GOD'S WINDOW_SKYWALK:

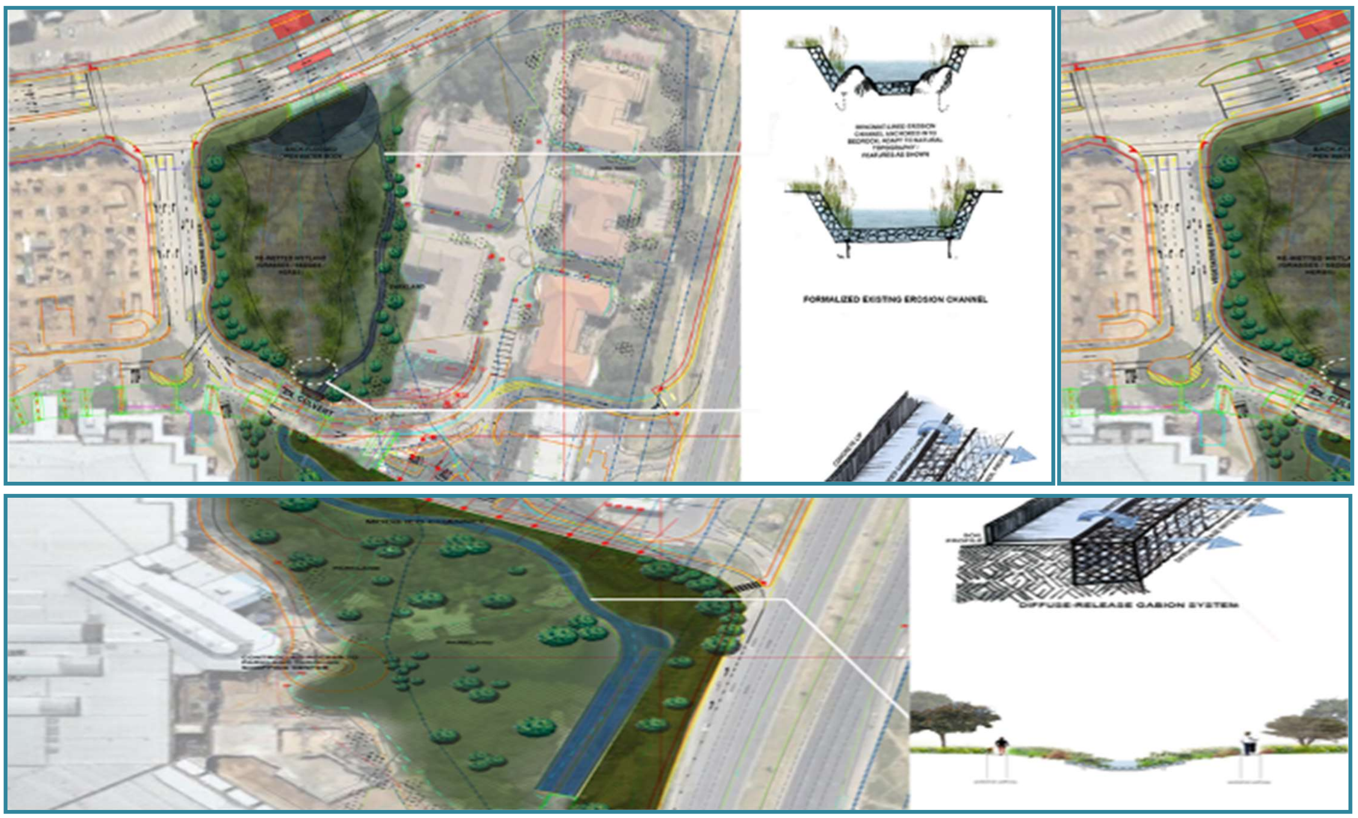
AQUATIC SPECIALIST BIODIVERSITY, WETLAND AND RIPARIAN ASSESMENT

Prepared for:

Zutari (Pty) Ltd

Prepared by:

WaterMakers



July 2022

Minimum Requirements for Aquatic Biodiversity Specialist Assessment as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Protocol ref	Aquatic Biodiversity Specialist Assessment	Section / Page
2.3.	The assessment must provide a baseline description of the site which includes, as a minimum, the following aspects:	Section 2 and Section 3
2.3.1.	a description of the aquatic biodiversity and ecosystems on the site, including;	Section 2, 2.2.3; 2.2.4; 2.2.5
2.3.1. (a)	aquatic ecosystem types; and	
2.3.1. (b)	presence of aquatic species, and composition of aquatic species communities, their habitat, distribution and movement patterns;	
2.3.2.	the threat status of the ecosystem and species as identified by the screening too1[1];	2.2.4; 2.2.5
2.3.3.	indication of national and provincial priority status of the aquatic ecosystem, including a description of the criteria for the given status (i.e. if the site includes a wetland or a river freshwater ecosystem priority area or sub catchment, a strategic water source area, a priority estuary, whether or not they are free-flowing rivers, wetland clusters, a critical biodiversity or ecologically sensitivity area);	Section 2.2.4
2.3.4.	a description of the ecological importance and sensitivity of the aquatic ecosystem including:	Section 3.6
2.3.4. (a)	the description (spatially, if possible) of the ecosystem processes that operate in relation to the aquatic ecosystems on and immediately adjacent to the site (e.g. movement of surface and subsurface water, recharge, discharge, sediment transport, etc.); and	Section 3 & 4
2.3.4. (b)	the historic ecological condition (reference) as well as present ecological state of rivers (in-stream, riparian and floodplain habitat), wetlands and/or estuaries in terms of possible changes to the channel and flow regime (surface and groundwater).	Section 3 and N/A
2.4.	The assessment must identify alternative development footprints within the preferred site which would be of a "low" sensitivity as identified by the screening tool and verified through the site sensitivity verification and which were not considered appropriate.	N/A
2.5.	Related to impacts, a detailed assessment of the potential impacts of the proposed development on the following aspects must be undertaken to answer the following questions:	Section 5
2.5.1.	is the proposed development consistent with maintaining the priority aquatic ecosystem in its current state and according to the stated goal?	Section 5
2.5.2.	is the proposed development consistent with maintaining the resource quality objectives for the aquatic ecosystems present?	N/A
2.5.3.	how will the proposed development impact on fixed and dynamic ecological processes that operate within or across the site? This must include:	
2.5.3. (a)	impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes (e.g. suppression of floods, loss of flood attenuation capacity, unseasonal flooding or destruction of floodplain processes);	Section 4 & 5
2.5.3. (b)	will the proposed development change the sediment regime of the aquatic ecosystem and its sub-catchment (e.g. sand movement, meandering river mouth or estuary, flooding or sedimentation patterns);	Section 5
2.5.3. (c)	what will the extent of the modification in relation to the overall aquatic ecosystem be (e.g. at the source, upstream or downstream portion, in the temporary / seasonal / permanent zone of a wetland, in the riparian zone or within the channel of a watercourse, etc.); and	Section 5
2.5.3. (d)	to what extent will the risks associated with water uses and related activities change;	Section 5
2.5.4.	how will the proposed development impact on the functioning of the aquatic feature? This must include:	Section 5
2.5.4. (a)	base flows (e.g. too little or too much water in terms of characteristics and requirements of the system);	
2.5.4. (b)	quantity of water including change in the hydrological regime or hydroperiod of the aquatic ecosystem (e.g. seasonal to temporary or permanent; impact of over-abstraction or instream or off-stream impoundment of a wetland or river);	

[1] These ecosystems include the National Environmental Management Biodiversity Act. 2004(Act No. 10 of 2004) listed ecosystems.

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Protocol ref	Aquatic Biodiversity Specialist Assessment	Section / Page
2.5.4. (c)	change in the hydrogeomorphic typing of the aquatic ecosystem (e.g,change from an unchannelled valley-bottom wetland to a channelled valley-bottom wetland);	Section 5
2.5.4. (d)	quality of water (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication);	
2.5.4. (e)	fragmentation (e.g. road or pipeline crossing a wetland) and loss of ecological connectivity (lateral and longitudinal); and	
2.5.4. (f)	the loss or degradation of all or part of any unique or important features, associated with or within the aquatic ecosystem (e.g. waterfalls, springs, oxbow lakes, meandering or braided channels, peat soils, etc.);	
2.5.5.	how will the proposed development impact on key ecosystems regulating, and supporting services especially:	Section 3 & 5
2.5.5. (a)	flood attenuation;	
2.5.5. (b)	streamflow regulation;	
2.5.5. (c)	sediment trapping;	
2.5.5. (d)	phosphate assimilation;	
2.5.5. (e)	nitrate assimilation;	
2.5.5. (f)	toxicant assimilation;	
2.5.5. (g)	erosion control; and	
2.5.5. (h)	carbon storage?	
2.5.6.	how will the proposed development impact community composition (numbers and density of species) and integrity (condition, viability, predator-prey ratios, dispersal rates, etc.) of the faunal and vegetation communities inhabiting the site?	
2.6.	In addition to the above, where applicable, impacts to the frequency of estuary mouth closure should be considered, in relation to:	Not applicable
2.6. (a)	size of the estuary;	
2.6. (b)	availability of sediment;	
2.6. (c)	wave action in the mouth;	
2.6. (d)	protection of the mouth;	
2.6. (e)	beach slope;	
2.6. (f)	volume of mean annual runoff; and	
2.6. (g)	extent of saline intrusion (especially relevant to permanently open systems),	

Minimum Content Requirements for Aquatic Biodiversity Specialist Reports as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Aquatic Biodiversity Specialist Assessment Report		
Protocol ref	Content requirement	Section / Page
2.7.1.	contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	Appendix B
2.7.2.	a signed statement of independence by the specialist;	Page v & p32
2.7.3.	a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	Section 3
2.7.4.	the methodology used to undertake the site inspection and the specialist assessment, including equipment and modelling used, where relevant;	Appendix A
2.7.5.	a description of the assumptions made, any uncertainties or gaps in knowledge or data;	Section 1.3
2.7.6.	the location of areas not suitable for development, which are to be avoided during construction and operation, where relevant;	Section 3.3
2.7.7.	additional environmental impacts expected from the proposed development;	Section 5.
2.7.8.	any direct, indirect and cumulative impacts of the proposed development on site;	
2.7.9.	the degree to which impacts and risks can be mitigated;	
2.7.10.	the degree to which the impacts and risks can be reversed;	
2.7.11.	the degree to which the impacts and risks can cause loss of irreplaceable, resources;	
2.7.12.	a suitable construction and operational buffer for the aquatic ecosystem, using the accepted methodologies;	Section 4
2.7.13	proposed impact management actions and impact management outcomes for inclusion in the Environmental Management Programme (EMPr);	Section 5, see recommendations.
2.7.14.	a motivation must be provided if there were development footprints identified as per paragraph 2.4 above that were identified as having a 'low" aquatic biodiversity sensitivity and that were not considered appropriate;	

2.7.15.	a substantiated statement, based on the findings of the specialist assessment, regarding the acceptability or not of the proposed development and if the proposed development should receive approval or not; and	Section 5
2.7.16.	any conditions to which this statement is subjected.	
Minimum Content requirement for Aquatic Biodiversity Compliance Statements as per Protocol for the Specialist Assessment of Environmental Impacts on Aquatic Biodiversity (GN 320 of 20 March 2020)		
Aquatic Biodiversity Compliance Statement		
Protocol ref	Content requirement	Section / Page
3.1.	The compliance statement must be prepared by a suitably qualified specialist registered with the SACNASP, with expertise in the field of aquatic sciences.	p.32. Section 3.4 and Appendix B
3.2.	The compliance statement must:	
3.2.1.	be applicable to the preferred site and the proposed development footprint;	
3.2.2.	confirm that the site is of "low" sensitivity for aquatic biodiversity; and	
3.2.3.	indicate whether or not the proposed development will have an impact on the aquatic features.	
3.3.	The compliance statement must contain, as a minimum, the following information:	
3.3.1.	contact details of the specialist, their SACNASP registration number, their field of expertise and a curriculum vitae;	
3.3.2.	a signed statement of independence by the specialist;	
3.3.3.	a statement on the duration, date and season of the site inspection and the relevance of the season to the outcome of the assessment;	
3.3.4.	a baseline profile description of biodiversity and ecosystems of the site;	
3.3.5.	the methodology used to verify the sensitivities of the aquatic biodiversity features on the site including the equipment and modelling used where relevant;	
3.3.6.	in the case of a linear activity, confirmation from the aquatic biodiversity specialist that, in their opinion, based on the mitigation and remedial measures proposed, the land can be returned to the current state within two years of completion of the construction phase;	
3.3.7.	where required, proposed impact management outcomes or any monitoring requirements for inclusion in the EMPr;	
3.3.8.	a description of the assumptions made as well as any uncertainties or gaps in knowledge or data;	
3.3.9.	any conditions to which this statement is subjected.	
3.4.	A signed copy of the compliance statement must be appended to the Basic Assessment Report or Environmental Impact Assessment Report.	

Declaration of Independence by Specialist

I, **WILLEM LUBBE**, in my capacity as a specialist consultant, hereby declare that I -

- act as an independent consultant;
- will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- declare that there are no circumstances that may compromise my objectivity in performing such work;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability;
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered; and
- as a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member.

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Willem Lubbe Pr.Sci.Nat
Wetland Specialist
SACNASP Reg. No. 004750

23/04/2022

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Date

EXECUTIVE SUMMARY

Zutari (in conjunction with other partners) has been appointed for the management of the God's Window Skywalk project. The God's Window lies on land owned by the State. Development of this area is to allow the communities and residents of nearby areas to derive economic benefits from this portion of land. The God's Window Skywalk Project has been proposed, to be managed by a Consortium involving the local communities surrounding God's Window in partnership with the Mpumalanga Tourist and Parks Agency (MTPA) and other project developers. A business ownership model for the project has been developed and a Public Private Partnership (PPP) agreement has been formed with Motsamayi Tourism Group (Pty) Ltd for the design, finance, build, operate and transfer of the God's Window Skywalk at the Blyde River Canyon Nature Reserve, Mpumalanga. Subsequently, WaterMakers in collaboration with Digital Soils Africa, were appointed to investigate watercourses and the drivers supporting these watercourses within the vicinity of the proposed development in order to qualify and quantify potential impacts and determine appropriate mitigation measures.

In order to enable an adequate description of associated watercourses and to ensure that the freshwater ecosystem study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application as well as in accordance with the Minimum Criteria for Reporting on Identified Environmental Themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, the following approach was to be undertaken:

- Desktop assessment of available freshwater ecosystems;
- Site assessment for identification and delineation of wetland and/or riparian habitat;
- Classification of identified wetland and/or riparian habitat;
- Identification of wetland goods and services by means of the Wet-EcoServices approach, where applicable;
- Determination of the Present Ecological State of identified wetlands by means of the Wet-Health approach, where applicable;
- Determination of Present Ecological State of identified riparian habitat by means of the VEGRAI approach, where applicable;
- Determination of the Ecological Importance and Sensitivity of identified wetlands and/or riparian habitat;
- Determination of potential functional buffer zones for the protection of the associated freshwater ecosystems to inform appropriate planning;
- Integration of hydropedological assessments and findings to quantify potential impact and mitigation measures on the drivers of watercourses;
- Impact assessment and mitigation measures in order to reduce negative impacts from the development; and
- DWS Risk assessment and Matrix compilation for watercourses within 500m from the development.

A total of four riparian networks were delineated within the study area and within 500m downstream from the study area. Several other riparian watercourses north of the study are (upstream) were delineated that support HGM 1. One hydro-geomorphic unit (HGM), comprising one HGM type, HGM 1, a hillslope seepage wetland connected to a watercourse, was delineated and classified within 500m from the proposed development, although upstream and within a neighbouring catchment (and therefore not relevant to the

current assessment). The Misbelt Forest that is situated approximately 300m north of the proposed development acts as a critically important water-source area, classification as true wetland habitat is debatable, albeit tiny pockets contain wetland conditions to some extent, not all classical criteria as a specific hydro-geomorphic type is met. From a hydrological perspective, the Misbelt Forest is situated uphill from the proposed development and thus also not relevant to the assessable impacts likely to arise from the development.

Watercourses within the vicinity of the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increase biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category A/B). The exception was Riparian 1, that has been seriously impacted through historic tourism and road infrastructure development. Collectively these heavily impacted zones form a very small percentage of the total riparian habitat (considering the downstream linkages) within the study area and surroundings. The impacted zone of Riparian 1 includes the historic development of the R534, up to which time both Riparian 1 and Riparian 2 were largely dominated by graminoids and associated grasslands on top of the escarpment. It is hypothesized that subsequent to the development of the road as well as commercial afforestation and associated practises supressed the natural fire regime responsible for maintaining the grasslands. Further impacts that resulted from current tourist facilities include increased run-off peak flows generated by the road and parking facilities, water quality deterioration due to lack of appropriate sewage treatment and management as well as prevalence of exotic invasive species.

