FRESHWATER ASSESSMENT

WATERCOURSE DELINEATION AND IMPACT ASSESSMENT IN SUPPORT OF THE ENVIRONMENTAL AUTHORISATION AND WATER USE LICENSE APPLICATION PROCESS FOR THE PROPOSED UPGRADE OF THE EXISTING R101 ROAD BETWEEN MODIMOLLE AND BELA-BELA WITHIN THE LIMPOPO PROVINCE, SOUTH AFRICA

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PREPARED FOR:	GA ENVIRONMENT (PTY) LTD.
PREPARED BY:	Environmental Assurance (Pty) Ltd.
SUBMITTED TO:	Nyaladzi Nleya
EMAIL:	Nyaladzin@gaenvironment.com
DATE:	29-07-2021
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EXPERTISE OF AUTHOR		
Accreditations	Professionally registered with South African Council for Natural Scientific Professionals (SACNASP) (Mr. Westcott- no. 117334 & Mrs. Zdanow no 114072). Department of Water and Sanitation (DWS) certified wetland assessment practitioners. DWS accredited SASS5 aquatic biomonitoring practitioner.	
QUALITY CONTROL		
	Co-Author	**Co-Author**
Name	Louise Zdanow	Wayne Westcott
Designation	Wetland Ecologist Pr.Sci.Nat. 114072	Aquatic & Wetland Ecologist Pr.Sci.Nat. 117334
Signature	Lzdanow	
Date	10-05-2021	21-05-2021

DISCLAIMER

SPECIALIST DECLARATION:

I Wayne Westcott, declare that:

- I acted as an independent specialist;
- The assessment results were interpreted in an objective manner, even if the conclusions were not favourable to the client;
- I have the relevant expertise required to conduct a specialist report of this nature in terms of the National Environmental Management Act (NEMA) (Act no. 107 of 1998) and the National Environmental Management; Biodiversity Act (Act no. 10 of 2004);
- The contents of this report comply with the relevant legislative requirements, specifically Appendix 6 of the NEMA: EIA Regulations (2014, as amended in 2017);
- I understand that any false information published in this document is an offence in terms of Regulation 71 and is punishable in terms of Section 24(f) of the Act; and
- I am a professionally registered scientist with the South African Council for Natural Scientific Professions (SACNASP) (no. 117334).

Wayne Westcott

Pr.Sci.Nat. 117334

SPECIALIST DECLARATION:

I Louise Zdanow, declare that:

- I acted as an independent specialist;
- The assessment results were interpreted in an objective manner, even if the conclusions were not favourable to the client;
- I have the relevant expertise required to conduct a specialist report of this nature in terms of the National Environmental Management Act (NEMA) (Act no. 107 of 1998) and the National Environmental Management; Biodiversity Act (Act no. 10 of 2004);
- The contents of this report comply with the relevant legislative requirements, specifically Appendix 6 of the NEMA: EIA Regulations (2014, as amended in 2017);
- I understand that any false information published in this document is an offence in terms of Regulation 71 and is punishable in terms of Section 24(f) of the Act; and
- I am a professionally registered scientist with the South African Council for Natural Scientific Professions (SACNASP) (no. 114072).

lzdanow

Lousie Zdanow

Pr.Sci.Nat. 114072

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EXECUTIVE SUMMARY

Environmental Assurance (Pty) Ltd. (hereafter referred to as "ENVASS") was appointed by GA Environment (Pty) Ltd. (hereafter referred to as "the client"), on behalf of BVi Consulting Engineers Western Cape (Pty) Ltd. and the South African National Road Agency (SANRAL), to undertake a watercourse delineation and impact assessment for the proposed upgrade of Section 8 of the existing R101 roadway between Modimolle and Bela-Bela within the Limpopo Province, South Africa. The direct alignment of the proposed upgrade, as supplied by the client, will hereafter be referred to as the proposed development and the proposed development inclusive of a 500 metre (m) assessment radius (buffer) around it will constitute as the study area within this report.

The proposed development starts in Bela-Bela at the intersection of the R101 and Voortrekker Road (km 0.0) and ends in Modimolle at the intersection of the R101 and R33 (km 26.8). The road will start at coordinates 24° 53' 5.16" S and 28° 17' 56.88" E and will end at coordinates 24° 42' 0.33" S and 28° 24' 21.10" E. The existing roadway consists of a two lane, single carriageway road with gravel shoulders along most of the route with an average surfaced width of 7.0 Metres (m). Climbing/passing lanes are provided from km 6.2 to km 7.5 (LHS) and km 14.4 to km 15.7 (RHS). This portion of the R101 has an average road reserve width of approximately 35 m. In both Bela-Bela (km 0.00 to km 0.10) and Modimolle (km 26.40 to km 26.80), the road widens to a four-lane undivided single carriageway, and a section in Modimolle (km 25.20 to km 26.40) consists of 3 lanes.

The general objective of this project is to successfully and optimally improve the National Road R101 Section 8 from Bela-Bela (km 0.0) to Modimolle (km 26.8). The broad goals of the road upgrade are to:

- Relieve traffic congestion to acceptable level of service;
- Improve road geometry to improve road safety;
- Replace bridges and other structures where required for hydraulic and traffic capacity improvement; and
- Provide adequate pavement capacity for the design period.

The proposed development will include:

- All horizontal sub-standard curves will be improved to suit a 100 km/h design speed with 8% emax and minimum 390 m radius;
- Section from km 0.00 to km 5.44 will be upgraded to a 4-lane urban configuration with median and sidewalk;
- Section from km 5.44 to km 24.00 will be upgraded to a 2-lane cross section with 3 m surfaced shoulders, existing climbing lanes and geometric realignment;
- Section from km 24.00 to km 26.80 will be upgraded to a 4-lane urban configuration with median and sidewalk; and
- A service road travelling parallel to the R101 road upgrade from 24° 52' 45.04" S, 28° 18' 35.89" E to 24° 52' 11.39" S, 28° 19' 17.08" E.

- Two (2) bridges and three (3) major culverts will be upgraded/replaced.
- Blasting may occur at the four (4) proposed realignment sections due to resistant lithologies.
- Temporary diversion of watercourses by means of pipe culverts or similar.

The field survey relevant to this combined watercourse impact assessment report was conducted on the 6th and 7th of May 2021 within the South African National Biodiversity Institution (SANBI) dry season for the region. The timing of this study did present a limitation, specifically with the identification of hydrophytic vegetation, however soil samples were used as the primary means to confirm the outer boundaries of wetlands. The aim of this study and the accompanying data is to provide specialist input into the relevant authorisation processes, which in the case of the proposed development will be a Water Use License Application (WULA) and Environmental Authorisation (EA) from the relevant Competent Authorities (CAs). This study will focus on the Section 21(c) and (i) water uses, which will apply to the proposed development.

At-risk Watercourses (wetlands and rivers)

All the at-risk watercourses (wetland and riverine systems) present within the study area were delineated using the Department of Water Affairs and Forestry`s (DWAF) (now the Department of Water and Sanitation (DWS)) (2008) ‘a practical field procedure for the identification and delineation of wetlands and riparian areas’ and subsequently classified according to the ‘classification systems for wetlands and other aquatic ecosystems in South Africa’ (Ollis *et al*., 2013). Subsequent to conducting an initial desktop study and undergoing a field survey of the study area, it was determined that out of the total thirty-eight (38) watercourses within the study area, sixteen (16) may be at-risk of being impacted on by the proposed development (**Table ES01**).

Table ES01: The risk categories of each HGM unit and the extent (ha) of watercourse within the proposed development footprint.

HGM UNIT CODE	RISK RATING
UVB01 (Bad se Loop River), UVB02, CVB01 (Modderloop River), CVB02 (Groot Nyl River), SEEP01, Rip01, Rip02, Rip03, Rip04, Rip06, Rip07, Rip08, Rip09, Rip10, Rip11 (**Total = 15 watercourses**)	High
Rip05 (**Total = 1 watercourse**)	Medium
UVB03, CVB03, Rip12 – Rip16, Dep01 – Dep08, Dam01 – Dam 07 (**Total = 22 watercourses**)	Low

Present Ecological State, Ecological Importance and Sensitivity and Recommended Management Objectives

Table ES02 below present the Present Ecological State (PES), Ecological Importance and Sensitivity (EIS) scores and Recommended Management Objectives (RMO’s) that were calculated for the at-risk wetland and riverine systems. Although the RMO for all watercourses is to improve the overall PES, it is not considered feasible to do so in this scenario as the majority of the watercourses are located on private land or are expected to be impacted upon by ongoing anthropogenic activities which the proponent has no control over. It is however considered possible to maintain the PES of all the affected watercourses with the implementing of the mitigation and/or rehabilitation measures presented within this report and the project-specific Environmental Management Programme (EMPr).

Table ES02: Summary table presenting the Present Ecological State (PES), Ecological Sensitivity and Importance (EIS) scores and Recommended Management Objectives (RMO's) of the at-risk watercourses.

HGM UNIT	PES SCORE	EIS	RMO/REC
UVB01	E	High	E/F Improve
UVB02	C	High	B/C Improve
CVB01	C	High	B/C Improve
CVB02	D	High	C/D Improve
SEEP01	C	High	B/C Improve
Rip01	C	Moderate	C Maintain
Rip02	C	Low	C Maintain
Rip03-Rip07	A	Low	A Maintain
Rip08	C	Low	C Maintain
Rip09	B	Low	B Maintain
Rip10	A	Low	A Maintain
Rip11	C	Low	C Maintain

KEY: PES Categories: A (Natural), B (Near natural), C (Moderately modified) & D (Largely modified) (Macfarlane *et al*., 2009).

Wetland Ecosystem Services

The wetlands were determined to provide, or have the potential to provide, valuable Ecosystem Services (ESS), specifically: flood attenuation, streamflow regulation, erosion control, nitrate and phosphate assimilation and toxicant removal services.

Water Quality

To assist with the interpretation of the biological information that was gathered during this assessment and provide baseline water quality data several parameters, namely: Temperature (ºC), pH, Electrical Conductivity (EC) (mS/m), Dissolved Oxygen (DO) (%) and Total Dissolved Solids (TDS) (mg/l) were tested for where conditions allowed. The results were compared against the Target Water Quality Range (TWQR) for aquatic ecosystems (DWAF, 1996) and Johnson (2008) limits to identify potential exceedances of the limits. **Table ES03** below presents the results obtained during the field survey. It is evident that the baseline results indicate that all sites were below the TWQR limit for DO (% & mg/l), with the worst results obtained at BT01 situated on the Bas se Loop River in Bela-Bela.

Water quality should be assessed at these sites on a weekly basis during the construction phase of the proposed development to act as an early warning system for potential impact on the downstream watercourses. Where exceedances of the baseline are observed, the site Environment Officer (EO) or foreman should conduct a visual survey of the construction site surrounding the sample area to determine if activities onsite were the cause of the elevated readings. All results and exceedances of the baseline data presented in **Table ES03** must be documented and kept onsite for review during the relevant compliance audits.

Table ES03: Water quality results obtained from at-risk watercourses.

SAMPLE SITE	LOCATION	TEMP.	PH	EC (mS/m)	DO (%)	DO (mg/l)	TDS (mg/l)
LIMIT		5 - 30	6.5 – 9.0	<154*	80 - 120	> 5.00	1,000*
GN01	24°45'40.75"S, 28°21'0.67" E	15.30	6.80	8.3	41.80	3.69	53
GNT02	24°46'7.28" S, 28°21'0.47" E	15.50	7.32	6.4	50.40	4.45	41
BLT01	24°52'0.03" S, 28°19'24.40" E	14.00	7.28	7.4	47.90	4.37	48
BLT02	24°52'12.28" S, 28°18'54.08 "E	17.20	7.30	8.6	52.90	4.52	55
BL01	24°52'56.92"S, 28°18'22.91"E	17.30	7.30	23.6	45.60	3.88	153

KEY: *- Johnson (2008) limit in absence of TWQR limit (DWAF, 1996); Red- Exceedances of the limit.

Buffer Zone Determination

Using the Buffer Zone Guideline Tool by Macfarlane & Bredin (2016), the buffer zones were determined for the at-risk watercourses within the study area. **Table ES04** below presents the calculated buffer zones that must be applied to all at-risk wetland and riverine systems within the study area.

It should be noted that proposed development related activities include the widening and realignment of an existing roadway through watercourses and the application of a no-go buffer area to areas within which construction is required is therefore considered impractical. However, it is recommended that non-essential construction and operational activities (e.g. ablution facilities, construction camps, laydown areas, mixing of cement, stockpiling of soils, waste dumping and any additional activities which may be detrimental to the health and functionality of the freshwater resources) must be strictly prohibited within the buffer zones.

It must also be noted that although the below presented buffer zones were calculated based on on-site analyses, applicable legislation must be consulted to determine the exact buffer zone requirements. The furthest buffer must be applied to each at-risk watercourse.

Table ES04: Presentation of the calculated buffer zones that should be implemented during the construction and operational phases associated with the proposed development.

SYSTEMS	CONSTRUCTION PHASE (m)	OPERATIONAL PHASE (m)
UVB01 and UVB02	**19**	15
CVB01, Rip01	**26**	15
CVB02	**23**	15
SEEP01	**27**	15
Rip02 - Rip11	**15**	15

Impact Statement

According to the KML file of the proposed road alignment provided to ENVASS by the client, the proposed road widening will predominantly take place in already infilled and transformed areas directly adjacent to the existing R101 roadway within the existing road reserve. However, small areas of wetland habitat will be lost during the widening of the R101 through UVB01 and during the upgrade and widening of bridge crossings at CVB01 and CVB02 (approximately 5,000 m[1]). Although wetland habitat will be permanently lost, the intensity of the impact has been reduced by recommending means of improving the currently degraded state of the at-risk watercourses to a condition better than the baseline data presented herein. The natural processes within the remainder of the wetlands will continue post-development. The impact prior to the implementation of mitigation measures was therefore calculated to be of a medium (negative) significance. The proposed upgrade and realignment of bridge and culvert structures to accommodate the design flood peak, and the implementation of additional design related mitigation measures aimed at improving flow patterns through watercourses will ultimately result in the improvement of the current status quo of the watercourse crossing areas. It has been recommended that IAPS control and management should be conducted within the remaining extent of wetland habitat located within the road reserve in order to attempt to mitigate this impact. However, the control of IAPS will not prevent the direct loss of wetland habitat, and the overall impact therefore remained of a medium (negative) significance after the implementation of mitigation measures.

Although the direct loss of wetland habitat from the development footprint cannot be avoided, the strict implementation of the mitigation, rehabilitation and monitoring measures as listed within this report will ensure that all remaining freshwater impacts are reduced to low (negative) significances and that the RMO/REC integrity that has been determined for all at risk systems can be maintained. The site-specific EMPr and conditions stipulated within the WUL and EA for the site as well as

[1] Estimation only, based on development footprint kml supplied to ENVASS.

an approved rehabilitation and monitoring programme should guide the conservation and/or rehabilitation of the at-risk watercourses.

Conclusion

Considering the project as a whole, it is the specialist's substantive opinion that the proposed development continues, provided that all buffer zones, mitigation and/or rehabilitation measures presented within this report and the site-specific EMPr are strictly implemented and subsequently monitored through a formal monitoring programme approved by the competent authority (DWS).

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LIST OF ABBREVIATIONS AND ACRONYMS

TERM	EXPANSION
CBA	Critical Biodiversity Area
CR	Critically Endangered
CVB	Channelled Valley-bottom
DAFF	Department of Agriculture, Forestry and Fisheries
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMPr	Environmental Management Programme
EN	Endangered
ESS	Ecosystem Services
FEPA	Freshwater Ecosystem Priority Area
FHIA	Freshwater Habitat Impact Assessment
GG	Government Gazette
GIS	Geographic Information System
GN	General Notice
GPS	Geographic Positioning System
HGM	Hydrogeomorphic
IAPS	Invasive Alien Plant Species
IHI	Index of Habitat Integrity
LCBv2	Limpopo Conservation Plan Version 2
LEDET	Limpopo Department of Economic Development, Environment and Tourism
LT	Least Threatened
MAMSL	Meters Above Mean Sea Level
MAP	Mean Annual Precipitation
MASR	Mean Annual Surface Runoff
MAT	Mean Annual Temperature

TERM	EXPANSION
NEMA	National Environmental Management Act (Act no. 107 of 1998)
NFEPA	National Freshwater Ecosystem Priority Area
NWA	National Water Act (Act no. 36 of 1998)
PES	Present Ecological State
PU	Planning Unit
REC	Recommended Ecological Category
RMO	Recommended Management Objective
RWQO	Resource Water Quality Objectives
SANBI	South African National Biodiversity Institute
SCC	Species of Conservation Concern
TOPS	Threatened and/or Protected Species
TWQR	Target Water Quality Range
VU	Vulnerable
WMA	Water Management Area
WULA	Water Use Licence Application
WUL	Water Use Licence

1 INTRODUCTION

1.1 Background

Environmental Assurance (Pty) Ltd. (hereafter referred to as "ENVASS") was appointed by GA Environment (Pty) Ltd. (hereafter referred to as "the client"), on behalf of BVi Consulting Engineers Western Cape (Pty) Ltd. and the South African National Road Agency (SANRAL), to undertake a watercourse delineation and impact assessment for the proposed upgrade of Section 8 of the existing R101 roadway between Modimolle and Bela-Bela within the Limpopo Province, South Africa. The direct alignment of the proposed upgrade, as supplied by the client, will hereafter be referred to as the proposed development, and the proposed development inclusive of a 500 metre (m) assessment radius (buffer) around it will constitute as the study area within this report.

The existing roadway consists of a two lane, single carriageway road with gravel shoulders along most of the route with an average surfaced width of 7.0 m. Climbing/passing lanes are provided from km 6.2 to km 7.5 (LHS) and km 14.4 to km 15.7 (RHS). This portion of the R101 has an average road reserve width of approximately 35 Metres (m). In both Bela-Bela (km 0.00 to km 0.10) and Modimolle (km 26.40 to km 26.80), the road widens to a four-lane undivided single carriageway, and a section in Modimolle (km 25.20 to km 26.40) consists of 3 lanes.

The general objective of this project is to successfully and optimally completely improve the National Road R101 Section 8 from Bela-Bela (km 0.0) to Modimolle (km 26.8). The broad goals of the road upgrade are
to:

- Relieve traffic congestion to acceptable level of service;
- Improve road geometry to improve road safety;
- Replace bridges and other structures where required for hydraulic and traffic capacity improvement; and
- Provide adequate pavement capacity for the design period.

The proposed development will include:

- All horizontal sub-standard curves will be improved to suit a 100 km/h design speed with 8% emax and minimum 390 m radii;
- Section from km 0.00 to km 5.44 will be upgraded to a 4-lane urban configuration with median and sidewalk;
- Section from km 5.44 to km 24.00 will be upgraded to a 2-lane cross section with 3 m surfaced shoulders, existing climbing lanes and geometric realignment;
- Section from km 24.00 to km 26.80 will be upgraded to a 4-lane urban configuration with median and sidewalk; and
- Bridges and major culverts will be upgraded/replaced.

The field survey relevant to this combined watercourse impact assessment report was conducted on the 6th and 7th of May 2021 within the South African National Biodiversity Institution (SANBI) dry season for the region. The timing of this study did present a limitation, specifically with the identification of hydrophytic vegetation, however soil samples were used as the primary means to confirm the outer boundaries of wetlands. The aim of this study and the accompanying data is to provide specialist input into the relevant authorisation processes, which in the case of the proposed development will be a Water Use License Application (WULA) and Environmental Authorisation (EA) from the relevant Competent Authorities (CAs). This study will focus on the Section 21(c) and (i) water uses, which will apply to the proposed development.

1.2 Locality

National Road R101 Section 8 is located within two (2) Local Municipalities (Bela-Bela and Modimolle) both situated within the Waterberg District Municipality of the Limpopo Province. The proposed development starts in Bela-Bela at the intersection of the R101 and Voortrekker Road (km 0.0) and ends in Modimolle at the intersection of the R101 and R33 (km 26.8). The road will start at coordinates 24°53'5.16" S and 28°17'56.88" E and will end at coordinates 24°42'0.33" S and 28°24'21.10" E. **Figure 1** overleaf presents the study area in relation to the surrounding towns within the relevant municipal boundaries.

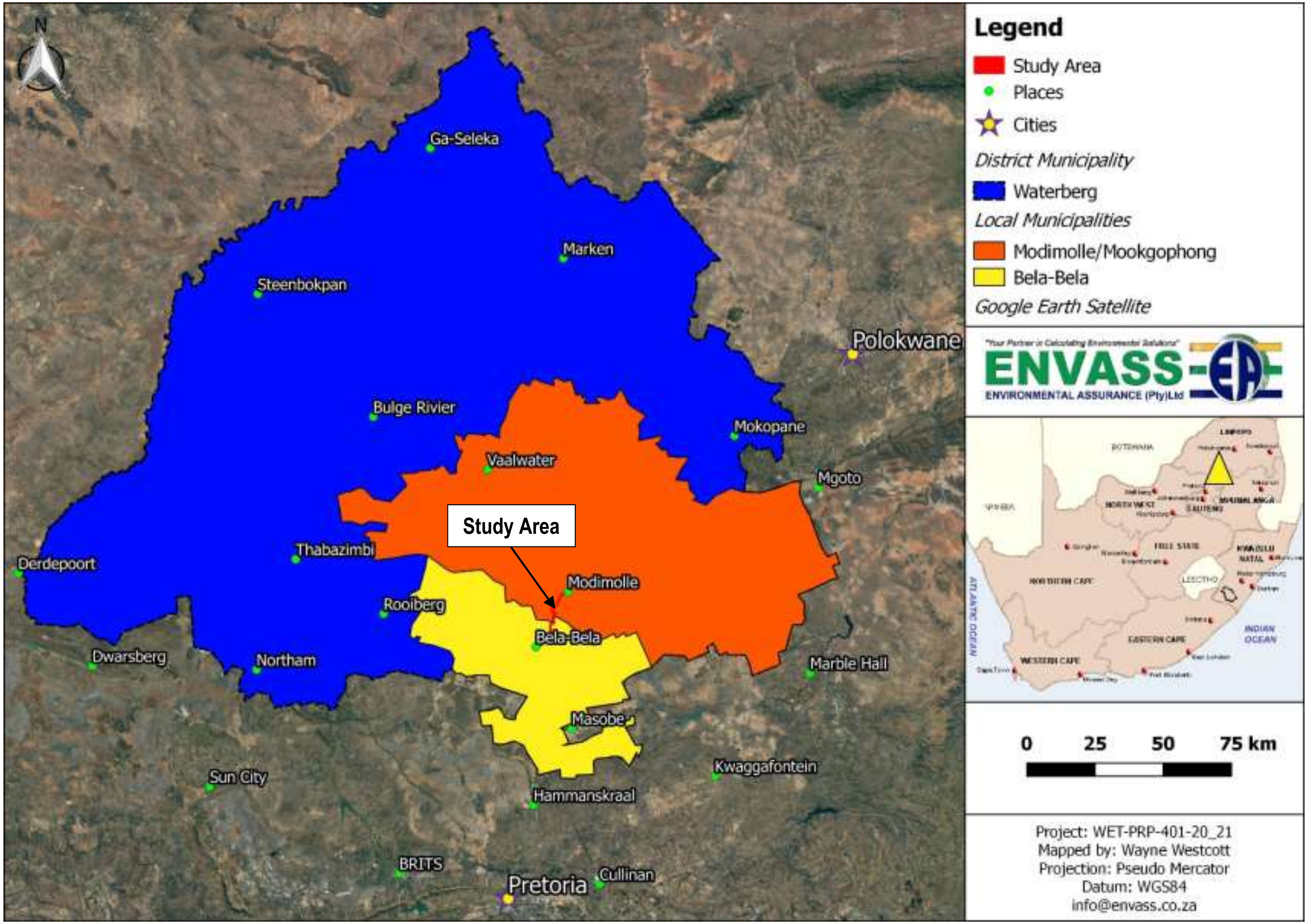

Figure 1: Locality map of the study area in relation to surrounding cities and municipal boundaries within the Limpopo Province, South Africa.

1.3 Applicable Legislation

This study was conducted and the relevant data and/or information obtained in accordance, or with consideration to, the following legislation (**Table 1**).

Table 1: Description of the legislation that was considered when drafting this watercourse impact assessment.

LEGISLATION	DESCRIPTION
South African Constitution (Act no. 108 of 1996)	The constitution is the overarching framework of South African law. It provides a legal foundation for the existence of the republic, outlines the rights and responsibilities of South African citizens and it defines the structure of government. Chapter 2- Bill of rights (Section 24) Everyone has a right to an environment that is not harmful to their health or wellbeing and is protected through reasonable legislative or other measures. (Section 27) National government is the custodian of all the country's water resources.
Conservation of Agricultural Resource Act (CARA) No. 43 of 1983	This act deals with control of the over-utilization of South Africa's natural agricultural resources, and to promote the conservation of soil and water resources and natural vegetation. This includes wetland systems and requires authorizations to be obtained for a range of impacts associated with cultivation of wetland areas.
Department of Water and Sanitation (DWS) General Notice 509 Government Gazette no. 40229 (2016)	This GA replaces the need for a water user to apply for a license in terms of the NWA provided that the water use is within the ambit of the aforementioned GA. Although this GA is legislated throughout South Africa, it only applies to water use in terms of Section 21 (c) and (i) of the NWA within the regulated area of a watercourse. In order to understand and interpret GN 509 (2016) the following definitions must be presented and expanded upon (GN509, 2016): Characteristics of a watercourse: the resource quality of a watercourse within the extent of a watercourse; Diverting: To, in any manner, cause the instream flow of water to be rerouted temporarily or permanently; Extent of a watercourse: (a) The outer boundary of the 1:100year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse; and (b) Wetlands and pans: the delineated boundary (outer temporary zone) of any wetland or pan. Flow-altering: To, in any manner, alter the instream flow route, speed or quantity of water temporarily or permanently. Impeding: to, in any manner, hinder or obstruct the instream flow of water temporarily, or permanently, but excludes the damming of flow so as to cause storage of water. Regulated area of a watercourse: For Section 21 (c) and (i) of the NWA water uses in terms of GN509 means:

LEGISLATION	DESCRIPTION
	(a) The outer boundary of the 1:100year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse; (b) In the absence of a determined 1:100year flood line or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse if the first identifiable annual bank fill flood bench; or (c) A 500 m radius from the delineated boundary of any wetland or pan. Rehabilitation: The process of reinstating natural ecological driving forces within part or the whole of a degraded watercourse to recover former or desired ecosystem structure, function, biotic composition and associated Ecosystem Services (ESS). Watercourse: (a) a river or spring; (b) a natural channel in which water flows regularly or intermittently; (c) a wetland, lake or dam into which, or from which, water flows; and (d) any collection of water which the Minister may, by notice in the Gazette declare to be a watercourse. Wetland: Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. According to GN509 (2016), a water use in terms of Section 21 (c) and (i) of the NWA may be granted under a GA as oppose to a full water use license if all activities within the regulated area of a watercourse is calculated to be low risk utilising the DWS adopted Risk Assessment Matrix. Furthermore, according to GN509 (2016)), a water use in terms of Section 21 (c) and (i) of the NWA may be granted under a GA as oppose to a full water use license for all maintenance of bridges over rivers, streams and wetlands and new construction of bridges done according to SANRAL Drainage Manual or similar norms and standards.
DWS Regulation No. R. 267, Government Gazette no. 40713 (2017)	The purpose of this regulation is to prescribe the procedure and requirements for Water Use License Applications (WULAs) as contemplated in Section 41, as well as an appeal in terms of Section 41(6) of the NWA. Within Section 6 of Regulations No. R. 267 the content required within a Wetland Delineation Report (including watercourses) are stipulated, and thus were considered by the author when drafting this report. Additionally, the standardised and DWS accepted methods that must be used for determining the various aspects of assessments during the WULA process related to wetlands are presented and their sources referenced.
National Environmental Management Act (NEMA): EIA Regulations	As the primary purpose of this assessment is to provide specialist input into the environmental management process, including the water use license application, associated with the proposed development the author has drafted this specialist report in accordance with the requirements listed under Appendix 6 of the NEMA: EIA Regulations (2014, as amended).

LEGISLATION	DESCRIPTION
(2014, as amended in 2017)	
National Water Act (NWA) (Act no. 36 of 1998)	The purpose of the NWA is to ensure that the national water resources are protected, used, developed, conserved, managed and controlled in ways which take into account amongst other factors: (g) protecting aquatic and associated ecosystems and their biological diversity: (h) reducing and preventing pollution and degradation of water resources; In terms of the NWA, water use is broadly defined as, and includes taking and storing water, activities which reduce stream flow, waste discharges and disposals, controlled activities (activities which impact detrimentally on a water resource), altering a watercourse, removing water found underground for certain purposes, and recreation. In general, a water use must be licensed unless it is listed in Schedule I, is an existing lawful use, is permissible under a General Authorisation (GA), or if a responsible authority waives the need for a license. The water uses, as listed under Section 21 of the NWA, that are applicable to this project are: (c) impeding and diverting the flow of water in a watercourse; and (i) altering the bed, banks, course or characteristics of a watercourse.
National Environmental Management Act: Biodiversity Act (NEM:BA) (Act No. 10 of 2004)	The objectives of the NEM:BA are (within the framework of NEMA) to provide for: (i) the management and conservation of biological diversity within the Republic and of the components of such biological diversity; (ii) the use of indigenous biological resources in a sustainable manner; and (iii) the fair and equitable sharing among stakeholders of benefits arising from bioprospecting involving indigenous biological resources.

2 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations are relevant to this study:

- The fieldwork was conducted along a route presented within a KML file that was provided to ENVASS by the client. The route was not pegged out at the time of the field survey.
- A 500 m assessment radius was applied to the proposed development footprint in order to account for any potential watercourses within the NWA defined 500 m regulated area of a wetland. The proposed development including the 500 m assessment radius is referred to as the study area within this report.
- Only those wetland/riverine habitats which may be impacted upon as a result of the proposed development activities were accurately delineated in the field. The remaining freshwater resources within the study area were delineated at a desktop level.
- No DWS Risk Assessment Matrix (RAM) (DWS, 2016) was applicable to this report on request of the client. An impact assessment was utilised to determine the overall impact significance of the proposed development. A separate DWS RAM was undertaken and can be made available on request.
- A transitional gradient occurs within wetlands from the saturated permanent zone to dry terrestrial areas. This gradient makes it difficult to determine the exact boundary of wetland features and some difference in opinion on wetland boundaries may therefore occur. The delineation as presented in this report is however considered to be a best estimate of the boundary of the temporary zone as determined by a wetland specialist with extensive experience in the wetland delineation techniques advocated by the DWS.
- The field survey relevant to this study was a once-off assessment that was conducted in May 2021, and therefore does not cover seasonal variations in freshwater habitat characteristics. Ecosystems vary both temporally and spatially. Once-off assessments such as this may potentially miss certain ecological information, specifically trends and floral species that do not flower within the field survey season.
- Wetland and/or riparian boundaries are essentially based on GPS coordinate waypoints taken on-site of soil sampling points and of important morphological features. The variations experienced in GPS precision will ultimately affect the accuracy of the GPS waypoints and consequently will affect the accuracy of the recorded freshwater resource boundaries. All sampling waypoints were recorded using a Garmin Montana 650 GPS (estimated accuracy rating of 3-5 metres) and captured, analysed and geoprocessed utilising a Geographic Information System (GIS) (i.e. QGIS and ArcGIS).
- The assessment of impacts and recommendation of mitigation measures was informed by the site-specific ecological issues identified during the field survey and based on the assessor's working knowledge and experience with similar linear activity projects.
- A KML file was provided to ENVASS indicating the proposed road alignment. During the assessment of impacts it has been assumed that all wetland and riparian habitat located within the boundary of this KML will be lost as a result of infill associated with road development activities.

- Evaluation of the significance of impacts with mitigation takes into account mitigation measures provided in this report and standard mitigation measures included in the project-specific Environmental Management Programme report (EMPr).
- This report is based on survey and assessment techniques which are limited by time and budgetary constraints relevant to the type and level of investigation undertaken and the author reserves the right to modify aspects of the report including the recommendations if and when new information may become available from ongoing research or further work in this field, or pertaining to this investigation.

