SPECIALIST BASIC ASSESSMENT REPORT

FOR THE PROPOSED RIVER BANK MAINTENANCE AT

SILVERSTREAM ESTATE ERF 508, PLETTENBERG BAY

Prepared for Hilland Environmental

by

Confluent Environmental (Pty) Ltd

DECALRATION OF SPECIALIST INDEPENDENCE

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

Specialist: Dr. James Dabrowski (Ph.D., Pr.Sci.Nat. Water Resources)

Date: 19 April 2018

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1. INTRODUCTION

1.1 Background

Confluent Environmental (Pty) Ltd was approached by HilLand Environmental to conduct a specialist estuarine impact assessment for the proposed maintenance and upgrade of riverbank infrastructure at Silverstream Estate, Plettenberg Bay. The proposed development will entail the following:

- Replacement of an existing creosote treated timber retaining wall with a sloping structure constructed from sand bags and geofabric covered with a reno mattress, which will then be vegetated with riparian vegetation. This will only take place when the existing retaining wall degrades;
- Replacement of wooden mooring poles with polywood or CCA treated poles within a plastic sleeve;
- Installation of six floating jetties attached to the new mooring poles with access from timber walkways onto existing stairs.

1.2 Terms of Reference

The terms of reference for this specialist report include the following:

- Compilation of specialist aquatic inputs to a Basic Assessment Report (BAR) for the proposed development which complies with the relevant legislation pertaining to the National Environmental Management Act (Act No. 107 of 1998) and the Integrated Coastal Management Act (Act No. 24 of 2008);
- Compilation of a report according to DEADP specialist reporting requirements for impact assessments (Brownlie, 2005);
- Assess the direct and indirect positive and negative implications of each phase of the proposed development on the Keurbooms estuary. This includes an assessment of the impacts identified in the pre-application BAR:
    - Pumping of mobile sediments from the river system to build up the banks;
    - Movement and redistribution of river bank material to shape the slope;
    - Establishment of riparian vegetation;
    - Access to mooring poles using floating jetties and wooden walkways;
    - Shading and disturbance of *Zostera capensis* beds;
    - Impact for aquatic biota including the Knysna seahorse (*Hippocampus capensis*);
    - Erosion implications upstream and downstream of the development.

1.3 Study Area

The Keurbooms and Bitou estuaries (collectively referred to as the Keurbooms) are permanently open and are located close to Plettenberg Bay and both feed into what is known as the Keurbooms Lagoon, which is separated from the sea by a prominent berm, prior to it flowing out to sea. The confluence of the Bitou and Keurbooms estuaries is approximately 3.5 km from the mouth. The Bitou River is 23 km long, with its source at Buffelsnek, and is tidal for 7.2 km from the confluence to the causeway at Wittedrift. The Keurbooms River is approximately 85 km long, with its source at Spitskop in the Outeniqua Mountains, and is tidal for approximately 8.5 km from the confluence (CAPE Estuaries Programme, 2010).

The Silverstream Estate is situated on the eastern bank of the Keurbooms Estuary (**Figure 1**). The proposed development will take place along an approximately 330 m stretch of the river bank and associated intertidal zone. The river bank is currently stabilised using a retaining wall constructed of creosoted timber poles (**Figure 2**). Boats are attached to mooring poles situated approximately 7.5 m from the edge of the retaining wall. Access to boats is via stairs leading directly into the estuary, resulting in foot traffic directly over the inter-tidal zone. The entire bank is devoid of any riparian vegetation and consists of kikuyu lawn. Patches of eelgrass (*Zostera capensis*) grow along the length of the river bank, largely restricted to the intertidal zone and margins of the subtidal zone. The Keurbooms Estuary is prone to episodic flooding that has significant consequences for landowners and infrastructure. Floodwaters cause extensive erosion, particularly in the lower reaches where extensive surface hardening has taken place and natural vegetation and riparian zones have been cleared to make way for residential developments and resorts (CAPE Estuaries Programme, 2010). In particular, the removal of riparian vegetation destabilises the bank, resulting in undercutting and ultimately collapse into the estuary. As such various bank stabilisation designs have been implemented along the banks of the estuary over time. These range from vertical retaining walls (currently utilised by the Silverstream Estate) to sloping banks constructed from a reno mattress over lying a stepped sandbag foundation (constructed at Blue Water Estate located upstream of the Silverstream Estate).

Figure 1: Location of the Silverstreams Estate where the proposed development will take place (yellow box).

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Figure 2: Photograph of the current bank stabilization structure and boat mooring design at Silverstreams Estate. Patches of *Z. capensis* are also visible.

1.4 Overview of the Proposed Development

The proposed upgrades entail the replacement of the existing creosote timber poles and vertical river bank retaining wall with a sloping stepped sandbag foundation covered by a reno mattress construction (**Figure 3**). The reno mattress will be re-vegetated with indigenous riparian plants that are suited to the salinity profile of the bank (i.e. salt marsh species near the base and more terrestrial species further up the slope, with a mixture of coastal thicket species, coastal fynbos species and salt tolerant grasses to bind the soil). It is planned that construction of the bank will only take place at the end of the current retaining wall lifespan (i.e. when these poles are rotting and require replacement).

It is proposed that the reno mattress will extend from the top of the existing retaining wall sloping downwards into the estuary, meeting the bed of the estuary approximately 4.5 m beyond the line of the existing retaining wall. The toe of the reno mattress will extend approximately another 2.5 m further into the estuary and will terminate below the line of the floating jetties (**Figure 4**). Timber walkways will link the top of the retained bank to the jetty to allow access to the boats without having to walk up and down the reno-mattress bank which will be re-vegetated.

Existing mooring poles will be replaced with new poles only once they have degraded and require replacement. The new poles will be placed equi-distant from the bank as they are currently positioned. The new poles will be covered by plastic sleeves to prevent burrowing worms. Alternatively, non-covered, suitable polywood poles will be selected. Six floating jetties are proposed to be attached to the new mooring poles. Each jetty will measure approximately 9700 mm X 1500 mm and will be attached to a narrow ramp accessible from existing steps (**Figure 5**). These jetties will be extended by an additional 9700 mm in the future. The design will result in large gaps (approximately 40 m) between each jetty structure.

The proposed upgrade replicates similar upgrades that have taken place both upstream and downstream of the study area (at Blue Water Estate and Sanderlings, respectively).

