Freshwater Assessment – Plettenberg Bay Country Club, Western Cape.

DRAFT FINAL REPORT

For:

Plettenberg Bay Country Club

By:

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Confluent Environmental

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EXECUTIVE SUMMARY

The Plettenberg Bay Country Club (PBCC) is a golf course located along the banks of the Piesang River in Plettenberg Bay. The golf course is an important feature for local sport and tourism and the local economy and attracts a significant number of European visitors each summer (during the European winter). The course is located below the 1:50 year flood line and frequently experiences flooding following heavy rainfall events in the catchment area which affects the playability of the course and therefore impacts on revenues that the course can earn. Routine maintenance of the course and its artificial and natural watercourses is therefore required in order to ensure adequate drainage, while ensuring watercourses are adequately protected. Planned maintenance activities will take place in the Piesangs River as well as artificial water features and drainage channels associated with the former extent of a relatively large wetland seep system. The scope of work for this report includes the following:

- A desktop review of freshwater features and provincial and national freshwater conservation plans relevant to the site;
- Undertake a site visit to the study area to verify the sensitivity of aquatic biodiversity affected by maintenance activities; and
- Develop a Management and Maintenance Plan (MMP) to guide the timing, extent and execution of maintenance activities.

Maintenance activities are likely to occur annually and are primarily aimed at improving drainage through the golf course by maintaining infrastructure (culverts) and clearing natural and artificial watercourses of sediment and nuisance aquatic plants (including encroaching *T. capensis* and the alien invasive *S. molesta*). The historic establishment of the PBCC together with regulation of streamflows caused by the Roodefontein Dam have resulted in a significant modification of the lower reaches of the Piesangs River and the former wetland seep and the Present Ecological State (PES) of these systems is D and E, respectively.

Given the highly modified state of these systems and assuming implementation of recommended mitigation measures, impacts to the watercourses are considered to be negligible. In addition, the DWS Risk Assessment matrix determined that the risk of maintenance activities to the watercourses is Low, and therefore qualifies for a General Authorisation. Based on this assessment it is recommended that the MMP for the PBCC be approved.

Declaration of Specialist Independence

- I consider myself bound to the rules and ethics of the South African Council for Natural Scientific Professions (SACNASP);
- At the time of conducting the study and compiling this report I did not have any interest, hidden or otherwise, in the proposed development that this study has reference to, except for financial compensation for work done in a professional capacity;
- Work performed for this study was done in an objective manner. Even if this study results in views and findings that are not favourable to the client/applicant, I will not be affected in any manner by the outcome of any environmental process of which this report may form a part, other than being members of the general public;
- I declare that there are no circumstances that may compromise my objectivity in performing this specialist investigation. I do not necessarily object to or endorse any proposed developments, but aim to present facts, findings and recommendations based on relevant professional experience and scientific data;
- I do not have any influence over decisions made by the governing authorities;
- I undertake to disclose all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by a competent authority to such a relevant authority and the applicant;
- I have the necessary qualifications and guidance from professional experts in conducting specialist reports relevant to this application, including knowledge of the relevant Act, regulations and any guidelines that have relevance to the proposed activity;
- This document and all information contained herein is and will remain the intellectual property of Confluent Environmental. This document, in its entirety or any portion thereof, may not be altered in any manner or form, for any purpose without the specific and written consent of the specialist investigators.
- All the particulars furnished by me in this document are true and correct.

Dr. James Dabrowski (Ph.D., Pr.Sci.Nat. Water Resources; SACNASP Reg. No: 114084)

March 2023

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1.1 Project Background

The Plettenberg Bay Country Club is a golf course located along the banks of the Piesang River in Plettenberg Bay. The golf course is an important feature for local sport and tourism and the local economy and attracts a significant number of European visitors each summer (during the European winter). The course is located below the 1:50 year flood line and frequently experiences flooding following heavy rainfall events in the catchment area which affects the playability of the course and therefore impacts on revenues that the course can earn. Routine maintenance of the course and its artificial and natural watercourses is therefore required in order to ensure adequate drainage, while ensuring watercourses are adequately protected.

1.2 Key Legislative Requirements

1.2.1 National Environmental Management Act (NEMA, 1998)

A Management and Maintenance Plan (MMP) is a document that describes maintenance activities that need to take place within a watercourse. The MMP specifically relates to Activities 19 and 27, as listed in the National Environmental Management Act, 1998 (Act No. 107 of 1998), as amended (NEMA) Environmental Impact Assessment (EIA) Regulations Listing Notice 1 of 2014 (GN R. 327), as amended. In line with the MMP, infilling or removal of more than 10 m^3 material within a watercourse, and/or the clearance of 1 ha or more of indigenous vegetation, are allowed only if the works are undertaken for maintenance purposes AND form part of the EMMP when approved by the Department of Environmental Affairs and Development Planning (DEA&DP).

1.2.2 National Water Act (NWA, 1998)

The Department of Water & Sanitation (DWS) is the custodian of South Africa's water resources and therefore assumes public trusteeship of water resources, which includes watercourses, surface water, estuaries, or aquifers. The National Water Act (NWA) (Act No. 36 of 1998) aims to protect water resources, through:

- The maintenance of the quality of the water resource to the extent that the water resources may be used in an ecologically sustainable way;
- The prevention of the degradation of the water resource; and
- The rehabilitation of the water resource.

A watercourse means:

- A river or spring;
- A natural channel in which water flows regularly or intermittently;
- A wetland, lake or dam into which, or from which, water flows; and
- Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

No activity may take place within a watercourse unless it is authorised by the Department of Water and Sanitation (DWS). According to Section 21 (c) and (i) of the National Water Act, a

Water Use License (WUL) is required for any activities that impede or divert the flow of water in a watercourse or alter the bed, banks, course or characteristics of a watercourse. The regulated area of a watercourse for section 21(c) or (i) of the Act water uses means:

a) The outer edge of the 1 in 100-year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;
b) In the absence of a determined 1 in 100-year flood line or riparian area the area within 100m from the edge of a watercourse where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or
c) A 500 m radius from the delineated boundary (extent) of any wetland or pan.

Maintenance and management activities on the golf course will require work to be undertaken within rivers and wetlands and therefore fall within the regulated area of a watercourse. Any water use activities that do occur within the regulated area of a watercourse must therefore be assessed using the DWS Risk Assessment Matrix (GN 509) to determine whether activities may be generally authorised (Low Risk according to the Risk Assessment Matrix) or require a WUL (Medium or High Risk according to the Risk Assessment Matrix).

1.3 Scope of Work

Based on the key legislative requirements listed above, the scope of work for this report includes the following:

- A desktop review of freshwater features and provincial and national freshwater conservation plans relevant to the site;
- Undertake a site visit to the study area to verify the sensitivity of aquatic biodiversity affected by maintenance activities; and
- Develop a MMP to guide the timing, extent and execution of maintenance activities.

2 METHODS

2.1 Watercourse Assessment

A desktop assessment was conducted to contextualize the affected watercourses in terms of their local and regional setting, and conservation planning. An understanding of the biophysical attributes and conservation and water resource management plans of the area assists in the assessment of the importance and sensitivity of the watercourses, the setting of management objectives and the assessment of the significance of anticipated impacts. The following data sources and GIS spatial information were consulted to inform the desktop assessment:

- National Freshwater Ecosystem Priority Area (NFEPA) atlas (Nel at al., 2011);
- National Wetland Map 5 and Confidence Map (CSIR, 2018);
- Western Cape Biodiversity Spatial Plan (CapeNature, 2017); and
- DWS hydrological spatial layers.

A site visit was conducted on the 9th of February 2023, with the objective of identifying and classifying watercourses affected by maintenance activities, determining their Present

Ecological State (PES) and Ecological Importance and Sensitivity (EIS), and assessing the impacts of the maintenance activities on these watercourses.

2.1.1 Watercourse Classification

Watercourses were classified based on their hydrological and geomorphological characteristics which provides a fundamental understanding of the drivers that characterize each watercourse and therefore assists in the interpretation of impacts to the watercourse. The classification of the watercourse also determines which PES and EIS assessment methodologies can be applied. Each watercourse was categorised into discrete hydrogeomorphic units (HGMs) based on its geomorphic characteristics, source of water and pattern of water flow through the watercourse. These HGMs were then classified according to Ollis et al. (2013).

2.1.2 Present Ecological State

An important factor that influences the diversity and abundance of aquatic communities is the condition of the surrounding physico-chemical habitat. Habitat loss, alteration, or degradation generally results in a decline in species diversity. The PES of affected watercourses was assessed using methods applicable to the classification of the watercourse (i.e. river or wetland). PES assessments for riverine and wetland sections were conducted using the Index of Habitat Integrity (IHI) and Wet-Health methodologies, respectively (see Appendix 1 and 2).

2.1.3 Ecological Importance and Sensitivity

The ecological importance of a watercourse is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. Ecological sensitivity refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred (resilience) (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. The EIS of affected watercourses was assessed using methods applicable to the classification of the watercourse (i.e. river or wetland). EIS assessment methodologies for rivers and wetlands can be viewed in Appendix 3 and 4, respectively.