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The current scoping phase report needs to be followed by integration of all specialist studies and associated sensitivities in order to avoid impact as far as possible. The mitigation hierarchy should lead the process and followed by a watercourse impact assessment in order to identify and assess the significance of potential impacts caused by the proposed activity and to provide a description of the mitigation required so as to limit the perceived impacts on the natural environment.

Impact considerations identified sedimentation, increased erosion, water quality deterioration, increase in alien vegetation species as well as an altered hydrological regime as the major potential impacts during the construction and operational phases. Several preliminary general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Some of the most pertinent recommendations include:

- The construction of foundations for the new tourist facility could potentially intercept surface water flows, a perched aquifer and or other water-bearing geological features leading to desiccation of wetland and other sensitive habitats, especially cliff edges and headwaters of riparian habitat. However, latest results from geotechnical and hydropedological modelling indicates that the main hydrological mechanisms in the vicinity of the footprint of the proposed development is suggested to be more surface flow orientated. A conservative and precautionary approach in the design has been taken, including limitation of impermeable surfaces as well as roof top indigenous gardens with sub-infrastructure drainage linked to the foundation via pillar drainage, thereby significantly reducing potential impacts on surface and subsurface drainage and daylighting hydrological regimes. Thus, rainwater from the building roof will be released into the environment in a controlled manner to also encourage recharging of the potential sub-surface flows. The development hydrology will thus mimic the site's hydropedology (filling and spilling) though allowing water to potentially recharge through cracks underneath the foundation with excess overflow directed towards Riparian 1 for further attenuation and diffuse release

- The incorporation of the ecological corridor through the rooftop garden would therefore also mimic preconstruction hydrological conditions in order to maximise hydrological support to watercourses via historic flow paths and also aims to restore some of these lost flow-paths as a result of historic infrastructure in the vicinity of the terrain. It is important that the hydropedologist and wetland ecologist continually collaborate with the engineering design team to optimise historic flow paths through appropriate further modelling and input.
- New parking to be laid with permeable block paving. Rainwater will infiltrate through the permeable concrete blocks into a sub-base comprising of stone layers and will encourage recharging of the sub-surface flow. Rainwater which does not infiltrate through the paving blocks will run overland and will be channelled into a stormwater attenuation pond. Stormwater discharged from the attenuation pond into the natural environment in a controlled manner to not exceed the pre-development peak flows, which will also encourage recharging of the sub-surface flow.
- Rehabilitation of Riparian 1 should include attenuation, infiltration and diffuse release mechanisms which can promote artificial wetland conditions capable of polishing stormwater and or treated sewage effluent.
- The watercourse rehabilitation and monitoring plan must be completed during the final detailed design phase in order to ensure that all aspects from the construction phase through to the operational and maintenance phase are incorporated to enhance potential positive outcomes

Considering the level of investigation, baseline conditions and potential impact and mitigation measures that are being developed, from a watercourse perspective it is recommended that the development continuous, as long as all mitigation measures recommended within the current report, the Ecological Report and Hydropedological report are implemented.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Acronyms

CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DWA	Department of Water and Sanitation
DWS	Department of Water and Sanitation
EC	Ecological Category
FEPA	Freshwater Ecosystem Priority Area
GPS	Global Positioning System
HGM	Hydrogeomorphic
NBA	National Biodiversity Assessment
NFEPA	National Freshwater Ecosystem Priority Areas project
NWRS	National Water Resource Strategy
PES	Present Ecological State
SAIAB	South African Institute for Aquatic Biodiversity
SANBI	South African National Biodiversity Institute
SANParks	South African National Parks
VEGRAI	Vegetation Reponses Assessment Index
WMA	Water Management Areas
WRC	Water Research Commission
WWF	Worldwide Fund for Nature

1. INTRODUCTION

1.1 Project Description

Zutari (in conjunction with other partners) has been appointed for the management of the God's Window Skywalk project. The God's Window lies on land owned by the State. Development of this area is to allow the communities and residents of nearby areas to derive economic benefits from this portion of land. The God's Window Skywalk Project has been proposed, to be managed by a Consortium involving the local communities surrounding God's Window in partnership with the Mpumalanga Tourist and Parks Agency (MTPA) and other project developers. A business ownership model for the project has been developed and a Public Private Partnership (PPP) agreement has been formed with Motsamayi Tourism Group (Pty) Ltd for the design, finance, build, operate and transfer of the God's Window Skywalk at the Blyde River Canyon Nature Reserve, Mpumalanga.

The God' Window Sky walk project is unique and a one-of-a kind project in South Africa. God's Window is a landmark in South Africa and its pristine natural beauty is what makes this location so special. The design, construction, development and operation of the God's Window Sky walk will honour this scared, pristine site. The God's Window project will allow one to physically step off the cliff, onto a glass walkway and walk out into the sky, suspended more than 900m over indigenous forest, with a 360° panoramic view of the Blyde River Canyon, the 3rd largest river canyon in the world. It will be the first sky walk of its kind in South Africa as shown in Figure 1, putting God's Window on the bucket list of South African and international tourists. Added to the wonder, the skybridge allows one to walk next to the cliff face suspended over the edge.

Figure 1: Rendering of the God's Window skywalk

The skywalk and skybridge structures will be suspended off the edge of the cliff as shown in Figure 2. The rock mass coupled with an anchorage-foundation system will be used to tie the skywalk back. The skybridge will be anchored on the cliff face. The skywalk structure is no ordinary structure and this feat of engineering will be a marval in itself. In order to deliver a complex engineering project of this nature, the team is made up of a multi-disciplinary technical team with experts covering all specialised requirements – all in South Africa. This project will showcase and be testament to the talent and expertise that South Africa has as it is designed and constructed by South Africans. The technical excellence shown in delivery of this project is potentially award winning in the technical realm. The project will not only be visited for its beauty but the engineering masterpiece that it is will also be the attraction.

Figure 2: The sky walk and sky bridge

The successful delivery of the project is driven by four key criteria: technical feasibility, business viability, human desirability and environmental sustainability. The development of the best solutions for the project will always look for the "sweet spot" between all four criteria. Environmental sustainability is the encircling factor and solution development will ensure the impact of the project is sustainable and honours this criteria. The creation of solutions and the successful development of the project requires a continual collaboration of all parties throughout the project between contractor, engineers, architect, environmental specialists, quantity surveyor, client and community. These parties will collaborate and ensure all four criteria are assessed and considered for design and construction. Technical mastery coupled with digital tools will be used to develop and deliver the project. Digital tools such as the detailed drone survey undertaken of the rock face are used to minimise risk and impact to the environment as well as to increase efficiency. The project team is committed to creating the best solutions for the project ensuring successful delivery of the project and honouring the site and the communities it serves.

1.2 Scope of Work

In order to enable an adequate description of associated watercourses and to ensure that the freshwater ecosystem study conducted is applicable for both an Environmental Authorisation as well as a Water Use Licence Application as well as in accordance with the Minimum Criteria for Reporting on Identified Environmental Themes in terms of sections 24(5)(a) and (h) and 44 of the National Environmental Management Act, 1998, the following approach was to be undertaken:

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- Impact assessment and mitigation measures in order to reduce negative impacts from the development; and
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Multiple site visits during different seasons to the area to be affected by the proposed activity were undertaken in April and June 2014, as well as from the 16th of February to the 18th of February 2022 and the 6th of June to the 9th of June 2022. A detailed description of the methodology used to address the above Terms of Reference is provided in Appendix A.

1.3 Assumptions and Limitations

During the course of the present study, the following limitations were experienced:

- In order to obtain definitive data regarding the biodiversity, hydrology and functioning of particular wetlands and riparian habitat, studies should ideally be conducted over a number of seasons and over a number of years. The current study relied on information gained during several field surveys conducted during two seasons, desktop information for the area, as well as professional judgment and experience;
- Wetland and riparian areas within transformed landscapes, such as tourism infrastructure facilitates, especially areas that have undergone several successional changes due to inappropriate management regimes, are often affected by disturbances that restrict the use of available wetland/riparian indicators, such as hydrophytic vegetation or soil indicators (e.g. as a result of dense stands of alien vegetation, dumping, sedimentation, infrastructure encroachment and infilling). Hence, a wide range of available indicators were considered in order to aid in determining wetland and riparian boundaries more accurately, including detailed UAV surveys with penetrating Lidar;
- Wetland and riparian assessments are based on a selection of available techniques that have been developed through the Department of Water and Sanitation (DWS). These methods are, however, largely qualitative in nature with associated limitations due to the range of interdisciplinary aspects that have to be taken into consideration. Current and historic anthropogenic disturbance within and surrounding the study area has resulted in soil profile disturbances as well as successional changes in species composition in relation to its original /expected benchmark condition;
- Delineations of wetland and riparian areas were largely dependent on the extrapolation of field indicator data obtained during field surveys, contour data for the study area, Lidar generated DEM's, Terrain Wetness Index's (TWI's) and from interpretation of geo-referenced orthophotos and satellite imagery as well as historic aerial imagery data sets received from the National Department of Rural Development and Land Reform. As such, inherent ortho-rectification errors associated with data

capture and transfer to electronic format are likely to decrease the accuracy of wetland boundaries in many instances.

- The author reserves the right to change impact ratings and mitigation measures as more information surfaces.

2. GENERAL CHARACTERISTICS

2.1 Location

The study area is located at God's Window in the Mpumalanga Province approximately 7km north-east of Graskop and falls in Quarter Degree Grid (QDG) 2430DD. The R543 road forms the western boundary of the site (Figure 4). The assessed area entails approximately 10ha around current infrastructure at God's Window, including steep cliffs and inaccessible areas. The approximate centre coordinates for the site is: 24°52'37.06"S and 30°53'16.75"E

2.2 Biophysical Attributes

2.2.1 Climate

The project falls within the summer rainfall area, with warm summers and cool winters. Summer rainfall usually exceeds 1 400 mm per annum, augmented by mist during large parts of the year (Mucina and Rutherford, 2006). The graphs below show the annual average temperatures and precipitation for the Graskop area. Most rain falls during December, which is also the warmest month. Mist is common and days are mostly partly cloudy during summer. Further, according to the Department of Tourism, warm moist air from the Eastern Lowveld and Mozambique coast rises against the slope of the escarpment and at higher altitude cools down to form clouds and precipitation along the escarpment edge. The long-term average annual rainfall at God's Window is approximately 2600mm, whilst extremes, such as during 1996 a total of 5780mm was recorded.

2.2.2 Geology

According to Aurecon (2013), the study area is underlain by sedimentary rocks of the upper and lower parts of the Wolkberg Group belonging to the Transvaal Sequence. The upper part of the Wolkeberg Group consists of the following three formations:

- Sadowa Formation, consisting of dark-grey to brown, well-bedded, micaceous shale with lenticular quartzite layers.
- Mabin Formation, consisting of white, grey to reddish brown, medium- to fine-grained quartzite with pebble fans and interlayered shale layers.
- Selati Formation, consisting of laminated micaceous and graphitic shale, locally interlayered with sandy shale, flagstone and quartzite.

According to ARQ (2013) the upper and lower undifferentiated Wolkberg Groups consist predominantly of conglomerates, quartzite and shale. The report further assumes a shallow sandy soil profile with rock close to surface (Aurecon 2013).

2.2.3 Geotech

The bedrock encountered from surface is generally described as moderately to slightly weathered, closely to medium jointed, medium to coarse grained, hard to very hard rock sandstone. The sandstone bedrock typically occurs from surface to the end of investigated depths with the diabase intrusion encountered between 4 and 5 m (Zutari, 2022). The sandstone from surface is occasionally with dark grey and brown bands of sandstone. These sandstone bands are encountered as soft rock to very hard rock. The diabase intrusion is encountered as closely to medium jointed, slightly to moderately weathered, very hard rock. The above is underlain by a layer of slightly weathered, closely to medium jointed sandstone with dark grey and brown bands of sandstone, that typically extends to 11 m. This is underlain by slightly weathered, close to widely jointed, very hard rock quarzitic sandstone that is interbedded with minor dark grey sandstone bands. This layer extends to about 20 m (Zutari, 2022).

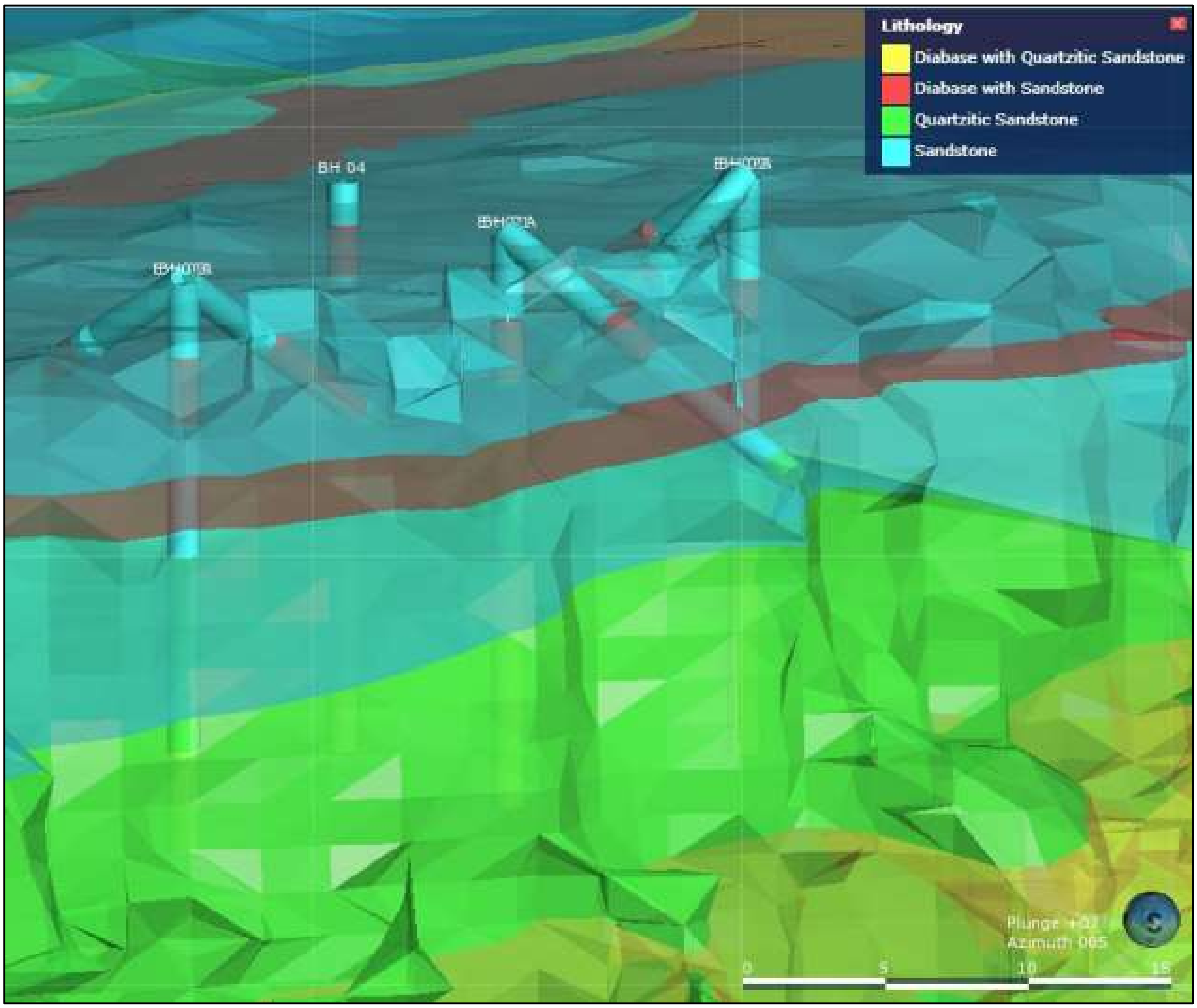

Figure 3: Initial interpretation of the ground model (Zutari, 2022)

2.2.4 Regional vegetation

Regional Vegetation The study area is situated within two Biomes, namely Afrotemperate, Subtropical and Azonal Forests Biome and the Grassland Biome. The Afrotemperate, Subtropical and Azonal Forests Biome is defined as multi-layered vegetation which is dominated by trees with overlapping crown cover and the graminoids in the herbaceous layer are generally rare (Mucina & Rutherford, 2006). These forests are limited to regions with high water availability and persist in areas with mean annual rainfall of more than 725mm per annum during summer. The Grassland Biome is characterized by high summer rainfall and dry winters. Frequent frost during the winter nights as well as marked diurnal temperature variations is unfavourable for tree growth resulting in the Grassland Biome consisting mainly of grasses and plants with perennial underground storage organs, such as bulbs and tubers. A large number of Rare and Threatened plant species in the summer rainfall regions of South Africa is restricted to high-rainfall grassland, making this the vegetation type in most urgent need of conservation.