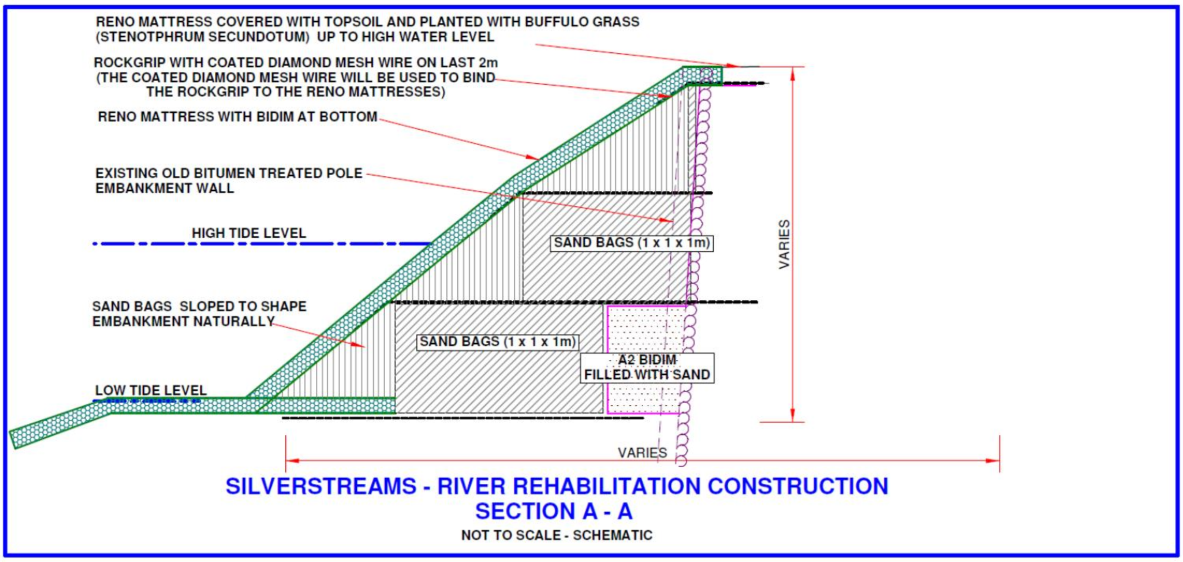

Figure 3: Cross section of the proposed construction of a sloping reno mattress and sand bag

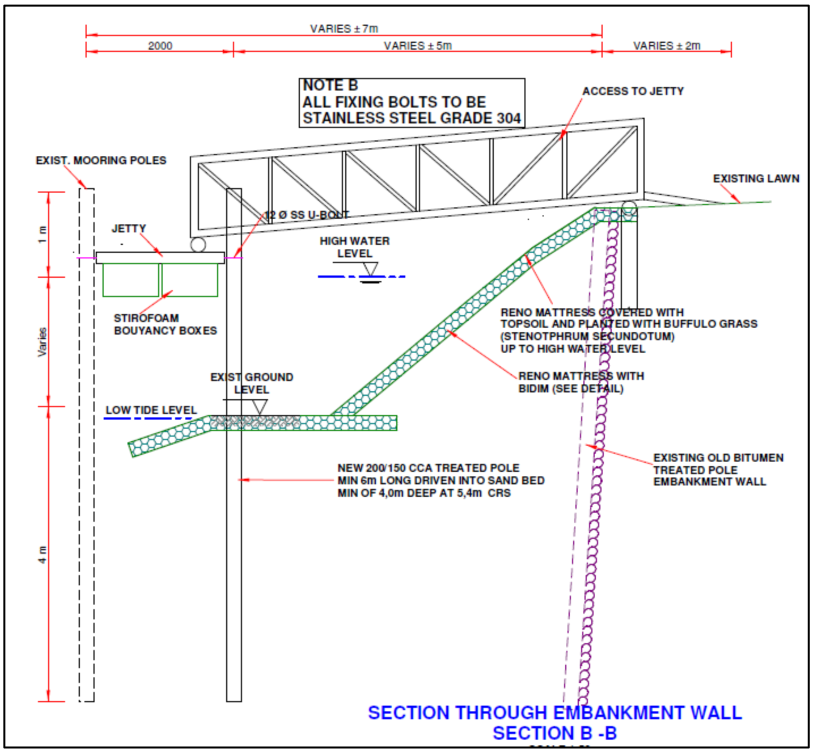

Figure 4: Cross section of the proposed design reno mattress embankment and associated floating jetty infrastructure.

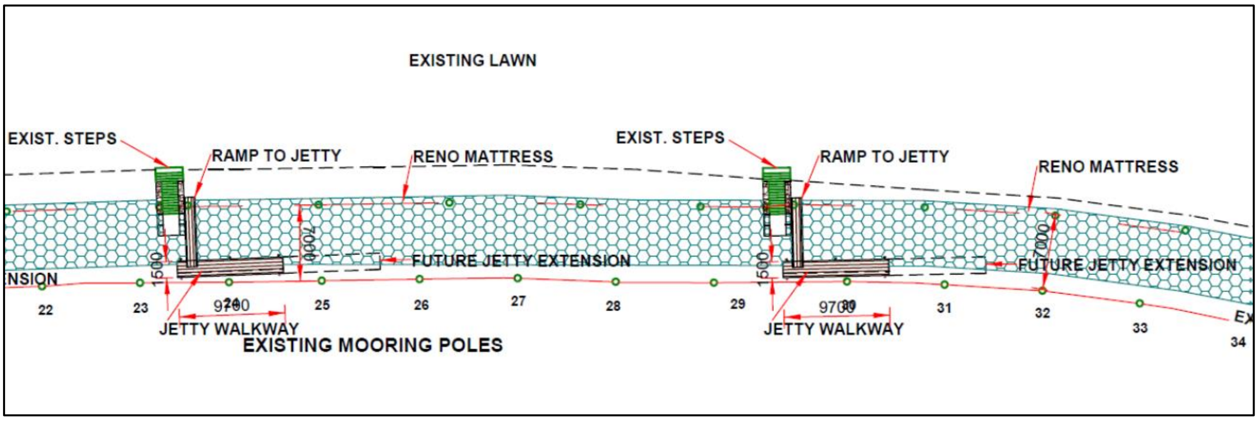

Figure 5: Plan view of the layout of a section of the floating jetties

1.5 Assumptions and Limitations

- Estuaries are complex, dynamic systems influenced by multiple environmental and anthropogenic variables. A comprehensive assessment that considers all of these variables did not form part of the scope of work. Assessments of the ecological state of the estuary were therefore derived using appropriate desktop resources.
- The dynamic nature of estuaries means that the structure of physical habitat and associated estuarine fauna and flora can change rapidly in response to tidal and hydrological (e.g. flooding events) influences. This assessment is based on a single site visit that took place on 11 April 2018 and represents a 'snapshot' in time.
- No sampling of biota was undertaken (e.g. fish, invertebrates, microphytes, etc.) and all biotic data was derived from desktop sources.
- No water quality sampling was undertaken in respect of potential impacts associated with the use of creosote poles in the current design.

2. ASSESSMENT METHODS

2.1 Present Ecological State of the Keurbooms Estuary

The Present Ecological State (PES) and Ecological Importance and Sensitivity (EIS) of the Keurbooms estuary was assessed using Van Niekerk et al. (2015) in which the PES of the temperate estuaries of South Africa was derived based on several abiotic (hydrology, state of the mouth, salinity, water quality and physical habitat) and biotic (microalgae, macroalgae, invertebrates, fish and birds) indices of estuarine health. Based on the combined score for each of these indices an overall PES was derived and classified according to the categories defined in **Table 1**.

