Province of the
EASTERN CAPE
ECONOMIC DEVELOPMENT,
ENVIRONMENTAL AFFAIRS & TOURISM

ESTUARINE MANAGEMENT PLAN FOR THE SWARTKOPS ESTUARY

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Project Team

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EXECUTIVE SUMMARY

PHYSICAL DESCRIPTION

The permanently open Swartkops Estuary is situated 15 km north of the Port Elizabeth harbour in the Eastern Cape, South Africa and the system extends 16.4 km inland. Hydrological data shows that the present Mean Annual Runoff (MAR) into the Swartkops Estuary is 80.3 million m^3. This is an increase of 41% compared to the natural MAR of 56.9 million m^3 due to inflow from upstream wastewater plants in the river. The Swartkops Estuary is a medium-large, warm-temperate open estuary with the importance being in its large size, diversity of habitats, and the high biodiversity it supports. The system measures approximately 90 m wide in the upper reaches and is characterized by steep banks and winding channels. Towards the middle reaches the banks are steep and the channels are slightly wider and less convoluted. The lower reaches are significantly wider with extensive intertidal mudflats, islands, salt marshes and sandbanks. The estimated habitat area covered by the estuary in 2021 is around 2947 hectares. The depth (m) in the upper reaches of the estuary is around 2 m and in the lower reaches approximately 1 m.

The estuary is fed by two major river systems, namely the Swartkops River the largest tributary and the Elands River, which both have their origin in the Groot Winterhoek mountains. The Swartkops river catchment falls in a transitional region between the summer rainfall of the KwaZulu Natal and Eastern Cape coast and the winter rainfall of Western Cape. The catchment measures 1390 km^2 and the mean annual runoff (MAR) is about 80 x 10^6 m^3 with an average precipitation of 636 mm per annum. Two tributaries of the Elands River are impounded, and the Groendal Dam is located on the Swartkops River approximately 35 km from the estuary. These obstructions are thought to hold back in the region of 16% of the MAR but reduce freshwater inflow by only 5%. The Chatty River is the largest tributary flowing directly into the estuary in the region of the Swartkops Village.

The Swartkops River catchment is in Water Management Area 15 and is approximately 1 390 km^2 in size and extends from the Groot Winterhoek mountains. The river drains to the M10 catchment, which includes the M10A (KwaZunga), M10B (Elandsrivier), M10C (Swartkops River: Elands Confluence), and M10D (Swartkops River: Despatch – River Mouth) quaternary catchments. Land-use in the upper catchment is predominantly natural vegetation and agriculture. Although the river flows through natural and agricultural areas for most of its length, significant portions of the lower catchment are highly urbanized. Large flood events (greater than 1:50 year) result in large-scale flooding and significant damage to the riparian

zone and floodplain. Urbanisation that has taken place below the 1:100-year flood line continues to remain at risk to flooding events.

SOCIAL PROFILE

There are three major residential nodes located immediately adjacent to the estuary, namely Swartkops Village, Redhouse and Amsterdamhoek/Bluewater Bay. The townships of Kwazakhele and Motherwell are located further from the estuary but have a direct effect on the system through pollution. Industrial activities are a major land-use within the immediate estuarine area and include salt works, sewage treatment works, sand/clay mining, brickworks, the motor industry, wool industry, tanneries, extractive/beneficiation processes, aquaculture and railway yards and depots, with only limited agriculture taking place. The Swartkops and proposed Aloes Nature Reserve are located on the northern banks of the middle and lower reaches respectively.

ECOLOGICAL STATUS

Swartkops Estuary is ranked as the high biodiversity priority estuary as per NBA (2018). Despite its importance, the estuary is highly urbanised and surrounded by residential and industrial activities. Anthropogenic impacts, particularly pollution, have been problematic since the 1950s and have increased with time. The present health, or Present Ecological State (PES), of an estuary is defined as the extent to which its present state differs from a natural condition that existed prior to human impacts (approximately 100 years ago). The Swartkops Estuary is currently in a highly degraded state (Adams et al., 2021). Table 1 shows the Present Ecological Status of the Swartkops Estuary. The red arrows indicate those components where there has been a deterioration in condition since the previous PES assessment by Van Niekerk et al. (2015)

Table 1: Present Ecological Status of the Swartkops Estuary assessed using the Estuarine Health Index

Variable	Present state
Hydrology	D/E
Hydrodynamics and mouth condition	D/C ↓
Water quality	D
Physical habitat alteration	D
Habitat health score	D
Microalgae	D/E ↓
Macrophytes	E ↓
Invertebrates	D
Fish	D/E
Birds	C/D ↓
Biotic health score	D/E
PES	**D**

*PES of "A" represents a pristine status and "F" represents a heavily degraded status.