2.2 Impact Assessment

The impact assessment methodology is described in the appendix to this report (Appendix 5). Development activities typically impact on the following important drivers of natural and artificial watercourses:

- *Hydrology:* Impacts on hydrological functioning at a landscape level and across the site which can arise from changes to flood regimes and base flows and modifications to general flow characteristics, 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 etc.);
- *Geomorphology:* This refers to the alteration of hydrological and geomorphological processes and drivers, and associated impacts to aquatic habitat and ecosystem goods and services primarily driven by changes to the sediment regime of the aquatic ecosystem and its broader catchment;

- *Modification of water quality:* This refers to the alteration or deterioration in the physical, chemical and biological characteristics of water within streams, rivers and wetlands, and associated impacts to aquatic habitat and ecosystem goods and services (e.g. due to increased sediment load, contamination by chemical and/or organic effluent, and/or eutrophication etc.);
- *Fragmentation:* Loss of lateral and/or longitudinal ecological connectivity due to structures crossing or bordering watercourses (e.g. road or pipeline crossing a wetland);
- *Modification of aquatic habitat:* This refers to the physical disturbance of in-stream and riparian aquatic habitat and associated ecosystem goods and services including 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.)*;* and
- *Aquatic biodiversity:* Impacts on 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.

Maintenance activities were therefore assessed with respect to their impact on these drivers (if applicable).

3 DESKTOP ASSESSMENT

The Plettenberg Bay Country Club is located on Portion 1 of Farm 456 Grootfontein, in Plettenberg Bay within quaternary catchment K60G (Figure 1). The main river flowing through the catchment is the Piesangs River, which flows through the property and shortly thereafter forms the Piesangs River estuary. The property is located downstream of the Roodefontien Dam which supplies the Bitou Municipality with drinking water. The catchment area falls within the South-Eastern Coastal Belt ecoregion, which is characterised by moderately undulating plains and low mountains with altitude ranging from 0 to 1 300 m above mean sea level. Mean annual precipitation for the catchment area is relatively high (between 500 and 800 mm per annum), and occurs year-round, with peaks in late winter and early spring (August to October).

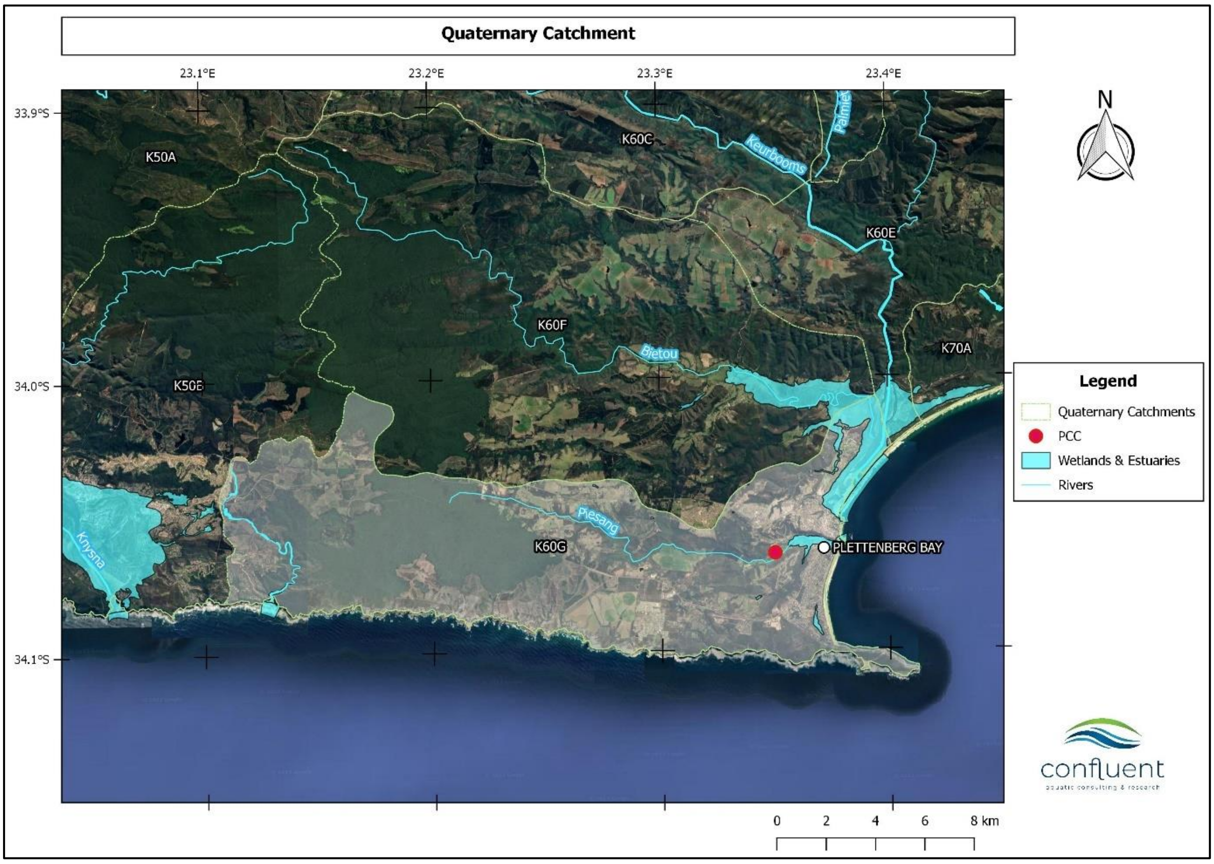

Figure 1: Location of the Plettenberg Bay Country Club in quaternary catchment K60G.

3.1 Freshwater Conservation & Management

3.1.1 National Freshwater Ecosystem Priority Atlas (NFEPA)

The PBCC is located within sub-quaternary catchment (SQC) 9200 (Figure 2), which, according to the National Freshwater Ecosystem Priority Atlas (NFEPA, Nel et al., 2011), has been classified as a Freshwater Ecosystem Priority Area (FEPA). River FEPAs achieve biodiversity targets for river ecosystems and threatened/near-threatened fish species and were identified in rivers that are currently in a good condition (A or B ecological category). Their FEPA status indicated that they should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources (Nel et al., 2011).

For river FEPAs, the whole SQC is identified as a FEPA, although the FEPA status applies to the actual river reach within such a sub-quaternary catchment. The shading of the whole sub-quaternary catchment indicates that the surrounding land and catchment area needs to be managed in a way that maintains the good ecological condition of the river reach, which in this case, is the Piesang River, which flows through the golf course. It is therefore important that any maintenance activities that occur on the golf course do not result in any deterioration of the river or its catchment area. Maintenance activities must ultimately aim to maintain or improve the ecological condition of the Piesangs River.

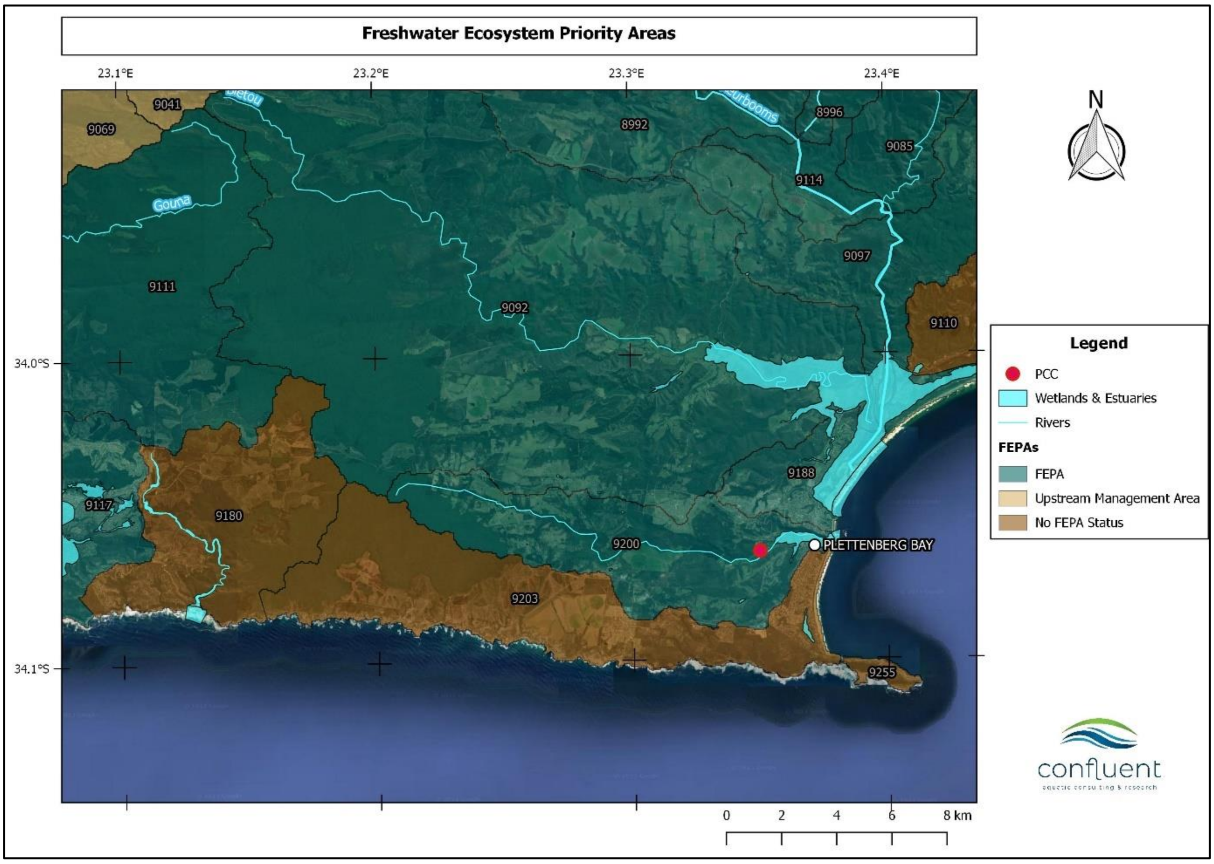

Figure 2: Map indicating the location the Plettenberg Bay Country Club in relation to FEPAs.

