WETLAND ASSESSMENT

Proposed Pipeline and Pump Station, Obed Nkosi, Heidelberg, Gauteng Province, South Africa

Flowers of the alien invasive *Cirsium vulgare* (Spear Thistle) at a riparian zone at the site.
Photo: R.F. Terblanche

MAY 2021

COMPILED BY:

Reinier F. Terblanche

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

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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 in July 2013. 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: 18 May 2021

1 INTRODUCTION

A wetland assessment is required for the proposed Pipeline and Pumpstations at Obed Nkosi, southwest of Heidelberg, Gauteng Province, South Africa (elsewhere 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

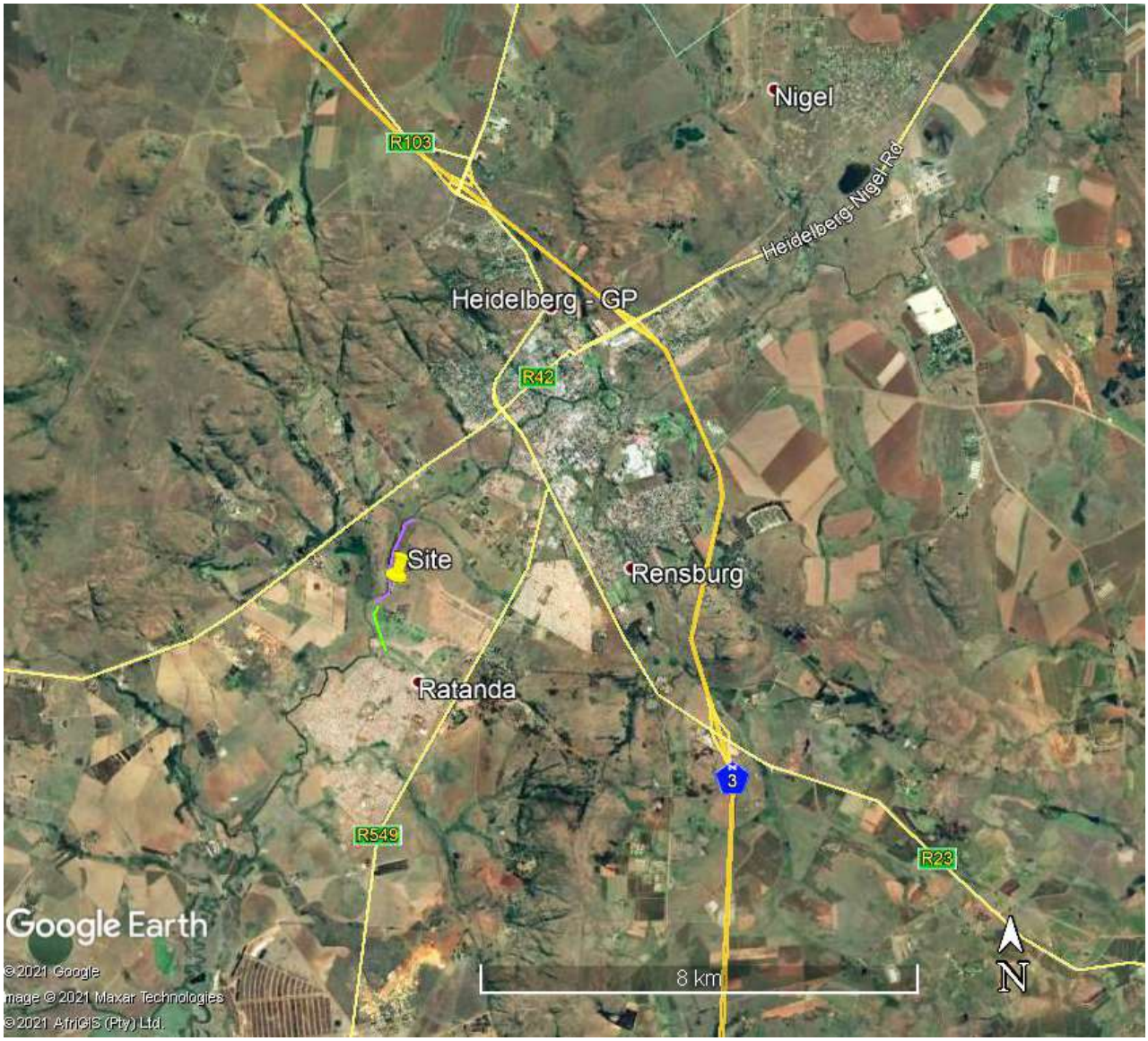

Figure 1 Map of larger area with indication of the location of the site.

Red outline Boundaries of the site

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, 2021).

The study area is southwest of Heidelberg in the Gauteng Province, South Africa. Study area is situated at the Grassland Biome (Mucina & Rutherford 2006). Grassland Biome at the site is represented by Soweto Highveld Grassland (Gm 8) (Mucina & Rutherford 2006).

Gm 8 Soweto Highveld Grassland

Distribution: In South Africa the Soweto Highveld Grassland is found in Mpumalanga, Gauteng (and to a very small extent also in neighbouring Free State and North West) Provinces; In a broad band roughly delimited by the N17 road between Ermelo and Johannesburg in the north, Perdekop in the southeast and the Vaal River (border with the Free State) in the south. It extends further westwards along the southern edge of the Johannesburg Dome (including part of Soweto) as far as the vicinity of Randfontein. In southern Gauteng it includes the surrounds of Vanderbijlpark and Vereeniging as well as Sasolburg in the northern Free State. Altitude 1420 – 1760 m (Mucina & Rutherford 2006).

