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FRESHWATER HABITAT ASSESSMENT: PHASE 1

for the proposed

Development of the remainder of Erf 464, adjacent to the Garden Route Dam, George

PREPARED FOR: George Local Municipality
Contact Person: Delia Powers

PREPARED BY: Sharples Environmental Services cc
Contact Person: Debbie Bekker
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DATE: 31 January 2019

DECLARATION OF INDEPENDENCE

Independent Specialist Consultant

I, Debbie Bekker, declare that I:

- Act as an independent specialist consultant, in this application, in the field of wetland and riparian ecology;
- Do not have and will not have any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the amended Environmental Impact Assessment Regulations, 2014;
- Have, and will have, no vested interest in the proposed activity proceeding;
- 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 have 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 amended Environmental Impact Assessment Regulations, 2014; and
- Will provide the competent authority with access to all the information at my disposal regarding the application, whether such information is favourable to the applicant or not.

The following report has been prepared:

- As per the requirements of Section 32 (3) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) Environmental Impact Assessment Regulations 2017 as per Government Notice No. 326 Government Gazette, 7 April 2017.
- In accordance with Section 13: General Requirements for Environmental Assessment Practitioners (EAPs) and Specialists as well as per Appendix 6 of GNR 982 - Environmental Impact Assessment 2014 Regulations and the National Environmental Management Act, 1998.
- With consideration to Cape Nature's standard requirements for biodiversity assessments.
- In accordance with DEA&DP's Guideline on Involving biodiversity specialists in the EIA process
- Independently of influence or prejudice by any parties.

AUTHOR

The author of this report is in agreeance with the 'Declaration of Independence'.

SPECIALIST	QUALIFICATIONS	DETAILS
DEBBIE BEKKER M.SC	M.Sc - Environmental Science BA (Hons) - Environmental Science BA - Environmental Science and Geography	Debbie is a qualified aquatic ecologist and environmental scientist. Debbie holds a BA (Environmental Science and Geography), BA (Hons) and M.Sc in Environmental Science from Rhodes University. She was awarded her Master of Science degree, by thesis, in Wetland Science, entitled: The origin and evolution of the Tierkloof Wetland, a peatland dominated by *Prionium serratum* in the Western Cape. She has specialised in aquatic habitat assessment and has produced numerous aquatic habitat impact assessment reports. She is well established in her specialist field and has worked in various provinces within South Africa.

INDEMNITY AND COPYRIGHT

Report citation:
Sharples Environmental Services cc, 2019. Phase 1 freshwater habitat assessment for the proposed development of the remainder of Erf 464, adjacent to the Garden Route Dam, George.

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1 INTRODUCTION

Sharples Environmental Services cc (SES) has been appointed by *George Municipality*, to conduct a Freshwater Specialist Assessment and undertake the water use authorisation application process for the proposed development of vacant land near the Garden Route Dam in George.

1.1 Background

The George Municipality is planning to develop a college or university, housing and recreational open spaces on a remainder of a portion of Erf 464, near the Garden Route Dam in George. The Garden Route Dam site was approved for some development on 16 September 2014 although only partial approval was achieved. The previous proposal was for a housing development, a hotel and a waterfront to be built on the property but with the northern portion been kept clear of development to ensure the impact on the dam was limited. Only partial authorisation for this was granted.

1.2 Location

It is again proposed to develop a portion of vacant land within the urban edge near the Garden Route Dam, in George, for housing and higher education (Figure 1). The property lies between the dam in the north and east, and the Swart River that flows in an easterly direction on the southern boundary of the property, before these systems converge. An artificial spillway for the dam lies within a steep-sided valley at the eastern edge of the study area.

Figure 1: Google satellite imagery showing the location of the study area in relation to George

1.3 Relevant Legislation

The protection of water resources is essential for sustainable development and therefore many policies and plans have been developed, and legislation promulgated, to protect these sensitive ecosystems. The proposed project must abide by the relevant legislative requirements. Table 1 below shows an outline of the environmental legislation relevant to the project.

Table 1: Relevant environmental legislation

Legislation	Relevance
South African Constitution 108 of 1996	The constitution includes the right to have the environment protected
National Environmental Management Act 107 of 1998	Outlines principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for coordinating environmental functions exercised by organs of state.
Environmental Impact Assessment (EIA) Regulations	The 2014 regulations have been promulgated in terms of Chapter 5 of NEMA and were amended on 7 April 2017 in Government Notice No. R. 326. In addition, listing notices (GN 324-327) lists activities which are subject to an environmental assessment.
The National Water Act 36 of 1998	Chapter 4 of the National Water Act addresses the use of water and stipulates the various types of licensed and unlicensed entitlements to the use of water. The water uses under Section 21 (NWA) that are associated with the proposed development are most likely section 21 (c) and (i). Also, according to the Department of Water and Sanitation (DWS), any structures within a 500 metre radius from the boundary of a wetland constitutes a Section 21(c) and (i) water use and as such requires a water use licence.
General Authorisations (GAs)	Any uses of water which do not meet the requirements of Schedule 1 or the GAs, require a license which should be obtained from the Department of Water and Sanitation (DWS). The project will require a Water Use Authorisation or General Authorisation in terms of Section 21 (c) and (i) of the National Water Act (NWA), Act 36 of 1998, as the development will cross a watercourse. Government Notice R509 of 2016 was issued as a revision of the General Authorisations (No. 1191 of 1999) for section 21 (c) and (i) water uses (impeding or diverting flow or changing the bed, banks or characteristics of a watercourse) as defined under the NWA. Determining if a water use licence is required is associated with the risk of impacting on that watercourse. A low risk of impact could be authorised in terms of a General Authorisations (GA).
National Environmental Management: Biodiversity Act No. 10 of 2004	This is to provide for the management and conservation of South Africa's biodiversity through the protection of species and ecosystems; the sustainable use of indigenous biological resources; the fair and equitable sharing of benefits arising from bioprospecting involving indigenous biological resources; and the establishment of a South African National Biodiversity Institute.
Conservation of Agricultural Resources Act 43 of 1967	To provide for control over the utilization of the natural agricultural resources of the Republic in order to promote the conservation of the soil, the water sources and the vegetation and the combating of weeds and invader plants; and for matters connected therewith.

1.4 Scope of Work

The Scope of Work in accordance with the specific Terms of Reference supplied by Sharples Environmental Services cc are described below:

1.4.1 Phase 1

- ✓ Contextualization of each study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information.
- ✓ Desktop delineation and illustration of all watercourses within each study area utilising available site-specific data such as aerial photography, contour data and water resource data.
- ✓ A risk/screening assessment of these identified watercourses to determine which ones will be impacted upon by the proposed development areas.

1.4.2 Phase 2

- ✓ Ground truthing, infield identification, delineation and mapping of any affected aquatic ecosystems in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*.
- ✓ Classification of the identified aquatic ecosystems in accordance with the, '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009).
- ✓ Description of the identified watercourses with photographic evidence
- ✓ Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland habitats, utilising:
  - → Level 1 WET-Health tool (Macfarlane *et al*., 2009) – PES
  - → WET-Ecoservices (Kotze *et al*., 2009) - Functional assessment
- ✓ Conduct a Present Ecological State (PES) and present Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats, utilising:
  - → Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
  - → DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- ✓ Indicate the Recommended Ecological Category (REC) of the potentially impacted aquatic ecosystems.
- ✓ Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project.
- ✓ Identify direct, indirect, and cumulative impacts the proposed development will have on aquatic habitats and the significance of these impacts. Rate the significance of the impacts.

- ✓ Recommend actions that should be taken to prevent impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas or ecological processes.
- ✓ Determination of No Go and buffer zones.
- ✓ Identify legislation and permit requirements that are relevant to the development proposal from an aquatic perspective.

2 STUDY AREA

George receives rainfall throughout the year, with the lowest amount in June and the highest amount in November. The average midday temperatures for the area range from 18.2°C in July to 27.6°C in February (Mucina and Rutherford, 2006). The area is characterised by gently undulating topography on the coastal plateau between the Outeniqua Mountains and the ocean. The geology comprises mainly of phyllite and quartzite strata of the Kaaimans Group, with quartzitic sandstones of the Table Mountain Group (Cape Supergroup), as well as gneissic granite and granodiorite from George Batholith (Cape Granite), which are highly erodible.

The rivers flow from the Outeniqua Mountains, over the narrow coastal plain, to form narrow estuaries at the mouth to the ocean. The larger rivers are typically perennial, as they are fed by precipitation and surface runoff during the winter rainfall season and supplemented by mountain seeps during the lower rainfall periods. These high gradient streams are typically peat coloured and humic stained.

The Swart River system joins the Kaaimans River downstream before the mouth to the Indian Ocean (Figure 2). Upslope of the dam and Kat River that feeds, is the George and Outeniqua Strategic Ground Water Area (2018). The site is within the Quaternary Catchment K30C of the Coastal Gouritz Water Management Area and the South Eastern Coastal Belt Ecoregion (Figure 3). Flow related activities, such as abstraction for domestic purposes, alien tree infestation, plantations and dams, are the largest drivers of degradation in watercourses of the area.

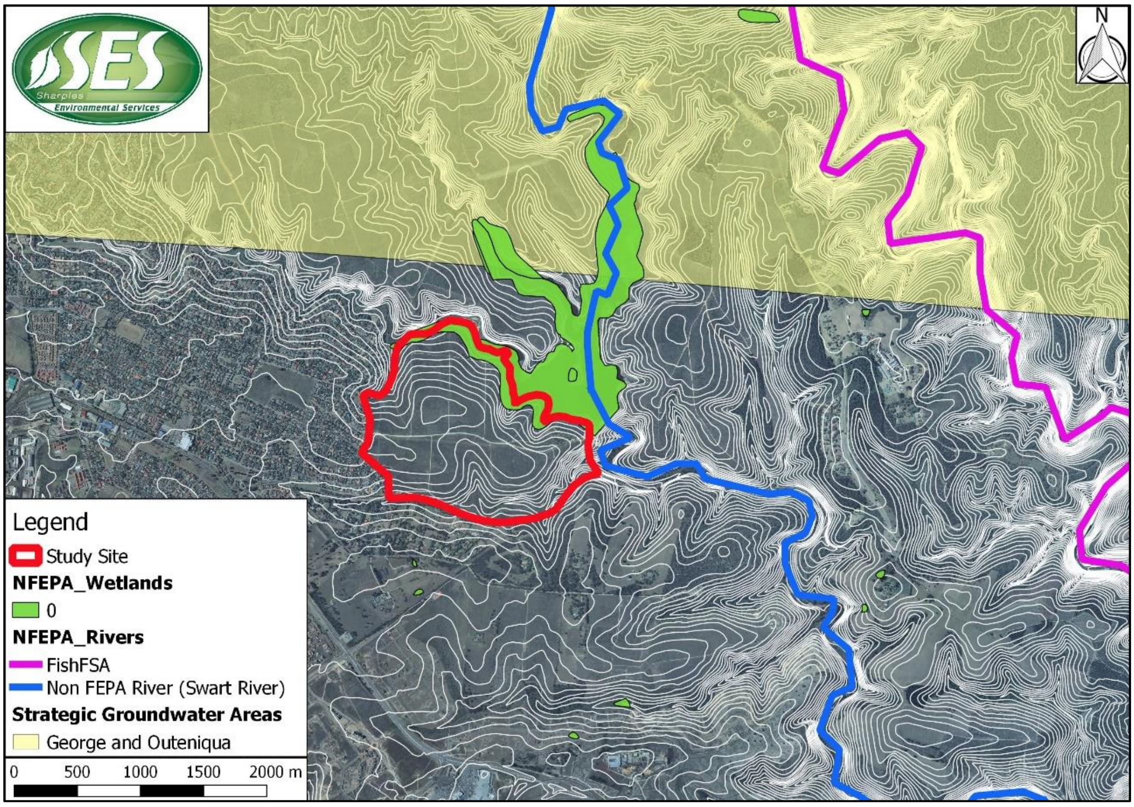

Figure 2: The site in relation to the Swart and Kaaimans Rivers as well as the George and Outeniqua SGA

