2	2	**1,5**	1	2	**4,5**
	Compacted and exposed soils do not recover easily without rehabilitation.	1	2	2	1	**1,5**	1	2	**4,5**

Table 5.3.2 Negative ratings of aspects for frequency of activity, frequency of impact, legal issues, detection, likelihood, significance and finally the Risk Rating. This table is part of a risk matrix (based on Section 21 c and (i) water use Risk Assessment Protocol and Notice 509 of 2016 (Government Gazette No. 40229: 105-133; Republic of South Africa).

Phase	**Aspect**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**
Construction	Clearing of vegetation at proposed footprint in preparation for construction and during construction.	1	2	5	1	9	**40,5**	**Low**
	Moving vehicles and working of machinery and equipment at bridge crossings and extra strip for manoeuvring.	4	2	5	1	12	**54**	**Low**
	Vehicles and machinery could leak which then result in spilling of hydrocarbons.	2	1	5	2	12	**54**	**Low**
	Waste or building rubble are generated during the construction phase.	3	2	5	1	11	**55**	**Low**
	Creating access road(s) to construction area.	1	1	5	1	8	**24**	**Low**
Construction	Cleared areas where alien invasive plant species establish.	2	2	5	2	11	**49,5**	**Low**
	Compacted and exposed soils do not recover easily without rehabilitation.	2	2	5	2	11	**49,5**	**Low**

Consequence = Severity + Spatial Scale + Duration

Likelihood = Frequency of the activity + Frequency of the impact + Legal issues + Detection

Risk = Consequence X Likelihood

Table 5.3.3 Summary of Negative Risk Ratings overall for all the aspects as well as the PES and EIS of the watercourses at the site.

Risk Rating	Confidence Level	PES of watercourse	EIS of watercourse
24-55 **Low**	80-90%	Category E Category E	Category C Category D

6 CONCLUSION

- Tributaries of the Tswane river run through the site. The active channels and riparian zones as well as the catchment area have been significantly impacted by very large-scale removal of vegetation and soils.
- No wetlands appear to be present at the site.
- Non-perennial rivers, with their active channels and riparian zones, are present at the site. Artificial waterbodies, mostly in-channel dams, with groundwalls, are also present at the site. Water gathers at numerous excavations at the site.
- Non-perennial rivers (tributaries of the Tshwane-river system) with small in-channel dams (Dam 2, Dam 3, Dam 4 and Dam 5) are present at the site. These non-perennial rivers consist of active channels and riparian zones that have been transformed or modified at many areas along the watercourses.
- The riparian zones at the tributaries at the site are modified and transformed to a very large scale. Extensive removal of vegetation and soils and numerous excavations are present. At some parts the active channel and riparian zone of the tributaries are difficult to follow and the connectivity broken up. Patches of vegetation along the riparian zones contain the indigenous reed *Phragmites mauritianus.* Other wetland plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae).
- Present ecological status (PES) of the non-perennial rivers at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic

ecosystem functions are extensive (Table 4.2 and Table 4.3). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the is Category C which is Moderate and refers to watercourses that are considered ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers (Table 4.4 and Table 4.5).

- An artificial waterbody, an in-channel dam, Dam 1, is present at the southern side of the northern boundary of the site. This dam is the largest of the dams at the site and could possibly still be an important area for waterbirds though the disturbances at and near the dam increased extensively over the past decade. Its functioning as a recreational area that harbours a high diversity of waterbirds and one which could be visited by bird enthusiasts and tourists are at present, in doubt.
- Extensive removal of vegetation and soils is present near Dam 1. Patches wetland plants such as *Cyperus* species, *Schoenoplectus* species (Cyperaceae), *Persicaria* species (Knot-weeds) and *Juncus* species (Juncaceae). Some indigenous trees also remained at the riparian zone.
- Present ecological status (PES) of Dam 1 at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.7 and Table 4.8). Ecological Importance and Sensitivity (EIS) of Dam 1 at the site is Category C which is Moderate and refers to watercourses 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 (Table 4.9 and Table 4.10).
- Dam 6 which could possibly be a quarry, is found at the eastern parts of the site. This dam is inherently transformed and modified. Riparian vegetation along the fringe of the dam is poorly developed. Many bare areas exist around the dam. Patches of a wetland plant species *Persicaria* species (Knot-weeds) are found at some places. Informal dumping has been occurring increasingly in recent years at Dam 6.
- Present ecological status (PES) of Dam 6 is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystm functions are extensive (Table 4.12 and Table 4.13). Ecological Importance and Sensitivity (EIS) of the non-perennial rivers at the central- and northern parts of the site is Category D which is Low/Marginal and refers to watercourses 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 (Table 4.14 and Table 4.15).