Biomes can further be divided into smaller units known as vegetation types and according to Mucina and Rutherford (2006), three vegetation types namely Northern Misbelt Forest, Northern Escarpment Afromantane Fynbos and Northern Escarpment Quartzite Sourveld are located within the study area. Northern Misbelt Forest occurs in Limpopo, Mpumalanga and Swaziland along the Soutpansberg from Blouberg in the northwest to the Samadou Plateau in the northeast as well as along the Abel Erasmus Pass to Badplaas and Baberton. This vegetation type is also known as the Mpumalanga Afromontane Forest (Ferrar and Lotter, 2007). The vegetation consists of tall, evergreen afrotemperate Misbelt Forests on east facing cliffs and sheltered kloofs. The most common canopy trees include *Xymalos monospora, Podocarpus latifolius, Combretum kraussii, Cryptocarya transvaalensis* and *Pterocelastrus galpinii*. The understory consists of species such as *Psycotria zombamontana, Canthium kuntzeanum, Gymnosporia harveyana, Peddiea Africana, Mackaya bella* and *Sclerochiton harveyanus*. Northern Misbelt Forest is classified as Least threatnened with about 10% statutorily conserved in the Blyde River Canyon, Lekgalameetse, Songimvelo, Barberton and Starvation Creek Nature Reserves.

Northern Escarpment Afromontane Fynbos is located in the Limpopo and Mpumalanga Provinces where it is restricted to the peaks of Thabakgolo Mountains above Penge, southwards along the highest peaks to Mariepskop and Graskop. The dominant vegetation structure is shrubland which consists of sclerophyllous shrubs and herbs. Important taxa include small trees such as *Protea caffra, P.roupelliae*, succulent species such as *Aloe arborescens* and herbaceous species such as *Erica natalitia, Hypericum revolutum, Passerina montana, Cliffortia linearifolia, Erica revoluta, Erica simii, Euryops pedunculatus* and various *Helichrysum* species. Northern Escarpment Afromontane Fynbos is classified as Least Threatened with more than 56% of this vegetation type protected. Skywalk Wetland Assessment 505201 Strategic Environmental Focus (Pty) Ltd 4 Northern Escarpment Quartzite Sourveld occurs in Limpopo and Mpumalanga Provinces where it occurs along the high-altitude crests of the Northern Escarpment from Haenertsburg to Blyde River Canyon and Kaapsehoop. The landscape is characteristically very rugged with steep east-facing cliffs which are dominated by species such as *Protea roupelliae, Faurea galpinii, Faurea rochetiana, Syzygium cordatum, Cyathea dregai, Vernonia myriantha*. Low shrub species includes *Athrixia phylicoides, Clutia monticola, Crotalaria doidgeae, Erica woodii, Euryops pedunculatus, Aloe arborescens, Crassula sarcocaulis* while the diverse herbaceous layer consists of species such as *Berkheya echinacea, Dicoma anomala, Eriosema angustifolium, Gerbera ambigua, Monsonia attenuate* and *Pearsonia sessilifolia*. Northern Escarpment Quartzite Sourveld is classified as Vulnerable with more than 38% transformed mainly by plantations. It is furthermore noted that this vegetation type coincides with the Wolkberg Centre of Endemism and is rich in endemic plants.

2.3 Freshwater Ecosystem Characteristics

2.3.1 Global Freshwater Ecoregion

The proposed Gods Window Skywalk is located within the Southern Temperate Highveld freshwater ecoregion, which is delimited by the South African interior plateau sub-region of the Highveld aquatic ecoregion, of which the main habitat type, in terms of watercourses, is regarded as Savannah-Dry Forest Rivers. Aquatic biotas within this bioregion have mixed tropical and temperate affinities, sharing species between the Limpopo and Zambezi systems. The Southern Temperate Highveld freshwater ecoregion is considered to be bio-regionally outstanding in its biological distinctiveness and its conservation status is regarded as Endangered. The ecoregion is defined by the temperate upland rivers and seasonal pans (Nel et al., 2004; Darwall et al., 2009; Scott, 2013).

2.3.2 National Ecoregional Typing

Ecoregional typing at a national level based on spatially variable combinations of causal factors including physiography, climate, geology, soils and potential natural vegetation. Accordingly, the proposed Gods Window Skywalk is located within the Northern Escarpment Mountains Ecoregion, and more specifically within Level II Ecoregion 10.02.

2.3.3 Wetland Vegetation

According to the National Biodiversity Assessment's Freshwater Component (Nel and Driver, 2012), the study area falls within the Mesic Highveld Grassland Group 9 wetland vegetation group which has a conservation status of Least Threatened according to the Wetland Vegetation Group's Ecosystem Threat Status.

2.3.4 Associated Aquatic Ecosystems

The NWRS-1 (National Water Resource Strategy, Version 1) originally established 19 Water Management Areas within South Africa and proposed the establishment of the 19 Catchment Management Agencies to correspond to these areas. In rethinking the management model and based on viability assessments with respect to water resources management, available funding, capacity, skills and expertise in regulation and oversight, as well as to improve integrated water systems management, the original 19 designated WMAs have been consolidated into nine WMAs.

The study area is situated within the Southern Temperate Highveld freshwater ecoregion (FEOW, 2014). Further, the study area is located on the watershed of the Inkomati Water Management Area (WMA) and the Olifants WMA. Wetlands within the study that drains west of the watershed feed into the Lisbon River that in turn feed into the Blyde River and eventually feed the Olifants River. Water that drains east of the watershed feeds into the Ngwaritsana River which eventually feeds into Inyaka Dam. (Figure 2).

2.3.5 National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) project represents a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA; now Department of Water and Sanitation, or DWS), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute of Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). More specifically, the NFEPA project aims to:

- Identify Freshwater Ecosystem Priority Areas (hereafter referred to as 'FEPAs') to meet national biodiversity goals for freshwater ecosystems; and
- Develop a basis for enabling effective implementation of measures to protect FEPAs, including free-flowing rivers.

The first aim uses systematic biodiversity planning to identify priorities for conserving South Africa's freshwater biodiversity, within the context of equitable social and economic development. The second aim comprises a national and sub-national component. The national component aims to align DWS and DEA policy mechanisms and tools for managing and conserving freshwater ecosystems. The sub-national component aims to use three case study areas to demonstrate how NFEPA products should be implemented to influence land and water resource decision-making processes at a sub-national level (Driver et al., 2011). The project further aims to maximize synergies and alignment with other national level initiatives such as the National Biodiversity Assessment (NBA) and the Cross-Sector Policy Objectives for Inland Water Conservation. Based on current outputs of the NFEPA project, no FEPA wetlands were identified within the study area, although FEPA wetlands and wetland clusters were identified 450m north of the study area (draining into another catchment (Figure 5).

However, the catchment of the Marite River upstream of its confluence with the Motitsi River (and within which the proposed development will occur) is recognised as a Fish Support Area for *Enteromius brevipinnis, Opsaridium peringueyi, Serranochromis meridianus* and *Labeobarbus nelspruitensis*, and supported wetlands representative of one wetland ecosystem type. In contrast, the catchment of the Lisbon River (located to the west of the proposed development) is identified as being a FEPA catchment, containing various representative river ad wetland ecosystem types that are deemed to be in a good condition (Ecological Category A/B), supporting at least one FEPA wetland cluster as well as being a sub-quaternary necessary for rehabilitation for threatened fish species, including *Enteromius anoplus, Enteromius lineomaculatus, Enteromius treurensis* and *Opsaridium peringueyi.*

2.3.6 Strategic Water Source Areas

Eight per cent of South Africa's land area produces 50% of our surface water. If we can protect this 8% we will go a long way to ensuring a water secure future for South Africa (WWF, 2013). Strategic Water Source Areas (SWSAs) are landscapes where a relatively large volume of runoff produces water for the majority of South Africa. Strategic water source areas can be regarded as natural 'water factories', supporting growth and development needs that are often a far distance away. Deterioration of water quality and quantity in these areas can have a disproportionately large negative effect on the functioning of downstream vegetation ecosystems and the overall sustainability of growth and development in the regions they support (Nel et al., 2013) According to Le Maitre et al. (2018), the project is in the Mpumalanga Drakensberg Surface Water & Northern Lowveld Escarpment Groundwater SWSA. Only 2.63% of this strategic water source is currently protected. Gods Window forms part of a protected area and is thus important to conserve the Mpumalanga Drakensberg Surface Water & Northern Lowveld Escarpment Groundwater SWSA.

2.3.7 Mpumalanga Biodiversity Sector Plan

The Mpumalanga Biodiversity Sector Plan (MBSP) delineates the following categories: Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESAs), Other Natural Areas (ONAs), Protected Areas (PAs), and Modified Area (areas that have been irreversibly modified from their natural state). The map is a fine-scale map (1:10 000 - 1:25 000) that aims to guide sustainable development by providing a map of biodiversity priority areas that can be used by planners and decision-makers in a range of sectors. According to the MBSP the study area falls within an Ecological Support Area (ESA) as important sub-catchment for fish support, as well as based on the SWSA classification of the area.

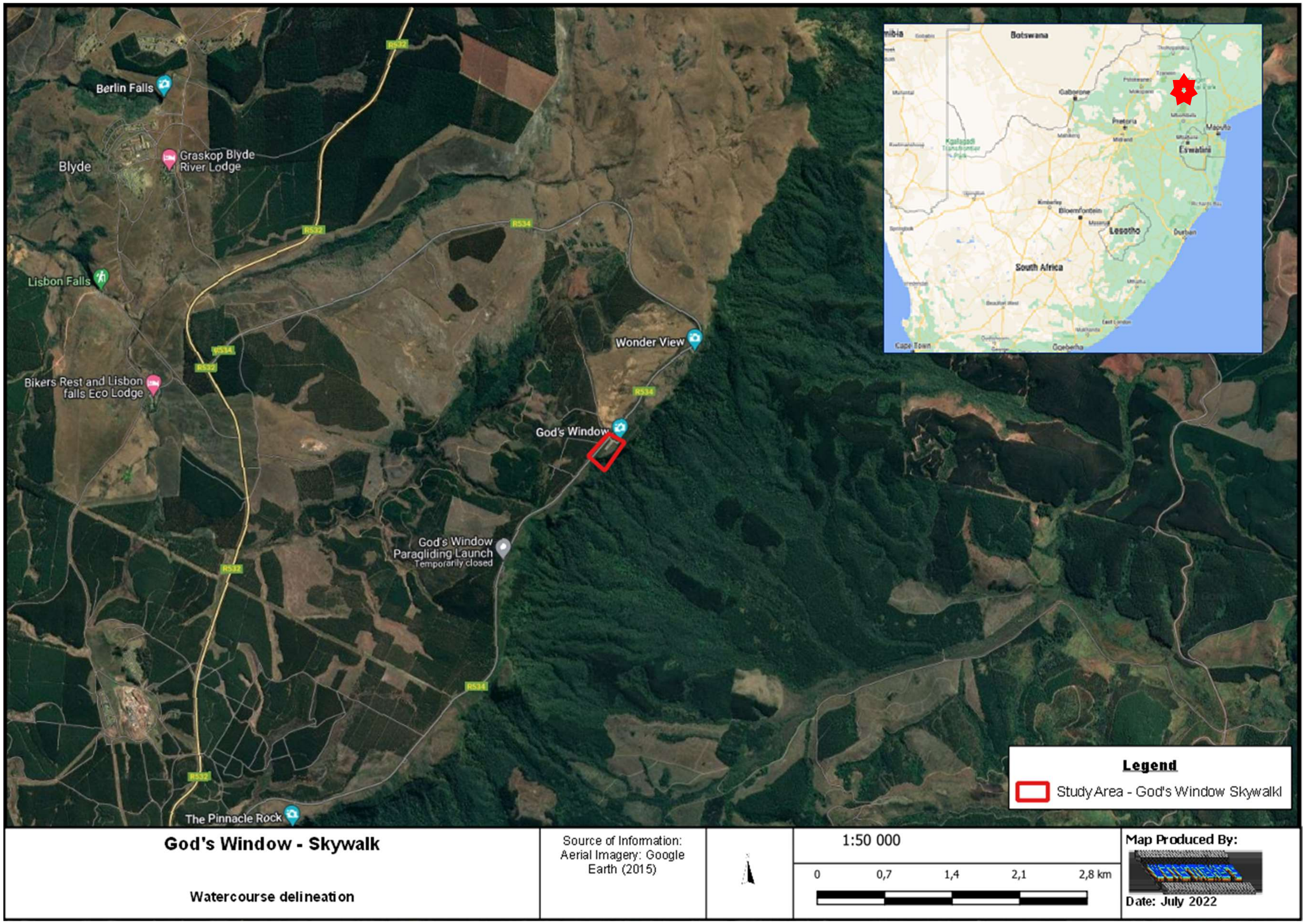

Figure 4: National Freshwater Ecosystem Priority Areas associated with the study area

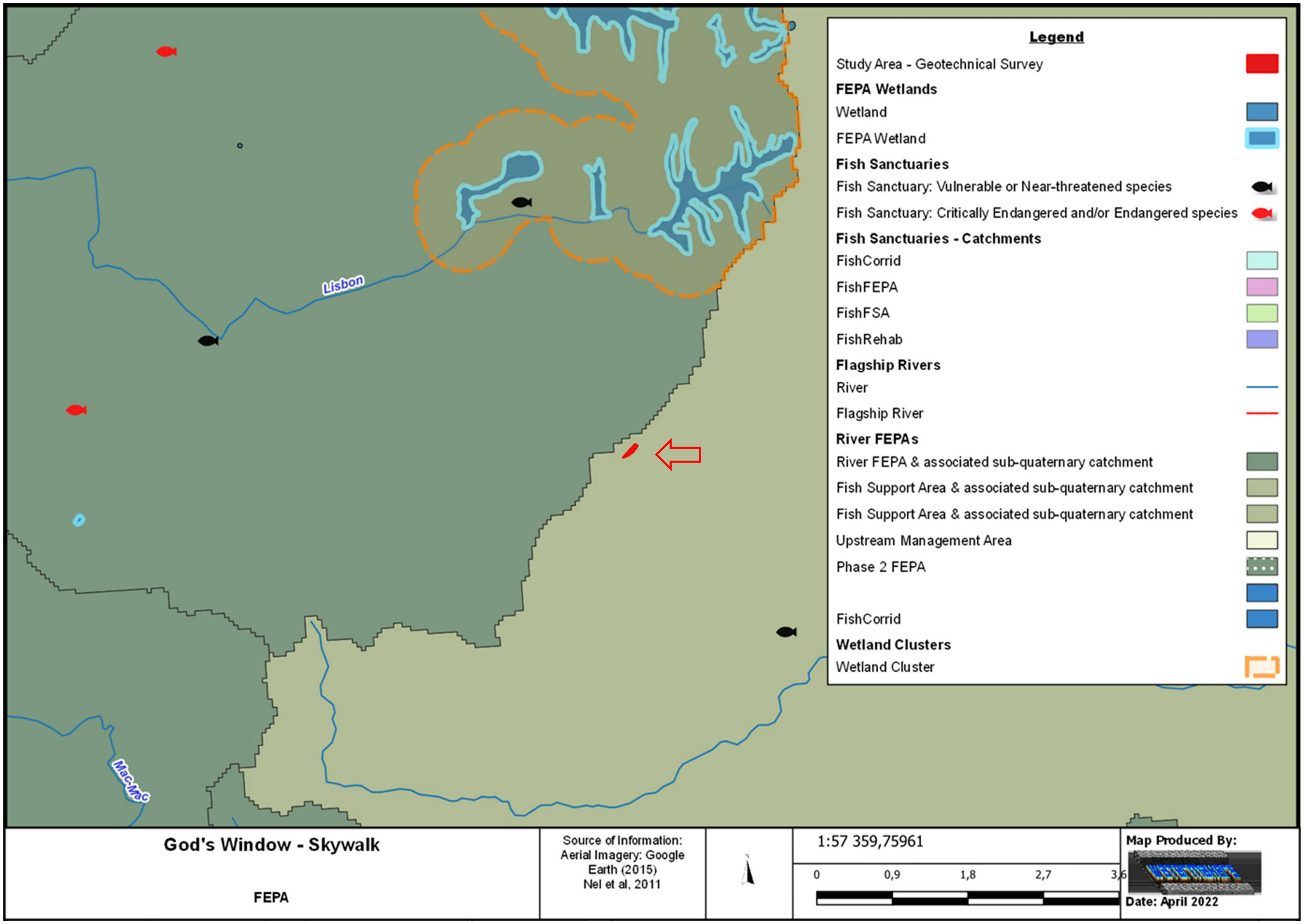

Figure 5: National Freshwater Ecosystem Priority Areas associated with the study area (indicated by red arrow)

3. ASSOCIATED WETLANDS/RIPARIAN AREAS

3.1 Wetland and Riparian soils

According to the Department of Water Affairs and Forestry (DWAF) (2005), the permanent zone of a wetland will always have either Champagne, Katspruit, Willowbrook or Rensburg soil forms present, as defined by the Soil Classification Working Group (1991). The seasonal and temporary zones of the wetlands will have one or more of the following soil forms present (signs of wetness incorporated at the form level): Kroonstad, Longlands, Wasbank, Lamotte, Estcourt, Klapmuts, Vilafontes, Kinkelbos, Cartref, Fernwood, Westleigh, Dresden, Avalon, Glencoe, Pinedene, Bainsvlei, Bloemdal, Witfontein, Sepane, Tukulu, Montagu. Alternatively, the seasonal and temporary zones will have one or more of the following soil forms present (signs of wetness incorporated at the family level): Inhoek, Tsitsikamma, Houwhoek, Molopo, Kimberley, Jonkersberg, Groenkop, Etosha, Addo, Brandvlei, Glenrosa, Dundee (Department of Water Affairs and Forestry, 2005).