Table 1: Estuary health scoring system indicating the relationship between the six Ecological Categories and the loss of ecosystem condition and functionality

Category	Description
A	**Natural:** The natural biotic processes should not be modified. The characteristics of the resource should be determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic processes and function.
B	**Largely Natural:** A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged.
C	**Moderately Modified:** A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged
D	**Largely Modified:** A large loss of natural habitat, biota, and basic ecosystem function has occurred.
E	**Seriously Modified:** The loss of natural habitat, biota and basic ecosystem function is extensive.
F	**Critically Modified:** Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural abiotic processes and associated biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Van Niekerk et al. (2015) assessed the overall ecological importance and sensitivity of estuaries based on several criteria including the size (i.e. surface area), habitat importance, zonal rarity type and biodiversity importance. These criteria were each rated (out of a score of 100) and the average of all criteria was used as the final EIS Score (**Table 2**).

Table 2: Description of EIS Scores for estuaries derived by Van Niekerk et al. (2015).

EIS Score	Description
0 – 60	Average Importance
61 – 80	Important
80 – 100	High Importance

2.2 Mapping of Macrophytes

The study area was surveyed by a DJI Phantom 3 Pro drone. Similar completed developments (where sloping banks and floating jetties have already been constructed) located upstream and downstream of the study area (Blue Water Estate and Sanderlings Estate, respectively) were also included in the survey for comparative purposes. Aerial images captured by the survey were uploaded to an online photogrammetry software programme (Precision Mapper) to produce a single, high resolution orthorectified orthophoto of the study area. The orthophoto was loaded into Quantum GIS (QGIS) to map the extent of visible macrophyte beds. In addition, the historical distribution of macrophyte beds was also assessed using historical Google Earth images.

2.3 Visual Inspection

Species identification of macrophyte beds was confirmed by means of visual inspection from the bank and a snorkelling survey. The snorkelling survey also included a visual inspection of the prevalence of vegetation growing beneath existing floating jetties located at the Blue Waters and Sanderlings estates.

2.4 Method of Impact Assessment

This section was prepared according to guidelines for specialists published by DEADP (Brownlie, 2005). Individual impacts for the construction and operational phase were identified and rated according to criteria which include their intensity, duration and extent. The ratings were then used to calculate the consequence of the impact which can be either negative or positive as follows:

Consequence *= type x (intensity + duration + extent)*

where type is either negative (i.e. -1) or positive (i.e. 1). The significance of the impact was then calculated by applying the probability of occurrence to the consequence as follows:

Significance *= consequence x probability*

The criteria and their associated ratings are shown in **Table 3**.

Table 3: Categorical descriptions for impacts and their associated ratings

Rating	Intensity	Duration	Extent	Probability
1	Negligible	Immediate	Very limited	Highly unlikely
2	Very low	Brief	Limited	Rare
3	Low	Short term	Local	Unlikely
4	Moderate	Medium term	Municipal area	Probably
5	High	Long term	Regional	Likely
6	Very high	Ongoing	National	Almost certain
7	Extremely high	Permanent	International	Certain

Categories assigned to the calculated significance ratings are presented in **Table 4**.

Table 4: Value ranges for significance ratings, where (-) indicates a negative impact and (+) indicates a positive impact

Significance Rating	Range	
Major (-)	-147	-109
Moderate (-)	-108	-73
Minor (-)	-72	-36
Negligible (-)	-35	-1
Neutral	0	0
Negligible (+)	1	35
Minor (+)	36	72
Moderate (+)	73	108
Major (+)	109	147

Each impact was considered from the perspective of whether losses or gains would be irreversible or result in the irreplaceable loss of biodiversity of ecosystem services. The level of confidence was also determined and rated as low, medium or high (**Table 5**).

Table 5: Definition of reversibility, irreplaceability and confidence ratings.

Rating	Reversibility	Irreplaceability	Confidence
Low	Permanent modification, no recovery possible.	No irreparable damage and the resource isn't scarce.	Judgement based on intuition.
Medium	Recovery possible with significant intervention.	Irreparable damage but is represented elsewhere.	Based on common sense and general knowledge
High	Recovery likely.	Irreparable damage and is not represented elsewhere.	Substantial data supports the assessment

3. ATTRIBUTES OF THE AFFECTED SYSTEM

3.1 Conservation Context

Key details regarding the conservation context of the affected area and surrounds are listed below:

I. According to the National Freshwater Ecosystem Priority Area (NFEPA) atlas (Nel at al., 2011):

- The Keurbooms Estuary falls within NFEPA area 9097 (quaternary catchment K60E) and is classified as an Estuary Freshwater Ecosystem Priority Area.
- Water quality and quantity and habitat and biota should therefore remain unchanged so as to maintain the current ecological condition.

II. According to the Western Cape Spatial Biodiversity Plan

- The Keurbooms estuary falls within a Critical Biodiversity Area 1 (CBA1) (**Figure 6**).
- CBA1 areas are regarded as areas in a natural condition that are required to meet biodiversity targets, for species, ecosystems or ecological processes and infrastructure
- The management objective for such areas is to maintain them in a natural or near-natural state, with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity-sensitive land uses are appropriate.

III. According to the National Biodiversity Assessment (Van Niekerk and Turpie, 2012):

- The Keurbooms Estuary has been assigned partial Estuarine Protected Status and is an important nursery area for Kob species and the Spotted Grunter (*Pomadasys commersonnii*).

IV. According to the Keurbooms-Bitou Estuary Management Plan (DEADP, 2017):

- Structures and privately owned and developed land should be managed in such a way as to prevent further bank erosion during flood events.