- Site is part of the Crocodile (West) and Marico Water Management Area (WMA 3). The site is not part of a Freshwater Ecosystem Priority Area (FEPA) or wetland cluster (Nel *et al.*, 2011a, 2011b).
- No Threatened or Near Threatened wetland plant or animal species appear to be resident at the site.
- Riparian zones at the site have been modified or transformed at a number of areas at the site by extensive excavations and removal of soil. In some areas reconstruction and rehabilitation will be needed.
- Though the riparian zones and active channels (of non-perennial rivers) are modified and transformed in many areas they remain important conservation corridors. A rehabilitation plan and actions are strongly recommended.
- Reconstruction of active channels and riparian zones are imperative in many areas. Where the active channel routes have been destroyed these should be reconstructed to link the riparian systems at the site.
- The non-perennial rivers at the site, with in-channel dams, their riparian zones and buffer zones, are likely to be impacted by the proposed developments, but to a very limited extent by road- and bridge crossings. If the development is approved the construction should be planned in such a manner that surface flow function well while erosion is limited. There is no distinct indication that interflow plays an important role in the maintenance of the non-perennial rivers. The geomorphological setting and flow regime should be as similar as possible post development as to prior the development, if the development is approved. Loss of any wetland animal or plant species of particular conservation importance is not expected.
- The Negative Risk Rating in accordance with a risk matrix based on Section 21 c and (i) water use Risk Assessment Protocol and Notice 509 of 2016 (Government Gazette No. 40229: 105-133; Republic of South Africa) at the site is Low.
- If the development is approved a 32 m buffer zone is practical for the riparian zones at the site.
- If the development is approved a key aim should be to cultivate indigenous vegetation at the site and in particular at riparian conservation corridors.

* Kindly see the ecological report (with photos) which accompanies this report and which also contains a risks, impact and mitigation section integrating both wetland and terrestrial systems.

7 REFERENCES

Alexander, G. & Marais, J. 2007. A guide to the reptiles of Southern Africa. Struik, Cape Town.

Apps, P. 2012. Smithers' mammals of Southern Africa 4th ed: A field guide, revised and updated by Peter Apps. Struik Nature, Cape Town.

Armstrong, A.J. 1991. On the biology of the marsh owl, and some comparisons with the grass owl. *Honeyguide* 37:148-159.

Barnes, K.N. *ed*. 2000. The Eskom Red Data Book of birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg.

Bates, M.F., Branch, W.R., Bauer, A.M., Burger, M., Marais, J., Alexander, G.J. & De Villiers, M.S. (eds). 2014. Atlas and Red List of the Reptiles of South Africa, Lesotho and Swaziland. *Suricata* 1. South African National Biodiversity Institute, Pretoria.

Boon, R. 2010. *Pooley's trees of eastern South Africa: a complete guide 2nd ed.* Flora and Fauna Publications Trust, Durban.

Branch, B. 1998. Field guide to snakes and other reptiles of southern Africa. 3rd ed. Struik, Cape Town.

Branch, B. 2008. Tortoises, Terrapins & Turtles of Africa. Struik Nature, Cape Town.

Branch, W.R., Tolley, K.A., Cunningham, M., Bauer, A.M., Alexander, G., Harrison, J.A., Turner, A.A. & Bates, M.F. *eds*. 2006. A plan for phylogenetic studies of southern African reptiles: proceedings of a workshop held at Kirstenbosch, February 2006. Biodiversity Series 5. South African National Biodiversity Institute, Pretoria.

Bronner, G. 2011. *Mammals.* In: Picker, M. & Griffiths, C. 2011. *Alien & Invasive animals: a South African perspective.* Struik Nature, Cape Town, p 22-35.

Bromilow, C. 2010. Problem plants and alien weeds of South Africa. Briza Publications, Pretoria.

Carruthers, V. & Du Preez, 2011. Frogs and froging in southern Africa 2nd ed. Struik, Cape Town.

Chittenden, H. 2007. Roberts Bird Guide. John Voelcker Book Fund, Cape Town.

Cillié, B., Oberprieler, U. & Joubert, C. 2004. Animals of Pilanesberg: an identification guide. Game Parks Publishing, Pretoria.

Cilliers, S.S., Müller, N. & Drewes, E. 2004. Overview on urban nature conservation: situation in the western-grassland biome of South Africa. *Urban forestry and urban greening* 3: 49-62.