3.2 Western Cape Biodiversity Spatial Plan

According to the Bitou WCBSP the entire golf course falls within a protected area known as the Plettenberg Bay Country Club Private Nature Reserve (Figure 3).

Figure 3: Map of the golf course in relation to the Western Cape Biodiversity Spatial Plan (WCBSP).

4 WATERCOURSE ASSESSMENT

4.1 Watercourse Classification

The entire reach of the Piesang River below the Roodefontein Dam that flows through the golf course can be classified as a perennial river. At a landscape level, the river flows through a relatively broad valley and the river is characterised by an active channel, with clearly discernible bed and banks. The geomorphological zonation is Upper Foothill, and is characterised by a moderately steep, cobble-bed or mixed bedrock-cobble bed channel, with plane bed, pool-riffle or pool-rapid reach types (see Figure 4). The more undisturbed sections of the river (immediately below the Roodefontein dam) are well shaded by a dense riparian zone comprising of tall indigenous trees. As the river flows through the golf course, the riparian zone becomes far more diminished and is also absent along some stretches.

Figure 4: Photographs of the Piesangs River downstream of the Roodefontein Dam, showing a dense riparian canopy and a mixed boulder and cobble river substrate.

In addition to the river, there are remnant seep wetlands that formerly formed part of a much larger wetland seep system that stretched across the current golf course (Figure 5). Establishment of the course has converted much of this former wetland system into a series of artificial water features (i.e. small dams/water holes) that are interconnected by a system of shallow, grassed drainage canals (Figure 6). Water is not actively pumped into any of these dams, and their permanent inundation indicates that they been excavated into a very shallow water table, which is consistent with conditions that would have caused the formation of a large seep wetland. This is further corroborated by the fact that boreholes located on the golf course actively decant to the surface without being actively pumped. The groundwater appears to be very rich in iron and there are widespread examples of a rusty coloured precipitate in many of the water features, which is caused by the oxidation of anaerobic soluble ferrous iron (Fe^{2+} - derived from groundwater) to insoluble ferric (Fe^{3+}) iron-hydroxide. Only two remnant patches of what could be considered as natural wetland habitat remain (see Figure 6). These are characterised by a dense and diverse coverage of wetland plants including species such as *Phragmites australis*, *Cliffortia odorata*, *Carpha glomerata* and a variety sedges and rushes (Figure 7).

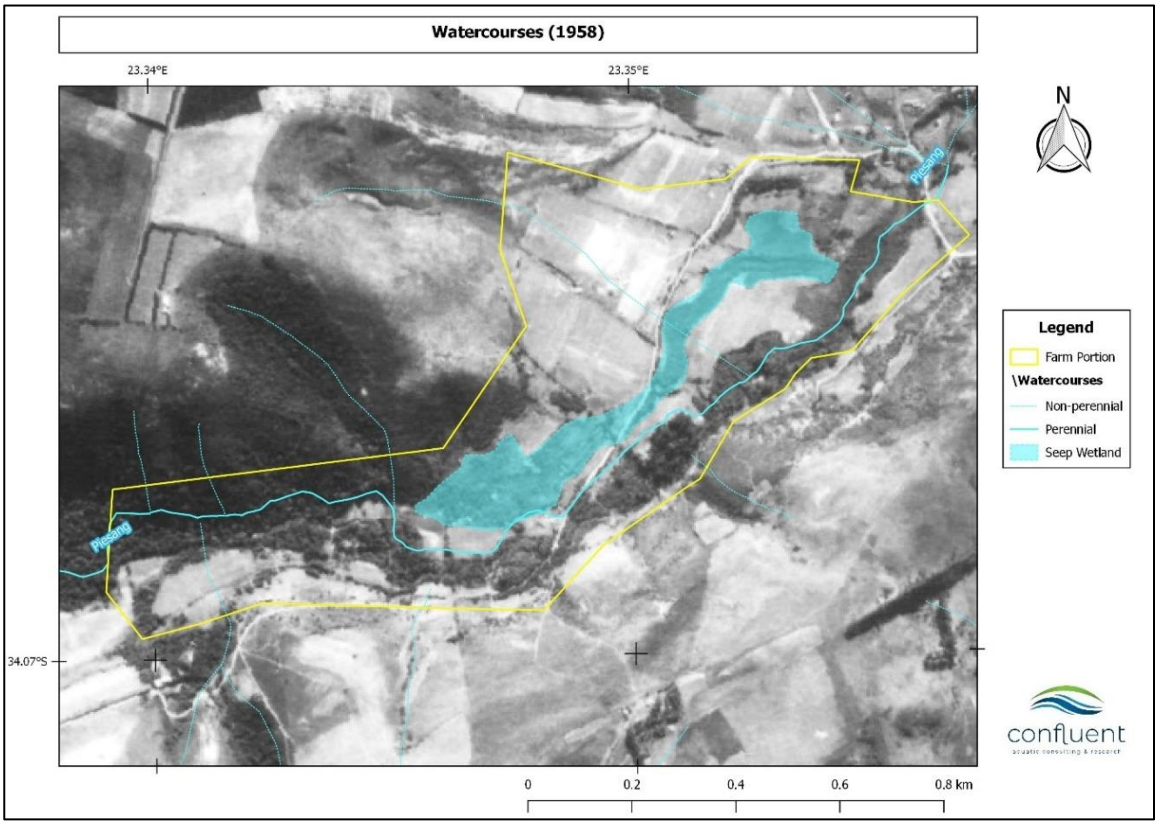

Figure 5: Historical ortho-photo from 1958 showing the likely former extent of the wetland seep system. Note also the dense riparian zone along most of the length of the Piesang River.

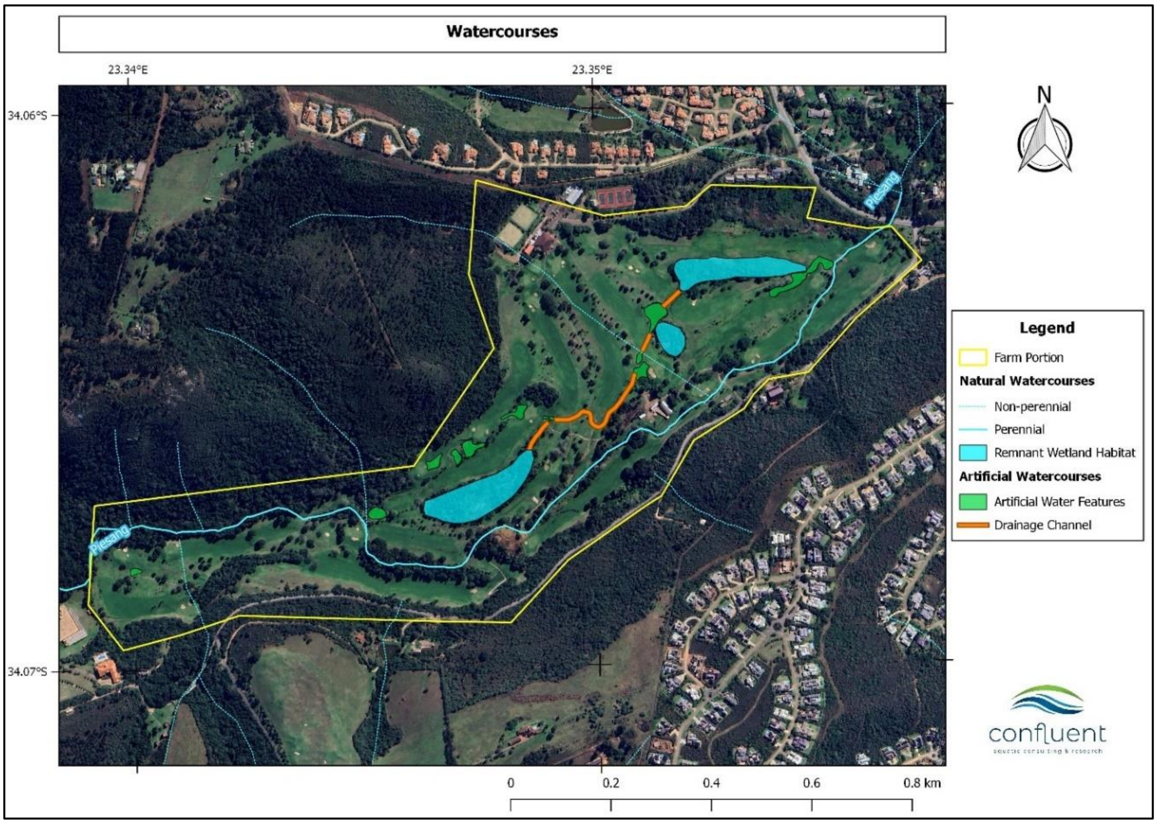

Figure 6: Map showing current day natural and artificial watercourses located throughout the golf course.

Figure 7: Photographs illustrating the dense wetland vegetation in the eastern-most remnant of the wetland seep.