The traversed catenas within the direct vicinity of the proposed development revealed no hydromorphic soil forms according to hydromorphic classification of DWAF (2005; 2008). The closest hydromorphic soils were located approximately 300m north of the development and or in a neighbouring catchment, these soils typically included gleylithic subsoil horisons as well as organic rich topsoil horisons. Graskop, Nomanci and Mispah soils with shallow rock dominated the proposed footprint and vicinity with the closest drainage line downstream being dominated by geolithic saprolites.

Redox morphology was absent within the saprolites of riparian habitat and closest delineated watercourse to the study area, Riparian 1, indicating a weak hydrodrological signature. A likely result of anthropogenic topographic manipulation and the possible sterilisation of the original watercourse during road construction of the R534 and existing tourist facilities. Gleyed saprolites and subsurface flow paths were identified upslope and approximately 300m north of the proposed development which indicated the importance of the Misbelt Forest as a water-source area. Soils associated with the Misbelt Forest also contained organic rich topsoils with faint red mottling and rhizospheres as well as gleyed subsoils (Figure 6) which are likely indicative of permanent wet conditions within the Misbelt Forest clumps along the escarpment. Cliff faces below the Misbelt Forest and below the proposed development contained overhangs and cave formations (Figure 7) which were ‘groundwater’ supported developed organic rich soils likely derived from especially mosses and ferns (Figure 8)

Redoximorphic features are the result of the reduction, translocation and oxidation (precipitation) of iron and manganese oxides that occur when soils are saturated for sufficiently long periods of time to become anaerobic. Redoximorphic features typically occur in three types (Collins, 2005):

- **A reduced matrix** - i.e. an *in situ* low chroma (soil colour), resulting from the absence of Fe^3+ ions which are characterised by "grey" colours of the soil matrix.
- **Redox depletions** - the "grey" (low chroma) bodies within the soil where Fe - Mn oxides have been stripped out, or where both Fe-Mn oxides and clay have been stripped. Iron depletions and clay depletions can occur.
- **Redox concentrations** - Accumulation of iron and manganese oxides (also called mottles). These can occur as:

Figure 6: Gleyed saprolites (gleylithic horizon) observed upslope approximately 300m north of the proposed development

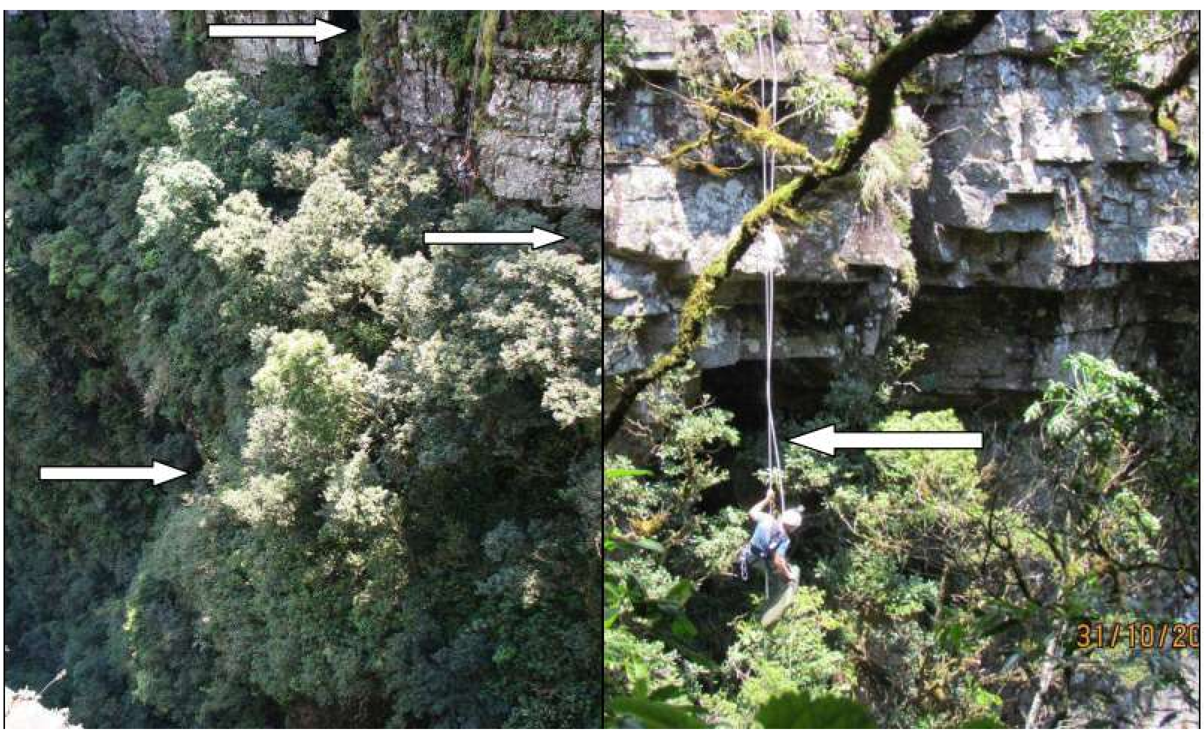

Figure 7: Examples of hydrologically-suported caves and overhangs on cliff faces indicated by white arrows

Figure 8: Caves situated on lower cliff faces supported hydrologically developing shallow organic soils

- Concretions - harder, regular shaped bodies;
- Mottles - soft bodies of varying size, mostly within the matrix, with variable shape appearing as blotches or spots of high chroma colours; and,
- Pore linings – zones of accumulation that may be either coatings on a pore surface, or impregnations of the matrix adjacent to the pore. They are recognised as high chroma colours that follow the route of plant roots, and are also referred to as oxidised rhizospheres

According to the Department of Water Affairs and Forestry (2005), soil wetness indicators (i.e. identification of redoximorphic features) are the most important indicator of wetland occurrence due to the fact that soil wetness indicators remain in wetland soils in most instances, even if they are degraded or desiccated. It is important to note that the presence or absence of redoximorphic features within the upper 500mm of the soil profile alone is sufficient to identify the soil as being hydric (a wetland soil), or non-hydric (non-wetland soil) (Collins, 2005). Redoximorphic features were present in some of the sampled soil profiles north of the study area, such as HGM 1. No redoximorphic features were observed within the vicinity of the proposed development.

3.2 Watercourse Drivers / Hydropedology

According to DSA (2022), modelling results were presented at two different scales to understand the hydrological processes. At the basin scale, the processes that contribute to the five subbasins were presented, while at the LSU scale, the flowpaths of the selected soils in the study are analysed. Evapotranspiration (ET) accounts for a significant portion of the water balance, which is expected from the climate of the site (Figure 9). Water yield (Runoff & Lateral flow) is the most dominant process and accounts for most of most of the water balance. This is expected as large rock outcrops will account for surface runoff and the slope will increase lateral flows (DSA, 2022).

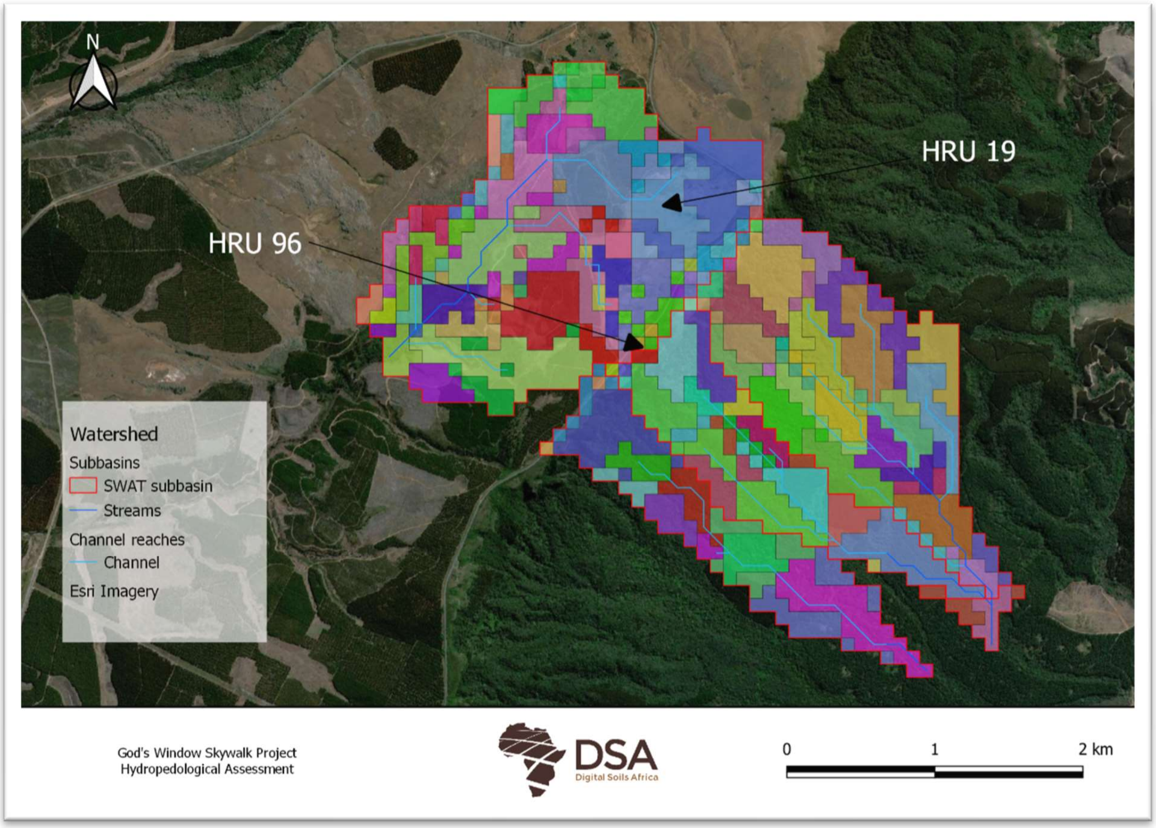

Figure 9: The position of the HRU's and subbasins of the site and surrounding area (DSA, 2022)

DSA (2022), further states that HRU 96 (pertaining to the proposed footprint), is dominated by ET (Evapotranspiration) losses, accounting for 90% of the water balance. This is largely due to losses from the forest vegetation. The transmission (Water lost from tributary channels in the HRU via transmission through the bed. This water becomes recharge for the shallow aquifer during the time step) losses are relatively high (8%). The laterals flows are low and most likely occur during higher rainfall events (These are the lateral flows over and through the soil, not in the drainage channels) (DSA, 2022).

HRU 19 is representative of the larger wetland (HGM1). The land use change to grassland drastically reduced the ET (42%) when compared to the forest (DSA, 2022). Lateral flows are high (35%), mostly dominated by overland flow. This is typical of wetland soils at a slight slope. The percolation is high (12%), this is due to the higher soil water contents which allow drainage through the soils (DSA, 2022).

3.3 Wetland and Riparian Vegetation

According to the Department of Water Affairs and Forestry (2005), vegetation is regarded as a key component to be used in the delineation procedure for wetlands. Vegetation also forms a central part of the wetland definition in the National Water Act, Act 36 of 1998. Using vegetation as a primary wetland indicator however, requires undisturbed conditions (Department of Water Affairs and Forestry, 2005). A cautionary approach must be taken as vegetation alone cannot be used to delineate a wetland, as several species, while common in wetlands, can occur extensively outside of wetlands. When examining plants within a wetland, a distinction between hydrophilic (vegetation adapted to life in saturated conditions) and upland species must be kept in mind. There is typically a well-defined 'wetness' gradient that occurs from the centre of a wetland to its edge that is characterized by a change in species composition between hydrophilic plants that dominate within the wetland to upland species that dominate on the edges of, and outside of the wetland (Department of Water Affairs and Forestry, 2005). It is important to identify the vegetative indicators which determine the three wetness zones (temporary, seasonal and permanent) which characterize wetlands.

Graminoid-dominated seepage wetlands (HGM 1) situated in the adjacent catchment towards the north-west of the proposed development did exhibit such a wetness gradient to some extent. However, as a result of the high rainfall experienced on the escarpment edge (orographic rainfall) combined with shallow soils, this typical gradient of wetness was obscured as many plants within the study area are well adapted to high moisture regimes.

Identified less disturbed riparian habitats of watercourse within the vicinity of the study area (Riparian 2) were dominated by large tree species such as *Afrocarpus falcatus* (Yellowood), *Xymalos monospora* (Lemonwood), *Cussonia spicata* (Cabbage Tree), *Schefflera umbellifera* (False Cabbage Tree) and *Psychotria capensis* (Black Bird Berry). The shrub layer consisted of *Obetia tenax* (Nettle Tree) as well as a diversity of fern species including *Cyathea capensis* (Tree Fern) which is currently listed as Declining. It is likely that water loving plants such as *Clivia caulescens* would utilise more saturated condition while species such as *Cussonia spicata* utilises elevated positions within the microhabitat to avoid more permanent saturated conditions. Other species associated with natural drainage lines included *Morella pilulifera* (broad-leaved waxberry), *Rapanea melanophloeos*(Cape beach), *Psychotria capensis* (yellow-flower bird berry), *Rawsonia lucida* (forest peach), *Kiggelaria africana* (wild peach), *Robsonodendron eucleiforme* (silky bark), *Bowkeria cymosa* (escarpment shellflower). According to Dimela 2022, The forest floor, particularly along the drainage line, were habitat to numerous orchids, ferns and *Streptocarpus* species. Climbers such as *Senecio tamoides* (canary creeper), *Secamone alpini* (monkey rope) and *Dioscorea cotinifolia* (wild yam) were recorded.

Riparian 1 which represented heavily disturbed and potentially artificial riparian habitat were dominated in sections by invasive species such as *Solanum mauritianum* (bugweed) and *Acacia* species as well as indigenous invasive species such as Cliffortia linearifolia and Seripheum species. Tree and shrub species representative of forest margin *Buddleja salvifolia, Hypericum revolutum, Bowkeria cymosa, Psychotria capensis, Trimeria grandiflora* and *Cussonia spicata* were also present with Riparian 1 habitat.

Headwaters that partially originated on the cliffs east of the proposed development hosts numerous rare, provincially protected species, as well as species of conservation concern. The species and their updated threat status included *Schizochilus lilacinus* (Rare), *Monopsis kowynensis* (Vulnerable), *Aloe nubigena* (provincially protected), *Streptocarpus fenestra-dei* (Vulnerable), *Clivia caulescens* (Near Threatened and provincially protected) as well as large populations of *Merwilla plumbea* (Near Threatened). These species are highly sensitive, and their fragile roots can easily be dislodged from the sheer rock faces (Dimela, 2022).

3.4 Delineated Wetland and Riparian Areas

According to the National Water Act (Act no 36 of 1998) a wetland is defined as, "*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." Wetlands typically occur on the interface between aquatic and terrestrial habitats and therefore display a gradient of wetness – from permanent, to seasonal, to temporary zones of wetness - which is represented in their plant species composition, as well as their soil characteristics. It is important to take cognisance of the fact that not all wetlands have visible surface water. An area which has a high water table just below the surface of the soil is as much a wetland as a pan that only contains water for a few weeks during the year. Hydrophytes and hydric soils are subsequently used as the two main wetland indicators. The presence of these two indicators is symptomatic of an area that has sufficient saturation to classify the area as a wetland. Terrain unit, which is another indicator of wetland areas, refers to the land unit in which the wetland is found.