Coetzee, N. & Monadjem, A. 2008. *Mystromys albicaudatus*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. <www.iucnredlist.org>.

Conradie, W., Du Preez, L.H., Smith, K. & Weldon, C. 2006. Field guide to the frogs and toads of the Vredefort Dome World Heritage Site. School of Environmental Sciences and Development, Potchefstroom.

Court, D. 2010. *Succulent Flora of Southern Africa*. Struik Nature, Cape Town.

Crouch, N.R., Klopper, R.R., Burrows, J.E. & Burrows, S.M. 2011. Ferns of Southern Africa: a comprehensive guide. Struik Nature, Cape Town.

Del Hoyo, J., Elliot, J. & Sargatal, J. 1992. Handbook of the birds of the world, Vol. 1. Lynx Editions, Barcelona.

Deutschländer, M.S. & Bredenkamp, C.J. 1999. Importance of vegetation analysis in the conservation management of the endangered butterfly *Aloeides dentatis* subsp. *dentatis* (Swierstra) (Lepidoptera: Lycaenidae). *Koedoe* 42(2): 1-12.

Dippenaar-Schoeman, A.S. 2002. Baboon and trapdoor spiders in southern Africa: an identification manual. Plant Protection Research Institute Handbook No. 13. Agricultural Research Council, Pretoria.

Dippenaar-Schoeman, A.S. & Jocqué, R. 1997. African spiders: an identification manual. Plant Protection Research Institute Handbook No. 9. Agricultural Research Council, Pretoria.

Drinkwater, T.W., Bate, R. & Du Toit, H.A. 1998. A field guide for identification of maize pests in South Africa. Agricultural Research Council: Grain-crops Institute, Potchefstroom.

Du Preez, L.H. 1996. Field guide and key to the frogs and toads of the Free State. Department of Zoology and Entomology, University of the Orange Free State, Bloemfontein.

Du Preez, L.H. & Carruthers, V. 2009. A complete guide to the frogs of southern Africa. Struik Nature, Cape Town. CD with calls included.

DWAF (Department of Water Affairs and Forestry). 1997. South African Water Quality Guidelines for Aquatic Ecosystems.

DWAF (Department of Water Affairs and Forestry). 1999. Resource Directed Measures for Protection of Water Resources: Wetland Ecosystems: W4. Department of Water Affairs and Forestry, Pretoria.

DWAF (Department of Water Affairs and Forestry). 2005. A practical field procedure for identification and delineation of wetland and riparian areas. DWAF, Pretoria.

Ellery, W., Grenfell, M., Grenfell, S., Kotze, D., McCarthy, T., Tooth, S., Grundling, P-L., Beckedahl, H., Le Maitre, D. & Ramsay, L. 2009. WET-origins: controls on the distribution and dynamics of wetlands in South Africa.

Ferguson-Lees, J. & Christie, D.A. 2001. *Raptors of the world.* Christopher Helm, London.

Filmer, M.R. 1991. Southern African spiders: an identification guide. Struik, Cape Town.

Germishuizen, G. 2003. Illustrated guide to the wildflowers of northern South Africa. Briza, Pretoria.

Germishuizen, G., Meyer, N.L. & Steenkamp (*eds*) 2006. A checklist of South African plants. Southern African Botanical Diversity Network Report No. 41. SABONET, Pretoria.

Goldblatt, P. 1986. The Moraeas of Southern Africa. Annals of Kirstenbosch Botanic Gardens, Volume 14. National Botanic Gardens, Cape Town.

Goldblatt, P. & Manning, J. 1998. Gladiolus in Southern Africa.

Henderson, L. 2001. *Alien weeds and alien invasive plants: a complete guide to the declared weeds and invaders in South Africa.* Plant Protection Research Institute Handbook No. 12. ARC: Plant Protection Research Institute, Pretoria.

Henderson, L. & Cilliers, C.J. 2002. *Invasive aquatic plants: a guide to the identification of the most important and potentially dangerous invasive aquatic and wetland plants in South Africa.* Plant Protection Research Handbook No. 16. Agricultural Research Council, Pretoria.

Henning, S.F. & Henning, G.A. 1989. South African Red Data Book: butterflies. *South African National Scientific Programmes Report* No. 158. CSIR, Pretoria.

Herman, P.P.J. 2002. Revision of the *Tarchonanthus camphoratus* complex (Asteraceae-Tarchonantheae) in southern Africa. *Bothalia* 32,1: 21-28.