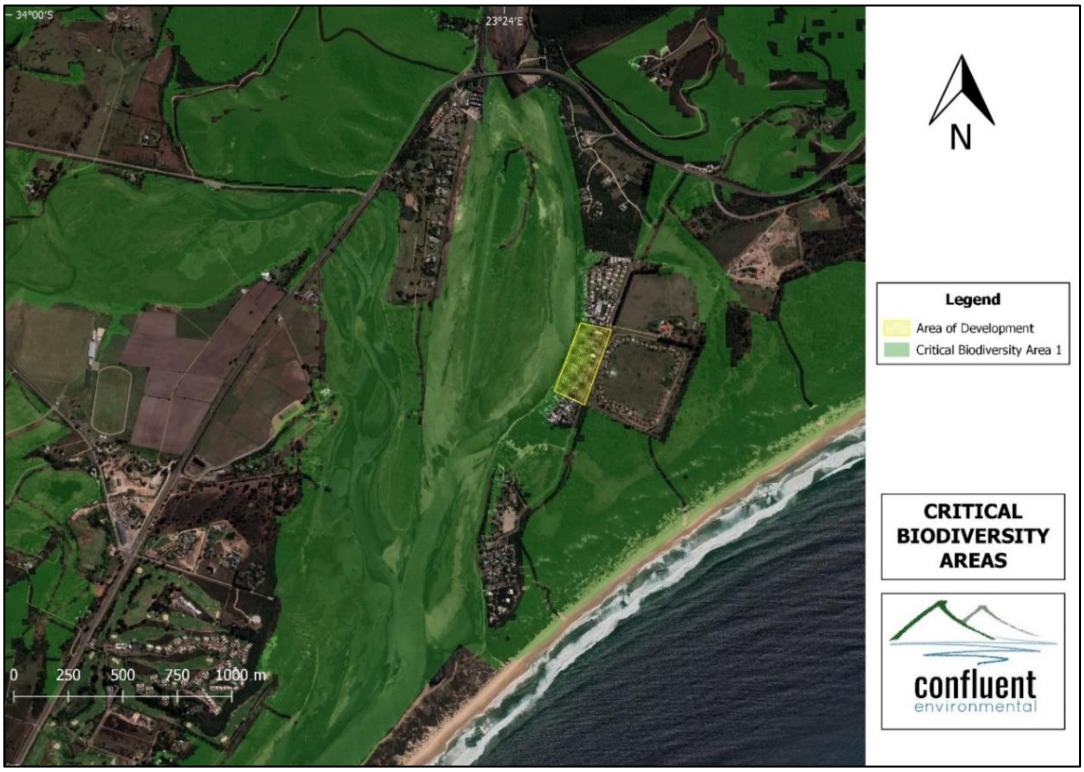

Figure 6: Map indicating the area of development in relation to Critical Biodiversity Area 1 as indicated by the Western Cape Spatial Biodiversity Plan.

3.2 Desktop EcoClassification

According to the desktop ecoclassification (Van Niekerk et al. 2015) the PES of the Keurbooms Estuary is B (**Table 6**), indicating that there has been a small change from the natural state (**Table 1**). Most of the abiotic indices used to derive the overall PES are in fact in a natural condition (A). Modifications to fish assemblages and bird populations are the most important drivers of change from the natural state. The ecological importance is therefore regarded as being high and Turpie (2004) ranked the Keurbooms estuary as the 18th most important system in South Africa in terms of conservation importance.

Table 6: Summary of the Present Ecological Status (PES) and Ecological Importance of the Keurbooms Estuary

Index	Category
Hydrology	*A*
Hydrodynamnics	*A*
Physical Habitat	*A*
Salinity	*A*
Water Quality	*A/B*
Microalgae	*A*
Macrophytes	*A/B*
Invertebrates	*A*
Fish	*B/C*
Birds	*B*
Overall PES	**B**
Ecological Importance	**High**

3.3 Species of Conservation Concern

3.3.1 Kynsna Seahorse (Hippocampus capensis)

The Knysna seahorse (*Hippocampus capensis*) occurs only in the Keurbooms, Kynsna and Swartvlei estuaries (Lockyear et al., 2006) and is listed as an endangered species on the IUCN Red List due to its fragmented distribution, small area of occupancy, the vulnerability of its habitat and susceptibility to high mortality due to freshwater flooding (Pollom, 2017). *Hippocampus capensis* is restricted to sub-tidal areas (Teske, 2003) and is usually found at depths between 0.5-20 m in association with submerged aquatic plants (Bell et al. 2003). Bell (2003) and Teske (2007) found the species to associate with *Zostera capensis*, *Caulerpa filiformis*, *Codium extricatum*, *Halophila ovalis* and *Ruppia cirrhosa.* While Teske (2007) did not report on any preference for a specific species of macrophyte, Bell (2003) did indicate a preference for *Z. capensis.* Both studies showed contrasting preference for percentage of cover ranging from dense (> 75 %; Teske, 2007) to sparse (< 20 % cover). More recent studies indicate that the species also use artificial habitats (including reno mattress) extensively (Claassens, 2017). *Hippocampus capensis* can also tolerate a wide range of environmental conditions (Lockyear et al. 2006).

3.3.2 Eelgrass (Zostera capensis)

Globally, seagrasses provide important ecological services in estuaries, including stabilizing sediment, preventing erosion, reducing water flow, trapping nutrients and organic materials and providing sheltered habitat for fish and invertebrates. Because of these ecological services they provide to coastal zones they are ranked among the most productive and valuable ecosystems on Earth (Adams, 2016). As a result of coastal development, habitat destruction and its continued decline, *Z. capensis* is listed as vulnerable in the Red Data List of Species (Short et al., 2010). Studies in South Africa have shown that *Z. capensis* beds support a more diverse and abundant invertebrate and fish community than unvegetated benthic habitats (Whitfield et al., 1989). Furthermore *Z. capensis* provides critical habitat for *H. capensis* (Lockyear et al., 2006). *Zostera capensis* is the dominant submerged aquatic macrophyte in the Keurbooms estuary (CAPE Estuaries Programme, 2010).

4. FIELD ASSESSMENT

The orthophoto generated from the drone survey was used to map and quantify the extent of aquatic macrophytes growing adjacent to the banks of the Silverstreams, Blue Water and Sanderlings estates (**Figure 7**). The snorkelling survey confirmed that all vegetation mapped in **Figure 7** was *Z. capensis*. In total, approximately 1900 m^2 of *Z. capensis* grows adjacent to the bank of the Silverstreams Estate. Visual inspection of jetty developments at the Blue Water and Sanderlings estates showed that *Z. capensis* was not growing beneath the jetties, most likely due to the lack of light penetration into the water column and the alteration of substrate from sand to reno mattress. There are however extensive beds of *Z. capensis* situated directly adjacent to the jetties (**Figure 8**). Fish and estuarine invertebrates were abundant in amongst the eelgrass beds as well as in association with the jetty structures which provide good cover and habitat. The entire length of the Silverstream Estate falls within a no-wake zone, where boats may not exceed a speed limit of 10 km/h.