4.2 Present Ecological State (PES)

4.2.1 Piesang River

The most serious impacts on the Piesang River are related to the regulation of flow caused by the Roodefontein Dam and the historical establishment of the golf course itself (Table 1). Below the dam, the river initially runs through a section of indigenous vegetation and shows geomorphological characteristics typical of an Upper Foothills system, comprising of a relatively steep system with a cobble and boulder substrate. The river is shaded by a dense riparian canopy and instream emergent or aquatic vegetation is negligible. Once the river enters the golf course it becomes distinctly narrower, with, steeper, higher banks, mostly grassed with kikuyu. The dense riparian canopy has been mostly removed along most of the length of the river through the golf course. Increased sunlight, together with modifications to the river substrate (which is more dominated by sediment as opposed to cobbles and boulders) and flow regime (i.e. reduced frequency and magnitude of flood events) has led to establishment of abundant instream vegetation (e.g. most notably *Tyhpa capensis* as well as other sedges and grasses) which chokes long lengths of the river. The invasive water fern, *Salivina molesta* was abundant throughout the river reach. A small instream dam is also located in the river which is used to abstract water for irrigation of the golf course. Remaining stretches of riparian vegetation are comprised of a mixture indigenous and alien vegetation (including Blackwood – *Acacia melanoxylyn*, Black Wattle – *Acacia mearnsii*, Brazilian Pepper Tree - *Schinus terebinthifolia*). In summary a large loss of natural habitat, biota and basic ecosystem functions has occurred in the lower reaches of the Piesangs River and the PES is therefore **D, Largely Modified.**

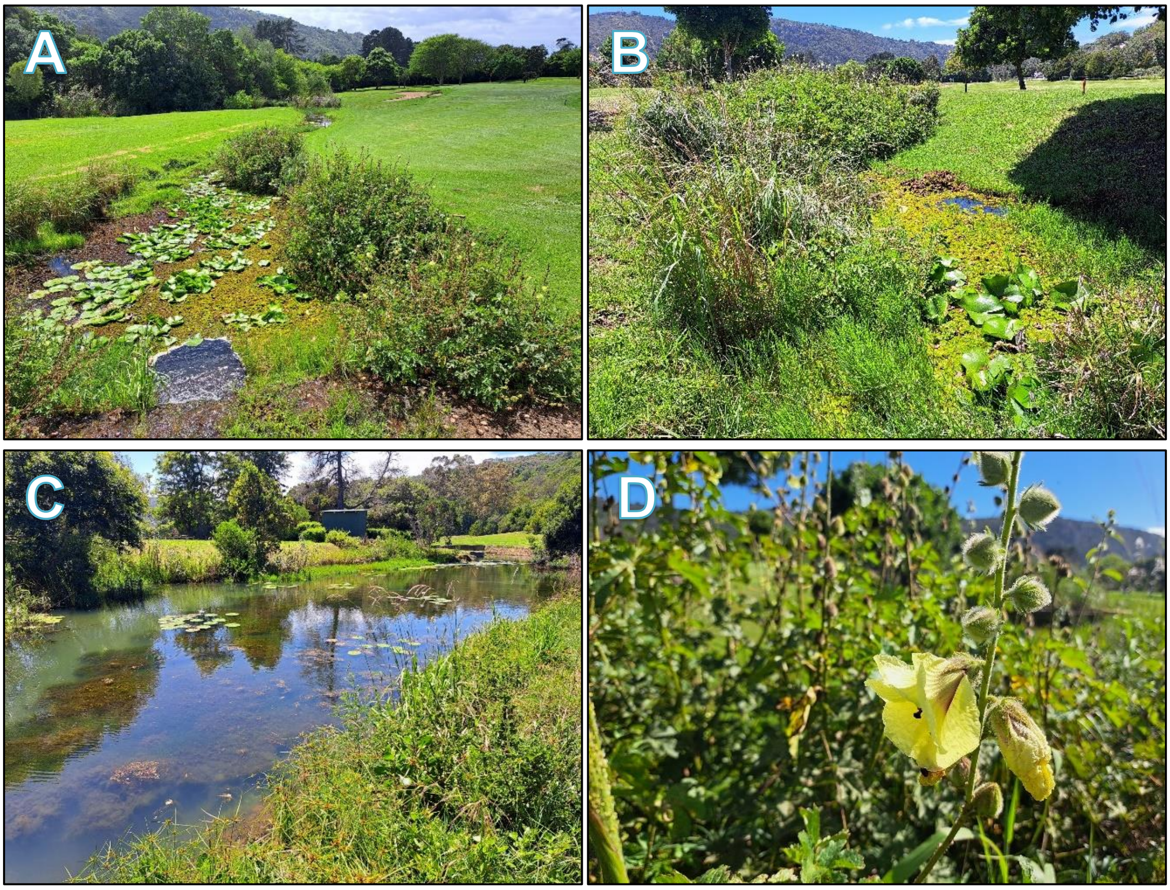

Figure 8: Photographs illustrating impacts on the lower reaches of the Piesangs River, including removal of the riparian zone, dense growth of instream aquatic vegetation (A and B), a small instream dam used for irrigation of the golf course (C) and the exotic *Hibiscus diversifolius* which was relatively abundant along the banks (D).

Table 1: Present Ecological State (PES) of the Piesangs River below the Roodefontain Dam.

Modification	Drainage Line
Water abstraction	**11 –** Relatively high rate of abstraction from the Roodefontein Dam and from lower down in the Piesang River for irrigation of the golf course.
Flow modification	**11 –** Reduced flows and flood peaks caused by the Roodefontein Dam
Bed modification	**11 –** Increased levels of sedimentation in the river.
Channel modification	**9 –** Parts of the channel has been narrowed, with steeper, higher banks – presumably caused by historical construction of the golf course
Physico-chemical modification	**4 –** Minor to moderate inputs associated with fertilisers and herbicides used on the golf course.
Inundation	**3 –** Narrower channel has led to submergence of what would have formerly been riffle habitat along most of the river reach.
Alien macrophytes	**11** – *Salvinia molesta* abundant in sections of the river reach.
Alien aquatic fauna	**0** - None
Rubbish dumping	**0 –** None

Modification	Drainage Line
Instream IHI score	**55 (D – Largely Modified)**
Vegetation removal	**17** – Large sections of riparian habitat have been removed.
Invasive vegetation	**11** – Alien tree species relatively widespread through remaining extent of riparian habitat
Bank erosion	**7 –** Some minor indications of bank erosion due to clearance of vegetation and
Channel modification	**10 –** Eroded channel due to alien invasive species.
Water abstraction	**2** – Minimally affected by exotic vegetation.
Inundation	**0–** None.
Flow modification	**0** – None
Physico-chemical modification	**0 –** None
Riparian IHI Score	**55 (D – Largely Modified)**
Combined Score	**58 (D – Largely Modified)**

4.2.2 Wetland Seep

The hydrology has been fundamentally altered through the creation of artificial water features which concentrates water at these points as opposed to allowing it to seep over a larger area. In terms of geomorphology and vegetation, the majority of the former extent of the wetland seep has been filled in and transformed into golf course (i.e. fairways, artificial water features etc.) and only a few remnant patches of natural wetland habitat remain. These remaining patches do however host a relatively high diversity of wetland plants and provide good habitat and refuge for a range of terrestrial and aquatic biota. The main impact on these remnant areas is invasion by alien tree species, including Blackwood - *Acacia melanoxylyn*, Black Wattle – *Acacia mearnsii*, Brazilian Pepper Tree - *Schinus terebinthifolia*. The western seep had a high abundance of yellow-wood saplings around the periphery and removal of alien invasives would allow these indigenous trees to re-establish. Overall, the PES for the wetland see system is **E: Seriously Modified.**

Table 2: Wet-Health scores and PES assessment for the remnant wetland seep.

Component	Score
Hydrology	15 % (F)
Geomorphology	30 % (E)
Vegetation	28 % (E)
Overall PES	**E (Seriously Modified)**

4.3 Ecological Importance & Sensitivity (EIS)

4.3.1 Piesang River

The lower reach of the Piesang River is a perennial system and therefore sensitive to changes in flow and water quality. It forms an important link between the Estuarine Functional Zone and the larger Piesang River catchment area. The EIS of the watercourse is therefore considered to be **High** (Table 3).

Table 3: Ecological Importance and Sensitivity (EIS) of Piesangs River below the Roodefontein Dam.

Determinant	Drainage Line
Presence of Rare & Endangered Species	**2** – Moderate probability of rare or endangered taxa.
Populations of Unique Species	**3 –** Endemic *Sandelia capensis* has been recorded to occur in the Piesangs River.
Intolerant Biota	**3** – A high proportion of the biota is expected to be dependent on permanently flowing water during all phases of their life cycle.
Species/Taxon Richness	**2** - High diversity of fauna and flora expected on a local scale.
Diversity of Habitat Types or Features	**2** – Good diversity at a local scale.
Refuge value of habitat types	**2** – Important at a local scale.
Sensitivity of habitat to flow changes	**3** – Lower foothill habitat – sensitive to changes in flow.
Sensitivity to flow related water quality changes	**3** – Perennial river sensitive to modifications in water quality.
Migration route for instream and riparian biota	**2** – The stream delineation is an important link in terms of connectivity for the survival of biota upstream and downstream.
Protection Status	**1** – Falls within the Plettenberg Bay Country Club Private Nature Reserve.
EIS Score	**2.5 (High)**

4.3.2 Remnant Wetland Seep

The remnant wetland seep system is rated as moderate in terms of its ecological importance and sensitivity, owing to its relatively large size and potential to host red data species (Table 4). Given its position within the landscape (outside of the main channel of the Piesangs River), its hydro-geomorphological characteristics (i.e. a seep wetland) and the highly modified nature of the remnant wetland system, it offers little with respect to important hydro-functional attributes (e.g. attenuating floods and improving water quality) (Table 5). The wetland system offers no direct human benefits (Table 6). The EIS is therefore considered to be **Moderate**.

Table 4. Ecological Importance and Sensitivity importance criteria for the remnant wetland habitats.