Vegetation and landscape features: Gently to moderately undulating landscape on the Highveld plateau supporting short to medium-high, dense, tufted grassland dominated almost entirely by *Themeda triandra* and accompanied by a variety of other grasses such as *Elionurus muticus*, *Eragrostis racemosa*, *Heteropogon contortus* and *Tristachya leucothrix*. In places not disturbed, only scattered small wetlands, narrow stream alluvia, pans and occasional ridges or rocky outcrops interrupt the continuous grassland cover (Mucina & Rutherford 2006).

Geology and soils: Shale, sandstone or mudstone of the Madzaringwe Formation (Karoo Supergroup) or the intrusive Karoo Suite dolerites which feature prominently in the area. In the south, the Volksrust Formation (Karoo Supergroup) is found and in the west, the rocks of the older Transvaal, Ventersdorp and Witwatersrand Supergroups are most significant. Soils are deep, reddish on flat plains and are typically Ea, Ba and Bb land types (Mucina & Rutherford 2006).
Climate: Climate is characterized by summer-rainfall with mean annual precipitation of 662 mm. Frequent occurrence of frost and large thermic diurnal differences are recorded (Mucina & Rutherford 2006).

Important taxa of the Soweto Highveld Grassland listed by Mucina & Rutherford (2006): Graminoids: *Andropogon appendiculatus, Brachiaria serrata, Cymbopogon pospischilii, Cynodon dactylon, Elionurus muticus, Eragrostis capensis, Eragrostis chloromelas, Eragrostis curvula, Eragrostis plana, Eragrostis planiculmis, Eragrostis racemosa, Heteropogon contortus, Hyparrhenia hirta, Setaria nigrirostris, Setaria sphacelata, Themeda triandra, Tristachya leucothrix, Andropogon shirensis, Aristida adscensionis, Aristida bipartita, Aristida congesta, Aristida junciformis* susbp. *galpinii, Cymbopogon caesius, Digitaria diagonalis, Diheteropogon amplectens, Eragrostis micrantha, Eragrostis superba, Harpochloa falx, Microchloa caffra, Paspalum dilatatum*. Herbs: *Hermannia depressa, Acalypha angustata, Berkheya setifera, Dicoma anomala, Euryops gilfillanii, Geigeria aspera* var. *aspera, Graderia subintegra, Haplocarpha scaposa, Helichrysum miconiifolium, Helichrysum nudifolium* var. *nudifolium, Helichrysum rugulosum, Hibiscus pusillus, Justicia anagolloides, Lippia scaberrima, Rhyncosia effusa, Schistostephium crataegifolium, Selago densiflora, Senecio coronatus, Vernonia oligocephala, Wahlenbergia undulata*. Geophytic Herbs: *Haemanthus humilus* subsp. *hirsutus, Haemanthus montanus.* Herbaceous Climber:

Rhyncosia totta. Low Shrubs: *Anthospermum hispidulum, Anthospermum rigidum* subsp. *pumilum, Berkheya annectans, Felicia muricata, Ziziphus zeyheriana*.

Note: The above is an outline of the vegetation type that serves as a larger ecological context within which the site occurs. Not all the plant species listed above for the vegetation type necessarily occur 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 April 2021 to note key elements of habitats on the site and surrounding areas, 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 the often 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 longer term features of a wetland. For each site visited, it should then be emphasized that surveys can by no means cover all longer terms flucations and can also not 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 April 2021 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 and active channels at and near the site

Photo 1 Artificial waterbody at the site.
Photo: R.F. Terblanche.

Photo 2 The sedge *Cyperus fastigiatus* is conspicuous at the artificial waterbody at the site.
Photo: R.F. Terblanche

Photo 3 Weltand seep at the site.
Photo: R.F. Terblanche.

Photo 4 View towards the outlet of the Wetland seep at the site.
Photo: R.F. Terblanche.

Photo 5 View of tributary that runs from the waterworks.
Photo: R.F. Terblanche.

Photo 6 Tributary that runs from the waterworks. Riparian zone appears to be narrow and poorly defined.
Photo: R.F. Terblanche

Photo 7 Sewage leak at the tributary at the southern part of the site.
Photo: R.F. Terblanche.

Photo 8 Tributary at the southern part of the site.
Photo: R.F. Terblanche.

Photo 9 Soil sample at artificial waterbody at the site. This soil was foul-smelling, also had a greenish tinge and it appears some unwanted pollutants could be present.
Photo: R.F. Terblanche.

Photo 10 Soil sample at the permanent zone of the wetland seep at the site.
Photo: R.F. Terblanche.

Photo 11 Birds, notably Hadada Ibis (*Bostrychia hagedash*), Blacksmith Plover (*Vanellus armatus*) and African Sacred Ibis (*Threskiornis aethiopicus*) at the tributary at the southern part of the study area. invasive weed *Plantago major* growing among grass at the site.
Photo: R.F. Terblanche.

Photo 12 Flowers of the alien invasive weed *Cirsium vulgare* a riparian zone at the site.
Photo: R.F. Terblanche

Photo 13 A *Persicaria* species at the artificial waterbody at the site.
Photo: R.F. Terblanche.

Photo 14 *Paspalum disticha* at the artificial waterbody at the site.
Photo: R.F. Terblanche.

