Aquatic specialist services

- Cell: 072 444 8243
- Email: debbie@upstreamconsulting.co.za
- Address: 25 Blommekloof Street, George, 6530

www.upstreamconsulting.co.za

AQUATIC BIODIVERSITY IMPACT ASSESSMENT

for the proposed

BIOSOLIDS BENEFICIATION FACILITY (BBF) AT GWAING WASTEWATER TREATMENT WORKS, GEORGE LOCAL MUNICIPALITY

DATE: 3 November 2025

Version 4

PREPARED FOR:

Sharples Environmental Services cc
102 Merriman Street
George
6529

PREPARED BY:

Debbie Fordham
Upstream Consulting
25 Blommekloof St, George, 6529
debbie@upstreamconsulting.co.za

Upstream Consulting

Address:
25 Blommekloof Street,
George,
6530
Tel:
+2772 444 8243
+2764 857 5560
Email:
debbie@upstreamconsulting.co.za
colin@upstreamconsulting.co.za

Website: www.upstreamconsulting.co.za

Specialist Details

SPECIALIST REPORT DETAILS

This report has been prepared as per the requirements of the Environmental Impact Assessment Regulations and the National Environmental Management Act (Act 107 of 1998), any subsequent amendments and any relevant National and / or Provincial Policies related to biodiversity assessments. This also includes the minim requirements as stipulated in the National Water Act (Act 36 of 1998), as amended in Water Use Licence Application and Appeals Regulations, 2017 Government Notice R267 in Government Gazette 40713 dated 24 March 2017, which includes the minimum requirements for an Aquatic Biodiversity Report.

Compiled By: Debra Fordham
SWSPCP (No. 3683),
SACNASP (119102 Ecology)
Aquatic ecologist (M.Sc.)
Director

Reviewed By: Colin Fordham
Pr Sci Nat. (400166/14 Ecology)
Director

Authors: D Fordham

Expertise / Field of Study: Internationally certified Professional Wetland Scientist and registered SACNASP ecologist, with 10 years of working experience, specialising in aquatic ecology. Debbie holds a M.Sc. degree in Environmental Science from Rhodes University, by thesis, entitled: The geomorphic origin and evolution of the Tierkloof Wetland, a peatland dominated by *Prionium serratum* in the Western Cape. She is a member of scientific organisations such as the Society of Wetland Scientists (SWS), the Society for Ecological Restoration (SER), the South African Wetland Society (SAWS), the South African Hydrology Society (SAHS), and the Southern African Association of Geomorphologists (SAAG). She is also a SWS committee member and holds a position on the Publications Committee since 2023.

I, **Debbie Fordham** declare that this report has been prepared independently of any influence or prejudice as may be specified by the National Department of Environmental Affairs Fisheries and Forestry and or Department of Water and Sanitation.

Signed:… .... Date:…3 November 2025………

Revision Note

This aquatic biodiversity impact assessment was originally compiled in July 2024 based on the "Gwaing Wastewater Treatment Works (WWTW) Concept Design Report – REV 00" submitted in June 2024. Since the submission of that assessment, a revised engineering design report has been produced: "Gwaing WWTW Concept Design Report Rev 02 – dated 09 April 2025." This new report introduced additional technical information and infrastructural modifications, including the addition of a Biosolids Beneficiation Facility (BBF) and detailed sludge management enhancements. Please note that the aquatic biodiversity impact assessment for the upgrades at the WWTW itself was undertaken separately but should be read in conjunction with this report on the construction of a BBF.

Additionally, following a site meeting with the project engineers and environmental assessment practitioners, the proponent committed to active rehabilitation of the valley bottom wetland system, beyond only the location of the discharge outlet structure to compensate for wetland habitat disturbance.

This updated aquatic report therefore constitutes a revised version, incorporating and responding to those technical changes and commitment to a rehabilitation plan, in order to appropriately characterise aquatic biodiversity risks under the latest available engineering information.

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EXECUTIVE SUMMARY

Upstream Consulting was appointed to undertake an aquatic biodiversity impact assessment to provide specialist input on the proposed construction of a Biosolids Beneficiation Facility (BBF) at the Gwaing Wastewater Treatment Works (WWTW), located in the George Local Municipality. The BBF is a component of broader infrastructure upgrades aimed at transforming the WWTW into a Water Resource Recovery Facility (WRRF), with improved sludge handling and resource recovery.

The assessment focused on identifying and characterising aquatic ecosystems potentially affected by the development. Fieldwork confirmed the presence of a small artificial wetland within the BBF footprint, originating from past excavations. No natural wetlands or sensitive aquatic habitats were found within the project footprint, and no rare or endangered species were recorded.

The proposed BBF will result in the permanent loss of this artificial wetland. However, this impact is of low ecological significance and does not warrant formal wetland offsets. To compensate and achieve a net gain, rehabilitation is proposed on the downstream HGM2 wetland reach affected by erosion and invasive species.

With the implementation of these mitigation measures, including stormwater management and active rehabilitation, the residual impact of the project on aquatic biodiversity is rated as Low. There are also benefits from improved sludge management and wetland rehabilitation. The development of the BFF is thus deemed acceptable from an aquatic ecological perspective.

1 INTRODUCTION

Debbie Fordham of Upstream Consulting has been appointed by Sharples Environmental Services CC to conduct an aquatic biodiversity impact assessment for the Gwaing biosolids beneficiation facility (BBF), which will form part of an extension of the existing Wastewater Treatment Works (WWTW) in George Municipality. An aquatic specialist impact assessment was undertaken for the proposed upgrades on existing infrastructure at the WWTW and the report entitled 'Aquatic Biodiversity Impact Assessment for the proposed upgrading of the Gwaing Wastewater Treatment Works, George Local Municipality' by Debbie Fordham of Upstream Consulting (dated 29 July 2025), should be read in conjunction with this report.

This revised aquatic biodiversity impact assessment has been compiled to reflect and incorporate recent updates to the engineering design for the Gwaing Wastewater Treatment Works (WWTW) upgrade project. The original version of this assessment, dated July 2024, was based on the 2024 Concept Design Report (Rev00, dated 28 June 2024). Since then, a revised Concept Design Report (Rev02, dated 9 April 2025) has been issued by Lukhozi Consulting Engineers.

1.1 BACKGROUND

George Local Municipality appointed Lukhozi Consulting Engineers (Pty) Ltd (LCE) to create a Master Plan to guide future upgrades at the Gwaing WWTW. According to the Design Report by LCE (April 2025), the vision for Gwaing WWTW extends beyond waste management. It aims to transform the facility into a Water Resource Recovery Facility (WRRF), emphasizing resource recovery. Sludge beneficiation in the form of composting or fertilizer production is envisioned as one of the key strategies.

Currently, the area between the ponds is being used for sludge stockpiling, which cannot be deemed either a temporary or long-term solution. The removal of sludge should be a priority as part of the first planned upgrade. Since neither the sludge stockpiling area between the ponds, nor the ponds themselves are lined, the nutrients from the sludge seeps into the maturation ponds and the effluent quality is negatively affected.

The need for improved sludge handling was identified in the 2024 Aquatic Biodiversity Impact Assessment report for the upgrades at the WWTW, which recommended the following mitigation measures:

- Improve sludge management to reduce the amount of sludge stockpiles on unlined ground.
- All stockpiles must be protected and located in flat areas where run-off will be minimised and sediment recoverable.

Since the aquatic biodiversity impact assessment of the proposed upgrades to the WWTW infrastructure (Upstream Consulting, 2024), a formal proposal for the biosolids beneficiation facility (BBF) has been developed and required additional assessment for potential impacts upon aquatic biodiversity. Following the initial assessment, site meetings, and feedback from the client, both reports have now been updated and finalised.

1.2 Location

This facility is planned as part of the wider mixed-use Gwayang Precinct Plan proposed by the George Municipality. The proposed BBF area, amounting to 5.9 ha, is to be located on Erf 73 (consolidated from erven 57, 59, 61 and 63 on the Gwayang Mixed Development Layout). The project area is highly transformed, within a municipal service zone, and is adjacent to the existing WWTW and landfill. The area has been extensively modified over decades from agriculture and development.

Figure 1 illustrates the site location and the 500-meter radius study area, in relation to the Gwaing WWTW and the R102 road.

Figure 2 shows the property location for the proposed BFF on land east of the Gwaing WWTW.

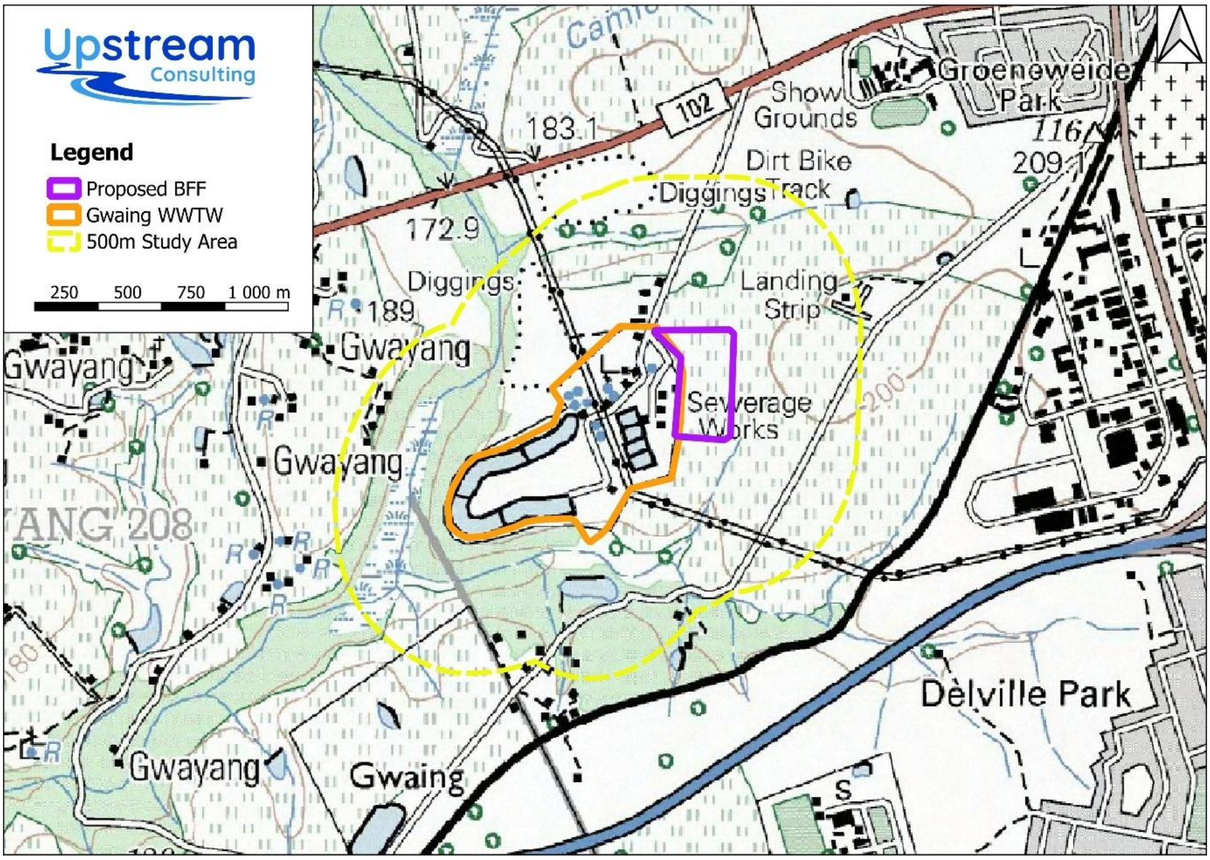

Figure 1: Topo-cadastral map showing the location of the site and 500m radius study area

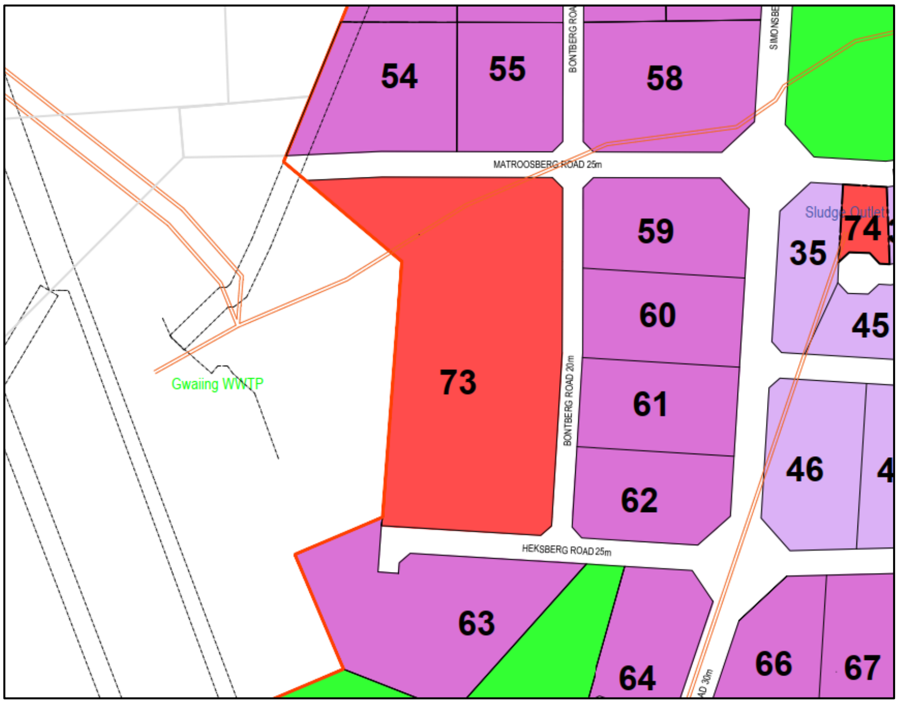

Figure 2: Proposed location for the BBF on the eastern border of the Gwaing WWTW

1.3 Project Description

1.3.1 Status Quo

According to the latest engineering design report (April 2025), George Municipality's current sludge disposal method is not compliant with sludge management guidelines. Sludge is currently being stored between the maturation ponds in an unlined area. This causes seepage of nutrients to the maturation ponds and the underlying aquifer. The sludge produced currently is classified as class B1a according to a report by Herselman Consulting Services compiled in October 2021. The 'B' designation refers to microbiological class with the presence of faecal coliforms above 1000 CFU/gdry and Helminth ova above 0.25 viable ova/gdry preventing the sludge from achieving an 'A' designation for microbiological class. This places restrictions on how the sludge can be utilised.