Criteria	Score
Biodiversity Support	
Presence of Red Data species	2
Populations of unique species	1
Migration/feeding/breeding sites	1
Average	**1.3**
Landscape Scale	
Protection status of wetland	1 – Poorly protected
Protection status of vegetation type	1 – Poorly protected
Regional context of the ecological integrity	1 – Seriously modified from natural
Size and rarity of the wetland types present	2 – Moderate size – vulnerable.
Diversity of habitat types	1 – densely vegetated with little diversity of habitat types
Average	**1.2**
Sensitivity of the Wetland	
Sensitivity to changes in floods	1

Sensitivity to changes in low flows	1
Sensitivity to changes in water quality	1
Average	**1**
ECOLOGICAL IMPORTANCE AND SENSITIVITY	**1.3 (Moderate)**

Table 5: Hydro-functional importance criteria results for the remnant wetland habitats.

Hydro-functional importance			Score
Regulating & supporting benefits	Flood attenuation		2
	Streamflow regulation		2
	Water quality enhancement	Sediment trapping	1
		Phosphate assimilation	1
		Nitrate assimilation	1
		Toxicant assimilation	1
		Erosion control	1
	Carbon storage		2
HYDRO-FUNCTIONAL IMPORTANCE			**1.4 (Moderate)**

Table 6: Direct human benefit importance criteria results for the remnant wetland habitats.

Direct human benefits		Score
Subsistence benefits	Water for human use	0
	Harvestable resources /cultivated foods	0
Cultural benefits	Cultural heritage	0
	Tourism and recreation & education and research	0
DIRECT HUMAN BENEFITS		**0**

5 PROPOSED MAINTENANCE ACTIVITIES

Maintenance activities as described below refer to artificial and natural watercourses as illustrated in Figure 9.

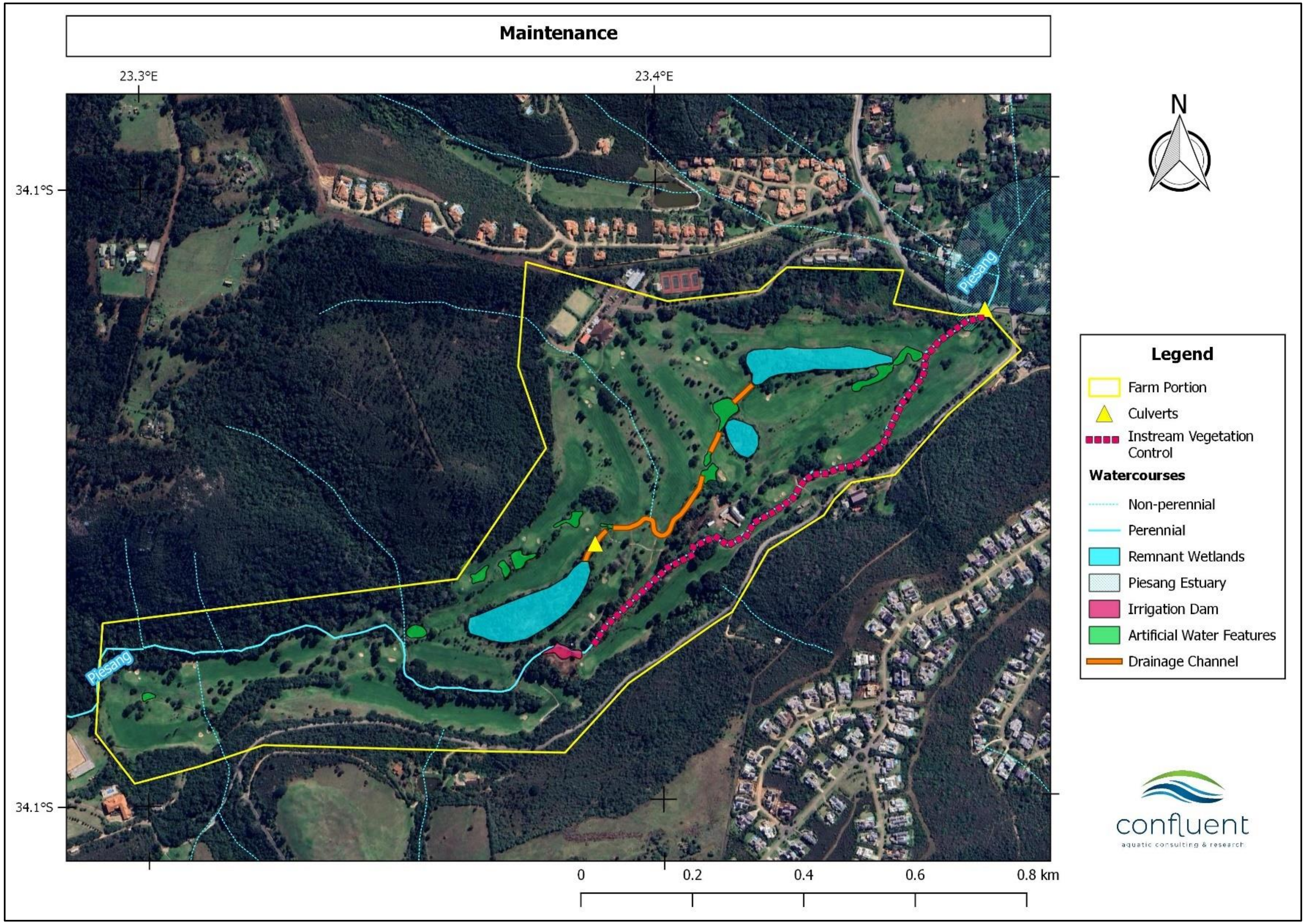

Figure 9: Map indicating artificial and natural watercourses on the golf course (not all culverts are mapped – only those that provide reference points to maintenance activities described below).

5.1 De-silting of Artificial and Natural Watercourses

Water features and artificial channels lines connecting these features have become silted up and heavily vegetated over time, which affects the drainage of water through the course during heavy rainfall events, causing localised flooding and inundation of sections of the course. Desilting of artificial watercourses (water features and drainage channels) is required to improve drainage throughout the course. Similarly, the culvert beneath Piesang Valley Road has become heavily vegetated and silted up and will require clearing to improve drainage through the culvert.

5.1.1 Extent and Timing of Activity

- This activity is restricted to artificial water features and drainage channels on the golf course and to the culvert passing under the Piesang River Valley Road (see Figure 9).
- For the culvert under the Piesangs River Valley Road removal of silt upstream and downstream of the culvert must ensure free flow of water through the culvert but may not extend more than 20 m upstream or downstream of the culvert.
- **Remnant wetland habitats as delineated in Figure 9 are excluded from this activity.**
- **Removal of sediment from the drainage channel may not extend more than 20 m upstream of the western most culvert indicated in Figure 9.**
- Clearing should be conducted at the end of summer during a relatively dry period (i.e. **May to July**) and should be conducted only once a year or following an extreme event that results in blockage of infrastructure.

5.1.2 Method Statement

- Sediment and silt will be removed by hand or using an excavator;
- Access points to be identified and planned to minimise disturbance to watercourses;
- Remove sediment from the location of infrastructure to reinstate the intended function of the infrastructure;
- Sediment must be removed to a suitable stockpile location outside of aquatic habitats;
- Any riparian areas disturbed by the activities must be revegetated; and
- Excavated sediment can be used for landscaping of the golf course.

5.2 Controlling Instream Vegetation.

Water features and lower sections of the Piesang River have become heavily encroached with instream aquatic vegetation, most notably *Typha capensis* (Cape Bulrush). Nuisance growth of indigenous aquatic vegetation (such as bulrush) and other aquatic vegetation often needs to be managed in rivers where hydrological flows have been regulated by dams and high abstraction rates, which have the effect of reducing the magnitude and frequency of natural control measures such as floods. Removal of riparian zone results in higher light exposure of the channel which further stimulates growth of instream vegetation. Lack of grazing by large mammals and elevated supply of nutrients caused by use of fertilisers further leads to the encroachment of vegetation in watercourses. This vegetation needs to be routinely cut back and/or removed in order to facilitate improved drainage through the golf course and the river.

In addition, vegetation in the eastern most remnant wetland area is encroaching onto the fairway of the 4th hole (see Figure 7) and needs to be controlled.