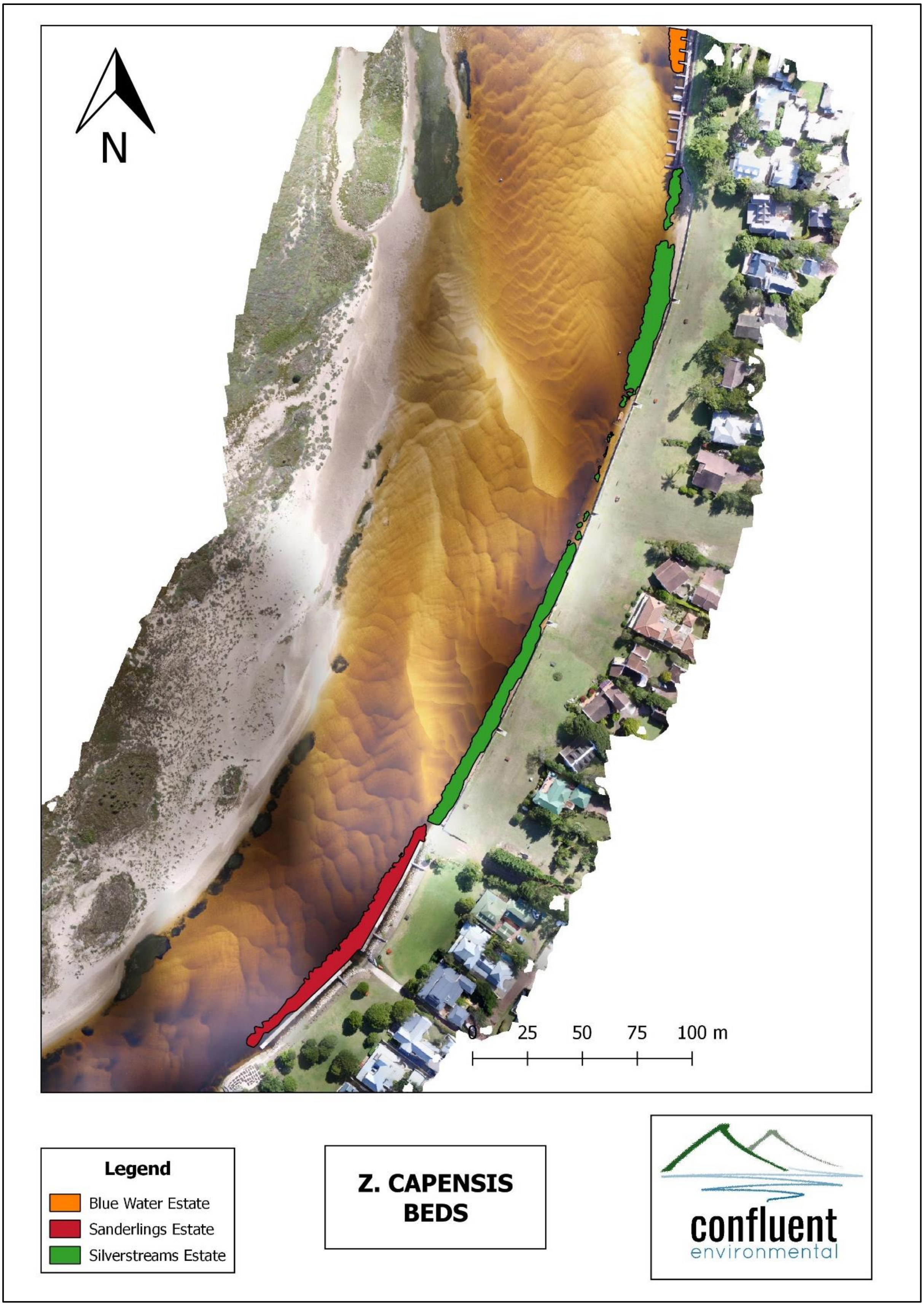

Figure 7: Extent of *Z. capensis* beds adjacent to three estates bordering the Keurbooms Estuary

Figure 8: *Zostera capensis* growing in close proximity to an existing floating jetty structure at the Blue Water Estate

4.1 Historical Perspective

Figure 9 illustrates how beds of *Z. capensis* have established since 2013, when no evidence of the presence of the species is apparent. Evidence of beds starting to establish is apparent in 2016, while expansive beds are currently present (2018).

Figure 9: Historical imagery illustrating the development of *Zostera capensis* beds in 2013 (left), 2016 (middle) and 2018 (right).

This suggests that the existing beds visible in Figure 7 (including those present on the opposite bank where no development has taken place) took between 2 to 5 years to establish to their current extent.

5. IMPACTS ASSOCIATED WITH THE DEVELOPMENT

Impacts are discussed according to two options. The current design (Option A) involves establishing the footprint of the sloping bank into the existing estuary, which will result in the inevitable loss of existing estuarine habitat. Impacts were therefore also assessed against an alternative option (Option B), which would involve shifting the line of construction 5 m back into the existing bank with the bottom of the sloped reno-mattress construction meeting the bed of the estuary at the foot of the existing creosote retaining wall (the profile of the bank could match that of the existing stairs). This construction would therefore require complete removal of the existing retaining wall. The sand that would have to be excavated from the existing bank could then be used to fill the required sandbags (as opposed to pumping and removal from the river bed).

5.1 Construction Phase Impacts

A summary of ratings for each impact associated with the construction phase can be viewed in **Table 7**.

5.1.1 Loss of Existing Zostera capensis Beds

Under option A, the placement of sand bags and reno mattress (with the toe extending below the line of the floating jetties) will cover large portions of existing *Z. capensis* beds that occur along the bank of the Silverstreams Estate. Given the vulnerable IUCN status of *Z. capensis* and its value to estuarine ecosystems (including the provision of habitat for the endangered Kynsna seahorse) the construction of the bank represents a potentially significant impact. Under option A, the physical footprint of the reno mattress would result in the loss of approximately 1286 m^2 (67 %) of the existing *Z. capensis* beds (Figure 10). In contrast, option B would result in only 174 m^2 (9 %) loss of *Z. capensis* beds and therefore represents a significantly lower level of impact.

<u>Mitigation measures for Option A and B:</u>

- Disturbance (i.e. trampling, smothering etc.) of *Z. capensis* that fall outside the footprint of the reno mattress should be minimised as far as is possible to ensure a remaining stock of plants that could expand in range post construction.
- Coverage of the existing beds by the reno mattress should be minimised wherever possible so as to ensure a remaining stock of plants that could expand in range post construction.
- Existing plants should be rescued if possible and transplanted to areas unaffected by the upgrade so as to establish new areas of growth. Boat traffic over these areas should be prevented (e.g. through the placement buoys indicating ‘no-go’ areas) until such time as the plants have established.