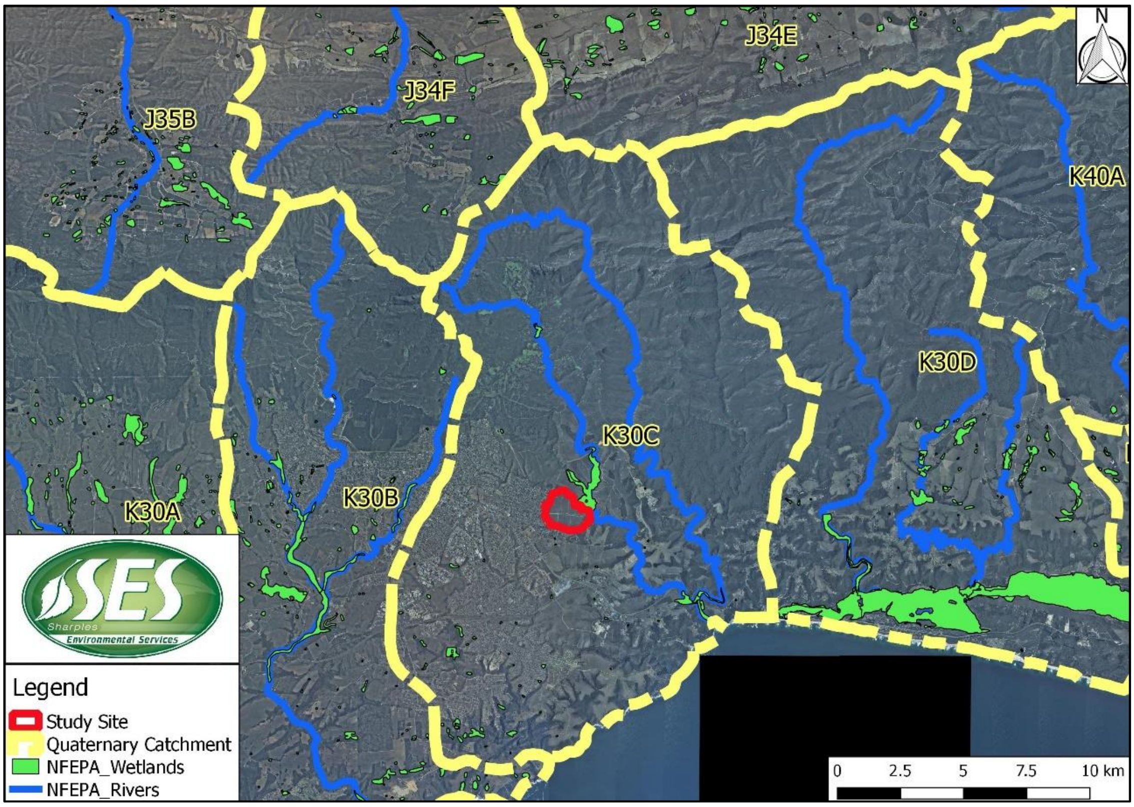

Figure 3: The quaternary catchment K30C

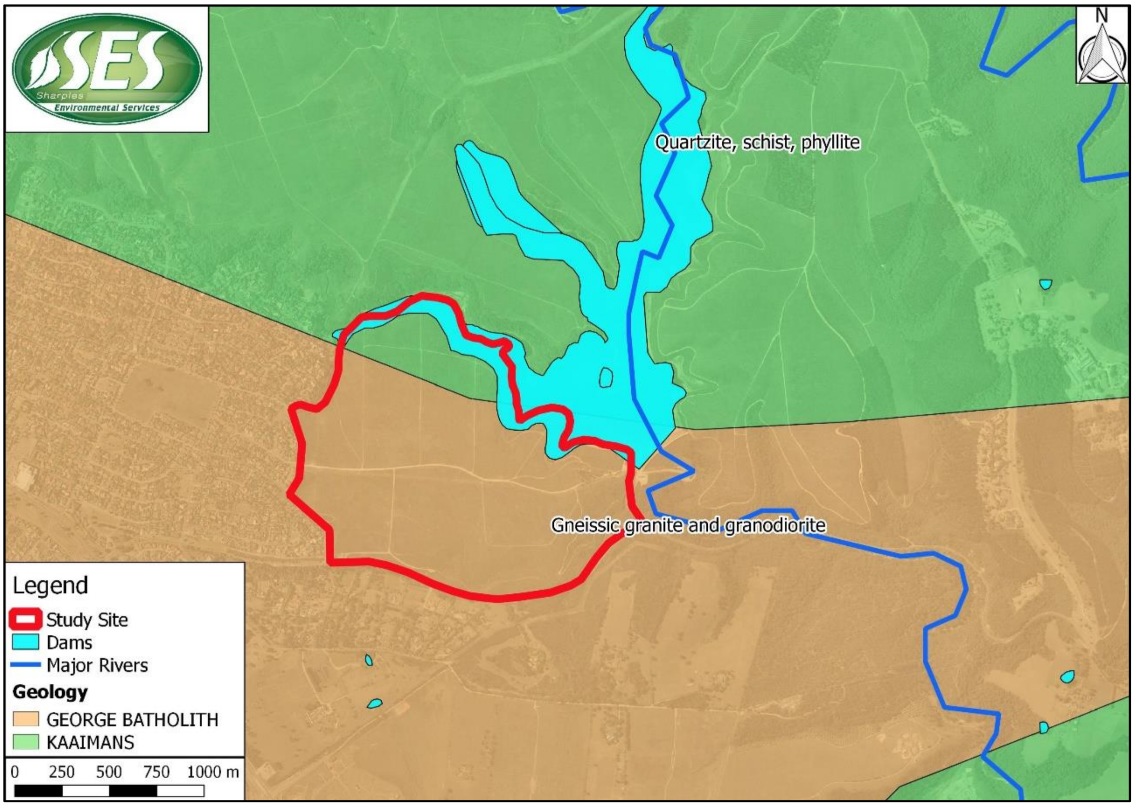

Figure 4: The geology of the area

According to Mucina and Rutherford (2012), the vegetation is sensitive in nature; largely mapped as Garden Route Shale Fynbos with a portion in the south classified as Garden Route Granite Fynbos (Figure 5). These vegetation units are classified as Endangered and Critically Endangered respectively (Figure 6). However, a comprehensive botanical assessment for this proposed development has been undertaken and should be read in conjunction with this report.

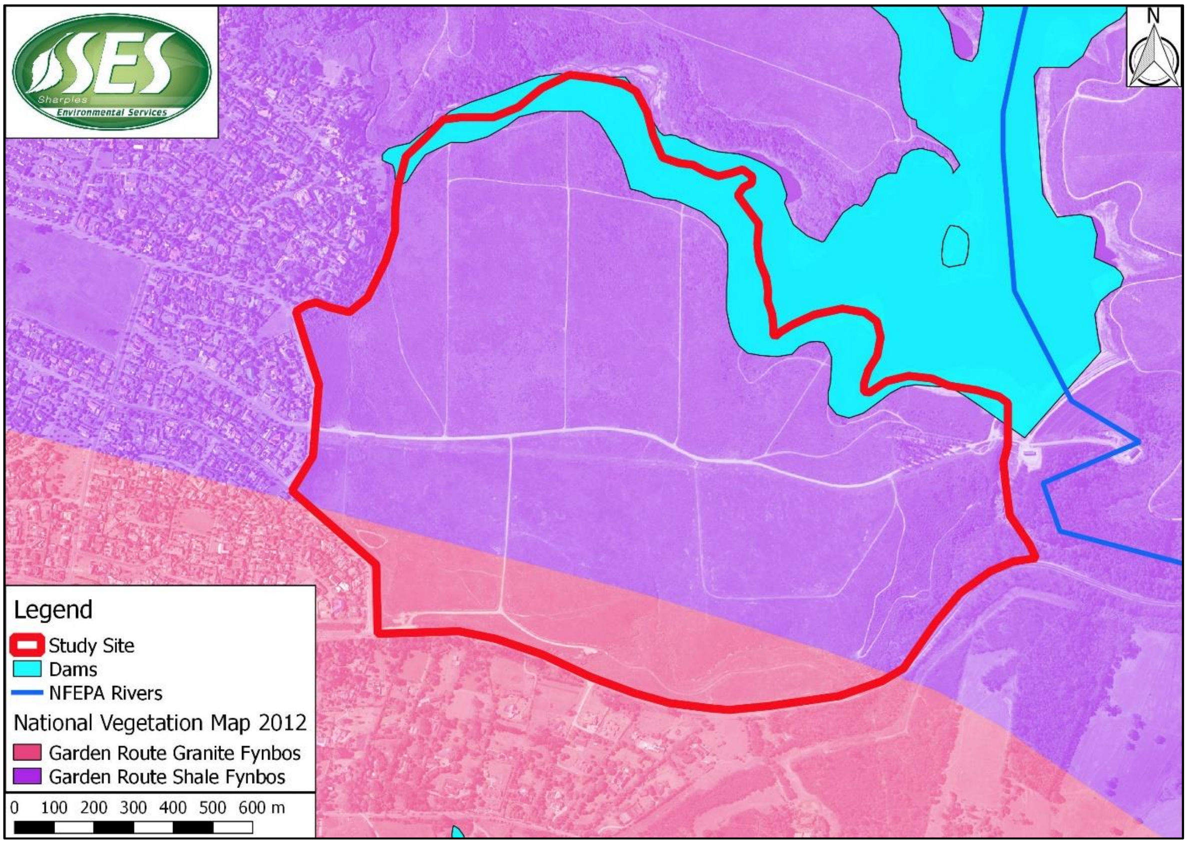

Figure 5: The vegetation types of the study area according to Mucina and Rutherford (2012).

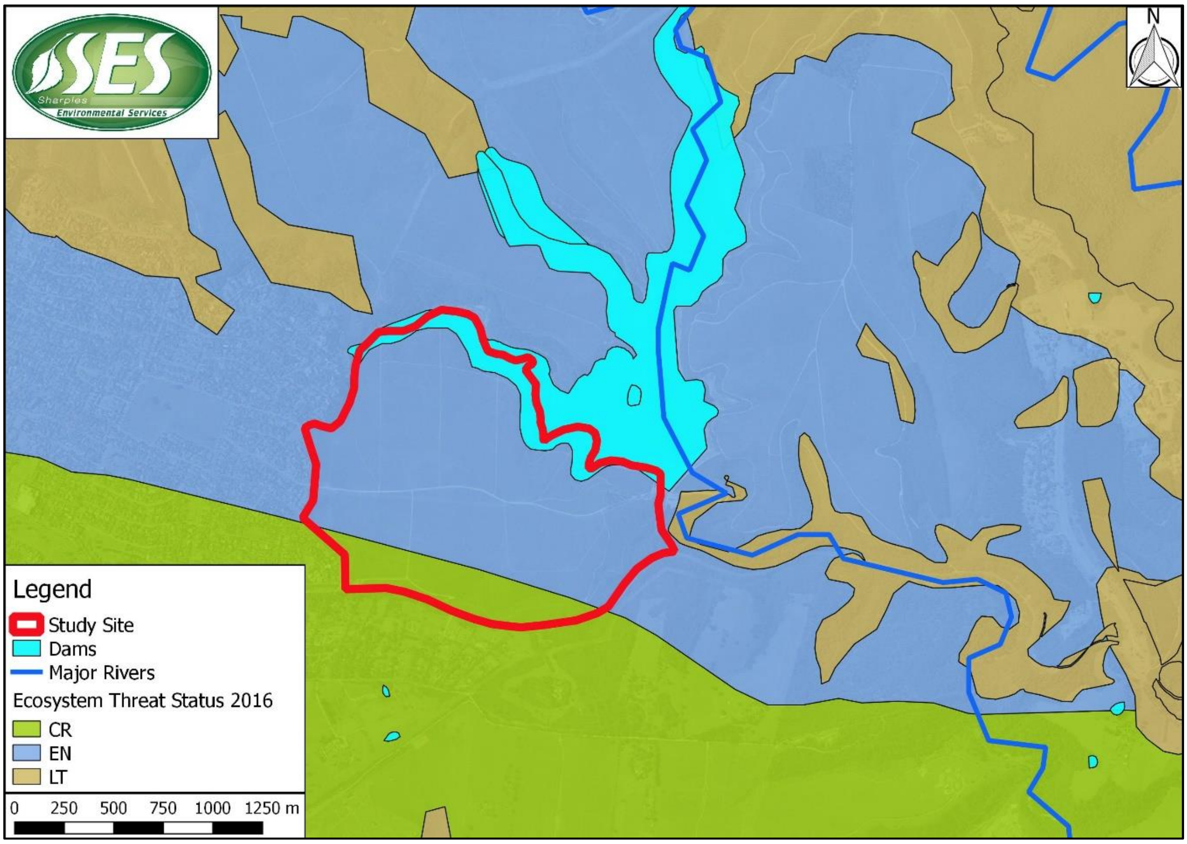

Figure 6: The threatened ecosystems in relation to the study area.