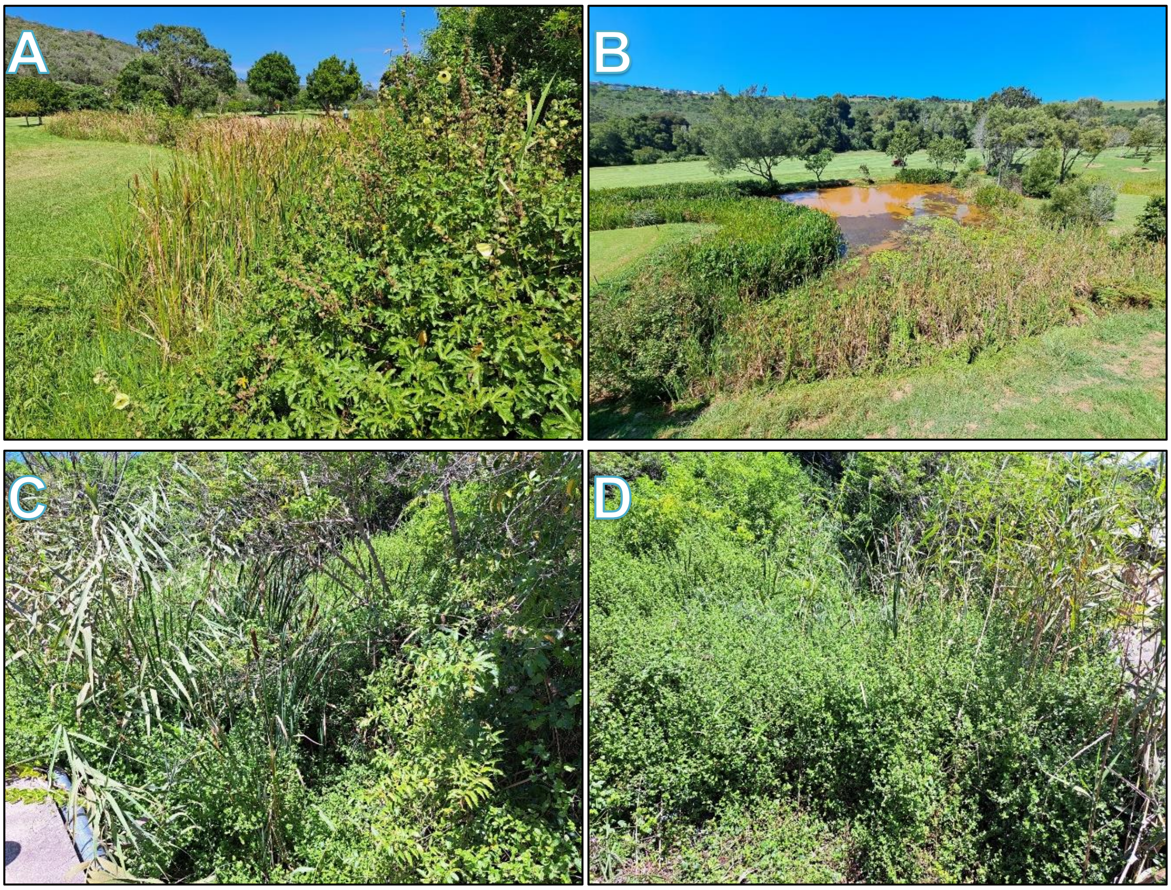

Figure 10: Photographs showing dense beds of *T. capensis* choking the Piesang River (A); dense reed beds in an artificial water feature on the golf course (B); and dense vegetation in the culvert below the Piesang River Valley Road obscuring the view of the channel (C and D).

5.2.1 Extent and Timing of Activity

- This activity is limited to artificial water features and drainage channels, the Piesang River downstream of the instream irrigation dam (including the culvert that passes beneath the Piesangs River Valley Road) (Figure 9) and the **outer edge** of vegetation in the eastern most remnant wetland.
- **Clearing of the drainage channel may not extend more than 20 m upstream of the western most culvert indicated in Figure 9.**
- Clearing should be conducted at the end of summer (**May to July**) and should not be conducted more than once a year.

5.2.2 Method Statement – Artificial Water Features, Drainage Channels and the Piesang River

- Brush-cutting:
    - The reeds should be cut below the lowest leaf and the remaining stump should not be longer than 15cm. If a brush cutter is used, mowing should be no lower than 12cm from the ground to minimise impacts to small animals and indigenous plants;

  - Remove all cut reeds (especially seed heads) and cleared alien vegetation from the watercourse/wetland area.
- Chemical Control:
  - Any chemical contrail should preferably be done according to a cut stem treatment.
  - Use herbicide approved for use in aquatic habitats (e.g. glyphosate and imazypyr).
  - Apply a few drops of the pesticide formulation to the freshly cut stems using a syringe or squirt bottle.

5.2.3 Method Statement – Eastern Remnant Wetland Area

- Brush-cutting:
  - **Brush cutting of wetland vegetation is limited to a distance of 1 m measured from the edge of the fairway into the wetland.**
  - Apply the same methods as described in Section 5.2.2.
  - Wetland vegetation may only be cut and the root systems of plants must not be removed.
- Chemical Control
  - **Chemical control may not be used on natural vegetation occurring in the remnant wetland areas.**

5.3 Clearing Flood Debris from the Piesangs River

Flood debris, particularly wood debris can block channels and culverts and cause localised flooding and associated scouring and erosion of the bed and banks. This debris needs to be removed periodically to ensure efficient drainage of the channel.

5.3.1 Extent and Timing of Activity

- The activity is applicable to all artificial water features and channels, all culverts and the Piesangs River.
- The activity is an ongoing maintenance activity and is not restricted to any specific time of the year.

5.3.2 Method Statement

- Debris to be removed by hand as and when required.
- Debris must not be stockpiled along the river banks and must be disposed of outside of the watercourse.

5.4 Replacing Culverts and Overflow Pipes

Some culverts and overflow pipes (that discharge water from the artificial water features) along the artificial drainage channel system are undersized and blocked, leading to localised flooding during heavy rainfall events (Figure 11). These culverts need to be enlarged to facilitate improved drainage through the channel (Figure 11). Main risks associated with replacing culverts are sedimentation of downstream habitats and disturbance to the bed and banks which could lead to erosion.

Figure 11: Photograph of the western-most culvert blocked by vegetation and sediment.

5.4.1 *Extent and Timing of Activity*

- The activity is applicable to all culverts associated with artificial water features and drainage channels on the golf course.
- No culverts will be replaced within the Piesangs River.
- Replacement of culverts must take place during the drier season (May to July).

5.4.2 *Method Statement*

- Existing culverts to be removed by hand or excavator.
- Installation of new culvert, aligned with orientation of channel (less than 30 % deviation from the channel alignment);
- Fill associated with the culvert installation and approach material must be structurally stable;
- Fill associated with the culvert installation and approach material must be protected from erosion;
- All disturbed areas must be re-graded and stabilized by seeding or re-vegetating the riparian area upon completion. This helps to prevent surface erosion and/or sedimentation of the watercourse.

5.5 Controlling Alien Invasive Riparian Species

Alien invasive tree species are common along the length of the Piesangs River and throughout the remnant patches of remaining wetland habitat, and include (but are not limited to) the following species:

- Prickly hibiscus (*Hibiscus diversifolius*) – common along the banks of the Piesang River
- Brazilian pepper tree (*Schinus terebinthifolia*) – common within remnant wetland areas
- Blackwood (*Acacia melanoxylyn*) – common along the Piesangs River and within remnant wetland areas
- Poplar (*Populus alba*) – common in the western most remnant wetland.

Growth of alien vegetation within and adjacent to river and wetlands, is usually at the expense of natural, indigenous aquatic vegetation which simply cannot compete. Negative impacts of alien vegetation include reduced water availability (due to increased rates of abstraction) and reduced habitat diversity and an associated reduction in biodiversity. The removal of invasive alien plants from the riparian zone and wetlands is desirable not only from an aquatic ecological perspective but also due to the fact that they reduce the ability of the aquatic features to provide a number of valuable goods and services.

5.5.1 Extent and Timing of Activity

- Activity can be undertaken in and along all artificial and natural watercourses (including remnant wetland areas).
- Activity can be undertaken throughout the year.

5.5.2 Method Statement

- Correctly identify alien invasive species – consult independent experts if necessary;
- Young plants and saplings can be pulled by hand or using an appropriate tool (e.g. Tree Popper). Care must be taken to replace and compact disturbed soil after removal (i.e. stamped down by foot);
- Trees or shrubs that are too large to be pulled must be felled using a saw or chainsaw. The freshly cut stump must be immediately painted with a herbicide that is registered for control of the alien tree species. Important species and registered herbicides include, *inter alia*:
    - *Hibiscus diversifolius*: Glyphosate (Roundup)
    - *Schinus terebinthifolia*: Triclopyr (Garlon)
    - *Acacia melanoxylyn*: Triclopyr (Garlon)
    - *Populus alba*: Imazapyr (Chopper or Hatchet)
- Herbicide must be mixed with a dye to identify stumps that have already been treated and prevent overuse/over application of the herbicide;
- All cut/felled plant material must be removed from the watercourse and/or riparian zone.

- Follow-up control must be conducted annually to prevent regrowth and the production of seed still remaining in soil.
- Revegetate areas with indigenous vegetation where necessary.

5.6 Controlling *Salvinia molesta*

Salvinia molesta (Kariba Weed) is an aquatic, mat-forming, free-floating fern with horizontal stems up to 25cm long is abundant throughout all watercourses (including dams and the Piesang River). It can form dense mats up to 50 cm thick which can completely cover the water surface. The mats clog watercourses and irrigation equipment and reduce waterflow. The mats also reduce light penetration, reduce oxygen levels and result in poor water quality and threaten indigenous aquatic plant and animal life. It is classified as a Category 1 NEMBA Category 1b weed and the PBCC is therefore obligated to attempt to control the weed as far as possible. The release of the salvinia weevil (*Cyrtobagous salvinae*) has brought this weed under full biological control throughout most of South Africa. However, the weed continues to persist in cooler temperate coastal zones along the Southern and Western Cape due to the agent's sensitivity to cooler temperatures.

Figure 12: Photographs illustrating dense mats of *S. molesta* in the Piesangs River.

5.6.1 Extent and Timing of Activity

- Activity can be undertaken in all natural and artificial watercourses throughout the property.
- Activity can be undertaken throughout the year.

5.6.2 Method Statement

- The weed can be removed by any means (hand or excavator) from artificial water courses and by hand from the Piesangs River.
- Biocontrol using the *C. salvinae* biocontrol agent is recommended. Once an assessment of the estimated biomass of the weed has been undertaken, the Department of Forestry Fisheries and Environment (DFFE) must be contacted to arrange release of the biocontrol agent (contact Debbie Muir: dsharp@dffe.gov.za).
- Following the release of the biocontrol, routine monitoring must be undertaken to estimate the presence and absence, and numbers of the biocontrol agents to determine whether any supplemental release is required.

- Once the biocontrol agents have been released, chemical control of the weed should not be undertaken. NO chemical control should be used without guidance from DFFE.