The designation '1' refers to the stability class while the 'a' refers to the pollutant class (metals). The sludge at Gwaing WWTW achieved the highest designation for these two classes. The dewatered sludge from the beltpresses has 14-17% dry solids (DS). While this is dry enough to be carted away, it is still too 'wet' for most commercial uses. Composting or fertilizer facilities require drier sludge and new legislation requires that sludge have at least 40% DS before it can be applied to landfills in South Africa. The Western Cape Government's DEADP and Waste Management Directorate has set targets to reduce organic waste to landfills by 50% by 2022 and to ban all organic waste from landfills by 2027. Hence application of sludge to landfills will not be a viable option in the near future.

To make the sludge a more attractive commodity for either the municipal composting facility or private compost and fertilizer manufacturers the sludge needs to be processed further at Gwaing WWTW to achieve a higher dryness (solids content) and/or a classification of A1a.

1.3.2 Proposal

The following information on the BBF relevant to this study has been taken from the latest design report (Lukhozi Engineers, 9 April 2025).

The infrastructure required for the Gwaing BBF facility can be summarized as follows:

i. Guard House

ii. Perimeter fencing and access gate

iii. Approximately 30 000 m2 of concrete slabs for the various stages of sludge stockpiling, solar drying, composing and sludge handling. This includes the areas under translucent roof sheeting for solar drying.

iv. Approximately 13 000 m2 in plan view of translucent roof sheeting ('greenhouse') structures.

v. One 18m x 36m shed with a clear height of 4.5m and without any columns inside the building for the sludge granulation plant.

vi. A second building of similar footprint for the packaging plant and distribution depot.

vii. Movable precast concrete walls placed on slabs to demarcate separated process areas and to prevent contamination of treated sludge by raw sludge.

viii. Access Roads

ix. Rainwater collection and storage from all roof structures

x. Stormwater collection and drainage from concrete slabs with pipeline to Gwaing WWTW inlet works.

Refer to Figure 3 below depicting the layout.

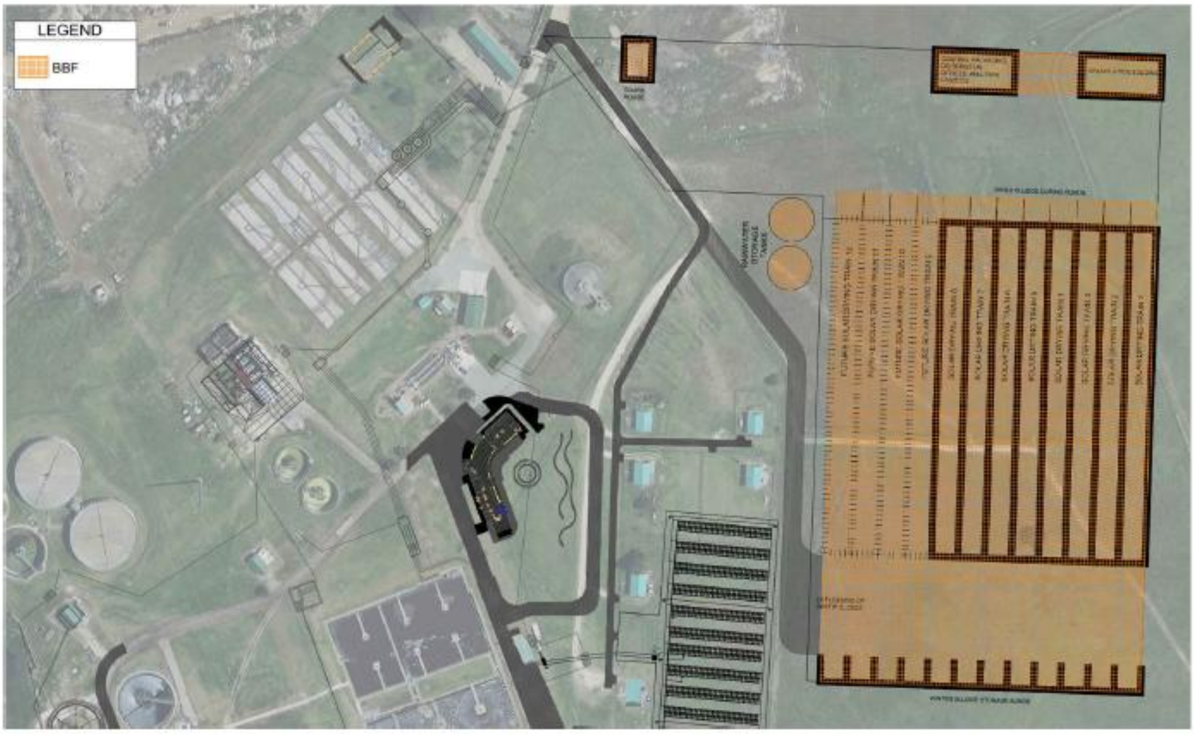

Figure 7-15: Layout of the Bio-Solids Beneficiation Facility phase layout

Figure 3: Proposed layout of the BBF taken from the Engineering Design Report

1.3.2.1 Sources and volumes

The George Municipal Area is serviced by six wastewater treatment works (WWTW), excluding private wastewater treatment works. The wastewater treatment works vary in capacity and the volume of sludge they produce. Wastewater streams are generally domestic in nature. Several registered industries and businesses discharge their waste through the bulk sewer system for treatment at the wastewater treatment works, these include cheese factories, restaurants etc. Outeniqua and the Gwaing WWTW both receive some industrial effluent.

Since it is planned that Outeniqua WWTW's sludge will also be dewatered and potentially dried at Gwaing WWTW, it is important that its sludge quantities are added to that of Gwaing WWTW. In the absence of detailed flow projections for Outeniqua WWTW at present it is estimated that the sludge from Outeniqua WWTW will approximately match that of Gwaing WWTW in the future. It is proposed that the facility be sized initially to receive approximately 50 tonne/d at 15% DS which will result in a dried mass of about 8.3 tonne/d at 90% DS. Additional drying trains can be added in future in line with the realized population rates. The capacity of the BBF should be sufficient until at least 2030, depending on the population growth rate.

1.3.2.2 Beneficiation Option 1: Producing Fertilizer

The preferred option for disposal of sludge is to produce fertilizer from it. Solar dried sludge (>80% DS) granules are optionally mixed with chemical fertilizers and sold to farmers for application to agricultural land. This option creates a high-value product that warrants the additional capital and operational expenditure required for a solar drying plant.

The current intention is for George Municipality to construct a solar drying and granulation plant. This will be referred to as the George Biosolids Beneficiation Facility, or Gwaing BBF.

1.3.2.3 Beneficiation Option 2: Composting

Composting could be employed to sterilize the sludge to a class A1a sludge. If this is achieved the sludge can be sold as compost for agriculture or horticulture use, reducing the need for sludge storage or landfill application. Presently the decision is not to pursue composting as a direct option for the beneficiation of the Gwaing WWTW sludge. However, with the implementation of a solar drying facility that achieves a class A1a sludge, the dried sludge will be more palatable for composting plants and end users and it is foreseen that the sludge could be sold or given to these facilities as an alternative option to fertilizer production.

1.3.2.4 Sludge Storage

Regardless of the sludge beneficiation option chosen by GM, there may well be a need for the temporary storage/stockpiling of sludge. Such a storage facility would be valuable if the composting facility is not able to receive sludge for a period. If solar drying is employed, the drying rate is much lower in winter and therefore it may be sensible to store a portion of the sludge during winter so that it can be dried in summer when higher drying rates are achievable. Due to the high rainfall in George, it is advisable to cover the sludge storage area to prevent rainwater ingress. By making the covers translucent, some consequential solar drying will also take place in the stockpiles. The bunded areas must include impermeable floors and contained stormwater retention so that nutrient-rich runoff does not enter the maturation ponds or stormwater networks.

1.3.2.5 Solar Drying

Solar drying of sewage sludge is typically done after initial dewatering to 14% - 17% dry solids (DS). Solar drying can be done to achieve between 65% and 90% DS. Above 65% DS the sludge forms granules or powder and is not lumpy or sticky any longer. The drying process reduces pathogens and faecal coliforms. A microbiological class of A could potentially be achieved to reach an overall sludge classification of A1a. However, it should be noted that temperature has been found to be the main parameter in the removal of helminth eggs and therefore the achievement of A1a may be dependent on the temperatures reached during the solar drying process. Stockpiling and curing of the sludge after drying has also been effective for pathogen reduction.

Figure 6-19: Example of advanced solar drying facility including translucent roof sheeting, forced ventilation and a sludge turner and spreader (Huber).

Figure 4: Example of a solar drying facility design from the engineering report

1.3.2.6 Stormwater Management

It is foreseen that the BBF will have approximately 13 000 m2 of roof area available. Rainwater harvesting will be done from the translucent roofs. It is foreseen that about 1000 kl of rainwater storage will be provided. This water will be used in the BBF and may be used at the WWTW as washwater at the inlet works or beltpress facility. The remaining area of approximately 13 000 m2 will primarily comprise of concrete slabs that will accommodate sludge stockpiles. These slabs will be sloped at approximately 1:200 to open v-drains. The slopes should not be too steep to prevent fluidisation and transport of sludge stockpiles during heavy rainfall. At the perimeter of the slabs kerbs will be provided to ensure that sludge and contaminated stormwater does not flow to the adjacent environment.

A combination of open v-drains and stormwater pipes will collect all the stormwater from the concrete slabs at the south-western corner of the site. This is the lowest point on the site, and the nearest point to the WWTW. The stormwater from the slabs will drain to the inlet works of the Gwaing WWTW. Since the stormwater from the concrete slabs will contain some sludge and organic matter it should not be discharged to a retention pond since it will become eutrophic and may produce a foul smell. The nature of the organic matter discharged to the WWTW will be beneficial to the WWTW process.

Refer to the stormwater management layout in the Figure below.

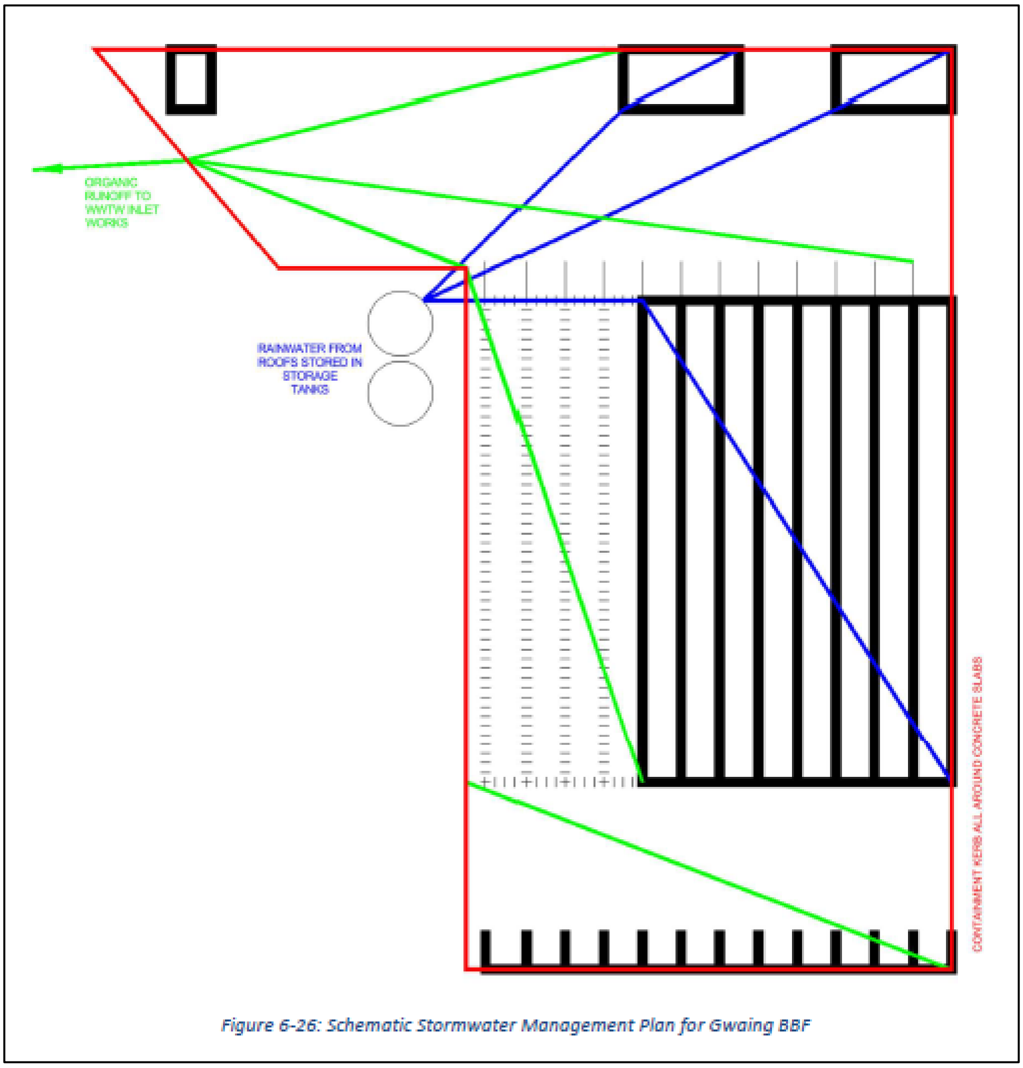

Figure 6-26: Schematic Stormwater Management Plan for Gwaing BBF

Figure 5: Schematic stormwater management plan for Gwaing BBF from Engineering Design Report

2 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. Chapter 1(4r) states that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as coastal shores, estuaries, wetlands, and similar systems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure. Section 24 of NEMA requires that the potential impact on the environment, socio-economic conditions and cultural heritage of activities that require authorisation, must be investigated and assessed prior to implementation, and reported to the authority.
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	The proposed project requires water use authorisation in terms of Chapter 4 and Section 21 of the National Water Act No. 36 of 1998, and this must be secured prior to the commencement of activities. 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.
Conservation of Agricultural Resources Act (Act 43 of 1983)	The Conservation of Agricultural Resources Act (CARA) is to provide for the conservation of the natural agricultural resources by the maintenance of production potential of land, by the combating and prevention of erosion and weakening or destruction of the water sources, and by the protection of the vegetation and the combating of weeds and invader plants.
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.
The Water Services Act (WSA) 108 of 1997	The WSA mandates the Minister responsible for water and sanitation to prescribe compulsory national norms and standards in accordance with Sections 9 and 10 of the Act. The National norms and standards for domestic water and sanitation services (GN R. 982 of 2017; DWS, 2017) set out the national norms and standards for levels of water services, including sanitation, which will be applicable from 2017 until the Minister requests another

	revision. According to section 6.2.4 of the norms and standards, wastewater sludge management must adhere to the Guidelines for the utilisation and disposal of wastewater sludge
National Environmental Management: Waste Act (Act no. 59 of 2008)	Wastewater sludge falls in the definition of waste under NEMWA and therefore the waste regulations, norms and standards must be considered in sludge management, especially when disposal is the preferred management option. The NEMWA norms and standards applicable to sludge storage and disposal are: • National norms and standards for the storage of waste (GN R. 926 of 2013); and • National norms and standards for the assessment of waste for landfill disposal (GN R.635 of 2013).