In practice all indicators should be used in any wetland assessment/delineation exercise, the presence of redoximorphic features being most important, with the other indicators being confirmatory. An understanding of the hydrological processes active within the area is also considered important when undertaking a wetland assessment. Indicators should be 'combined' to determine whether an area is a wetland and to delineate the boundary of a wetland. According to Department of Water Affairs and Forestry (2005), the more wetland indicators that are present the higher the confidence of the delineation. In assessing whether an area is a wetland, the boundary of a wetland or a non- wetland area should be considered to be the point where indicators are no longer present.

According to SEF (2014), the hydrology of the area seems interconnected and important in terms of regulating different moisture regimes in different areas, many of these areas serving as habitat harbouring a multitude of species of conservation concern. Lateral water movement seems likely to be an important component of the geohydrology of the area with several seeps occurring in several locations at approximately similar altitudes within the vicinity of the study area. Sub-surface lateral water movement is potentially facilitated in the landscape as a result of the horizontal plain of the quartzite that dominate the site (Figure 4). In addition to the need of providing geotechnical information for the viability and design of sound founding structures, the geological cores and geophysical surveys to be undertaken by this proposed geotechnical survey will hopefully also provide some insight into the potential distribution and flow quantities of subsurface flow paths.

Subsequent to the SEF (2014) watercourse assessment several of the watercourses were re-classified based on new evidence and approaches (including hydropedology and geotechnical surveys) that emerged in subsequent research. A major tool that was utilised in the current delineation was a detailed DEM that was generated by a DEM composition of a UAV born detailed LIDAR and stereoscopic techniques as well as subsequent generated Topographical Wetness Index (TWI), (DSA, 2022) (Figure 10). This approach proved to be cardinal in delineating cryptic riparian habitat within the vicinity of the study area

A total of four riparian networks were delineated within the study area and within 500m downstream from the study area (Figure 12). Several other riparian watercourses north of the study are (upstream) were delineated that support HGM 1. One hydro-geomorphic unit (HGM), comprising one HGM type, HGM 1, a hillslope seepage wetland connected to a watercourse, was delineated and classified within 500m from the proposed development, although upstream and within a neighbouring catchment (and therefore not relavant to the current assessment). The Misbelt Forest that is situated approximately 300m north of the proposed development acts as a critically important water-source area, classification as true wetland habitat is debatable, albeit tiny pockets contain wetland conditions to some extent, not all classical criteria as a specific hydro-geomorphic type is met. From a hydrological perspective, the Misbelt Forest is situated uphill from the proposed development and thus also not relevant to the assessable impacts likely to arise from the development.

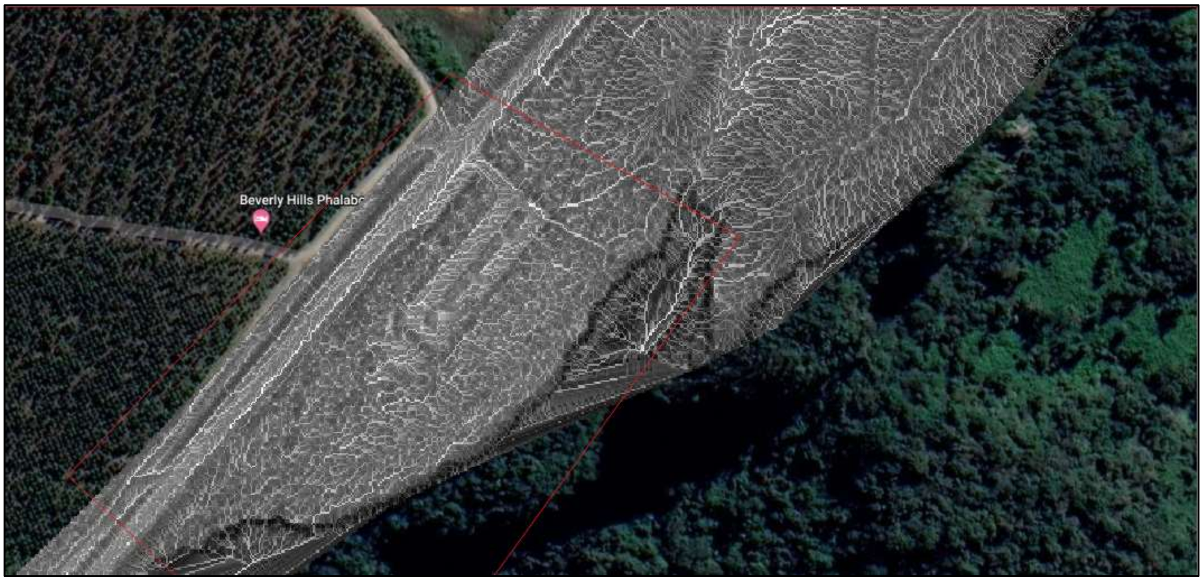

Figure 10: Topographical Wetness Index (TWI) generated for the terrain that simulates preferential drainage patterns (DSA, 2022)

It should be noted that Riparian 1 was previously classified as a hillslope seepage based on what was interpreted as potential champagne soil forms (organic soils), this was likely however sewage solids which was subsequently flushed out of the system which is currently functioning as a riparian channel. Several transects through Riparian 1 indicated geolithic saprolitihic horizons which translates to a likely ephemeral system. The possibility exist that this riparian channel is anthropogenic in nature due to topographical manipulation of the area during the construction of the R543 and existing tourist facilities. Historic imagery suggest that the riparian channel could have been situated slightly more west historically which would explain that geolithic nature of bedrock within the current channel (Figure 11).

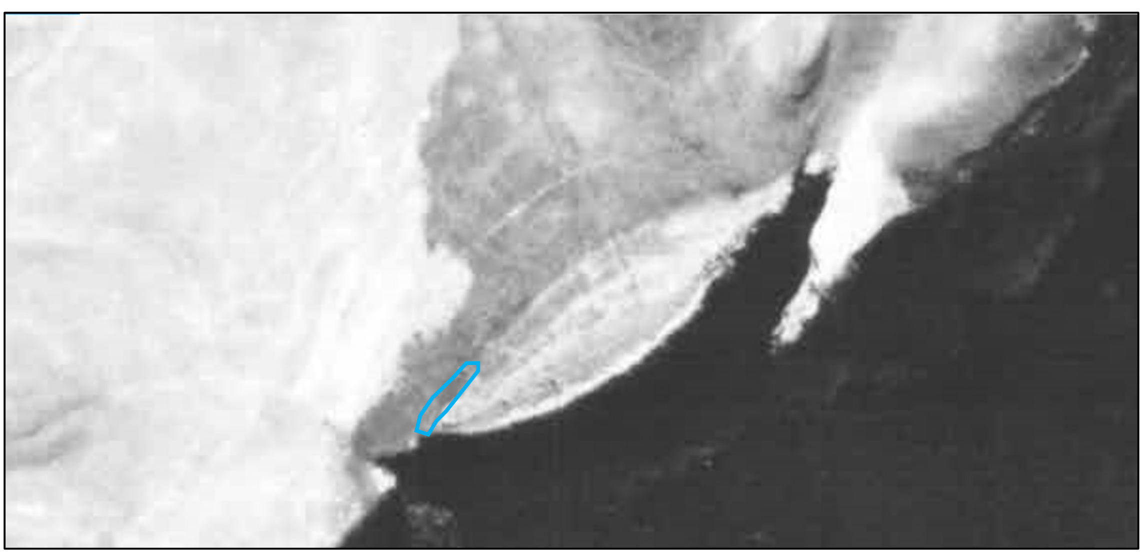

Figure 11: Historic imagery from 1935 (CDNGI, 2022) showing the graminoid dominating vegetation habitat prior to the construction of the R534 and introduction of forestry. Riparian 1 likely historic - light blue;

Further, the portion directly downstream of Riparian 1 could contain what would best be described as small vertical hanging wetlands (hugging the overhanging cliff edge laterally) situated on the >30m vertical cliff face edge. Verification of these “hanging wetlands” will require a rope access approach and will highly likely cause considerable damage to the habitat, therefore it is strongly recommended not to verify and use the pre-cautionary principle instead and consider the cliff edge as hydrologically and ecologically sensitive (due to likelihood of several red data species).

Figure 12: A single transect through the cliff edge vegetation during a study conducted in 2014 suggested some wetland conditions (although not conforming to classical hydro-geomorphological classification) are present (SEF,2014)

The same required NEMA pre-cautionary principle should also be applied to the cliff and cliff edge habitat on the cliffs situated directly south-east and east from the study site, where there is the potential for several small daylighting headwaters through fissures and cracks, representing the very head of several riparian drainages (including Riparian 2 and Riparian 3). Following the NEMA precautionary principle, and considering potential sub-surface drivers of watercourses within the vicinity of the study area, a GN 509 DWS Risk Assessment was followed and a geotechnical investigation subsequently completed in order to enhance understanding of the terrain.

Channel differentiation should be based on the classification of river channels outlined in the DWAF delineation guideline for wetlands and riparian areas Department of Water Affairs and Forestry (2005). The channel network is divided into three types of channels, which are referred to as A Section, B Section or C Section channels. The essential difference between the “A”, “B” and “C” Sections is their position relative to the zone of saturation in the riparian area. The zone of saturation must be in contact with the channel network for base flow to take place at any point in the channel and the classification separates the channel sections that do not have base flow (A Sections) from those that sometimes have base flow (B Sections) and those that always have base flow (C Sections). Riparian networks within the vicinity of the proposed development were regarded as A Section channels, B Section channels and C Section channels. The A Sections are those headward channels that are situated well above the zone of saturation at its highest level and because the channel bed is never in contact with the zone of saturation, these channels do not carry baseflow (DWAF, 2005). The A Sections are the least sensitive watercourses in terms of impacts on water yield from the catchment and are not regarded as having riparian habitat (Department of Water Affairs and Forestry, 2005). B and C section channels were delineated and represented in the current delineation with Riparian 1 being delineated on a precautionary principle.

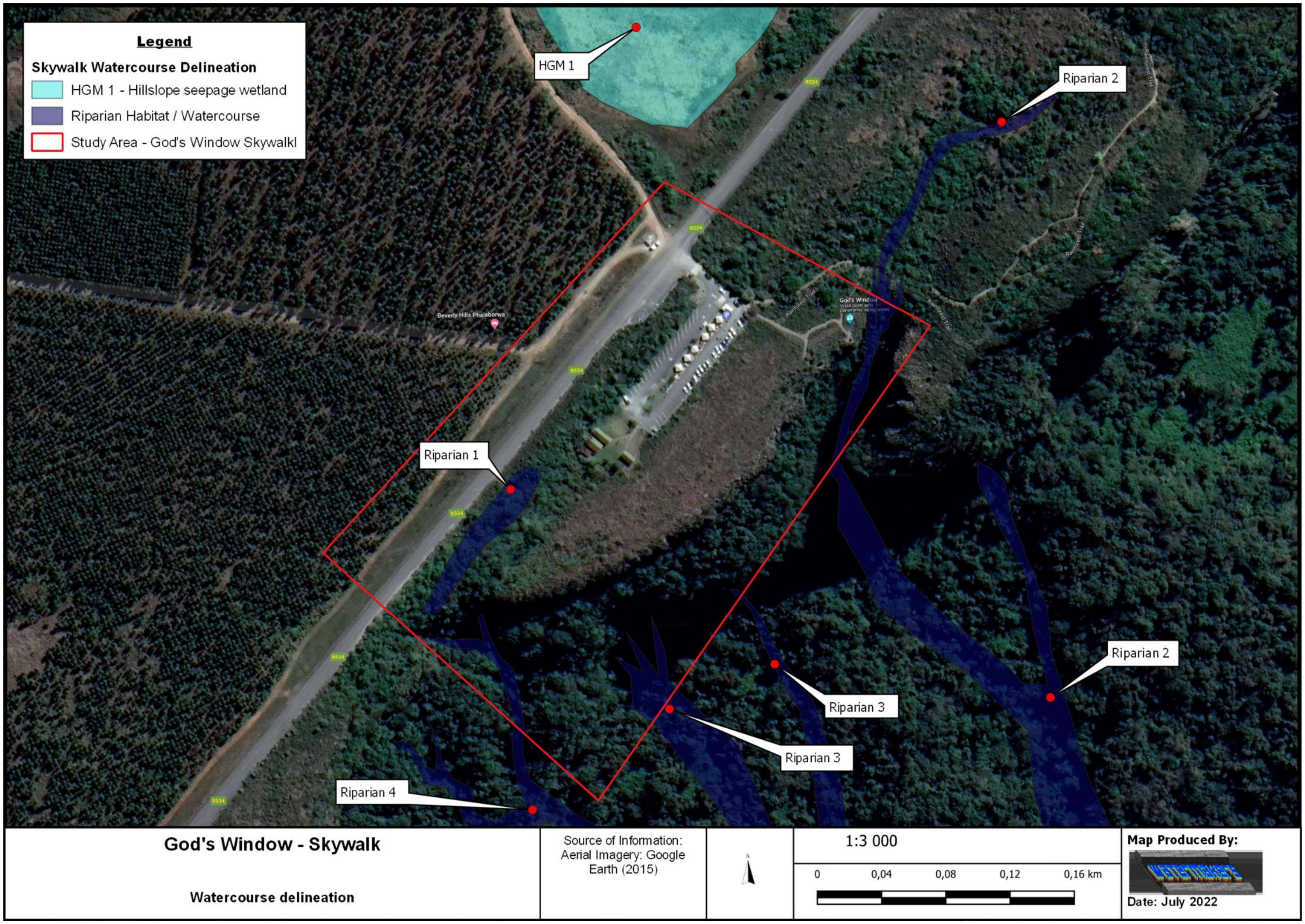

Figure 13: Wetland and Riparian Delineation for the study area

3.5 Aquatic Biota and Freshwater Biodiversity Impact Statement

"Given the lack of surface water associated with the development footprint of the proposed Gods Window Skywalk, no aquatic biodiversity elements are expected. Accordingly, no aquatic biodiversity studies are deemed feasible.

With regards to Impacts on Aquatic Biodiversity Features, given the lack of surface water presence within the proposed footprint of the Gods Window site, it is unlikely that the proposed development will have any direct impact on aquatic biota within the larger affected catchment, and thus any direct impact on the FEPA designation of the associated catchment. However, one must be cognisance of possible surface water runoff and discharges in downslope watercourses and mitigated accordingly through appropriately designed and maintained infrastructure as well as appropriate management regimes. In addition, consideration must be given to possible impacts associated with potential rockfalls into watercourses located at the base of the escarpment, and every effort should be made in preventing such rockfalls. An additional consideration should be the potential for members of the public (i.e. users of the Skywalk facility) to dispose of waste over the Skywalk, with such items accumulating within the natural habitat at the base of the escarpment (including watercourses)."

25 July 2022

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3.6 Functional and Present Ecological State Assessment

The Present Ecological State of the riparian zones were assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Level 3 approach (Kleynhans et al., 2007). Riparian vegetation areas were divided into two sub-zones which included marginal and non-marginal zones. Recognition of the different zones are important given that riparian vegetation distribution and species composition varies in different sub-zones, which has implications for flow-related impacts. Since all VEGRAI assessments are relative to the natural unmodified conditions (reference state) it is necessary and important to define and describe the reference state for the study area (Kleynhans et al., 2007). This was done (in part) before going into the field using historic aerial imagery, present and historic species distributions, general vegetation descriptions of the study area, knowledge of the area and comparison of the study area characteristics to other comparable sections of the stream that might be in a better state. According to Kleynhans et al. (2007), the reference (and present state) is quantified on site; the assessor reconstructs and quantifies the reference state from the present state by understanding how visible impacts have caused the vegetation to change and respond.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category A/B; Table 1).

The exception was Riparian 21 that has been seriously impacted through historic tourism and road infrastructure development. Collectively these heavily impacted zones form a very small percentage of the total riparian habitat (considering the downstream linkages) within the study area and surroundings. The impacted zone of Riparian 1 includes the historic development of the R534, up to which time both Riparian 1 and Riparian 2 were largely dominated by graminoids and associated grasslands on top of the escarpment (Figure 6). It is hypothesized that subsequent to the development of the road as well as commercial afforestation and associated practises supressed the natural fire regime responsible for maintaining the grasslands. The construction of the R534 and associated manipulation of the local manipulation could have sterilised the very upper head portion of Riparian 2. Further, the development of the sealed parking lot which likely resulted in a significant increase in run-off peak flows received during precipitation events. The construction of sewage infrastructure and concrete settling tanks directly impacted on the riparian habitat and was continuously overflowing during both last two site visits. Overflowing sewage also potentially represents a significant quality impact on the downstream watercourses and surrounding habitat (vertical drop > 30m just downslope from Riparian 1). In addition to the successional vegetation changes observed post 1935 (relating to forestry and road construction), significant vegetation changes were also observed within Riparian 1 from 2014 to the current field surveys in 2022, where large sections that was previously dominated by Bracken Fern (*Pteridium aquilinum*), now being dominated by Bugweed (*Solanum mauritianum)*. There is also substrate changes and an increase of signs of recent erosion that are evidently the result of high run-off events. According to Dimela (2022), a recent fire and associated helicopter water drops could have caused significant impacts on the local vegetation in especially particular patches e.g. cliff edge communities. In addition, the overflowing sewage is also creating marshy conditions resembling a wetland, further continuing causing successional changes to the riparian vegetation.