5.7 General Maintenance Practices

In general, maintenance activities must implement the following mitigation measures:

- Repairs and maintenance should be undertaken within the dry season, except for emergency maintenance works.
- Where at all possible, existing access routes should be used. In cases where none exist, a route should be created through the most degraded area avoiding sensitive/indigenous vegetation areas.
- Responsible management of pollutants through ensuring handling and storage of any pollutants is away from the watercourse. When machinery is involved, ensure effective operation with no leaking parts and refuel outside of the riparian area, at a safe distance from the watercourse to manage any accidental spillages and pose no threat of pollution.
- At no time should the flow of the watercourse be blocked (temporary diversions may be allowed) nor should the movement of aquatic and riparian biota (noting breeding periods) be prevented during maintenance actions.
- In circumstances which require the removal of any topsoil, this must be sufficiently restored through sustainable measures and practices.
- Concerted effort must be made to actively rehabilitate repaired or reshaped banks with indigenous local vegetation.
- No deepening of the watercourse beyond the original, pre-damage determined thalweg, unless such deepening is directly related to the natural improved functioning and condition of such a watercourse.
- Where at all possible, limit the disturbance to the zone of the thalweg. This is due to the ecological importance of the low flow channel and respective habitat being allowed to re-establish improving the ecological condition.
- The build-up of debris/sediment removed from a maintenance site may:
    - be utilised for the purpose of in-filling or other related maintenance actions related to managing erosion, which form part of an adopted MMP;
    - not be deposited anywhere within the watercourse or anywhere along the banks of a river where such action is not part of the proposed maintenance activity (ies).
    - Material that cannot be used for maintenance purposes must be removed out of the riparian area to a suitable stockpile location or disposal site.
- The use of foreign material, such as concrete, rubble, woody debris and/or dry land based soil, is strictly prohibited from being used in maintenance actions, unless for the specific purpose of repairs to existing infrastructure, coupled with appropriate mitigation measures.
- On completion of the maintenance action, the condition of the site in terms of relative topography should be similar to the pre-damaged state (i.e. the shape of the river bank should be similar or in a state which is improved to manage future damage). This ultimately dictates that the channel, banks and bed cannot be made narrower, higher

or deepened respectively. Exceptions are considered for systems involved with the management of stormwater and improvements for water quality within the urban context.

6 IMPACT ASSESSMENT

Impact 1: Impact of excavation of sediment (for routine desilting and replacement of culverts) on water quality and aquatic biota.

The clearing of sediment can result in a localized disturbance within the associated aquatic habitats. This disturbance can result in increased turbidity as a result of suspension of silt into the water column if the work is undertaken in inundated areas. Invasion by alien plants also tends to occur at the disturbed area.

Desilting will be limited to highly transformed aquatic habitats (i.e. water features and channels associated with the former extent of the wetland seep area) and the culvert that passes under the Piesang River Valley Road. Remnant wetland areas as indicated in Figure 9 are excluded from this activity.

	Without Mitigation	With Mitigation
Intensity	Moderate	Low
Duration	Short term	Brief
Extent	Limited	Very limited
Probability	Probably	Unlikely
Significance	**-36: Minor**	**-18: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Material may only be removed from aquatic habitats after summer and during the dry season (i.e. May to July) except for when emergency maintenance works need to be undertaken;
- The disturbed area around infrastructure (e.g. culverts that need to be cleared) should be kept to a minimum. Where possible existing access points to the site should be used and any indigenous vegetation that is established adjacent to the works should preferably remain intact;
- If required, temporary sediment trapping should be put in place to filter water draining the area that will most likely contain high sediment loads;
- Manual labour should be used where possible within the aquatic habitats. Where the use of mechanical removal is unavoidable, the extent of operation of the machinery within aquatic habitats must be minimized;
- Desilting, must, where applicable coincide with the programme for clearing instream vegetation so as to minimise the frequency of disturbance in watercourses;
- Responsible management of pollutants must be practiced by ensuring that they are handled and stored at safe distance away from the watercourse. When machinery is involved, ensure effective operation with no leaking parts and refuel outside of the riparian area, at a safe distance from the watercourse to manage any accidental spillages;
- Excavated material that cannot be used for maintenance purposes or landscaping must be removed out of the riparian area to a suitable stockpile location or disposal site; and
- Disturbed areas should be kept clear of alien vegetation and must be actively reshaped and rehabilitated with indigenous, local vegetation.

Impact 2: Impact of clearing of vegetation on instream habitat and biota. Bulrush (*Typha capensis*) and common reeds (*Phragmites australis*) are indigenous plants that can encroach into and dominate wetland and river habitat. The primary impact of clearing of reeds and bulrushes is the disturbance of riparian and aquatic habitat. Secondary impacts include exposure of soil and erosion and invasion of disturbed areas by alien plant species. Furthermore, the reduction in surface roughness caused by removal of vegetation allows results in higher flow velocities which could lead to erosion of the bed and banks of the river.		
	Without Mitigation	**With Mitigation**
Intensity	Moderate	Low
Duration	Short term	Brief
Extent	Limited	Very limited
Probability	Probably	Unlikely
Significance	**-36: Minor**	**-18: Negligible**
Reversibility	High	High
Irreplaceability	Low	Low
Confidence	High	High

Mitigation:

- Removal of instream indigenous vegetation should be limited to nuisance growth of reeds and bulrushes that impede flow through channels and drains (as indicated in the Figure 9) and should not extend to vegetation along the banks (which must be retained to limit soil erosion);
- Clearing should be conducted at the end of summer during the dry season (May to July) to minimise sedimentation and should not be conducted more than once a year;
- Brush-cutting must avoid damage to the banks or other indigenous vegetation such as sedges and rushes;
- For brush cutting, the reeds should be cut below the lowest leaf and the remaining stump should not be longer than 15cm. If a brush cutter is used, mowing should be no lower than 12cm from the ground to minimise impacts to small animals and indigenous plants;
- Remaining indigenous vegetation should not be cleared. The disturbance of the watercourses and wetland areas when undertaking clearing activities should also be limited as far as possible, using existing access points;
- If surrounding plants and soil are disturbed by the clearing of vegetation, follow-up revegetation should be undertaken, using indigenous species; and
- In artificial water features, 10 to 20 % of vegetation must be retained to provide habitat and refuge for aquatic biota.

Impact 3: Impact of alien invasive plant control on riparian and instream habitat Clearance of alien invasive vegetation can result in negative impacts to soil and remaining indigenous vegetation. If undertaken correctly however, clearing of AIPs will have a positive effect on the ecological condition of watercourses.		
	Without Mitigation	**With Mitigation**
Intensity	Moderate	High
Duration	Short term	Long term
Extent	Limited	Limited
Probability	Probably	Likely
Significance	**-36: Minor**	**+60: Minor**
Reversibility	High	High

Irreplaceability	Low	Low
Confidence	High	High
Mitigation:		

- Identify alien plants to be removed. If unsure, contact the Department of Agriculture or Cape Nature for assistance.
- Clear alien vegetation according to the described alien vegetation removal methods for each invasive species as provided in the detailed method statements or with the methods and herbicides/biological control recommended on the Working for Water website: http://www.dwaf.gov.za/wfw/.
- Avoid trampling or clearing indigenous vegetation by using established paths where possible;
- Clear felled alien vegetation from the watercourse and riparian zone. Larger tree stumps can be left to minimise erosion of the cleared area;
- Where necessary revegetate cleared areas with suitable indigenous vegetation. Planted areas will require irrigation and care for a period of 1-2 years following planting.. Planting of the new vegetation at the start of the wet season can assist ensuring that the new vegetation is kept wet however one would need to then avoid planting new vegetation within the areas that will be inundated in winter or subjected to flood flows; and
- Ongoing monitoring and clearing of regrowth of alien plants must be undertaken on an annual basis. Regular monitoring and control of alien vegetation should be undertaken to ensure that the plants are removed while still young saplings that can more easily by removed (usually pulling of seedlings by hand is possible when the soil is wet). This also prevents the spread of the alien plants once seeds have been produced;

7 DWS RISK ASSESMENT

The risk assessment matrix (Based on DWS 2015 publication: Section 21 (c) and (i) water use Risk Assessment Protocol) was implemented to assess risks of management and maintenance activities on the watercourses. The first stage of the risk assessment is the identification of environmental activities, aspects and impacts. This is supported by the identification of receptors and resources, which allows for an understanding of the impact pathway and an assessment of the sensitivity to change. The definitions and methodology applied in the impact assessment are provided in Appendix 3 of this report.

Risks were assessed assuming full implementation of method statements described in Section 3. All ratings fall within a Low Risk class (Table 7). Given the low impact associated with all activities highlighted in this report, and according to Government Notice 509 of August 2016 (RSA, 2016) of the National Water Act, the proposed maintenance activities are Generally Authorised and do not require a Water Use License. While the development is generally authorised, it is important to note that the water use activity should still be registered with the DWS. In this respect the following steps, as highlighted in the General Authorisation for Section 21 (c) and (i) water uses, are relevant:

1. Subject to the provisions of the General Authorisation, the applicant must submit the relevant registration forms to the responsible authority;
2. Upon completion of registration, the responsible authority will provide a certificate of registration to the water user within 30 working days of the submission;

3. On written receipt of a registration certificate from the Department, the applicant will be regarded as a registered water user and can only then commence with the water use as contemplated in the General Authorisation; and
4. The registration forms can be obtained from DWS Regional Offices or Catchment Management Agency office of the Department or from the Departmental website: http://www.dwa.gov.za/Projects/WARMS/Licensing/licensing1.aspx

Table 7: DWS Risk Assessment matrix for maintenance activities undertaken as part of the MMP.