3 TERMS OF REFERENCE

- Contextualization of the study area in terms of important biophysical characteristics and the latest available aquatic conservation planning information (including but not limited to the South African Inventory of Inland Aquatic Ecosystems (SAIIAE), vegetation, CBAs, Threatened ecosystems, any Red data book information, NFEPA data, broader catchment drainage and protected areas).
- Desktop delineation and illustration of all watercourses within and surrounding the study area utilising available site-specific data such as aerial photography, contour data and water resource data.
- Prepare a map demarcating the respective watercourses or wetland/s, within the study area. This will demonstrate, from a holistic point of view the connectivity between the site and the surrounding regions, i.e. the hydrological zone of influence while classifying the hydrogeomorphic type of the respective water courses / wetlands in relation to present land-use and their current state. The maps depicting demarcated waterbodies will be delineated to a scale of 1:10 000, following the methodology described by the DWS.
- A risk/screening assessment of the identified aquatic ecosystems to determine which ones will be impacted upon and therefore require ground truthing and detailed assessment.
- Ground truthing, identification, delineation and mapping of the 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).
- Conduct a Present Ecological State (PES), functional importance assessment and Ecological Importance and Sensitivity (EIS) assessment of the delineated wetland and riparian habitats.
- Identification, prediction and description of potential impacts on aquatic habitat during the construction and operational phases of the project. Impacts are described in terms of their extent, intensity, and duration. The other aspects that must be included in the evaluation

are probability, reversibility, irreplaceability, mitigation potential, and confidence in the evaluation.

- All direct, indirect, and cumulative impacts for each alternative will be rated with and without mitigation to determine the significance of the impacts.
- Recommend actions that should be taken to avoid impacts on aquatic habitat, in alignment with the mitigation hierarchy, and any measures necessary to restore disturbed areas or ecological processes.
- Rehabilitation guidelines for disturbed areas associated with the proposed project and monitoring. See Appendix 2.

4 APPROACH AND METHODS

The study followed the same approach and methods detailed within the 2024 impact assessment report for the WWTW upgrades. Refer to 2024 report and see Appendix 1.

5 ASSUMPTIONS AND LIMITATIONS

The same assumptions and limitations from the previous report apply. The site assessment for the BFF site was undertaken on the 25th of April 2025, following significant rainfall, and the confidence level is deemed as high.

6 DESKTOP ASSESSMENT OF THE STUDY AREA

The aquatic impact assessment report for the upgrades within the WWTW (Upstream Consulting, 2024) provided a detailed description with maps of desktop findings. In order to avoid unnecessary repetition, only the desktop findings relevant to the specific BFF site, or those which differ from the WWTW site already covered, are reported below.

6.1 SOUTH AFRICAN INVENTORY OF INLAND AQUATIC ECOSYSTEMS

There are no watercourses mapped within the proposed BFF site by the national river and wetland inventory. There is a 1:50 000 cadastral NGI river line depicted on the southeastern site boundary. The National Wetland Map 5 (NWM5) shows no wetlands within or near the BFF site. Refer to Figure 6.

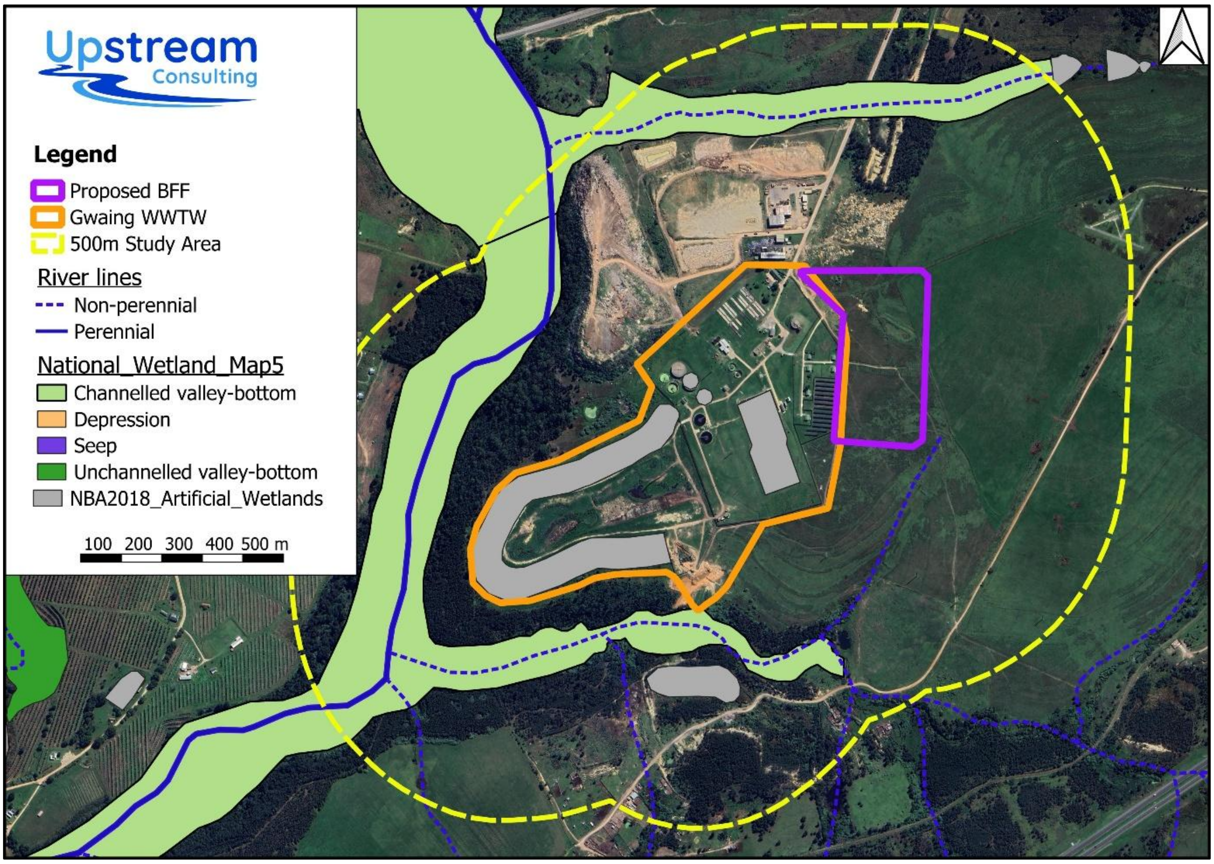

Figure 6: The BFF site in relation to the national river and wetland inventories (CSIR, 2018)

6.2 CONSERVATION CONTEXT

The Western Cape Biodiversity Spatial Plan (WCBSP) identifies biodiversity priority areas, Critical Biodiversity Areas, Ecological Support Areas (ESAs) and Other Natural Areas (ONA), which, together with Protected Areas (PA), are important for the persistence of a viable representative sample of all ecosystem types and species, as well as the long-term ecological functioning of the landscape as a whole.

Figure 7 shows that the site is not located upon any biodiversity priority areas, CBA nor ESAs. However, the drainage line located south of the BFF is classified as ESA 2 aquatic habitat.

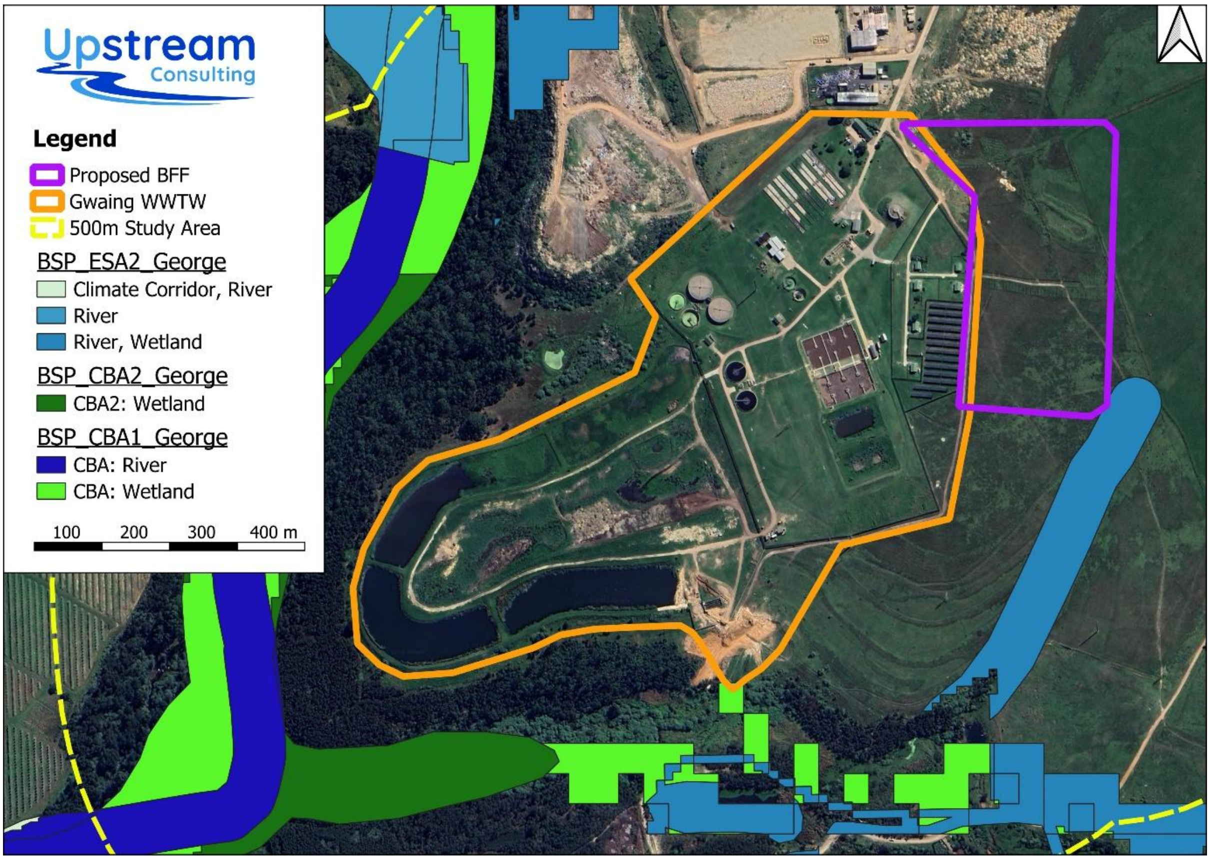

Figure 7: The site in relation to aquatic biodiversity priority areas identified in the WCBSP (2017)

6.3 HISTORIC CONTEXT

In the aquatic sensitivity assessment of the Gwayang Precinct Plan, conducted in May 2024 by Confluent Environmental (Pty) Ltd, entitled 'Mixed Use Development for RE/464 Gwayang Industrial Park, George', a small area in the BFF locality is described as "*historical natural wetland now excavated"*. It is indicated by an arrow on historic Google imagery in Section 3.4 – Artificial Wetlands. Refer to Figure 6. However, it is important to note that this area was seemingly not groundtruthed by the Confluent aquatic specialist, as shown by the fieldwork map of GPS tracks taken from the Gwanyang Precinct Plan report. Refer to Figure 8.

In this assessment, a comprehensive groundtruthing exercise was undertaken which found only a small pocket of artificial wetland within an old excavation. All evidence indicates that this artificial wetland originated from a small livestock drinking pond excavated into the perched water table (Figure 9), which later was modified into the old sludge ponds (Figure 10). It is disputed that this site ever contained natural wetland habitat. It is argued to be a result of past excavations (Figure 11).

3.4 Artificial Wetlands

Historical irrigation with wastewater from the WWTW creates what can appear to be wetlands in some of the fields (Figure 13). However, irrigation has ceased for approximately 5 years and areas that were previously irrigated now show no indication of wetland features.

Figure 13. Periodic irrigation of wastewater from the WWTW on agricultural fields. Arrow indicates historical natural wetland now excavated.