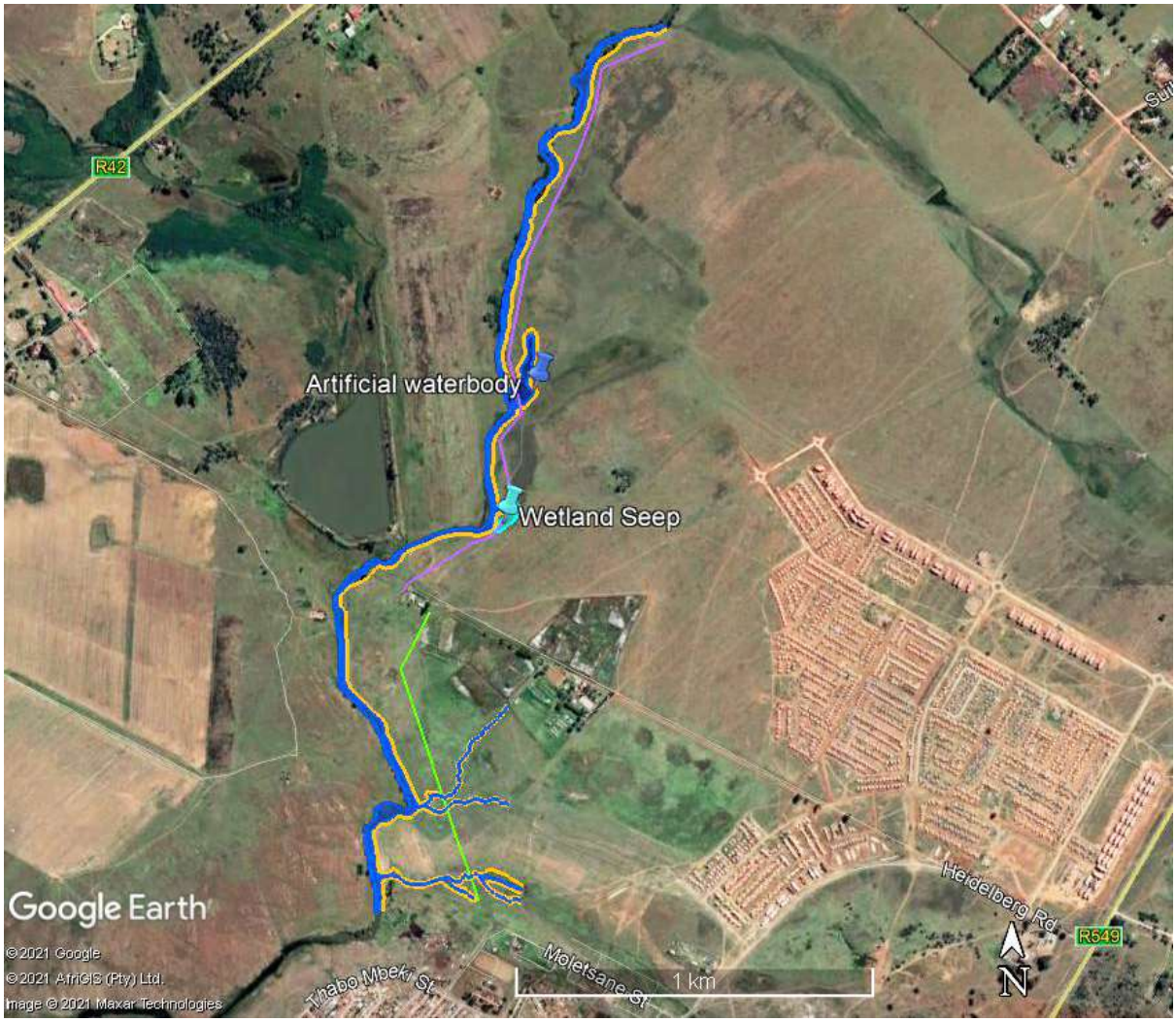

Figure 2 Indication of perennial river (Blesbokspruit outside the proposed footprint), an artificial waterbody, a wetland seep and two small tributaries at the site.

Purple outline	Part of the site (proposed pipeline)
Green outline	Part of the site (proposed pipeline)
Orange outline	Outer edge of riparian zone
Darker blue outline and shading	Active channels and artificial waterbody
Light blue outline and shading	Wetland at the site