3 OBJECTIVES

The primary objective of this watercourse impact assessment was to delineate all watercourses (wetlands and riverine ecosystems) within the study area and identify those watercourses that may be at-risk of being impacted upon by the proposed development. The Present Ecological State (PES), Ecological Importance and Sensitivity (EIS), as well as the opportunity/effectiveness of the at-risk systems to supply valuable Ecosystem Services (ESS) to the surrounding catchment area required to be determined using best-practice and legislated methodologies and techniques. Based on the calculated integrity of the watercourses and the impacts recorded (if any), mitigation and/or rehabilitation measures were identified if required to maintain the Recommended Management Objectives (RMOs), as determined using the Department of Water Affairs and Forestry (DWAF) (now the DWS) management hierarchy (DWAF, 2007). To determine the impact significance of the proposed development on the at-risk watercourses, an impact assessment was be conducted using the DEA (2013) methodology.

The content and structure of this watercourse impact assessment report was formulated in accordance with the requirements stipulated within the DWS Regulation no. 267, which was published within Government Gazette ((GG) no. 40713 of 2017, as well as Appendix 6 of the National Environmental Management Act (NEMA) Act no. 107 of 1998).

4 METHODOLOGY

This section details the different techniques and methods used to obtain the data for this report in order to finally assess the overall ecological integrity of the at-risk watercourses and identify appropriate mitigation and/or rehabilitation measures to implement in an effort to reduce the potential impact (if any) on the receiving aquatic environment.

4.1 Freshwater Habitat Assessment

Assessment of the freshwater ecosystem entails the characterisation of the aquatic environment, aquatic habitat and associated biota. In order to enable an adequate description of the aquatic environment and determination of the PES, the following stressor, habitat and response indicators were evaluated:

- Current and potential threats to water quality and watercourse condition;

- Information regarding upstream and downstream conditions, point and non-point pollution sources, water usage etc. and translate it into information that may be used to measure the compliance against WUL conditions and the integrity of the watercourses;
- Baseline data with regard to PES, resources water quality objectives and the desired future system condition;
- Isolate point source impacts and assess the nature and significance of these impacts;
- Provide specialist recommendations that may be implemented to mitigation and/or rehabilitated the identified and quantified impacts;
- Identify or expand on the baseline condition at each watercourse against which future studies and monitoring works may be measured;
- Implement the most up-to-date best practice methodologies and techniques (e.g. WET-Health (Macfarlane *et al.,* 2009)) to accurately assess the current and change in condition within each reach; and
- Develop a comprehensive report containing result analyses and specialist recommendations that will assist with decisions and the development of management objectives.

4.2 Desktop Assessment

A desktop assessment was undertaken, in which all the available data (e.g. government records and previous studies) pertaining to the proposed study area was sourced and subsequently utilised to determine the theoretical importance and sensitivity of the freshwater ecosystems involved. Additionally, the study area was digitally illustrated and mapped utilising GIS (e.g. QGIS and/or ArcGIS) to better understand the layout and structure of the surrounding environment and study area.

During this process, all the relevant GIS shapefiles were overlain onto Google Earth Satellite imagery to provide the reader with a holistic view of the study area. **Table 2** below presents the datasets that were utilised, their references and date of publication.

Table 2: Presentation of the datasets and available information that was utilised during the desktop study associated with this assessment.

DATASET/TOOL	SOURCE	RELEVANCE
Catchment data	DWS (2012)	Determine the regional hydrological characteristics of the site (e.g. Mean Annual Precipitation (MAP), Mean Annual Simulated Runoff (MASR), Mean Annual Temperature (MAT) and the general flow direction into, through and out of the study area.
Google Earth Pro™ Imagery	Google Earth Pro™ (2019)	Survey the current and historical imagery of the study area to determine the change in land-use practices, and thus identify potential impacts.

DATASET/TOOL	SOURCE	RELEVANCE
DWS Ecoregions (Geographic Information System (GIS) data)	DWS (2005)	Determine the characteristics of the freshwater resources within the study area.
National Freshwater Ecosystem Priority Areas (NFEPA) river and wetland inventories (GIS coverage)	Council for Scientific and Industrial Research (CSIR) (2011)	Ascertain which freshwater resources have been categorised as important and/or sensitive habitats at a national scale, and thus those that will require conservation.
National Wetland Map Version 5 (NWM5).	SANBI (2018)	National Wetland Map 5 includes inland wetlands and estuaries, associated with river line data and many other data sets within the South African Inventory of Inland Aquatic Ecosystems (SAIIAE) 2018. This dataset was therefore used as a guideline to the location and extent of the wetlands within the study area.
Limpopo Conservation Plan Version 2 (LCPv2)	Limpopo Department of Economic Development, Environment and Tourism (LEDET, 2013)	Ascertain which planning units have been categorised as critically important to maintaining, or achieving the conservation targets at a national and regional scale, and thus those that will require conservation.
South African Geological Map (GIS coverage)	Geological Survey (1988)	Determine the underlying lithostratigraphic units to extrapolate the sub-surface flow movements and the parent material of the hydric soils.
South African national land-cover (GIS coverage)	DEA (2018)	To conduct a comparison of what is presented in the dataset against what is currently observed on-site, and thus identify potential disturbance/impacts.
Wetland Vegetation dataset of South Africa	SANBI (2011)	Determine the presumed natural hydrophilic vegetation communities within the study area to ascertain the degree to which the natural cover has been altered by change in land-use practices.
South African National Vegetation Map	SANBI (2006-2018)	Used as a broad baseline against which the on-site land-cover and vegetation condition was compared in order to determine whether changes had occurred on-site.
National Biodiversity Assessment (NBA, 2018) Ecosystem Threat Status and Protection Level.	SANBI (2018)	These two metrics indicate the current status and protection level of South Africa's ecosystems as determined by the National Biodiversity Assessment 2018 Process. The data forms the

DATASET/TOOL	SOURCE	RELEVANCE
		foundation for many land use decision processes including conservation planning.

4.3 Visual Inspection

During the fieldwork, a visual investigation of the study area was conducted to identify any on site and upstream impacts, from both the surrounding land-use activities and environmental processes which may have influenced the overall health and functionality of the impacted watercourses. The impacts observed and condition of the study area were photographed, documented and related to professional experience. This essentially provided a baseline for further studies and justified the PES of the impacted watercourses.

4.4 Field Survey

A field assessment of the watercourses situated within the study area associated with the proposed development was conducted on the 6th and 7th May 2021. The primary objectives of the field survey were to; 1) Verify and accurately delineate the watercourses that were deemed to be at high or medium risk of being impacted on by the proposed development, 2) Record the current ecological integrity of the surrounding catchment areas by identifying disturbances and areas of degradation in relation to the reference, or natural state, 3) Conduct an in-depth analysis of the PES of the at-risk watercourses and determine the potential of, and level to which, the systems supply valuable ESS to the surrounding natural and anthropogenic environments.

4.5 Delineation of Wetland Areas

The wetlands deemed to be at high or medium risk were delineated in detail during the field assessment utilising the methodology and techniques outlined within the wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2008). The permanent, seasonal and temporary (outer boundary) zones of wetness were determined by infield investigation of the wetness indicators, namely (**Figure 2**):

1. The Terrain Unit Indicator helps to identify those parts of the landscape where wetlands are more likely to occur.
2. The Soil Form Indicator identifies the soil forms, as defined by the Soil Classification Working Group (1991-2018), which are associated with prolonged and frequent saturation.
3. The Soil Wetness Indicator identifies the morphological "signatures" developed in the soil profile as a result of prolonged and frequent saturation.
4. The Vegetation Indicator identifies hydrophilic vegetation associated with frequently saturated soils.

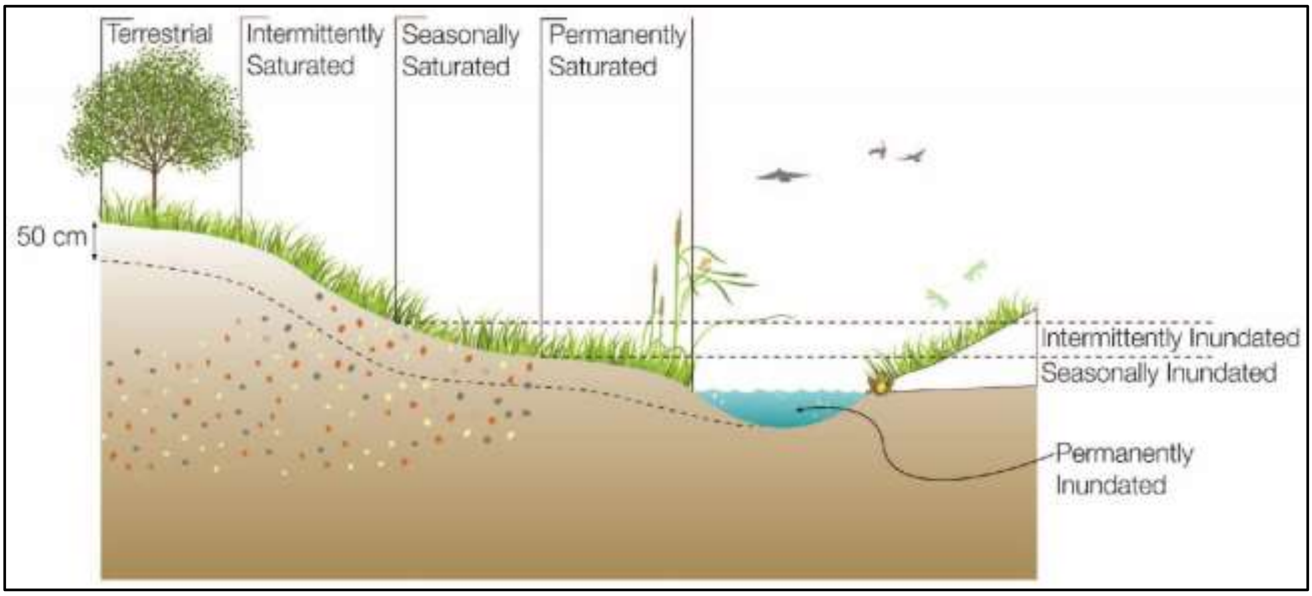

Figure 2: Illustration of the wetness zones typically present through a wetland system (Ollis *et al.*, 2013).

According to the wetland definition used in the NWA (Act no. 36 of 1998), vegetation is the primary indicator of wetness, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained. The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display.

4.6 Wetland Integrity: WET-Health Assessment

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation modules. The technique compares the presumed natural state of a wetland to the current condition observed on-site to ascertain what impacts/disturbances may have occurred within and surrounding the wetland, and thus determine the PES of the system by evaluating this in terms of the three aforementioned modules. Subsequent to determining the impacts that were recorded to have acted, or are acting, on the wetland, specific mitigation and/or rehabilitation measures can be formulated and implemented to reduce the impact with the end-goal of obtained the Recommended Management Objective (RMO) of each wetland.

There are two levels of complexity, namely: Level 1 that is used for assessment at a broad catchment level, and Level 2 which provides detailed and confident analyses of individual wetlands based on in-field survey of the three WET-Health modules. Level 1 was utilised for the assessment of the wetlands that may be impacted on by the proposed development. The following will briefly describe the three modules, followed by a presentation of the overall PES score categorisation that is used to represent the overall integrity/health of an assessed wetland.

Hydrology is defined in this context as the distribution and movement of water into, through and out of a wetland and its hydric soils. This module focuses on changes in water inputs as a result of changes in catchment activities and characteristics that affect water supply and its timing, as well as on modifications within the wetland that alter the water distribution and retention patterns within the system.

Geomorphology is defined in this context as the distribution and retention patterns of sediment within the wetland. This module focuses on evaluating current geomorphic health through the presence of indicators of excessive sediment inputs and/or losses for clastic (minerogenic) and organic sediment (peat).

Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic on-site transformation and/or disturbance in comparison to the presumed natural state, or reference condition. The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a PES score.

The WET-Health tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (**Table 3**).

Table 3: Guideline for interpreting the magnitude of impacts on wetland integrity (Macfarlane *et al.*, 2009).

IMPACT CATEGORY	DESCRIPTION	SCORE
None	No discernible modification or the modification is such that it has no impact on this component of wetland integrity.	0 – 0.9
Small	Although identifiable, the impact of this modification on this component of wetland integrity is small.	1 – 1.9
Moderate	The impact of this modification on this component of wetland integrity is clearly identifiable but limited.	2 – 3.9
Large	The modification has a clearly detrimental impact on this component of wetland integrity. Approximately 50% of wetland integrity has been lost.	4 – 5.9
Serious	The modification has a highly detrimental effect on this component of wetland integrity. Much of the wetland integrity has been lost but remaining integrity is still clearly identifiable.	6 – 7.9
Critical	The modification is so great that the ecosystem processes of this component of wetland integrity are almost totally destroyed, and 80% or more of the integrity has been lost.	8 – 10

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from “unmodified/natural” (Category A) to “severe/complete deviation from natural” (Category F) as depicted in **Table 4** below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table 4: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al.*, 2009).

IMPACT CATEGORY	DESCRIPTION	RANGE	PES CATEGORY
None	Unmodified, natural.	0 – 0.9	**A**
Small	Largely natural with few modifications. A slight change in ecosystem processes is discernible and a small loss of natural habitats and biota may have taken place.	1 - 1.9	**B**
Moderate	Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact	2 – 3.9	**C**
Large	Largely modified. A large change in ecosystem processes and loss of natural habitat and biota and has occurred.	4 – 5.9	**D**
Serious	The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	6 – 7.9	**E**
Critical	Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	8 - 10	**F**

An overall wetland health score was calculated by weighting the scores obtained for each module and combining them to give an overall combined score using the following formula:

Overall health rating = [(Hydrology*3) + (Geomorphology*2) + (Vegetation*2)] / 7

This overall score assists in providing an overall indication of wetland health/functionality which can in turn be used for recommending appropriate management measures.

4.7 Wetland Functionality: WET-Ecoservice Assessment

WET-EcoServices is used to assess the potential and effectiveness of a wetland at providing Ecosystem Services (ESS) (regulatory and supporting, and cultural and provisional benefits) to the surrounding anthropogenic and natural environment, thereby quantifying the value of the wetland and thus aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ESS (e.g. flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydrogeomorphic setting (e.g. floodplain or unchannelled valley-bottom wetland). ESS delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on an in-field assessment of key descriptors (e.g. flow pattern through the wetland). The tool assists the practitioner to determine what ESS are currently being supplied, and to what degree/level, and thereafter identify any threats are acting on the benefits and if/what opportunities are available for enhancing the benefits.

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ESS that they supply. This allows for more informed planning and decision making. **Table 5** overleaf presents the ESS/benefits that are utilised within the WET-Ecoservice assessment, followed by **Table 6** overleaf which illustrates the categories used to rank the ability of a wetland to provide each ESS.

Table 5: Ecosystem Services that are used in the WET-Ecoservices assessment.

Ecosystem services supplied by wetlands	Indirect benefits	Regulating and supporting benefits	Flood attenuation		The spreading out and slowing down of floodwaters in the wetland, thereby reducing the severity of floods downstream
			Streamflow regulation		Sustaining streamflow during low flow periods
			Water quality enhancement benefits	Sediment trapping	The trapping and retention in the wetland of sediment carried by runoff waters
				Phosphate assimilation	Removal by the wetland of phosphates carried by runoff waters
				Nitrate assimilation	Removal by the wetland of nitrates carried by runoff waters
				Toxicant assimilation	Removal by the wetland of toxicants (e.g. metals, biocides and salts) carried by runoff waters
				Erosion control	Controlling of erosion at the wetland site, principally through the protection provided by vegetation.
			Carbon storage		The trapping of carbon by the wetland, principally as soil organic matter
	Direct benefits	**Biodiversity maintenance**[2]			Through the provision of habitat and maintenance of natural process by the wetland, a contribution is made to maintaining biodiversity
		Provisioning benefits	Provision of water for human use		The provision of water extracted directly from the wetland for domestic, agriculture or other purposes
			Provision of harvestable resources		The provision of natural resources from the wetland, including livestock grazing, craft plants, fish, etc.
			Provision of cultivated foods		The provision of areas in the wetland favourable for the cultivation of foods
		Cultural benefits	Cultural heritage		Places of special cultural significance in the wetland, e.g., for baptisms or gathering of culturally significant plants
			Tourism and recreation		Sites of value for tourism and recreation in the wetland, often associated with scenic beauty and abundant birdlife
			Education and research		Sites of value in the wetland for education or research

Table 6: The classes for determining the likely extent to which a benefit is being supplied based on the overall score for that benefit (Kotze *et al.,* 2007).

SCORE RANGE (0-4)	< 0.5	0.5-1.2	1.3-2.0	2.1-2.8	> 2.8
RATING OF THE LIKELY EXTENT TO WHICH A BENEFIT IS BEING SUPPLIED	Low	Moderately Low	Intermediate	Moderately High	High

4.8 Wetland: Ecological Importance and Sensitivity (EIS)

The EIS of the wetlands was determined by utilising a rapid scoring system that was developed by Rowntree (2013), which incorporates aspects of the WET-Ecoservices tool (Kotze *et al.,* 2007) and earlier DWS EIS assessment tools. The purpose of assessing the EIS of a watercourse is to identify those watercourses that are of high conservation concern, primarily as a result of their ability to provide ESS at an above average level, biodiversity function or are specifically susceptible to impacts/disturbances within the catchment area. Water resources with a higher ecological importance may require managing such systems in a better condition than the present to ensure the continued provision of ESS in the long-term (Rowntree, 2013).

Three proposed suites of criteria for assessing the EIS of wetlands form the basis of this tool, namely (**Table 7**):

- EIS, incorporating the traditionally examined criteria used in EIS assessments of other water resources by DWA and thus enabling consistent assessment approaches across water resource types;
- Hydro-functional importance, taking into consideration water quality, flood attenuation and sediment trapping ecosystem services that the wetland may provide; and
- Importance in terms of socio-cultural benefits, including the subsistence and cultural benefits provided by the wetland system.

The highest score out of the three abovementioned suites is then used to determine the overall EIS category of the wetland system (**Table 8**).

Table 7: Template used to calculate the overall Ecological Importance and Sensitivity of a wetland (Rowntree, 2013).

ECOLOGICAL IMPORTANCE AND SENSITIVITY			
Ecological Importance	**Score (0-4)**	**Confidence (1-5)**	**Motivation for site**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			

ECOLOGICAL IMPORTANCE AND SENSITIVITY			
Ecological Importance	**Score (0-4)**	**Confidence (1-5)**	**Motivation for site**
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			
HYDROLOGICAL/FUNCTIONAL IMPORTANCE			
IMPORTANCE OF DIRECT HUMAN BENEFITS			
OVERALL IMPORTANCE			

Table 8: Presentation of the categories used to rank the EIS of each wetland system (Rowntree, 2013).

ECOLOGICAL IMPORTANCE AND SENSITIVTIY CATEGORY	RANGE OF EIS SCORE
Very High: Wetlands that are considered ecologically important and sensitive on a **national or even international scale**. The biodiversity of these systems 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
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these systems 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
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these systems 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
Low/Marginal: Wetlands that are not ecologically important or sensitive at any scale. The biodiversity of these systems 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

4.9 Delineation of Riparian Areas

Riparian zones are described as “the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas”, Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (**Figure 3**).

Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel. Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas.

Landscape Position as discussed above, a typical landscape can be divided into 5 main units, namely the: - Crest (hilltop); - Scarp (cliff); - Mid-slope (often a convex slope); - Foot-slope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or stream channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

The NWA’s (Act no 36 of 1998) definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised macro-channels, which are typical of many of Southern Africa’s eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area, and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or stream channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of "restrictive floodplain" within which one or more active channels flow.

Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

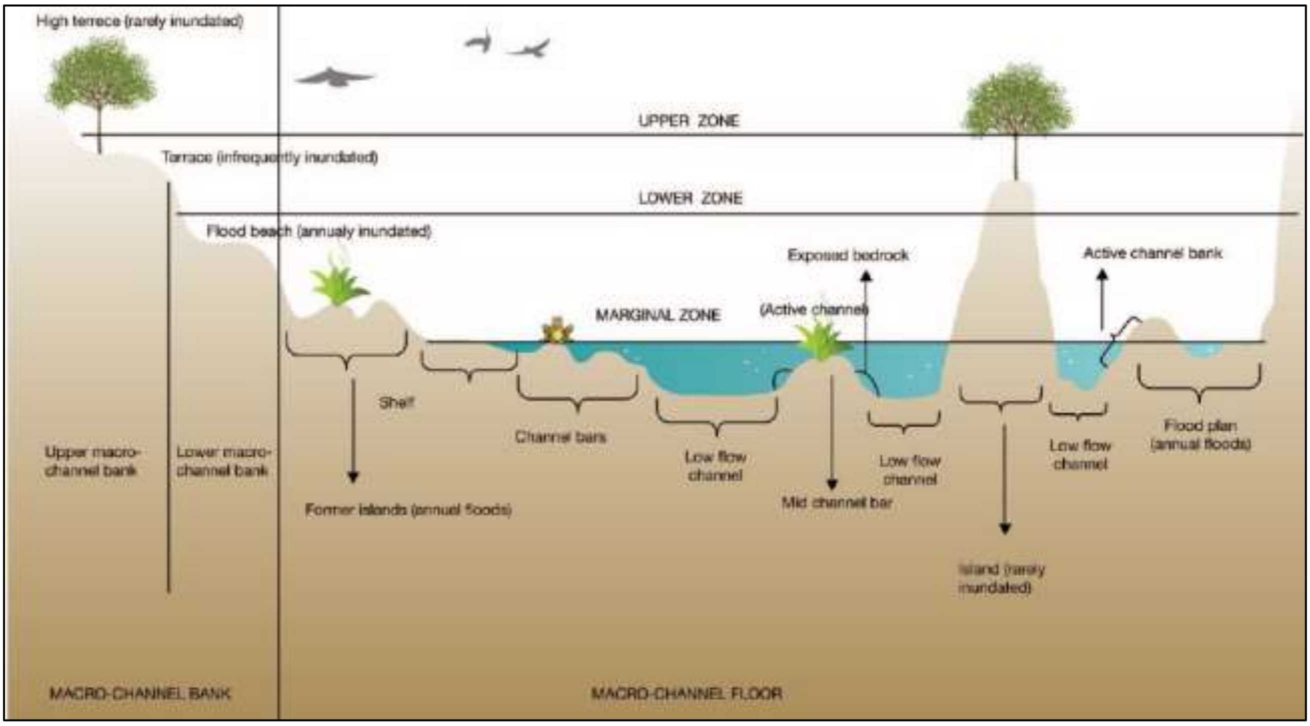

Figure 3: A schematic diagram illustrating the typical dissection of a river system (Kleynhans *et al*., 2007).

4.10 Present Ecological State (PES) – Riverine Systems

Habitat is one of the most important factors that determine the health of river ecosystems since the availability and diversity of habitats (instream and riparian areas) are important determinants of the biota that are present in a river system (Kleynhans, 1996). The 'habitat integrity' of a river refers to the "maintenance of a balanced composition of physicochemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region" (Kleynhans, 1996). It is seen as a surrogate for the assessment of biological responses to driver changes.

The site-specific habitat integrity was assessed utilising the Index of Habitat Integrity Assessment (IHIA), which was developed by Kleynhans (1996) and modified by Kemper (1999) and the DWS (2008). The riparian and instream habitat of each site were scored separately according to twelve (12) different criteria, which attempt to quantify the anthropogenically induced impacts on the relevant system (**Table 9**). This tool compares the current state of the instream and riparian habitats (with existing impacts) relative to the presumed natural, or reference state (in the absence of anthropogenic impacts). The overall integrity of each zone is thus based on the deviation from the natural or reference condition, expressed as a percentage where 100 % is the unmodified natural state. To obtain the overall habitat Integrity score for each site the mean of the instream and riparian habitat scores was calculated. The overall Habitat Integrity score was then be classified into one of six classes, ranging from unmodified/natural (Class A) to critically modified (Class F) (**Table 10**). This class/score describes the PES of both the instream and riparian habitats of each site.

Table 9: Criteria and relevance to the assessment of riverine habitat integrity (Kleynhans, 1996).

CRITERIA	RELEVANCE
Water Abstraction	Direct impact on habitat type, abundance and size. Also implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow can have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed Modification	Regarded as the result of increased input of sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al*., 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow which may alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. Dependent upon the species involved and scale of infestation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.

Solid waste disposal	A direct anthropogenic impact which may alter habitat structurally. Also a general indication of the misuse and mismanagement of the river.
Vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al*., 1992). Refers to physical removal for farming, firewood and overgrazing. Includes both exotic and indigenous vegetation.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous organic matter input will also be changed. Riparian zone habitat diversity is also reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

Table 10: Description of the Present Ecological State (PES) score categories of the IHIA model (DWS, 2008).

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

4.11 Ecological Importance & Sensitivity – Riverine Systems

The ecological importance of a river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh, *et. al*., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (**Table 11**).

Table 11: Components considered for the assessment of the ecological importance and sensitivity of a riverine system. An example of the scoring has also been provided.

ECOLOGICAL IMPORTANCE AND SENSITIVITY ASSESSMENT (RIVERS)		
DETERMINANTS		SCORE (0-4)
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	0,5
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0,0
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	2
	Species/taxon richness (range: 4=very high - 1=low/marginal)	1,5
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	1,0
	Refugia (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,0
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	2.0
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	1,0
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2
MEDIAN OF DETERMINANTS		1,00
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		LOW, EC=D

The scores assigned to the criteria in **Table 11** were used to rate the overall EIS of each mapped unit according to **Table 12** below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane *et al*., 2009).

Table 12: The ratings associated with the assessment of the EIA for riparian areas.

RATING	DESCRIPTION
None, Rating = 0	Rarely sensitive to changes in water quality/hydrological regime
Low, Rating =1	One or a few elements sensitive to changes in water quality/hydrological regime
Moderate, Rating =2	Some elements sensitive to changes in water quality/hydrological regime
High, Rating =3	Many elements sensitive to changes in water quality/ hydrological regime
Very high, Rating =4	Very many elements sensitive to changes in water quality/ hydrological regime

4.12 Water Quality Analysis

All water quality sampling and field analyses were conducted by a qualified ENVASS specialist who was fully trained in implementing the below presented SANS and ISO protocols and guidelines. At each of the predetermined biomonitoring sites the ENVASS specialist made use of a hand-held Aquaprobe AP-800 to assess *in situ* water quality parameters such as pH, DO (mg/l & % sat.), Temp (ºC), EC, Turbidity and TDS.

The water sampling that was conducted at the plant was done in accordance with the following guidelines:

1. Guidance on the preservation and handling of water samples:
   SANS 5667-3:2006/ISO 5667-3:2003 (SABS ISO 5667-3)
2. Guidance on sampling of rivers and streams:
   SANS 5667-6:2006/ISO 5667-6:2005 (SABS ISO 5667-6)
3. Guidance on quality assurance of environmental water sampling and handling:
   SANS 5667-14:2007/ISO 5667-14:1998

The water quality results obtained were then compared to the TWQR for aquatic ecosystems (DWAF, 1996), and if no parameter limit was present within this document it was sourced from literature (**Table 13**).

Table 13: Description of the water quality limits used for the relevant water quality parameters.

PARAMETER	UNIT	LIMIT	GUIDELINE REFERENCE
pH	N/A	6.5 – 9.0	DWAF (1996), Alabaster & Lloyd (1982)
EC	mS/m	15.30 – 154	Johnson (2008)
		<15 % change from normal cycles of the water body under impacted conditions	DWAF (1996)
TDS	mg/l	Pure rainwater: <10	Johnson (2008)
		Freshwater river: 100 – 1,000	
		Brakish water: 1,000 – 3,000	
		Saline water: > 3,000	
		Sea water: 35,000	
		OPTIMUM TDS: 100 – 1000	
		<15 % change from normal cycles of the water body under impacted conditions	DWAF (1996)
DO	mg/l	>5.00	Kempster et al. (1980)
DO Percentage saturation	%	80 – 120	DWAF (1996)
Temperature	ºC	5 – 30	DWAF (1996)

4.13 Impact Assessment Methodology

The perceived impacts associated with the proposed development were assessed using a quantitative impact assessment methodology, which was formalised to comply with Regulation 31(2)(l) of the NEMA (Act no. 107 of 1998). The aim of this assessment was to identify and assess the significance of all the perceived impacts, which may arise as a result of the proposed development. The methodology employed makes use of the following procedure:

1. Identification and assessment of potential impacts;
2. Prediction of the nature, duration, extent, likelihood and significance;
3. Identification of mitigation measures that could be implemented to reduce the significance of the potential impact; and
4. Evaluation of the significance of the potential impacts following the implementation of mitigation measures.

Potential impacts will be assessed using the following factors and associated score ratings (**Table 14**).

Table 14: Table outlining the various factors considered when determining the significance of each potential impact associated with the proposed development.

CRITERIA	INDICATOR	
The nature	A description of what causes the effect, what will be affected and how it will be affected.	
The physical extent (spatial scale)	Wherein it is indicated whether:	
	1	The impact will be limited to the site
	2	The impact will be limited to the local area
	3	The impact will be limited to the region
	4	The impact will be national
	5	The impact will be international
The duration (temporal scale)	Wherein it is indicated whether the lifetime of the impact will be of:	
	1	A very short duration (0–1 years)
	2	A short duration (2-5 years)
	3	Medium-term (5–15 years)
	4	Long term (> 15 years)
	5	Permanent

CRITERIA	INDICATOR
The intensity/magnitude of the impact on ecological processes (severity)	Impacts quantified on a scale from 0-10, where a score is assigned: 0 – Small and will have no effect on the environment 2 – Minor and will not result in an impact on processes 4 – Low and will cause a slight impact on processes 6 – Moderate and will result in processes continuing but in a modified way 8 – High (processes are altered to the extent that they temporarily cease) 10 – Very high and results in complete destruction of patterns and permanent cessation of processes
The probability of occurrence/likelihood of the impact (Likelihood of occurring)	Probability is estimated on a scale where: 1 – Very improbable (probably will not happen) 2 – Improbable (some possibility, but low likelihood) 3 – Probable (distinct possibility) 4 – Highly probable (most likely) 5 – Definite (impact will occur regardless of any prevention measures)

Subsequent to the abovementioned factors being ranked for each potential impact, the ecological significance of each impact was calculated utilising the following formulae:

Significance = (Intensity + Duration + Extent) x Probability. The maximum value is 100 Significance Points.

- The significance, which is determined through a synthesis of the characteristics described above and can be assessed as low, medium or high;
- The status, which is described as either positive, negative or neutral;
- The degree to which the impact can be reversed;
- The degree to which the impact may cause irreplaceable loss of resources;
- The degree to which the impact can be mitigated;

The significance weightings for each potential impact are outlined in **Table 15**.

Table 15: Table illustrating the significance weighting that can be allocated to each impact significance score.

SIGNIFICANCE VALUE	SIGNIFICANCE WEIGHTING	DESCRIPTION
< 30	**Low**	This impact has a Low ecological significance, and does not impact on the decision to develop within the area
31-60	**Medium**	Where the impact could influence the decision to develop in the area unless it is effectively mitigated
> 60	**High**	Where the impact must have an influence on the decision process to develop in the area

5 DESKTOP ASSESSMENT

The following sections consist of information obtained during the desktop study of the study area and the surrounding terrestrial and aquatic environment. The information obtained at a desktop level was ground-truthed and used to provide input into the perceived changes that may have occurred to the presumed natural state of the at-risk watercourses.

5.1 Hydrological Setting

The study area was observed to fall within the Apies/Pienaars and Mogalakwena Sub-Water Management Areas (WMA). The Apies/Pienaar SubWMA is located within the larger Crocodile (West) and Marico WMA and the Mogalakwena SubWMA is located within the larger Limpopo WMA (**Figure 4**). The study area was recorded to traverse four (4) Sub-Quaternary Reaches (SQR) namely: A61A- 520, A61A – 561, A61C- 574 and A23G- 593 (DWS, 2012). The desktop calculated PES score, Ecological Sensitivity (ES) and Ecological Importance (EI) of the aforementioned SQRs are as follows (DWS, 2012):

- A61A- 520: PES= Class D (Largely modified), EI= High & ES= High;
- A61A – 561: PES= Class C (Moderately modified), EI= High & ES= Very High;
- A61C- 574: PES= Class C (Moderately modified), EI= Moderate & ES= Very Low; and
- A23G- 593: PES= Class D (Largely modified), EI= Moderate & ES= Moderate.