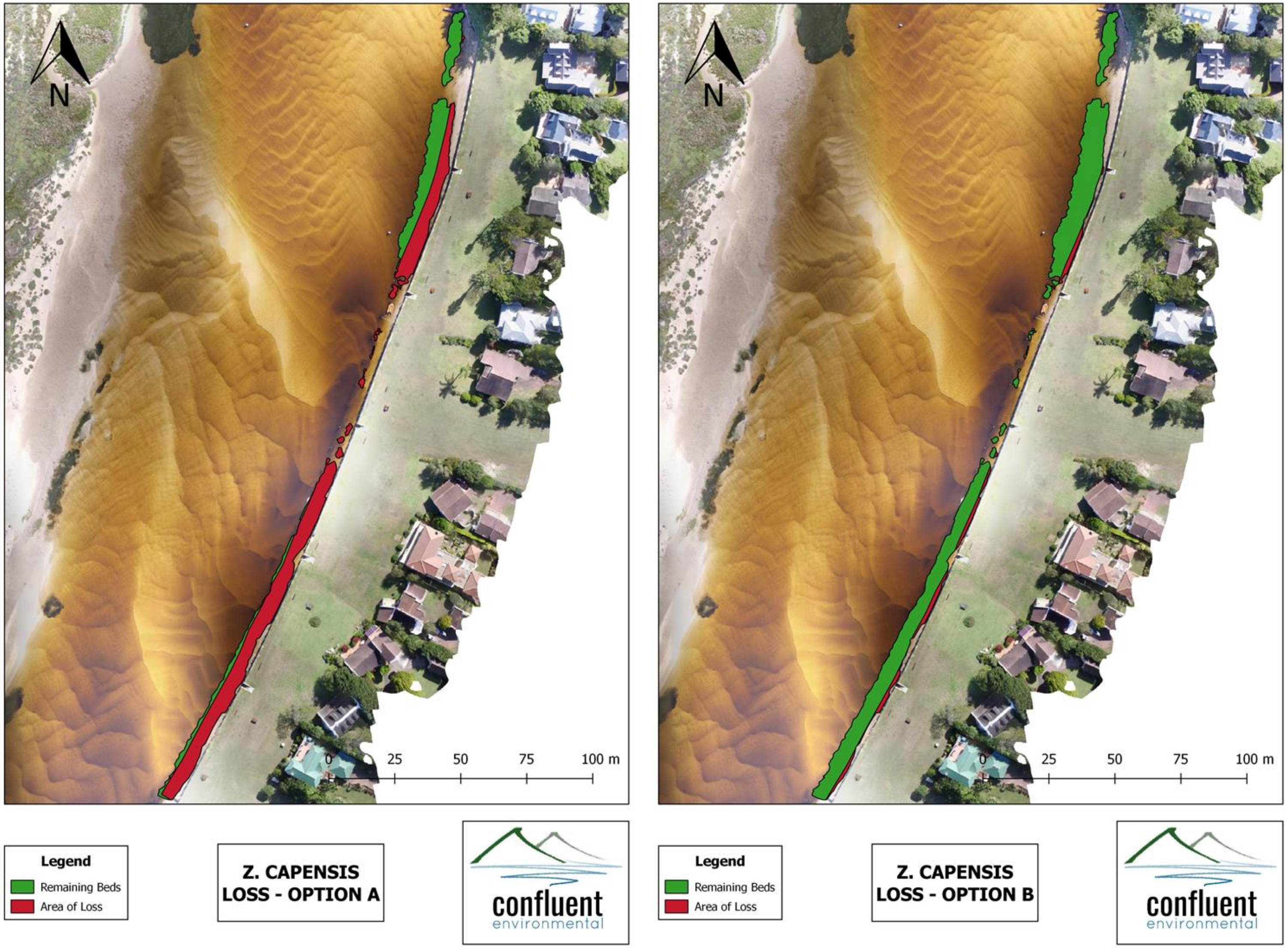

Figure 10: Estimated loss of *Z. capensis* beds under upgrade options A and B.

5.1.2 Installation of Floating Jetties

Floating jetties will be installed adjacent to the existing mooring poles (forming the outside line of the jetties) under both option A and B. New mooring poles will have to be installed along the inside line of the floating jetties. These will be CCA treated or composed of polywood to phase out the use of creosote treated timber. Installation of new poles is likely to result in localised, brief mobilisation of sediment which is unlikely to have significant short or long-term effects on estuarine biota.

Mitigation measures for Option A and B:

- The floating jetty structures should, as far as possible, be assembled on land to minimise the amount of time spent working within in the estuary and associated disturbance to the inter-tidal zone.
- Jetty installation sites should be clearly demarcated and accessed directly from the bank to avoid unnecessary trampling of inter-tidal areas that are not ear-marked for jetty installation.

5.1.3 Sand mining for sand bags

Option A would require pumping of sand from the bed of the estuary in order to fill the sandbags required for the construction of the bank. This would result in a short-term, localised disturbance to benthic invertebrates in particular. The process of removing sand from the estuary is unlikely to have any detrimental long terms impacts on sediment dynamics and habitat structure given the large quantities of sand available and mobilised by the tidal system on a daily basis.

Option B would significantly reduce the quantities of sand that would need to be pumped from the estuary as sand excavated from the bank could be used to fill sand bags.

Mitigation measures for Option A and B:

- Sand should be pumped from areas devoid of and in distant proximity to any sub-merged aquatic vegetation to prevent any unnecessary destruction to instream habitat.

5.1.4 Disturbance to Banks and Erosion

Option A requires the excavation of a level platform at the low tide level mark and building the reno mattress slope up to the level of the existing creosote retaining wall. The retention of the creosote retaining wall in this option will minimise disturbance to and erosion of the banks. Excavation of the estuary bed is however likely to result in the mobilisation of sand and sediment downstream which can potentially smother in-stream habitats. This material could be transported downstream or upstream, depending on the whether the tide is in-coming or out-going.

Mitigation measures for Option A:

- Excavations should take place during low tide to minimise the mobilisation and transport of high volumes of sediment into the estuary.

- Excavation of the estuary bed and placement of sandbags and reno mattress should take place systematically (i.e. one section at a time) to avoid exposing sections of excavated bed or banks to fluctuating tide levels. The excavation of a section of the bed and placement of sand bags should therefore be completed within a single low tide cycle, before moving onto the next section. Excavation of the bank and placement of sand bags therefore needs to be planned according to the time provided by the low tide cycle.
- Construction activities should be timed to avoid periods of high rainfall and should be avoided during wet weather conditions.
- Construction activities should also be timed in relation to potential rainfall occurring higher up in the Keurbooms river catchment to mitigate against the effects of flooding in the estuary.

Option B would require excavating into the existing bank and removing the existing retaining wall. This option therefore results in a greater degree of bank destabilisation and associated erosion and sedimentation potential.

<u>Mitigation measures for Option B (in addition to those listed for Option A:</u>

- The retaining wall could be kept in place until such time as the section of bank has been excavated, thereby acting as a physical barrier and limiting the transport of sediment into the estuary.

Table 7: Summarised impact rating table (Construction Phase) for the upgrade of banks and installation of floating jetties along the Keurbooms Estaury at Silverstreams Estate

Impact	Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Loss of *Z. capensis* beds associated with the construction footprint	**Option A**								
	Without Mitigation	High	Permanent	Limited	Certain	Moderate (-)	Low	Low	High
	With Mitigation	Moderate	Permanent	Limited	Certain	Moderate (-)	Low	Low	High
	Option B								
	Without Mitigation	Very Low	Permanent	Limited	Certain	Moderate (-)	Low	Low	High
	With Mitigation	Negligible	Permanent	Very Limited	Certain	Minor (-)	Low	Low	High
Installation of floating jetties	**Option A**								
	Without Mitigation	Very low	Immediate	Limited	Unlikely	Negligible (-)	High	Low	High
	With Mitigation	Negligible	Immediate	Limited	Unlikely	Negligible (-)	High	Low	High
	Option B								
	Without Mitigation	Very low	Immediate	Limited	Unlikely	Negligible (-)	High	Low	High
	With Mitigation	Negligible	Immediate	Limited	Unlikely	Negligible (-)	High	Low	High
Pumping sand from the estuary for filling sandbags	**Option A**								
	Without Mitigation	Low	Brief	Limited	Almost Certain	Minor (-)	High	Low	High
	With Mitigation	Very Low	Brief	Limited	Almost Certain	Minor (-)	High	Low	High
	Option B								
	Without Mitigation	Very Low	Brief	Limited	Almost Certain	Minor (-)	High	Low	High
	With Mitigation	Negligible	Brief	Limited	Almost Certain	Negligible (-)	High	Low	High
Erosion as a result of disturbance to the bed and banks of the estuary	**Option A**								
	Without Mitigation	High	Brief	Local	Almost Certain	Minor (-)	High	Low	High
	With Mitigation	Low	Brief	Local	Probably	Negligible (-)	High	Low	High
	Option B								
	Without Mitigation	Very High	Brief	Local	Almost Certain	Minor (-)	High	Low	High
	With Mitigation	Moderate	Brief	Local	Probably	Minor (-)	High	Low	High

5.2 Operational Phase Impacts

A summary of ratings for each impact associated with the operational phase can be viewed in **Table 8**

5.2.1 Establishment of Zostera capensis Beds

Z. capensis represents an important component of the estuarine ecosystem due to the large number of ecological functions it provides including stabilizing sediment, preventing erosion, reducing water flow, trapping nutrients and organic materials and providing habitat, shelter, foraging sites and nurseries for fish and invertebrates (Adams, 2016). The potential for this species to re-establish post construction is therefore important to understanding impacts under the operational phase of the bank and jetty upgrade. It should furthermore be noted that eelgrass beds move around in response to changes in freshwater inflow and marine sediment input (Adams, 2016) and it is therefore difficult to predict where new beds will establish and if existing beds will remain in the future.