The Western Cape Biodiversity Spatial Plan identifies areas crucial for conserving a representative sample of biodiversity and maintaining ecosystem functioning. There are small pockets of the study area that are classified as Critical Biodiversity Areas, such as a portion of wetland habitat in the south and terrestrial habitat in the eastern area (Figure 7). However, the majority of the site is considered to have potential for restoration or is mapped as an ecological support area. The reasons provided by the WCBSP (Pence, 2016) include Threatened Vertebrate and Water Resource Protection. Additionally, a segment along the dam in the northern part of the site is part of a protected area called the Katrivier Nature Reserve.

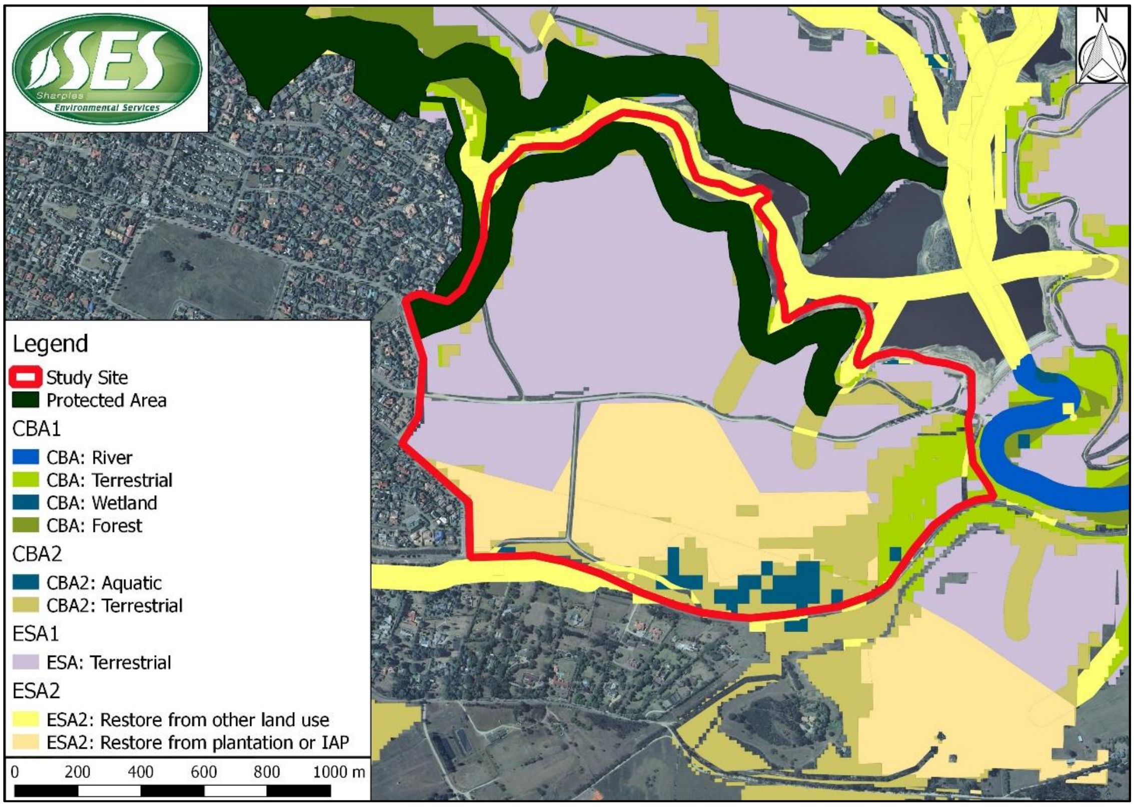

Figure 7: The site in relation to the Western Cape Biodiversity Spatial Plan (Pence, 2016)

Mapping the locality of aquatic habitat is essential for classification into the different wetland and river ecosystem types across the country, which in turn can be used with other data to identify aquatic systems of conservation significance. The National Freshwater Ecosystem Priority Area project (NFEPA) provides strategic spatial priority areas for conserving South Africa's aquatic ecosystems and supporting sustainable use of water resources. These priority areas are called Freshwater Ecosystem Priority Areas (FEPAs) and the main output of the NFEPA project was the creation of FEPA maps. FEPAs were identified based on a range of criteria dealing with the maintenance of key ecological processes and the conservation of ecosystem types and species associated with rivers, wetlands and estuaries (Driver *et al.* 2011). However, the Swart River, Kat River and the dam are not classified as FEPA systems despite being identified by the NFEPA project (Figure 2 & 3).

3 APPROACH AND METHODS

3.1 Desktop Assessment Methods

- The contextualization of each study area was undertaken in terms of important biophysical characteristics and the latest available aquatic conservation planning information in a Geographical Information System (GIS). It is imperative to develop an understanding of the regional drainage setting and longitudinal dynamics of the watercourse. The conservation planning information aids in the determination of importance and sensitivity, management objectives, and the significance of potential impacts.
- Following this, desktop delineation and illustration of all watercourses within the study area was undertaken utilising available site-specific data such as aerial photography, contour data and water resource data. Digitization and mapping was undertaken using QGIS 2.18 GIS software (Table 2).
- These results, as well as professional experience, allowed for the identification of specific watercourses that could potentially be impacted by the development and therefore required groundtruthing and detailed assessment. The following data sources listed within Table 2 assisted with the assessment.

Table 2: Utilised data and associated source relevant to the proposed project

Data	Source
Google Earth Pro™ Imagery	Google Earth Pro™
DWS Eco-regions (GIS data)	DWS (2005)
South African Vegetation Map (GIS Coverage)	Mucina & Rutherford (2006)
National Biodiversity Assessment Threatened Ecosystems (GIS Coverage)	SANBI (2011)
Geology	Surveyor General
Contours (elevation) - 5m intervals	Surveyor General
NFEPA river and wetland inventories (GIS Coverage)	CSIR (2011)
NEFPA river, wetland and estuarine FEPAs (GIS Coverage)	CSIR (2011)
Western Cape Biodiversity Framework 2017: Critical Biodiversity Areas of the Western Cape.	Pence (2017)

3.2 Baseline Assessment Methods

- An infield site assessment was conducted on the 26th of September 2018 to confirm the location and extent of the systems identified as likely to be impacted by the proposed project. There are a number of factors which influence the level of impact, such as type of system, position of the system in relation to the project and position the system is located in the landscape. The identified aquatic ecosystems were classified in accordance with the, '*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa'* (Ollis *et al*. 2013) and *WET-Ecoservices* (Kotze *et al*. 2009).

- Infield delineation was undertaken with a hand-held GPS, for mapping of any potentially affected aquatic ecosystems, in alignment with standard field-based procedures in terms of the Department of Water and Sanitation (DWAF 2008) *Updated Manual for the Identification and Delineation of Wetlands and Riparian Areas*. The delineation is based upon observations of the landscape setting, topography, vegetation and soil characteristics (using a hand-held soil auger for wetland soils).
- Determination of the Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of any affected wetland habitats.
    - The health/condition or Present Ecological State (PES) of the wetland was assessed using the Level 2 WET-Health assessment tool Version 2 (Macfarlane *et al.* 2008), which is based on an understanding of both catchment and on-site impacts and the impact that these aspects have on system hydrology, geomorphology and the structure and composition of wetland vegetation.
    - Wetland benefits can be classified into goods/products (directly harvested from wetlands), functions/ services (performed by wetlands), and ecosystem scale attributes. The WET-Ecoservices tool (Kotze *et al*., 2009) is utilised to assess the goods and services that the individual wetlands under assessment provide, thereby aiding informed planning and decision-making. The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing).
    - The Ecological Importance and Sensitivity (EIS) of freshwater habitats is an expression of the importance of the water resource for the maintenance of biological diversity and ecological functioning on local and wider scales; whilst Ecological Sensitivity (or fragility) refers to a system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (Kleynhans & Louw, 2007). The Wetland EIS Tool was utilised to determine EIS (Kleynhans, 1999).
- Determination of the Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) assessment of the delineated river/riparian habitats was undertaken utilising:
    - Qualitative Index of Habitat Integrity (IHI) tool adapted from (Kleynhans, 1996) – PES
    - DWAF (DWS) River EIS tool (Kleynhans, 1999) - EIS
- The PES and EIS results then allowed for the determination of management objectives for the potentially impacted aquatic ecosystems.

Table 3: Tools utilised for the assessment of water resources impacted upon by the proposed project.

METHOD/TOOL*	SOURCE	REFERENCE
Delineation of wetland and/or Riparian areas	*A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas.*	(DWAF 2005)
Classification of wetlands and/ or other aquatic ecosystems	*National Wetland Classification System for Wetlands and other Aquatic Ecosystems in South Africa & WET-Ecoservices*	(Ollis *et al*., 2013), Kotze *et al*., 2009)
Present Ecological State (PES) Assessment (Wetland)	*WET-Health Assessment Version 2*	(McFarlane *et al.* 2009)
Functional Importance Assessment (Wetland)	*WET-Ecoservices Assessment*	(Kotze *et al*., 2009)
Ecological Importance & Sensitivity (EIS) Assessment (wetland)	*DWAF Wetland EIS Tool*	(Duthie 1999)
Present Ecological State (PES) Assessment (River)	*Rapid IHI (Index of Habitat Integrity) tool developed Kleynhans (1996), Modified by DWAF*	(Ecoquat)
Ecological Importance & Sensitivity (EIS) Assessment (River)	*DWAF EIS tool developed by Kleynhans (1999)*	(Kleynhans, 1999)

3.3 Impact Assessment Methods (Phase 2)

- The approach adopted is to identify and predict all potential direct and indirect impacts resulting from an activity from planning to rehabilitation. Thereafter, the impact significance for the three alternatives is determined.
- Impact significance is defined broadly as a measure of the desirability, importance and acceptability of an impact to society (Lawrence, 2007). The degree of significance depends upon three dimensions: the measurable characteristics of the impact (e.g. intensity, extent and duration), the importance societies/communities place on the impact, and the likelihood / probability of the impact occurring.
- Actions are thereafter recommended to prevent and mitigate the identified impacts on aquatic habitat, in alignment with the mitigation hierarchy, as well as any measures necessary to restore disturbed areas or ecological processes.
- Any necessary buffer areas or No-Go areas are visually represented. The buffer zone was determined by a tool developed by Macfarlane and Bredin (2016) called *Buffer zone guidelines for rivers, wetlands and estuaries*, site-based information and professional opinion. The final buffer requirement includes the implementation of practical management considerations/ mitigation measures.