5.2 Ecoregion

According to the delineation provided by Dallas (2005), the study area extends across the Bushveld Basin and Western Bankenveld ecoregions (**Figure 5**). **Table 16** below presents the primary characteristics and data that have been collected for the relevant ecoregions.

Table 16: Bushveld Basin and Western Bankenveld Ecoregion attributes (Kleynhans *et al.,* 2005) (Bold indicates the most dominant attribute/s).

MAIN ATTRIBUTES	BUSHVELD BASIN	WESTERN BANKENVELD
Terrain Morphology: Broad division (dominant types in bold) (Primary)	**Plains; Low Relief**; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited)	Plains; Low Relief; Plains; Moderate Relief; **Lowlands; Hills and Mountains; Moderate and High Relief;** **Open Hills; Lowlands; Mountains; Moderate to High Relief;** **Closed Hills; Mountains; Moderate and High Relief**;
Vegetation types (dominant types in bold) (Primary)	**Mixed Bushveld;** Clay Thorn Bushveld; Waterberg Moist Mountain Bushveld (limited)	**Waterberg Moist Mountain Bushveld; Mixed Bushveld**; Kalahari Plains Thorn Bushveld (limited); Clay Thorn Bushveld; (limited) Rocky Highveld Grassland; Dry Clay Highveld Grassland; (limited)
Altitude (m a.m.s.l) (secondary)	700-1700 (1700-1900 very limited)	900-1700
MAP (mm) (modifying)	400 to 600	400 to 700
Coefficient of Variation (% of annual precipitation)	25 to 35	20 to 35
Rainfall concentration index	55 to >65	60 to >65
Rainfall seasonality	Early to mid summer	Early to mid summer
Mean annual temp. (°C)	14 to 22	14 to 22
Mean daily max. temp. (°C): February	22 to 32	24 to 32
Mean daily max. temp. (°C): July	14 to 24	14 to 24
Mean daily min. temp. (°C): February	12 to 20	12 to 20
Mean daily min temp. (°C): July	0 to 6	0 to 6
Median annual simulated runoff (mm) for quaternary catchment	20 to 100	20 to 80, 80 to 100 (limited)

5.3 Land Use

The dominant land cover categories recorded within the study area included open woodland, formal residential areas, commercial annual crops (dryland) and fallow lands and old fields. Scattered areas of dense forest and woodland, grassland and herbaceous wetland were also recorded (**Figure 6**). Subsequent to conducting a field survey it was recorded that the majority of the desktop modelled land cover classes were correct, however the extent of watercourses within the study area had not been adequately estimated. In addition to this, the existing road and associated reserve was not adequately presented as a previously disturbed area.

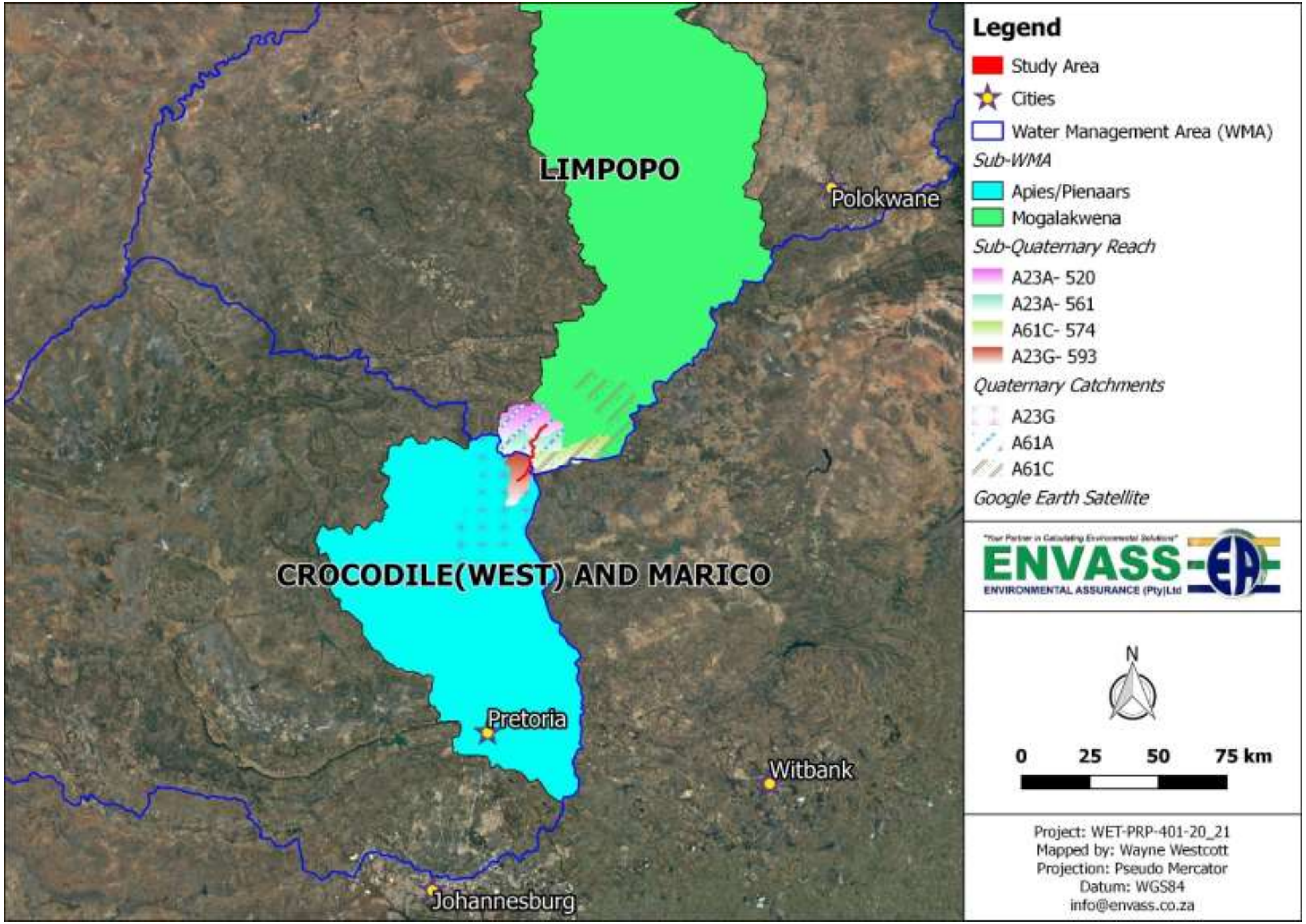

Figure 4: Illustration of the Water management Areas (WMAs), Sub Water Management Areas (SubWMAs) and Sub-Quaternary Reaches (SQR) associated with the study area (Kleynhans, 2005).

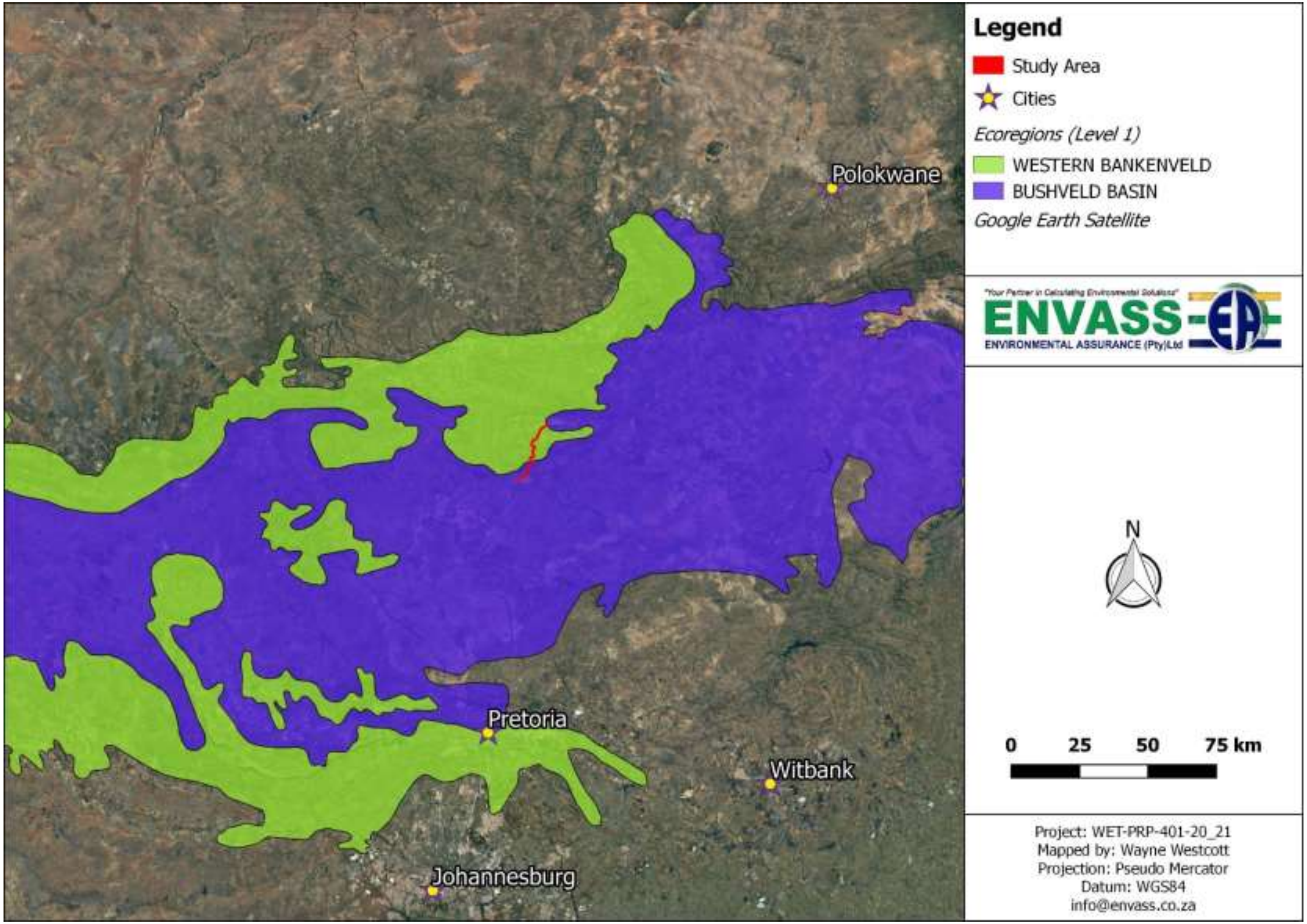

Figure 5: Ecoregions associated with the study area (Kleynhans, 2005).

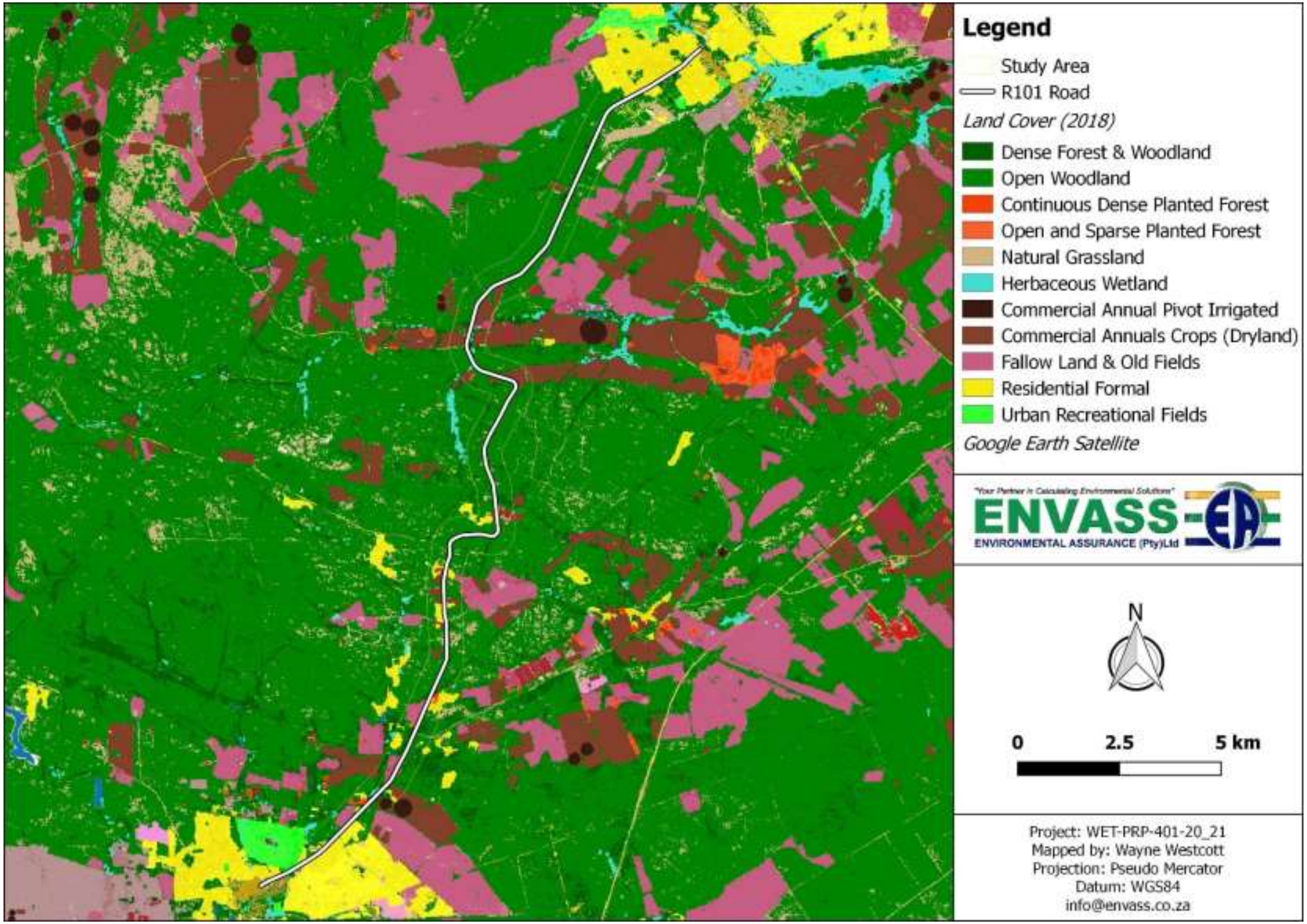

Figure 6: Land cover associated with the study area (DEA, 2018).

5.4 Vegetation

Vegetation types were identified and delineated on a national scale by Mucina and Rutherford (2006), and this terrestrial vegetation delineation has since been continually modified at five (5) year intervals to account for changes in land cover. The most recent version of the dataset at the time of this study was from 2018. As this delineation was at a national scale, the vegetation dataset was used as a broad baseline against which the on-site land-cover and vegetation condition was compared to in order to determine whether changes had occurred on-site.

According to the most recent SANBI (2006-2018) delineation, the study area was recorded to extend through the following terrestrial vegetation units: Springbokvlakte Thornveld, Central Sandy Bushveld and Waterberg Mountain Bushveld (**Figure 7**). **Table 17** below presents the conservation information relative to the vegetation types. It must however be noted that the condition of the aforementioned vegetation types varied according to the degree to which the changing land-use practices within and surrounding the study area had encroached on the overall delineated boundaries, and thus this has altered the desktop delineated vegetation units.

Table 17: National vegetation types that may be impacted on by the proposed development (SANBI, 2006-2018) as well as their threat status and protection level (NBA, 2018).

CODE	VEGETATION TYPE	THREAT STATUS	PROTECTION LEVEL
SVcb15	Springbokvlakte Thornveld	**Vulnerable**	Poorly Protected
SVcb17	Central Sandy Bushveld	Least Concern	Poorly Protected
SVcb12	Waterberg Mountain Bushveld	Least Concern	Moderately Protected

Figure 7 below also presents the wetland vegetation (WetVeg) types that were delineated within the study area, at a national scale (Driver *et al*., 2011). The WetVeg types that were observed within the study area included the Central Bushveld Group 1 (Critically Endangered), the Central Bushveld Group 2 (Vulnerable) and the Central Bushveld Group 3 (Endangered) (Driver *et al*., 2011). Remnants of these WetVeg units were recorded on-site, however the majority of the watercourses had been invaded by Invasive and Alien Plant Species (IAPS) and pioneer species within the proposed disturbance footprints.

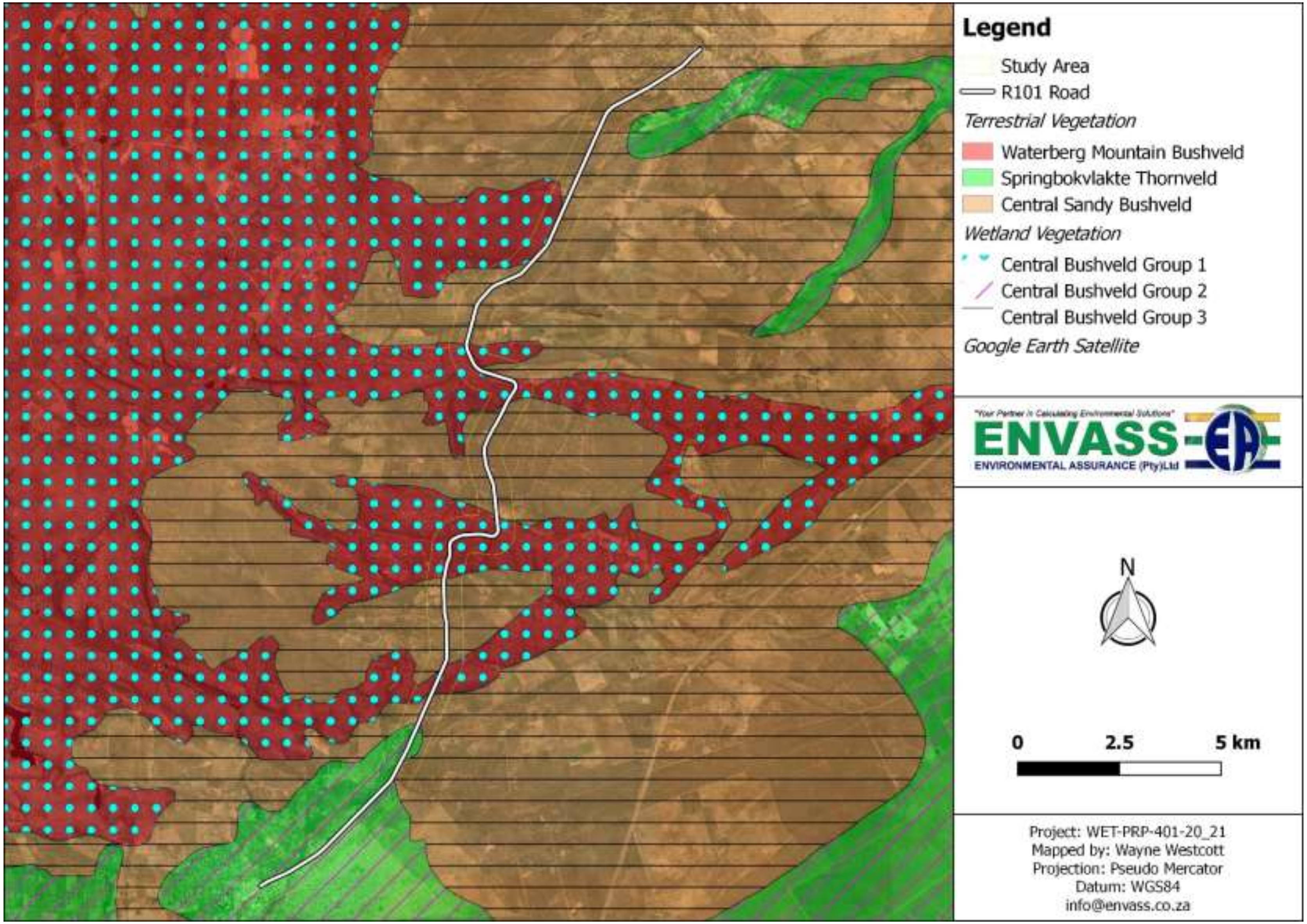

Figure 7: Terrestrial and wetland vegetation type associated with the study area (SANBI, 2006-2018 and Driver *et al.*, 2011).

5.5 Limpopo Conservation Plan Version 2 (2013)

The purpose of the Limpopo Conservation Plan version 2 (LCPv2) was to develop the spatial component of a bioregional plan (i.e. map of Critical Biodiversity Areas (CBA) and associated land-use guidelines). This conservation plan is consistent with NEMA principles and the NEMBA. It is designed to support integrated development planning and sustainable development by identifying an efficient set of CBAs that are required to meet national and provincial biodiversity objectives, in a configuration that is least conflicting with other land uses and activities.

In terms of terrestrial conservation units, the study area extends through units which have been categorised as CBA 1, CBA 2, Ecological Support Area (ESA) 1, ESA 2, Other Natural Areas and No Natural Habitat Remaining (**Figure 8**). For ease of reference, the descriptions and land management objectives for these units are summarised in **Table 18** below.

Table 18: Summary of the LCPv2 planning units that were relevant to the study area (LEDET, 2013).

UNIT	DESCRIPTION	LAND MANAGEMENT OBJECTIVES
CBA 1	Irreplaceable Sites. Areas required to meet biodiversity pattern and/or ecological processes targets. No alternative sites are available to meet targets.	Maintain in a natural state with limited or no biodiversity loss. Rehabilitate degraded areas to a natural or near natural state, and manage for no further degradation.
CBA 2	Best Design Selected Sites. Areas selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets.	Maintain in a natural state with limited or no biodiversity loss. Maintain current agricultural activities. Ensure that land use is not intensified and that activities are managed to minimize impact on threatened species.
ESA 1	Natural, near natural and degraded areas supporting CBAs by maintaining ecological processes.	Maintain ecosystem functionality and connectivity allowing for limited loss of biodiversity pattern.
ESA 2	Areas with no natural habitat that is important for supporting ecological processes.	Avoid additional new impacts on ecological processes.
Other Natural Areas	Natural and intact but not required to meet targets, or identified as CBA or ESA.	No Land Management Objectives prescribed. Where possible existing no natural habitat remaining areas should be favoured for development before Other Natural Areas.
No Natural Habitat Remaining	Areas with no significant direct biodiversity value. Not Natural or degraded natural areas that are not required as ESA, including intensive agriculture, urban, industry; and human	No Land Management Objectives prescribed.

	infrastructure.	

5.6 National Wetland Map Version 5 (NWM5) and Freshwater Ecosystem Priority Areas (NFEPAs)

The NFEPA database provides strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. NFEPAs were identified based on a range of criteria dealing with the maintenance of key ecological processes and the conservation of ecosystem types and species associated with rivers, wetlands and estuaries (Driver *et al.,* 2011). The NWM5 was developed to provide input into the 2018 NBA, as well as to improve the overall land-use planning and decision mapping surrounding wetland ecosystems at a national scale.

According to the NFEPA dataset, the northern portion of the proposed development will traverse a Fish Sanctuary; and a small portion of the centre of the proposed development will traverse a Phase 2 Freshwater Ecosystem Priority Area (FEPA) (**Figure 9**). Fish sanctuaries are rivers that are essential for protecting threatened freshwater fish that are indigenous to South Africa. The entire sub-quaternary catchment associated with the river is indicated as a Fish Sanctuary. There should be no further deterioration in river condition in fish sanctuaries and no new permits should be issued for stocking invasive alien fish in farm dams in the associated sub-catchment. Phase 2 FEPAs were identified in moderately modified rivers (C ecological category) and their associated sub-quaternary catchments, only in cases where it was not possible to meet biodiversity targets for river ecosystems in rivers that were still in good condition (A or B ecological category). The condition of these Phase 2 FEPAs should not be degraded further, as they may in future be considered for rehabilitation once FEPAs in good condition (A or B ecological category) are considered fully rehabilitated and well managed.

According to the NFEPA wetland datasets, as well as the NWM5, seven (7) natural and nine (9) artificial wetlands are located within the 500 m assessment radius around the proposed development (**Figure 9**). However, of the wetlands identified only three (3) areas indicated as natural wetlands by NFEPA will be traversed by the proposed development. During the field investigation it was determined that only one (1) of these areas contained wetland habitat (UVB01 discussed below). The remaining two (2) natural wetlands indicated by the NFEPA dataset did not contain wetland habitat and were determined to be associated with a riparian area.

The proposed development also traverses two (2) rivers which are indicated by the NFEPA rivers layer. These include the ephemeral Bad se Loop River and the perennial Groot Nyl River. However, during the field investigation it was determined that the habitat associated with both rivers at the proposed development crossing areas is considered to be more representative of wetland rather than riparian habitat (UVB01 and CVB02 discussed below). The hydrological flow regime through these systems within the study area were recorded to have been dominated by diffuse flow as oppose to linear flow, providing further justification for wetland conditions.

5.7 Geology and Soils

Figure 10 below illustrates the geological units that were recorded to be underlying the study area, and consequently providing the parent material from which the overlying soils were created. It was evident that the study area is underlain by four (4) lithostratigraphic units, namely the: Clarens Formation, Swaershoek Formation, Alma Formation and Diabase (Dolerite) around Modimolle.

The Clarens Formation forms part of the Karoo Supergroup and was deposited approximately 200 Million Years ago (Ma) during the Jurassic Period of the Mesozoic Era, Phanerozoic Eon (Council for Geoscience, 2008). The Clarens Formation typically consists of fine-grained sandstone and siltstone (Council for Geoscience, 2008). The Swaershoek Formation is the basal unit of the Waterberg Group in the Nylstroom Subgroup basin and was assumed to have been deposited as fan deltas and subsequently reworked. Consisting of medium- to coarse-grained sandstone (pebbles in places), conglomerate, trachytic lava and quartz porphyry (Council for Geoscience, 2008). The Alma Formation was interpreted as a series of alluvial fans which formed a bajada along the scarp of the Waterberg caused by uplifted through various episodes of faulting. This unit consists of felspathic and lithic sandstone, sub-ordinate conglomerate and mudrock (mainly siltstone) (Council for Geoscience, 2008). Kheisian diabase, or dolerite igneous rock, is an intrusive body into the Alma Formation with the study area around Modimolle.

The lithostratigraphic units within the northern portion of the study area were recorded to have eroded to sandy soils which did not encourage the formation of wetland, but instead provided a platform for ephemeral drainage lines to develop. The sandstone areas within the mid and lower (southern) portion of the study area exhibited soils with a higher clay content and water retention capabilities. These characteristics and the flatter terrain unit encouraged wetland formation, evident by UVB01, UVB02, CVB01 and CVB02.

Subsequent to a review of the hydrological soil properties of the profiles within the study area, it was evident that Class A/B, Class B/C and Class C formed the material overlying the abovementioned lithostratigraphic units (**Figure 11**). Hydrological soil group A/B demonstrates a high infiltration rate and rapid permeability with low inherent runoff potential; hydrological soil group B/C demonstrates a moderate infiltration rate and slightly restricted permeability with a moderate inherent runoff potential: and hydrological soil group C demonstrates a slow infiltration rate and a restricted permeability with moderately high inherent runoff potential (Schultze *et al*., 1992).

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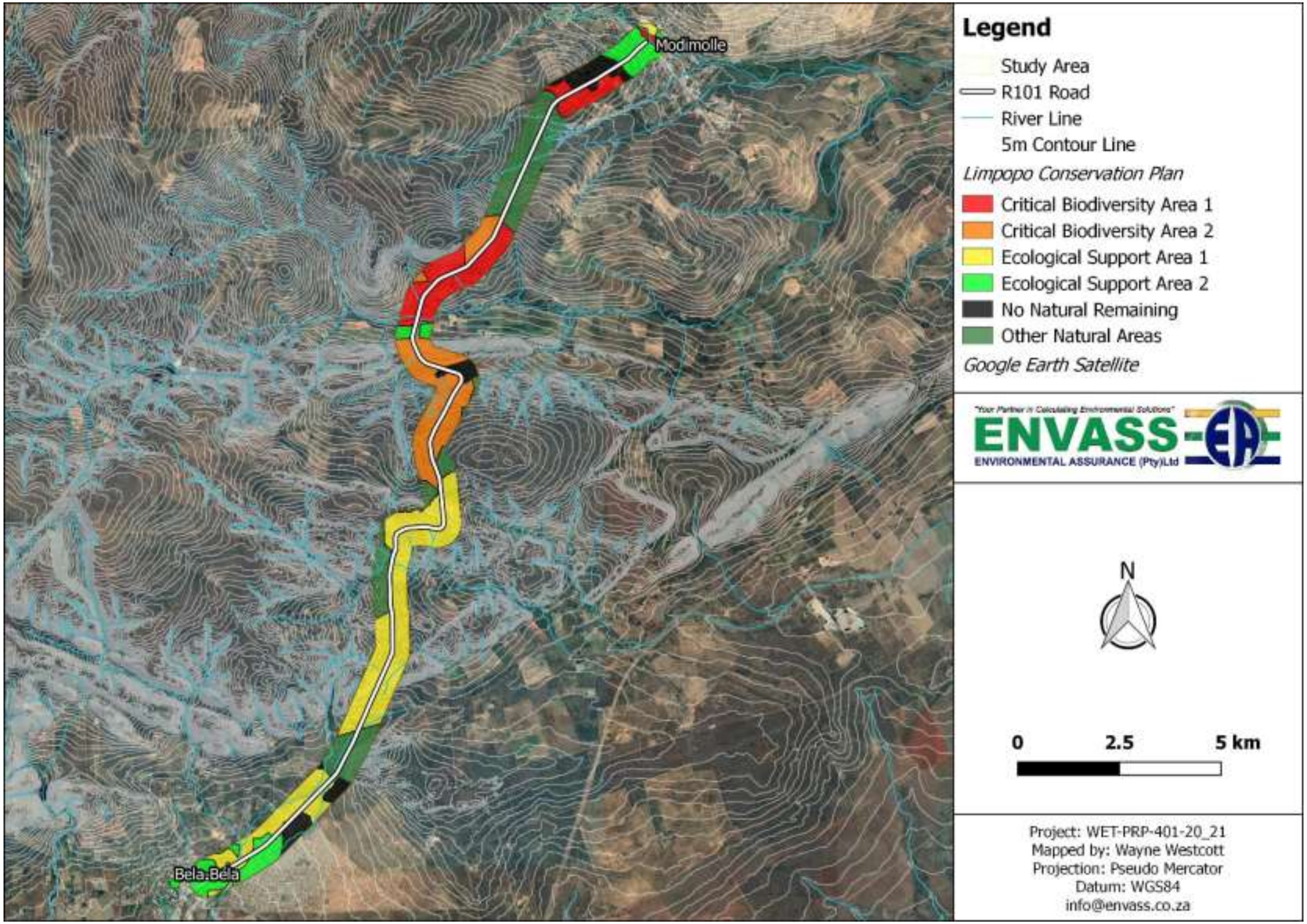

Figure 8: Systematic Conservation Planning units that were determined to be situated within the study area (LCPv2, 2013).