Hill, C.J. 1995. Conservation corridors and rainforest insects. (*In* Watt, A.D., Stork, N.E. & Hunter, M.D. (*eds*.), Forests and Insects. Chapman & Hall, London. p. 381-393.)

Hockey, P. 2011. *Birds.* In: Picker, M. & Griffiths, C. 2011. *Alien & Invasive animals: a South African perspective.* Struik Nature, Cape Town, p 36-44.

Hockey, P.A.R., Dean, W.J.R. & Ryan, P.G. (*eds*.). 2005. Roberts Birds of Southern Africa. John Voelcker Bird Book Fund, Cape Town.

Holm, E. & Marais, E. 1992. Fruit chafers of southern Africa. Ekogilde, Hartebeespoort.

IUCN. 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

IUCN. 2012. IUCN Red list of Threatened Species. Version 2012.1)

Kemper, N.P. 2001. RVI: Riparian Vegetation Index, final report, WRC Report No. 850/3/1. Institute for Water Research, Pretoria.

Kleynhans, C.J. 1999. A procedure for the determination of the ecological reserve for the purposes of the national water balance model for South African River. Institute of Water Quality Studies, Department of Water Affairs & Forestry, Pretoria.

Kleynhans, C.J., Thirion, C. & Moolman, J. 2005. A level 1 ecoregion classification system for South Africa, Lesotho and Swaziland. Report No. N/0000/00/REQ0104. Resource Quality Services, Department of Water Affairs and Forestry, Pretoria.

Kotze, D., Marneweck, G., Batchelor, A., Lindley, D. and Collins, N. 2008. WET-EcoServices: A technique for rapidly assessing ecosystem services supplied by wetlands. Wetland Management Series. Water Research Commission Report TT339/08, Water Research Commission, Pretoria.

Liebenberg, L. 1990. A field guide to the animal tracks of Southern Africa. David Philip Publishers, Cape Town.

Leeming, J. 2003. Scorpions of southern Africa. Struik, Cape Town.

Leroy, A. & Leroy, J. 2003. Spiders of southern Africa. Struik, Cape Town.

Manning, J. 2003. Photographic guide to the wild flowers of South Africa. Briza, Pretoria. .

Manning, J. 2009. Field guide to the wild flowers of South Africa. Struik, Cape Town.

Marneweck, G.C. & Batchelor, A. 2002. Wetland inventory and classification. In: Ecological and economic evaluation of wetlands in the upper Olifants River catchment. Palmer, R.W., Turpie, J., Marneweck, G.C. and Batchelor, A. (eds). Water Research Commission Report No. 1162/02.

McMurtry, D., Grobler, L., Grobler, J. & Burns, S. 2008. Field guide to the orchids of northern South Africa and Swaziland. Umdaus Press, Hatfield.

Mecenero, S., Ball, J.B., Edge, D.A., Hamer, M.L., Henning, G.A., Krüger, M, Pringle, E.L., Terblanche, R.F. & Williams, M.C. 2013. *Conservation Assessment of Butterflies of South Africa, Lesotho and Swaziland: Red List and Atlas.* Saftronics, Johannesburg & Animal Demography Unit, Cape Town.

Minter, L.R., Burger, M., Harrison, J.A., Braack, H.H., Bishop, P.J. & Kloepfer, D. *eds.* 2004. Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland. SI/MAB series 9, Smithsonian Institution, Washington DC.

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

Mucina, L., Rutherford, M.C., and Powrie, L.W. *eds*. 2005. Vegetation map of South Africa, Lesotho and Swaziland, 1:1 000 000 scale sheet maps. Pretoria: South African National Biodiversity Institute.

Nel, J.L., Driver, A., Strydom, W.F., Maherry, A.M., Petersen, C.P., Hill, L., Roux, D.J., Nienaber, S., Van Deventer, H., Swartz, E.R. & Smith-Adao, L.B. 2011. Atlas of Freshwater Ecosystem Priority Areas in South Africa: Maps to support sustainable development of water resources. WRC Report No. TT 500/11. Water Research Commission, Pretoria.

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. & Nienaber, S. 2011. Technical Report for the Freshwater Ecosystem Priority Areas Project. WRC Report No. TT 1801/2/11. Water Research Commission, Pretoria.

Ollis, D.J., Snaddon, C.D., Job, N.M. & Mbona, N. 2013. Classification System for Wetlands and other Aquatic Ecosystems in South Africa. User Manual: Inland Systems. *SANBI Biodiversity Series 22.* South African National Biodiversity Institute, Pretoria.