4 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations are relevant:

- No shapefiles of data (apart from contour data), updated layouts, designs nor methods statements have as yet been provided by the client. However, this report will assist to inform these outputs and parameters and assess them in Phase 2.
- Aquatic ecosystems vary both temporally and spatially. Once-off surveys such as this are therefore likely to miss certain ecological information due to seasonality, thus limiting accuracy and confidence.
- Infield soil and vegetation sampling was only undertaken within a specific focal area around the proposed development, while the remaining watercourses were delineated at a desktop level with limited accuracy.
- No detailed assessment of aquatic fauna/biota was undertaken.
- The vegetation information provided is based on observation not formal vegetation plots. As such species documented in this report should be considered as a list of dominant and/or indicator wetland/riparian species and only provide a very general indication of the composition of the riverine vegetation communities. Please refer to the botanical assessment for detailed vegetation descriptions.

5 RESULTS

The property is bordered by, and traversed by the Kat River in the north, that feeds the adjoining Garden Route Dam, and the Swart River in the south. Small drainage lines within the site contain non perennial tributary streams that drain into the larger systems.

Any development of the vacant land is highly likely to impact the habitat, biota, and water quality of the freshwater systems, and they were therefore assessed further.

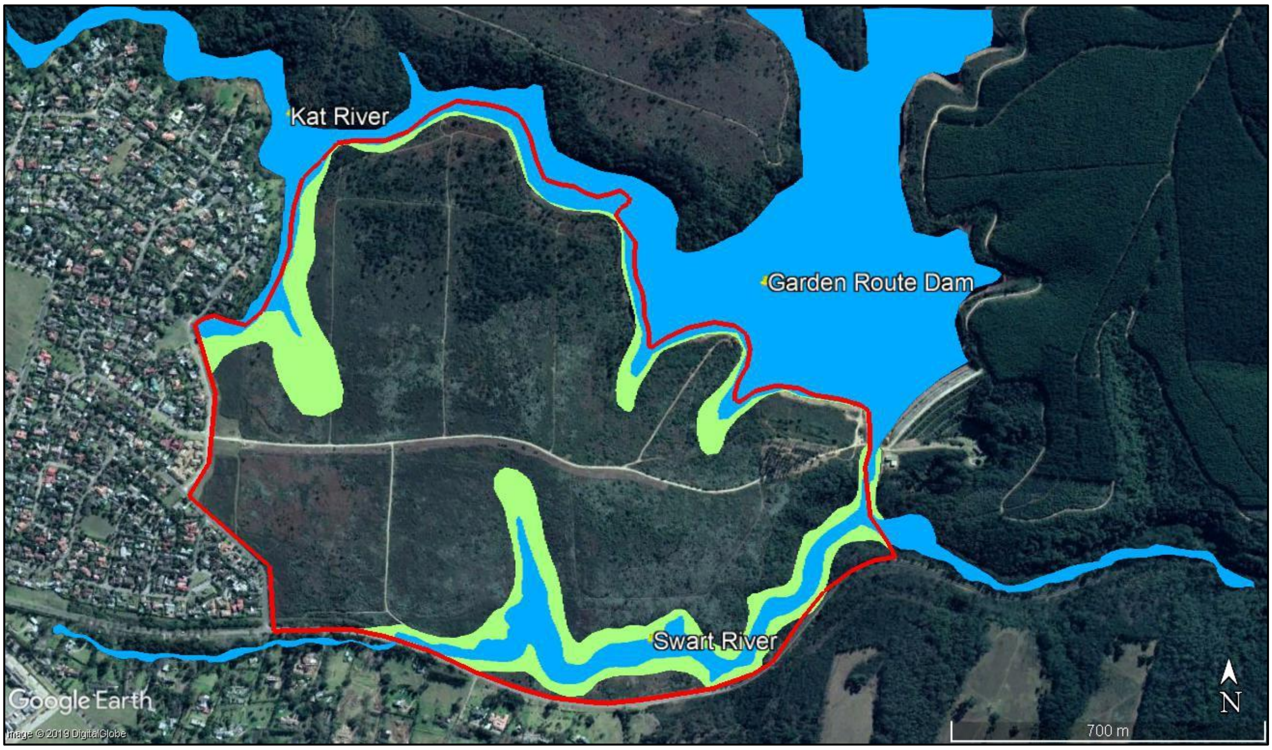

Figure 8: The study area in relation to the identified freshwater habitat. The blue polygon symbolising the delineated watercourses and the green indicating the riparian habitat surrounding them.

5.1 Kat River and Garden Route Dam

The Kat River is a perennial stream with its source in the Outeniqua Mountains above the town of George. It flows along the edge of the developed area and then becomes dammed shortly upslope of the confluence with the Swart River to the south (Figure 9). The reach of the Kat River assessed has a moderately steep gradient and is within the Upper foothills longitudinal zone. It is situated within a semi-confined valley floor and has a narrow channel with limited floodplain development. The substrate is dominated by gravel and course sand. The river is relatively well vegetated but largely with alien invasive trees species such as *Acacia mearnsii*. It has been subjected to significant degradation due to land cover and land use changes associated with urban development, plantation, damming, and alien invasive tree infestation. However, it is important to manage the system wisely due to its value as a corridor network, domestic water provisions, and the important rivers downstream. The assessment of the river PES and EIS is detailed in Tables 4 and 5, respectively.

Figure 9: Photograph of the Garden Route Dam on the Kat River system

Table 4: The Kat River Present Ecological State Assessment and Result

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	4	30	The Kat River has been subjected to significant purposeful and direct bed alterations. The reach upslope of the Garden Route Dam has been subjected to sedimentation, channel straightening, infilling and excavation from urban development. The construction of the dam has transformed the river bed morphology and led to downstream erosion due to sediment starvation and the altered longitudinal profile. Bed modifications have substantially reduced the quality /availability of habitat for biota.
Flow modification	3,5	40	The Garden Route Dam has resulted in significant flow modifications by impounding flows and through water abstraction whilst insufficient flows are released for the natural reserve. This has substantially impacted the Swart River and Kaaimans River downstream. Upslope of the dam the urban area and plantations have caused changes in temporal and spatial characteristics of flow. There has been a reduction in habitat types and water availability as a result of the many impacted habitat attributes.
Inundation	4	30	The Garden Route Dam is a significant impoundment that supplies George with water for domestic use. It has caused the inundation of a significant reach of the Kat River destroying riffle, rapid, and riparian zone habitat. It has completely obstructed the movement of aquatic fauna, influences the water quality characteristics, and the movement of sediments.

Bank condition	3	50	The bank condition has been altered by the urban development and plantation impacts as well as erosion due to alien invasive plant species compromising the banks. However, the level of incision in this reach is relatively mild and controlled by the dam spillway, but downslope of the dam the river has eroded to bedrock and unstable banks have resulted. The magnitude of the impact of this upon aquatic habitat is of a lesser degree than other attributes.
Riparian condition	3,5	40	The riparian area of the Kat River above the dam has been significantly encroached into by urban development, plantation and exotic vegetation which have compromised the available habitat extent, diversity and removed the buffering capabilities. However, the remaining habitat is vegetated and not entirely transformed.
Water quality modification	3	50	The reduced water quality of the Kat River is largely due to general misuse and mismanagement. decreased by urban pollutants such as untreated sewage, domestic effluent, polluted runoff and submerged macrophytes.
Average Score	**3,5**	40,0	*Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.*
Ecological Category	**D**	**Poor**	

Table 5: The Kat River EIS assessment and result

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1,5	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	2,0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	3,0	A substantial proportion of the biota is expected to be permanently dependent on flowing water for all phases of their life cycle.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2,0	The system has moderate species/taxon richness rated on a local scale.
RIPARIAN & INSTREAM HABITATS	Diversity of types (4=Very high - 1=marginal/low)	3,0	Despite the reduction in habitat types due to physical modifications, the system still provides a moderate level of habitat diversity, such as pools, runs, and marginal wetland area.
	Refugia (4=Very high - 1=marginal/low)	3,0	The refuge value is moderate to high as the system does occasionally provide refugia to biota during times of environmental stress, largely due to the remaining diversity of habitat types.

	Sensitivity to flow changes (4=Very high - 1=marginal/low)	2,0	A limited change in flows of the stream does affect habitat types such as the marginal wetland areas and extent of the channel. However, the biota is only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	2,0	The river has some habitat types that are sensitive to water quality change related to flow decreases or increases, but it is also influenced by the seasons.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	4,0	The river corridor links the Outeniqua Mountains to the coast. It is therefore an important link in terms of connectivity for the survival of biota and is moderately sensitive to modification. However, the garden route dam reduces the connectivity substantially.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	3,0	As stated above, the river is part of an important corridor network that should be carefully managed for its conservation value. The reach of the river above the dam is a protected area (although unmanaged) but the system is important for the conservation of ecological diversity on a provincial /regional scale.
MEDIAN OF DETERMINANTS		2,50	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**HIGH, EC=B**	*Many elements sensitive to changes in water quality/ hydrological regime*

5.2 Swart River Wetland

The reach of the Swart River system that will be impacted by the proposal can be classified as a channelled valley bottom wetland (Figure 10). Historically, it is likely that wetland habitat occupied the entire (although narrow) valley floor but various impacts through time have resulted in the loss of connectivity in wetland habitat along the reach. The channel incision has caused the loss of some marginal wetland habitat due to flow modification. The pockets of wetland habitat that remain consist largely of robust indigenous vegetation such as *Phragmites australis, Typha capensis, Pteridium aquilinum* , *Cyperus sp., Zantedeschia aethiopica, Helichrysum sp.* (Figure 11). The disturbed areas are however dominated by alien invasive plant species such as *Acacia melanoxylon*, *Acacia mearnsii, Rubus cuneifolius, Arundo donax,* and *Pinus sp.* (please refer to the botanical study for a more detailed species list).

The wetland has been subjected to impacts caused by past forestry activities, infrastructure, and alien invasive plant species infestation. The construction of the road to the south of the wetland has directly destroyed habitat, altered flow movements, and increased sediment inputs. A sewage pump station has been constructed within the wetland habitat, pipelines cross the wetland, and the colour and odour of the water indicated that this effluent is escaping into the system and causing pollution (Figure

12). This has altered the morphology and hydrology of the wetland and resulted in habitat fragmentation within the valley. Any proposed development within this catchment will result in further impacts on the watercourse but there are opportunities to rehabilitate it.

Figure 10: Photograph of the incised wetland channel near the pump station

Figure 11: Photograph showing the wetland in the valley bottom with associated hydrophilic vegetation (largely sedges) in the permanent zone and the encroachment of alien invasive plant species such as <u>Sesbania punicea</u>

Figure 12: Photograph of the murky, polluted water flowing within the incised channel in the lower reaches of the wetland

Past and present impacts have resulted in significant wetland habitat loss in large sections of the system. The hydrological regime has deviated greatly from the perceived reference state due to changes in water movement and retention patterns. The geomorphological characteristics have been transformed from the natural condition largely through erosion and sedimentation. Channel incision and straightening resulting in no bank overspill are especially harmful to a system dependent upon over-topping of the channel Although the area is well vegetated with hydrophilic indigenous vegetation, most areas are infested with alien invasive trees. The infestation of alien invasive plants in the catchment has altered the surface runoff and water inputs of the wetland area. Within the wetland, these plants confine flows and smother indigenous vegetation from the periphery. Additionally, the alien species decrease dry season flow which has resulted in terrestrial plant species encroaching into and establishing in the freshwater habitat.

The Present Ecological State (PES) of the Swart River Wetland in the south of the property is defined as Largely Modified represented by an overall 'D' score category for the WET-Health 2 assessment (Table 6). This category is indicative of a system where a large change in ecosystem processes and loss of natural habitat and biota and has occurred. Should development on the property, and cause addition impacts from increased hardened surfaces, concentrated flows and pollutants, there will be a negative trajectory of change in wetland integrity.