Figure 8: Excerpt from the Confluent 2024 aquatic assessment of the Gwayang Precinct Plan indicating artificial wetland on the BFF site on Google imagery

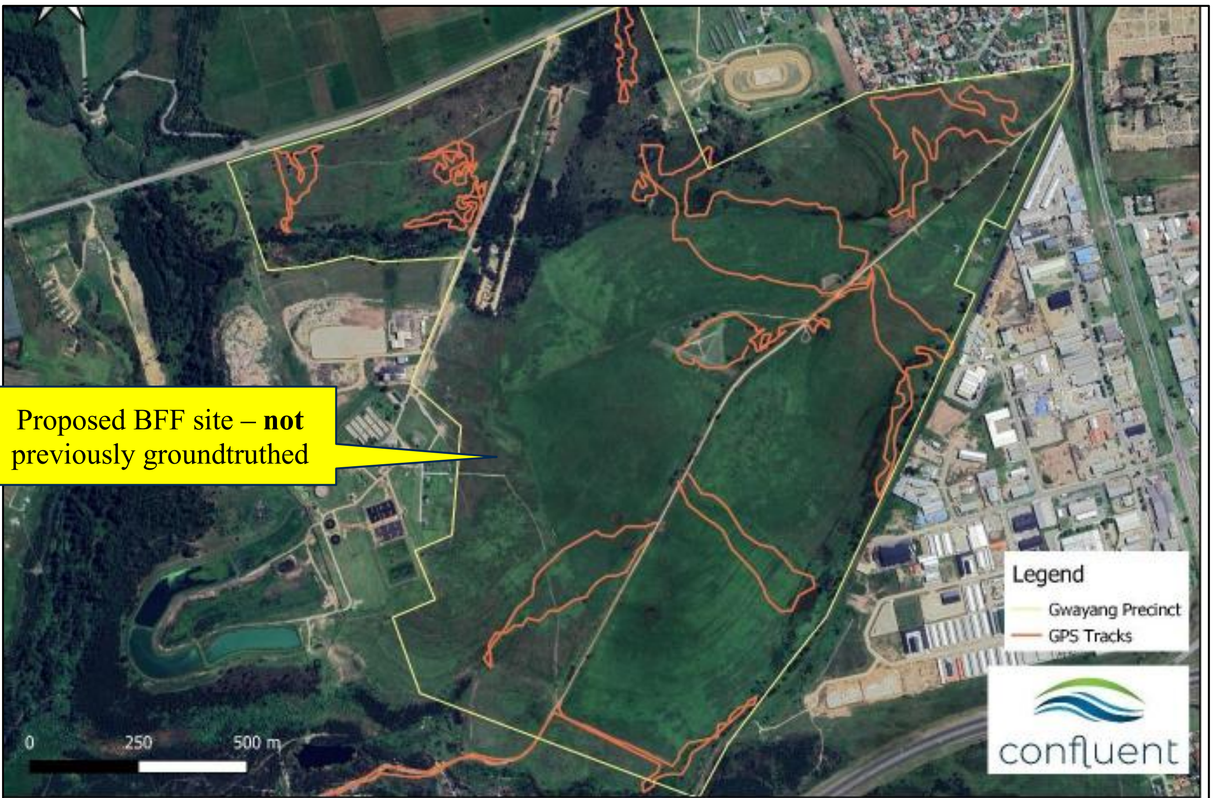

Figure 11. Property boundary showing GPS track walked during different dates for the site visit.

Figure 9: Excerpt from the Confluent 2024 aquatic specialist assessment report showing that the BFF site was not groundtruthed during the fieldwork.

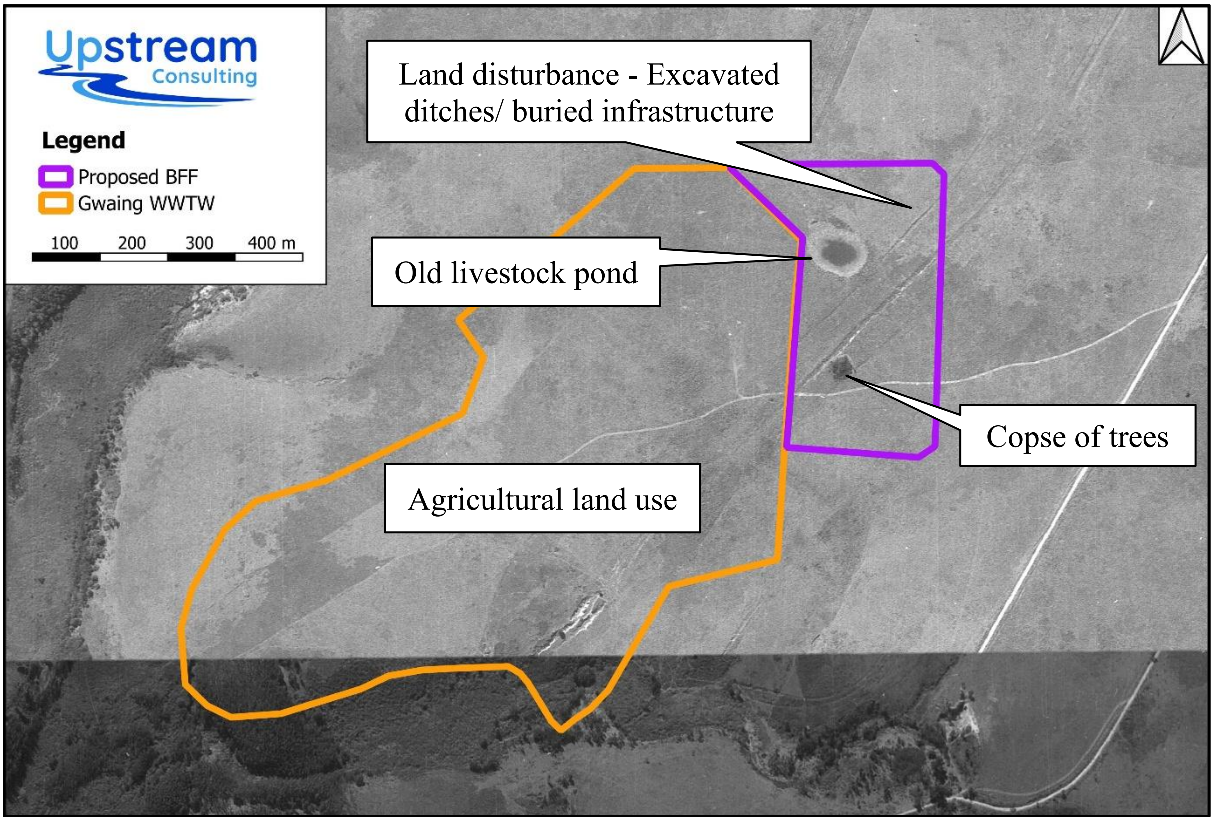

Figure 10: Historic aerial photography of the site in 1957

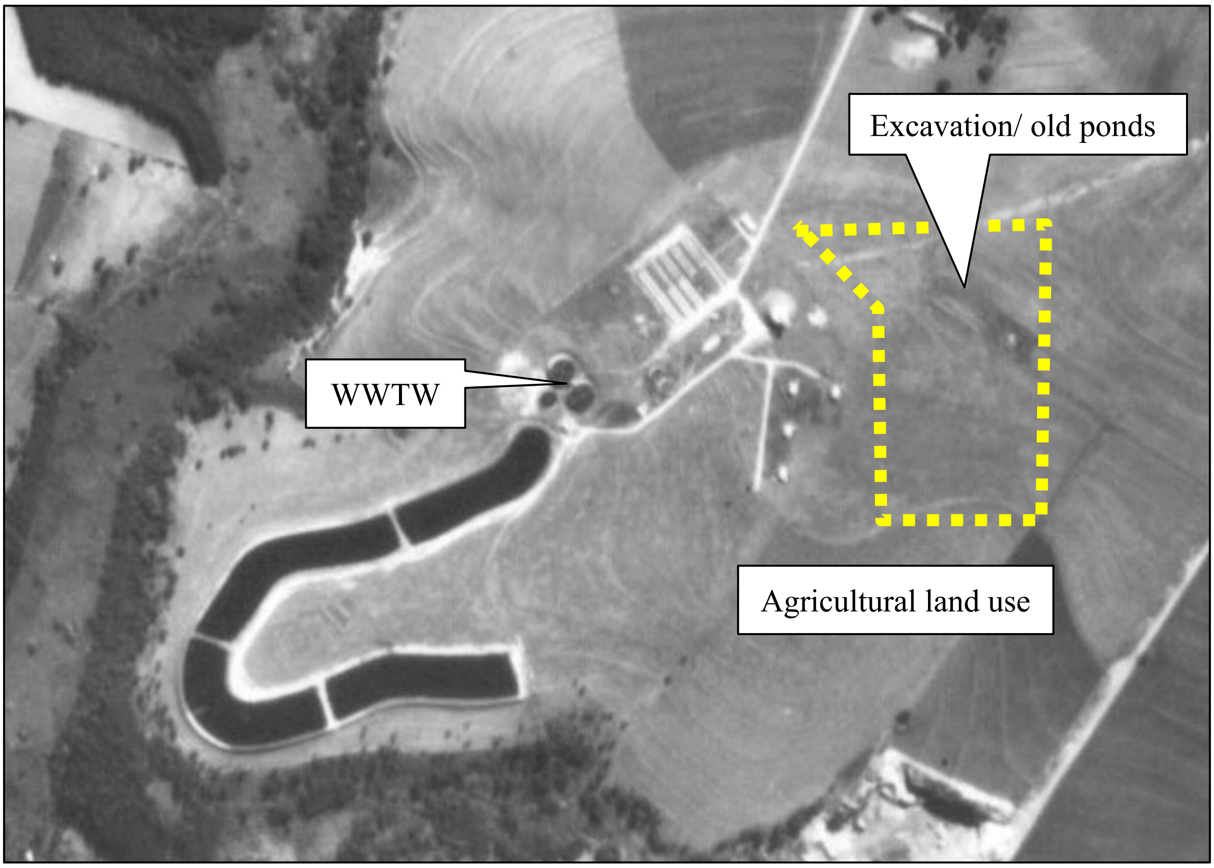

Figure 11: Historic aerial photography of the Gwaing WWTW in 1979

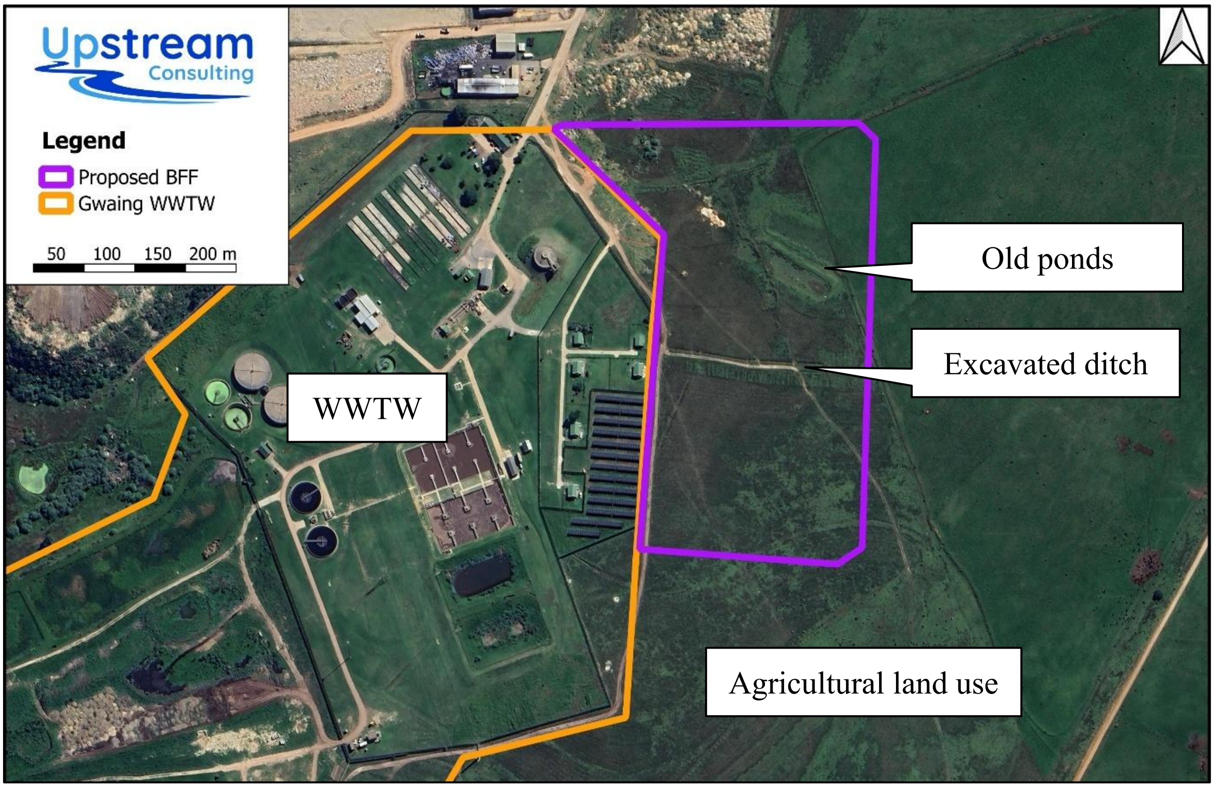

Figure 12: Google Satellite Imagery of the site dated 11/3/2025

7 RESULTS

The aquatic habitats within a 500 metre radius of the proposed project were identified and mapped on a desktop level utilising available data. In order to identify the wetland/river types, using Kotze *et al.* (2009) and Ollis *et al*. (2013), a characterisation of hydrogeomorphic (HGM) types was conducted. Following the desktop findings, the infield site assessment (conducted on the 26th of March 2024 and the 25th of April 2025) confirmed the location and extent of these systems. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project. The findings are detailed in this section below.

7.1 DELINEATION AND CLASSIFICATION

Following the contextualisation of the study area with the available desktop data, a site visit was conducted to ground truth the findings and delineate the aquatic habitat and map it within the 500m radius of the development area. The additional information collected in the field allowed for the development of an improved baseline aquatic habitat delineation map (Figure 13).

Five (5) watercourses were identified and mapped within a 500m radius of the proposed upgrade works. An artificial wetland was identified and delineated within excavations on the BBF site. Subsequent screening provided an indication of which of these systems may potentially be impacted upon by the project and required further assessment. 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.

Due to the topography of the site resulting in surface runoff in a south westerly direction, and location of the WWTW outlet, it was determined that the southern watercourse (mapped as HGM 2) has potential to be directly impacted by the upgrades (Figure 14). However, there is also potential for the downstream section of the Gwaing River (mapped as HGM 1) to be indirectly impacted by the WWTW upgrades. Less likely, but still possible, is for the HGM 4 watercourse (located south of the BFF site) to be indirectly impacted by construction upslope. However, it is definite that the artificial wetland formed in the old excavations on the BFF site will be directly impacted. The other watercourses identified within the 500m radius of the site are unlikely to be impacted by any of the proposed activities and were therefore not assessed further.