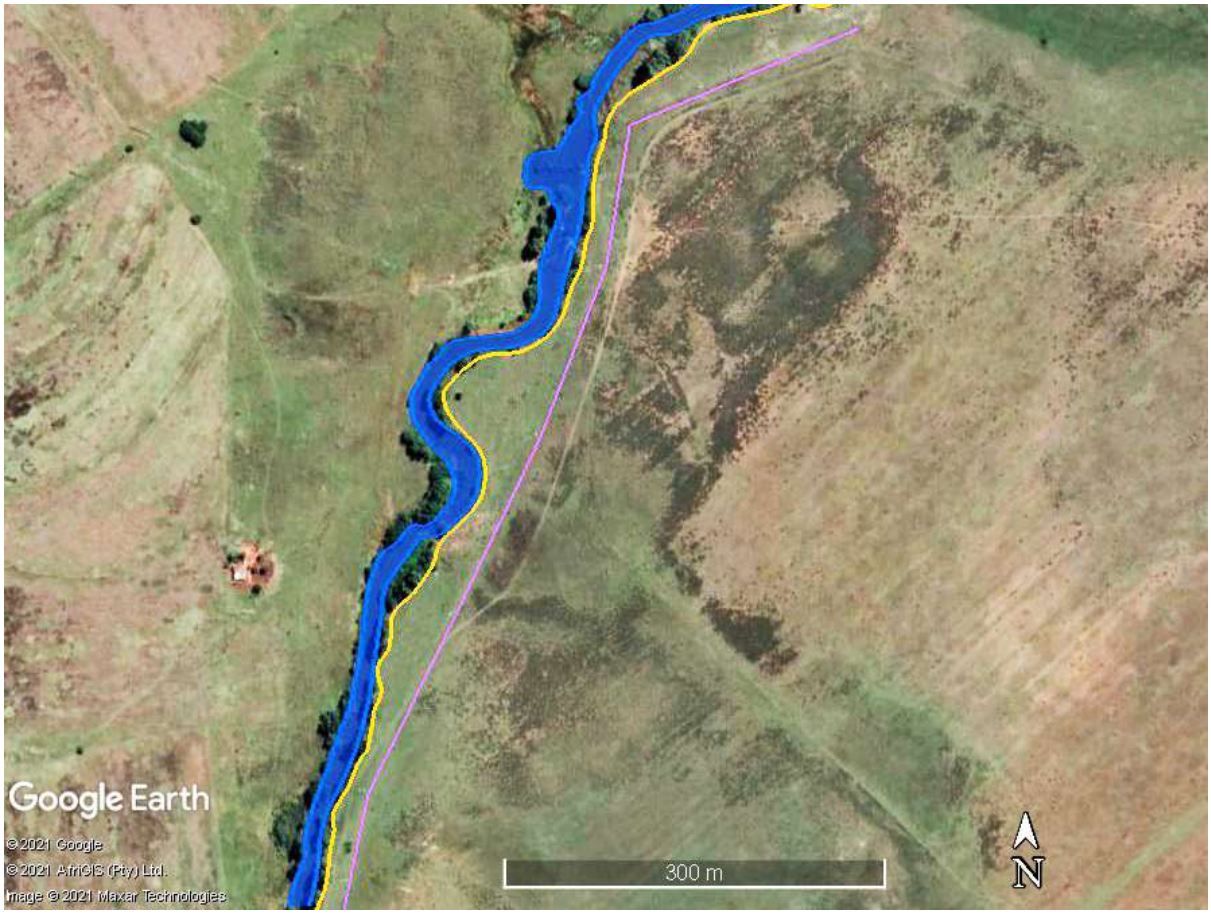

Figure 3 Indication of perennial river (Blesbokspruit outside the site) at the northern part of the study area.

Purple outline	Part of the site (proposed pipeline)
Orange outline	Outer edge of riparian zone
Darker blue outline and shading	Active channels and artificial waterbody

Figure 4 Indication of perennial river (Blesbokspruit outside the site) and an artificial waterbody at the study area.

Purple outline	Part of the site (proposed pipeline)
Orange outline	Outer edge of riparian zone
Darker blue outline and shading	Active channels and artificial waterbody

Figure 5 Indication of perennial river (Blesbokspruit outside the site) and a wetland seep at the study area.

Purple outline	Part of the site (proposed pipeline)
Orange outline	Outer edge of riparian zone
Darker blue outline and shading	Active channel
Light blue outline and shading	Wetland at the site

Figure 6 Indication of perennial river (Blesbokspruit outside the site) and two small non-perennial tributaries at the southern parts of the site. The small tributaries were fed by outflow from a water treatment plant or sewage leakages at the time of the site visits.

Green outline	Part of the site (proposed pipeline)
Orange outline	Outer edge of riparian zone
Darker blue outline and shading	Active channels

The narrow, proposed footprint crosses four watercourses: 1) an artificial waterbody, 2) a wetland (a seep) and 3,4) two small tributaries of the Blesbokspruit at the southern part of the site. These water courses appear to be modified by excavations, cultivated fields, planting of alien invasive *Eucalyptus* tree species, possible overgrazing by cattle as well as impacts from the residential areas upstream. A perennial river, the Blesbokspruit, is present north of the site and is excluded from the proposed footprint.

4.2 Assessment and classification of artificial waterbody at the site

Vegetation at the artificial waterbody contains wetland plant species such as the sedge *Cyperus fastigiatus*, herbacous *Persicaria* species and the grass species *Paspalum distichum*. This artificial waterbody is partly present owing to a dirt road elevation and could also have formed relatively recent owing to "extra" waterflow from residential areas up-slope. It it is difficult to trace the origins of the artificial waterbody. Soil at the artificial waterbody was foul-smelling and also had a greenish tinge at the time of the surveys (April 2021) and it appears that some unwanted pollutants could be present.

Present ecological status (PES) of the Artificial Waterbody 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 Artificial Waterbody 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 4.4 and Table 4.5).

Table 4.1 Classification and outline of characteristics of **Artificial Waterbody** 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)	Highveld (Kleynhans *et al.,* 2005)
Landscape unit (level 3)	Valley
Hydrogeomorphic unit (level 4)	Artificial Waterbody (Small dam)
Hydrological regime (Level 5)	This artificial waterbody is partly present owing to a dirt road elevation and could also have formed relatively recent owing to "extra" waterflow from residential areas up-slope. It it is difficult to trace the origins of the artificial waterbody.
Additional descriptors (Levels 5,6)	Vegetation at the artificial waterbody contains wetland plant species such as the sedge *Cyperus fastigiatus*, herbacous *Persicaria* species and the grass species *Paspalum distichum*. This artificial waterbody is partly present owing to a dirt road elevation and could also be formed relatively recent owing to "extra" waterflow from residential areas up-slope. It it is difficult to trace the origins of the artificial waterbody. Soil at the artificial waterbody was foul-smelling and also a greenish tinge at the time of the surveys (April 2021) and it appears that some unwanted pollutants could be present.

Table 4.2 Scoresheet with criteria for assessing habitat integrity of the **Artificial Waterbody** 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.	2	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.	1	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.	2	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 **Artficial Waterbody** 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.

Table4.4 Score sheet for determining ecological importance and sensitivity for floodplains of **Artificial Waterbody** 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	1	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	1	4
10. Ecological Integrity	1	4
TOTAL	**14**	32
MEAN	**1.4**	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 **Artificial Waterbody** at the site is indicated in blue font.

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

4.3 Assessment and classification of Wetland Seep at the site

A small Wetland Seep which could have formed recently owing to excess waterflow from residential areas up-slope is present at the site. Some diversity of indigenous wetland graminoids is found at the wetland seep. The wetland seep vegetation is visibly dominated by graminoids such as the sedges *Pycreus macranthus* and *Pycreus mundtii* and the grass species *Paspalum distichum*, whereas trees and megagraminoids are absent.