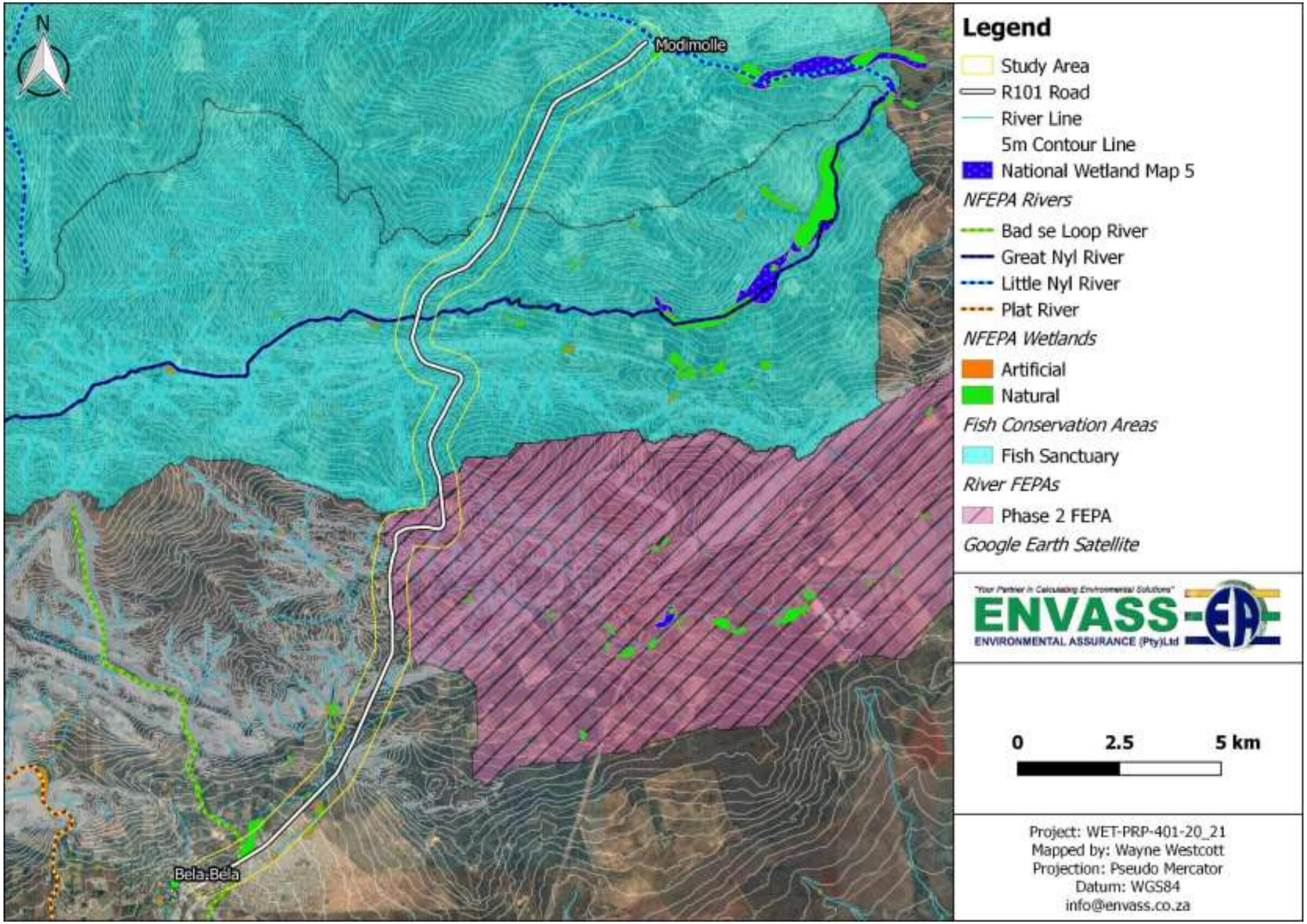

Figure 9: Illustration of the NFEPA and NWM5 systems that were recorded within and around the study area (Driver *et al.*, 2011 and SANBI, 2018).

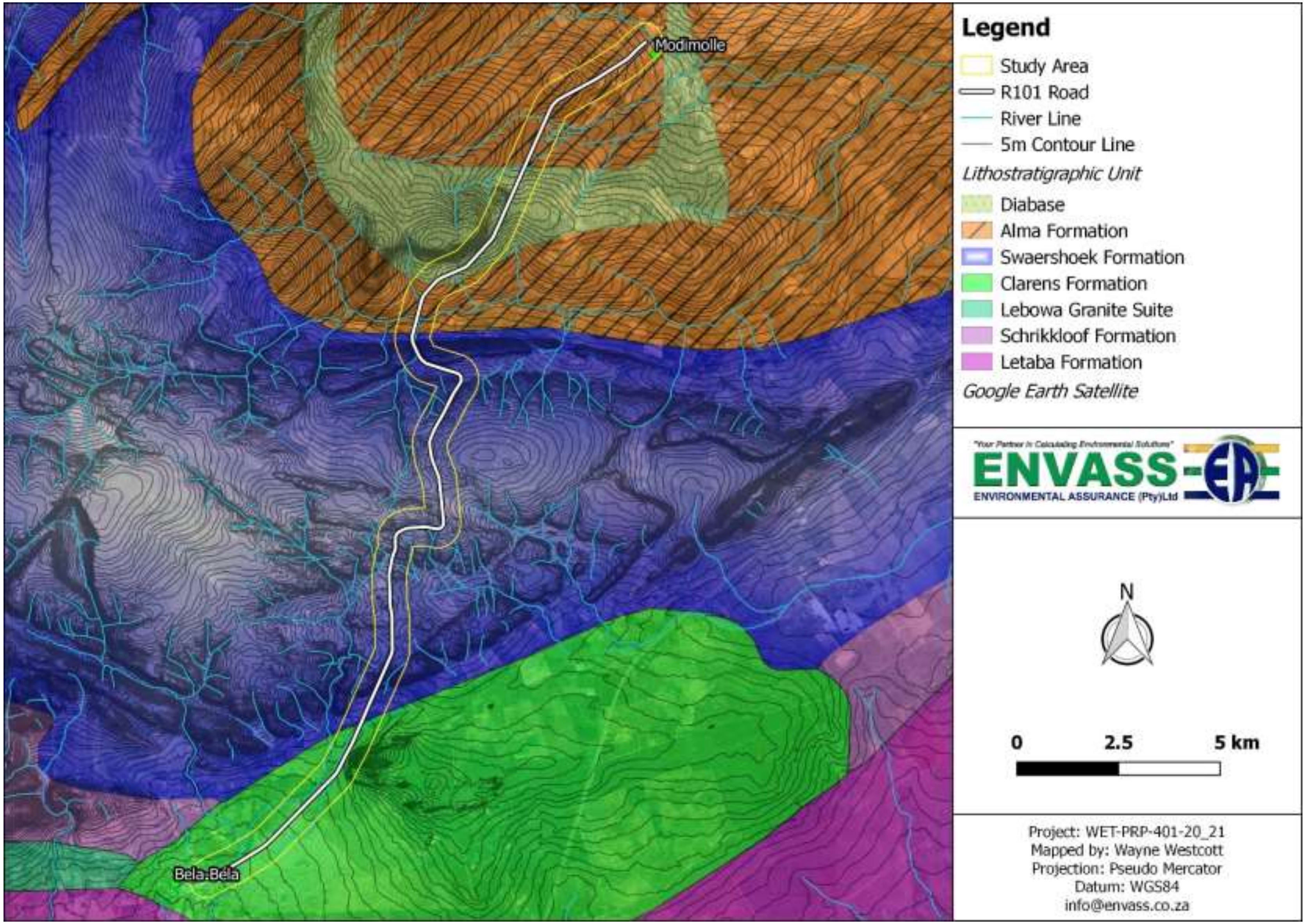

Figure 10: Geology recorded in the study area (Council for Geoscience, 2008).

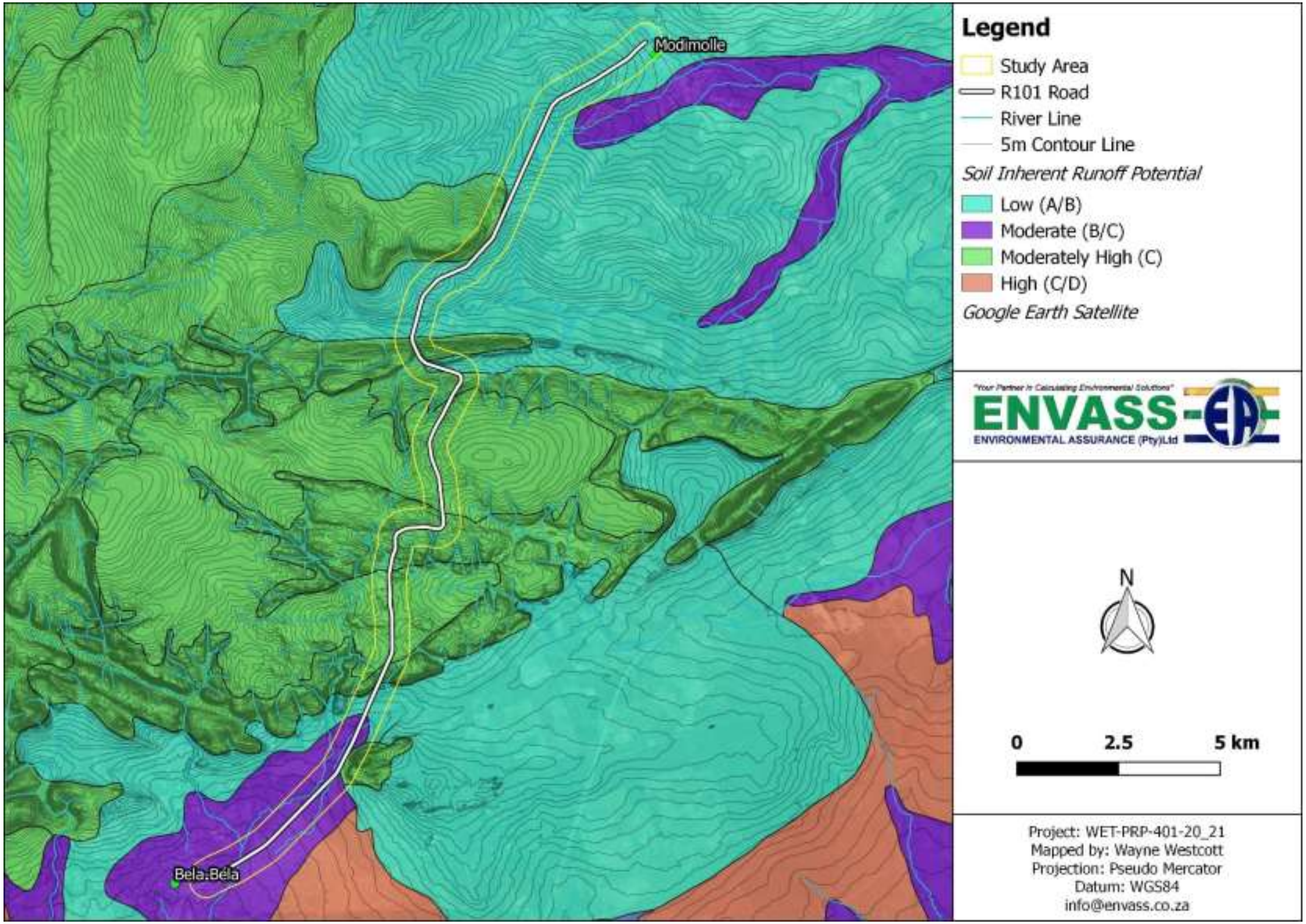

Figure 11: Soils recorded in the study area (Schultze *et al*., 1992).

6 RESULTS

The field survey associated with this study took place on the 6th and 7th of May 2021. This section provides the findings subsequent to the implementation of the various methodologies/tools utilised during this assessment.

6.1 Delineation and Classification of Watercourses

6.1.1 Wetness Indicators

All at-risk watercourses within the study area were delineated on-site utilising the wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2008). The following sections provide descriptions of the wetness indictors that were recorded during the field survey associated with site. It must be noted that both wetland and riverine systems were at-risk of being impacted on by the proposed development.

6.1.1.1 Terrain Unit Indicator

Figure 12 below illustrates the overall topography of the study area from a south to north direction, with the highest point being within the mid-reaches (Google Earth™, 2021). This illustration presents the potential terrain units in which watercourses (wetland and rivers) may develop, and was used to classify the delineated systems according to Ollis *et al.* (2013). The average slope gradient along the proposed development, from highest to lowest point within the study area, was calculated to be approximately 2.3 %; -2.5 % (Google Earth™, 2021).

The central portion of the proposed development traverses incised river valleys which are associated with sandstone slopes, and the southern portion traverses a shallow valley subtended by sandstone. The flat, gently sloping floors and hillsides associated with these valleys together with underlying sedimentary lithostratigraphy features provide for good wetland forming conditions.

The riverine systems are located within shallow valleys on steep sandstone slopes which are traversed by the northern portion of the proposed development as well as within shallow valleys on the more gentle slopes associated with the northern portion of the proposed development.

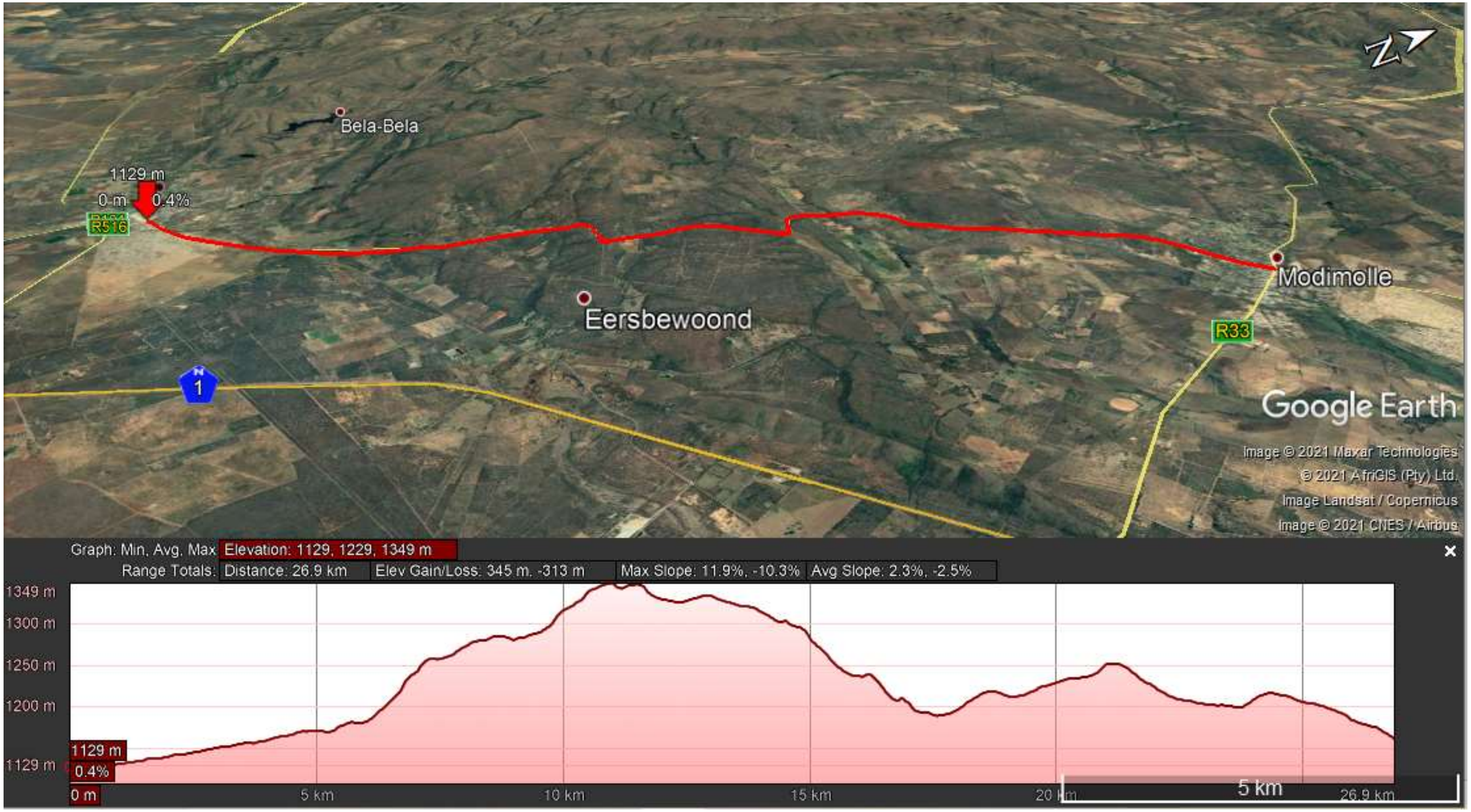

Figure 12: Topographic illustration of the proposed development from Bela-Bela in the south to Modimolle in the North (Google Earth, 2021).

6.1.1.2 Soil Wetness Indicator

In practice, the soil wetness indicator is used as the primary indicator of the presence of hydric soils, and thus a wetland (DWAF, 2008). Various colour components of the soil profile provide evidence of hydric soils, which can be defined as soils that undergo repeated and prolonged period of saturation (DWAF, 2008). These components include the presence of mottling (i.e. brightly coloured streaky, or specks of iron compounds), a gleyed soil matrix (i.e. grey coloured soil) and iron or manganese concretions. It must be noted that the hydromorphic soils must exhibit signs of wetness within the top 50 centimetres (cm) of the soil profile to be classified as a wetland. These soil wetness indicators were utilised on-site to determine whether there may have been wetlands within the study area. **Table 19** below presents the various soil wetness indicators, as well as the Munsell Soil Chart values recorded within the three wetness zones of the watercourses surveyed within the study area.

Table 19: Presentation of the soil wetness indicators recorded within each zone of wetness of the watercourses delineated within the study area, as well as an image and Munsell Colour Chart description of example soil samples.

WETNESS ZONE	WETNESS INDICATORS	SOIL TEXTURE	MATRIX MUNSELL COLOUR CHART VALUES		IMAGE
			0-10CM	40-50CM	
Permanent	- Prominent gleyed matrix - Few to no mottles present - Wetness throughout the year	Clay loam	Hue: 10YR Value: 3 Chroma: 1	Hue: 10YR Value: 3 Chroma: 1	
Seasonal	- >10% of matrix gleyed - High abundance of mottles - Frequently saturated	Clay loam	Hue: 10YR Value: 4 Chroma: 1-2	Hue: 10YR Value: 4 Chroma: 1-2	

WETNESS ZONE	WETNESS INDICATORS	SOIL TEXTURE	MATRIX MUNSELL COLOUR CHART VALUES		IMAGE
			0-10CM	40-50CM	
Temporary	- <10% of matrix gleyed - Moderate to low abundance of mottles - Saturated less then 3months per annum	Sandy Loam	Hue: 10YR Value: 5 Chroma: 1-3	Hue: 10YR Value: 5 Chroma: 1-2	
Terrestrial	Does not exhibit any signs of wetness	Sandy	Hue: 10YR Value: 5-6 Chroma: >3	Hue: 10YR Value: 5-6 Chroma: >3	

6.1.1.3 Vegetation Indicator

Although the majority of vegetation encountered within the proposed development footprint during the site survey was observed to have been moderately-to-highly degraded in comparison to the natural state, the floral species composition observed provided a useful guide to finding the outer boundary of the watercourses. As the zone of wetness within a watercourse changes, so too does the species composition of the floral community. This provides a very helpful guide to distinguishing the potential wetness zone boundaries. It must be noted that the riverine systems within the study area contained few hydrophytes[2], and thus these delineations were primarily based on landscape position, topography, alluvial soil, deposited material and riparian vegetation (where present). **Tables 20** and **21** below present the definitions of the

[2] Hydrophyte: Plant species that are adapted to living in soils that are either periodically, or permanently saturated/inundated and hence are adapted to anoxic conditions.

various vegetation classifications used for hydrophilic plant species and the wetness zones these species are typically recorded in.

Table 20: Relationship between wetness zones and vegetation types (Adapted from DWAF, 2008).

VEGETATION CLASS	WETNESS ZONE		
	TEMPORARY	SEASONAL	PERMANENT
Herbaceous	Predominantly grass species. A mixture of species, which occur extensively in the terrestrial zone, as well as hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic sedge and grass species, which are restricted to wetland areas.	Dominated by: 1) Emergent plants, including reeds, a mixture of sedges and bulrushes that are usually >1 m tall, or 2) Floating or submerged aquatic plants.
Woody	Mixture of woody species, which occur extensively in the terrestrial zone, as well as hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species, which are restricted to wetland areas.	Hydrophilic woody species, which hare restricted to wetland areas. Morphological adaptions to prolonged wetness (e.g. prop roots).

Table 21: Classification of plant species according to occurrence in wetland systems (Adapted from DWAF, 2008).

PLANT SPECIES TYPE	DESCRIPTION
Obligate wetland (ow) species	Almost always grow in wetlands (>99% occurrence).
Facultative wetland (fw) species	Usually grow in wetlands (67 – 99% occurrence), but occasionally found in non-wetland areas.
Facultative (f) species	Are equally likely to grow in wetlands and non-wetland areas (34 – 66% occurrence).
Facultative dry-land (fd) species	Usually grow in non-wetland areas, but sometimes grow in wetlands (1 – 34% occurrence).

Table 22 below presents the plant species that were recorded within the different wetness zones that were delineated within the study area relative to this project. These species were observed to be dominant, and thus were considered strong indicators of hydric conditions within the at-risk watercourses.

Table 22: Various plant hydrophilic plant species that were identified within the wetness zones delineated within the study area.

WETNESS ZONE	PLANT SPECIES	PLANT SPECIES TYPE
Permanent	1. *Phragmites australis* 2. *Cyperus spp.* 3. *Juncus sp* 4. *Persicaria lapathifolia* 3. *Thelypteris sp.*	1. Graminoid, ow 2. Graminoid fw 3. Graminoid, ow 4. Herbaceous, ow 5. Fern, fw
Seasonal	1. *Phragmites australis* 2. *Juncus* sp. 3. *Cyperus spp.* 4. *Paspalum urvillei* 5. *Thelypteris sp.*	1. Graminoid, ow 2. Graminoid, ow 3. Graminoid, fw 4. Graminoid, ow 5. Herbaceous, ow
Temporary	1. *Cynodon dactylon* 2. *Themeda triandra*	1. Graminoid, fw 2. Graminoid, fw
Riparian	1. *Jacaranda mimosifolia* (Rip01) 2. *Melia azadarach* (Rip01) 3. *Salix babylonica* (Rip01) 4. *Philenoptera violaceae* 5. *Combretum molle* 6. *Searsia* sp.	1. Woody (Alien) 2. Woody (Alien) 3. Woody (Alien) 4. Woody 5. Woody 6. Woody

6.1.2 Watercourse Delineation Map

The watercourses within the study area were identified on a desktop level, classified and delineated in-field and subsequently mapped utilising GIS (QGIS 2.18 and Google™ Earth Pro) and available spatial data (**Figure 13**). For ease of reference the study area was broken up into sections and presented in **Figures 13** to **17**, with **Figure 13** presenting the overall project delineation map.

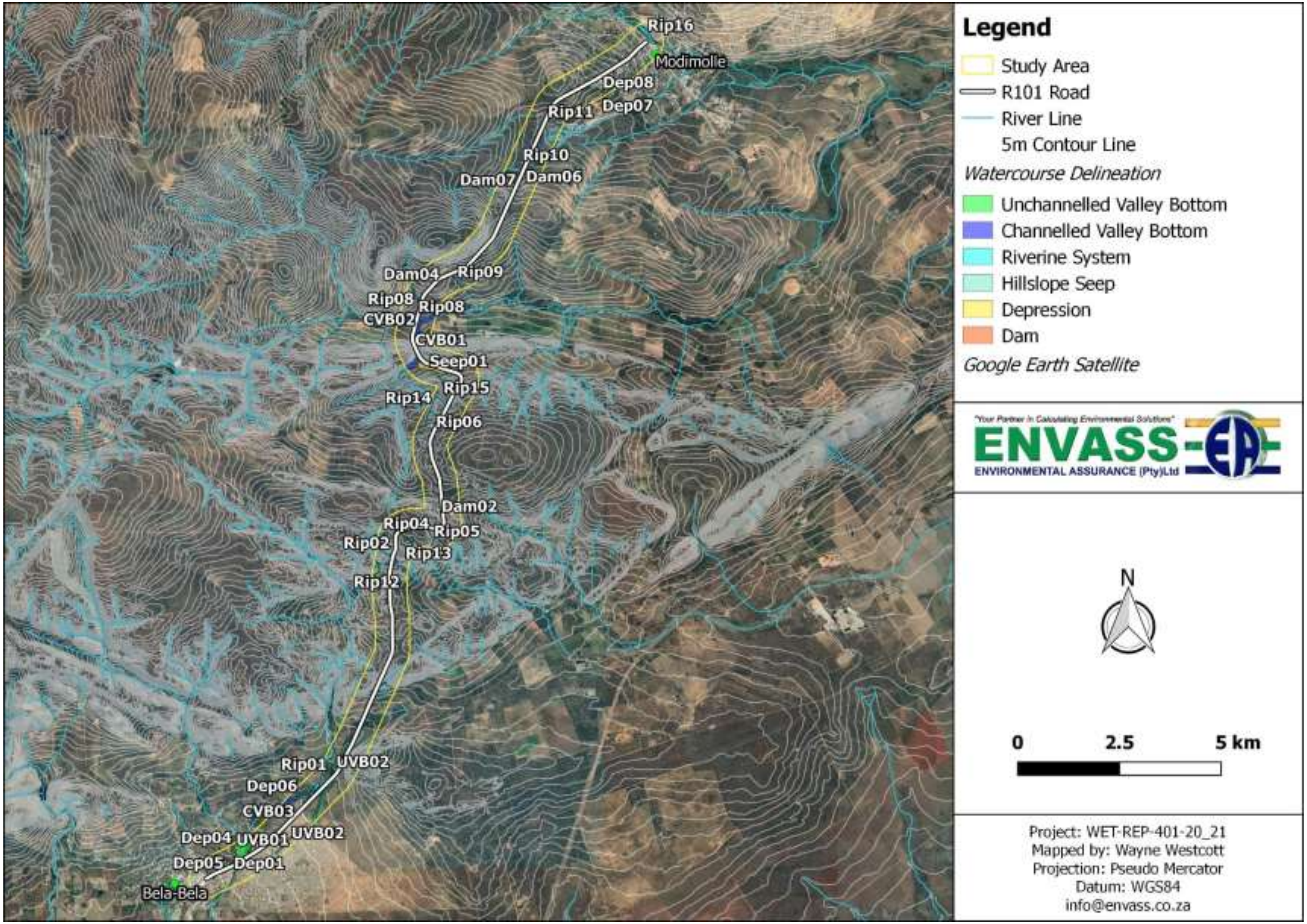

Figure 13: Map illustrating the watercourses delineated within the study area associated with the site.

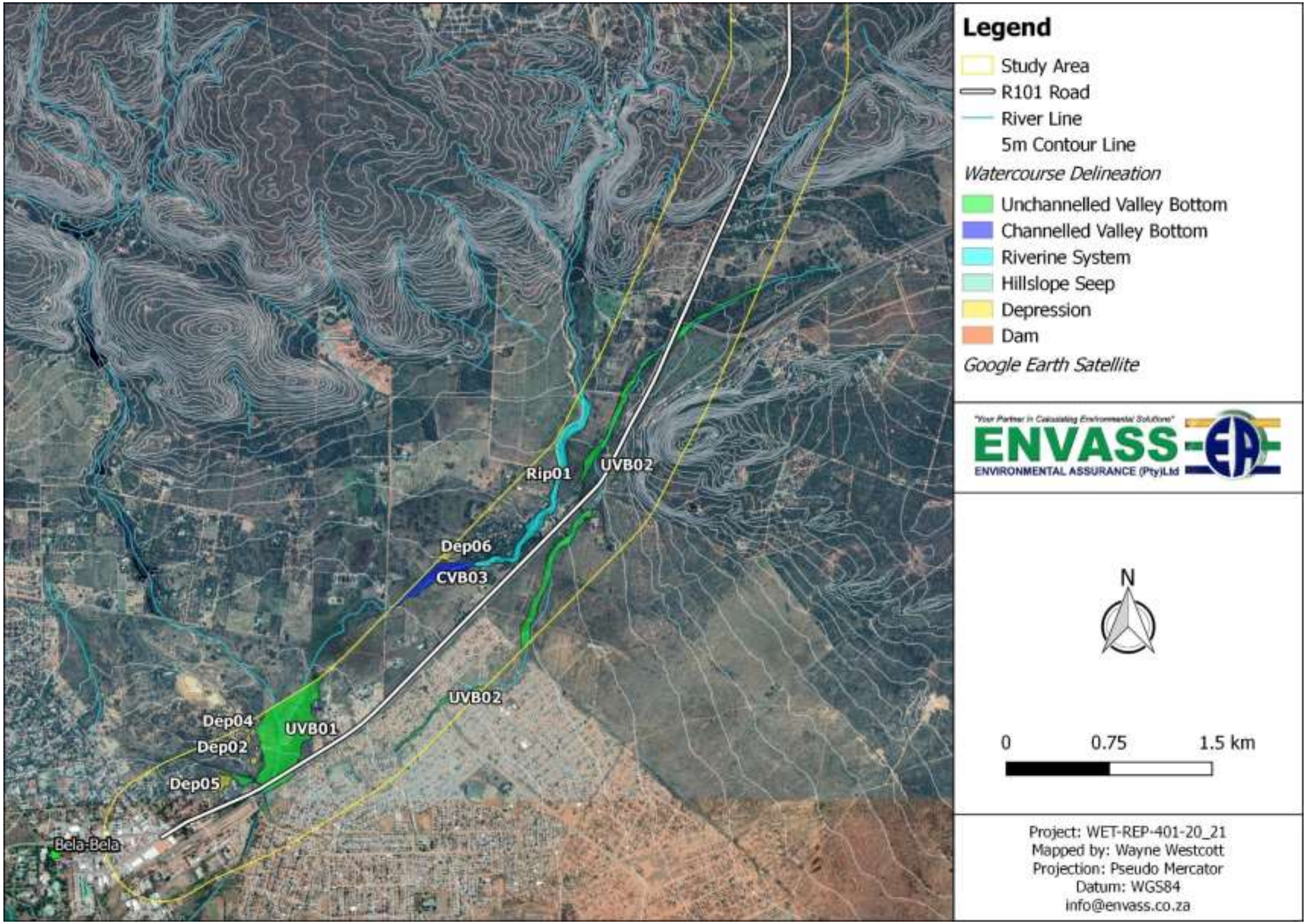

Figure 14: Map illustrating the delineated watercourses within the southern portion of the study area near Bela-Bela.

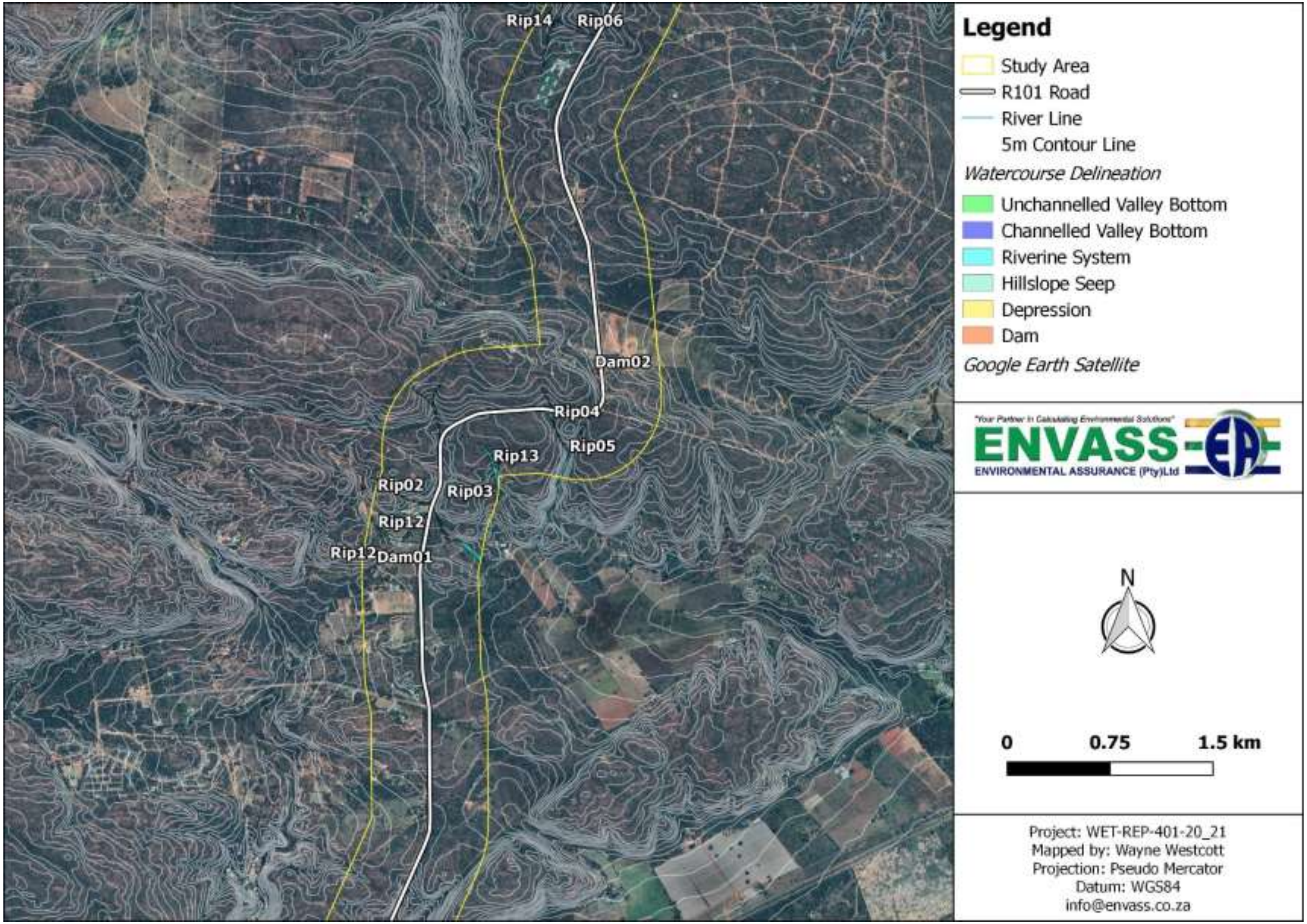

Figure 15: Map illustrating the delineated watercourses within the middle portion of the study area.