Figure 13 shows the watercourses in relation to the 500m radius study area. Figure 14 shows the artificial wetland within the proposed BFF site.

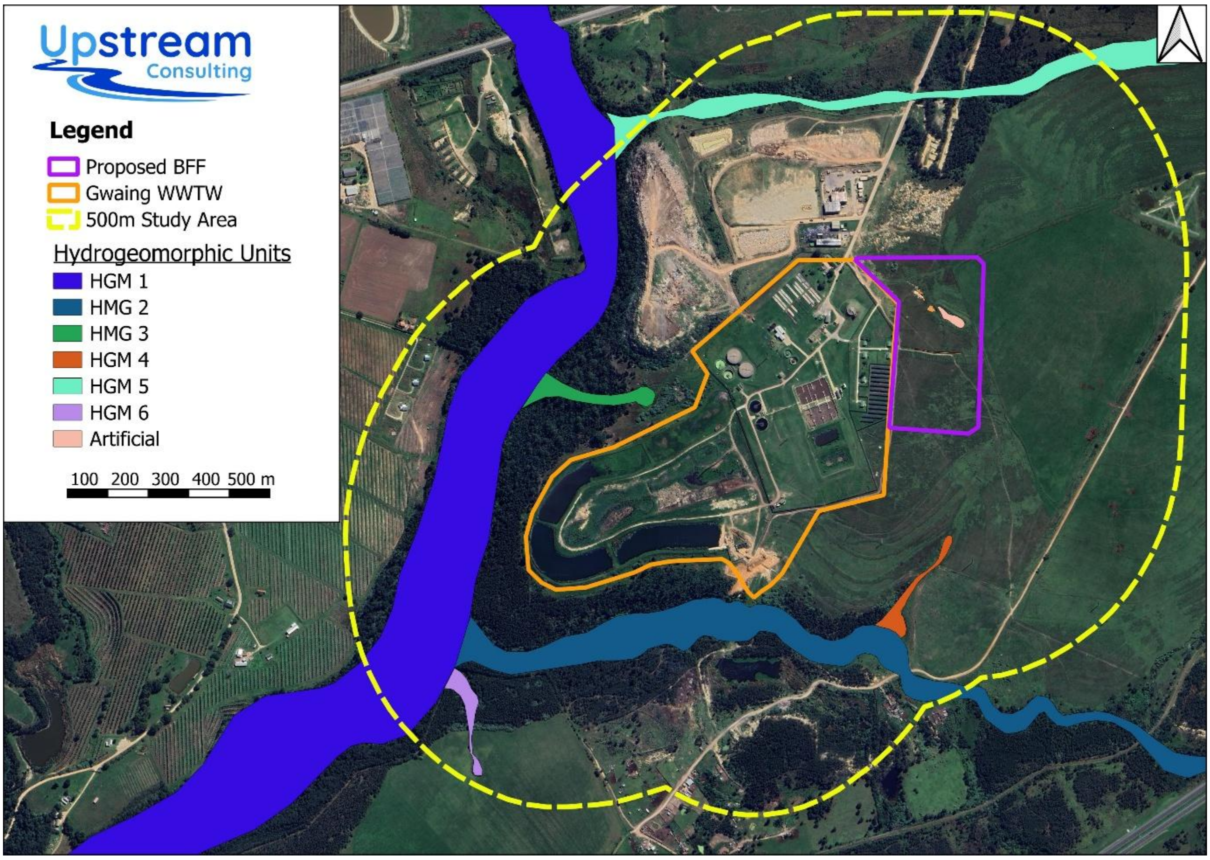

Figure 13: Map of the aquatic habitat identified within the 500m radius study area

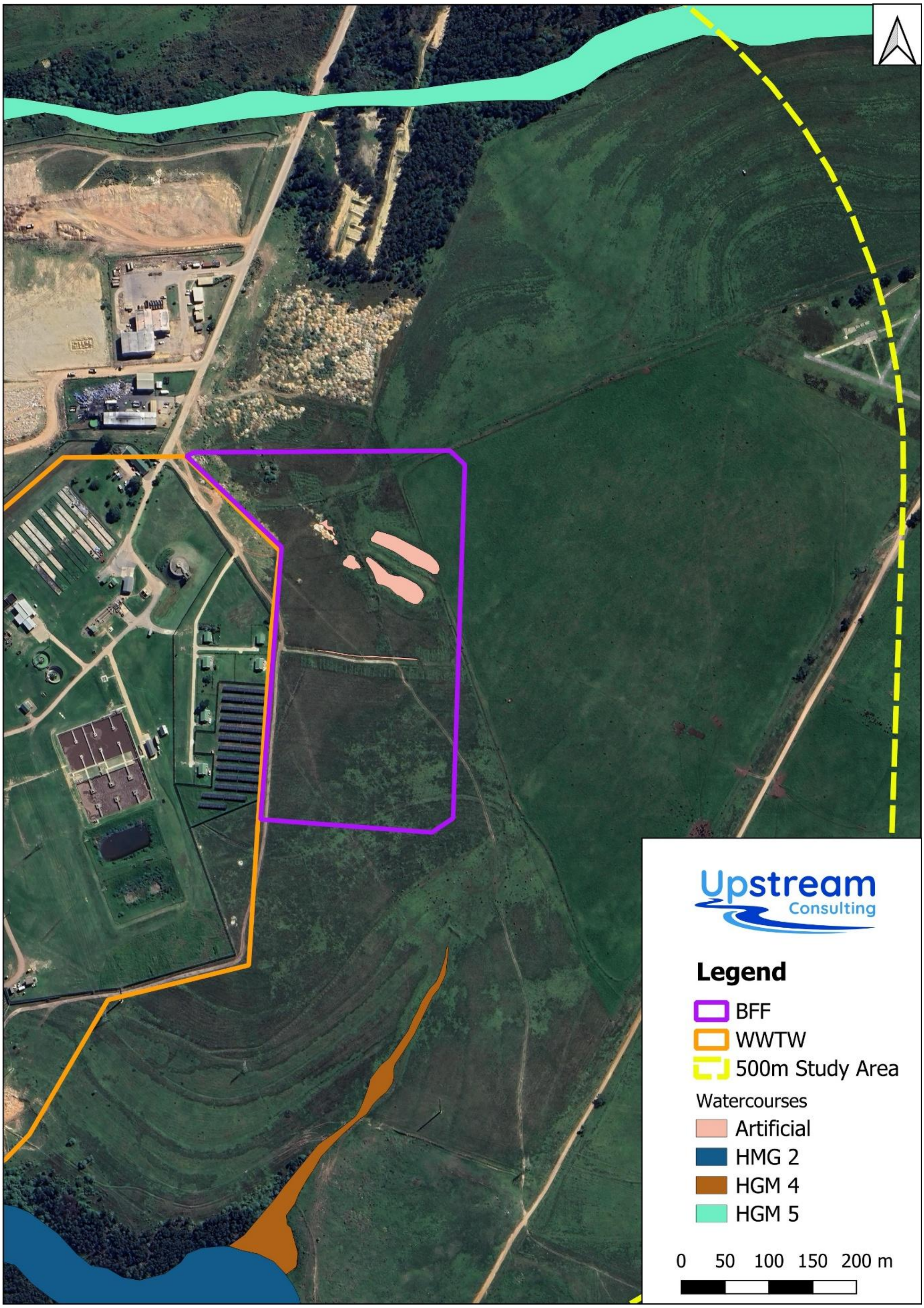

Figure 14: Map of the artificial wetland formed in old excavation at the proposed BFF site

7.2 DESCRIPTION OF AFFECTED AQUATIC HABITAT

The watercourses potentially affected by the upgrades to the WWTW infrastructure have already been assessed in the 2024 report. Therefore, to avoid repetition, only the artificial wetland on the BFF site, and HGM 4 to the south, are described below.

7.2.1 Artificial wetland

The site proposed for the BFF is located upon a relatively flat hilltop and slopes gently towards both the north and south. Past excavations and land surface disturbances upon this level plateau (probably undertaken for old sludge ponds, drainage ditches, buried infrastructure, or simply soil material) have resulted in numerous small, artificial depressions. Over time, wetland characteristics have developed due to prolonged soil saturation from digging into the perched water table. These wetland areas are not connected to the drainage network and soil augering throughout the site determined that there are no natural wetlands.

Although site assessment took place after a heavy rainfall event, there were only very small areas inundated within the depression. The site is intensely grazed and trampled but there are obligate plant species in these depressions, which have adapted to the seasonally saturated soils.

These artificial depressions do not support sensitive aquatic habitat. No rare, endangered, nor endemic species were observed, and none are expected to occur.

Plate 1: Artificial wetland formed in a shallow excavation

Plate 2: Obligate wetland plant species established in an excavated ditch

Plate 3: Soil mottling, indicating hydric conditions within the old, excavated area, characteristic of wetlands

7.2.2 HGM 4

The southern portion of the BFF site slopes more steeply towards the HGM 4 drainage, which joins the tributary to the Gwaing in the valley bottom. HGM 4 can be classified as a 1st order ephemeral stream. However, the upper reach is critically modified by agricultural activity and supports very little aquatic habitat.

HGM 4 is more than 100m away from the proposed BFF and therefore, provided stormwater runoff is managed appropriately, it is unlikely to be impacted by the project.

Plate 4: Looking south from the BFF site to the head of the HGM 4 drainage line located > 100m away

8 RESULTS

The impacts upon aquatic biodiversity as a result of the upgrades proposed at the Gwaing WWTW were discussed and assessed within the 2024/ 2025 aquatic report. Therefore, only impacts relating to the proposed BFF are described below.

8.1 POTENTIAL IMPACTS

In order to construct the BFF in this location (and it is understood that other locations have been investigated but are not deemed suitable), the artificial wetland within the site will need to be infilled. This is a minor negative impact upon aquatic biodiversity; and it is of low cumulative significance.

The construction of the facility will positively reduce the impacts of the existing sludge stockpile on the Gwaing River from seepage. Therefore, while a small area of low sensitivity, artificial wetland will be lost, the construction of the facility will remove a source of pollutants to the mainstem river system. Additionally, to compensate for the infilling of the old excavation (despite its low significance), the Municipality proposes to undertake rehabilitation in a section of the downstream wetland near the treatment works outlet. So, while the increase in discharge volumes from the treatment plant will still have a negative impact, the rehabilitation in that section in lieu of the artificial wetland will reduce the impacts associated with the BBF.

8.2 OFFSET INVESTIGATION

The construction of the BFF will result in the infilling of the very small artificial wetland (0.465ha). Loss of any wetland area is undesirable from an ecological perspective, and guidelines encourage a 'No Net Loss' approach, even with degraded systems. Therefore, where wetlands are lost or degraded as a result of development impacts then some level of compensation should be considered.

In order to assess the need for any formal compensation, such as offsets, a wetland offset investigation was undertaken to determine if such an approach is required to mitigate the residual impacts of loss of the artificial depression. It determined that due to the negligible size and low importance of the excavation there would not in fact be any remaining significant residual negative impacts on biodiversity. No offsets are required.

The potential loss of the wetland area was assessed using the DWS Wetland Offset Calculator (as developed by McFarlane *et al* (2014) and included in the 2017 Draft National Offset Guidelines (GN 276 of March 2017)) to determine the wetland targets that would need to be achieved by any wetland offset. The offset calculations include consideration of wetland condition, extent, existing buffer condition, likely wetland condition in a development context, wetland importance in local, regional and bioregional conservation plans and the impacts of development on so-called wetland functionality. The offset calculation is based on the loss of

0.465 ha of artificial depression wetland. A summary of the wetland offset targets for the artificial wetland area to be lost is provided in Table 2 below.

It was determined that no functional wetland offsets are required. The small, artificial depression does not provide significant ecological functions at any scale and therefore there is a negligible loss. The same result was calculated for species conservation offset targets as there are no species of conservation concern within, or supported by, the artificial wetland.

The loss of the artificial wetland will not influence any biodiversity conservation targets or compromise water resource protection in any way, or on any scale. There is no need for wetland offsets to be implemented. However, compensation is encouraged to achieve a net gain. Any activities to improve nearby watercourses, such as the Gwaing River, and/ or the tributary by the WWTW Discharge outlet, would be an example of such voluntary compensation for wetland loss.

It is therefore recommended as a mitigation measure in this report that the scope of works for the project also include the financial provisioning and implementation of rehabilitation of the incision of the wetland below the WWTW discharge outlet and eradication of the alien invasive tree and shrub species (i.e. Black Wattle and Bugweed) in this reach and at least 100m downstream (but ideally at intervals all the way to the confluence with the Gwaing River).

Table 3 shows a summary of the assessment of wetland gains associated with rehabilitation of the HGM2 system at the discharge outlet (erosion control and alien plant clearing). It is clear from the offset investigation and calculations in the tables below, that the rehabilitation of habitat, after mitigation, outweigh the loss of the small artificial wetland area.

Table 2: Summary of wetland offset calculations for artificial excavation wetland

Determining wetland offset targets			
Wetland Functionality Targets			
Impact Assessment	Prior to development	Wetland size (ha)	0,465
		Functional value (%)	20
	Post development	Functional value (%)	0
		Change in functional value (%)	20
	Key Regulating and Supporting Services Identified		Small area of intermittent innundation in artificial depression providing temporary habitat for wetland biota, but very limited, and not supporting any rare or endanged species.
	Development Impact (Functional hectare equivalents)		0,1
Offset calculation	Offset Ratios	Triggers for potential adjustment in exceptional c	None
		Functional Importance Ratio	1,0
	Functional Offset Target (Functional hectare equivalents)		0,1
Further considerations	Have other key Provisioning or Cultural Services Identified that require compensation?		No
	Additional compensatory mechanisms proposed	The artificial depression does not have any key provisioning or cultural services associated with it. Therefore, no residual cumulative impact and no compensation required. Regardless, additional efforts to improve the nearby wetland integrity at the WWTW discharge outlet are encouraged.	