Present ecological status (PES) of the Wetland Seep at site is CATEGORY D which means the wetland is largely modified and a large loss of natural habitats and basic ecosystem functions has occurred (Table 4.6 and Table 4.7). Ecological importance and sensitivity (EIS) of the Wetland Seep 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 **Wetland Seep** 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 wetland
Regional setting (level 2)	Highveld (Kleynhans *et al.,* 2005)
Landscape unit (level 3)	Slope
Hydrogeomorphic unit (level 4)	Seep
Hydrological regime (Level 5)	The Wetland Seep occurs on a moderate slope. Water feeds into the wetland from possible excess water from residential areas upstream and maybe recently formed and is probably not fully functional.
Additional descriptors (Levels 5,6)	Dark brown-greyish soils are present at the wetland. Some diversity of indigenous wetland graminoids is found at the wetland seep. The wetland seep vegetation is visibly dominated by graminoids such as the sedges *Pycreus macranthus* and *Pycreus mundtii* and the grass species *Paspalum distichum*, whereas trees and megagraminoids are absent.

Table 4.7 Scoresheet with criteria for assessing habitat integrity of the **Wetland Seep** 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.	3	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.	2	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.	2	4
TOTAL **MEAN**		**22** **x=2**	42 x=2.0

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 **Wetland Seep** at the site according to DWAF (1999) such as adapted from Kleynhans (1999). Present ecological status of the wetlands 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.

Table 4.9 Score sheet for determining ecological importance and sensitivity for floodplains at **Wetland Seep** 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	1	3
5. Migration route/breeding and feeding site for wetland species	1	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	0	4
10. Ecological Integrity	1	4
TOTAL	**12**	32
MEAN	**1.2**	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 **Wetland Seep** at the site is indicated in blue font.

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

4.4 Non-perennial active channel ("dry streambed", but possibly to an extent artificially perennial) that runs from the waterworks

The small tributary that runs from the waterworks at the southern part of the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the waterworks on a constant basis. Exotic plant species at the streambank include the herbs *Rumex crispus* and *Trifolium repens* as well as the grass *Pennisetum clandestinum*. The indigenous herb *Berkheya radula* as well as the alien invasive herb *Cirsium vulgare* are found at the riparian zone and adjacent terrestrial zone.

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).

Present ecological status (PES) of the Non-perennial River that runs from the waterworks at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystem functions are extensive. The present ecological status is outside the general acceptable range (Table 4.12 and Table 4.13). Ecological Importance and Sensitivity (EIS) at the site is CATEGORY C which is Moderate and refers to 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 (Table 4.14 and Table 4.15).

Table 4.11 Classification and outline of characteristics of **Non-perennial River that runs from the waterworks** 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)	Highveld (Kleynhans *et al.,* 2005)
Landscape unit (level 3)	Valley
Hydrogeomorphic unit (level 4)	River
Hydrological regime (Level 5)	The small tributary that runs from the waterworks at the western part of the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the waterworks on a constant basis.
Additional descriptors (Levels 5,6)	Exotic plant species at the streambank include the herbs *Rumex crispus* and *Trifolium repens* as well as the grass *Pennisetum clandestinum*. The indigenous herb *Berkheya radula* as well as the alien invasive herb *Cirsium vulgare* are found at the riparian zone and adjacent terrestrial zone.

Table 4.12 Scoresheet with criteria for assessing habitat integrity of the **Non-perennial River that runs from the waterworks** 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.	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.	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.	2	4
TOTAL **MEAN**		**16** **x=1.5**	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 **Non-perennial River that runs from the waterworks** 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 4.14 Score sheet for determining ecological importance and sensitivity for floodplains of **Non-perennial River that runs from the waterworks** 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	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	2	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	**11**	32
MEAN	**1.1**	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 **Non-perennial River that runs from the waterworks** at the site is indicated in blue font.

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

4.5 Non-perennial active channel ("dry streambed", but possibly to an extent artificially perennial) at and near the southern boundary of the site

The small tributary that runs near and at the southern boundary the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the sewage leak on a constant basis. Exotic plant species at the streambank include the herbs *Rumex crispus* and *Trifolium repens* as well as the grass *Pennisetum clandestinum*. The indigenous herb *Berkheya radula* as well as the alien invasive herb *Cirsium vulgare* are found at the riparian zone and adjacent terrestrial zone.

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).

Present ecological status (PES) of the Non-perennial River at and near the southern boundary of the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystem functions are extensive. The present ecological status is outside the general acceptable range (Table 4.17 and Table 4.18). Ecological Importance and Sensitivity (EIS) at non-perennial river that runs at and near the southern boundary of the site is CATEGORY C which is Moderate and refers to 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 (Table 4.19 and Table 4.20).

Table 4.16 Classification and outline of characteristics of **Non-perennial River at and near the southern boundary** of 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)	Highveld (Kleynhans *et al.,* 2005)
Landscape unit (level 3)	Valley
Hydrogeomorphic unit (level 4)	River
Hydrological regime (Level 5)	The small tributary that runs near and at the western boundary the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the sewage leak on a constant basis.
Additional descriptors (Levels 5,6)	Exotic plant species at the streambank include the herbs *Rumex crispus* and *Trifolium repens* as well as the grass *Pennisetum clandestinum*. The indigenous herb *Berkheya radula* as well as the alien invasive herb *Cirsium vulgare* are found at the riparian zone and adjacent terrestrial zone.

Table 4.17 Scoresheet with criteria for assessing habitat integrity of the **Non-perennial River at and near the southern boundary** of 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.	1	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.	2	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 4.18 Interpretation of scores for determining present ecological status **(PES)** of the **Non-perennial River at and near the southern boundary** of 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 4.19 Score sheet for determining ecological importance and sensitivity for floodplains of **Non-perennial River at and near the southern boundary** of 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	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	2	3
7. Sensitivity to Water Quality Changes	1	3
8. Flood Storage, Energy Dissipation & Particulate/Element Removal	2	3
MODIFYING DETERMINANTS		
9. Protected Status	1	4
10. Ecological Integrity	1	4
TOTAL	**11**	32
MEAN	**1.1**	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 4.20 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 **Non-perennial River at and near the southern boundary** boundary of the site is indicated in blue font.