Peacock, F. 2006. Pipits of Southern Africa. Published by the author, Pretoria. www.pipits.co.za.

Pfab, M.F. 2002. Priority ranking scheme for Red Data plants in Gauteng, South Africa. *South African Journal of Botany* (68): 299-303.

Pfab, M.F. & Victor, J.E. 2002. Threatened plants of Gauteng, South Africa. *South African Journal of Botany* (68): 370-375.

Picker, M. & Griffiths, C. 2011. Alien & Invasive animals: a South African perspective. Struik Nature, Cape Town.

Picker, M., Griffiths, C. & Weaving, A. 2004. Field guide to insects of South Africa. 2nd ed. Cape Town: Struik.

Pooley, E. 1998. A field guide to wild flowers of KwaZulu-Natal and the eastern region. Natal Flora Publications Trust, Durban.

Rautenbach, I.L. 1982. The mammals of the Transvaal. Ecoplan monograph 1: 1-211.

Retief, E. & Herman, P.P.J. 1997. Plants of the northern provinces of South Africa: keys and diagnostic characteristics. Strelitzia 6. National Botanical Institute, Pretoria.

Rutherford, M.C. & Westfall, R.H. 1994. Biomes of southern Africa: An objective categorisation, 2nd ed. Memoirs of the Botanical Survey of South Africa, Vol. 63, pp. 1-94. National Botanical Institute, Pretoria.

Ryan, P. 2001. Practical Birding: A guide to birdwatching in southern Africa. Struik, Cape Town.

Samways, M.J. 2005. Insect diversity conservation. Cambridge University Press, Cambridge.

Sieben, E.E., Kotze, D.C., Ellery, W.N. & Russell, W.B. 2009. Chapter 6: Using vegetation in wetland rehabilitation. In: Russel, W. 2009. *WET-RehabMethods: National guidelines and methods for*

wetland rehabilitation. WRC Report TT 341/09, Water Research Commission, Pretoria, pp. 54-94.

Skelton, P. 2001. A complete guide to the freshwater fishes of Southern Africa. Struik, Cape Town.

Skelton, P. & Weyl, O. 2011. *Fishes.* In: Picker, M. & Griffiths, C. 2011. *Alien & Invasive animals: a South African perspective.* Struik Nature, Cape Town, p 36-44.

Skinner, J.D. & Chimimba, C.T. 2005. The mammals of the southern African subregion. Cambridge University Press, Cape Town.

Smit, N. 2008. Field guide to the *Acacias* of South Africa. Briza, Pretoria.

Smithers, R.H.N. 1986. South African Red Data Book: Terrestrial mammals. *South African National Scientific Programmes Report* No. 125. CSIR, Pretoria.

South Africa. 2004. National Environmental Management: Biodiversity Act No. 10 of 2004. Government Printer, Pretoria.

Stuart, C. & Stuart, T. 2006. Field guide to the larger mammals of Africa 3rd ed. Struik Nature, Cape Town.

Stuart, C. & Stuart, T. 2013. A field guide to the tracks and signs of Southern, Central and East African wildlife 4th ed. Struik Nature, Cape Town.

Tarboton, W. & Erasmus, R. 1998. Owls and owling in southern Africa. Struik, Cape Town.

Taylor, J.C., Janse Van Vuuren, M.S. & Pieterse , A.J.H. 2007. The application and testing of diatom-based indices in the Vaal and Wilge Rivers, South Africa. *Water SA* 33(1): 51-59.

Van Ginkel, C.E., Glen, R.P., Gordon-Gray, K.D., Cilliers, C.J., Muasya, M. & van Deventer, P.P. 2011. Easy identification of some South African Wetland Plants. WRC Report No TT 479/10. Water Research Commission, Gezina.

Van Jaarsveld, E.J. 2006. The Southern African *Plectranthus* and the art of turning shade to glade.

Van Oudtshoorn, F. 2012. Guide to grasses of southern Africa. Briza, Pretoria.

Van Wyk, B. 2000. A photographic guide to wild flowers of South Africa. Struik, Cape Town.

Van Wyk, B. & Malan, S. 1998. Field Guide to the Wild Flowers of the Highveld. Struik, Cape Town.

Van Wyk, A.E. & Smith, G.F. 2001. Regions of floristic endemism in Southern Africa: a review with emphasis on succulents, Umdaus Press, Pretoria.

Van Wyk, B. & Van Wyk, P. 2013. Field guide to trees of southern Africa 2nd ed. Struik, Cape Town.