Table 6: The WET-Health Version 2 PES scores for the wetland on the Swart River

PES Assessment	Hydrology	Geomorphology	Water Quality	Vegetation
Impact Score	7,7	3,8	3,4	3,0
PES Score (%)	23%	62%	66%	70%
Ecological Category	**E**	**C**	**C**	**C**
Trajectory of change	↓	↓	↓	→
Combined Impact Score	5,6			
Combined PES Score (%)	44%			
Combined Ecological Category	**D**			
Hectare Equivalents	10,7 Ha			
Confidence	Moderate: Field-based 'Level 2' assessment but relatively high probability of connection to regional aquifer			

At a desktop level the functionality of channelled valley-bottom wetlands as a whole tend to contribute less towards flood attenuation and sediment trapping than typical floodplain wetland types but would supply these benefits to a certain extent. Channelled valley bottom wetlands have potential for removal of nutrients and toxicants to some degree, particularly from diffuse water inputs from adjacent hillslopes (Kotze *et al*. 2009).

The indirect goods and services provided by the wetland, such as sediment and nutrient trapping, were assessed as being Moderate to High (Table 7 and Figure 13). However, the wetland has a very low provision of direct ecosystem services apart from the small amount it contributes to the open space recreational setting (such as cycling) on the property. The system is not significant in terms of food or resource provisions, education/research and/or socio-cultural. This is mostly due to the lack of any endangered species, no known traditional practices, and the poor condition of the system.

Table 7: Scores for Swart River Wetland EcoServices Assessment

Swart River Wetland - Ecosystem Services Scores	Overall score (0- 4)
Flood attenuation	1,6
Streamflow regulation	2,2
Sediment trapping	2,7
Phosphate trapping	2,6
Nitrate removal	2,5
Toxicant removal	2,6
Erosion control	1,9
Carbon storage	2,0
Maintenance of biodiversity	1,6
Water supply for human use	1,2
Natural resources	0,2
Cultivated foods	0,0
Cultural significance	0,0

Tourism and recreation	1,9
Education and research	1,3
Threats	3,0
Opportunities	4,0

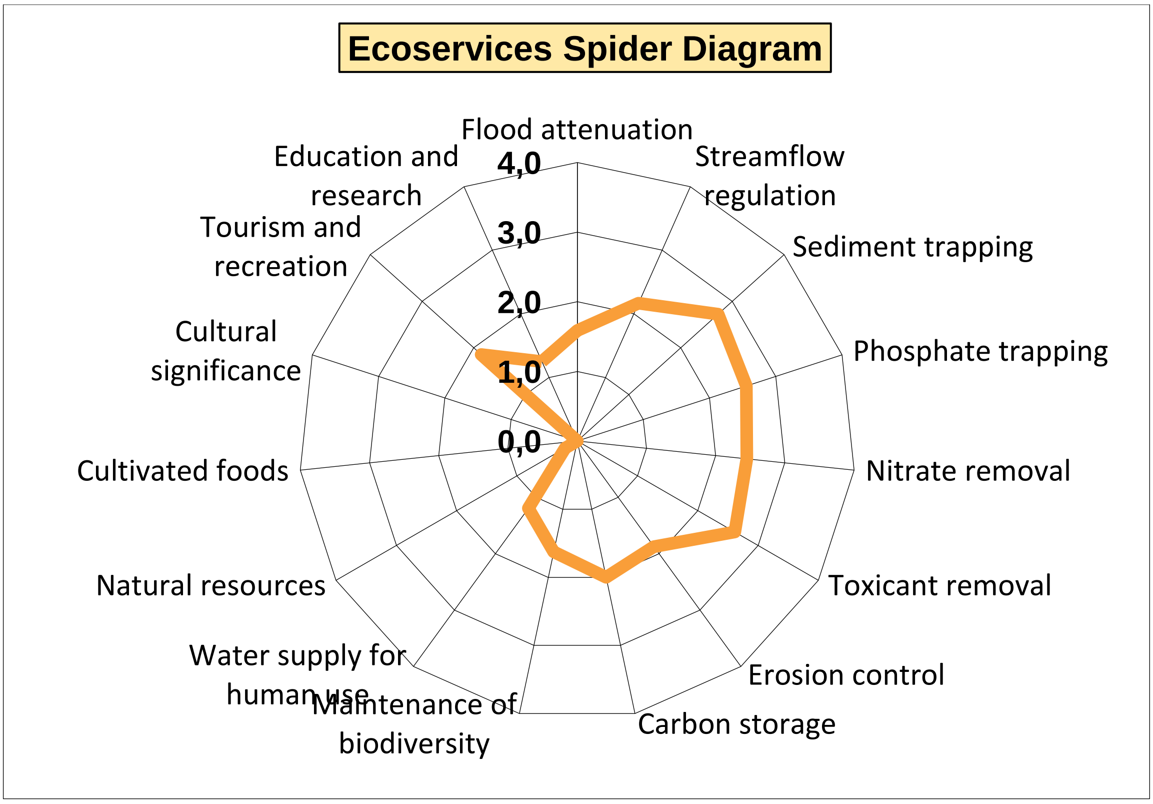

Figure 13: WET-Ecoservices Results

The Ecological integrity and sensitivity of the Swart River Wetland was assessed and obtained a Moderate EIS score (Table 8). Similar to the functional assessment above, the results show that the wetland provides very limited direct human benefits yet has moderate significance regarding indirect services. Ecologically, the wetland is not conserved in any way and no red data species or populations of unique species were observed. However, the wetland is an important piece of the larger river corridor network, influences significant downstream systems, and is moderately sensitive to changes to flow regime and periods of low flows.

Table 8: EIS Scores for the Swart River Wetland

SUMMARY	**Swart River Wetland**	
	Score (out of 4)	**Rating**
BIODIVERSITY IMPORTANCE	2,33	Moderate
FUNCTIONAL/HYDROLOGICAL IMPORTANCE	1,63	Low
DIRECT BENEFITS TO SOCIETY	1,17	Low
Ecological Importance and Sensitivity (EIS)	**2,33**	**Moderate - High**

The management objective was determined through the recommended ecological category of the wetland. This places it in the REC 'D' category which recommends maintaining the river from its present state. However, it is recommended that the development proposal incorporate basic measures to make improvements in ecological functioning (such as the halting and management of erosion and pollution and alien invasive removal that is in any case mandatory).

5.3 Tributary streams

There are three small drainage lines that concentrate runoff from the property into the Kat River and dam, and there is one tributary draining in a southernly direction into the Swart River Wetland. These tributaries are small natural systems with temporary flow. The systems are of similar ecological integrity as they share biophysical characteristics and have been similarly impacted by land use and cover changes. The tributaries all have narrow, shallow channels that are stable despite being steep longitudinally. No erosion was evident within these catchments. The tributaries are well-vegetated with shrubs such as *Diospyros dichrophylla* and *Searsia glauca,* with an understory dominated by Helichrysum Sp. and *Pteridium aquilinum*. However, there is a moderate level of alien invasive tree infestation (largely *Acacia mearnsii, Acacia melanoxylon* and Pinus sp.). *Rapanea melanophloeos trees* (Cape Beech), a protected species, were observed within the southern tributary riparian zone.

The four drainage systems will have been impacted upon in the past by forestry activities associated with the planation on the property, but they are not currently subjected to anthropogenic impacts and function in a near natural manner. The present ecological state of the small tributary systems was determined to be within the "B" category, indicating that modification is limited to very few localities and the impact on habitat quality, diversity, size and variability is also very small or not evident (Table 9). The proposed development is located within these catchments and will impact these systems.

Table 9: The PES results for the tributary streams

Rapid Habitat Integrity Assessment (Ecoquat Model)			
Determinand	**Score (0-5)**	**% intact**	**Rationale**
Bed modification	0,5	90	The systems are unimpacted by roads, erosion or any impacts causing bed modification. There is no evidence of sedimentation or erosion.
Flow modification	0,5	90	The systems only flow intermittently from surface runoff. These flows have been marginally impacted by altered runoff patterns caused by the gravel roads upslope. The regime has not been impacted by decreased or increased inputs. There have been no significant flow modifications.
Inundation	0	95	There are no inundated areas.
Bank condition	0,5	90	The riparian banks are stable, shallow in depth and not well defined. They are well vegetated with a mix of

			indigenous species and alien species. There has been no decrease in bank condition in these systems.
Riparian condition	2,5	60	The riparian areas are stable and well vegetated. However, there is a moderate level of alien invasive plant infestation that threatens the habitat integrity.
Water quality modification	0	95	There are no anthropogenic impacts in the systems micro catchments. There is no potential for pollutants to enter the systems. Additionally, there is no erosion to cause sedimentation.
Average Score	**0,7**	86,7	*Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.*
Ecological Category	**B**	**Good**	

The ecological importance and sensitivity category of the tributary network was determined as being 'Moderate' (C category). The systems do not have a high sensitivity as they are only intermittently inundated with no significant diversity of habitat along the reach. However, they act as an important ecological corridor.

Table 10: The EIS results for the tributary stream assessment

Ecological Importance and Sensitivity assessment (Rivers)			
Determinants		**Score (0-4)**	**Rationale**
BIOTA (RIPARIAN & INSTREAM)	Rare & endangered (range: 4=very high - 0 = none)	1,0	Although no rare or endangered species were encountered on site there are some species that are vulnerable on a local scale.
	Unique (endemic, isolated, etc.) (range: 4=very high - 0 = none)	1,0	Fynbos species: More than one population (or taxon) judged to be unique on a local scale.
	Intolerant (flow & flow related water quality) (range: 4=very high - 0 = none)	1,0	The species associated with these riparian systems are likely very tolerant of increases and decreases in flow as the systems are intermittently inundated. A very low proportion of the biota is expected to be only temporarily dependent on flowing water for the completion of their life cycle. Sporadic and seasonal flow events expected to be sufficient.
	Species/taxon richness (range: 4=very high - 1=low/marginal)	2,0	Despite the presence of alien invasive plants, the untransformed habitat and fynbos vegetation type results in a moderate species/taxon richness
RIPARIAN & INSTREAM	Diversity of types (4=Very high - 1=marginal/low)	2,0	There is a low diversity in aquatic habitat types do to the shallow, straight, and intermittently flowing systems with a uniform substrate material

	Refugia (4=Very high - 1=marginal/low)	2,0	The systems have a limited ability to provide refuge to biota during times of environmental stress. This is due to the limited diversity of habitat and intermittent flow.
	Sensitivity to flow changes (4=Very high - 1=marginal/low)	1,5	These small intermittent rivers, with limited habitat types, are only susceptible to flow decreases or increases during certain seasons.
	Sensitivity to flow related water quality changes (4=Very high - 1=marginal/low)	1,0	These are streams with habitat types rarely sensitive to water quality change related to flow decreases or increases.
	Migration route/corridor (instream & riparian, range: 4=very high - 0 = none)	2,0	The tributaries are a moderately important link in terms of connectivity for the survival of biota upstream and downstream and is moderately sensitive to modification. The network provides a corridor to the Kat River system.
	Importance of conservation & natural areas (range, 4=very high - 0=very low)	2	The tributaries are in a semi natural area which is important for the conservation of ecological diversity on a provincial /regional scale.
MEDIAN OF DETERMINANTS		1,75	
ECOLOGICAL IMPORTANCE AND SENSITIVITY CATEGORY (EIS)		**MODERATE, EC=C**	*Some elements sensitive to changes in water quality/hydrological regime*

6 POTENTIAL IMPACTS OF THE PROPOSED DEVELOPMENT

Aquatic ecosystems are particularly vulnerable to human activities and these activities can often result in irreversible damage or longer term, cumulative changes. The significance of an impact to the environment or ecosystem can only be assessed in terms of the change to ecosystem services, resources and biodiversity value associated with that system or component being assessed.