Based on the site visit it is unlikely that *Z. capensis* will grow beneath the floating jetties due to a lack of suitable light penetration. It is however clear from neighbouring jetty designs that the presence of a jetty and associated boat traffic does not prevent the establishment of *Z. capensis* adjacent to the jetty and that shading will therefore have a relatively low impact on the broader establishment of *Z. capensis*. This can be seen in Figure 7 and **Figure 9** where large beds of *Z. capensis* have established adjacent to a jetty at Sanderlings Estate since 2013 when no beds were present.

Operational impacts associated with option A will therefore be dependent on the ability of the *Z. capensis* to regenerate and expand from remaining and/or transplanted patches following construction activities. Given the loss of *Z. capensis* that will occur during the construction phase it can be anticipated that the regeneration and expansion will take some time to reach present coverage in comparison to option B, where large areas of *Z. capensis* will still remain (Figure 7). Historical imagery indicates that beds of *Z. capensis* were not present in August 2013, were clearly developing in 2016 and were relatively well established in 2018 (**Figure 9**). This suggests that re-establishment of *Z. capensis* in the area impacted by the construction could take from as little as 2 years to as much as 5 years. Most importantly, historical images indicate that there is a strong likelihood that eelgrass will be able to expand in range over time and that the impact associated with the development is likely to be relatively short term. Furthermore, *Z. capensis* is the dominant aquatic plant in the Keurbooms estuary (CAPE CAPE Estuaries Programme, 2010) and beds established in the larger area of the estuary should therefore provide a sustainable seed bank for further re-colonization of the estuary.

Increasing the space between planks of the walkways could potentially improve light penetration beneath the jetties. It is however unlikely that gaps large enough to allow for sufficient light penetration could be accommodated without compromising safety of users of the jetty.

<u>Mitigation measures for Option A and B:</u>

- The phased approach of jetty installation and large gaps (~40 m) between each jetty installation (**Figure 5**) is likely to improve the potential for remaining patches of *Z. capensis* to establish and spread over time

confluent environmental

- The width of the jetty walkways should be minimised as far as possible to reduce the effect of shading on *Z. capensis*.
- Removal of the existing steps leading from the bank into the estuary would restrict pedestrian access to the estuary and minimise trampling of fauna and flora in the inter-tidal zone.

5.2.2 Effects on Estuarine Fish and Invertebrates

While the installation of the reno mattress and floating jetties will permanently alter existing habitat under option A, it is unlikely to result in significant impacts to aquatic biota during the operational phase. Jetties provide good cover for fish species, which was apparent by their abundance during the snorkelling survey and can provide additional habitats for fish (Derybshire, 2006). In addition, invertebrates were also abundant in proximity to established floating jetty structures and will readily utilise habitat provided by the reno mattress and jetty infrastructure. The combination of jetties and beds of eelgrass therefore potentially provides a diverse habitat for utilization by aquatic biota.

Of particular concern is the threat to *H. capensis*, which is known to occur in the Keurbooms Estuary. A recent study by Claassens (2017) found that reno mattresses have created new habitat options for *H. capensis* in the Knysna Estuary, with experiments showing that seahorses showed a preference for reno mattress over *Z. capensis* when provided a choice of the two. The study concluded that, in addition to the protection and restoration of natural habitats in which *H. capensi*s is found, the conservation potential of artificial structures such as reno mattresses should also be realised. According to the Silverstreams estate manager, *H. capensis* have recently been found in high numbers associated with jetties located at the Sanderlings Estate.

Impacts associated with Option A are therefore primarily related to the loss of *Z. capensis* during the construction phase and is dependent on the ability of the species to re-establish in the future (see Section 5.2.1). Impacts to estuarine biota under Option B are likely to be negligible due to the high coverage of *Z. capensis* that will remain under this option. Furthermore, the floating jetties will provide physical structure and habitat that will likely be utilised by fish and estuarine invertebrates.

5.2.3 Mooring of Boats and Boat Traffic

Under options A and B, boats will be moored in deeper water with access to boats via gangplanks leading onto the floating jetties. This design is likely to improve existing impacts on the intertidal zone by preventing trampling of the estuary bed by foot traffic and preventing the boats from resting on the bed of the estuary during low tide.

<u>Mitigation measures for Option A and B:</u>

- The ‘No Wake’ zone rule should be strictly enforced to minimise disturbance to estuarine habitat and biota.

5.2.4 Water Quality

Potential impacts associated with water quality are largely associated with the gradual phasing out of creosote treated poles used in the current design (i.e. retaining wall and mooring poles). Creosote, a distillate of coal tar, is a complex chemical mixture, up to 80% of which is comprised of polycyclic aromatic hydrocarbons (PAHs) of which naphthalene forms the largest fraction. High molecular weight PAHs can be carcinogenic, whereas the more volatile, low molecular weight PAHs are more likely to be acutely toxic to aquatic life (Hutton and Samis, 2000). In general, creosote constituents have low solubility in water, readily bind to soil or sediment, biodegrade over time and are non-bioaccumulative (Smith, 2002). As a result, the potential for creosote or its constituents to impair water quality and aquatic ecosystem health is relatively low (Brooks, 2000). Installations involving large volumes of creosote-treated wood could however theoretically be the source of enough PAH dissolved in surrounding waters to be expected to cause toxic impacts to aquatic life (Hutton and Samis, 2000), although this source is not expected to be long lasting.

Option A does not involve the removal of existing creosote poles that make up the retaining wall and will be left to degrade over time. There is thus a possibility that low concentrations of contaminants could still leach into surface water over time due to the porous nature of the new bank design. It is however unlikely that this source would represent a long-lasting impact to the aquatic environment. Existing creosote mooring poles will be replaced with polywood or CCA treated poles within a plastic sleeve. The design will lead to a slight improvement over water quality, although this positive effect may not be immediately realised.

<u>Mitigation measures for Option A:</u>

- Removal of the existing creosote retaining wall will result in a more immediate improvement of water quality

Option B provides a similar positive impact which will result in more immediate improvements in water quality due to the proposed removal of the retaining wall.