Ecosystem Conservation Targets

Impact Assessment	Prior to development	Wetland size (ha)		0,465
		Habitat intactness (%)		20
	Post development	Habitat intactness (%)		0
		Change in habitat intactness (%)		20
	Development Impact (Habitat hectare equivalents)			0,093
Determining offset ratios	Ecosystem Status	Wetland Vegetation Group (or type based on local clasification)	Artificial - dominated by wide-spread sedge species and alien invasive plants, such as Kikuyu Grass. Highly degraded and previously disturbed vegetation. Grazed and trampled.	
		Threat status of wetland	Threat status	LT
			Threat status Score	1
		Protection level of wetland	Protection level	Not Protected
			Protection level Score	2
			Ecosystem Status Muliplier	2
	Regional and National Conservation context	Priority of wetland as defined in Regional and National Conservation Plans	Not specifically identiifed as important	0,5
			Regional & National Context Multiplier	0,5
	Local site attributes	Uniqueness and importance of biota present in t	Low biodiversity value	0,5
		Buffer zone integrity (within 500m of wetland)	Buffer compatability score	0,2
		Local connectivity	Low connectivity	0,5
			Local Context Multiplier	0,4
			Ecosystem Conservation Ratio	0,44
Offset Calculation	Development Impact (Habitat hectare equivalents)			0,0930
	Ecosystem Conservation Ratio			0,4
	Ecosystem Conservation Target (Habitat hectare equivalents)			0,0

Species Conservation Targets

Species review and selection	**Desktop Evaluation:** Species flagged as potentially occurring at the site	Species Name	
		Juncus effusus	
		Cyperus congestus	
		Cenchrus clandestinus	
		Eleocharis limosa	
		Persicaria decipiens	
	Specialist assessment: Species of conservation concern identified as requiring offset activities	Species Selected	Rationale for species selection
		None	No species of concern
Target Species 1:		No species of concern	
Impact Assessment	Impact measure	No species of concern	Habitat measure
		No species of concern	Habitat measure
		Description and rationale for species impact measure selected	
		No species of concern	
	Prior to development	Species impact measure	0
	Post development	Species impact measure	0
		Change in species impact measure	0
	Development Impact (Species impact measure)		0
Determining offset ratios	Offest Ratios	Offset Ratio	0,0
		Description and rationale for offset ratio selected	
		No species of concern	
		Species Conservation Ratio	0,0
Offset Calculation	Development Impact (Species impact measure)		0,0
	Species Conservation Ratio		0,0
	Species Conservation Target (Species measure)		0,0

Table 3: Assessment of gains of receiving wetland – HGM2 – from rehabilitation efforts

Offset Receiving Areas: Assessing potential gains				
Contribution Towards Wetland Functionality Targets				
Wetland attributes	Wetland Reference		**HGM 2 - tributary wetland to Gwaing River at WWTW outlet**	
Alignment with site selection guidelines	**Criterion**	**Relevance**	**Site attributes**	**Acceptability Guidelines**
	Wetland type	Targeted wetlands should typically be of the same type to ensure that similar services to those impacted are improved through offset activities.	Wetland is of a different type to the impacted wetland.	Acceptable
	Key services targeted	Targeted wetlands should be prioritised and selected based on their ability to compensate for key regulating and supporting services impacted by the proposed development.	Selected wetland is well placed to contribute meaningfully towards improving key regulating and supporting services identified.	Ideal
	Offset site location relative to impacted wetland	Targeted wetlands should ideally be located as close to the impacted site as possible.	Selected wetland is located within the same local catchment as the impacted wetland.	Ideal
	Overall comment on alignment with site selection guidelines	Rehabilitation of a reach of the dowsnstream wetland (a tributary to the Gwaing River) at the WWTW discharge pipe outlet will improve the regulatory and supporting services provided by the nearby, ecologically important wetland system (such as water purification and sediment trapping). This will more than compensate for the loss of a small patch of artificial, temprary wetland formed within the old excavation on the BFF site.		
Preliminary Offset Calculation	**Prior to offset activities**	Wetland size (ha)	2,7	
		Functional value (%)	60	
	Following sucessful offset implimentation	Functional value (%)	68	
		Change in functional value (%)	8	
	Preliminary Offset Contribution (Functional hectare equivalents)		**0,2**	
Final Offset Calculation	**Criterion**	**Relevance**	**Offset activity**	**Adjustment factor**
	Types of offset activities proposed	The risk of offset failure is linked to the type of offset activity planned with wetland establishment considered less preferable and more risky than rehabilitation or averted loss activities.	Rehabilitation & Protection	0,66
	Final Offset Contribution (Functional hectare equivalents)		**0,1**	
Contribution Towards Ecosystem Conservation Targets				
Wetland attributes	Wetland Reference		HGM 2 - tributary wetland to Gwaing River at WWTW outlet	
	Wetland Vegetation Group (or type based on local clasification)		Garden Route Granite Fynbos	
	Threat status of wetland		Threat status	CR
Alignment with site selection guidelines	**Criterion**	**Relevance**	**Site attributes**	**Acceptability Guidelines**
	Like for Like	Targeted wetlands should be aligned with "like-for-like" criteria to ensure that gains associated with wetland protection are commensurate with losses.	Wetland is of an alternative wetland type of a higher threat status in another wetland vegetation group (trading up)	Potentially acceptable
	Landscape planning	To what degree is wetland selection aligned with Regional and National Conservation Plans	Wetlands have been identified as being of high importance in landscape planning	Ideal
	Wetland condition	The habitat condition of the wetland should ideally be as good / better that that of the impacted site prior to development (or at least B PES Category in the case of largely un-impacted wetlands)	Final habitat condition is likely to be better than that of the impacted wetland.	Ideal
	Local biodiversity value	Wetlands that are unique or that are recognised as having a high local biodiversity value should be prioritised for wetland protection.	The wetland is charachterised by habitat and / species of high biodiversity value.	Ideal
	Viability of maintaining conservation values	Connectivity and consolidation with other intact ecosystems together with the potential for linkage between existing protected areas is preferable.	The wetland is well connected to other intact natural areas	Acceptable
	Overall comment on alignment with site selection guidelines	The site is within the same local catchment and the wetland is of higher conservation value but needs rehabilitation		
Preliminary Offset Calculation	Wetland areas to be secured	Wetland size (ha)	**2,7**	
		Habitat intactness (%)	**68**	
		Wetland habitat contribution (hectare equivalents)	**1,8**	
	Buffer zones to be secured	Area of wetland buffer zone included in the wetland offset site	**0**	
		Integrity of buffer zone	**1**	
		Buffer zone hectare equivalents	**0,0**	
		Buffer zone contribution (hectare equivalents)	**0,0**	
Final Offset Calculation	**Criterion**	**Relevance**	**Site attributes**	**Adjustment factor**
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement are more likely to be maintained in the long-term and are therefore preferred.	Minimum acceptable security of tenure for shortest acceptable period	1
	Offset Contributions	Wetland habitat contribution (hectare equivalents)	1,8	
		Buffer zone contribution (hectare equivalents)	0,0	
		Functional Offset Contribution (hectare equivalents)	**1,8**	
Contribution Towards Species Conservation Targets				
Target Species 1:		**Natural habitat and biota - potentially endemic species**		
Proposed offset activities	Description of offset activities proposed	Rehabilitation of degraded wetland		
	Rationale for proposed offset activities	Improvement of nearby, ecologically important habitat in lieu of artificial wetland loss		
Preliminary Offset Calculation	Species impact measure	Selected species impact measure	Habitat measure	
		Selected unit of measurement	Habitat measure	
		Species impact measure (secured)	**2,0**	
	Preliminary species contribution		**2,0**	
Final Offset Calculation	**Criterion**	**Relevance**	**Site attributes**	**Adjustment factor**
	Security of tenure	Offset activities that formally secure offset sites for longer than the minimum requirement are more likely to be maintained in the long-term and are therefore preferred.	Minimum acceptable security of tenure for shortest acceptable period	1
	Risk of proposed activities	The risk of activities potentially failing to deliver desired outcomes should be taken into accont when assessing the potential offset contributions.	Moderate Risk	0,66
	Species Adjustment Factor			0,66
	Final Offset Contribution (Species measure)		**1,3**	

8.3 SIGNIFICANCE OF IMPACTS

The impact significance of the proposed BBF project was determined to be Low, after mitigation and rehabilitation. Positive impacts can be achieved. Refer to Table 4 for the impact assessment table.

Mitigation requires the implementation of rehabilitation efforts in nearby aquatic habitat.

A meeting with the client was undertaken on site on the 23rd of May 2025 to discuss potential rehabilitation measures. It was agreed that additional rehabilitation measures, over and above those required following upgrades to the outlet structure, will be implemented in the wetland between the WWTW outlet and Gwaing River. This will involve, as a minimum, (i) alien invasive plant species clearance for a minimum of 100m downstream of the outlet and the width of the valley floor, and (ii) channel bed and bank rehabilitation at intervals (identified by an engineer) until the confluence. This voluntary compensation measure (also related to Duty of Care principles) ensures the overall low impact of the project and will assist in mitigating against the increased discharge volumes.

Table 4: Impact of loss of artificial depression for the BBF

PHASE:	Construction (at BBF)	
Potential impact and risk:	Loss of artificial wetland habitat	
Nature of impact:	Negative	
Alternative:	**Alternative A**	**No-Go**
Extent and duration of impact:	Site and Permanent	None
Magnitude of impact or risk:	Low	
Probability of occurrence:	Definite	
Degree to which the impact may cause irreplaceable loss of resources:	Irreplaceable loss	
Degree to which the impact can be reversed:	Irreversible	
Indirect impacts:	None	
Cumulative impact prior to mitigation:	Medium	
Significance rating of impact prior to mitigation	Low	
Degree to which the impact can be avoided:	None	
Degree to which the impact can be managed:	None	
Degree to which the impact can be mitigated:	Can be mitigated	
Proposed mitigation:	• Implement rehabilitation efforts in nearby aquatic habitat to compensate for loss of artificial depression. • Appropriate stormwater management and prevention of hillslope erosion surrounding the facility.	Duty of Care- Alien clearing, erosion prevention, and

	• Rehabilitation activities should be in place prior to impacts from increased discharge volumes and any stormwater runoff. • Aquatic specialist input should be sought on intervention designs and rehabilitation planning prior to commencement. • No removal of indigenous vegetation should occur during rehabilitation activities. • Monitoring of the rehabilitation activities should involve quarterly auditing by an aquatic specialist during construction and one year thereafter. • An ECO should be appointed for more frequent monitoring a staff induction, as well as monitoring of rehabilitation success. • Funds should be specifically allocated to these undertakings.	pollution control
Residual impacts:	Positive	
Cumulative impact post mitigation:	Very Low	
Significance rating of impact after mitigation	Very Low/ Negligible	None

For potential impact assessment of the increased discharge volumes and changes to water quality please refer to the aquatic assessment of the upgrades at the WWTW itself. The assessment of this BBF was commissioned after that report was concluded and is therefore presented as a stand-alone report, but they are related.

9 MITIGATION

It was determined that no wetland offsets for the loss of the artificial wetland on the BBF site are necessary (refer to Section 8.2 above).

Rehabilitation efforts in nearby aquatic habitat will sufficiently compensate for the negligible amount and significance of loss. It should also be a requirement for the overall upgrade project to ensure that the wetland can 'cope' and adapt with the increased discharge volumes. This rehabilitation is also in alignment with the Duty of Care principles and CARA legislation. Therefore, from an aquatic perspective, the proposed project is deemed as acceptable, and the BBF construction will have a Low impact, after mitigation and rehabilitation.

The rehabilitation efforts must be undertaken concurrently with the upgrades to the discharge outlet and/or construction of the BBF but prior to any increased discharge from the WWTW. It is important that additional funding, above that dedicated to the standard rehabilitation after work on the outlet, be budgeted for rehabilitation.

The area recommended for rehabilitation of HGM2 is (as a minimum) approximately 50m upstream and 100m downstream of the WWTW discharge point, in lieu of infilling the artificial depression within the BBF site. While the focus is on the eroding channel, alien plant clearing should span over the width of the valley floor adjacent to this reach of the channel. The location of rehabilitation interventions for channel incision is also to be focused on the area approximately 100m downstream of the discharge point (as a minimum), however, interventions at key intervals all the way to the confluence are encouraged (to be identified by the engineer in consultation with a professional wetland scientist).

Key rehabilitation measures include:

- Including the recommended rehabilitation in the project scope
- Provision of financial resources for rehabilitation efforts
- Appointment of a qualified engineer to design and implement interventions to rehabilitate the eroded channel
- Stabilisation of the erosion at the discharge outlet in the reach of the HGM2 wetland and at least 100m downstream, but ideally at intervals until the confluence, identified by the engineer.
- Compile a method statement for the removal of alien invasive plant species, and follow-up, in an area of at least 100m downstream, 50m upstream, and the width of the valley floor, in the HGM2 wetland.
- Provide for the financial resources required for the alien plant clearing as part of this project
- Include the rehabilitation and monitoring of the alien plant clearing activities in project scope as separate section – not to be confused with the standard rehabilitation of work at the outlet
- Consult with an ecologist throughout regarding rehabilitation measures and monitoring of success

The wetland provides valuable ecosystem services that if lost will have negative environmental impact but also significant (and potentially irretrievable) socio-economic impacts. It is currently vulnerable to collapse but can be retained with intervention, such as erosion control and alien invasive plant removal.

10 REHABILITATION INTERVENTIONS

Refer to Appendix 2 for specific rehabilitation guidelines.

The HGM2 wetland would not naturally have such an incised channel, and this change is related to the concentrated discharge of water at the outlet. Higher discharge volumes will likely cause further degradation, and even collapse, should the erosion at the outlet not be remediated and the upgraded outlet structure designed accordingly. Therefore, as part of mitigation, the disturbance area at the outlet associated with the upgrades should be rehabilitated.

Over-and -above this, it is recommended that ecological rehabilitation be done downstream. This will increase the resilience of the wetland to increased volumes in future. Following project team discussions, it was accepted that such rehabilitation can be conducted as part of the BBF facility report, but perhaps simultaneously with the upgrades at the outlet. But that rehabilitation will be included into the overall project plan.