				Severity																	
Phase	**Activity**	**Aspect**	**Impact**	**Flow Regime**	**Water Quality**	**Habitat**	**Biota**	**Severity**	**Spatial scale**	**Duration**	**Consequence**	**Frequency of activity**	**Frequency of impact**	**Legal Issues**	**Detection**	**Likelihood**	**Significance**	**Risk Rating**	**Confidence level**	**Control Measures**	**PES AND EIS OF WATERCOURSE**
Maintenance Phase	Excavation of Sediment from Artificial Water Features and Drainage Canals	Operation of machinery and vehicles in watercourse	Contamination of watercourse with hydrocarbons	**1**	**2**	**1**	**1**	**1.25**	**1**	**1**	**3.25**	**1**	**1**	**5**	**1**	**8**	**26**	**Low**	**95**	See Section 5.1	PES: D EIS: Low
			Disturbance of aquatic habitat	**1**	**1**	**2**	**2**	**1.5**	**1**	**1**	**3.5**	**1**	**1**	**5**	**1**	**8**	**28**	**Low**	**95**	See Section 5.1	
		Stockpiling of excavated material	Erosion and disturbance of aquatic habitat	**1**	**2**	**1**	**1**	**1.25**	**1**	**1**	**3.25**	**1**	**1**	**5**	**1**	**8**	**26**	**Low**	**95**	See Section 5.1	
		Excavation of bed	Erosion and disturbance of aquatic habitat	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**5**	**1**	**8**	**24**	**Low**	**95**	See Section 5.1	
	Clearing of Instream Vegetation from Artificial and Natural Watercourses	Cutting Vegetation	Disturbance of aquatic habitat	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**1**	**1**	**5**	**1**	**8**	**24**	**Low**	**95**	See Section 5.2	

8 CONCLUSION

The historic establishment of the PBCC together with regulation of streamflows caused by the Roodefontein Dam have resulted in a significant modification of the lower reaches of the Piesangs River and former wetland areas. The PES of the Piesangs River is D and the wetland is E (Largely and Seriously modified, respectively).

Planned maintenance activities will take place in the Piesangs River as well as in artificial water features (small ponds and dams) and drainage channels associated with the former extent of the wetland seep system. The activities are likely to occur annually and are primarily aimed at improving drainage through the golf course by maintaining infrastructure (culverts) and clearing natural and artificial watercourses of sediment and nuisance aquatic plants (including encroaching *T. capensis* and the alien invasive *S. molesta*). Assuming implementation of mitigation measures, impacts to the watercourses are considered as negligible. In addition, the DWS Risk Assessment matrix determined that the risk of maintenance activities to the watercourses is Low, and therefore qualifies for a General Authorisation.

Based on this assessment it is recommended that the MMP for the PBCC be approved.

9 REFERENCES

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10 APPENDICES

Appendix 1 – Index of Habitat Integrity

Index of Habitat Integrity (IHI; Kleynhans, 1996). The IHI was regarded as the most appropriate method for assessing riverine habitats as it is not dependent on flow in the watercourse and, therefore, produces results that are directly comparable across perennial and non-perennial systems. The IHI was developed as a rapid assessment of the severity of impacts on criteria affecting habitat integrity within a river reach. Instream (water abstraction; flow modification; bed modification; channel modification; physico-chemical modification; inundation; alien macrophytes; rubbish dumping) and riparian (vegetation removal, invasive vegetation, bank erosion, channel modification, water abstraction, inundation, flow modification, physico-chemistry) criteria are assessed as part of the index. Each of the criteria are given a score (from 0 to 25, corresponding to no and very high impact, respectively – Table 8) based on their degree of modification, along with a confidence rating based on the level of confidence in the score.

Weighting scores are used to assess the extent of modification for each criterion (x):

$$Weighted\ Score = \frac{IHI_x}{25} \times Weight_x$$

Where;

- IHI = rating score for the criteria (Table 8);
- 25 = maximum possible score for a criterion; and
- Weight = Weighting score for the criteria (Table 9).

Table 8: Descriptive classes for the assessment of habitat modifications (Kleynhans, 1996)

Impact Class	Description	Score
None	No discernible impact, or the modification is located in a way that has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability is limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
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 affected.	16-20
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.	21-25

Table 9: Criteria and weights used for the assessment of instream and riparian zone habitat integrity

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**		**100**

The estimated impacts of all criteria calculated this way are summed, expressed as a percentage and subtracted from 100 to arrive at an assessment of habitat integrity for the instream and riparian components, respectively. An IHI class indicating the present ecological state of the river reach is then determined based on the resulting score (ranging from Natural to Critically Modified – Table 10).

Table 10: Index of habitat integrity (IHI) classes and descriptions

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

Reference:

Kleynhans, C.J. (1996). A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa) Journal of Aquatic Ecosystem Health 5:41-54 1996.

Appendix 2 – Wet-Health

Desktop and field data were captured in GIS software and used to populate the Level 1 WET-Health tool (Macfarlane et al., 2008) which was used to derive the PES of the wetland HGM units. The magnitude of observed impacts on the hydrological, geomorphological and vegetation components of the wetland were calculated and combined as per the tool to provide a measure of the overall condition of the wetland on a scale from 1-10. Resultant scores were then used to assign the wetland into one of six PES categories as shown in Table 11 below.

Table 11: Wetland Present Ecological State categories and impact descriptions.

Ecological Category	Description	Impact Score
A	Unmodified, natural.	0 – 0.9
B	Largely natural with few modifications / in good health. A small change in natural habitats and biota may have taken place but the ecosystem functions are still predominantly unchanged.	1 – 1.9
C	Moderately modified / fair condition. Loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.	2 – 3.9
D	Largely modified / poor condition. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	4 – 5.9
E	Seriously modified / very poor condition. The loss of natural habitat, biota and basic ecosystem functions is extensive.	6 – 7.9
F	Critically modified / totally transformed. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota.	8 – 10

Reference

Macfarlane, D., Kotze, D., Ellery, W., Walters, D., Koopman, V., Goodman, P. and Goge, M. 2007. *WET-Health: A technique for rapidly assessing wetland health. Wetland Management Series.* Water Research Commission Report TT 340/09.

Appendix 3 – Ecological Importance & Sensitivity (River)

The ecological importance and sensitivity (EIS) of the watercourse was assessed using a method developed by Kleynhans (1999). In summary, several biological and aquatic habitat determinants are assigned a score ranging from 1 (low importance or sensitivity) to 4 (high importance or sensitivity). These determinants include the following:

- **Biodiversity support:**
  - Presence of Red Data species;
  - Presence of unique instream and riparian biota;
  - Use of the ecosystem for migration, breeding or feeding.
- **Importance in the larger landscape:**
  - Protection status of the watercourse;
  - Protection status of the vegetation type;
  - Regional context regarding ecological integrity;
  - Size and rarity of the wetland types present;
  - Diversity of habitat types within the wetland.
- **Sensitivity of the watercourse:**
  - Sensitivity of watercourse to changes in flooding regime;
  - Sensitivity of watercourse to changes in low flow regime, and
  - Sensitivity to water quality changes.

The median value of the scores for all determinants is used to assign an EIS category according to Table 12.

Table 12: Ecological importance and sensitivity categories. Interpretation of average scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Quaternaries/delineations that are considered to be unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.	>3 and <=4	A
High: Quaternaries/delineations that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) may be sensitive to flow modifications but in some cases, may have a substantial capacity for use.	>2 and <=3	B
Moderate: Quaternaries/delineations that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use	>1 and <=2	C
Low/marginal: Quaternaries/delineations that are not unique at any scale. These rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.	>0 and <=1	D

Reference:

Duthie, A. (1999). IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and Ecological Management Class (EMC). Resource Directed Measures for Protection of Water Resources: Wetland Ecosystems. Department of Water Affairs and Forestry.

Appendix 4 – Ecological Importance and Sensitivity (Wetlands)

The revised method for the determination of the EIS of a wetland considers the three following ecological aspects (Rountree et al., 2013):

- **Ecological importance and sensitivity**
  - Biodiversity support including rare species and feeding/breeding/migration;
  - Protection status, size and rarity in the landscape context;
  - Sensitivity of the wetland to floods, droughts and water quality fluctuations.
- **Hydro-functional importance**
  - Flood attenuation;
  - Streamflow regulation;
  - Water quality enhance through sediment trapping and nutrient assimilation;
  - Carbon storage
- **Direct human benefits**
  - Water for human use and harvestable resources;
  - Cultivated foods;
  - Cultural heritage;
  - Tourism, recreation, education and research.

Each criterion is scored between 0 and 4, and the average of each subset of scores is used to derive a score for each of the three components listed above. The highest score is used to determine the overall Importance and Sensitivity category of the wetland system.

Table 13: Ecological importance and sensitivity categories. Interpretation of average scores for biotic and habitat determinants.

Ecological Importance and Sensitivity Category (EIS)	Range of Median	Recommended Ecological Management Class
Very high: Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these floodplains is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water of major rivers.	>3 and <=4	A
High: Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these floodplains may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers.	>2 and <=3	B
Moderate: Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these floodplains is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water of major rivers.	>1 and <=2	C
Low/marginal: Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these floodplains is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water of major rivers.	>0 and <=1	D

<u>Reference:</u>

Rountree, M.W., Malan, H.L., Weston, B.C. (2013). Manual for the Rapid Ecological Reserve Determination of Inland Wetlands (Version 2). Water Research Commission report No. 1788/1/12.