Table 1: VEGRAI score for the riparian vegetation calculated for riparian habitat associated with the various riparian areas associated with the present study area

Riparian Unit	VEGRAI Score	Ecological Category
Riparian 1	81.8	**E**
Riparian 2	83.1	**B**
Riparian 3	82.9	**A**
Riparian 4	81.2	**A**

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment. The study area forms part of an Ecological Support Area (ESA) and Strategic Water Source Area (SWSA) and forms part of a protected area. Taking the above into consideration there is a opportunity to have a positive impact through appropriate infrastructure development on Riparian 1, especially through implementing SUDS principles and especially through resolving the continuous pollution issue emanating from the failed sewage infrastructure currently operating on terrain.

3.7 Ecological Importance and Sensitivity

All wetlands, rivers, their flood zones and their riparian areas are protected by law and no development is allowed to negatively impact on rivers and river vegetation without a water use license. The vegetation in and around rivers and drainage lines play an important role in water catchments, assimilation of phosphates, nitrates and toxins as well as flood attenuation. Quality, quantity and sustainability of water resources are fully dependent on good land management practices within the catchment. All flood lines, riparian zones and wetlands along with corresponding buffer zones must be designated as sensitive.

Ecological importance refers to biophysical aspects in the sub-quaternary reach that relates to its capacity to function sustainably. In contrast, ecological sensitivity considers the attributes of the sub-quaternary reach that relates to the sensitivity of biophysical components to general environmental changes such as flow, physico-chemical and geomorphic modifications. Essentially, the ecological importance and the ecological sensitivity of the relevant reaches are assessed to obtain an indication of its vulnerability to environmental modification within the context of the PES. This would relate to the ability of the sub-quaternary reach to endure, resist and recover from various forms of human use (Department of Water and Sanitation, 2014).

The Ecological Importance and Sensitivity (EIS) assessment was undertaken to rank water resources in terms of:

- Provision of goods and service or valuable ecosystem functions which benefit people;
- biodiversity support and ecological value; and
- Reliance of subsistence users (especially basic human needs uses).

Water resources which have high values for one or more of these criteria may thus be prioritised and managed with greater care due to their ecological importance (for instance, due to biodiversity support for endangered species), hydrological functional importance (where water resources provide critical functions upon which people may be dependent, such as water quality improvement) or their role in providing direct human benefits (Rountree et al., 2013). The Ecological Importance and Sensitivity of the riparian habitat in the study area were determined using the River Ecological Importance & Sensitivity (EIS) DWAF riverine EIS tool (Kleynhans, 1999). A Summary of results are displayed in Table 2 below.

Table 2: Ecological Importance and Sensitivity scores for Riparian habitat within the study area.

Riparian Unit	EIS Score (0 – 5)	Class
Riparian 1	2.9	**Moderate**
Riparian 2	4,8	**Very High**
Riparian 3	4,8	**Very High**
Riparian 4	4,7	**Very High**

In terms of ecological importance and sensitivity, riparian habitat (Riparian 1 to Riparian 4) within the study area was designated as sensitive as a result of the ecological and functional values attributed to riparian areas in general, legal regulations and requirements as well as the supporting ecological services afforded to the downstream ecosystems.

Further, in support of the above statement, riparian functions have both on-site and off-site effects, some of which may be expressed as goods and services available to society (Table 3). For example, functions related to hydrology and sediment dynamics include storage of surface water and sediment, which reduces damage from floodwaters downstream from the riparian area. Similarly, the function of cycling and accumulating chemical constituents has been measured in a number of studies on nitrogen and phosphorus cycling (Anon, 2002). These studies have shown that nutrients are intercepted, to varying degrees, as runoff passes through managed and natural riparian zones. The societal benefit is the buffering effect of pollutant removal, a service that has been a major motivation for protecting and managing riparian areas.

The hydrologic, nutrient cycling, and habitat/food web functions of riparian areas correspond to goods and services such as support of biodiversity, flood peak reduction, and removal of pollutants from runoff (Anon, 2002). Except for support of biodiversity, some of the environmental services of riparian areas can be provided by technologies, such as reservoirs for flood peak reduction and wastewater treatment plants for pollutant removal. However, these substitutions are directed at single functions rather than the multiple functions that riparian areas carry out simultaneously and with little direct costs to society (Anon, 2002).

Table 3: Functions of riparian areas and their relationship to environmental services (Anon, 2002)

Examples of functions	**Indicators that functions exist**
Hydrology and Sediment Dynamics	
Stores surface water over the short term	Floodplain connected to stream channel
Maintains a high-water table	Presence of flood-tolerant and drought intolerant plant

	species
Accumulates and transports sediments	Riffle-pool sequences, point bars, and other features
Biogeochemistry and Nutrient Cycling	
Produces organic carbon	A balanced biotic community
Contributes to overall biodiversity	High species richness of plants and animals
Cycles and accumulates chemical constituents	Good chemical and biotic indicators
Sequesters carbon in soil	Organic-rich soils (marginal zone)
Habitat and Food Web Maintenance	
Maintains streamside vegetation	Presence of shade-producing canopy
Supports characteristic terrestrial vertebrate populations	Appropriate species having access to riparian area
Supports characteristic aquatic vertebrate populations	Migrations and population maintenance of fish

According to Anon (2002), the effects of functions sometimes are expressed off-site as well. Indicators are often used to evaluate whether or not a function exists and are commonly used as shortcuts for evaluating the condition of riparian areas. The functions listed in Table 4 are examples only and are not comprehensive.

Table 4: Examples of on-site and off-site riparian functions in terms of goods and services valued by society (modified from NRC, 1995)

On-site or of-site Effects of Functions	**Goods and Services Valued by Society**
Attenuates downstream flood peaks	Reduces damage from floodwaters (Daily, 1997)
Maintains vegetation structure in arid climates	Contributes to regional biodiversity through habitat (e.g., forest canopy) provision (Szaro, 1991; Ohmart, 1996; James et al., 2001)
Contributes to fluvial geomorphology	Creates predictable yet dynamic channel and floodplain dynamics (Beschta et al., 1987a; Klingeman et al., 1999)
Provides energy to maintain aquatic and terrestrial food webs	Supports populations of organisms (Gregory et al., 1991; Meyer and Wallace, 2001)
Provides reservoirs for genetic diversity	Contributes to biocomplexity (Szaro, 1991; Naiman and Rogers, 1997; Pollock et al., 1998)
Intercepts nutrients and toxicants from runoff	Removes pollutants from runoff (Bhowmilk et al., 1980; Peterjohn and Correll, 1984)
Contributes to nutrient retention and to sequestration of carbon dioxide from the atmosphere	Potentially ameliorates global warming (Van Cleve et al., 1991)
Provides shade to stream during warm season	Creates habitat for fish dependant on colder water (Beschta et al., 1987b; McCullough, 1999)
Allows daily movements to annual migrations	Supplies objects for bird watching, wildlife enjoyment, and game hunting (Green and Tunstall, 1992; Flather and Cordell, 1995)
Allows migratory fish to complete life cycles	Provides fish for food and recreation (Nehlsen et al, 1991; Naiman et al., 2000)

Anon (2002) further states that riparian areas, in proportion to their area within a watershed, perform more biologically productive functions than do uplands (terrestrial habitat). Riparian areas provide a wide range of functions such as microclimate modification and shade, bank stabilization and modification of sedimentation processes, contributions of organic litter and large wood to aquatic systems, nutrient retention and cycling, wildlife habitat, and general food-web support for a wide range of aquatic and terrestrial organisms. Thus, even though they occupy only a small proportion of the total land base in most watersheds, they are uniquely positioned between the aquatic and terrestrial ecosystems to provide a wide range of functions critical for many aquatic and terrestrial species, for maintenance of water quality, for aesthetics, for the production of goods and services, and for a wide range of social and cultural values (Anon, 2002). Because riparian areas are located at the convergence of terrestrial and aquatic ecosystems, they are regional hot spots of biodiversity and often exhibit high rates of biological productivity in marked contrast to the larger landscape. This is particularly dramatic in arid regions, as evidenced by the high number of plant and animal species that find crucial habitats along watercourses and washes. Riparian areas provide connectivity at all spatial and temporal scales, helping maintain landscape biodiversity by countering the negative ecological effects of habitat fragmentation (Anon, 2002).

Considering the largely intact nature and present ecological condition associated with the majority of riparian habitat within the study area, all riparian habitat within the vicinity of the study area was designated as sensitive as a result of the high ecological and functional values attributed to riparian areas in general and specifically the presence of so many species of conservation concern, legal regulations and requirements.

4. FRESHWATER ECOSYSTEM BUFFERS

Buffer zones associated with water resources have been shown to perform a wide range of functions, and have been proposed as a standard measure to protect water resources and associated biodiversity on this basis. These functions can include (Macfarlane & Bredin, 2016):

- Maintaining basic aquatic processes;
- Reducing impacts on water resources from upstream activities and adjoining land uses;
- Providing habitat for aquatic and semi-aquatic species;
- Providing habitat for terrestrial species; and
- A range of ancillary societal benefits.

However, despite the range of functions potentially provided by buffer zones, buffer zones are unable to address all water resource-related problems. For example, buffers can do little to address impacts such as hydrological changes caused by for example stream flow reduction activities or changes in flow brought about by abstractions or upstream impoundments. Buffer zones are also not the appropriate tool for mitigating against point-source discharges (e.g. sewage outflows), which can be more effectively managed by targeting these areas through specific source-directed controls (Macfarlane & Bredin, 2016).

Considering the specific and unique singularity of the proposed footprint of the development, the degraded/anthropogenic state of Riparian 1 (and required rehabilitation within and directly surrounding Riparian 1), freshwater ecosystem buffers were not considered a viable option from a watercourse mitigation perspective. Instead, mitigation measures will be designed site specifically in order to eliminate current negative impacts associated with riparian habitat and aim to enhance potential positive outcomes such as more sensitive stormwater attenuation, infiltration and appropriate sewage treatment and polishing with diffuse release where appropriate. See Impact session for further details pertaining to mitigation.

5. IMPACT ASSESSMENT

Potential impacts of the proposed activity on the associated aquatic ecosystem were assessed in terms a formalised method, whereby a typical risk assessment process was undertaken in order to determine the significance of the potential impacts without the application of mitigation/management measures (i.e. without mitigation measures, or WOMM). Once the significance of the impacts without the application of mitigation/management measures was known, the impacts were then re-evaluated, taking cognisance of proposed mitigation/management measures provided in order to reduce the impact (i.e. with mitigation measures, or WMM), thus enabling an understanding of the overall impact after the implementation of mitigation/management measures.

In order to assess these impacts, the proposed development has been divided into two project phases, namely the construction phase and the operational phase. The criteria against which these activities were assessed are discussed below.

The possible impacts, as described in the next section, were assessed based on the Significance Rating as received from Zutari. The Significance of the impact is calculated as follows and rating significance is explained below:

Significance = Consequence (Extent + Duration+ Magnitude) X Probability

I. The nature, which shall include a description of what causes the effect, what will be affected and how it will be affected.
II. The extent, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high):
III. The duration, wherein it will be indicated whether

- the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
- the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
- medium-term (5–15 years) – assigned a score of 3;
- long term (> 15 years) - assigned a score of 4; or
- permanent - assigned a score of 5;

IV. The consequences (magnitude), quantified on a scale from 0-10, where

- 0 is small and will have no effect on the environment,
- 2 is minor and will not result in an impact on processes,
- 4 is low and will cause a slight impact on processes,
- 6 is moderate and will result in processes continuing but in a modified way,
- 8 is high (processes are altered to the extent that they temporarily cease), and
- 10 is very high and results in complete destruction of patterns and permanent cessation of processes.

V. The probability of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where

- 1 is very improbable (probably will not happen),
- 2 is improbable (some possibility, but low likelihood),

- 3 is probable (distinct possibility),
- 4 is highly probable (most likely) and
- 5 is definite (impact will occur regardless of any prevention measures).

VI. The significance, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
VII. The status, which will be described as either positive, negative or neutral.
VIII. The degree to which the impact can be reversed.
IX. The degree to which the impact may cause irreplaceable loss of resources.
X. The degree to which the impact can be mitigated.

The significance weightings for each potential impact are as follows:

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

Table 5: Possible impacts arising during the construction phase

Possible impact	Source of impact
Sedimentation of watercourse	Runoff from construction activities associated with clearing of natural vegetation
Increased erosion and increased run-off received by water courses	Heavy machines clearing vegetation for construction
Introduction and spread of invasive vegetation	Disturbance / destruction of indigenous vegetation making ecosystem vulnerable to invasions
Impacts on ground and surface water quality (Water quality deterioration)	Activities of workforce, e.g., concrete mixing and sediment release including hydrocarbon spillages

Table 6: Possible additional impacts arising during the operational phase

Possible impact	Source of impact
Altered hydrological regime	The establishment of hard surfaces and increases in hard surfaces into the area leads to increased stormwater runoff volume and intensity and reduced subsurface flow supporting slow release mechanism, could potentially negatively affect watercourses downstream.
Impacts on ground and surface water quality as well as soils	The possibility of water and sewage infrastructure leaks should be considered as well as chemicals utilised in maintenance of the infrastructure.

5.1.1 Construction phase

5.1.1.a Sedimentation

Project phase	**Construction**			
Impact	**Sedimentation of watercourse**			
Description of impact	**The clearing of natural vegetation and the stripping of topsoil will result in increased runoff of sediment from the site and potentially into watercourses downstream of the study area, particularly during times of high rainfall. Water flowing down trenches and access roads, as well as movement of construction vehicles and personnel, could cause additional sediment to accumulate within downstream watercourses and in severe circumstances potentially impact FEPA Fish support catchments downstream. The potential siltation of watercourses downstream would alter geomorphologic functioning, the movement of water through the system (hydrological functioning) as well as having an impact on water quality within the resource.**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	On-going	Impact will last between 15 and 20 years	Short term	impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Certain / definite	There are sound scientific reasons to expect that the impact will definitely occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	High	The resource is irreparably damaged and is not represented elsewhere	High	The resource is irreparably damaged and is not represented elsewhere
Significance	**Moderate - negative**		**Negligible - negative**	
Comment on significance	Appropriate planned mitigation would likely prevent obeservable sedimentation to the downstream environment			
Cumulative impacts	There are no other developments planned within the specific catchment.			

<u>Mitigation Measures - Planning phase</u>

- Plan the development footprint to stay well clear of watercourses, particularly Riparian 1. This has been achieved as per the latest lay-out.
- The design of drainage and stormwater systems for the construction period must ensure there is no sedimentation, eutrophication or erosion of riparian habitat or its associated catchment.
- It is advised that silt fences and coir logs be installed in areas of expected run-off to collect sediment. The southern and western boundary of the development footprint (downstream side) must therefore be “coir-logged” on contour to force any run-off through these sediment traps.

- Keep the development and construction footprint as small as possible through planning various components of construction flow with limited space in mind. Timing, orientation, spatial utilisation and optimisation by appropriate planning throughout the entire construction process, is therefore cardinal

Mitigation Measures - Construction phase

- An independent Ecological Control Officer (ECO) should be appointed to oversee construction and appropriately briefed and trained by the freshwater ecologist on all issues pertaining to watercourses and site stormwater management. The ECO should in turn train any new construction staff and or contractors that arrive on site ensuring that all environmental are appropriately considered and managed.
- As first point of departure it must be ensured that all no-go areas on the perimeter of the footprint is appropriately fenced off before construction are initiated. Coir logs must be installed on this fence line also prior to initiation of construction
- Only remove vegetation where necessary and retain vegetation in place for as long as possible prior to removal.
- Prohibit vehicular or pedestrian access into natural areas beyond the demarcated boundary of the construction area. Ensure this aspect form part of training
- Formalise access roads and make use of existing roads and tracks where feasible, rather than creating new routes through naturally vegetated areas.
- As per Dimela 2022, a vegetation rehabilitation plan should already be implemented during construction to rehabilitate areas that will be affected by edge effects. Such a plan should use indigenous species from the study area and must restore disturbed areas beyond the footprint of the infrastructure to what it was prior to construction, thereby making the impact on the remainder of the site negligible in the long term. Natural colonisation could take a long time, in which vegetation may degrade further or become dominated by encroacher or alien invasive plant species. Therefore, timeous rehabilitation is imperative. Even in the event of good rains, annual pioneer plants are short-lived and therefore an effort must be made to keep as many shrubs in place as possible or to replace these as part of rehabilitation.
- Where topsoil needs to be removed, store such in a separate area where such soils can be protected until they can be re-used for post-construction rehabilitation where applicable. Never mix topsoil with subsoils or other spoil materials.
- All stockpiles must be protected from erosion, stored for the minimum amount of time necessary and on flat areas where run-off will be minimized, and be surrounded by bunds;
- If possible, re-position the topsoil stockpile (where relevant) upslope of any infrastructure within the surface infrastructure footprint so as to prevent contaminated surface water coming into contact with topsoil;
- The ECO must be vigilant to detect any negative impacts on watercourses and consult with a wetland specialist if erosion, sedimentation or other negative impacts within the vicinity of watercourses are noticed.