The overall goal of rehabilitation should be to restore the hydrological and geomorphic stability of the eroded channel reach downstream of the Gwaing WWTW discharge outlet by halting active incision, re-establishing stable base levels, and re-wetting the adjacent wetland zone. The aim is not only to stabilise the banks but to reconnect the channel to its floodplain, reduce flow energy, and raise the local water table to allow wetland vegetation to re-establish. The detailed design and sizing of structures must be undertaken by a qualified civil/hydraulic engineer in collaboration with a wetland ecologist. The recommended rehabilitation approach is detailed in Appendix 2.

It is important for downstream habitat to be improved to avoid collapse in future. For the entire project, including the BBF, to achieve a low impact to aquatic biodiversity, and implement the required duty of care, it is recommended that apart from fixing erosion at the outlet during upgrades, appropriate rehabilitation interventions be constructed in the wetland and alien invasive plants be controlled throughout the wetland going forward. Interventions should be designed to withstand the discharge flow velocities and stabilise the channel.

11 CONCLUSION

The proposed BBF development will result in the loss of a small, artificial wetland that has formed within an old excavation. This feature is not considered a natural wetland and does not support sensitive aquatic biodiversity. The significance is negligible at both local and broader ecological scales.

Crucially, the BBF will reduce ongoing pollution risks from unlined sludge stockpiles, thereby improving water quality protection for the Gwaing River. No formal wetland offsets are required; however, voluntary compensation through rehabilitation of the eroded wetland area downstream of the WWTW discharge outlet is to be adopted and can result in ecological gain. Improving the resilience of this wetland will be extremely beneficial from both an environmental but also a socio-economic perspective.

The detailed rehabilitation design can be undertaken by the appointed engineer, provided the design objectives are clearly defined: to halt further incision, raise the bed profile in stages, and re-establish wetland hydrology by slowing flow and promoting local base-level control at intervals downstream to the confluence. The exact structure type and locations should be determined by the engineer in consultation with the wetland specialist.

From an aquatic biodiversity perspective, the BBF project is considered acceptable, provided that the recommended mitigation and rehabilitation measures are implemented.

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APPENDIX 1 –DETAILED METHODOLOGY

For reference the following definitions are as follows:

- **Drainage line**: A drainage line is a lower category or order of watercourse that does not have a clearly defined bed or bank. It carries water only during or immediately after periods of heavy rainfall i.e. non-perennial, and riparian vegetation may not be present.
- **Perennial and non-perennial:** Perennial systems contain flow or standing water for all or a large proportion of any given year, while non-perennial systems are episodic or ephemeral and thus contains flows for short periods, such as a few hours or days in the case of drainage lines.
- **Riparian**: the area of land adjacent to a stream or river that is influenced by stream-induced or related processes. Riparian areas which are saturated or flooded for prolonged periods would be considered wetlands and could be described as riparian wetlands. However, some riparian areas are not wetlands (e.g. an area where alluvium is periodically deposited by a stream during floods but which is well drained).
- **Wetland**: land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which under normal circumstances supports or would support vegetation typically adapted to life in saturated soil (Water Act 36 of 1998); land where an excess of water is the dominant factor determining the nature of the soil development and the types of plants and animals living at the soil surface (Cowardin *et al*., 1979).
- **Water course**: as per the National Water Act means -
  (a) a river or spring;
  (b) a natural channel in which water flows regularly or intermittently;
  (c) a wetland, lake or dam into which, or from which, water flows; and
  (d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks

12.1 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.

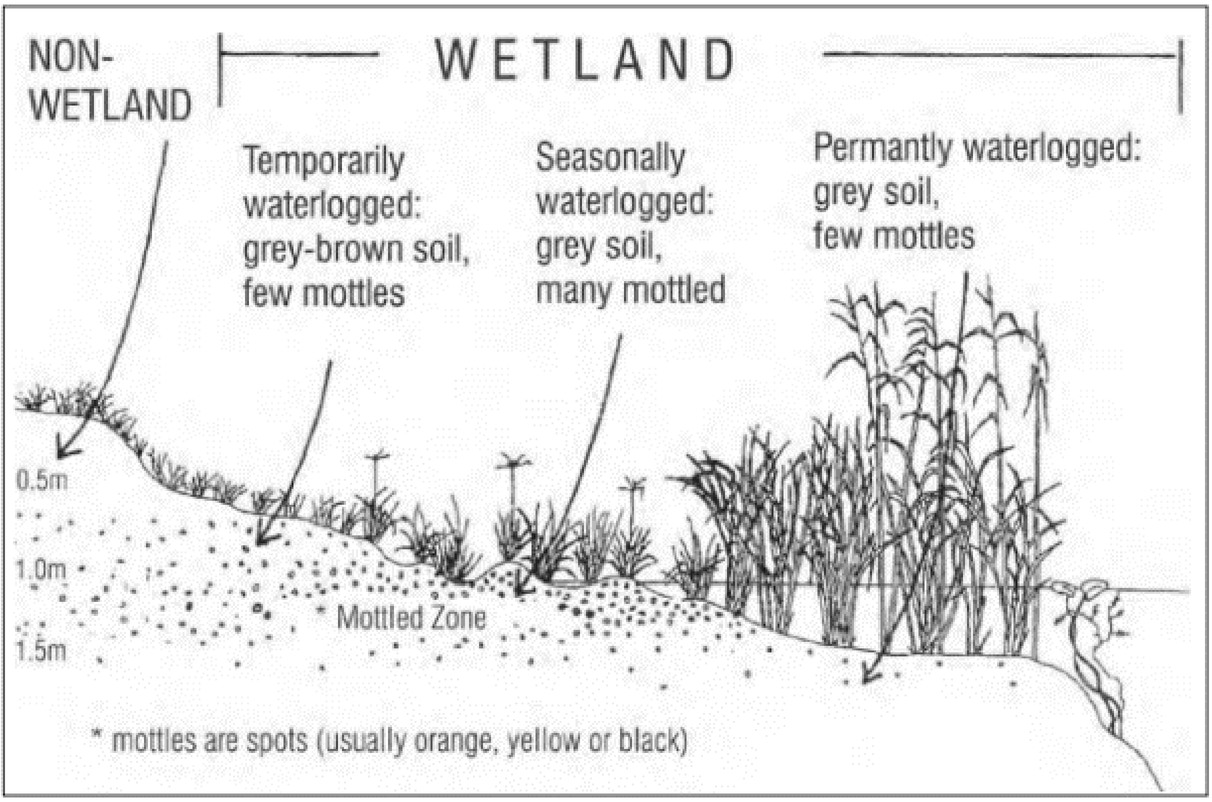

Figure A12.1a: Cross section through a wetland, indicating how the soil wetness and vegetation indicators change as one moves along a gradient of decreasing wetness, from the middle to the edge of the wetland. Source: Donovan Kotze, University of KwaZulu-Natal.

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 A12.1a)

A12.1a: 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 A12.1b: 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 A12.1b).

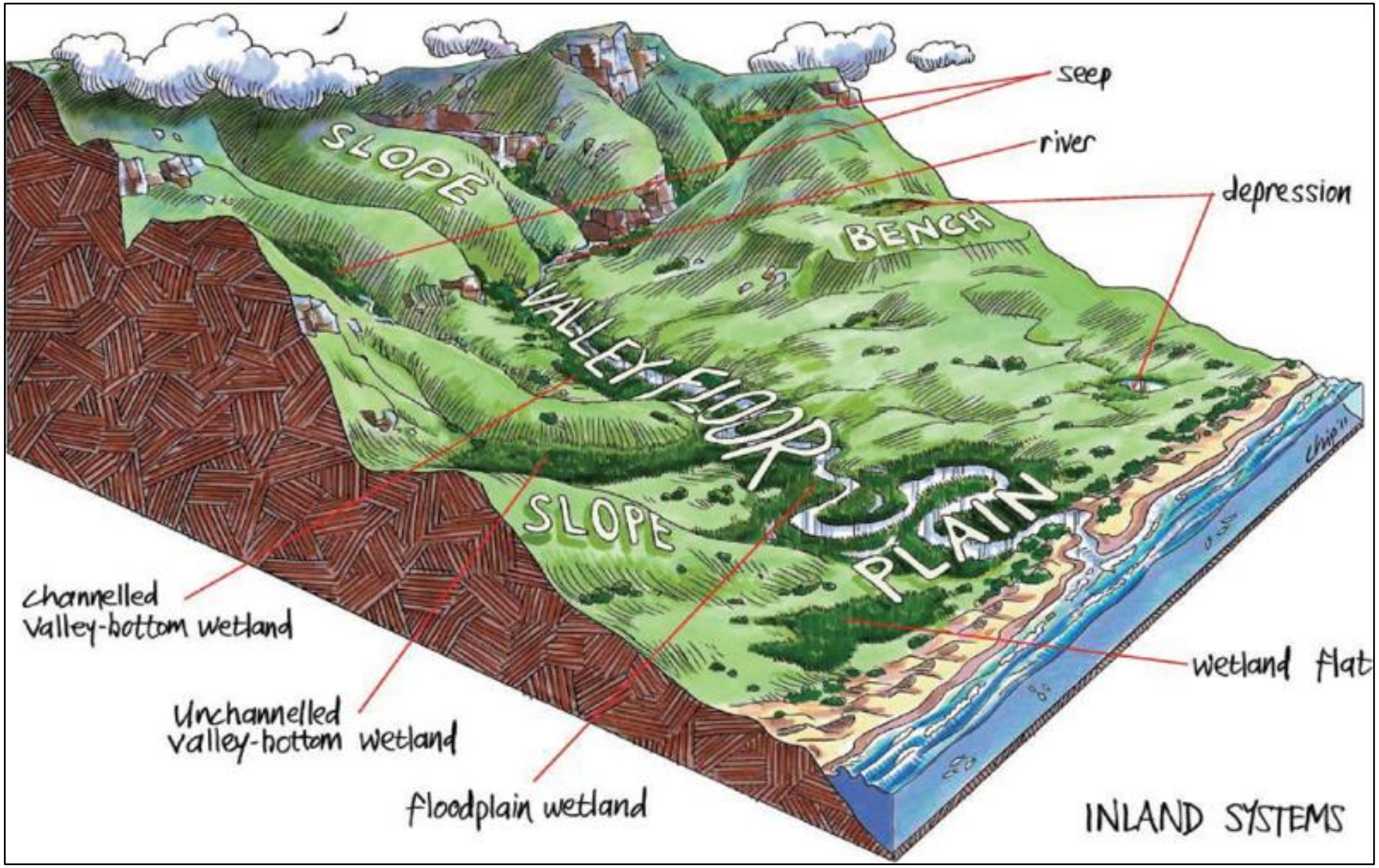

Figure A12.1b: Illustration of wetland types and their typical landscape setting (From Ollis et al. 2013)

12.2 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 12.2a). Unlike wetland areas, riparian zones are usually not saturated for a long enough duration for redoxymorphic features to develop. Riparian zones instead develop in response to (and are adapted to) the physical disturbances caused by frequent overbank flooding from the associated river or stream channel.

Like wetlands, riparian areas can be identified using a set of indicators. The indicators for riparian areas are: - **Landscape position**; - Alluvial soils and recently deposited material; - **Topography** associated with riparian areas; and - **Vegetation** associated with riparian areas. Landscape Position As discussed above, a typical landscape can be divided into 5 main units), namely the: - Crest (hilltop); - Scarp (cliff); - 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.

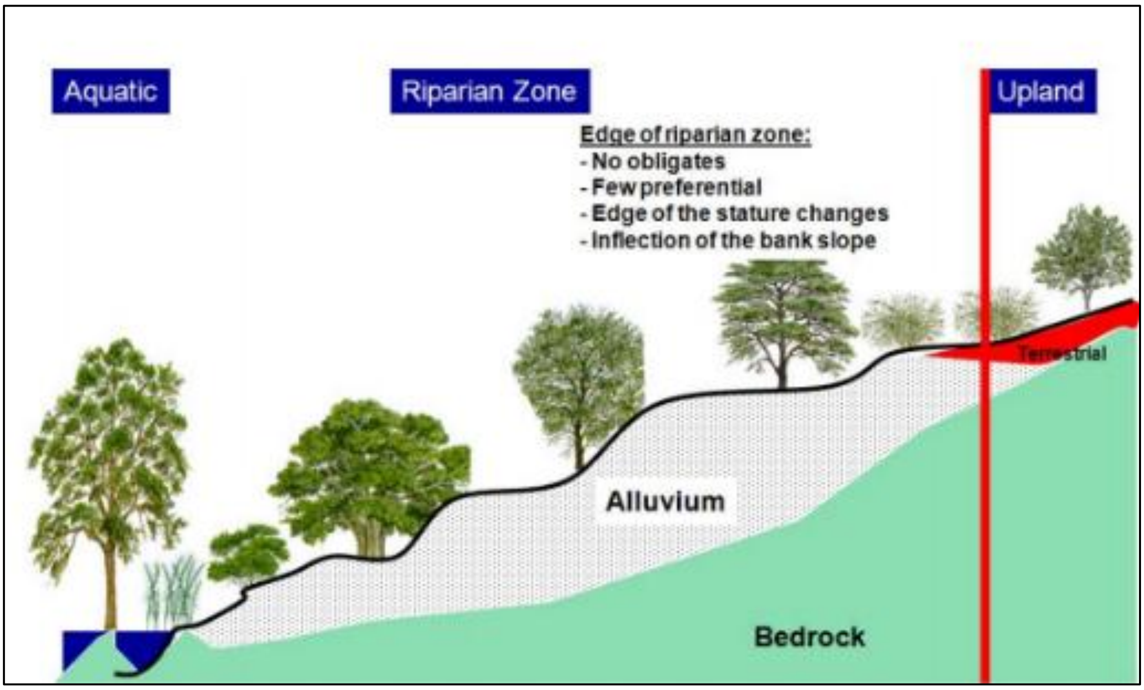

Figure A12.2a: A schematic diagram illustrating the edge of the riparian zone on one bank of a large river. Note the coincidence of the inflection (in slope) on the bank with the change in vegetation structure and composition. The edge of the riparian zone coincides with an inflection point on the bank; where there are not obligates upslope; few preferential. The boundary also coincides with the outer edge of the stature differences (DWAF 2008).