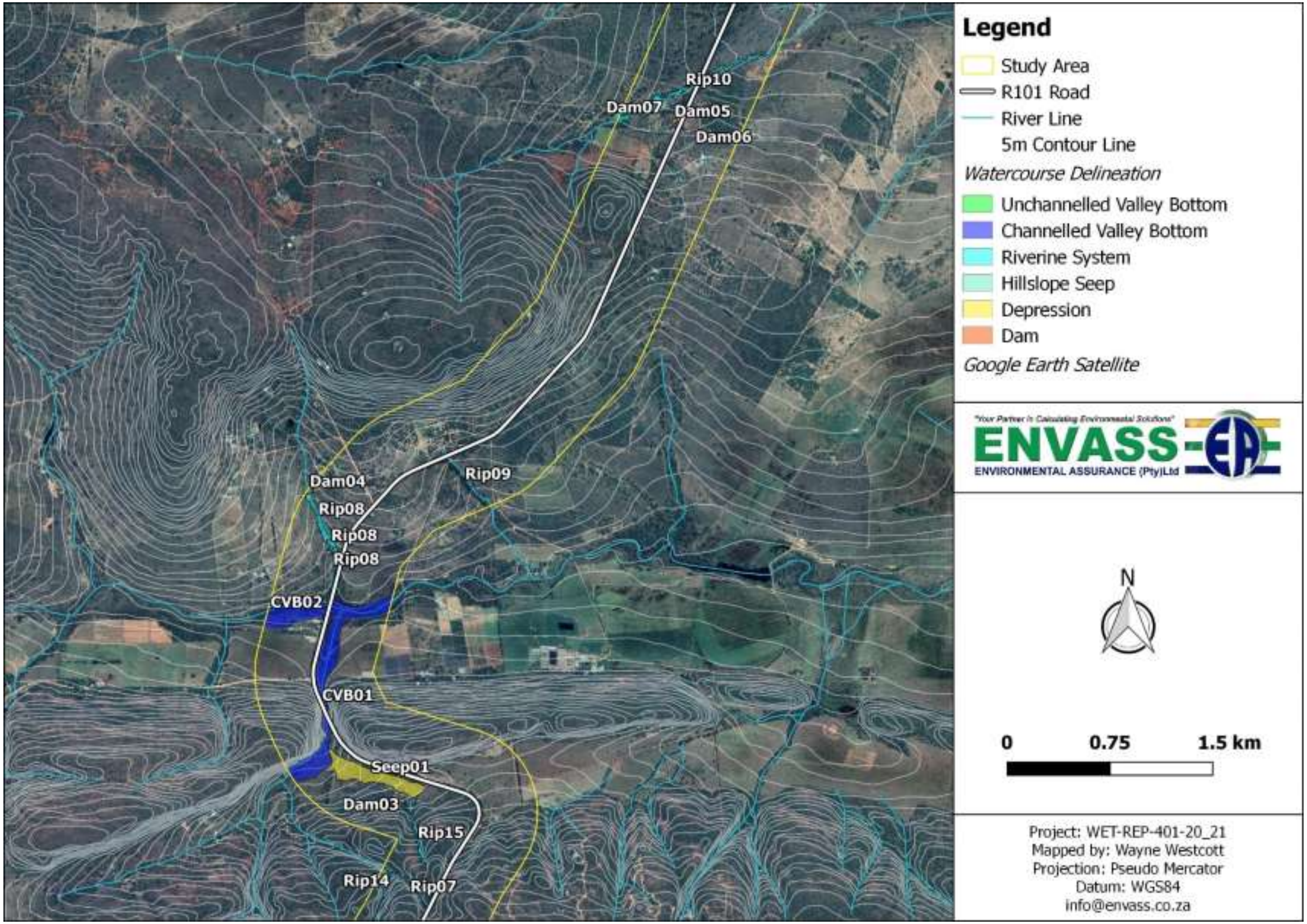

Figure 16: Illustration of the watercourses delineated within the middle portion of the study area near the Groot Nyl.

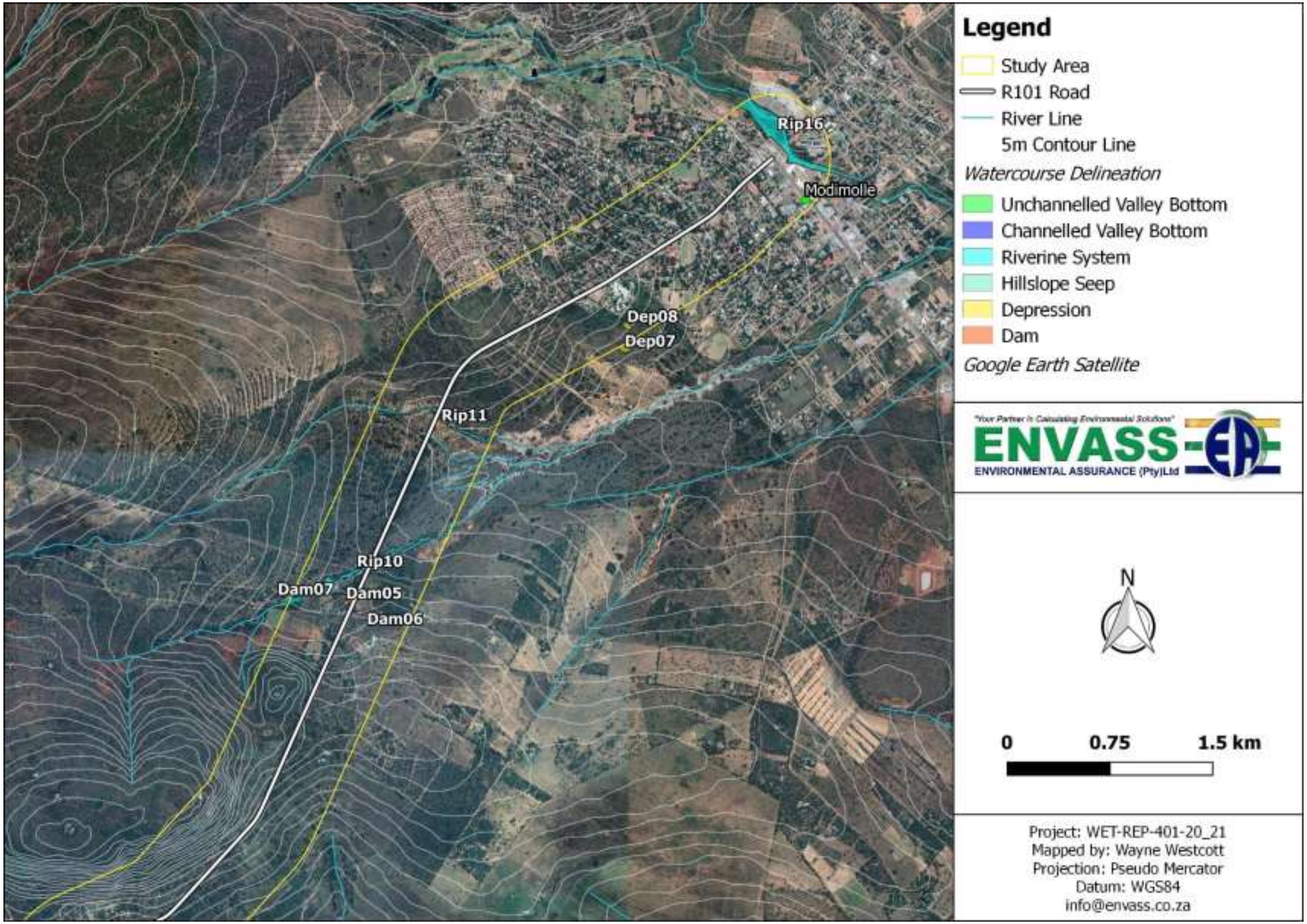

Figure 17: Illustration of the watercourses delineated within the northern portion of the study area near Modimolle.

6.1.3 Watercourse Classification

To allow for in-depth system-specific analysis to occur within this study, the various watercourses that were delineated within the study area were classified in accordance with the Classification System for Wetlands and other Aquatic Ecosystems in South Africa (Ollis *et al*., 2013). The classification system uses six tiers to differentiate between each system at a fine scale, namely: level 1- broadest spatial scale (marine, estuarine or inland systems), level 2- regional setting (i.e. NFEPA WetVeg unit), level 3- landscape unit, level 4- Hydrogeomorphic (HGM) unit, level 5- hydrological regime and level 6- descriptors (Ollis *et al*., 2013). For the purpose of this study the watercourses were classified to level 5, however descriptions of their hydrological regimes and other characteristics are elaborated on in the sections to follow. It must be noted that as a result of all the systems within the study area being classified as inland at level 1, **Table 23** below begins at level 2.

Table 23: Presentation of the classification of each watercourse to level 5 of Ollis *et al.* (2013).

No	LEVEL 2: REGIONAL SETTING	LEVEL 3: LANDSCAPE UNIT	LEVEL 4: HGM UNIT			LEVEL 5: HYDROLOGICAL REGIME	
			A- HGM Unit	B- Longitudinal Zonation/Landform	C- Landform/ Inflow Drainage	A- Perenniality /Inundation	B- Non-perennial subgroups/Saturation
A	WetVeg: Central Bushveld Group 2 (VU)	Valley Floor	UVB	N/A	N/A	Intermittently inundated	Permanently saturated
B	WetVeg: Central Bushveld Group 2 (VU)	Valley Floor	UVB	N/A	N/A	Intermittently inundated	Intermittently saturated
C	WetVeg: Central Bushveld Group 1 (CR), Group 2 (VU) and	Valley Floor	CVB	N/A	N/A	Seasonally inundated	Permanently saturated

	Group 3 (EN)						
D	WetVeg: Central Bushveld Group 1 (CR)	Slope	HS	Without channelled outflow	N/A	Never inundated	Intermittently saturated
E	WetVeg: Central Bushveld Group 2 (CR) and Group 3 (EN)	Valley	RIV	Upper Foothill	Active Zone and Riparian Zone	Perennial	N/A
F	WetVeg: Central Bushveld Group 1 (CR) and Group 3 (EN)	Slope	RIV	Mountain Stream	Active Zone	Non-Perennial	Intermittent
G	WetVeg: Central Bushveld Group 3 (EN)	Slope	RIV	Transitional	Active Zone	Non-Perennial	Intermittent
H	WetVeg: Central Bushveld Group 3 (EN)	Valley	RIV	Upper foothills	Active Zone and Riparian Zone	Non-Perennial	Intermittent
I	WetVeg: Central Bushveld Group 1 (CR),	Valley floor and slope	DEP	Endorheic and dammed	Without channelled inflow and with channelled inflow	Seasonally inundated	Permanently saturated

	Group 2 (VU) and Group 3 (EN)						

KEY: CR- Critically Endangered, EN – Endangered, VU – Vulnerable, UVB – Unchannelled Valley Bottom, CVB – Channelled Valley Bottom, HS- Hillslope Seep, DEP – Depression / Dam and RIV- River/Stream.

Based on the classification system described in **Table 23** and the delineation map (**Figures 13**) above, **Table 24** below present the watercourses that were delineated within the study area and subsequently classified according to Ollis *et al.* (2013).

Table 24: Classification of the delineated watercourses according to Table 23.

CLASSIFICATION	HGM UNIT CODE
A	UVB01, UVB03
B	UVB02
C	CVB01, CVB02, CVB03
D	SEEP01
E	Rip01, Rip16
F	Rip02, Rip03, Rip04, Rip05, Rip06, Rip07, Rip12, Rip13, Rip14, Rip15
G	Rip08, Rip09
H	Rip10 and Rip11
I	Dep01-Dep08, Dam01 – Dam 07

6.1.4 At-risk Watercourses

Based on the in-field watercourse delineation and the activities associated with, as well as the location of the watercourses in relation to the proposed development the risk categories were determined for each HGM unit. There are several factors that must be considered in determining whether and to what degree a watercourse may be impacted on by activities associated with a specific site. These factors, among others, include: 1) Type of watercourse, 2) Position of the watercourse within the landscape in comparison to the proposed development and associated infrastructure, 3) Surface and sub-surface hydrological flow regime and 4) Other land-use practices within the minor catchment area. **Table 26** below presents the risk category that was determined for each HGM unit based on the criteria described in **Table 25**. Only the watercourses that were determined to be of medium-to-high risk of being impacted on by the proposed development were assessed further during this study using the legislated tools. Representative images of the at-risk watercourses which are discussed in the sections to follow are available in Appendix B.

Table 25: Presentation of the risk categories used to analyse the delineated watercourses within the study area.

RISK CATEGORY	CRITERIA
High	The watercourse is situated directly within or in close proximity to the proposed development footprint. Therefore, the aquatic habitat, biota present within, water quality of and/or the hydrological regime through the watercourse are highly likely to be impacted on by aspects of the proposed development.
Medium	The watercourse is situated directly upstream, or within a medium distance (32m to 50m) downstream of the proposed development within the same minor catchment area. This may result in the aquatic habitat, biota present within, water quality of and/or the hydrological regime through the watercourse being indirectly impacted on by aspects pertaining to the proposed development (e.g. sedimentation, pollution and/or a change in the hydrological characteristics of the system).
Low	The watercourse/wetland is situated a significant distance (>50m) upstream or downstream of the proposed development, or within a landscape that prevents any direct/indirect impacts that have been determined to originate from the activity from reaching it, and thus is not likely to be impacted on by the proposed development.

Table 26 below presents the risk screening results of this study area. Only those watercourses determined to be of medium or high risk of being impacted on by the proposed development will be assessed further within this assessment.

Table 26: The risk categories of each HGM unit and the extent (ha) of watercourse within the proposed development footprint.

HGM UNIT CODE	RISK RATING
UVB01 (Bad se Loop River), UVB02, CVB01 (Modderloop River), CVB02 (Groot Nyl River), SEEP01, Rip01, Rip02, Rip03, Rip04, Rip06, Rip07, Rip08, Rip09, Rip10, Rip11 (**Total = 15 watercourses**)	**High**
Rip05 (**Total = 1 watercourse**)	**Medium**
UVB03, CVB03, Rip12 – Rip16, Dep01 – Dep08, Dam01 – Dam 07 (**Total = 22 watercourses**)	**Low**

6.2 Wetland Systems: Present Ecological Score

The assessment of the condition or PES of the at risk HGM units is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of hydrophilic floral species. WET-Health works by comparing a wetland in its current state with a natural/reference condition (Macfarlane *et al*., 2009). For this reason, only natural watercourses delineated within the study area were assessed using this methodology, as artificial systems do not have a natural condition. The following section presents the current PES scores that were calculated for the at-risk wetland systems. These scores should be used as the baseline for all future studies within the study area.

6.2.1 Unchannelled Valley-bottom Wetlands

Definition: A valley-bottom wetland without a river channel running through it (Ollis *et al*., 2013). UVBs are characterised by their location within the valley floor, an absence of a distinct channel and the prevalence of diffuse flow (Ollis *et al*., 2013).

6.2.1.1 Current PES Score of UVB01

The key findings of the PES assessment for UVB01 are summarised below, and the results are presented in **Table 27** below:

- Dams within the catchment have reduced flows into the wetland.
- An increase in runoff from disturbed, historically excavated and urban areas within the catchment of the wetland has resulted in an increase in flood peaks into the wetland.
- The historical development of the R101 roadway through the wetland, the resultant impoundment of flow above the roadway and the canalisation of flow below the roadway has had a significant impact on the natural hydrology of the wetland.
- Pioneer and IAPS have encroached into disturbed areas adjacent to the existing R101 roadway.
- The northern portion of UVB01 has been significantly impacted as a result of excavation, presumably during historical mining activities.
- Alien trees have established within disturbed, excavated areas.
- Sediment has been deposited within the wetland from disturbed areas within the catchment.

6.2.1.2 Current PES Score of UVB02

The key findings of the PES assessment for UVB02 are summarised below, and the results are presented in **Table 27** below:

- The historical development of the R101 roadway and a railway line through UVB02 has had a significant impact on the natural hydrology of the wetland at the crossing area.
- Multiple access roads with small, insufficient culverts have been constructed through the wetland and are resulting in the impoundment of flow above the access roads and in the desiccation of wetland habitat below the access roads.
- Alien trees have encroached into the northern portion of the wetland.
- Sediment from gravel roads and disturbed areas within the catchment has been deposited within the wetland.

6.2.2 Channelled Valley-bottom Wetlands

Definition: A valley-bottom wetland with a river channel running through it (Ollis *et al*., 2013). CVB wetlands must be consider as wetland ecosystems that are distinct from, but sometimes associated with, the adjacent river channel itself (Ollis *et al*., 2013).

6.2.2.1 Current PES Score of CVB01

The key findings of the PES assessment for CVB01 are summarised below, and the results are presented in **Table 27** below:

- Small dams within the catchment are reducing flows into the wetland.
- The historical development of the R101 roadway through CVB01 has had an impact on the natural hydrology of the wetland at the crossing area. Flow confinement and impoundment have altered the natural through-flow of the system and resulted in deposition on the upstream side of the R101.
- A small instream dam located to the west of the R101 is resulting in the obstruction of flow through the wetland;
- The portion of the wetland located to the east of the R101 has been significantly encroached by alien and invasive *Eucalyptus* trees.
- Current and historical agricultural croplands within the catchment have altered the sediment balance within the system.

6.2.2.2 Current PES Score of CVB02

The key findings of the PES assessment for CVB02 are summarised below, and the results are presented in **Table 27** below:

- Dams within the catchment and the irrigation of commercial annual crops within the catchment has reduced flows into the wetland.
- The historical development of the R101 roadway through CVB01 has had an impact on the natural hydrology of the wetland at the crossing area. Flow confinement and impoundment have altered the natural through-flow of the system and resulted in deposition on the upstream side of the R101. The impoundment has cause large clumps of *Phragmites australis* and sand bars forming upstream.
- Wetland habitat located to the west of the R101 roadway has been significantly degraded as a result of historical cultivation activities.
- Wetland habitat has been significantly encroached by alien *Eucalytus* trees.

6.2.3 Hillslope Seepage Wetland

Definition: A wetland area located on gently to steeply sloping land and dominated by colluvial (i.e. gravity-driven), unidirectional movement of water and material downslope (Ollis *et al*., 2013). These wetlands are usually driven by subsurface flow inputs and interflow through-flow, which are characterised by their association with the underlying geological lithologies and topographic position.

6.2.3.1 Current PES Score

The key findings of the PES assessment for SEEP01 are summarised below, and the results are presented in **Table 27** below:

- An access road has been constructed through the upper reaches of the wetland and impedes flow through the wetland.
- An erosion gully has developed below an access road at the toe of the wetland.
- Alien *Eucalyptus* trees have encroached into small areas within the wetland.
- Wetland habitat appears to have been degraded as a result of historical agricultural activities.
- Areas of historic earthen material dumping and concrete debris were evident within the system.

Table 27: Presentation of the current Present Ecological Scores (PES) that were calculated for the at-risk wetland systems.

WET-HEALTH SCORES				
HGM UNIT	HYDROLOGY	GEOMORPHOLOGY	VEGETATION	**OVERALL SCORE**
UVB01	F →	C →	E →	**E**
UVB02	C →	C →	D →	**C**
CVB01	D →	B →	D →	**C**
CVB02	E →	C →	D →	**D**
SEEP01	C →	A →	D →	**C**

KEY: A- Natural, B- Largely Natural, C- Moderately modified, D- Largely modified, E- Seriously Modified, ↓: State is likely to deteriorate slightly over the next five (5) years, → State is likely to remain stable over the next 5 years (Macfarlane *et al.*, 2009).

6.3 Wetland Systems: Ecosystem Service Delivery and Functionality

Tables 28 below presents the functionality in terms of ESS that the wetlands have the potential to supply, or were recorded to provide to the surrounding natural and anthropogenic environments. Brief explanations of the most noteworthy results are provided below:

- All wetlands were calculated to be of an intermediate to high importance in terms of flood attenuation, stream flow regulation, sediment trapping and erosion control. The high vegetation cover associated with the wetlands reduces the erosive potential of flood waters by reducing the velocity of water moving through the wetlands. Furthermore, the roots of the vegetation binds and protects the soil from erosion. Sediment which enters into the wetlands with floodwaters from bare / degraded / cultivated areas within their catchments is also trapped and deposited within the wetlands.
- All wetlands have the potential to provide varying degrees of water quality enhancement benefits. However, UVB01 is located within an urban catchment area and CVB02 is located adjacent to and downstream of agricultural areas and these features therefore have the greatest opportunity in terms of the assimilation of contaminants which may enter into the features with runoff from their catchments.

- Water quality enhancement benefits supplied by CVB01, CVB02 and SEEP01 are considered to be of particular importance due to their locality upstream of the Nylsvley wetland, which is a Ramsar site of international significance.
- Although all wetlands have been degraded to varying degrees, they are located within Vulnerable and Critically Endangered wetland vegetation groups which increases their importance in terms of the maintenance of biodiversity.
- No known cultural significance is associated with the wetlands and the wetlands were observed to provide minimal education, tourism or recreational benefits.

Table 28: Presentation of the ecosystem services that the at-risk wetland systems were calculated to supply, or have the potential to supply to the surrounding environments.

WET-ECOSERVICES					
ECOSYSTEM GOODS AND SERVICES	UVB 01	UVB 02	CVB 01	CVB 02	SEEP 01
Flood attenuation	1.7	2.1	1.3	1.4	1.8
Streamflow regulation	2.7	1.8	2.7	2.5	2.3
Sediment trapping	2.3	2.0	1.5	2.0	1.4
Phosphate trapping	2.4	2.0	2.3	2.7	2.3
Nitrate removal	2.2	1.5	2.8	3.1	2.7
Toxicant removal	2.5	1.8	2.4	2.8	1.9
Erosion control	2.5	2.4	2.8	3.1	2.5
Carbon sequestration	2.7	1.7	2.7	2.7	1.7
Maintenance of biodiversity	1.2	1.6	1.7	1.4	2.0
Water supply for human use	1.1	0.5	1.8	2.3	0.6
Natural resources	0.6	0.4	0.0	0.8	0.6
Cultivated foods	0.6	0.4	0.0	0.0	0.0
Cultural significance	0.0	0.0	0.0	0.0	0.0
Tourism and recreation	1.0	0.3	0.9	1.0	0.6
Education and research	0.5	0.0	0.5	0.0	0.5

KEY: Dark Green= High, Light Green= Moderately High, Yellow= Intermediate, Orange= Moderately Low and Red= Low (Kotze *et al.*, 2007).

6.4 Wetland Systems: Ecological Importance and Sensitivity

The majority of the wetlands within the study area were determined to have been moderately to seriously degraded as a consequence of current and historic disturbance recorded in, and/or around their outer boundaries. However, UVB01 and UVB02 fall within the Vulnerable Central Bushveld (Group 2) wetland vegetation group and are located within an ESA (LCPv2). Furthermore, CVB01, CVB02 and SEEP01 fall within the Endangered Central Bushveld (Group 3) and Critically

Endangered Central Bushveld (Group 1) wetland vegetation groups, are located within a CBA (LCPv2), and form part of an important migratory corridor which connects upstream areas with the downstream Nylsvley Ramsar Site. All wetland features were therefore calculated to fall within a high ecological importance category with exception of UVB01 which has been seriously modified and which was calculated to fall within an intermediate ecological importance category.

The hydrological importance of these wetland systems must also be noted, as they provide valuable services to the aquatic environment and thus reduce the risk of impact to downstream watercourses with special mention of the Nylsvley Ramsar site, which is located approximately 10 km downstream of CVB01, CVB02 and SEEP01.

Considering the above, all wetlands are considered to be of a high overall EIS (**Table 29**).

Table 29: Presentation of the ecological importance and sensitivity that was calculated for the at-risk wetland systems within the study area.

WETLAND EIS					
ATTRIBUTE	**UVB 01**	**UVB 02**	**CVB 01**	**CVB 022**	**SEEP 01**
	Score	Score	Score	Score	Score
Ecological Importance	1.67	2.10	2.80	3.00	2.70
Functional/Hydrological Importance	2.37	1.91	2.29	2.53	2.07
Direct Benefits to Society	0.64	0.26	0.53	0.68	0.38
Overall Importance and Sensitivity	2.37	2.10	2.80	3.00	2.70

KEY: Dark Green= Very High (>3 and ≤4), Light Green= High (>2 and ≤3), Orange= Moderate (>1 and ≤2) and Red= Low/Marginal (>0 and ≤1) (Rountree, 2013).

6.5 Riverine Systems: Present Ecological State

At-risk riverine systems associated with the proposed development were assessed utilising the Rapid Index of Habitat Integrity (IHI) tool (Kleynhans, 1996, modified by the Department of Water and Forestry (DWAF), 2012). These scores formed the baseline condition of the assessed systems and provided input into the formulation of the system-specific mitigation measures pertaining to the impacts associated with the proposed development.

It must however be noted that this assessment only provides the condition of the assessed systems at a specific point in time and does not account for seasonal variation. Additionally, the PES assessment only applied to the portions of the riverine systems delineated in the vicinity of the proposed development and not the entire reach. Thus, the PES of the system proper may be different from that of the assessed portion. The assessment of the condition or PES of the habitats is based on an understanding of both catchment and on-site impacts and the impact that these aspects may have on system hydrology, geomorphology and the structure and composition of riverine ecosystem. The following sections will provide the general characteristics of the riverine systems followed by the PES scores calculated for the watercourses.

Due to the at-risk watercourses exhibiting flow conditions that were not conducive to the implementation of the SASS5 (Dickens & Graham, 2002) and IHAS (McMillan, 1998) the IHI PES scores were recorded as the baseline for the at-risk riverine systems.

6.5.1 Rip01

Table 30 below presents the general characteristics that were recorded within the Rip01 system.

Table 30: Presentation of the general characteristics of the Transitional longitudinal zonation systems.

AT RISK WATERCOURSE	RIP01
Longitudinal zone	Upper foothill
Flow Type	Perennial "C" Channel Stream
Hydrological Setting	Ecoregion: Bushveld Basin Quaternary catchment: A23G
Channel Dimensions	Macro-channel: 45 - 100 m, Active-channel: 1 - 5 m; Estimated depth in flow: 0.3-1.0 m
Wetland Vegetation Type	Central Bushveld (Group 2) (Vulnerable)
Average Longitudinal Gradient	0.6 %, -1.2 %
Instream Habitat	Shallow bedrock channel. Access roads through the assessed reach have impounded flow and resulted in the upstream ponding of surface water. Shallow pools have been encroached by alien hydrophytes such as *Pistia stratiotes* (Water lettuce).
Riparian Habitat	Dominated by alien and invasive tree species such as *Jacaranda mimosifolia* (Blue Jacaranda), *Melia azedarach* (Syringa) and *Salix* sp. (Willow).

Table 31 below presents the PES result calculated for Rip01 using the IHI assessment tool (Kleynhans *et al*., 2012). The instream and riparian zone PES scores were calculated to be 58.76 % and 72.80 %, respectively, which fall within the Class D (Largely modified) and Class C (Moderately modified) PES score categories, respectively.

The primary factors that were recorded to have influenced the natural state of this system included:

- The development of access roads through the watercourse and the consequent loss of riparian habitat, alteration of the bed and banks of the watercourse and impoundment of flow upstream of the access roads.
- The proliferation of exotic hydrophytes within artificially created pools upstream of access road crossings.

- The removal of indigenous vegetation and the subsequent encroachment of alien and invasive trees into the riparian area.
- The historic infilling of sections of the riparian habitat as a result of existing R101 road.

Table 31: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for the Rip01.

RIP01			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	10	14	5.6
Flow modification	15	13	7.8
Bed modification	10	13	5.2
Channel modification	12	13	6.24
Water quality	5	14	2.8
Inundation	16	10	6.4
Exotic macrophytes	20	9	7.2
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**58.76 % (Class D)**
RIPARIAN ZONE			
Indigenous vegetation removal	10	13	5.2
Exotic vegetation encroachment	20	12	9.6
Bank erosion	5	14	2.8
Channel modification	5	12	2.4
Water abstraction	0	13	0
Inundation	5	11	2.2
Flow modification	5	12	2.4
Water quality	5	13	2.6
		TOTAL RIPARIAN IHI	**72.80 % (Class C)**

6.5.2 Rip02 – Rip07

Table 32 below presents the general characteristics that were recorded within Rip02 – Rip07.

Table 32: Presentation of the characteristics associated with Rip02 – Rip07.

AT RISK WATERCOURSE	RIP02-RIP07
Longitudinal zone	Mountain stream
Flow Type	Non-perennial "A" Channel Stream
Hydrological Setting	Ecoregion: Western Bankenveld Quaternary catchment: A23G, A61A and A61C
Channel Dimensions	Macro-channel: 5 - 11 m, Active-channel: 1 -2 m; Estimated depth in flow: 0.1-0.4 m
Wetland Vegetation Type	Central Bushveld (Group 1) (Critically Endangered) – Rip02 - Rip05 Central Bushveld (Group 3) (Endangered) – Rip06 - Rip07
Average Longitudinal Gradient	Rip02 – 3.1%, -5.3 % Rip03 – -%, -7.9 % Rip04 – 0.4%, -6.5 % Rip05 – 0.4%, -8.0 % Rip06 – 4.8%, -% Rip07 – -%, -7.3%
Instream Habitat	Poorly defined, shallow channels devoid of vegetation aside from ruderal weeds and scattered grass species. The channel bed is characterised by exposed sandstone bedrock and coarse sediment wash. Only likely to carry stormwater runoff during heavy rainfall events.
Riparian Habitat	No clearly defined riparian habitat present.

Table 33 and **Table 34** below presents the PES scores calculated for Rip02 – Rip07 using the IHI assessment tool (Kleynhans *et al*., 2012). Rip03-Rip07 are characterised by similar morphologies and hydrological regimes and are located within catchment areas that contained similar land-use practices and these features were therefore considered in a single IHI assessment. Due to a lack of riparian habitat, the riparian habitat module of the IHI could not be applied to these riverine systems, and to some degree aspects assessed as part of the instream assessment would not be entirely applicable either. However, to obtain an estimated PES category for these watercourses, the IHIA instream module was applied.

The instream zone PES score for Rip02 was calculated to be 77.52 % which falls within the Class C (Moderately modified) PES score category. The primary factors that were recorded to have influenced the natural state of this system included:

- The bed and banks of the watercourse have been altered as a result of the historical development of the R101 through the system and the channelling of flow through a culvert below the road.
- The bed and banks of the watercourse have also been altered as a result of the development of lodge infrastructure on the banks of the watercourse.

- The increase in stormwater runoff from hardened surfaces associated with the lodge likely results in increased flow velocities through the channel after heavy rainfall events.

The instream zone PES score for Rip03 - Rip07 was calculated to be 94.20 % which falls within the Class A (Unmodified, natural) PES score category. The primary factors that were recorded to have influenced the natural state of this system included:

- The most noteworthy impact observed was the limited alteration of the bed, banks and flow patterns through the watercourses as a consequence of the historical development of the R101 through / upstream of the watercourses.

Table 33: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip02.

RIP02			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	0	14	0
Flow modification	12	13	6.24
Bed modification	14	13	7.28
Channel modification	14	13	7.28
Water quality	3	14	1.68
Inundation	0	10	0
Exotic macrophytes	0	9	0
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**77.52 % (Class C)**

Table 34: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip03-Rip07.

Rip03 - Rip07			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	0	14	0
Flow modification	3	13	1.56
Bed modification	3	13	1.56
Channel modification	3	13	1.56
Water quality	2	14	1.12
Inundation	0	10	0
Exotic macrophytes	0	9	0

Rip03 - Rip07			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**94. 2 % (Class A)**

6.5.3 Rip08

Table 35 below presents the general characteristics that were recorded within Rip08.

Table 35: Presentation of the characteristics associated with Rip08.