**It is not possible to accurately assess the significance of any of the potential impacts of development upon the watercourses without the provision of further information such as a detailed layout plan and civil designs.*

The most severe potential impacts associated with the development will likely be habitat disturbance/loss due to flow modifications, erosion and sedimentation as a result of new road and pipeline crossings and stormwater runoff. The transformed land surface will promote increased volumes and velocities of storm water runoff, which can be detrimental to the rivers receiving concentrated flows off of the area. According to the SANRAL (2006), urbanisation typically increases the runoff rate by 20 -50%, compared with natural conditions. Increased volumes and velocities of storm water draining from the area and discharging into the rivers can alter the natural ecology, increasing the risk of erosion and channel incision/scouring.

Roads, pipelines, culverts and bridges create migration barriers to biota, resulting in reach to zone scale instream biological impacts. Localised scour around structures or flow impediments may result and alter the natural bank and channel, channel bank stability and floodplain processes. Road and pipeline crossings that concentrate diffuse, wide floodplain flows into a few small channels or culverts can also inadvertently trigger gully formation. Additionally, flood protection measures and general infilling within the watercourses will modify the bed and bank characteristics. This has resulted in habitat loss and change to the watercourse and reduced aquatic species diversity. The encroachment of roads and housing onto floodplains and wetlands can dramatically alter the flow rates, water quality and sediment regimes of watercourses.

The greater the extent of hardened surfaces (e.g. roofs, parking lots etc.), the lower the infiltration of stormwater and therefore the greater the surface runoff and increase in flood peaks. A change in water distribution generally results in altered wetness regimes, which in turn affect the biophysical processes and the vegetation patterns. Urbanization of the catchment and its associated stormwater runoff is increasingly recognised as a threat to freshwater biodiversity not only because of the increased hydrological disturbance and habitat loss, but also because of an increased delivery of pollutants to streams. Stormwater runoff from urban surfaces may include nutrients, pollutants, raw sewage and other domestic waste. This waste can lead to eutrophication, excess plant growth causing changes to community dynamics, hypoxia (oxygen depletion) as well as inhibit the growth of bacteria that play an important role in removing nitrogen from water.

However, should the development be designed, constructed, and managed in an environmentally sensitive manner then there is potential to improve the current condition of the watercourses. The proposal must incorporate the most innovative, site specific, and proactive approach to stormwater management, erosion prevention, and alien invasive plant eradication. It is essential to maintain the corridor network as well as a sufficient buffer area around the riparian areas. Figure 14 below is a map indicating the recommended buffer and corridor network for the maintenance of the watercourses. However, with the provision of final layout and civil designs, and subsequent impact assessment, the areas may need to be amended.

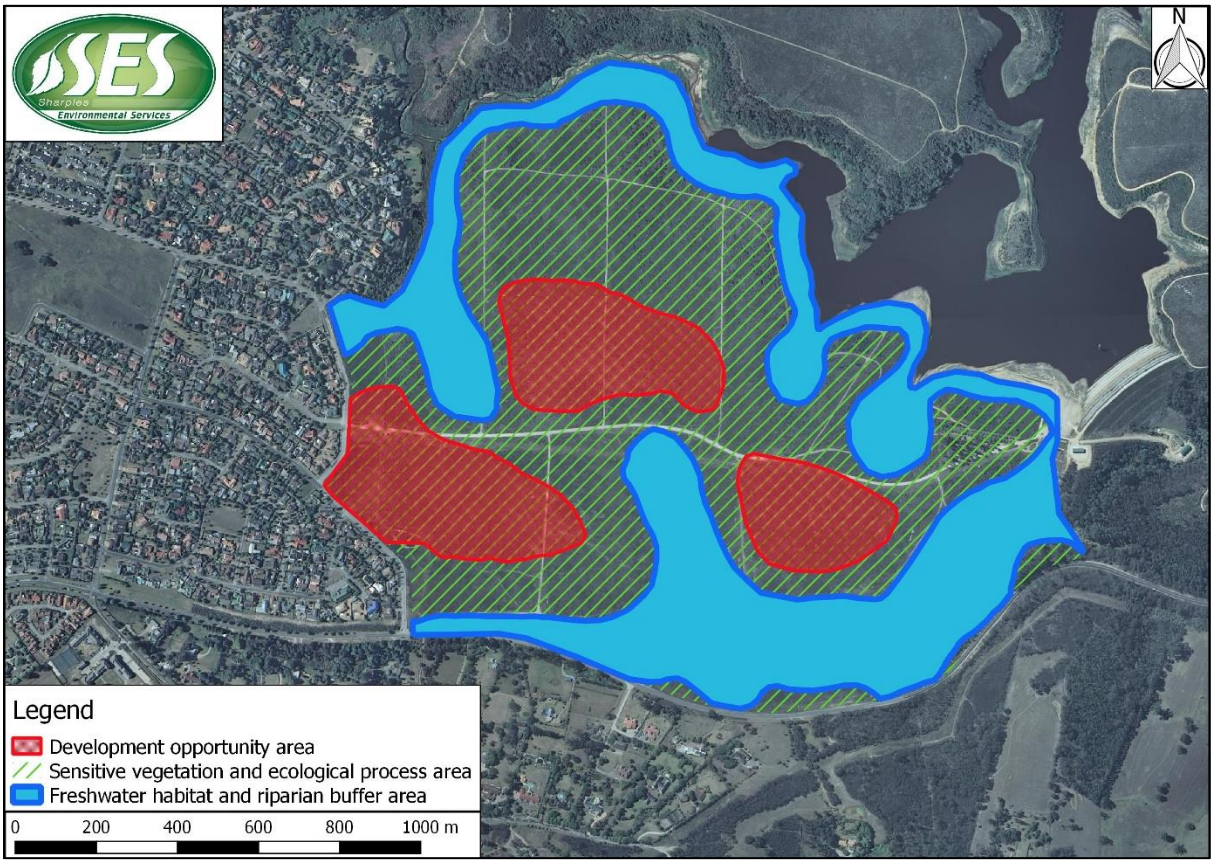

Figure 14: A spatial representation of the recommended opportunity and constraints regarding the proposal

7 PHASE 2 ASSESSMENT

The impact significance of the proposed development will be determined for each potential impact of the project once detailed layouts and planning has been finalised. It is necessary to have this information to accurately determine the level of impact as well as propose alternatives. Additionally, the associated mitigation and monitoring measures will be adapted accordingly.

8 CONCLUSION

Cumulative impacts on the environment can result from broader, long term changes and not only as a result of a single activity or development. They are rather from the combined effects of many activities overtime. Rivers are longitudinal systems where different reaches interact in a continuum along the length of the river. This is vitally important to understand in the context of cumulative impacts from developments. Activities in the upper reaches influence the processes of the lower reaches and it must therefore be viewed as a whole. Regarding the proposed Garden Route Dam development, it is largely the cumulative impacts upon the broader river corridor network than need to be mitigated against. Sustainable design (suitable buffer areas, effective stormwater management etc.) and the implementation of detailed management plans, can result in acceptable impact levels and potentially positive impacts upon water resources.

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10 ANNEXURE (METHODOLOGIES)

10.1 Wetland delineation and HGM type identification

Wetland delineation includes the confirmation of the occurrence of wetland and a determination of the outermost edge of the wetland. The outer boundary of wetlands was identified and delineated according to the Department of Water Affairs wetland delineation manual 'A Practical Field Procedure for Identification and Delineation of Wetland and Riparian Areas' (DWAF, 2005a). Wetland indicators were used in the field delineation of the wetlands: position in landscape, vegetation and soil wetness (determined through soil sampling with a soil auger and the examining the degree of mottling).

Four specific wetland indicators were used in the detailed field delineation of wetlands, which include:

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

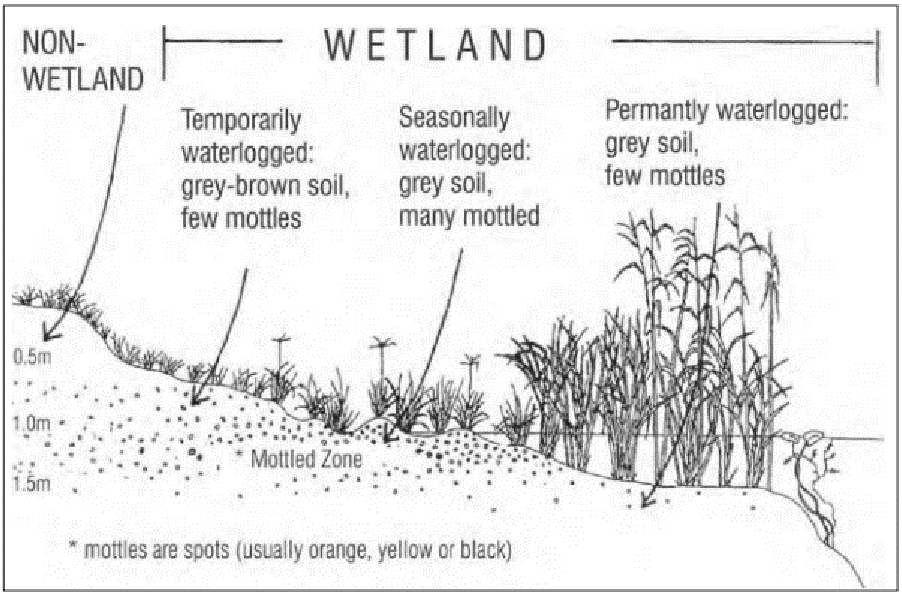

Figure A11.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

According to the wetland definition used in the National Water Act, vegetation is the primary indicator, which must be present under normal circumstances. However, in practise the soil wetness indicator tends to be the most important, and the other three indicators are used in a confirmatory role. The reason is that vegetation responds relatively quickly to changes in soil moisture regime or management and may be transformed; whereas the morphological indicators in the soil are far more permanent and will hold the signs of frequent saturation long after a wetland has been drained (perhaps for several centuries).

The permanent, seasonal and temporary wetness zones can be characterised to some extent by the soil wetness indicators that they display (Table A11.1a)

A11.1a: Soil Wetness Indicators in the various wetland zones

TEMPORARY ZONE	SEASONAL ZONE	PERMANENT ZONE
Minimal grey matrix (<10%)	Grey matrix (<10%)	Prominent grey matrix
Few high chroma mottles	Many low chroma mottles present	Few to no high chroma mottles
Short periods of saturation (less than three months per annum)	Significant periods of wetness (at least three months per annum)	Wetness all year round (possible sulphuric odour)

Table A11.1b: Relationship between wetness zones and vegetation types and classification of plants according to occurrence in wetlands

VEGETATION	TEMPORARY WETNESS ZONE	SEASONAL WETNESS ZONE	PERMANENT WETNESS ZONE
Herbaceous	Predominantly grass species; mixture of species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas	Hydrophilic sedges and grasses restricted to wetland areas	Dominated by: (1) emergent plants, including reeds (*Phragmites australis*), a mixture of sedges and bulrushes (Typha capensis), usually >1m tall; or (2) floating or submerged aquatic plants.
Woody	Mixture of woody species which occur extensively in non-wetland areas, and hydrophilic plant species which are restricted largely to wetland areas.	Hydrophilic woody species restricted to wetland areas	Hydrophilic woody species, which are restricted to wetland areas. Morphological adaptations to prolonged wetness (e.g. prop roots).