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 RISKS, IMPACTS AND MITIGATION

The following potential risks, impacts and mitigation measures apply to the proposed development:

5.1 Identification of potential impacts and risks

The potential impacts identified are:

Construction Phase

- Potential impact 1: Loss of wetland habitat owing to the removal of vegetation at the proposed footprint for development.
- Potential impact 2: Loss of sensitive wetland species (Threatened, Near Threatened, Rare, Declining or Protected species) during the construction phase.
- Potential impact 3: Loss of wetland connectivity and conservation corridor networks in the landscape.
- Potential impact 4: Contamination of wetland soil during construction in particular by hydrocarbon spills.

Operational Phase

- Potential impact 5: An increased infestation of exotic or alien invasive plant species owing to disturbance.

5.2 Potential impacts and risks during the construction phase

Classes of impacts for this study: Very High, High, Moderate, Low, Very Low

Aspect/Activity	Clearance of vegetation at part of the site for the development
Type of Impact (i.e. Impact Status)	Direct
Potential Impact	Clearing of vegetation at the proposed development. This will entail an open-and close exercise of a narrow strip of soil for the proposed pipeline development next to an existing footprint of an old pipeline.
Status	Negative
Mitigation Required	Apart from selective and restricted pipeline crossings, no other developments or activities should take place at the watercourses and bufferzones. The Blesbokspruit perennial river falls outside the narrow, proposed footprint and is excluded from the proposed footprint.
Impact Significance (Pre-Mitigation)	High
Impact Significance (Post-Mitigation)	Moderate
RISK	Following the mitigation measures a moderate risk of impact is expected.

Aspect/Activity	Removal of sensitive species
Type of Impact (i.e. Impact Status)	Direct
Potential Impact	Sensitive species: Loss of Threatened or Near Threatened Plants, Mammals, Reptiles, Amphibians and Invertebrates at the proposed footprint appears to be unlikely. No threatened wetland species are anticipated to occur at the site.
Status	Neutral.
Mitigation Required	No mitigation measures specific to sensitive wetland species apply directly at the site.
Impact Significance (Pre-Mitigation)	Low
Impact Significance (Post-Mitigation)	Low
RISK	A low risk of impact is anticipated if the mitigations relevant to connectivity and biodiversity corridors are upheld.

Aspect/Activity	Fragmentation of corridors of particular conservation concern
Type of Impact (i.e. Impact Status)	Direct
Potential Impact	There is little scope for the terrestrial modified grassland at the site to be a conservation corridor of particular importance. The Artificial waterbody (small dam), Wetland seep and two conspicuously disturbed non-perennial tributaries the site are part of a corridor system of particular conservation importance. The perennial river, the Blesbokspruit, near and outside the site is not included in the proposed footprint.
Status	Negative
Mitigation Required	The Artificial waterbody (small dam), Wetland seep and two conspicuously disturbed non-perennial tributaries the site will be selectively impacted at a narrow footprint that which will comprise an open- and close exercise of the soil. The perennial river, the Blesbokspruit, near and outside the site is not included in the proposed footprint.
Impact Significance (Pre-Mitigation)	High
Impact Significance (Post-Mitigation)	Moderate
RISK	Following mitigation, a moderate impact risk is expected.

Aspect/Activity	Contamination of soil by leaving rubble/ waste or spilling petroleum fuels or any pollutants on soil which could infiltrate the soil
Type of Impact (i.e. Impact Status)	Direct
Potential Impact	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.
Status	Negative
Mitigation Required	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.
Impact Significance (Pre-Mitigation)	Moderate
Impact Significance (Post-Mitigation)	Low
RISKS	A low risk is expected following mitigation.

5.3 Potential impacts during the operational phase

Aspect/Activity	An increased infestation of exotic or alien invasive plant species owing to clearance or disturbance where the footprint took place.
Type of Impact (i.e. Impact Status)	Direct
Potential Impact	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.
Status	Negative
Mitigation Required	Continued monitoring and eradication of alien invasive plant species are imperative.
Impact Significance (Pre-Mitigation)	Moderate
Impact Significance (Post-Mitigation)	Low
RISKS	Following mitigation, a low risk is anticipated.

5.4 Risk and impact assessment summary for the Construction Phase

Aspect/ Impact Pathway	Nature of Potential Impact/ Risk	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility of Impact	Irreplaceability	Potential Mitigation Measures	Significance of Impact and Risk		Confidence Level
										Without Mitigation/ Management	With Mitigation/ Management (Residual Impact/ Risk)	
Clearing of vegetation	Habitat loss, loss of indigenous species	Negative	Part of site	Long-Term	Substantial	Very likely	Low	Low	Apart from selective and restricted pipeline crossings, no other developments or activities should take place at the watercourses and bufferzones. The Blesbokspruit perennial river falls outside the narrow, proposed footprint and is excluded from the proposed footprint.	High	Moderate	High
Loss of sensitive species	Loss of sensitive species	Neutral	Site	Long-Term	Low (No Threatened species anticipated)	Unlikely	Not applicable	Not applicable	No mitigation measures specific to sensitive wetland species apply directly at the site. As a pre-caution and	Low	Low	High

Loss of corridors of particular conservation concern	Fragmentation of landscape and loss of connectivity	Negative	Site	Long-Term	Moderate	Unlikely	Moderate	Moderate	The Artificial waterbody (small dam), Wetland seep and two conspicuously disturbed non-perennial tributaries the site will be selectively impacted at a narrow footprint that which will comprise an open- and close exercise of the soil. The perennial river, the Blesbokspruit, near and outside the site is not included in the proposed footprint.	High	Moderate	High
Contamination of soil by spilling pollutants on soil which could infiltrate the soil	Soil contamination	Negative	Site	Long-Term	Moderate	Unlikely	Moderate	Moderate	Rubble and waste removal. Measures that avoid hydrocarbon (petroleum) spills to get into contact with the soil.	Moderate	Low	High