12.3 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.

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 A12.2a).

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 A12.2b, below. This classification is consistent with DWAF categories used to evaluate the present ecological state of aquatic systems.

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.

Table A12.2a: Guideline for interpreting the magnitude of impact on integrity

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

Table A12.2b. 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	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

12.4 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 20 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 A12.4a) - that is, the benefits provided to people by the ecosystem.

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 A12.4a: Ecosystem services assessed by WET-Ecoservices

12.5 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 A1.1) 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 A1.1: 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 A1.2).

Table A1.2: 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.

12.6 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 A1.3).

The scores assigned to the criteria in Table A1.3 were used to rate the overall EIS of each mapped unit according to Table A1.4, 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 A1.3: 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

Table A1.4: 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

APPENDIX 2: REHABILITATION GUIDELINES

PURPOSE AND SCOPE

This appendix provides guidance for the rehabilitation of the eroded wetland channel (HGM2) located downstream of the Gwaing Wastewater Treatment Works (WWTW) discharge outlet.

The purpose of the rehabilitation is to:

- Arrest ongoing channel incision and bank erosion.
- Restore hydrological and geomorphic stability.
- Re-establish wetland hydrology and vegetation.
- Remove invasive alien plant species (notably *Acacia mearnsii* [Black Wattle] and *Solanum mauritianum* [Bugweed]) to promote recovery of indigenous riparian and wetland species.

The design and implementation of these measures must be undertaken by the appointed engineer and environmental specialist in consultation with a wetland ecologist.

REHABILITATION OBJECTIVES

1. Stabilise and protect the eroding wetland reach and prevent further headcut migration.
2. Re-establish natural hydrological functioning by raising local base levels and promoting lateral wetting of the wetland floor.
3. Reduce flow velocity and energy to prevent further erosion and enhance sediment deposition.
4. Encourage natural regeneration of indigenous hydrophilic vegetation and restore ecological connectivity.
5. Remove and control invasive alien vegetation to ensure the persistence of native wetland communities and reduce evapotranspiration losses.
6. Integrate rehabilitation activities with ongoing WWTW operations to ensure long-term sustainability.

DESIGN PRINCIPLES

- Rehabilitation design must be process-based, targeting causes of degradation (flow concentration, outlet energy, incision) rather than symptoms alone (bank collapse).
- Structural measures should aim to reconnect the channel with its floodplain, creating a stable, self-sustaining system that mimics natural morphology.
- Soft engineering (bio-engineering and natural materials) should be utilised where appropriate but hard infrastructure will likely be required as the key intervention structure type.
- Flow and sediment dynamics should be restored gradually — avoid over-steep or rigid structures that could shift erosion downstream.
- The engineer must design the structures, but the wetland ecologist must define the ecological objectives, monitor outcomes, and guide vegetation establishment.

RECOMMENDED INTERVENTIONS

Channel Erosion Rehabilitation

Grade-Control Structures

Objective: Halt incision and raise the wetland bed profile.

Options:
- Gabion weirs or rock-packed check dams spaced at intervals (typically every 15–25 m, depending on slope) to create a stepped longitudinal profile.
- Log or brush weirs (bio-check structures) for smaller, shallower sections -constructed from anchored logs or brush fascines, backfilled with brush and rock.
- Reno mattresses on flatter gradients to spread flow and trap fine sediment.

Design notes:
- Crest heights should match the upstream invert to ensure a stable energy gradient.
- Structures should be semi-permeable to allow controlled seepage and sediment deposition.
- Each structure must be keyed securely into the bed and banks (minimum 0.3 m embedment).

Expected outcomes:
- Flow velocity reduction.
- Sediment deposition upstream of structures.
- Gradual bed level rise and rehydration of adjacent wetland soils.

Refer to Figures A2.1-A2.3 below for examples of hard engineering intervention structures, and A2.4. for an example of softer approaches.

Figure A2.1: Example of a weir structure

Figure A2.215: Example of multiple check dams for gully control

Figure A2.3: Example of fibre bags used to deactivate gully head erosion

Figure A2.4: Example of soft engineering intervention – a stake and brush mattress structure

Two-Stage Channel Design

Objective: Create a self-maintaining morphology that can handle both low-flow and high-flow conditions.

Approach:

- Excavate inset floodplain benches along one or both sides of the entrenched channel.
- The main (low-flow) channel conveys baseflow, while benches accommodate moderate flood events.
- Benches should be vegetated with emergent wetland species to stabilise soils and slow overbank flow.

Ecological outcome:

- Improved hydraulic diversity.
- Enhanced floodplain connectivity.
- Restored groundwater levels through lateral water retention.

Flow Energy Dissipation at Discharge Point

Objective: Reduce erosive energy of effluent discharge before entering natural soil.

Options:

- Construct a stilling basin or plunge pool immediately below the outlet.
- Install rock rip-rap aprons or cascades with variable stone sizes to break up turbulence.
- Incorporate a v-notch spreader weir to distribute flow evenly into the wetland channel.

Ecological outcome:

- Minimized scour at discharge.
- Controlled flow velocity entering wetland channel.

Channel Re-Profiling and Benching

Objective: Re-shape steep eroded banks to stable slopes (ideally 1:3 or flatter) and create vegetated benches.

Methods:
- Cut back vertical banks and re-grade to stable slopes.
- Place excavated material behind erosion control structures for backfilling.
- Plant or seed with indigenous wetland and riparian vegetation.

Ecological outcome:
- Reduced risk of bank collapse.
- Enhanced habitat diversity and vegetative reinforcement.

Bio-engineering Measures

Objective: Stabilise re-profiled banks and enhance ecological recovery using natural materials.

Methods:
- Coir logs, brush mattresses, bundles, or plant plugs with indigenous species (e.g., *Phragmites australis*, *Juncus kraussii*, *Cyperus textilis*).
- Protect young vegetation with temporary fencing from trampling by livestock.

Ecological outcome:
- Biological soil reinforcement.
- Improved moisture retention and rapid vegetation establishment.

Refer to Figures A2.5-6 below for examples of bank re-profiling and stabilisation (without channel deepening or straightening.

Figure A2.516: Example of re-sloped and re-vegetated banks

Figure A2.6: Example of stronger bank protection for bank stabilisation of higher velocity flow areas but allowing for vegetation establishment

ALIEN INVASIVE PLANT CONTROL

Target Species

- *Acacia mearnsii* (Black Wattle)
- *Solanum mauritianum* (Bugweed)

Control Objectives

- Eradicate mature stands of *A. mearnsii* and *S. mauritianum* in the designated HGM2 reach.
- Prevent re-establishment through follow-up control and revegetation.
- Restore wetland species to stabilise soils and shade out seedlings.

Recommended Methods

Mechanical & Chemical Integration:

- Fell mature wattle trees at ground level. Immediately apply an approved herbicide (e.g. Triclopyr or Glyphosate formulation) to the cut surface within 30 seconds.
- Remove smaller saplings and resprouting bugweed manually, ensuring root removal.
- Stack felled biomass outside the 1:100-year floodline. Either chip or burn under controlled conditions (with approval).
- Conduct follow-up control after 6 months and again after the next growing season.

Rehabilitation After Clearing

- Replant disturbed soil with indigenous pioneer grasses (*Eragrostis curvula*, *Panicum maximum*) and wetland sedges (*Cyperus textilis*, *Juncus effusus*).

- Mulch cleared areas to retain moisture and suppress regrowth.
- Monitor quarterly for regrowth and re-treat as required for at least 3 years.

Implementation Sequence

1. Pre-construction survey – confirm erosion hotspots, select control structure locations, and mark alien vegetation stands.
2. Engineering design – develop detailed drawings and bill of quantities for structures and earthworks.
3. Construction / installation – implement energy dissipaters, grade control, and re-profiling works.
4. Revegetation and alien clearing – immediately following construction.
5. Maintenance and monitoring – monthly inspections in the first six months, quarterly thereafter.
6. Adaptive management – adjust structure spacing or vegetation efforts as needed based on performance.

Monitoring Indicators

Indicator	Target / Success Criterion	Monitoring Frequency
Channel headcut movement	None detected	Quarterly
Sediment accumulation behind structures	≥ 10 cm within first wet season	Biannual
Soil moisture and wetland extent	Increasing lateral wetting	Seasonal
Vegetation cover (indigenous wetland species)	> 70 % within two years	Biannual
Alien species density	< 5 % cover within two years	Biannual

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- Macfarlane et al. (2014). *Wetland Offsets and Rehabilitation Framework for South Africa.*
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APPENDIX 3- SPECIALIST CV

CURRICULUM VITAE

Debra Jane Fordham

Cell: 0724448243
Email: debrajanefordham@gmail.com
Date of birth: 26th August 1987
Country of origin: South Africa
ID Number: 8708260094081

Professional profile

Debbie is a certified Professional Wetland Scientist (PWS certification number 3683) by the Society for Wetland Scientists (SWS) Professional Certification Program, which is internationally accredited by the Council of Engineering and Scientific Specialty Boards (CESB). She is also a SACNASP registered ecologist (119102), with over 10 years of working experience, specialising in aquatic ecology. She has authored over 100 reports and applications and she constantly contributes to the scientific and local community. Most of her projects involve (as a minimum) in-depth wetland and river field delineation (including soil investigations via augering, vegetation identification, and classifying the hydrological characteristics), laboratory analysis (such as water quality and sediment analysis), classification, characterisation, ecological health and ecosystem functioning assessments (using the latest available tools), as well as impact rating, buffer determinations, mitigation recommendations and detailed rehabilitation plans. She is highly proficient using GIS software to incorporate accurate spatial analysis and visual aids (No Go Area maps etc.) into her reports.

Debbie holds a M.Sc. degree in Environmental Science from Rhodes University, by thesis, entitled: The geomorphic origin and evolution of the Tierkloof Wetland, a peatland dominated by Prionium serratum in the Western Cape. She is a member of scientific organisations such as the Society of Wetland Scientists (SWS), the South African Wetland Society (SAWS), the Southern African Association of Geomorphologists (SAAG), the South African Hydrological Society (SAYS), the Society for Ecological Restoration (SER), and the International Association for Impact Assessment (IAIAsa).

As the founder and director of Upstream Consulting, Debra has successfully led and managed complex projects across mining, infrastructure development, renewable energy, and conservation sectors, providing cutting-edge ecological solutions that balance development with environmental integrity. She has played a key role in securing regulatory approvals for numerous high-profile developments.

Key skills:

- Aquatic Biodiversity & Wetland Assessments
- Water Use Licensing & Regulatory Compliance
- Impact Assessment & Ecological Risk Analysis

- Wetland & River Delineation (Hydrology, Vegetation, Soil Analysis)
- GIS Mapping & Spatial Analysis
- Ecosystem Restoration & Mitigation Planning
- Technical Report Writing & Peer Review
- Stakeholder Engagement & Public Presentations

Tertiary Education

- M.Sc. Environmental Science (Rhodes University):

Master of Science thesis entitled: The geomorphic origin, evolution and collapse of a peatland dominated by Prionium serratum: a case study of the Tierkloof Wetland, Western Cape.

- BA Hons. Environmental Science (Rhodes University):

Honours dissertation: The status and use of Aloe ferox. Mill in the Grahamstown commonage, South Africa.

Courses: Wetland Ecology, Environmental Water Quality /Toxicology, Biodiversity, Non-Timber Forest Products (NTFPs) and Rural Livelihoods, Environmental Impact Assessment (EIA), Statistics

- BA - Environmental Science and Geography (Rhodes University)

Work Experience:

- Ecological specialist (2022/03/01 – present)
- Sharples Environmental Services cc (2016/08/10 – 2022/03/01)

Position: Aquatic Ecologist and WULA Manager

- KSEMS Environmental Consulting (2015/08/10 - 2016/07/31)

Position: Wetland specialist

- AGES EC (Pty) Ltd (2014/10/01 – 2015/08/10)

Position: Aquatic Ecologist and WULA Manager

- Environmental Impact Management Services (2014/02/04-2014/02/07)

Position: Environmental consultant

- Rhodes University Alumni Relations (2010/04/01 – 2010/12/17)

SPECIALIST DECLARATION

Specialist Company Name:	Upstream Consulting			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	NA
Specialist name:	Debra Fordham			
Specialist Qualifications:	M.Sc. – Environmental Science (Wetland Ecology) B. Sc. (Hons) - Environmental Science B.A. – Environmental Science and Geography SACNASP registered Professional Wetland Scientist			
Professional affiliation/registration:	Debra Fordham is a Professional Wetland Scientist and SACNASP registered ecologist with 10 years of experience in the environmental and conservation sectors, specialising in aquatic biodiversity assessment.			
Physical address:	25 Blommekloof Street, George			
Postal address:	25 Blommekloof Street, George			
Postal code:	6530	Cell:	0724448243	
Telephone:		Fax:		
E-mail:	debbie@upstreamconsulting.co.za			

DECLARATION BY THE SPECIALIST

I, __Debra Fordham__________________________________, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist
Name of Company: Upstream Consulting
DATE: 12/08/2025

REVIEWER

Specialist Company Name:	Upstream Consulting			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	NA
Specialist name:	Colin Fordham			
Specialist Qualifications:	M.Sc. – Entomology (Biological Control) B. Sc. (Hons) - Botany (Environmental Management) B.Sc. – Botany and Biochemistry SACNASP registered Professional Wetland Scientist			
Professional affiliation/registration:	Colin Fordham is a SACNASP registered Professional Natural Scientist (Pr. Sci. Nat.) Ecologist with 14 years of experience in the environmental and conservation sectors.			
Physical address:	25 Blommekloof Street, George			
Postal address:	25 Blommekloof Street, George			
Postal code:	6530	Cell:	0648575560	
Telephone:		Fax:		
E-mail:	Colin@upstreamconsulting.co.za			

DECLARATION BY THE SPECIALIST

I, __Colin Fordham__________________________________, declare that –

- I act as the independent review specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Reviewer
Name of Company: Upstream Consulting
DATE: 12/08/2025