AT RISK WATERCOURSE	RIP08
Longitudinal zone	Transitional
Flow Type	Non-perennial "A" Channel Stream
Hydrological Setting	Ecoregion: Western Bankenveld Quaternary catchment: A61A
Channel Dimensions	Macro-channel: 5 - 11 m, Active-channel: 1 -4 m; Estimated depth in flow: 0.1-0.4 m
Wetland Vegetation Type	Central Bushveld (Group 3) (Endangered)
Average Longitudinal Gradient	-% 2.0, -2.7 %
Instream Habitat	Shallow channel containing coarse, sandy substrate. Significantly encroached by *Eucalyptus* saplings Only likely to carry stormwater runoff during heavy rainfall events.
Riparian Habitat	No clearly defined riparian habitat present.

Table 36 below presents the PES scores calculated for Rip08 using the IHI assessment tool (Kleynhans *et al*., 2012). Due to a lack of riparian habitat, the riparian habitat module of the IHIA could not be applied to Rip08, and to some degree aspects assessed as part of the instream assessment would not be entirely applicable either. However, to obtain an estimated PES category for these watercourses, the IHIA instream module was applied.

The instream zone PES score for Rip08 was calculated to be 69.20 % which falls within the Class C (Moderately modified) PES score category. The primary factors that were recorded to have influenced the natural state of this system included:

- Small instream dams impede flows through the system and abstraction from dams likely reduces overall flows through the system.
- The channel of Rip08 has been significantly encroached by alien and invasive *Eucalyptus* trees. An effort has been made to fell trees but small saplings are re-emerging within the channel.

- Small access roads traversing the channel have resulted in the alteration of the channel bed and banks at crossing points.

Table 36: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip08.

RIP08			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	16	14	8.96
Flow modification	16	13	8.32
Bed modification	10	13	5.2
Channel modification	10	13	5.2
Water quality	2	14	1.12
Inundation	5	10	2
Exotic macrophytes	0	9	0
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**69.2 % (Class C)**

6.5.4 Rip09

Table 37 below presents the general characteristics that were recorded within Rip09.

Table 37: Presentation of the characteristics associated with Rip09.

AT RISK WATERCOURSE	RIP09
Longitudinal zone	Transitional
Flow Type	Non-perennial "A" Channel Stream
Hydrological Setting	Ecoregion: Western Bankenveld Quaternary catchment: A61A
Channel Dimensions	Macro-channel: 5 - 11 m, Active-channel: 1 -4 m; Estimated depth in flow: 0.1-0.4 m
Wetland Vegetation Type	Central Bushveld (Group 3) (Endangered)
Average Longitudinal Gradient	-% 1.0, -3.2 %
Instream Habitat	Shallow channel containing coarse, sandy substrate. Only likely to carry stormwater runoff during heavy rainfall events.

AT RISK WATERCOURSE	RIP09
Riparian Habitat	Poorly defied riparian habitat dominated by medium sized woody indigenous trees such as *Combretum molle* (Velvet Bushwill), *Searsia* sp. and *Philenoptera violaceae* (Appelblaar).

Table 38 below presents the PES scores calculated for Rip09 using the IHI assessment tool (Kleynhans *et al*., 2012). The instream and riparian zone PES scores were calculated to be 87.96 % and 91.76 %, respectively, which fall within the Class B (Largely natural) and Class A (Unmodified, natural) PES score categories, respectively.

The primary factors that were recorded to have influenced the natural state of this system included:

- The historical development of the R101 and a small access road through Rip09 has resulted in a small alteration of the bed, banks and flow patterns through the watercourse.
- A small dam has been developed within the watercourse and is resulting in the impoundment of flows through the system.

Table 38: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip09.

RIP09			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	0	14	0
Flow modification	11	13	5.72
Bed modification	5	13	2.6
Channel modification	5	13	2.6
Water quality	2	14	1.12
Inundation	0	10	0
Exotic macrophytes	0	9	0
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**87.96 % (Class B)**
RIPARIAN ZONE			
Indigenous vegetation removal	3	13	1.56
Exotic vegetation encroachment	0	12	0
Bank erosion	2	14	1.12
Channel modification	5	12	2.4

RIP09			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
Water abstraction	0	13	0
Inundation	5	11	2.2
Flow modification	2	12	0.96
Water quality	0	13	0
		TOTAL RIPARIAN IHI	**91.76 % (Class A)**

6.5.5 Rip10 and Rip11

Table 39 below presents the general characteristics that were recorded within Rip10 and Rip11.

Table 39: Presentation of the characteristics associated with Rip10 and 11.

AT RISK WATERCOURSE	RIP10 and RIP11
Longitudinal zone	Upper foothill
Flow Type	Non-perennial "A" Channel Stream
Hydrological Setting	Ecoregion: Western Bankenveld Quaternary catchment: A61A
Channel Dimensions	Macro-channel: 5 - 20 m, Active-channel: 1 -4 m; Estimated depth in flow: 0.1-0.4 m
Wetland Vegetation Type	Central Bushveld (Group 3) (Endangered)
Average Longitudinal Gradient	Rip10: -%, -1.9 % Rip11: 0.3%, -1.6%
Instream Habitat	Poorly defined, shallow channels devoid of vegetation aside from ruderal weeds and scattered grass species. Sandy channel bed with isolated areas of exposed sandstone bedrock. Only likely to carry stormwater runoff during heavy rainfall events.
Riparian Habitat	Poorly defined riparian habitat dominated by medium sized woody indigenous trees such as *Combretum molle* (Velvet Bushwill), *Searsia* sp. and *Philenoptera violaceae* (Appelblaar).

Table 40 and **Table 41** below presents the PES scores calculated for Rip10 and Rip11 using the IHI assessment tool (Kleynhans *et al*., 2012).

The instream and riparian zone PES scores of Rip10 were calculated to be 90.04 % and 94.80 %, respectively, which fall within the Class A (Largely natural) PES score category. The primary factors that were recorded to have influenced the natural state of this system included:

- The historical development of the R101 and small access roads through Rip10 has resulted in a small alteration of the bed, banks and flow patterns through the watercourse.

The instream and riparian zone PES scores of Rip11 were calculated to be 70.28 % and 78.16 %, respectively, which fall within the Class C (Moderately modified) PES score category. The primary factors that were recorded to have influenced the natural state of this system included:

- The historical development of the R101 and small access roads through Rip11 has resulted in a small alteration of the bed, banks and flow patterns through the watercourse.
- An increase in runoff from bare, eroded areas in the catchment of Rip11 has resulted in an increase in flows through the system during flood events and in the erosion of the bed and banks of the watercourse.

Table 40: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip10.

RIP10			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	0	14	0
Flow modification	5	13	2.6
Bed modification	6	13	3.12
Channel modification	6	13	3.12
Water quality	2	14	1.12
Inundation	0	10	0
Exotic macrophytes	0	9	0
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**90.04 % (Class A)**
RIPARIAN ZONE			
Indigenous vegetation removal	10	13	5.2
Exotic vegetation encroachment	20	12	9.6
Bank erosion	5	14	2.8
Channel modification	5	12	2.4
Water abstraction	0	13	0
Inundation	5	11	2.2
Flow modification	5	12	2.4
Water quality	5	13	2.6

RIP10			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
		TOTAL RIPARIAN IHI	**94.8 % (Class A)**

Table 41: Presentation of the Index of Habitat Integrity (IHI) Assessment scores that were calculated for Rip11.

RIP11			
CRITERION	**IMPACT SCORE**	**WEIGHTING**	**IHI SCORE**
INSTREAM ZONE			
Water abstraction	0	14	0
Flow modification	15	13	7.8
Bed modification	20	13	10.4
Channel modification	20	13	10.4
Water quality	2	14	1.12
Inundation	0	10	0
Exotic macrophytes	0	9	0
Exotic fauna	0	8	0
Solid waste disposal	0	6	0
		TOTAL INSTREAM IHI	**70.28 % (Class C)**
RIPARIAN ZONE			
Indigenous vegetation removal	2	13	1.04
Exotic vegetation encroachment	0	12	0
Bank erosion	20	14	11.2
Channel modification	20	12	9.6
Water abstraction	0	13	0
Inundation	0	11	0
Flow modification	0	12	0
Water quality	0	13	0
		TOTAL RIPARIAN IHI	**78.16 % (Class C)**

6.6 Riverine Systems: Ecological Importance and Sensitivity

The EIS of freshwater habitats is an expression of the importance of the water resource for the maintenance of biological diversity and ecological functioning on local and wider scales, whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007).

Tables 42 below present the EIS scores that were calculated for the at-risk perennial Rip01 system, as well as the non-perennial riverine systems Rip02-Rip11.

The degraded, alien encroached riparian and instream habitat associated with Rip01 is unlikely to support any rare, endangered or unique species. Furthermore, the flow patterns associated with the reach assessed have already been subjected to significant alterations as a result of the impoundment of the system by access roads. However, the watercourse is a perennial system which is still likely to provide refugia for common indigenous aquatic species and provides a natural migratory corridor through the catchment area. Rip01 was therefore calculated to fall within a moderate EIS category.

Rip02-Rip11 are only likely to flow for short intervals of time after sufficient rainfall and are not associated with a diversity of habitat units such as riffles, runs or rapids. Furthermore, the lack of sufficient surface water flow is not conducive to the formation of a distinctive riparian zone in the majority of the features. The poor diversity of habitat units decreases the ability of the systems to support a high diversity of species or to provide refugia to aquatic biota. The poor diversity of habitat units also decreases the sensitivity of the features to flow changes and flow related water quality changes. Furthermore, the lack of flowing water for the majority of the year decreases the importance of the systems in terms of the provision of migration corridors for aquatic biota. Rip02 – Rip11 were therefore calculated to fall within a low EIS category.

Table 42: Presentation of the Ecological Importance and Sensitivity (EIS) results obtained for Rip01 and Rip02 – Rip11.

AT-RISK RIVERINE SYSTEMS		
DETERMINANTS	Rip01	Rip02 - Rip11
	SCORE	SCORE
BIOTA (RIPARIAN & INSTREAM)	(0-4)	(0-4)
Rare & endangered (range: 4=very high - 0 = none)	0	0
Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	0	0
Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	2	0
Species/taxon richness (range: 4=very high - 1=low/marginal)	1	1
RIPARIAN & INSTREAM HABITATS	(0-4)	(0-4)
Diversity of types (4=very high - 1=marginal/low)	2	1
Refugia (4=very high - 1=marginal/low)	2	1
Sensitivity to flow changes (4=very high - 1=marginal/low)	2	1
Sensitivity to flow related water quality changes (4=very high - 1=marginal/low)	2	1
Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	3	1
Importance of conservation & natural areas (range, 4=very high - 0=very low)	1	1
MEDIAN OF DETERMINANTS	**2.00 (Moderate EIS)**	**1.00 (Low EIS)**

6.7 Water Quality

Water quality is an ecosystem driver that has the ability to influence the ecosystem service delivery of a system by impacting (positively or negatively) on the aquatic habitat and biota (i.e. the ecosystem responses) within the system. Changes in the water quality of an aquatic system have the potential to drastically alter the integrity of an aquatic system as a whole, and thus must be closely monitored to ensure that any spikes, or drops in quality parameters are reported on. The specific changes in parameters can provide an indication of the surrounding land uses that may have impacted on the system, which enables the end-user to formulate site-specific mitigation and/or rehabilitation measures to remediate the adverse impact.

To assist with the interpretation of the biological information that was gathered during this assessment, several parameters, namely: pH, EC, TDS, DO (mg/l), DO (% saturation) and Temp (ºC), were recorded *in situ* on the field survey day using a calibrated hand-held Aquaread AP-800 probe. In addition to providing invaluable insight into the current onsite condition of the water quality, the data obtained was used as the baseline data associated with the R101 road upgrade. The TWQR limits for aquatic ecosystems (DWAF, 1996), as well as limits presented in literature were used as guidelines to the determine the water quality and the potential impact (if any) that the surrounding land-uses may have had on the watercourses.

Table 43 presents and described the sites along the proposed development where water quality was sampled *in situ*. **Table 44** below presents the results obtained during the May 2021 field survey. Only the DO (mg/l and %) were recorded to have been outside of the TWQR for aquatic ecosystems (DWAF, 1996). The results should be utilised as a baseline for the proposed development water quality monitoring that should be conducted weekly during the construction phase.

Table 43: Description of the five (5) water quality monitoring site within the study area.

SITE	LATITUDE	LONGITUDE	DESCRIPTION
GN01	24°45'40.75" S	28°21'0.67" E	At the R101 bridge-crossing over the Groot Nyl River.
GNT02	24°46'7.28" S	28°21'0.47" E	At the R101 bridge-crossing over a tributary of the Groot Nyl River.
BLT01	24°52'0.03" S	28°19'24.40" E	On a tributary of the Bad se Loop River adjacent to the R101.
BLT02	24°52'12.28" S	28°18'54.08 " E	On a tributary of the Bad se Loop River adjacent to the R101.
BL01	24°52'56.92" S	28°18'22.91" E	Downstream of the R101 on the Bad se Loop River.

Table 44: *In situ* water quality of the samples collected during the once-off field survey.

SAMPLE POINT	pH	EC mS/m	TDS (Mg/l)	DO (Mg/l)	DO (%)	TEMP (˚C)
TWQR	**6.5-9.0**	**<15∆**	**<15∆**	**>5.00**	**80-120**	**5-30**
JOHNSON (2008)	**-**	**< 154**	**1,000**	**-**	**-**	**-**
GN01	6.80	8.3	53	3.69	41.80	15.30
GNT02	7.32	6.4	41	4.45	50.40	15.50
BLT01	7.28	7.4	48	4.37	47.90	14.00
BLT02	7.30	8.6	55	4.52	52.90	17.20
BL01	7.30	23.6	153	3.88	45.60	17.30

KEY: Red indicates those readings outside of the relevant limits.

6.8 Recommended Management Objectives

The Recommended Management Objective (RMO) or Recommended Ecological Category (REC) for each of the HGM units was determined utilising the overall PES and EIS scores that were calculated for the at-risk wetland and riverine systems and interpreting them using **Table 45**. However, during the determination of the RMOs it is also important to take into consideration the feasibility/practicality of improving the PES of the HGM units based on the current development pressures as well as the catchment context.

The relevant RMOs of the at-risk watercourses are presented in **Table 46**. Although the RMO for all wetland features is to improve the overall PES, it is not considered feasible to do so in this scenario as the majority of the wetlands are located on private land or are expected to be impacted upon by ongoing anthropogenic activities which the proponent has no control over. It is however considered possible to maintain the PES of all the affected watercourses with the implementing of the mitigation and/or rehabilitation measures presented within this report and the project-specific Environmental Management Programme (EMPr).

Table 45: Interpretation of the recommended management objectives for wetland and river systems (DWAF, 2007)

			ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS)			
			Very High	**High**	**Moderate**	**Low**
PRESENT ECOLOGICAL	**A**	**Pristine**	A Maintain	A Maintain	A Maintain	A Maintain
	B	**Natural**	A Improve	A/B	B	B

			ECOLOGICAL IMPORTANCE AND SENSITIVITY (EIS)			
			Very High	**High**	**Moderate**	**Low**
				Improve	Maintain	Maintain
	C	**Good**	B Improve	B/C Improve	C Maintain	C Maintain
	D	**Fair**	C Improve	C/D Improve	D Maintain	D Maintain
	E/F	**Poor**	D Improve	E/F Improve	E/F Maintain	E/F Maintain

Table 46 presents a summary of the overall results per at-risk watercourse, and the RMO/REC that was determined using the DWAF (2007) methodology above.

Table 46: Summary of the overall scores per watercourse, as well as the calculated RMO/REC.

HGM UNIT	PES SCORE	EIS	RMO/REC
UVB01	E	High	E/F Improve
UVB02	C	High	B/C Improve
CVB01	C	High	B/C Improve
CVB02	D	High	C/D Improve
SEEP01	C	High	B/C Improve
Rip01	C	Moderate	C Maintain
Rip02	C	Low	C Maintain
Rip03-Rip07	A	Low	A Maintain
Rip08	C	Low	C Maintain
Rip09	B	Low	B Maintain
Rip10	A	Low	A Maintain
Rip11	C	Low	C Maintain

6.9 Buffer Zone Determination

Buffer zones are defined as a strip of land with a use, function or zoning specifically designed to protect one area of land against impacts from another (DWA, 2005). Due to the increasing stress from anthropogenic pressures impacting on the ecological condition of freshwater resources throughout South Africa it is vital that measures to prevent further degradation be implemented. Thus, buffer zones can play a meaningful role in reducing impacts to aquatic resources and, in doing so, protect the ecosystem services they provide the communities and ecosystems which surround them. The following points summarise the essential importance of the implementation of relevant buffer zones, these include;

- Maintaining basic ecosystem services and aquatic processes.

- Reducing impacts on water resources from adjacent land-use practices and upstream activities.
- Providing habitats for fauna and flora, including rare and endangered species.
- Meeting life need requirements for aquatic and semi-aquatic species.
- Providing several ancillary societal benefits.

Buffer zones for all the at-risk watercourses within the study area were determined using the Buffer Zone Guideline Tool by Macfarlane & Bredin (2016), which was drafted for the Water Research Commission and the national DWS.

Table 47 below presents the calculated buffer zones that must be applied to the at-risk watercourses. The proposed development was assessed as a paved road transportation infrastructure and buffer zones were calculated assuming that all mitigation measures as listed within this report will be effectively implemented. It should be noted that the buffer guideline does not apply to channels which lack active channel characteristics i.e. channels which are not in contact with the zone of saturation and which do not have base flow (Macfarlane & Bredin, 2016); and could therefore not be applied to Rip02 - Rip11. However, the minimum buffer zone requirements for watercourses associated with paved roads is 15m (Macfarlane and Bredin, 2016) and a 15m buffer was therefore applied to these systems.

Proposed development related activities include the widening and realignment of an existing roadway through watercourses. The application of a no-go buffer area to areas within which construction is required is therefore considered impractical. However, it is recommended that non-essential construction and operational activities (e.g. ablution facilities, construction camps, laydown areas, mixing of cement, stockpiling of soils, waste dumping and any additional activities which may be detrimental to the health and functionality of the freshwater resources) must be strictly prohibited within the buffer zones. Any unauthorised or potentially detrimental activities which occur in the direct vicinity or upstream of the freshwater resources should be rehabilitated according to the site EMPr and preventative or mitigation strategies.

It must also be noted that although the below presented and illustrated buffer zones were calculated based on on-site analyses, applicable legislation must be consulted to determine the exact buffer zone requirements. The furthest buffer must be applied to each at-risk watercourse.

Table 47: Presentation of the calculated buffer zones that should be implemented during the construction and operational phases associated with the proposed development.

SYSTEMS	CONSTRUCTION PHASE (m)	OPERATIONAL PHASE (m)
UVB01 and UVB02	**19**	15
CVB01, Rip01	**26**	15
CVB02	**23**	15
SEEP01	**27**	15
Rip02-Rip11	**15**	15

7 FRESHWATER IMPACT ASSESSMENT

The perceived impacts associated with the proposed development were assessed using a quantitative impact assessment methodology, which was formalised to comply with Regulation 31(2)(I) of the NEMA (Act no. 107 of 1998). The aim of this assessment was to identify and assess the significance of all the perceived impacts, which may arise as a result of the proposed development. The methodology employed makes use of the following procedure:

1. Identification and assessment of potential impacts;
2. Prediction of the nature, duration, extent, likelihood and significance;
3. Identification of mitigation measures that could be implemented to reduce the significance of the potential impact; and
4. Evaluation of the significance of the potential impacts following the implementation of mitigation measures.

The NEMA (Act no 107 of 1998), specifies the following under Chapter 1, Section 2(4) regarding sustainable development and the management of sensitive ecosystems:

(**a**), “Sustainable development requires the consideration of all relevant factors including the following:

(i) That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

(ii) that pollution and degradation of the environment are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

(vi) that the development, use and exploitation of renewable resources and the ecosystems of which they are part do not exceed the level beyond which their integrity is jeopardised;

(vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions; and

(viii) That negative impacts on the environment and on people's environmental rights be anticipated and prevented, and where they cannot be altogether prevented, are minimised and remedied.”

(**r**) Sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

Therefore, to encourage the above to become a reality the precautionary principle was applied within this study to ensure that cost-effective measures are implemented to proactively prevent degradation of the region’s water resources and the social systems that depend on these ecosystems and habitats. To further guide the preservation of the at-risk watercourses within the study area, the mitigation hierarchy was applied (**Figure 18**). Its application is intended to strive to first avoid disturbance of ecosystems and loss of biodiversity, and where this cannot be avoided altogether, to minimise, rehabilitate, and then finally offset any remaining significant residual negative impacts on biodiversity (DEA, 2013). In the case of the proposed development, the activities fell within the rehabilitation category.

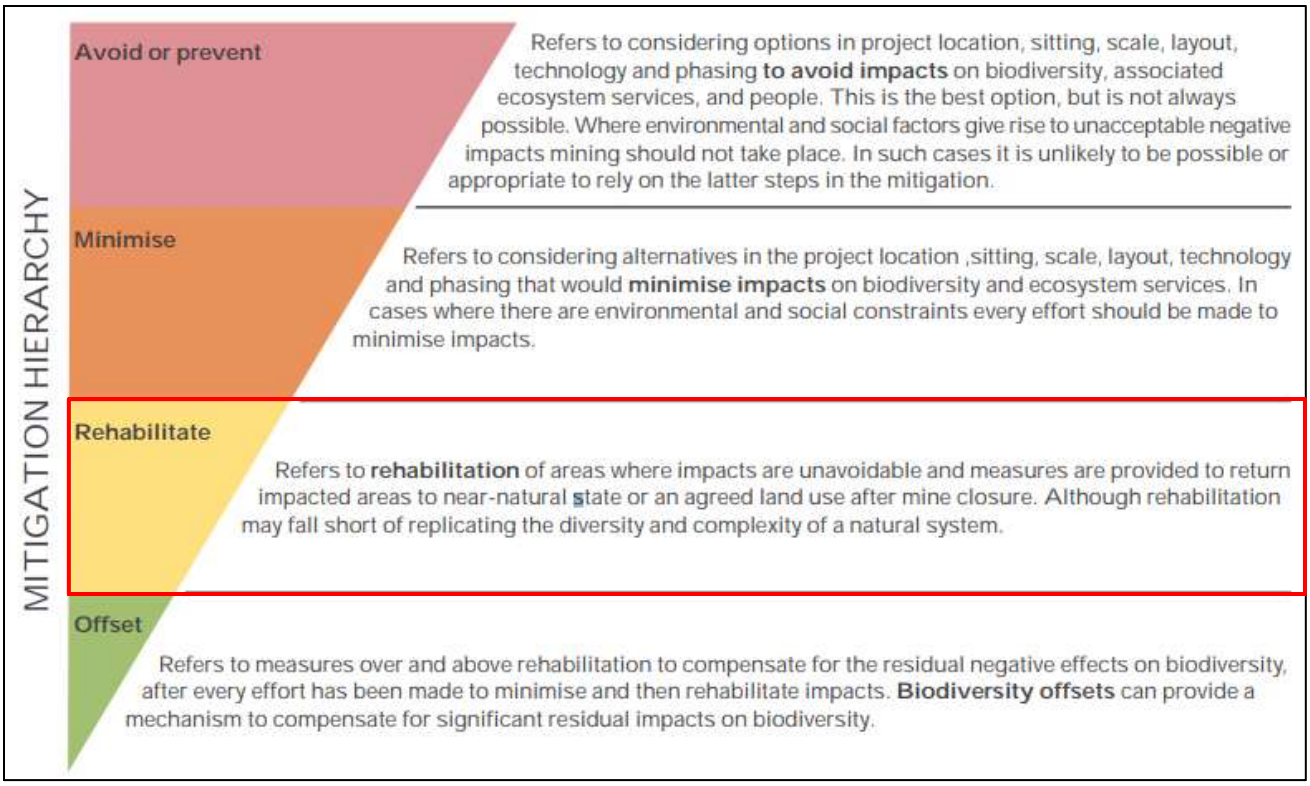

Figure 18: The mitigation hierarchy for dealing with negative impacts on biodiversity (DEA, 2013).

Table 48 overleaf presents the perceived impacts associated with the proposed development, as well as the mitigation measures that should be implemented to reduce their impact significance on the receiving aquatic environment.

Table 48: Impact assessment and mitigation measures.

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
CONSTRUCTION PHASE					
Direct construction phase impact 1: Loss of approximately 5,000 m³ of wetland habitat from within the direct footprint of the proposed development. The proposed road widening will predominantly take place into already infilled and transformed areas directly adjacent to the existing R101 roadway, within the existing road reserve. However, small areas of wetland habitat will be lost during the widening of the R101 through UVB01 and during the replacement of bridge crossings over CVB01 and CVB02. Although wetland habitat will be permanently lost the intensity of the impact has been reduced due to the	Extent	1	• The existing hydrological flow through the at-risk watercourses in the vicinity of the existing R101 must be improved via realignment of existing stormwater infrastructure as far as reasonably possible. All stormwater infrastructure must be constructed at the same level as the bed of the watercourse. This will reduce the risk of upstream ponding and deposition and increase consistent flow to downstream sections. • To compensate for the direct loss of vegetation in the footprint of the proposed development, IAPS control and management should be conducted within the remaining extent of wetland habitat located within the road reserve. An IAPS control and management plan should be drafted by a suitably qualified botanist to guide the control and maintenance of the IAPS. • Areas adjacent to any disturbed watercourses must be revegetated with hydrophilic plugs sourced from the adjacent wetland area to encourage the reestablishment of system-specific vegetation cover. This will mitigate the impact of the edge effect becoming a reality post-construction. Disturbed terrestrial areas should also be revegetated according to the methodology prescribed in the project-specific terrestrial biodiversity impact assessment and the EMPr. • The rehabilitation of all directly impacted watercourses should be guided by a watercourse rehabilitation and monitoring programme that should be drafted by a suitably qualified wetland and/or aquatic ecologist.	Extent	1
	Duration	5		Duration	5
	Intensity	6		Intensity	2
	Probability	5		Probability	5
	Significance rating	**60** (Medium)		Significance rating	**40** (Medium)

³ Estimation only, based on development alignment KML supplied to ENVASS by the client.

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
already degraded nature of the habitat that will be infilled as well as due to the fact that natural processes within the remainder of the wetland will continue. The through flow of the systems will also be improved by constructing stormwater infrastructure that can better accommodate periods of high flow.					
Direct construction phase impact 2: Disturbance of wetland, riparian and instream habitat. The clearing of vegetation from construction working servitudes through watercourses; the setting up of construction camps and storage areas; the movement of construction vehicles and personnel during bridge and	Extent	2	• A detailed method statement for proposed upgrade activities within watercourses must be compiled prior to construction and should be included with the EMPr for approval. • Limit upgrade activities within watercourses and their associated buffer areas to the dry winter months. • Clearly demarcate the construction footprint[4] with orange hazard tape (or similar) and strictly prohibit the movement of construction vehicles and personnel outside of the demarcated areas. Portions of the watercourses and associated buffer areas or the 1:100year flood line, (whichever is greatest) that are located outside of the demarcated construction footprint must be designated as no-go areas.	Extent	1
	Duration	4		Duration	2
	Intensity	6		Intensity	2
	Probability	5		Probability	5
	Significance rating	**60** (Medium)		Significance rating	**25** (Low)

[4] The construction footprint includes the direct development footprint as well as any construction servitudes required.

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	

culvert upgrade / demolition, road widening / realignment and stormwater infrastructure upgrade activities; as well as the inappropriate storage or dumping of building material / concrete in areas surrounding the direct development footprint may result in the disturbance of wetland, riparian and instream habitat as well as in the compaction / disturbance of soils. This disturbance may also result in the proliferation of alien and invasive species within the surrounding watercourses.			• Demarcation of the construction footprint must be signed off by an Environmental Control Office (ECO). Demarcation should not be removed until construction is complete, and rehabilitation has taken place.
			• The construction footprint through watercourses and their associated buffer areas must be as narrow as possible. In this regard:
			  ○ Utilise the existing R101 roadway / existing gravel roads / tracks where access into watercourses and their associated buffer areas is required.
			  ○ Where required, the construction servitude through watercourses should only include a one-way access road / track (approximately 3m wide) and a working corridor (approximately 1m wide).
			  ○ All access roads must be clearly demarcated prior to use by construction vehicles.
			  ○ Limit the movement of construction personnel and construction vehicles through watercourses and their associated buffer areas to that which is absolutely necessary.
			• Locate laydown areas and construction camps outside of no-go areas, preferably within historically disturbed or transformed areas of vegetation.
			• Prohibit the dumping of excavated material, rubble or building materials within no-go areas. Building material must be stored at designated areas outside of the no-go areas, preferably within historically disturbed areas. Spoil material and rubble must be appropriately disposed of at a registered waste disposal facility.
			• Appoint an experienced machine operator to conduct any excavation activities required within watercourses and their associated buffer areas, preferably with the use of an excavator and not a bulldozer.
			• Minimise the extent of infilling within wetland, riparian and instream habitat during upgrade activities.
			• Prevent excessive disturbance of watercourses during construction activities.		

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
			• Removal of vegetation must only be done when essential for the construction of the proposed development. Do not allow any disturbance to the adjoining natural vegetation cover or soils. All disturbed areas must be prepared and then revegetated to the satisfaction of the ECO as per the rehabilitation measures listed in Section 8 and according to the relevant EMPr to be composed. • Where possible, vegetation within the working servitude but outside of the direct construction footprint should be cut to ground level rather than completely removed. This will assist with soil stabilisation and with the rehabilitation of cleared areas. • Vegetation which is considered suitable for rehabilitation activities after construction (such as indigenous grasses and other herbaceous species) should be carefully removed from the direct construction footprint and stored at an appropriate facility for use in later rehabilitation activities. • Excavated soils must be placed in a stockpile area outside of the watercourses and associated buffer areas or the 1:100year flood line, (whichever is greatest), preferably within historically disturbed or transformed areas of vegetation approved by the ECO. Topsoil and subsoil must be stored separately for future rehabilitation. Soils excavated from watercourses must be stored separately to terrestrial soils. Soil replacement must be conducted in same sequence as excavated (i.e. subsoils followed by topsoil). • An ECO must inspect the construction footprint on a weekly basis and must take immediate measures to address unforeseen disturbances to watercourses. Any disturbed / compacted areas falling outside of the construction footprint must be immediately rehabilitated. • Once construction has been completed orange hazard fences as well as all construction waste, rubble, and equipment must be removed from the development footprint.		