SYMBOL	HYDRIC STATUS	DESCRIPTION/OCCURRENCE
Ow	Obligate wetland species	Almost always grow in wetlands (>90% occurrence)
Fw/F+	Facultative wetland species	Usually grow in wetlands (67-99% occurrence) but occasionally found in non-wetland areas
F	Facultative species	Equally likely to grow in wetlands (34-66% occurrence) and non-wetland areas
Fd/F-	Facultative dryland species	Usually grow in non-wetland areas but sometimes grow in wetlands (1-34% occurrence)

D	Dryland species	Almost always grow in drylands

In order to identify the wetland types, using Kotze *et al.* (2009) and Ollie *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. These have been defined based on the geomorphic setting of the wetland in the landscape (e.g. hillslope or valley bottom, whether drainage is open or closed), water source (surface water dominated or sub-surface water dominated), how water flows through the wetland (diffusely or channelled) and how water exits the wetland (Figure A11.1b).

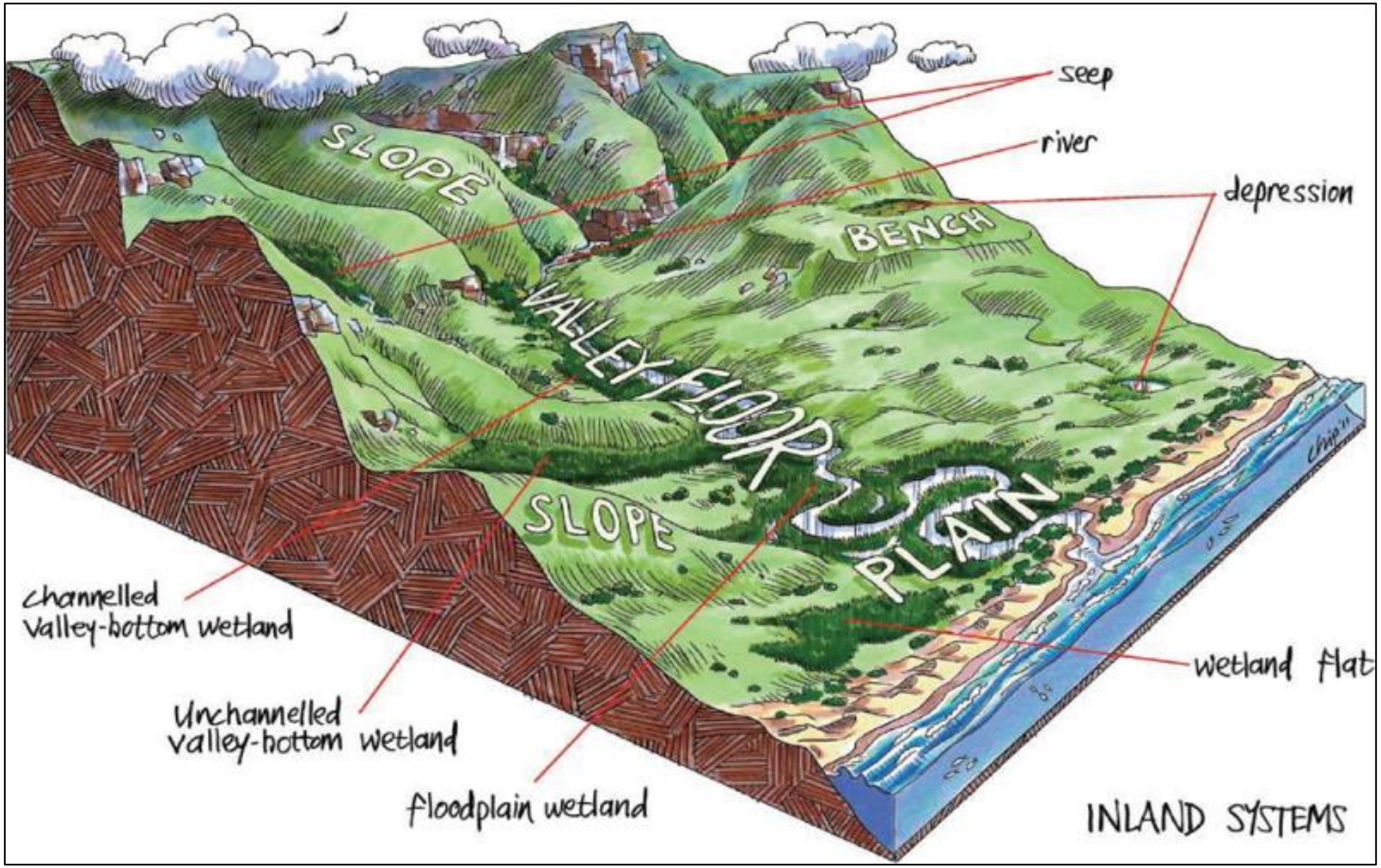

Figure A11.1b: Illustration of wetland types and their typical landscape setting (From Ollie et al. 2013)

10.2 Delineation of Riparian Areas

Riparian zones are described as "the physical structure and associated vegetation of the areas associated with a watercourse which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent areas" i , Riparian zones can be thus be distinguished from adjacent terrestrial areas through their association with the physical structure (banks) of the river or stream, as well as the distinctive structural and compositional vegetation zones between the riparian and upland terrestrial areas (Figure 8). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units (Figure 2), namely the: - Crest (hilltop); - Scarp (cliff); - Midslope (often a convex slope); - Footslope (often a concave slope); and - Valley bottom. Amongst these landscape units, riparian areas are only likely to develop on the valley bottom landscape units (i.e. adjacent to the river or stream channels; along the banks comprised of the sediment deposited by the channel). Alluvial soils are soils derived from material deposited by flowing water, especially in the valleys of large rivers. Riparian areas often, but not always, have alluvial soils. Whilst the presence of alluvial soils cannot always be used as a primary indicator to accurately delineate riparian areas, it can be used to confirm the topographical and vegetative indicators. Quaternary alluvial soil deposits are often indicated on geological maps, and whilst the extent of these quaternary alluvial deposits usually far exceeds the extent of the contemporary riparian zone; such indicators are useful in identifying areas of the landscape where wider riparian zones may be expected to occur.

Topography and recently deposited material associated with riparian areas The National Water Act definition of riparian zones refers to the structure of the banks and likely presence of alluvium. A good indicator of the presence of riparian zones is the presence of alluvial deposited material adjacent to the active channel (such as benches and terraces), as well as the wider incised "macro-channels" which are typical of many of southern Africa's eastern seaboard rivers. Recently deposited alluvial material outside of the main active channel banks can indicate a currently active flooding area; and thus the likely presence of wetlands. Vegetation associated with riparian areas unlike the delineation of wetland areas, where redoxymorphic features in the soil are the primary indicator, the identification of riparian areas relies heavily on vegetative indicators. Using vegetation, the outer boundary of a riparian area can be defined as the point where a distinctive change occurs: - in species composition relative to the adjacent terrestrial area; and - in the physical structure, such as vigour or robustness of growth forms of species similar to that of adjacent terrestrial areas. Growth form refers to the health, compactness, crowding, size, structure and/or numbers of individual plants.

As with the delineation approach for wetlands, the field delineation method for riparian areas focuses on two main indicators of riparian zones: - **Vegetation Indicators**, and - **Topography** of the banks of the river or stream.

Additional verification can be obtained by examining for any recently alluvial deposited material to indicate the extent of flooding and thus obtain at least a minimum riparian zone width. The following procedure should be used for delineation of riparian zones: A good rough indicator of the outer edge of the riparian areas is the edge of the macro channel bank. This is defined as the outer bank of a compound channel, and should not be confused with the active river or stream channel bank. The macro-channel is an incised feature, created by uplift of the subcontinent which caused many rivers to cut down to the underlying geology and creating a sort of "restrictive floodplain" within which one or more active channels flow. Floods seldom have any known influence outside of this incised feature. Within the macro-channel, flood benches may exist between the active channel and the top of the macro channel bank. These depositional features are often covered by alluvial deposits and may have riparian vegetation on them. Going (vertically) up the macro channel bank often represents a dramatic decrease in the frequency, duration and depth of flooding experienced, leading to a corresponding change in vegetation structure and composition.

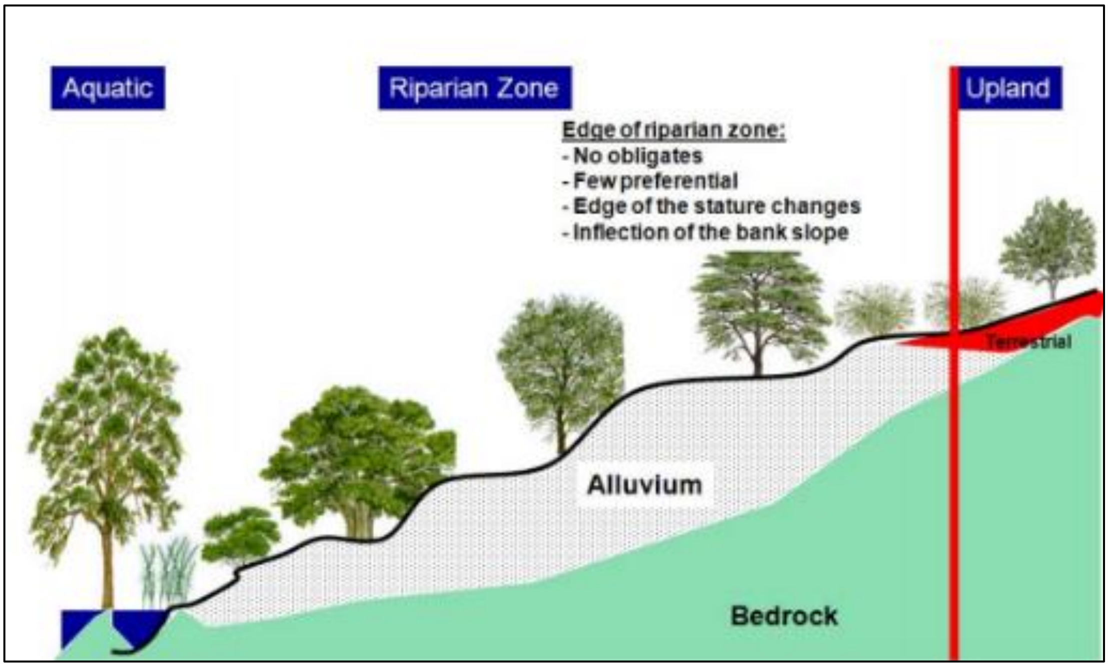

Figure A11.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).

10.3 Present Ecological State (PES) – Wetlands

WET-Health assists in assessing the health of wetlands using indicators based on geomorphology, hydrology and vegetation. For the purposes of rehabilitation planning and assessment, WET-Health helps users understand the condition of the wetland in order to determine whether it is beyond repair, whether it requires rehabilitation intervention, or whether, despite damage, it is perhaps healthy enough not to require intervention. It also helps diagnose the cause of wetland degradation so that rehabilitation workers can design appropriate interventions that treat both the symptoms and causes of degradation. WET-Health is tailored specifically for South African conditions and has wide application, including assessing the Present Ecological State of a wetland. There are two levels of complexity: Level 1 is used for assessment at a broad catchment level and Level 2 provides detail and confidence for individual wetlands based on field assessment of indicators of degradation (e.g. presence of alien plants). A basic tertiary education in agriculture and/or environmental sciences is required to use it effectively. Level 1 was utilised for the assessment.

WET-Health is a tool designed to assess the health or integrity of a wetland. Wetland health is defined as a measure of the deviation of wetland structure and function from the wetland's natural reference condition. This technique attempts to assess hydrological, geomorphological and vegetation health in three separate modules.

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

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

Vegetation is defined in this context as the vegetation structural and compositional state. This module evaluates changes in vegetation composition and structure as a consequence of current and historic onsite transformation and/or disturbance.

The overall approach is to quantify the impacts of human activity or clearly visible impacts on wetland health, and then to convert the impact scores to a Present State score. The tool attempts to standardise the way that impacts are calculated and presented across each of the modules. This takes the form of assessing the spatial extent of impact of individual activities and then separately assessing the intensity of impact of each activity in the affected area. The extent and intensity are then combined to determine an overall magnitude of impact (Table A11.2a).