5.1.1.b Erosion

Project phase	**Construction**
Impact	**Erosion**

Description of impact	**The removal of surface vegetation will cause exposed soil conditions where rainfall and high winds can cause mechanical erosion. In addition, hardened surfaces and bare areas are likely to increase surface run off velocities and peak flows received by watercourses.**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	On-going	Impact will last between 15 and 20 years	Short term	impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	High	The resource is irreparably damaged and is not represented elsewhere	High	The resource is irreparably damaged and is not represented elsewhere
Significance	**Moderate - negative**		**Negligible - negative**	
Comment on significance	Appropriate planned mitigation would likely prevent observable erosion impacting on the downstream environment			
Cumulative impacts	There are no other developments planned within the specific catchment.			

Mitigation Measures

- An ecologically-sound stormwater management plan must be implemented at the onset of the construction phase;
- A riparian monitoring program should be initiated before the onset of the construction phase. The Environmental Control Officer should be briefed by a wetland / aquatic specialist on specific monitoring issues. An inspection of cleared and disturbed areas as well as any stormwater infrastructure needs to take place after each large rain event. Appropriate mitigation needs to be implemented after consultation with relevant specialist if any problems are detected;
- Erosion must not be allowed to develop on a large scale before effecting repairs;
- All areas susceptible to erosion must be protected and ensure that there is no undue soil erosion resultant from activities within and adjacent to the construction camp and work areas;
- Natural trees, shrubbery and grass species must be retained wherever possible;
- Areas exposed to erosion due to construction should be vegetated with species naturally occurring in the area;
- Surface water or storm water must not be allowed to concentrate, or flow down cut or fill slopes

without erosion protection measures being in place; and

- The incorporation of Sustainable Drainage Systems (SuDS) as well as Water Sensitive Urban Design (WSUD) (e.g. permeable pavements, alignment/orientation of roads, etc.) within the layout planning and design is required to reduce runoff from the site.

5.1.1.c Alien Invasive Vegetation

Project phase	**Construction**			
Impact	**Alien Invasive Vegetation**			
Description of impact	**During construction, vegetation will be removed and soil disturbed. The seed of alien invasive species that occur on and in the vicinity of the construction area could spread into the disturbed and stockpiled soil. In addition, the construction vehicles and equipment were likely used on various other sites and could introduce alien invasive plant seeds or indigenous plants not belonging to this vegetation unit to the construction site. Alien vegetation could easily disperse into the watercourses through stormwater infrastructure located on site.**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Positive	
Duration	Long term	Impact will last between 10 and 15 years	Short term	impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Local	Extending across the site and to nearby settlements
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	Medium	The affected environment will only recover from the impact with significant intervention	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	Medium	The resource is damaged irreparably but is represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Moderate - negative**		**Minor - positive**	
Comment on significance	In addition to removing recruiting alien species during the construction process, exisiting alien vegetation established on site will be removed			
Cumulative impacts	Due to the high occurrence of alien invasive plant species in the area, the residual risk of increased alien vegetation cover is moderate to high			

Mitigation Measures

- All protocols and mitigation measures as recommended by Dimela (2022) pertaining vegetation and alien invasive species control must be implemented
- During construction, the construction area and immediate surroundings should be monitored regularly for emergent invasive vegetation;
- Surrounding natural vegetation should not be disturbed to minimize chances of invasion by alien vegetation;
- All alien seedlings and saplings must be removed as they become evident for the duration of construction and operational phase;
- Manual / mechanical removal is preferred to chemical control;
- All construction vehicles and equipment, as well as construction material should be free of plant material. Therefore, all equipment and vehicles should be thoroughly cleaned prior to access on to the construction site. This should be verified by the ECO; and
- An alien invasive eradication and monitoring plan must be compiled and implemented whereby all emergent invasive species are removed during construction. The monitoring plan must also ensure that the re-emergence of invasive species is monitored continuously during the operational and decommissioning phases and that monitoring and eradication continues post decommissioning.

5.1.1.d Water Quality Deterioration

Project phase	**Construction**			
Impact	**Water Quality Deterioration**			
Description of impact	**Hydrocarbon-based fuels or lubricants spilled from construction vehicles, construction materials and litter deposited by construction workers may be washed into drainage lines and wetlands. The mobilisation of sediments, excavations, removal and disturbances to vegetation, mobilisation of hydrocarbon and other compounds could have various negative impacts on wetland/riparian areas and their associated functionality. Should appropriate toilet facilities not be provided for construction workers at the construction crew camps, the potential exists for surface water resources and surroundings to be contaminated by raw sewage**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Immediate	Impact will self-remedy immediately
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	High	Natural and/ or social functions and/ or processes are notably altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Likely	The impact may occur	Probable	The impact has occurred here or elsewhere and could therefore occur

Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	High	The affected environmental will be able to recover from the impact	High	The affected environmental will be able to recover from the impact
Resource irreplaceability	High	The resource is irreparably damaged and is not represented elsewhere	Medium	The resource is damaged irreparably but is represented elsewhere
Significance	**Moderate - negative**		**Negligible - negative**	
Comment on significance	Considering the red data species situated on the cliff edge directly downstream from Riparian 1, a chemical or hydrocarbon spill could have high significance if not prevented through appropriate mitigation			
Cumulative impacts	There are no other developments planned within the specific catchment.			

Mitigation Measures

- Construction vehicles are to be maintained in good working order so as to reduce the probability of leakage of fuels and lubricants;
- A walled concrete platform, dedicated store with adequate flooring or bermed area should be used to accommodate chemicals such as fuel, oil, paint, herbicide and insecticides, as appropriate, in well-ventilated areas;
- Storage of potentially hazardous materials should take place far away from preferential flow paths and or stormwater infrastructure. These materials include fuel, oil, cement, bitumen etc.;
- Surface water draining off contaminated areas containing oil and petrol would need to be channelled towards a sump which will separate these chemicals and oils;
- Concrete is to be mixed on mixing trays only, not on exposed soil;
- Concrete and tar shall be mixed only in areas which have been specially demarcated for this purpose;
- After all the concrete / tar mixing is complete all waste concrete / tar shall be removed from the batching area and disposed of at an approved dumpsite;
- Stormwater shall not be allowed to flow through the batching area. Cement sediment shall be removed from time to time and disposed of in a manner as instructed by the Consulting Engineer;
- All construction materials liable to spillage are to be stored in appropriate structures with impermeable flooring;
- Portable septic toilets are to be provided and maintained for construction crews, and are to be located at least 100m from designated buffer zones. Maintenance must include their removal without sewage spillage;
- No uncontrolled discharges from the construction crew camps to any surface water resources shall be permitted. Any discharge points need to be approved by the relevant authority;
- In the case of pollution of any surface or groundwater, the Regional Representative of the Department of Water and Sanitation must be informed immediately;
- Provide bins for construction workers and staff at appropriate locations, particularly where food is consumed;
- The construction site should be cleaned daily and litter removed;
- Conduct ongoing staff awareness programs so as to reinforce the need to avoid littering; and

5.1.2 Operational phase

Impacts described in the construction phase are in most instances also applicable to the operational phase. The following are additional impacts during the operational phase.

5.1.2.a Altered Hydrologic Regime

Project phase	**Operation**			
Impact	**Altered Hydrologic Regime**			
Description of impact	**The clearing of natural vegetation with high basal cover and subsequent replacement with hardened surfaces and other infrastructure including an increase of access roads and other compacted areas as well as roofs are likely to result in increased run-off, especially peak flow velocities received by watercourses and potential recharge areas. The hydrology of the area seems interconnected and important in terms of regulating different moisture regimes in different areas, many areas serving as habitat harbouring a multitude of species of conservation concern. Lateral water movement seems likely to be an important component of the geohydrology of the area with potential groundwater-fed headwaters occurring in several locations within and surrounding the study area. Large foundations and or cut and fill or blasting operations could have a significant impact on subsurface flows. Further, albeit likely to be a very minor impact, the building itself could result in changes to the orthographic generated precipitation proccess and patterns, especially mist, on the escarpment edge**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Negative	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Short term	impact will last between 1 and 5 years
Extent	Local	Extending across the site and to nearby settlements	Very limited	Limited to specific isolated parts of the site
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Low	Natural and/ or social functions and/ or processes are somewhat altered
Probability	Likely	The impact may occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	Medium	Determination is based on common sense and general knowledge	Medium	Determination is based on common sense and general knowledge
Reversibility	High	The affected environmental will be able to recover from the impact	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	High	The resource is irreparably damaged and is not represented elsewhere	Low	The resource is not damaged irreparably or is not scarce
Significance	**Moderate - negative**		**Negligible - negative**	
Comment on significance	The potetnial significance could be high considering the amount and conservation importance of species of conservation concern potetnially impacted by an altered hydrological regime			
Cumulative impacts	There are no other developments planned within the specific catchment.			

<u>Mitigation Measures</u>

- The construction of foundations for the new tourist facility could potentially intercept surface water flows, a perched aquifer and or other water-bearing geological features leading to desiccation of wetland and other sensitive habitats, especially cliff edges and headwaters of riparian habitat. However, latest results from geotechnical and hydropedological modelling indicates that the main hydrological mechanisms in the vicinity of the footprint of the proposed development is suggested to be more surface flow orientated. A conservative and precautionary approach in the design has been taken already, including limitation of impermeable surfaces as well as roof top indigenous gardens with sub-infrastructure drainage linked to the foundation via pillar drainage, thereby significantly reducing potential impacts on surface and subsurface drainage and daylighting hydrological regimes (Figure 14; Figure 15). Thus, rainwater from the building roof will be released into the environment in a controlled manner to also encourage recharging of the potential sub-surface flows. The development hydrology will thus mimic the site's hydropedology (filling and spilling) though allowing water to potentially recharge through cracks underneath the foundation with excess overflow directed towards Riparian 1 for further attenuation and diffuse release
- New parking to be laid with permeable block paving. Rainwater will infiltrate through the permeable concrete blocks into a sub-base comprising of stone layers and will encourage recharging of the sub-surface flow. Rainwater which does not infiltrate through the paving blocks will run overland and will be channelled into a stormwater attenuation pond. Stormwater discharged from the attenuation pond into the natural environment in a controlled manner to not exceed the pre-development peak flows, which will also encourage recharging of the sub-surface flow.
- The incorporation of Sustainable Drainage Systems (SuDS) as well as Water Sensitive Urban Design (WSUD) (e.g. permeable pavements, alignment/orientation of roads, etc.) within the layout planning and design is required to decrease runoff from the site during rainfall periods;
- Implement an ecologically-sensitive stormwater management plan that includes not allowing stormwater to be discharged directly into regional stormwater systems but rather be attenuated on site through attenuation facilities with diffuse release infrastructure.
- It should be investigated through the ARC what temporary weather station monitoring programs and equipment would be necessitated to determine baseline and monitor precipitation regimes pre and post development and whether such endeavours could be done cost effectively.

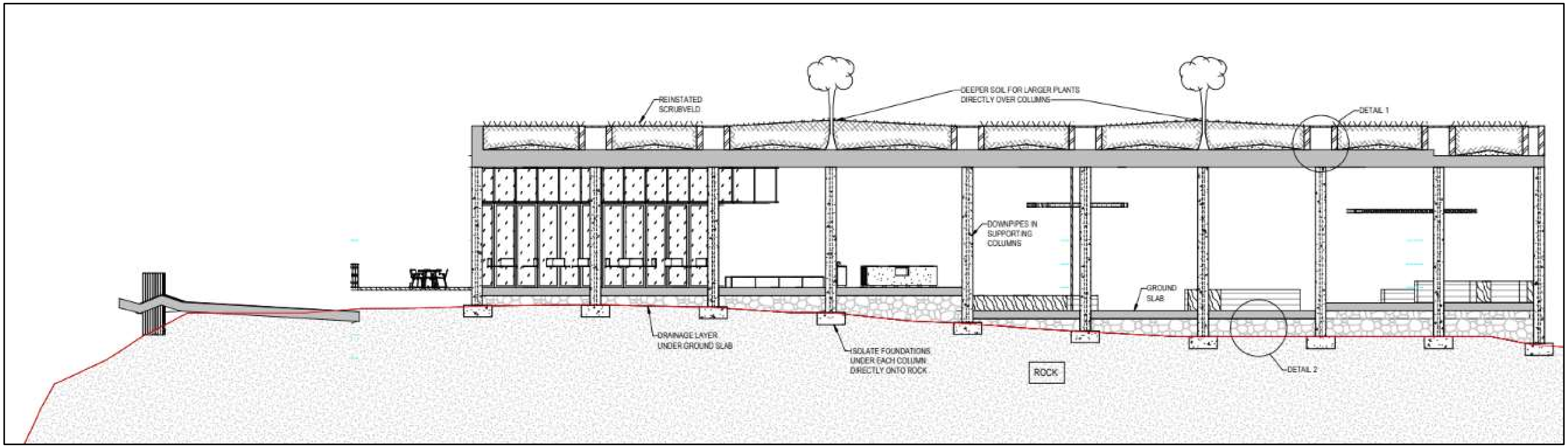

Figure 14: Visitor Centre _ Concept of roof planting and building drainage system

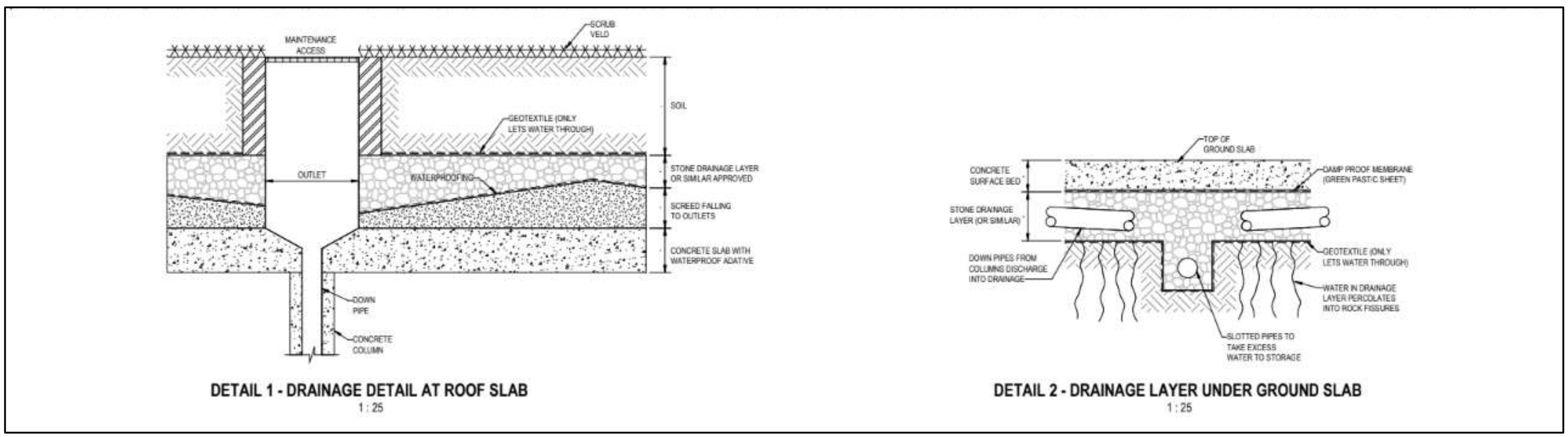

Figure 15: Drainage detail at roof slab on left, Drainage layer detail underneath the ground slab on right

5.12.b Water Quality Deterioration

Project phase	**Operation**			
Impact	**Water Quality deterioration**			
Description of impact	**Operational impacts on water quality include discharge of inappropriately treated sewage effluent, spillages of chemicals and or cleaning agents utilised for maintenance purposes.**			
Mitigatability	High	Mitigation exists and will considerably reduce the significance of impacts		
Potential mitigation	**See Below**			
Assessment	**Without mitigation**		**With mitigation**	
Nature	Negative		Positive	
Duration	Permanent	Impact may be permanent, or in excess of 20 years	Permanent	Impact may be permanent, or in excess of 20 years
Extent	Local	Extending across the site and to nearby settlements	Limited	Limited to the site and its immediate surroundings
Intensity	Very high	Natural and/ or social functions and/ or processes are majorly altered	Very low	Natural and/ or social functions and/ or processes are slightly altered
Probability	Almost certain / Highly probable	It is most likely that the impact will occur	Probable	The impact has occurred here or elsewhere and could therefore occur
Confidence	High	Substantive supportive data exists to verify the assessment	Medium	Determination is based on common sense and general knowledge
Reversibility	High	The affected environmental will be able to recover from the impact	Medium	The affected environment will only recover from the impact with significant intervention
Resource irreplaceability	High	The resource is irreparably damaged and is not represented elsewhere	High	The resource is irreparably damaged and is not represented elsewhere
Significance	**Moderate - negative**		**Minor - positive**	
Comment on significance	The potential significance could be high considering the amount and conservation importance of species of conservation concern potentially impacted by an altered hydrological regime. However, introduction of effective sewage management on terrain will halt current ongoing sewage pollution to Riparian 1			
Cumulative impacts	There are no other developments planned within the specific catchment.			