<table>
<tr><th>POTENTIAL IMPACT</th><th colspan="2">SIGNIFICANCE RATING OF IMPACTS

PRIOR TO MITIGATION</th><th>PROPOSED MITIGATION</th><th colspan="2">SIGNIFICANCE RATING OF IMPACTS

AFTER MITIGATION</th></tr>
<tr><td></td><td></td><td></td><td>• Alien and Invasive plant species control:
o The construction footprint, construction camps, laydown areas and any additional bare areas must be checked by a suitably qualified professional for alien and invasive species on a weekly basis and alien species noted must be removed.
o Alien species removal is to take place manually, by hand as far as possible. The use of herbicides should be avoided. Should the use of herbicides be required, only herbicides which have been certified safe for use in aquatic environments by an independent testing authority may be considered. The ECO must be consulted in this regard.
o Care must be taken in order to avoid the disturbance of indigenous species during the removal of alien plants.
o Dispose of removed alien plant material at a registered waste disposal site or burn on a bunded surface where no stormwater runoff is expected.
o Remove vegetation before seed is set and released.
o Cover removed alien plant material properly when transported, to prevent it from being blown from vehicles.
• Rehabilitate any areas of watercourses located outside of the direct construction footprint which have been disturbed as a result of construction related activities. Refer to Sections 8 and 9 below for rehabilitation and monitoring requirements.</td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="5">Direct construction phase impact 3: Erosion and sedimentation of watercourses.</td><td>Extent</td><td>2</td><td rowspan="5">• Limit upgrade activities within watercourses and their associated buffer areas to the dry winter months.
• Design a stormwater management plan prior to the commencement of construction related activities which details how stormwater runoff from cleared, compacted surfaces will be controlled in order to prevent the erosion</td><td>Extent</td><td>1</td></tr>
<tr><td>Duration</td><td>3</td><td>Duration</td><td>1</td></tr>
<tr><td>Intensity</td><td>6</td><td>Intensity</td><td>4</td></tr>
<tr><td>Probability</td><td>4</td><td>Probability</td><td>4</td></tr>
<tr><td>Significance rating</td><td>44</td><td>Significance rating</td><td>24</td></tr>
</table>

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
The removal of vegetation and stripping of soils from the construction footprint will result in the exposure of soils to erosive elements. An increase in stormwater runoff and velocities from bare, disturbed and compacted areas may result in the formation of erosion gullies and rills, and in the erosion of surrounding watercourses. In addition, the disturbance of soils during the removal of vegetation and earth moving activities will result in an increase in the runoff of sediment laden stormwater into the watercourses from the construction footprint.		(Medium)	and sedimentation of watercourses. Examples of measures which can be included in the stormwater management plan are listed below: ○ Strategically divert stormwater runoff from the construction footprint into sediment trapping devices. ○ Energy dissipaters must be constructed where stormwater is released in order to reduce the water velocity and therefore erosion. ○ Divert stormwater away from areas susceptible to erosion. ○ Control stormwater runoff from cleared/disturbed areas with sandbags, swales or berms. ○ Install rows of silt fences on exposed areas of soil to break energy of stormwater runoff and prevent sedimentation. • Only clear vegetation immediately prior to the commencement of construction related activities in order to reduce the duration of exposure of bare soils. • Schedule construction activities to minimise the total amount of soil exposed at any given time. In this regard vegetation should be cleared in a phased approach and rehabilitation must take place concurrently with construction. • Implement erosion control measures where required. Examples of erosion control measures include: ○ Covering steep / unstable / erosion prone areas with geotextiles. ○ Covering areas prone to erosion with brush packing, straw bales, mulch. ○ Stabilizing cleared / disturbed areas susceptible to erosion with sandbags. ○ Utilising sandbags in order to support channel banks and prevent bank slump. • Care must be taken to prevent additional disturbance to watercourses during the implementation of erosion control measures. • Construct silt fences / traps in areas prone to erosion, to retain sediment-laden runoff:		(Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
			○ Place silt fences / traps strategically on the periphery of the construction footprint area, the construction camp, cleared areas, storage areas, soil stockpile areas and laydown areas. ○ Silt fences/traps must be installed downslope of all of the at-risk watercourse crossing points to reduce the risk of sediment entering the downstream systems. The ECO must be consulted on the number and location of silt fences, and silt fences must not result in any unnecessary disturbance to wetland, riparian and instream habitat. ○ All sediment trapping devices should be checked weekly by the appointed contractor / ECO and cleared as needed. ○ Ensure silt fences / traps are adequately maintained. ○ Sediment traps should not be removed immediately after the completion of construction activities. Sediment traps should only be removed once at least 80% vegetation cover has re-established on disturbed, bare soils. • Stormwater, sediment and erosion control measures must be installed before earthworks are initiated. • Stockpile management: ○ Locate stockpile areas in designated areas outside of the buffer area / 1:100year flood line of the watercourses. Stockpiles should preferably be located on level ground within historically disturbed or transformed areas of vegetation approved by the ECO. ○ Store topsoil separately from subsoils for use in future rehabilitation activities. ○ Soils excavated from watercourses must be stored separately to terrestrial soils. ○ Protect stockpiles, if required, from erosion using tarp or erosion blankets.		

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
			○ Stockpiled soils must not be compacted and must be kept weed free. ○ Stockpiled soils must be kept moist in order to prevent dust creation. ○ Soil stockpiles must not exceed 4m in height as this will result in soil compaction. • Where possible, vegetation within the construction footprint but outside of the direct development footprint should be cut to ground level rather than completely removed. This will assist with soil stabilisation and with the rehabilitation of cleared areas. • The contractor / ECO must check the watercourses and buffer areas for erosion damage and sedimentation weekly and after every heavy rainfall event. Should erosion or sedimentation be noted, immediate corrective measures must be undertaken. Care must be taken to prevent additional disturbance to the watercourses during the implementation of these measures. • Implement rehabilitation and monitoring measures as indicated within Section 8 and 9 in order to stabilise soils and prevent erosion.		
Direct construction phase impact 4: Water quality impairment. Water quality is based on the contamination of water by solutes, solids and sediments. However, sedimentation was dealt with as part of direct construction phase impact 3 and so the impact to water	Extent	3	• A method statement must be developed indicating how the contractor will minimise the passage of contaminants such as fuel, cement and asphalt into the watercourses. This method statement must be included with the EMPr for approval. • Locate construction camps, laydown areas, topsoil stockpile areas, construction material, equipment storage areas, concrete batching areas, vehicle parking areas, bunded vehicle servicing areas and re-fuelling areas in designated areas outside of watercourses and their associated buffer areas or the 1:100year flood line (whichever is greatest). These areas should preferably be located on level ground in a previously disturbed area of vegetation approved by the ECO.	Extent	2
	Duration	2		Duration	1
	Intensity	8		Intensity	4
	Probability	4		Probability	3
	Significance rating	**52** (Medium)		Significance rating	**21** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
quality as discussed below only focuses on contamination by solutes and solids. The movement of construction vehicles within the construction footprint and the use of machinery during construction, increases the possibility of the contamination of watercourses by hydrocarbons, oils and grease which may leak from the vehicles/machinery or spill during poor dispensing practices and enter into the features directly, or indirectly with stormwater runoff. There is also a possibility that the watercourses will be contaminated as a result of the runoff/spillage of cement and other construction related materials from the construction footprint. Contamination of the watercourses by sewage may occur as a result of leakages			• Fuel, chemicals and other hazardous substances should preferably be stored offsite, or as far away as possible from the watercourses and their associated buffer areas or the 1:100year flood line, (whichever is greatest). These substances must be stored in suitable secure weather-proof containers with impermeable and bunded floors to limit pilferage, spillage into the environment, flooding or storm damage. • Inspect all storage facilities and vehicles daily for the early detection of deterioration or leaks. • Mixing and transferring of chemicals or hazardous substances must take place on drip trays, shutter boards or other impermeable surfaces. • Drip trays must be utilised at all fuel dispensing areas. • Vehicles and machinery should preferably be cleaned off site. Should cleaning be required on site it must only take place within designated areas outside of the watercourses and their associated buffer areas or the 1:100year flood line (whichever is greatest) and should only occur on bunded areas with a water/oil/grease separator. • Dispose of used oils, wash water from cement and other pollutants at an appropriate licensed landfill site. • Avoid the use of infill material or construction material with pollution / leaching potential. • Concrete must not be mixed on exposed soils. Concrete must be mixed on an impermeable surface in an area of low environmental sensitivity identified by the ECO outside of the buffer area or the 1: 100year flood line, whichever is greatest. • Construct temporary bunds around areas where cement is to be cast *in-situ*. • Dispose of concrete and cement-related mortars in an environmental sensitive manner (can be toxic to aquatic life). Washout should not be discharged into		

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
from portable chemical toilet facilities, or the informal use of surrounding areas by workers. Additional impacts to the watercourses as a result of the disposal of solid waste including litter and building material may also occur.			the watercourses. A washout area should be designated, and wash water should be treated on-site. • Clean up any spillages immediately with the use of a chemical spill kit and dispose of contaminated material at an appropriately registered facility. • Provide portable toilets where work is being undertaken (1 toilet per 10 workers). These toilets must be located within an area designated by the ECO outside of the watercourses and their associated buffer areas or the 1:100year flood line, (whichever is greatest) and should preferably be located on level ground. Portable toilets must be regularly serviced and maintained. • Provide an adequate number of bins on site and encourage construction personnel to dispose of their waste responsibly. • Waste generated by construction personnel must be removed from the project footprint and disposed of at a registered waste disposal facility on a weekly basis.		
Direct construction phase impact 5: Alteration of the natural hydrological regime at watercourse crossings. The natural flow patterns through watercourses will be altered as a result of the diversion or obstruction / concentration of flow during construction activities. The impoundment and diversion of	Extent	3	• A method statement must be developed by the contactor indicating how flow patterns will be maintained through the watercourses during construction. • Limit upgrade activities within watercourses and their associated buffer areas to the dry winter months when flows within the watercourses are at their lowest. • Limit the duration of construction activities within the watercourses. • Strictly prohibit the excavation of new channels or drainage canals for the diversion of water away from construction areas. • The diversion pipe culverts must be placed on the natural floor of the watercourse to avoid undercutting and channel scouring downstream.	Extent	2
	Duration	5		Duration	1
	Intensity	6		Intensity	2
	Probability	4		Probability	4
	Significance rating	**56** (Medium)		Significance rating	**20** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
flow around construction areas may lead to the concentration of flows and the erosion and incision of potions of watercourses at diversion outlet points.			• The diversion pipe culverts must allow for the 1:50year flood peak to reduce the risk of flow impediment and unnecessary destruction of aquatic habitat caused by upstream pooling. • Any diversions / impoundments required upstream of the watercourses crossings in order to allow for construction activities to take place must be temporary in nature (e.g. a sandbag diversion / impoundment) and flow to areas downstream of the construction footprint must be maintained (e.g. water must be allowed to flow through one half of the channel while construction takes place in the other; or water which collects behind the impoundment can be piped through the construction footprint and released downstream). • Should sandbags be utilised for the impoundment / diversions, they must be in good condition so as to avoid the bursting of the bags and sedimentation of downstream areas. • Care must be taken so as to avoid the erosion of the watercourse beds and banks due to the diversion of water. • Should dewatering of the construction area be required in order to ensure a safe working environment, water must be passed into sediment ponds or other sediment trapping devices prior to it being released into downstream areas of the watercourse. Water must be released in a slow, controlled manner so as to prevent the erosion of downstream areas. Erosion control measures may also be located at the release point in order to further reduce the risk of erosion (e.g. ponding or cascading with stone formed berm, strategically placed straw bales, diverting stormwater away from areas susceptible to erosion etc.). • Once construction is complete any disturbance to the watercourses as a result of the diversion must be immediately rehabilitated. • Ensure that the beds of watercourses as crossing points are restored to the natural base level in order to prevent erosion or upstream ponding (i.e. the		

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
			foundations of bridge support structures and culverts must tie in with the natural base level of the watercourse). • Any impoundments / diversions required must be removed in order to reinstate natural flow patterns immediately after the completion of construction and rehabilitation activities.		
Direct construction phase impact 6: Disturbance of watercourses by blasting in road realignment sections Blasting may occur at three (3) realignment localities within the study area around centre points: Realignment 1: 24°48'34.22"S; 28°20'44.51"E Realignment 2: 24°48'22.95"S; 28°21'19.43"E Realignment 3: 24°46'28.64"S; 28°21'34.95"E The blasting may directly impact on ephemeral watercourses Rip03 and Rip04, as well as an artificial farm dam labelled	Extent	2	• Blasting may only occur during the daytime hours as defined with the municipal Bylaws applicable to the study area. This will reduce the risk to nocturnal faunal species that may take refuge within the at-risk watercourses. • Blasting should only occur within the direct footprint of the proposed realignment and only when all other excavation avenues have been considered and deemed not feasible. • Blasting should ideally not occur directly within Rip03 and Rip04 due to the risk of unnecessary damage occurring to the morphology of the ephemeral streams. However, as both riverine systems are highly ephemeral in nature the significance can be reduced post-mitigation by landscaping the disturbed areas and constructing stormwater infrastructure to accommodate flow through the systems. This should be guided by a watercourse rehabilitation and monitoring programme drafted by a suitably qualified wetland and/or aquatic ecologist. • No obstacles must impede the flow through Rip03 and Rip04 (i.e. all rubble must be removed from the systems using the least intrusive method possible).	Extent	1
	Duration	4		Duration	2
	Intensity	6		Intensity	2
	Probability	5		Probability	5
	Significance rating	**60** (Medium)		Significance rating	**25** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
Dam02, of which portions are within the proposed realignments. The noise may impact on the faunal species within and surrounding the watercourses as a result of noise. If rubble is not removed the baselevel of the ephemeral drainage-lines could be altered, resulting in channel scouring. The altered landscape could also			• All blasting and construction should only occur during the dry season for the region to limit impeding and ponding of flow within the blast landscape. • Rubble and associated infrastructure must be stockpile and stored outside of all watercourses and associated buffer zones (i.e. no-go zones for temporary infrastructure).		
Direct construction phase impact 7: Influence of Aquatic Biota During the construction phase the temporary diversions of flow by means of pipe culverts may negatively influence the migratory routes of fish and aquatic macroinvertebrate species to downstream areas.	Extent	2	• During the construction phase continuous flow to downstream systems must be maintained by means of pipe culverts (or similar). The pipe culverts must be placed directly on the flood of the watercourse with no uplift evident in the upstream direction to avoid upstream ponding and channel scouring downstream. • Construction should take place in the dry season when aquatic biota are least mobile, thus reducing the impact on migratory routes and general mobility. • Temporary infill in the watercourses for access should be limited as far as possible to reduce the input of earthen materials into the system, and thus decrease the potential influence on water quality. Planks and larger boulders	Extent	2
	Duration	1		Duration	1
	Intensity	6		Intensity	4
	Probability	4		Probability	2
	Significance rating	**36** (Medium)		Significance rating	**14** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
The construction of major bridges B375 and B447 across the Modderloop and Groot Nyl Rivers, respectively, may result in disturbance of aquatic biota by means of sedimentation and temporary movement of construction vehicles within the instream and riparian environments.			(not containing pyrite) should be preferred over fine-grained earthen material. • No fishing by construction personnel is to occur within the rivers without obtaining the relevant permits from the provincial environmental authority. • No indiscriminate movement of construction vehicles, stockpiling, waste dumping, equipment storage or ablution facilities are to be placed within the no-go areas (i.e. watercourses and buffer zones).		
Indirect construction phase Impact 1: Sedimentation of adjacent watercourses The movement of construction vehicles in and around watercourses may cause excess dust which has the potential to travel via aeolian and fluvial processes to the downstream watercourses. The water quality of the affected watercourses may consequently deteriorate. Activities with the highest potential to cause sedimentation include the development of a new service road and the three (3) realignments as well as construction at the two (2)	Extent	2	• All open excavations and stockpiles should be cordoned off using sediment netting secured at the base by sandbags or pegs to reduce uplift. • Dust suppression should be applied to all gravel access roads utilised by construction vehicles to reduce the risk of sedimentation of the downstream watercourses. This includes the newly proposed service road along the R101 upgrade. • Stormwater infrastructure directed to adjacent vegetated areas should be constructed within and around all construction site camps and laydown areas to reduce the risk of stockpiled material and sediment from construction vehicles tyres entering downstream watercourses via surface wash. • Rubble from blasting should be removed from site and stockpiled outside of all no-go zones directly after blasting has occurred. • Weekly water quality monitoring should occur upstream and downstream of construction within watercourses (i.e. major bridges and culverts) during the construction phase. This will act as an early warning system for potential water contamination, which can be addressed by implementing adequate mitigation measures if deviation from the baseline water quality results is observed.	Extent	1
	Duration	1		Duration	1
	Intensity	6		Intensity	4
	Probability	4		Probability	3
	Significance rating	**36** (Medium)		Significance rating	**18** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
major bridges and three (3) major culverts.					
OPERATIONAL PHASE					
Direct operational phase impact 1: Alteration of the natural hydrological regime at watercourse crossing areas. Poor bridge and culvert alignment may result in the further alteration of the natural flow patterns through watercourses, which could lead to turbulent flow and further erosion of watercourses during the operational phase. There is also the potential that the base levels of watercourses may be lowered or raised at the points where excavations and infilling for the new bridge foundations and culverts take place. The lowering of the base level of the watercourses may result in the scouring of the	Extent	3	• The following design related mitigation measures will reduce impacts to watercourses during the operational phase: ○ Bridge and culvert upgrades must accommodate the design flood peaks. ○ Bridges must be stable and must be appropriately protected so as to withstand major flood events. ○ The proposed bridges and culverts should be designed in such a way as to prevent the alteration of the natural flow patterns through the watercourses and the extent of the flood lines of the watercourses. ○ Proposed bridges and culverts must be positioned at a right-angles (perpendicular) to the longitudinal flow-path of the watercourses. This will limit the area of direct disturbance and may avoid scouring and undercutting from occurring. ○ Bridge and culvert design must allow for natural dispersion of water through the watercourses to prevent the concentration of flow and the resultant scouring and incision of the watercourses. ○ The proposed bridges and culverts must span the entire width of the watercourses, not just the active channel. ○ The number and width of pillars, vertical columns and buttresses placed within watercourses should be minimised as far as possible. ○ If required, incorporate erosion control measures and protection such as reno mattresses, gabions, rock rip-rap or other support structures at areas where bridge support structures will intersect the channel beds of CVB01 and CVB02. These measures will prevent the scouring of the riverbed and bank during the operational phase.	Extent	1
	Duration	5		Duration	5
	Intensity	6		Intensity	2
	Probability	4		Probability	2
	Significance rating	**56** (Medium)		Significance rating	**16** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
watercourse beds downstream of the crossings and in headward erosion during the operational phase. Alternatively, the raising of the watercourse beds may result in upstream ponding and downstream erosion. However, it should be noted that the flow patterns through watercourses have already been altered as a result of the historical development of existing bridge structures and culverts. The proposed upgrade of bridge and culvert structures to accommodate the design flood peak and incorporating the proposed design measures as listed adjacent will therefore ultimately improve hydrological flow patterns through the affected watercourses.			○ Appropriate design measures must be put in place in order to dissipate flow velocity below bridges and around support structures, and in order to prevent turbulent flow (e.g. through the use of streamlined support column shapes). ○ Stormwater from bridge surfaces must be directed to the outer edges of the bridges and must be passed through filter strips/energy dissipaters (e.g. areas of rock riprap grassed with indigenous vegetation) before being released into the watercourses below. • After construction is complete the bed and banks of watercourses must be rehabilitated to as close to their original condition as possible (refer to rehabilitation measures listed in Section 8 below). Ensure that the beds of the watercourses are restored to their natural base levels in order to prevent erosion or upstream ponding. • All bridges and culverts must be inspected annually as well as after heavy rainfall events for the build-up of debris. Any debris noted must be removed.		
Direct operational phase impact 2: Disturbance of	Extent	2		Extent	1
	Duration	2		Duration	1

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
watercourses during road maintenance activities. The indiscriminate movement of maintenance vehicles and personnel during maintenance activities will result in an impact on watercourses within which maintenance of infrastructure is required.	Intensity	6	• Strictly prohibit the indiscriminate movement of vehicles and personnel during maintenance activities. • Utilise the existing R101 roadway / existing gravel roads / tracks where access into watercourses and their associated buffer areas is required for maintenance activities. • Limit the movement of maintenance personnel and vehicles through watercourses and their associated buffer areas to that which is absolutely necessary. • Prevent excessive disturbance of watercourses during maintenance activities. • Removal of vegetation must only be done when essential for maintenance to proceed. Do not allow any disturbance to the adjoining natural vegetation cover or soils. • All areas disturbed during maintenance activities must be rehabilitated and monitored according to measures listed within Section 8 and 9 below.	Intensity	2
	Probability	4		Probability	2
	Significance rating	**40** (Medium)		Significance rating	**8** (Low)
Indirect operational phase impact 1: IAPS proliferation Alien vegetation is likely to proliferate in areas disturbed during the construction phase of the development. The implementation of rehabilitation measures post construction will reduce the intensity of the impact; however, without follow up	Extent	2	• Refer to rehabilitation and monitoring requirements listed in Section 8 and 9 below.	Extent	1
	Duration	4		Duration	1
	Intensity	6		Intensity	2
	Probability	4		Probability	4
	Significance rating	**48** (Medium)		Significance rating	**16** (Low)

POTENTIAL IMPACT	SIGNIFICANCE RATING OF IMPACTS PRIOR TO MITIGATION		PROPOSED MITIGATION	SIGNIFICANCE RATING OF IMPACTS AFTER MITIGATION	
alien vegetation control, encroachment is still highly likely to occur. Watercourses in the area have already been impacted as a result of the proliferation of alien trees such as *Eucalyptus* sp. and the proliferation of aliens in disturbed areas will add to this problem.					

7.1 Impact Statement

According to the KML file provided to ENVASS, the proposed road widening will predominantly take place into already infilled and transformed areas directly adjacent to the existing R101 roadway within the existing road reserve. However, small areas of wetland habitat will be lost during the widening of the R101 through UVB01 and during the upgrade and widening of bridge crossings at CVB01 and CVB02 (approximately 5,000 m[5]). Although wetland habitat will be permanently lost, the intensity of the impact has been reduced due to the already degraded nature of the habitat that will be infilled and due to the fact that natural processes within the remainder of the wetlands will continue. The impact prior to the implementation of mitigation measures was therefore calculated to be of a medium (negative) significance. The proposed upgrade and realignment of bridge and culvert structures to accommodate the design flood peak, and the implementation of additional design related mitigation measures aimed at improving flow patterns through watercourses will ultimately result in the improvement of the current status quo of the watercourse crossing areas. It has also been recommended that IAPS control and management should be conducted within the remaining extent of wetland habitat located within the road reserve in order to attempt to mitigate this impact. However, the control of IAPS will not prevent the direct loss of wetland habitat, and the overall impact therefore remained of a medium (negative) significance after the implementation of mitigation measures.

Although the direct loss of wetland habitat from the development footprint cannot be avoided, the strict implementation of the mitigation, rehabilitation and monitoring measures as listed within this report will ensure that all remaining freshwater impacts are reduced to low (negative) significances and that the RMO/REC integrity that has been determined for all at risk systems can be maintained. The site-specific EMPr and conditions stipulated within the WUL and EA for the site, as well as a watercourse rehabilitation and monitoring programme should guide the conservation and rehabilitation of the at-risk watercourses.

[5] Estimation only, based on development footprint kml supplied to ENVASS.

8 REHABILITATION STRATEGY

Rehabilitation is not the static endpoint of a recipe-like process (Kusler & Kentula, 1990). Rather, it is a process in its own right, whereby the wetland/riparian system is given an opportunity for a new beginning (Grenfell, *et. al*., 2007). Rehabilitation requires that there is an attempt to imitate natural processes and reinstate natural ecological driving forces in such a way that it aids the recovery (or maintenance) of dynamic systems so that, although they are unlikely to be identical to their natural counterparts, they will be comparable in critical ways so as to function similarly (Jordan *et al*., 1987). It must be recognised that rehabilitation interventions may have different ecological starting points (ranging from totally degraded to slightly degraded) and different goal endpoints (ranging from a state that is close to the pristine to one which is still far from pristine, but nonetheless an improvement on the state of the system without any rehabilitation intervention). The chosen goal endpoint depends on what is achievable, given the site conditions, and those ecosystem attributes and services that are considered most important. Any rehabilitation project should therefore be based on an understanding of both the ecological starting point and on a defined goal endpoint, and should accept that it is not possible to predict exactly how the wetland/riparian system is likely to respond to the rehabilitation interventions.

The following rehabilitation strategy is applicable to the proposed development:

- All disturbed areas must be rehabilitated within 30 days of the end of each construction activity.
- It is the responsibility of the developer to appoint a suitably experienced rehabilitation specialist to implement an approved Rehabilitation Plan. The specialist must have a sound knowledge of the vegetation types and communities of the site and his/her appointment must be approved by the ECO. The plan shall include (but not be limited to):
    - Detailed rehabilitation methodology;
    - Details for potential structures proposed within existing systems to assist with the prevention of further erosion and improve flooding of watercourses;
    - Methods for the removal and control of IAPS within the proposed development footprint and adjacent corridor;
    - Assessment of current vegetation species within the study area;
    - Proposed plant species to be replanted in and around the disturbed development footprint; and
    - Monitoring requirements to assess how successful the rehabilitation techniques are.
- All post-construction building material and waste must be cleared in accordance with the EMPr, before any revegetation may take place.
- Erosion features that have developed as a result of construction/operation related disturbances are required to be stabilised. This may also include the need to deactivate any erosion head cuts/rills/gullies that may have developed by either compacted soil infill, rock plugs, gabions or any other suitable measures.
- Slopes that have been altered due to construction must be reshaped to replicate the original condition and contours.

- If the gradient of the banks is greater than 1:1.75, the banks must be stabilised with a biodegradable cover such as Geojute which must be secured to the steep slope with wooden (biodegradable) pegs. This will reduce soil erosion potential.
- Any areas which fall outside the development footprint that have been compacted are required to be ripped to allow for the establishment of vegetation. This ripping must not result in the mixing of sub- and topsoil.
- Redistribute stockpiled topsoil across the disturbed areas of the riverbanks, wetland and ephemeral drainage line.
- No imported soil material may be utilised for rehabilitation, unless it can be ensured that it is free of any IAPS seeds.
- Before adding the topsoil, all weeds and IAPS must be removed.
- Additional stabilisation of cleared areas to prevent and control erosion must be actively managed. The method of stabilisation should be determined in consultation with the ECO and engineer. The following methods (or a combination) may be considered, depending on the specific conditions of the site:
  - Brush packing;
  - Mulch or chip cover;
  - Terracing;
  - Straw stabilising (at the rate of one bale/m² and rotated into the top 100mm of the completed earthworks);
  - Watering;
  - Planting / sodding;
  - Hand-seeding / Hydro-seeding; and/or
  - Mechanical cover or packing structures (Geofabric, Hessian cover, Armourflex, Log / pole fencing).
- A suitably qualified ECO / botanist / horticulturist must supervise the handling, maintenance and planting of the plants / trees. No IAPS may be utilised during the rehabilitation process.
- Rapidly germinating indigenous species (e.g. fast growing, deep rooting, rhizomatous, stoloniferous) known to bind soils in terrestrial, riparian and/or wetland areas must be utilised where there is a strong motivation for stabilisation over reinstating similar plant communities to that being disturbed. This should be informed by a suitably qualified specialist.
- Exposure of plant root systems to drying winds, high temperatures or water logging must be avoided.
- Where possible, revegetation must take place at the start of the spring rains to maximise water availability and minimise the need for irrigation. This will ensure optimal conditions for germination and rapid vegetation establishment.
- If this is not possible, irrigation of planted areas may be necessary during dry periods (external sources of water must be utilised e.g. Joe-Joe tanks).
- Water utilised for irrigation must be free of any chlorine or contaminants that may negatively affect the plant species.
- The use of irrigation may be halted where hydro-seeding shall be utilised, until seeds have germinated and growth has commenced.

- All alternative tracks and footpaths created during the operational phase should be appropriately rehabilitated (e.g. tillage and revegetation of the affected areas). This rehabilitation should result in improved surface roughness and increased infiltration along with reduced stormwater flow and consequently reduced rill erosion.
- Any haulage or access roads (legal or illegal) which were created must be decommissioned and rehabilitation to reinstate the natural vegetation, increase the surface roughness and resultantly increase infiltration (e.g. tillage and revegetation) post-construction.
- All construction waste materials must be removed, and temporary structures (e.g. offices, workshops, storage containers, ablution facilities) dismantled, from site and the surrounding environment, this will need to be checked by the ECO and the various contractors.
- All banks where there is exposed soil, with the potential for rill/gully erosion to take place, must be stabilised.
- Longitudinal bank profiles which have been altered, must be rehabilitated if possible. The soil horizons must be reinstated on the correct structural order and the vegetation groundcover over the disturbed area revegetated according to the site-specific rehabilitation plan.
- It is the property owner's responsibility to continuously monitor the area for IAPS during the contract and establishment period, and any alien species encountered must be removed.
- IAPS must be removed manually without further disturbance to the surrounding ecosystems. If manual removal is not possible, seek guidance from a local cooperative extension service or Working for Water. Dispose of the removed IAPS at a registered dumping site or burn the material on a bunded surface.
- Removal of these species shall be undertaken in a way which prevents any damage to the remaining indigenous species and inhibits the re-infestation of the cleaned areas.
- Rehabilitation of the sections where IAPS are removed must take place. The appropriate indigenous grass and woody vegetation species seeds must be attained from a registered nursery with the guidance of a botanist who is familiar to the region.

9 MONITORING REQUIREMENTS

The monitoring of the watercourses will be essential for the maintenance and/or improvement of the PES scores that were calculated for the at-risk watercourses and the natural terrestrial biodiversity of the study area. The mitigation / rehabilitation recommendations stated above must be incorporated into the project-specific EMPr and compliance with the requirements/recommendations must be audited by a suitability qualified independent ECO. The key to a successful EMPr is appropriate monitoring and review to ensure effective functioning of the EMPr and to identify and implement corrective measures in a timely manner. Monitoring for non-compliance must be undertaken on a daily basis during the construction phase by the contractors under the guidance of the Project Manager / ECO / Engineer. An appropriately timed audit report should be compiled by an independent ECO. Paramount to the reporting of non-conformance and incidents is that appropriate corrective and preventative action plans are developed and adhered to. Photographic records of all incidents and non-conformances must be retained. This is to ensure that the key impacts on the receiving aquatic and terrestrial habitats are adequately managed and mitigated against and that the rehabilitation of any disturbed areas within any system is successful.

A monitoring programme must be in place not only to ensure compliance with the EMPr throughout the construction and operational phases, but also to monitor any environmental issues and impacts during the vegetation establishment phase during rehabilitation. Compliance against the EMPr must be monitored during the construction phase monthly by an ECO. The period and frequency of monitoring required post-construction must be determined by a suitably qualified specialist and approved by the ECO. Once the initial transplants / plugs / seeds are planted during the rehabilitation phase, a suitably qualified professional must conduct weekly site visits to remove IAPS (in accordance with the latest revised NEM:BA requirements) and address any revegetation concerns until revegetation is considered successful (i.e. >80% indigenous cover). A generally accepted monitoring period of revegetated areas after this initial period is monitoring every 3 months for the first 12 months and every 6 months thereafter until the vegetation has successfully been established. If the revegetated areas have inadequate surface coverage (less than 30% within 9 months after re-vegetation) the disturbed areas should be prepared and re-vegetated again.

- The cost-effective qualitative monitoring of the rehabilitation area may be time based through the use of periodic photographs taken from permanent photo viewpoints. These points are required to be established during site inception. The timeline created between the pre- and post-rehabilitation photos will provide an invaluable visual representation of the progress that is conveyed in a straightforward manner. The photographer should be an environmental scientist (may be the site ECO), therefore allowing an expert assessment of the site adding to the qualitative information gathered from the photographs.

The below mentioned criteria must be adhered to, ensuring the quality of the information collected:

  - Establishment of the photo points must be completed during site inception/establishment. This will allow for pre-rehabilitation imagery spanning more than a once off photograph.

- These points should be permanently marked and assigned a unique identify number to ensure continual relocation and accuracy of the photographs. GPS coordinates should be recorded of each site. This is to ensure if any markers are removed or vandalised then they can be replaced.
- Photo point locations should be easily relocated and accessible and must not be obscured by future vegetation growth.
- The level of detail captured must be appropriate to the area that has undergone rehabilitation.
- Photo record forms must be development and utilised for every photo taken. The information required will be project name, location, unique identity number, directional point (e.g. North, South), date, time, photographers name and additional comments.
- Qualitative ecological information that must be visually interpreted and recorded at the same time as taking the photograph include:
    - Extent of the site vegetation ground cover.
    - General level of plant growth, substrate levels, and water levels.
    - General observations of water quality such as clarity and presence of litter.
    - Evidence of anthropogenic presence and bird species.
    - Vegetation condition, extent of alien invasive plants; and
    - Evidence of erosion and close monitoring of the post-construction erosion-control measures which must be implemented.

This is to ensure that the key impacts on the aquatic and terrestrial habitats are adequately managed and mitigated against and that rehabilitation of any disturbed areas within the study area is successful.

Additional monitoring should include the following:

- Weekly water quality monitoring during the construction phase at upstream and downstream sites at construction activities within watercourse (i.e. at the two (2) major bridges and three (3) major culverts (if inflow)). The parameters to be monitored should include as a minimum pH, EC, TDS, Total Suspended Solids (TSS), Turbidity, DO (mg/l), DO (%) and *in situ* temperature. Hydrocarbon monitoring utilised Total Petroleum Hydrocarbons (TPH) as the parameter measured should also be conducted on a 2weekly basis (i.e. twice a month).
- ECO to undertake Fixed Point Photography (FPP) at each construction site within the at-risk watercourses on a weekly basis to document the disturbances and thus inform the rehabilitation efforts that may be required post-construction. The photography should be documented as described above, but specific focus must be placed on the condition of the watercourse morphology and vegetation.

10 CONCLUSION AND RECOMMENDATIONS

Subsequent to conducting a desktop study and field survey of the watercourses within the study area, it was determined that sixteen (16) watercourses are at-risk of being impacted upon by the proposed development, namely UVB01, UVB02, CVB01, CVB02, SEEP01 and Rip01 to Rip11.