5.2.5 Stabilization of Bed and Banks

Due to the frequency of flooding events the Keurbooms/Bitou Estuary Management Plan (DEADP, 2017) recommended that structures and privately owned and developed land be managed in such a way as to prevent further bank erosion during flood events. It also recommends that a standardised methodology be adopted for the purposes of bank stabilization. In this respect the method proposed for this development is consistent with that adopted in neighbouring estates.

Hydrological armoring of stream banks (e.g. wooden retaining wall, rip rap or reno mattress constructions) is a common technique used to stabilise banks for erosion protection. They often tend to cause problems further downstream in that these hardened structures tend to increase the speed of water flow along an armored reach, as the water has no points of friction to come up against and nothing to slow it down. This additional strength of flow can cause problems further downstream, as water is deflected off the hardened surface and directed at other points of the riverbank. The increased strength and speed of the water can increase erosive forces at these new locations, the result of which is the necessity of installing additional armoring, which merely moves the problem further down the stream.

The proposed upgrade (Option A) does however represent a positive impact over the current vertical retaining wall design. The sloping profile and porous nature of the reno mattress revetment will improve the ability of the bank to absorb and dissipate the energy associated with large flooding events in comparison to the current vertical timber retaining wall design. Furthermore, this construction provides a longer-term solution to stabilizing the bank against flooding events and persistent tidal flow, due to a reduced risk of structural failure.

Mitigation measures for Option A:

- Planting indigenous plants to create a riparian zone along the reno mattress construction will add further stability to the banks and improve the general biodiversity and ecological connectivity of the river banks.

Option B is likely to have a similar effect to option A but would result in the bank being set back from the line of the existing bank (i.e. line extending from Blue Water Estate to Sanderlings Estate). This could potentially lead to alterations in the dynamics of stream flow and sediment transport could lead to localised scour and/or sediment deposition.

Mitigation measures for Option B (in addition to Option A):

- The northern and southern most ends of the new bank construction must align with the existing Blue Water Estate and Sanderlings Estate, respectively. The transition from these “tie-in” points to the alignment of the new bank should follow a gentle, curved path to minimise localised disturbance to flow patterns and sediment transport.

Table 8: Summarised impact rating table (Operational Phase) for the upgrade of banks and installation of floating jetties along the Keurbooms Estaury at Silverstreams Estate, where (-) indicates a negative impact and (+) indicates a positive impact.

Impact	Impact	Intensity	Duration	Extent	Probability	Significance	Reversibility	Irreplaceability	Confidence
Impact of jetties and reno mattress on the re-establishment of *Zostera capensis*	**Option A**								
	Without Mitigation	High	Short Term	Limited	Unlikely	Negligible (-)	High	Low	High
	With Mitigation	Moderate	Short Term	Limited	Unlikely	Negligible (-)	High	Low	High
	Option B								
	Without Mitigation	Low	Brief	Limited	Unlikely	Negligible (-)	High	Low	High
	With Mitigation	Very Low	Brief	Limited	Unlikely	Negligible (-)	High	Low	High
Impact of jetties and reno mattress on aquatic biota (fish and aquatic invertebrates)	**Option A**								
	Without Mitigation	High	Short Term	Limited	Likely	Minor (-)	High	Low	High
	With Mitigation	No Mitigation Possible							
	Option B								
	Without Mitigation	Low	Short Term	Limited	Unlikely	Negligible (-)	High	Low	High
	With Mitigation	No Mitigation Possible							
Impact of boat traffic and mooring on aquatic biota.	**Option A**								
	Without Mitigation	Moderate	Permanent	Limited	Likely	Minor (+)	High	Low	High
	With Mitigation	High	Permanent	Limited	Likely	Minor (+)	High	Low	High
	Option B								
	Without Mitigation	Moderate	Permanent	Limited	Likely	Minor (+)	High	Low	High
	With Mitigation	High	Permanent	Limited	Likely	Minor (+)	High	Low	High
Impact of removal of creosote poles on water quality	**Option A**								
	Without Mitigation	Very Low	Permanent	Local	Probably	Minor (+)	High	Low	High
	With Mitigation	Low	Permanent	Local	Likely	Minor (+)	High	Low	High
	Option B								
	Without Mitigation	Low	Permanent	Local	Likely	Minor (+)	High	Low	High
	With Mitigation	No Mitigation Possible							
Impact of bank construction on stream bank stability	**Option A**								
	Without Mitigation	Moderate	Permanent	Local	Likely	Minor (+)	High	Low	High
	With Mitigation	High	Permanent	Local	Likely	Moderate (+)	High	Low	High
	Option B								
	Without Mitigation	Low	Permanent	Local	Likely	Minor (+)	High	Low	High
	With Mitigation	High	Permanent	Local	Likely	Moderate (+)	High	Low	High

5.3 Cumulative Impacts

Given the minor to negligible impact on aquatic biota under option B and the potential for recovery under option A, the cumulative impact of the bank and jetty upgrade on the greater Keurbooms Estuary is likely to be positive overall. This is primarily due to the following reasons:

- Improved bank stabilization and flood protection over the existing vertical retaining wall design. This will reduce the potential for flood damage and erosion at the Silverstreams Estate which is of benefit to the broader Keurbooms system.
- Enhanced capacity to absorb energy of floods over the current vertical retaining wall design. This is likely to reduce the erosivity of high flow volumes at downstream properties, many of which have already implemented bank stabilization measures.
- A slight improvement in general water and sediment quality in the broader estuary due to the removal of creosote timber from the banks.
- Enhanced biodiversity and ecological connectivity associated with the development of a riparian buffer established with indigenous plants

6. CONCLUSION

This assessment indicates that the operational phase of the proposed upgrade is likely to result in a number of positive impacts related to bank stabilisation, mitigation against floods, water quality and the method of accessing moored boats. While negative impacts are expected to occur, these are unlikely to be permanent and there is strong evidence to suggest that recovery will occur in the short term (1 to 5 years). The negative impacts to aquatic biota under option A relate primarily to the loss of *Z. capensis* beds associated with the installation of the reno mattress and sand bag construction.

Given the high conservation status and ecological importance of the Keurbooms Estuary (as indicated by NFEPA, the Western Cape Spatial Biodiversity Plan and the desktop ecoclassification of estuaries of South Africa) and the presence of IUCN Red Listed species (*Z. capensis and H. capensis*) that are likely to be affected, option B should be considered as an alternative to the current design (option A). This is primarily due to the fact that this option will result in a lower impact to aquatic biota.

It must be stressed however, that this option should only be considered on the condition that it is technically feasible from an engineering perspective and does not compromise on the quality or integrity of the proposed upgrades, which, as mentioned previously, have several positive long-term benefits. If these conditions cannot be met, it is the opinion of this specialist that option A (and its associated mitigation measures) remains a sustainable option given the evidence that negatively impacted components of the system (i.e. *Z. capensis* and other aquatic biota) are likely to recover and utilise the new infrastructure in the short-term future. The fact that similar activities have been approved and implemented successfully at other locations along the estuary and are associated with abundant eelgrass and fish communities provides further support to this view.

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