5.5 Risk/ Impact assessment summary for the Operational Phase

Aspect/ Impact Pathway	Nature of Potential Impact/ Risk	Status	Spatial Extent	Duration	Consequence	Probability	Reversibility of Impact	Irreplaceability	Potential Mitigation Measures	Significance of Impact and Risk		Confidence Level
										Without Mitigation/ Management	With Mitigation/ Management (Residual Impact/ Risk)	
Increased infestation of exotic or alien invasive plant species	Loss of habitat quality	Negative	Site	Long-Term	Substantial	Likely	Moderate	Moderate	Monitoring and eradication of alien invasive plant species. Implementation of rehabiliation plan which include the establisment of indigenous plant species.	Moderate	Low	High

5.6 Summary of risks and impacts

The narrow, proposed footprint crosses four watercourses: 1) an artificial waterbody, 2) a wetland (a seep) and 3,4) two small tributaries of the Blesbokspruit at the southern part of the site. These water courses appear to be modified by excavations, cultivated fields, planting of alien invasive *Eucalyptus* tree species, possible overgrazing by cattle as well as impacts from the residential areas upstream. A perennial river, the Blesbokspruit, is present north of the site and is excluded from the proposed footprint.

The proposed pipeline development comprises a narrow open- and close exercise of the soil through highly disturbed watercourses of which most appear to have undergone extensive artificial impacts modifications or increas in waterflow. Water from the up-slope residential areas as well as sewage leaks appear to have considerably impacts on the watercourses at the site. The Present Ecological Status as well as Ecological Importance and Sensitvity of the wetland systems at the site is relatively poor and low.

There appears to be no threatened animal or plant species that use the site in particular as a habitat.

Impacts on the artificial waterbody, wetland seep (perhaps artificial), and two conspicuously disturbed non-perennial tributaries are of a low\ moderate risk. If the development is approved the surface flow and erosion at the wetlands are likely to be limited. There is no distinct indication that interflow play of the wetlands would be impacted significantly by the proposed developments. The geomorphological setting and flow regime likely to be similar post development, if the development is approved according to the mitigation measures stated. Loss of any wetland animal or plant species of particular conservation importance are not expected.

A key issue at the site that emerged from the risk and impact assessment is the implementation of efficient control of alien invasive plant species and rehabilitation. Following the mitigations which will be upheld and planned footprint for development all the impact risks listed above are moderate or low.

6 CONCLUSION

- The narrow, proposed footprint crosses four watercourses: 1) an artificial waterbody, 2) a wetland (a seep) and 3,4) two small tributaries of the Blesbokspruit at the southern part of the site. These water courses appear to be modified by excavations, cultivated fields, sewage leaks, possible overgrazing by cattle as well as impacts from the residential areas upstream. A perennial river, the Blesbokspruit, is present north of the site and is excluded from the proposed footprint.
- Vegetation at the artificial waterbody contains wetland plant species such as the sedge *Cyperus fastigiatus*, herbacous *Persicaria* species and the grass species *Paspalum distichum*. This artificial waterbody is partly present owing to a dirt road elevation and could also have formed relatively recent owing to "extra" waterflow from residential areas up-slope. It it is difficult to trace the origins of the artificial waterbody. Soil at the artificial waterbody was foul-smelling and also had a greenish tinge at the time of the surveys (April 2021) and it appears that some unwanted pollutants could be present.
- Present ecological status (PES) of the Artificial Waterbody 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 Artificial Waterbody 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 4.4 and Table 4.5).
- A small Wetland Seep which could have formed recently owing to excess waterflow from residential areas up-slope is present at the site. Some diversity of indigenous wetland graminoids is found at the wetland seep. The wetland seep vegetation is visibly dominated by graminoids such as the sedges *Pycreus macranthus* and *Pycreus mundtii* and the grass species *Paspalum distichum*, whereas trees and megagraminoids are absent.
- Present ecological status (PES) of the Wetland Seep at site is CATEGORY D which means the wetland is largely modified and a large loss of natural habitats and basic ecosystem functions has occurred (Table 4.6 and Table 4.7). Ecological importance and sensitivity (EIS) of the Wetland Seep 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).
- The small tributary that runs from the waterworks at the western part of the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the waterworks on a constant basis.

- Present ecological status (PES) of the Non-perennial River that runs from the waterworks at the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystem functions are extensive. The present ecological status is outside the general acceptable range (Table 4.12 and Table 4.13). Ecological Importance and Sensitivity (EIS) at the site is CATEGORY C which is Moderate and refers to 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 (Table 4.14 and Table 4.15).
- The small tributary that runs near and at the southern boundary the site has a narrow active channel and narrow poorly defined riparian zone with a noticeable high cover of exotic weeds. The tributary could turn into a perennial stream if water feeds from the sewage leak on a constant basis.
- Present ecological status (PES) of the Non-perennial River at and near the southern boundary of the site is CATEGORY E which means the watercourse is seriously modified. The losses of natural habitats and basic ecosystem functions are extensive. The present ecological status is outside the general acceptable range (Table 4.17 and Table 4.18). Ecological Importance and Sensitivity (EIS) at non-perennial river that runs at and near the southern boundary of the site is CATEGORY C which is Moderate and refers to 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 (Table 4.19 and Table 4.20).
- Exotic plant species at both the conspicuously disturbed non-perennial rivers include the herbs *Rumex crispus* and *Trifolium repens* as well as the grass *Pennisetum clandestinum*. The indigenous herb *Berkheya radula* as well as the alien invasive herb *Cirsium vulgare* are found at the riparian zone and adjacent terrestrial zone.
- Site is part of the Upper Vaal Water Management Area (WMA 8). The site is not part of a FEPA (Freshwater Ecosystem Priority Area) (Nel *et al.*, 2011a, 2011b).
- The proposed pipeline development comprises a narrow open- and close exercise of the soil through highly disturbed watercourses of which most appear to have undergone extensive impacts, modifications or artificial increase in waterflow. Water from the up-slope residentials areas as well as sewage leaks appear to have considerably impacts on the watercourses at the site. The Present Ecological Status as well as Ecological Importance and Sensitvity of the wetland systems at the site is in general relatively poor and low.
- There appears to be no threatened animal or plant species that use the site in particular as a habitat.
- Impacts on the artificial waterbody, wetland seep, and two conspicuously disturbed non-perennial tributaries are of a low\ moderate risk. If the development is approved the surface flow and erosion at the wetlands are likely to be limited. There is no distinct indication that interflow play of the wetlands would be impacted significantly by the proposed developments. The geomorphological setting and flow regime likely to be similar post development, if the