At-risk wetland features have already been impacted upon as a result of the historical construction of the existing R101 roadway which has altered natural flow patterns through the features. Additional factors influencing the PES of the wetlands include the alteration of the natural flow regime within their catchment areas, the encroachment of IAPS into the wetlands, as well as urban and agricultural activities within wetlands and their catchment areas. These impacts have resulted in the reduction of the overall PES of wetland features to Category C (UVB02, CVB01 and SEEP01), Category D (CVB02) and Category E (UVB01). However, although degraded, all wetland features were determined to provide, or have the potential to provide, valuable ESS and were ultimately calculated to fall within High EIS Categories.

The majority of the at-risk riverine systems are located within largely natural areas with limited development and the key impact to the systems is therefore the small loss of habitat and slight alteration of flow patterns due to the historical construction of the R101 roadway. The PES scores for the majority of the features were therefore calculated to fall within Class A and B. However, Rip01, Rip02 and Rip11 have been degraded as a result of various factors including the development of lodge infrastructure, the development of access roads, IAPS encroachment, flow modification and erosion. Although significantly degraded, Rip01 is a perennial system which provides a natural migratory corridor through the landscape and is therefore considered to be of a moderate EIS. The remaining riverine systems are intermittent features with poorly defined or non-existent riparian zones and are therefore considered to be of a low EIS. However, these watercourses still provide valuable functions such as attenuation of floodwaters and retention of excess sediments, and the unnecessary disturbance of these features must therefore also be avoided.

According to the KML file provided to ENVASS by the client, the proposed road alignment will predominantly take place into already infilled and transformed areas directly adjacent to the existing R101 roadway within the existing road reserve. However, small areas of wetland habitat will be lost during the widening of the R101 through UVB01 and during the upgrade and widening of bridge crossings at CVB01 and CVB02 (approximately 5,000 m[6]). Although wetland habitat will be permanently lost, the intensity of the impact has been reduced due to the already degraded nature of the habitat that will be infilled and due to the fact that natural processes within the remainder of the wetlands will continue. The impact prior to the implementation of mitigation measures was therefore calculated to be of a medium (negative) significance. The proposed upgrade and realignment of bridge and culvert structures to accommodate the design flood peak, and the implementation of additional design related mitigation measures aimed at improving flow patterns through watercourses will ultimately result in the improvement of the current status quo of the watercourse crossing areas. It has been recommended that IAPS control

[6] Estimation only, based on development footprint kml supplied to ENVASS.

and management should be conducted within the remaining extent of wetland habitat located within the road reserve in order to attempt to mitigate this impact. However, the control of IAPS will not prevent the direct loss of wetland habitat, and the overall impact therefore remained of a medium (negative) significance after the implementation of mitigation measures.

Although the direct loss of wetland habitat from the development footprint cannot be avoided, the strict implementation of the mitigation, rehabilitation and monitoring measures as listed within this report will ensure that all remaining freshwater impacts are reduced to low (negative) significances and that the RMO/REC integrity that has been determined for all at risk systems can be maintained. The site-specific EMPr and conditions stipulated within the WUL and EA for the site, as well as an approved rehabilitation and monitoring programme should guide the conservation and rehabilitation of the at-risk ecosystems.

Considering the project as a whole, it is the specialist's substantive opinion that the proposed development continues, provided that all buffer zones, mitigation and/or rehabilitation measures presented within this report and the site-specific EMPr are strictly implemented and subsequently monitored through a formal monitoring programme approved by the competent authority (DWS).

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12 APPENDIX A: REPRESENTATIVE IMAGES OF AT-RISK WATERCOURSES

Figure A01. Representative images of UVB01 at the existing R101 crossing.

Figure A02. Representative images of UVB02 at the existing R101 crossing.

Figure A03. Representative images of CVB01 at the existing R101 crossing.

Figure A04. Representative images of CVB02 at the existing R101 crossing.

Figure A05. Representative images of portions of CVB02 located directly adjacent to the R101.

Figure A06. Representative images of portions of SEEP01 located adjacent to the R101.

Figure A07. Representative images of portions of perennial Rip01 located adjacent to the R101.

Figure A08. Representative images of portions of non-perennial Rip02 (a), Rip03 (b), Rip04 (c), Rip06 (d), Rip07 (e) and Rip08 (f) at existing R101 crossing points.

Figure A09. Representative images of portions of non-perennial Rip09 (a), Rip10 (b), and Rip11 (c) at existing R101 crossing points.

13 APPENDIX B: SPECIALIST'S QUALIFICATIONS

EMPLOYEE NAME	**WAYNE JOHN WESTCOTT**
POSITION	**BUSINESS UNIT MANAGER/ WETLAND & AQUATIC ECOLOGIST**
DETAILS	**Office: 29 Greenmeadow Lane, Hillcrest, Durban.** **M: 079 491 8685; F: 012 460 3071** **E mail: Wayne@envass.co.za**

EDUCATION AND QUALIFICATIONS

2015	**BSc Honours in Water Resource Management** Department of Environmental Science, Rhodes University
2014	**BSc in Environmental Science and Geography/Geology** Department of Environmental Science, Rhodes University
2010	**Matriculation (IEB Examination)** Stanford Lake College, Limpopo

PROFESSIONAL AFFILIATIONS

Professionally registered with the South African Council of Natural Scientific Professionals (SACNASP) (no. 117334)

Wetland Society of South Africa and KwaZulu-Natal

EXPERIENCE

Employer	**Environmental Assurance (Pty) Ltd. (ENVASS)**
Period	November 2018 – Current
Position	**Business Unit Manager and Divisional Head: Wetland and Aquatics**
Responsibilities	Proposal composition, budget tracking, marketing, fieldwork and report planning, primary client liaison, Freshwater Habitat (wetlands and rivers) Impact Assessments, DWS Risk Assessment Matrix, Aquatic Biomonitoring etc.

Employer	**KSEMS Environmental Consulting**
Period	August 2016 – November 2018
Position	**Project Manager: Specialist Division**
Responsibilities	Proposal composition, budget tracking, marketing, fieldwork and report planning, primary client liaison, Freshwater Habitat (wetlands and rivers) Impact Assessments, DWS Risk Assessment Matrix, Aquatic Biomonitoring etc.

Employer **Westfalia Technological Services**

Period January 2016 – August 2016

Position **Environmental Scientist**

Responsibilities Compilation and management of the Water Management Plan for South Africa, Wetland and Aquatic Delineation Assessments, Compilation and management of Environmental Action and Management Plans, Invasive Alien Species Control Plans, ensure compliance with Tesco, Woolworths and GlobalGap Standards etc.

EXTERNAL COURSES

2019 **Introduction to Hydropedology**
Digital Soils Africa

2019 **Foundations of Project Management**
University of Cape Town

2017 **Soil Classification and Land Capability**
Department of Agriculture, Forestry and Fisheries (DAFF), Cedara College

2017 **SASS5 Aquatic Biomonitoring Accreditation**
Department of Water and Sanitation (DWS)

2016 **Introduction Environmental Impact Assessments (EIA) Procedures**
Rhodes University, EOH Coastal and Environmental Services

2016 **Tools for Wetland Assessment**
Rhodes University (Presented by Prof. William 'Fred' Ellery)

2016 **South African Green Industries Council (SAGIC) Invasive Species Training**
SAGIC

2015 **ESRI GIS Conference Workshops and Seminars**
ESRI South Africa

2015 **Google Earth Pro Workshop**
Rhodes University Environmental Science Department

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Aquatic biodiversity compliance statement for the proposed Kephri Innovation Bioconversion Facility, GP.	Lead Author	Specialist wetland and aquatic work	Kephri Innovations	2021
Wetland and aquatic impact assessment of the proposed upgrade of the SANRAL R101 road from Modimolle to Bela-Bela, LP.	Lead Author	Specialist wetland and aquatic work	GA Environment	2021

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Wetland and aquatic impact assessment of a proposed submarine cable landing in Port Elizabeth, EC.	Lead Author	Specialist wetland, botanical and aquatic work	ACER Africa	2021
Wetland and aquatic impact assessment of a proposed submarine cable landing in Amanzimtoti, KZN.	Lead Author	Specialist wetland, botanical and aquatic work	ACER Africa	2021
Wetland and aquatic impact assessment and rehabilitation plan for the proposed Lwala Mine extension, LP.	Lead Author	Specialist wetland and aquatic work	Samancor ECM	2021
Wetland and aquatic impact assessment and rehabilitation plan for the proposed Mareesburg Mine, LP.	Lead Author	Specialist wetland and aquatic work	Samancor ECM	2021
Wetland impact assessment of the proposed Skanskop Toboggan track, GP.	Lead Author	Specialist wetland work	Nali Solutions	2021
Hillendale Mine 2021 wet season biannual aquatic biomonitoring, KZN.	Lead Author	Specialist aquatic work	Tronox KZN	2021
Fairbreeze Mine 2021 wet season biannual aquatic biomonitoring, KZN.	Lead Author	Specialist aquatic work	Tronox KZN	2021
Central Processing Complex 2021 wet season biannual aquatic biomonitoring, KZN.	Lead Author	Specialist aquatic work	Tronox KZN	2021
Phase 1 desktop screening of three (3) proposed cemetery sites in Mandeni, KZN.	Lead Author	Specialist wetland work	Hanslab	2021
Biannual Aquatic Biomonitoring of the Lydenburg Smelter (Wet season- 2020), MP.	Lead Author	Specialist aquatic work	Glencore SA	2020
Biannual Wetland and Aquatic Assessment of the Exxaro Leeuwpan Colliery (Wet season- 2020), MP.	Lead Author	Specialist wetland & aquatic work	Exxaro	2020
Biannual Wetland Assessment of the Ukufisa Colliery (Wet season- 2020), MP.	Lead Author	Specialist wetland work	Canyon Resources	2020
Biannual Wetland Assessment of the Rietkuil Siding (Wet season- 2020), MP.	Lead Author	Specialist wetland work	Canyon Resources	2020
Biannual Wetland Assessment of the Phalanndwa Colliery Extension (Wet season- 2020), MP.	Lead Author	Specialist wetland work	Canyon Resources	2020
Wetland rehabilitation and monitoring programme for the Erasmus park mixed-use development, GP.	Lead author	Specialist wetland work	Atterbury Group	2020
Wetland assessment of the Hillendale Mine footprint for mine closure application, KZN.	Lead author	Specialist wetland work	Tronox KZN	2020

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Amendments to the wetland, vegetation and aquatic impact assessment of Mtunzini sewer reticulation system, KZN.	Lead Author	Specialist wetland, botanical and aquatic work	ACER Africa	2020
Wetland and Aquatic (SASS5) Impact Assessment of the proposed Benmore Dam rehabilitation project, GP.	Lead Author	Specialist wetland and aquatic work	GA Environment	2020
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 2- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 2- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 2- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020
Biannual SASS5 Biomonitoring of the Glencore Lydenburg Smelter (Dry season 2020), MP.	Lead Author	Specialist aquatic work	Glencore	2020
Biannual SASS5 Biomonitoring of the Arcelor Mittal Vanderbijlpark plant, GP.	Lead Author	Specialist aquatic work	Arcelor Mittal	2020
Biannual SASS5 Biomonitoring of the NECSA facility (Dry season 2020), NW.	Lead Author	Specialist aquatic work	NECSA	2020
Aquatic biomonitoring baseline study of the Sundays River in the vicinity to the existing Olifantskop WWTW, KZN.	Lead Author	Specialist aquatic work	ACER Africa	2020
Wetland delineation and impact assessment of the proposed Mareesburg Haulage Road, MP.	Lead Author	Specialist wetland work	EastPlat	2020
Wetland delineation and impact assessment of the proposed Mpumalanga Business Hive, KZN.	Lead Author	Specialist wetland work	Hanslab	2020
Wetland delineation and impact assessment of the proposed Die Kom and Graauwduin mining extensions at Tronox Namaqua Sands, WC.	Lead Author	Specialist wetland work	Tronox Namaqua Sands	2020
Wetland delineation and rehabilitation plan for the Lydenburg Smelter site, LP.	Lead Author	Specialist wetland work	Glencore	2020
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 1- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 1- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 1- 2020).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2020

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Biannual SASS5 Biomonitoring of the South Deep Gold mine (Wet season 2019), GP.	Lead Author	Specialist aquatic work	Goldfields	2020
Aquatic impact assessment and toxicity testing of a riverine system downstream of Sovereign Foods, NW.	Lead Author	Specialist wetland and aquatic work	Sovereign Foods	2020
Biannual SASS5 Biomonitoring of the Zululand Anthracite Colliery Wet season 2019), KZN.	Lead Author	Specialist aquatic work	Zululand Anthracite Colliery	2020
Biannual Wetland Assessment of the Phalanndwa Colliery Extension (Dry season- 2020), MP.	Lead Author	Specialist wetland work	Canyon Resources	2020
Wetland and Aquatic Impact Assessment of the proposed Ekuvukeni Bulk Water Pipeline and WWTW, KZN.	Lead Author	Specialist wetland and aquatic work	ACER Africa	2019
Wetland Rehabilitation and Management Plan for the proposed Grootfontein Mine, GP.	Lead Author	Specialist wetland work	Brikor	2019
Freshwater Habitat Impact Assessment of the Proposed Mareesburg Haul Road, LP.	Lead Author	Specialist wetland and aquatic work	EastPlats	2019
Freshwater Habitat Impact Assessment of the Proposed L311 and P176 District Roads, KZN.	Lead Author	Specialist wetland and aquatic work	Hanslab	2019
Freshwater Habitat Impact Assessment of the Proposed P280 District Road, KZN.	Lead Author	Specialist wetland and aquatic work	Hanslab	2019
Freshwater Habitat Impact Assessment of the Proposed Majola Bridge, KZN.	Lead Author	Specialist wetland and aquatic work	Hanslab	2019
Biannual Wetland and Aquatic Assessment of the Exxaro Leeuwpan Colliery, MP (Wet- 2019).	Lead Author	Specialist wetland & aquatic work	Exxaro	2019
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 4- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 4- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 4- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Siyaya Estuarine Assessment for the existing Tronox Fairbreeze Mine, KZN (Wet- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Freshwater Habitat Impact Assessment of the Proposed Mtunzini Sewer Reticulation System, KZN.	Lead Author	Specialist wetland and aquatic work	ACER Africa	2019

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Freshwater Habitat Impact Assessment of the Proposed D919 Road Upgrade, KZN.	Lead Author	Specialist wetland and aquatic work	KZN DoT	2019
Aquatic Impact Assessment of the Proposed Mtunzini Waste Water Treatment Works, KZN.	Lead Author	Specialist aquatic work	ACER Africa	2019
Biannual Wetland and Aquatic Assessment of the Exxaro Leeuwpan Colliery, MP (Dry- 2019).	Lead Author	Specialist wetland & aquatic work	Exxaro	2019
Siyaya Estuarine Assessment for the existing Tronox Fairbreeze Mine, KZN (Dry 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Biannual Wetland Assessment of the Phalanndwa Colliery Extension (Wet season- 2019)	Lead Author	Specialist wetland work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Phalanndwa Colliery (Wet season- 2019)	Lead author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Zululand Anthracite Colliery (Dry season 2018).	Lead Author	Specialist aquatic work	Zululand Anthracite Colliery	2019
Biannual Wetland Assessment of the Phalanndwa Colliery Extension (Dry season- 2019)	Lead Author	Specialist wetland work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Phalanndwa Colliery (Dry season- 2019)	Lead author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Singani Colliery Sites (Wet season- 2019).	Lead author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Hakhano Colliery Sites (Wet season- 2019).	Lead author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Khanye Colliery Sites (Wet season- 2019).	Lead author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Bronkhorstspruit Siding Sites (Wet season- 2019).	Lead author	Specialist aquatic work	Canyon Resources	2019
Wetland Impact Assessment of the Rietkuil Siding, GP (Wet season 2019).	Lead Author	Specialist wetland work	Canyon Coal	2019
Biannual SASS5 Biomonitoring of the Blinkpan Railway Siding, MP (Wet season 2019).	Lead Author	Specialist aquatic work	Makoya Group	2019
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 3- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 3- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 3- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Wetland Impact Assessment of the Ukufisa Colliery, GP (Dry season 2019).	Lead Author	Specialist wetland work	Canyon Coal	2019
Biannual SASS5 Biomonitoring of the South Deep Gold mine (Dry season 2019)	Lead Author	Specialist aquatic work	Goldfields	2019
Biannual SASS5 Biomonitoring of the Singani Colliery Sites (Dry season 2019).	Lead Author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Hakhano Colliery Sites (Dry season 2019).	Lead Author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Khanye Colliery Sites (Dry season 2019).	Lead Author	Specialist aquatic work	Canyon Resources	2019
Biannual SASS5 Biomonitoring of the Bronkhorstspruit Siding Sites (Dry season 2019).	Lead Author	Specialist aquatic work	Canyon Resources	2019
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 2- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 2- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 2- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Freshwater Habitat Impact Assessment of the Proposed Woodmead Estate, KZN.	Lead Author	Specialist wetland and aquatic work	ACER Africa	2019
Freshwater Habitat Impact Assessment of the Proposed Hluhluwe Rhino Reserve, KZN.	Lead Author	Specialist wetland and aquatic work	ACER Africa	2019
Freshwater Habitat Impact Assessment of the Proposed Paling Manganese Mine, Northern Cape (NC).	Lead Author	Specialist wetland and aquatic work	PMG Mining	2019
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 1- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 1- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 1- 2019).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2019
Biannual SASS5 Biomonitoring of the Blinkpan Railway Siding, MP (wet season 2018).	Lead Author	Specialist aquatic work	Makoya Group	2019
Wetland Impact Assessment of the Ukufisa Colliery, GP (Wet season 2018).	Lead Author	Specialist wetland work	Canyon Coal	2019
Biannual SASS5 Biomonitoring of the South Deep Gold mine (Wet season 2018)	Lead Author	Specialist aquatic work	Goldfields	2018

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Biannual SASS5 Biomonitoring of the Zululand Anthracite Colliery (Wet season 2018).	Lead Author	Specialist aquatic work	Zululand Anthracite Colliery	2018
Biannual SASS5 Biomonitoring of the Singani Colliery Sites (Wet season 2018).	Lead Author	Specialist aquatic work	Canyon Resources	2018
Biannual SASS5 Biomonitoring of the Hakhano Colliery Sites (wet season 2018).	Lead Author	Specialist aquatic work	Canyon Resources	2018
Bi-annual SASS5 Biomonitoring of the Khanye Colliery Sites (wet season 2018).	Lead Author	Specialist aquatic work	Canyon Resources	2018
Biannual SASS5 Biomonitoring of the Bronkhorstspruit Siding Sites (wet season 2018).	Lead Author	Specialist aquatic work	Canyon Resources	2018
Biannual SASS5 Biomonitoring of the East Plats Western Limb Sites (wet season 2018).	Lead Author	Specialist aquatic work	Eastern Platinum	2018
Biannual SASS5 Biomonitoring of the East Plats MB Sites (wet season 2018).	Lead Author	Specialist aquatic work	Eastern Platinum	2018
Quarterly SASS5 Biomonitoring of the Tronox Fairbreeze Mine (Quarter 4- 2018).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2018
Quarterly SASS5 Biomonitoring of the Tronox Hillendale Mine (Quarter 4- 2018).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2018
Quarterly SASS5 Biomonitoring of the Tronox Central Processing Plant (Quarter 4- 2018).	Lead Author	Specialist aquatic work	Tronox KZN Sands	2018
Biannual SASS5 Biomonitoring of the Lydenburg Smelter Sites (wet season 2018).	Lead Author	Specialist aquatic work	Glencore	2018
Updated Aquatic Impact Assessment for the Existing Tweefontein Waste Water Treatment Works.	Lead Author	Specialist aquatic work	Ix Engineering	2018
Freshwater Habitat Impact Assessment of the Proposed Construction of the Vulindlela Bulk Water Supply Pipeline, KwaZulu-Natal (KZN).	Lead Author	Specialist wetland and aquatic work	Umgeni Water	2018
Freshwater Habitat Impact Assessment of the Proposed National Route 2 (N2) Wild Coast Toll Highway, Section 20, Auxiliary Roads and Material Sources, Eastern Cape (EC).	Co-author	Specialist wetland and aquatic work	SANRAL & Aurecon Group	2018
Freshwater Habitat Impact Assessment of the Proposed Verulam Housing Development, KZN.	Lead Author	Specialist wetland and aquatic work	Cassandra Naidoo	2018

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Freshwater Habitat Impact Assessment of the Proposed Umtshezi East Bulk Water Pipeline, KZN.	Lead Author	Specialist wetland and aquatic work	Acer Africa	2018
Wetland Rehabilitation and Monitoring Plan for the Cato Manor Sewage Pipeline Leakage within Bellair, KZN.	Co-author	Specialist rehabilitation works	eThekwini Metropolitan Municipality: Water and Sanitation	2018
Freshwater Habitat Impact Assessment of the Proposed Diesel Locomotive Workshop and Siding at the Richard's Bay Port, KZN.	Co-author	Specialist wetland and aquatic work	Transnet	2017
Wetland and Aquatic Rehabilitation Plan for the Proposed Diesel Locomotive Workshop and Siding at the Richard's Bay Port, KZN.	Co-author	Specialist wetland and aquatic work	Transnet	2017
Wetland and Aquatic Rehabilitation Implementation Plan for the Dube Precinct (Phase 1), KZN.	Lead Author	Specialist wetland and aquatic work	ACSA & Dube Tradeport (La Mercy Joint Venture)	2017
Freshwater Habitat Impact Assessment of the Proposed Upgrade of the Umbumbulu MR30 Road, KZN.	Lead Author	Specialist wetland and aquatic work	Nyeleti Engineering Consulting	2017
Eskom Road Emergency Maintenance, KZN	Internal reviewer	Specialist wetland and aquatic work	CBR Investments	2017
Freshwater Habitat Impact Assessment of the Proposed Upgrade to the National Route 8 (N8) between Thaba Nchu and Tweespruit and the use of the Eden and Devonshire Borrow Pits, Free State (FS).	Lead Author	Specialist wetland and aquatic work	SANRAL & Royal HaskoningDHV	2017
Freshwater Habitat Impact Assessment of the Proposed Upgrade of the National Route 2 (N2) from the Durban Airport to the iLovu River, KZN.	Lead Author	Specialist wetland and aquatic work	SANRAL & GIBB Engineering	2017
Freshwater Habitat Impact Assessment of the Proposed Construction of the Bloemfontein N8 Ring-road, FS.	Lead Author	Specialist wetland and aquatic work	The Free State Department of Police, Roads & Transport and Nyeleti Consulting	2016

WETLAND AND AQUATIC WORK				
Project	**Role**	**Description**	**Client**	**Year**
Freshwater Habitat Impact Assessment of the Proposed Upgrade to the N2 Gwaaing River Bridge, Western Cape (WC).	Lead Author	Specialist wetland and aquatic work	SANRAL & GIBB Engineering	2016
Freshwater Habitat Impact Assessment of the Proposed Construction of the Mzimkhulwana Bridge, KZN.	Internal review	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Freshwater Habitat Impact Assessment of the Emergency Maintenance Work for the P197-3 Road Culverts, KZN.	Lead Author	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Freshwater Habitat Impact Assessment of the Proposed Keystone Petrol Filling Station, KZN.	Internal reviewer	Specialist wetland and aquatic work	Keystone Developments	2016
Freshwater Habitat Impact Assessment of the Kusa-kusa Irrigation Scheme, KZN.	Internal reviewer	Specialist wetland and aquatic work	Delta BEC	2016
Freshwater Habitat Impact Assessment of the Re-establishment of the P73 road Borrow Pits, KZN.	Internal reviewer	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Freshwater Habitat Impact Assessment of the Proposed Upgrade to the P740 and D985 Roads and Establishment of Two Borrow Pits, KZN.	Co-author	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Freshwater Habitat Impact Assessment of the Proposed Upgrade to the P728 District Road, KZN.	Co-author	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Freshwater Habitat Impact Assessment of the Proposed Baboyi River Bridge, KZN.	Co-author	Specialist wetland and aquatic work	Samani Engineering Consulting	2016
Wetland Delineation Report for the Proposed Ngyico Wetland Tourism Development, EC.	Lead Author	Specialist wetland work	Rhodes University	2015
Delineation and Assessment of Several Wetlands within the Kromme River Catchment, EC.	Field work and assessments	Research work	Rhodes University	2015

CERTIFICATION

I, **WAYNE JOHN WESTCOTT**

Declare that, to the best of my knowledge, all the information contained herein is true.

Signature: ___________________

On the ___24th___ day of May 2021

Louise Zdanow (Pr. Sci. Nat)

Personal Information

Full name:	Louise Zdanow
Nationality:	South African
Address:	Manguzi, KwaZulu-Natal
Cell phone number:	0767255657
Date of Birth:	24/04/1988
Sex:	Female
Home Language:	English
Marital Status:	Married
Drivers Licence:	Code B
Email:	louise@enviroswift.co.za

Professional Profile

Louise is the Managing Director of EnviroSwift KZN (Pty) Ltd. She has a BSc Honours degree in Botany from the University of Cape Town. She began working as an environmental specialist in 2012 and has since gained extensive experience in conducting freshwater as well as vegetation assessments in the residential, mining and infrastructure development industries. Louise is a registered Professional Natural Scientist (Pr. Sci. Nat.) with the South African Council for Natural Scientific Professions (SACNASP, Reg. no. 114072), and is an accredited SASS5 practitioner. She is a member of the South African Wetland Society and the International Association of Impact Assessments South Africa. She has received a certificate of competence for the Tools for Wetland Assessments course attended at Rhodes University; has attended a soil classification course presented by Jon Atkinson of the KZN Department of Agriculture and Rural Development; and has attended a wetland soils course presented by UFS in association with Piet-Louis Grundling.

Areas of Expertise

- Project management
- Riparian Assessments
- Vegetation Assessments
- Environmental Impact Assessments
- Water Use Licence Applications
- Wetland Assessments
- GIS analysis
- Rehabilitation Plans
- General Authorisation Application

Education

2011	**Bachelor of Science (Honours) in Botany** *University of Cape Town*
2007 – 2009	**Bachelor of Science in Environmental Sciences (Cum Laude)** *Nelson Mandela Metropolitan University*
2005	**Matric Certificate** *Pearson High School*

Employment History

EnviroSwift KZN (February 2016 – Present)

Freshwater and Botanical Specialist

Roles and Responsibilities:

- Project management and client liaison;
- Background information gathering with the use of information resources such as ARC GIS and BGIS;
- Identification and delineation of wetlands and riparian zones according to the method supplied by DWA (2005, updated 2008) in combination with wetland soil characteristics guidelines drafted by Job (2009);
- Buffer allocation according to the Buffer Zone Guidelines for Rivers, Wetlands and Estuaries (Macfarlane and Bredin, 2016);
- Classification of freshwater systems according to Ollis *et al* ., 2013;
- Assessment of Wet-Health according to Macfarlane *et al* .,
- Assessment of Wet-Ecoservices according to Kotze *et al* ., 2008;
- Application of the Wetland Index of Habitat Integrity according to DWAF, 2007;
- Application of the river Index of Habitat Integrity Assessment according to Kemper, 1999;
- Application of the Riparian Vegetation Response Assessment Index according to Kleynhans *et al*., 2007;
- Determination of the Ecological Importance and Sensitivity according to Rountree *et al*., 2013.
- Vegetation Present Ecological State assessments;
- Species of Conservation Concern assessments;
- Assessment of the Ecological Importance and Sensitivity of vegetation;
- Assessment of impacts (construction and operation) associated with projects;
- Providing mitigation measures and recommendations in line with the National Water Act as well as National Environmental Management Act;
- Assistance with Water Use Licenses and General Authorisations;
- Application of the Risk Assessment Matrix as required in terms of GA 509 gazetted on the 26th of August 2016;
- Assistance with plant permit applications.

SAS Environmental (January 2012 - November 2015)

Field Biologist

Roles and Responsibilities:

- Vegetation Assessments;
- Freshwater Assessments;
- Desktop Evaluations;
- Permit Applications for Protected Trees and Plants;
- Water Use Licence Applications (WULAs); and
- River Rehabilitation Plans.

External Courses

- **Wetland Rehabilitation Course (2020)**
  Presented by Piet Louis Grundling, Cilliers Blaauw and Jacolette Adams in association with the Centre for Wetland Research and Training (WetRest).
- **Wetland Legislation Course (2020)**
  Presented by Piet-Louis Grundling, Wietsche Roets, Jacolette Adams, Pieter Botha, Franci Gresse and Graeme Engelbrecht in Association with the Centre for Wetland Research and Training (WetRest).
- **Introduction to Wetland Mapping and Ground Truthing Virtual Workshop**
  Presented by Nancy Job, Heidi Nieuwoudt and Faeeza Fortune in association with the Western Cape Wetlands Forum.
- **Wetland Soils (2018)**
  Presented by Piet-Louis Grundling in association with the Centre for Environmental Management, University of the Free State.

- **Soil Classification and Land Capability (2017)**
  Presented by Jon Atkinson of the KZN Department of Agriculture and Rural Development, Cedara College.
- **SASS5 Aquatic Biomonitoring (2017)**
  Presented by Dr Mark Graham in association with the Department of Water and Sanitation.
- **Tools for Wetland Assessment (2016)**
  Presented by Prof Fred Ellery in association with Rhodes University.
- **Grass Identification (2013)**
  Presented by Frits van Oudtshoorn in association with Africa Land Use Training.
- **Fynbos Identification (2013)**
  Presented by Wendy Hitchcock in association with Eco-Activities.

Professional Society Memberships/Accreditations

- SACNASP Professional Natural Scientist (Registration number:114072)
- IAIAsa
- Member of the South African Wetland Society

Relevant Project Experience

Project Title	**Client**	**Year of Assessment**
Freshwater specialist assessment for the proposed Marselle bulk water and sewerage upgrade, Nldambe Local Municipality, Eastern Cape	Indwe Environmental Consulting	2019
Freshwater specialist assessment for Phase 2 of the proposed upgrade of the National Route R336 between Addo and Kirkwood, Sundays River Local Municipality, Eastern Cape.	Terreco Environmental	2019
Freshwater Specialist Assessment for the proposed Thornhill Ministerial Housing Project: Phase 1 Link Upgrades, Nldambe Local Municipality, Eastern Cape	Terreco Environmental	2019
Freshwater specialist assessment for the proposed Sunnydale Phase 2 Extension, Eshowe, KwaZulu Natal	IDM Consultants	2018
Specialist freshwater assessment report for the proposed development of supporting electrical infrastructure to the proposed Kuruman Phase 1 and Phase 2 Wind Energy Facilities near Kuruman in the Northern Cape	CSIR	2018
Freshwater and vegetation assessment for the proposed development of a bridge traversing the White Mfolozi River near Babanango within the Ulundi Local Municipality, KwaZulu Natal	IDM Consultants	2018
Freshwater and vegetation assessment for the proposed Langakazi access road, near Libode, Eastern Cape	Ikamva Consulting	2018
Freshwater specialist assessment for the proposed Vayi-Gxeni stream crossing at Ntsimbini a/a, Bizana, within the Alfred Nzo District Municipality, Eastern Cape	Ikamva Consulting	2017
Freshwater assessment for the proposed development of the Mbabane Pedestrian Bridge II Near Scrum, KwaZulu Natal	Afzelia Environmental Consultants	2016

Ecological assessment for the upgrade of the Lumayeni-Wobe access road near Lusikisiki, Eastern Cape	Ikamva Consulting	2016
Freshwater assessment as part of the Water Use Authorisation Application required for the upgrade of the Hamburg access road from the R72, Eastern Cape Province	Indwe Environmental Consulting	2016
Freshwater assessment as part of the Water Use Authorisation Application required for the upgrade of the Katburg access road from the R67, Eastern Cape Province	Indwe Environmental Consulting	2016
Freshwater ecological assessment as part of the environmental assessment and authorisation process for the proposed Levendal bulk service sewage pipelines, Western Cape Province	Terramanzi Environmental Consulting	2015
Wetland and riparian resource assessment undertaken as part of the Water Use Authorisation for phase 2 and phase 3 of the R310 road upgrade, Stellenbosch, Western Cape Province	SRK	2014
Wetland PES, ecoservices and impact assessment as part of the EIA process for the R45 Road upgrade, Malmesbury, Western Cape Province	SRK	2012