Table A11.2a: Guideline for interpreting the magnitude of impacts on integrity (Macfarlane et al., 2008).

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

Impact scores obtained for each of the modules reflect the degree of change from natural reference conditions. Resultant health scores fall into one of six health categories (A-F) on a gradient from “unmodified/natural” (Category A) to “severe/complete deviation from natural” (Category F) as depicted in Table A11.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

Table A11.2b. Health categories used by WET-Health for describing the integrity of wetlands (after Macfarlane et al., 2008).

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

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

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

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

10.4 Wetland Functional Importance (Goods and Services)

WET-EcoServices is used to assess the goods and services that individual wetlands provide, thereby aiding informed planning and decision making. It is designed for a class of wetlands known as palustrine wetlands (i.e. marshes, floodplains, vleis or seeps). The tool provides guidelines for scoring the importance of a wetland in delivering each of 15 different ecosystem services (including flood attenuation, sediment trapping and provision of livestock grazing). The first step is to characterise wetlands according to their hydro-geomorphic setting (e.g. floodplain). Ecosystem service delivery is then assessed either at Level 1, based on existing knowledge or at Level 2, based on a field assessment of key descriptors (e.g. flow pattern through the wetland).

The overall goal of WET-EcoServices is to assist decision makers, government officials, planners, consultants and educators in undertaking quick assessments of wetlands, specifically in order to reveal the ecosystem services that they supply. This allows for more informed planning and decision making. WET-EcoServices includes the assessment of several ecosystem services (listed in Table A11.4a) - that is, the benefits provided to people by the ecosystem.

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

Table A11.4a: Ecosystem services assessed by WET-Ecoservices

The steps involved in applying WET-EcoServices can be summarised as follows.

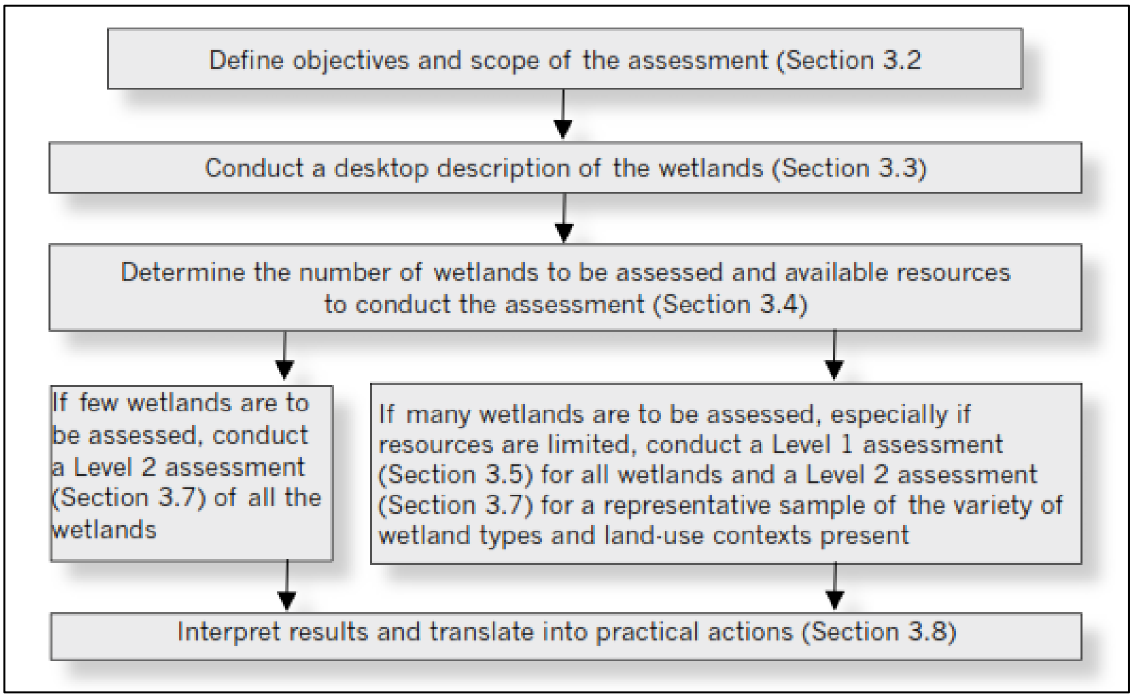

Figure A11.4a: Steps required for Wet-EcoServices. The sections referred to within this figure relate back to the Wetland Management Series: Wet-Ecoservices. WRC Report TT 339/08

10.5 Ecological Importance & Sensitivity (EIS) - Wetlands

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 (DWAF, 1999), and the work conducted by Kotze et al (2008) on the assessment of wetland ecological goods and services from the WET-EcoServices tool (Rountree, 2010). An example of the scoring sheet is attached as Table A11.5a. The scores are then placed into a category of very low, low, moderate, high and very high as shown in Table 14.5b.

Table A11.5a: Example of scoring sheet for Ecological Importance and sensitivity

ECOLOGICAL IMPORTANCE AND SENSITIVITY:			
Ecological Importance	Score (0-4)	*Confidence (1-5)*	**Motivation for site**
Biodiversity support			
Presence of Red Data species			
Populations of unique species			
Migration/breeding/feeding sites			
Landscape scale			
Protection status of the wetland			
Protection status of the vegetation type			
Regional context of the ecological integrity			
Size and rarity of the wetland type/s present			
Diversity of habitat types			
Sensitivity of the wetland			
Sensitivity to changes in floods			
Sensitivity to changes in low flows/dry season			
Sensitivity to changes in water quality			
ECOLOGICAL IMPORTANCE & SENSITIVITY			
HYDROLOGICAL/FUNCTIONAL IMPORTANCE			
IMPORTANCE OF DIRECT HUMAN BENEFITS			
OVERALL IMPORTANCE			

Table A11.5b: Category of score for the Ecological Importance and Sensitivity

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

10.6 Present Ecological State (PES) – Riparian

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

DWAF have developed a modified IHI, designed to accommodate the time constraints associated with desktop assessments or for instances where a rapid assessment of river conditions is required. The protocol does not distinguish between instream and riparian habitat and addresses six simple metrics to obtain an indication of Present Ecological State (PES). Each of the criteria are rated on a scale of 0 (close to natural) to 5 (critically modified) (Table A11.6a) according to the following metrics:

- Bed modification
- Flow modification
- Inundation
- Bank condition
- Riparian zone condition
- Water quality modification

This assessment was informed by (i) a site visit where potential impacts to each metric were assessed and evaluated and (ii) an understanding of the catchment feeding the river and landuses / activities that could have a detrimental impact on river ecosystems.

Table A11.6a: The rating scale for each of the various metrics in the assessment

Rating Score	Impact Class	Description
0	**None**	*No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.*
0.5 - 1.0	**Low**	*The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.*
1.5 - 2.0	**Moderate**	*The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.*
2.5 - 3.0	**Large**	*The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.*
3.5 - 4.0	**Serious**	*The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.*
4.5 - 5.0	**Critical**	*The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.*

The six metric ratings of the HGM under assessment are then averaged, resulting in one value. This value determines the Habitat Integrity PES category for the HGM (Table A11.6b).

Table A11.6b: The habitat integrity PES categories

Habitat Integrity PES Category	Description
A: Natural	Unmodified, natural.
B: Good	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
C: Fair	Moderately modified. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
D: Poor	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E: Seriously modified	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
F: Critically modified	Critically / Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

10.7 Ecological Importance & Sensitivity – Riparian

The ecological importance of a wetland/river is an expression of its importance to the maintenance of biological diversity and ecological functioning on local and wider scales. Ecological sensitivity (or fragility) refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (Kleynhans & Louw, 2007; Resh et al., 1988; Milner, 1994). Both abiotic and biotic components of the system are taken into consideration in the assessment of ecological importance and sensitivity (Table A11.7a).

Table A11.7a: Components considered for the assessment of the ecological importance and sensitivity of a riparian system. An example of the scoring has also been provided.

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

The scores assigned to the criteria in Table A11.7a were used to rate the overall EIS of each mapped unit according to Table A11.7b, below, which was based on the criteria used by DWS for river eco-classification (Kleynhans & Louw, 2007) and the WET-Health wetland integrity assessment method (Macfarlane et al., 2008).

Table A11.7b: The ratings associated with the assessment of the EIA for riparian areas

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

11 ANNEXURE: ALIEN INVASIVE PLANT CONTROL

Table showing control options for likely alien invasive plants species (Adapted from Day et al. 2016)

Acacia cyclops (Rooikrans)		**Manual:** Hand pulling or hoeing of seedlings or saplings. Grubbing, hoeing and digging out of immature stage up to 2 m. Felling and cutting of stump to the ground for larger mature trees. **Bio-Control:** Indigenous field mice eat the seeds. Rooikrans seed weevil. Flower galler (*Dasineura dielsi* Rubsaamen). Seed feeder (*Melanterius servulus*).
Acacia mearnsii (Black Wattle)		**Manual:** Hand pulling of seedlings or saplings <40 cm. Grubbing. Hoeing. Digging of immature trees up to 2 m. Felling used for large mature trees. Ringing, ring of 10 cm width in large plants. **Chemical:** Seedlings – Mamba, Garlon 4, Viroaxe. Tree stumps – Timbrel 3A. **Bio Control:** Stump fungus *(Cylindrobasidium laeve)* applied to freshly cut stumps. Seed weevil (*Melanterius maculates*).

Arundo donax (Spanish Reed)			**Manual:** Repeated removal. Cutting of stalks. However, cut stalks can re-root and manual methods generally unsustainable. **Chemical:** 3Apply MAMBA or Nexus GLYPHOSATE 360 Reg. NO L7113: Act /Wet no 36/ 1947. This is a broad spectrum herbicide so applicable in dense monospecific stands. Ideally use as foliar spray, just before winter (as this is the time that translocation in plant nutrients to the root-mass takes place in preparation for winter dormancy and toxin transfer to roots is most effective. If stands too dense for good foliar application, cut stems and then apply as foliar to resprouting material – but note that cut material may resprout and transfer to roots less effective as cutting stimulates stem growth. If mixed stands, use GLYPHOSATE 360, on cut stems, but note less effective.
Lantana camara			**Manual:** Hand pulling of seedlings or saplings. Grubbing or hoeing of small patches. Cutting is ineffective as plant coppices use of herbicides needed. Large infestation should be crushed or rolled with brush cutters then stumps treated with herbicides. **Chemical:** Seedlings/ saplings – Mamba/Kilo Touchdown / Access. Mature tree stumps – Chopper / Access/ Timbrel 3A. **Bio Control:** Flower galler (Aceria *lantanae* Cook). Leaf miner (*Calycomyza lantanae*). Leaf sucker (Falconia intermedia). Leaf feeder (*Hypena laceratalis* Walker). Leaf miner (*Octotoma scabripennis* Guerin-Meneville). Leaf miner (*Ophiomyia camarae* Spencer). Seed miner (*Ophiomyia lantanae*). Leaf & flower sucker (*Teleonemia scrupulosa* Stal). Leaf miner (*Uroplata girardi* Pic).
Pennisetum Clandestinum (Kikuyu grass)			**Manual:** hand pull by roots; kikuyu often associated with raised fill / disturbed areas – removal will reduce invasion opportunities; Inclusion of hard paths on upland edge of river, buffer or wetland provides hard management edge from which to manage invasion and also reduces to some extent root spread **Chemical:** Spray with Roundup ® while grass is actively growing (not when dormant) and follow up spray any regrowth after 4 months.

Rubus spp (Bramble)		**Chemical:** Mamba max – most effective in autumn when downward sap movement.
Cirsium vulgare (Scottish Thistle)		**Manual:** hand pull
Hedychium gardnerianum (Kahili ginger lily)		**Manual:** hand pull