development is approved according to the mitigation measures stated. Loss of any wetland animal or plant species of particular conservation importance are not expected.

- A key issue at the site that emerged from the risk and impact assessment is the implementation of efficient control of alien invasive plant species and rehabilitation. Following the mitigations which will be upheld and planned footprint for development all the impact risks listed above are moderate or low.

7 REFERENCES

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

Apps, P. 2000. Smither's mammals of southern Africa: a field guide. Cape Town: Struik.

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. Johannesburg: BirdLife South Africa. 169 p.

Branch, B. 1998. Field guide to snakes and other reptiles of southern Africa. 3rd ed. Cape Town: Struik. 399 p.

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. Pretoria: South African National Biodiversity Institute. 48 p.

Bromilow, C. 2001. Problem Plants of South Africa. Pretoria: Briza Publications.

Carruthers, V. 2001. Frogs and froging in southern Africa. Cape Town: Struik.

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

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

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.

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. Potchefstroom: School of Environmental Sciences and Development, Gauteng University. 53 p.

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.

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. Pretoria: Agricultural Research Council.

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

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

Du Preez, L.H. & Carruthers, V. 2009. A complete guide to the frogs of southern Africa. Struik Nature, Cape Town. 488p. CD with calls included.

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.

GDARD (Gauteng Department of Agriculture and Rural Development). 2012. GDARD requirements for biodiversity assessments, Version 2. GDARD, Directorate of Nature Conservation.

Germishuizen, G. 2003. Illustrated guide to the wildflowers of northern South Africa. Briza, Pretoria. 224 p.

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. 224 p.

Goldblatt, P. & Manning, J. 1998. Gladiolus in Southern Africa. 320 p.

Henderson, L. 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. Pretoria: ARC: Plant Protection Research Institute.

Henning, G.A., Terblanche, R.F. & Ball, J.B. (eds) 2009. South African Red Data Book: butterflies. *SANBI Biodiversity Series No 13.* South African National Biodiversity Institute, Pretoria. 158 p.

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

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

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

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. Cape Town: David Philip Publishers.

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

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

Low, A.B. & Rebelo, A.G. (Eds.) 1996. Vegetation of South Africa, Lesotho and Swaziland. Pretoria: Department of Environmental Affairs and Tourism.

Manning, J. 2003. Photographic guide to the wild flowers of South Africa. Briza, Pretoria. 352 p.

Manning, J. 2009. Field guide to the wild flowers of South Africa. Struik, Cape Town. 487 p.

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. 482 p.

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. Washington, DC: Smithsonian Institution.

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

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. & 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.

Pryke, S.R. & Samways, M.J. 2001. Width of grassland linkages for the conservation of butterflies in South African afforested areas. *Biological Conservation* 101: 85-96.

Pullin, A.S. *ed*. 1995. Ecology and conservation of butterflies. London: Chapman & Hall.

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. Pretoria: National Botanical Institute.

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. Pretoria: National Botanical Institute.

Ryan, P. 2001. Practical Birding: A guide to birdwatching in southern Africa. Cape Town: Struik. 96 p.

SANBI. 2009. Further development of a proposed National Wetland Classification System for South Africa. Primary Project Report. Prepared by the Freshwater Consulting Group (FCG) for the South African National Biodiversity Institute (SANBI).

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

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.

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

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

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

Stuart, C. & Stuart, T. 2000. A field guide to the tracks and signs of Southern and East Africa. Cape Town: Struik.

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

Terblanche, R.F. *In prep.* Wetland butterflies of South Africa, a preliminary synthesis with ecological notes for environmental management.

Terblanche, R.F. & Van Hamburg, H. 2003. The taxonomy, biogeography and conservation of the myrmecophilous *Chrysoritis* butterflies (Lepidoptera: Lycaenidae) in South Africa. *Koedoe* 46(2): 65-81.

Terblanche, R.F. & Van Hamburg, H. 2004. The application of life history information to the conservation management of *Chrysoritis* butterflies (Lepidoptera: Lycaenidae) in South Africa. *Koedoe* 47(1): 55-65.

Terblanche, R.F. & Edge, D.A. 2007. The first record of an *Orachrysops* in Gauteng. *Metamorphosis* 18(4): 131-141.

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, South Africa.

Van Jaarsveld, E.J. 2006. The Southern African *Plectranthus* and the art of turning shade to glade. 176 p.

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

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. Cape Town:Struik.

Van Wyk, B.E. & Smith, G.F. 2003. Guide to the aloes of South Africa. 2nd ed. Pretoria: Briza Publications.

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

Walker, C. 1996. Signs of the Wild. 5th ed. Cape Town: Struik.