Mitigation Measures

- Appropriate backup and fail systems should be built into the design of the sewage treatment works to prevent any spillages into the downstream environment
- Rehabilitation of Riparian 1 should include attenuation, infiltration and diffuse release mechanisms which can promote artificial wetland conditions capable of polishing stormwater and or treated sewage effluent. The upper most attenuation facility should be lined and act as a last fail save to prevent any effluent that does not meet the DWS determined discharge qualities to be kept temporarily (either pumped back into treatment works for further treatment or pumped to honey sucker.
- Pressurised water should be utilised as far as possible rather than any chemicals. Only bio-friendly cleaning agents should be utilised as last necessity where required.

Considering the level of investigation, baseline conditions and potential impact and mitigation measures that are being developed, from a watercourse perspective it is recommended that the development continuous, as long as all mitigation measures recommended within the current report, the Ecological and Hydropedological report are implemented.

6. CONCLUSION AND RECOMMENDATIONS

A total of four riparian networks were delineated within the study area and within 500m downstream from the study area. Several other riparian watercourses north of the study are (upstream) were delineated that support HGM 1. One hydro-geomorphic unit (HGM), comprising one HGM type, HGM 1, a hillslope seepage wetland connected to a watercourse, was delineated and classified within 500m from the proposed development, although upstream and within a neighbouring catchment (and therefore not relevant to the current assessment). The Misbelt Forest that is situated approximately 300m north of the proposed development acts as a critically important water-source area, classification as true wetland habitat is debatable, albeit tiny pockets contain wetland conditions to some extent, not all classical criteria as a specific hydro-geomorphic type is met. From a hydrological perspective, the Misbelt Forest is situated uphill from the proposed development and thus also not relevant to the assessable impacts likely to arise from the development.

Watercourses within the vicinity of the study area serve to improve habitat within and potentially downstream of the study area through the provision of various ecosystem services. Many of these functional benefits therefore contribute directly or indirectly to increase biodiversity within the study area as well as downstream of the study area through provision and maintenance of appropriate habitat and associated ecological processes.

Findings of the VEGRAI vegetation assessment conducted on riparian units identified within the study area indicated that riparian habitat associated with the study area were regarded as being in a largely natural state (i.e. Ecological Category A/B).

The exception was Riparian 1, that has been seriously impacted through historic tourism and road infrastructure development. Collectively these heavily impacted zones form a very small percentage of the total riparian habitat (considering the downstream linkages) within the study area and surroundings. The impacted zone of Riparian 1 includes the historic development of the R534, up to which time both Riparian 1 and Riparian 2 were largely dominated by graminoids and associated grasslands on top of the escarpment. It is hypothesized that subsequent to the development of the road as well as commercial afforestation and associated practises supressed the natural fire regime responsible for maintaining the grasslands. Further impacts that resulted from current tourist facilities include increased run-off peak flows generated by the road and parking facilities, wate quality deterioration due to lack of appropriate sewage treatment and management as well as prevalence of exotic invasive species.

Any developmental activities in a natural system will have an impact on the surrounding environment, usually in a negative way. The current scoping phase report needs to be followed by integration of all specialist studies and associated sensitivities in order to avoid impact as far as possible. The mitigation hierarchy should lead the process and followed by a watercourse impact assessment in order to identify and assess the significance of potential impacts caused by the proposed activity and to provide a description of the mitigation required so as to limit the perceived impacts on the natural environment.

Impact considerations identified sedimentation, increased erosion, water quality deterioration, increase in alien vegetation species as well as an altered hydrological regime as the major potential impacts during the construction and operational phases. Several preliminary general and specific mitigation measures were proposed in order to reduce negative impacts and incorporate some potentially positive impacts from the proposed development. Some of the most pertinent recommendations include:

- The construction of foundations for the new tourist facility could potentially intercept surface water flows, a perched aquifer and or other water-bearing geological features leading to desiccation of wetland and other sensitive habitats, especially cliff edges and headwaters of riparian habitat. However, latest results from geotechnical and hydropedological modelling indicates that the main hydrological mechanisms in the vicinity of the footprint of the proposed development is suggested to be more surface flow orientated. A conservative and precautionary approach in the design has been taken, including limitation of impermeable surfaces as well as roof top indigenous gardens with sub-infrastructure drainage linked to the foundation via pillar drainage, thereby significantly reducing potential impacts on surface and subsurface drainage and daylighting hydrological regimes. Thus, rainwater from the building roof will be released into the environment in a controlled manner to also encourage recharging of the potential sub-surface flows. The development hydrology will thus mimic the site's hydropedology (filling and spilling) though allowing water to potentially recharge through cracks underneath the foundation with excess overflow directed towards Riparian 1 for further attenuation and diffuse release
- The incorporation of the ecological corridor through the rooftop garden would therefore also mimic preconstruction hydrological conditions in order to maximise hydrological support to watercourses via historic flow paths and also aims to restore some of these lost flow-paths as a result of historic infrastructure in the vicinity of the terrain. It is important that the hydropedologist and wetland ecologist continually collaborate with the engineering design team to optimise historic flow paths through appropriate further modelling and input.
- New parking to be laid with permeable block paving. Rainwater will infiltrate through the permeable concrete blocks into a sub-base comprising of stone layers and will encourage recharging of the sub-surface flow. Rainwater which does not infiltrate through the paving blocks will run overland and will be channelled into a stormwater attenuation pond. Stormwater discharged from the attenuation pond into the natural environment in a controlled manner to not exceed the pre-development peak flows, which will also encourage recharging of the sub-surface flow.
- Rehabilitation of Riparian 1 should include attenuation, infiltration and diffuse release mechanisms which can promote artificial wetland conditions capable of polishing stormwater and or treated sewage effluent.

- The watercourse rehabilitation and monitoring plan must be completed during the final detailed design phase in order to ensure that all aspects from the construction phase through to the operational and maintenance phase are incorporated to enhance potential positive outcomes

Considering the level of investigation, baseline conditions and potential impact and mitigation measures that are being developed, from a watercourse perspective it is recommended that the development continuous, as long as all mitigation measures recommended within the current report, the Ecological Report and Hydropedological report are implemented.

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APPENDIX A – Methodology

Wetland Delineation

The report incorporated a desktop study, as well as field surveys, with site visits conducted during August 2021. Additional data sources that were incorporated into the investigation for further reliability included:

- Google Earth images;
- 1:50 000 cadastral maps;
- ortho-rectified aerial photographs;
- Historic imagery from NGI; and
- 1m contour data.

A pre-survey wetland delineation was performed in order to assist the field survey. Identified wetland areas during the field survey were marked digitally using GIS (changes in vegetation composition within wetlands as compared to surrounding non-wetland vegetation show up as a different hue on the orthophotos, thus allowing the identification of wetland areas). These potential wetland areas were confirmed or dismissed and delineation lines and boundaries were imposed accordingly after the field surveys.

The wetland delineation was based on the legislatively required methodology as described by Department of Water Affairs and Forestry (2005). The DWAF delineation guide uses four field indicators to confirm the presence of wetlands, namely:

- terrain unit indicator (i.e. an area in the landscape where water is likely to collect and a wetland to be present);
- soil form indicator (i.e. the soils of South Africa have been grouped into classes / forms according to characteristic diagnostic soil horizons and soil structure);
- soil wetness indicator (i.e. characteristics such as gleying or mottles resulting from prolonged saturation); and
- vegetation indicator (i.e. presence of plants adapted to or tolerant of saturated soils).

The wetland delineation guide makes use of indirect indicators of prolonged saturation by water, namely wetland plants (hydrophytes) and (hydromorphic) soils. The presence of these two indicators is indicative of an area that has sufficient saturation to classify the area as a wetland. Hydrophytes were recorded during the site visit and hydromorphic soils in the top 0.5 m of the profile were identified by taking cored soil samples with a bucket soil auger and Dutch clay auger (photographs of the soils were taken). Each auger point was marked with a handheld Global Positioning System (GPS) device.

Wetland Functionality

The methodology "Wet-EcoServices" (Kotze et al., 2008) was adapted and used to assess the different benefit values of the wetland units. A level two assessment, including a desktop study and a field assessment were performed to determine the wetland functional benefits between the different hydro-geomorphological types within the study area. Other documents and guidelines used are referenced accordingly. During the field survey, all possible wetlands and drainage lines identified from maps and aerial photos were visited on foot. Where feasible, cross sections were taken to determine the state and boundaries of the wetlands.

Following the field survey, the data was submitted to a GIS program for compilation of the map sets. Subsequently the field survey and desktop survey data were combined within a project report.
In order to gauge the Present Ecological State of various wetlands within the study area, a Level 2 Wet-Health assessment was applied in order to assign ecological categories to certain wetlands. Wet-Health (Macfarlane et al., 2008) is a tool which guides the rapid assessment of a wetland's environmental condition based on a site visit. This involves scoring a number of attributes connected to the geomorphology, hydrology and vegetation, and devising an overall score which gives a rating of environmental condition.

Wet-Health is useful when making decisions regarding wetland rehabilitation, as it identifies whether the wetland is beyond repair, whether rehabilitation would be beneficial, or whether intervention is unnecessary, as the wetland's functionality is still intact. Through this method, the cause of any wetland degradation is also identified, and this facilitates effective remediation of wetland damage. There is wide scope for the application of Wet-Health as it can also be used in assessing the Present Ecological State of wetlands and thereby assist in determining the Ecological Reserve as laid out under the National Water Act. Wet-Health offers two levels of assessment, one more rapid than the other.

For the assessment, an impact and indicator system were used. The wetland is first categorized into the different hydrogeomorphic (HGM) units and their associated catchments, and these are then assessed individually in terms of their hydrological, geomorphologic and vegetation health by examining the extent, intensity and magnitude of impacts, of activities such as grazing or draining. The extent of the impact is measured by estimating the proportion the wetland that is affected. The intensity of the impact is determined by looking at the amount of alteration that occurs in the wetland due to various activities. The magnitude is then calculated as the combination of the intensity and the extent of the impact and is translated into an impact score. This is rated on a scale of 1 to 10, which can be translated into six health classes (A to F – compatible with the EcoStatus categories used by DWAF, Table 8). Threats to the wetland and its overall vulnerability can also be assessed and expressed as a likely Trajectory of Change.

Determination of Ecological Importance and Sensitivity

The Ecological Importance and Sensitivity was determined by utilising a rapid scoring system. The system has been developed to provide a scoring approach for assessing the Ecological, Hydrological Functions; and Direct Human Benefits of importance and sensitivity of wetlands. These scoring assessments for these three aspects of wetland importance and sensitivity have been based on the requirements of the NWA, the original Ecological Importance and Sensitivity assessments developed for riverine assessments, and the work conducted by Kotze et al. (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree et al., 2013). An example of the scoring sheet is attached as Table 9. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 10.

Table 7: Interpretation of scores for determining present ecological status (Kleynhans 1999)

Rating of Present Ecological State (Ecological Category)
CATEGORY A Score: 0-0.9; Unmodified, or approximates natural condition.
CATEGORY B Score: 1-1.9; Largely natural with few modifications, but with some loss of natural habitats.
CATEGORY C Score: 2 – 3.9; Moderately modified, but with some loss of natural habitats.
CATEGORY D Score: 4 – 5.9; Largely modified. A large loss of natural habitats and basic ecosystem functions has occurred.
OUTSIDE GENERAL ACCEPTABLE RANGE
CATEGORY E Score: 6 -7.9; Seriously modified. The losses of natural habitats and basic ecosystem functions are extensive.
CATEGORY F Score: 8 - 10; Critically modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat.

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

Table 8: Example of scoring sheet for Ecological Importance and sensitivity

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

Table 9: Category of score for the Ecological Importance and Sensitivity

Rating	Explanation
Very low (0-1)	Rarely sensitive to changes in water quality/hydrological regime.
Low (1-2)	One or a few elements sensitive to changes in water quality/hydrological regime.
Moderate (2-3)	Some elements sensitive to changes in water quality/hydrological regime.
High (3-3.5)	Many elements sensitive to changes in water quality/ hydrological regime.
Very high (+3.5)	Very many elements sensitive to changes in water quality/ hydrological regime.

Riparian Habitat Delineation

The riparian delineation was based on the legislatively required methodology as described by Department of Water Affairs and Forestry (2005; 2008) Although the Department of Water Affairs and Forestry's manual discusses wetlands and riparian areas as separate concepts, it makes good sense to delineate both habitats during the same field visit, if necessary. It is likely that wetlands and riparian areas will overlap, and delineating both habitats during the same visit can save much time and effort. The delineation procedure is summarised here (Department of Water Affairs and Forestry 2005; 2008). In the case of a riparian area, look for the active channel or the lowest part of the river course. Most likely cues like water with associated emergent vegetation, sedges and reeds or alluvial soil and bedrock will be visible. From this point some topographic units like sandbars, active channel bank, flood benches and macro channel bank with associated riparian vegetation will be identifiable. Proceed upwards towards the macro channel bank, taking note of alluvial soil, topographic units and vegetation indicators. The outer boundary will be the point on the edge of the macro channel bank where there is a distinct difference between the riparian and terrestrial vegetation. In some cases where riparian vegetation is unrecognisable, because of land-use activities, indicators like alluvial material and topographical units can still be used to visualize the edge of a riparian area. If you are adjacent to a watercourse, it is also important to check for the presence of riparian indicators. Although a specific method for delineating riparian areas has not been defined in this manual, the general approach and principles outlined for wetlands can be used, with substitution of riparian indicators for wetland indicators.

Riparian Assessment

The Present Ecological State of the riparian zone was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) Level 3 approach (Kleynhans et al., 2007). Riparian vegetation areas were divided into two sub-zones which included marginal and non-marginal zones. Recognition of the different zones are important given that riparian vegetation distribution and species composition varies in different sub-zones, which has implications for flow-related impacts. Since all VEGRAI assessments are relative to the natural unmodified conditions (reference state) it is necessary and important to define and describe the reference state for the study area (Kleynhans et al., 2007). This was done (in part) before going into the field, using historic aerial imagery, present and historic species distributions, general vegetation descriptions of the study area, knowledge of the area and comparison of the study area characteristics to other comparable sections of the stream that might be in a better state. According to Kleynhans et al. (2007), the reference (and present state) is quantified on site; the assessor reconstructs and quantifies the reference state from the present state by understanding how visible impacts have caused the vegetation to change and respond.

Impacts on riparian vegetation at the site are then described and rated. Kleynhans et al. (2007) further states that it is important to distinguish between a visible / known impact (such as flow manipulation) and the response of riparian vegetation to other impacts such as erosion and sedimentation, alien invasive species and pollution. If there is no response to riparian vegetation, the impact is noted but not rated since it has no visible / known effect. These impacts are then rated as per a scale from 0 (No Impact) to 5 (Critical Impact). Once the riparian zone and sub- zones have been delineated, the reference and present states have been described and quantified (basal cover is used) and species description for the study area has been compiled, the VEGRAI metrics were rated and qualified. The riparian ecological integrity was assessed using the spreadsheet tool that is composed of a series of metrics and metric groups, each of which was rated in the field with the guidance of data collection sheets. The metrics in VEGRAI describe the following attributes associated with both the woody and non-woody components of the lower and upper zones of the riparian area:

- Removal of the riparian vegetation; Invasion by alien invasive species;
- Flow modification; and
- Impacts on water quality.

Results from the lower and upper zones of the riparian vegetation were then combined and weighted with a value that reflects the perceived importance of that criterion in determining habitat integrity, allowing this to be numerically expressed in relation to the perceived benchmark. The score is then placed into one of six classes (Table 11).

Table 10: Allocation protocol for the determination of the Present Ecological State (or Ecological Category) for riparian habitat following the VEGRAI application (Kleynhans et al., 2007)

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

Appendix B – CV