Reserve categories for rivers have been set at quaternary catchment level across the country at a desktop, low confidence level. The PES and Ecological Importance and Sensitivity (EIS) were sourced for the quaternary catchments of the Swartkops River. The desktop PES, EIS and Recommended Ecological Category (REC) for the Swartkops Catchment are provided below:

Table 2: Catchment Ecological Status

Quaternary catchment	PES	EIS	REC	Total EWR flows (MCM /annum)	EWR% of natural MAR
M10A: KwaZunga	A	High	A		
M10B: Elands	D	High	C		
M10C: Swartkops	E-F	High	D	9.531	11.44
M10D: Swartkops	E-F	High	D		

FRESHWATER INFLOW

The estuary experiences its driest months during summer and receives most rainfall around October, with a smaller peak in April. The maximum rainfall occurs at the headwaters of the Swartkops River system and decreases towards the coast (DWAF, 1999). The flow pattern in the catchment is distinguished by low baseflows, with minor floods of 40 to 80 x 10^6 m^3. The most severe floods (120 to 160 x 10^6 m^3) ever recorded occurred in 1879, 1912, 1914, 1971 and 1979 (HKS, 1974). A flood event with a recurrence probability of 1 in 100 years occurred in 1981 (Ninham Shand, 1994). Although groundwater is important there is little understanding of surface water and groundwater interactions.

Significant decreases in certain macrobenthic species have been recorded after flood events. Reasons for this are thought to be a combination of animals leaving their burrows and being flushed out to sea, low salinity leading to hypo-osmotic stress and the deposition of fine silt that smothers the habitat.

SALINITY AND TEMPERATURE GRADIENT

Salinity characteristics in the system are largely influenced by river inflow ranges and tidal exchange. Variability in salinity is high due to a combination of dry periods interspersed with frequent episodic floods. Elevated salinity (42 ‰) has been recorded in the upper reaches and could be due to seepage of high saline waters from the saltpans, high evaporation rates and low freshwater inflow. Vertical salinity gradients measured in the upper reaches reflect the intrusion of high salinity water far upstream and a well-mixed water column for most of the time. Vertical stratification occurs during and after flood events but is restricted to the upper reaches. Temperatures are similar along the length of the estuary and vary seasonally, with highest recordings in summer months.

ECOSYSTEM GOODS AND SERVICES

Swartkops Estuary provides various ecosystem goods and services to the surrounding communities (Table 3). Fishing is one of the key activities taking place**.** Approximately 50 species of bony and cartilaginous fishes are known to occur in the warm temperate Swartkops Estuary on a regular basis. The Swartkops Estuary is subject to excessive fishing pressure and many larger piscivorous predators are reduced in numbers and caught soon after entry into the estuary. The current state is an artefact of high fish extraction from the estuary from all reaches and the estuary is already in a state of reduced fish biomass. Spotted grunter is by far the most dominant catch by club anglers, comprising 87% of the total catch by number

and 83% by weight. White Steenbras and leervis were the next dominant species. Species such as white Steenbras and dusky kob were more frequent in early 20th century catches when compared to recent surveys, and spotted grunter only appeared in 2% of anglers catches. The reasons for the change in catch composition were attributed to over-fishing in estuaries and the ability of spotted grunter to withstand angling pressure. However, it is more likely that a combination of factors has led to the perceived decline of certain species in anglers catches.

Due to its proximity to a major city (Gqeberha, previously called Port Elizabeth) and the number of urban and informal settlements adjacent to the estuary, levels of angling effort are exceptionally high. Countless shore-based fishermen are seen during the week and on weekends. The exact number of so-called subsistence fishermen is not known, but they are numerous. A lot of boat-based anglers' fish at night, especially those who use bait. Boat and shore-based anglers that fish more during the day have greater success with species such as dusky kob and leervis.

Numerous invertebrate species are exploited as bait. Organisms are either collected by the fishermen themselves or by subsistence bait collectors who then sell to recreational anglers. There are several subsistence collectors who are licensed in accordance with the Marine Living Resources Act to sell their catch, but numerous illegal operators are also in play. The most frequently collected species, and those collected in the greatest numbers, include mudprawn, sandprawn, pencil bait and tongue worm. Additional bait organisms include tapeworm, cracker and bloodworm. Most collecting effort takes place in the lower reaches below the railway bridge, with the dominant area for bloodworm and sandprawn being near the N2 bridge. The rest of the bait organisms are collected on both vegetated and unvegetated intertidal mudbanks.

Table 3: Present Ecosystem Services of the Swartkops Estuary, associated benefits and well-being (Adams et al., 2021)

Provisioning	**Benefits & human well being**
Food supply	Fish and mud crabs, subsistence use to combat poverty
	Key fishing species: grunter, steenbras, kob, elf, leervis, stumpnose
	Oysters: collected in the mouth and lower reaches
Bait collection	Mudprawns, sandprawns, pencil bait, bloodworm, tapeworm and tongue worm collected for recreational use and to sell by subsistence collectors
Medicines & pharmaceuticals	Medicinal plant harvesting by traditional healers
Supporting	
Nursery habitat for fish	Contributing to fisheries resources
Biodiversity maintenance	Healthy ecosystems such as maintenance of Important Bird Area. Large important salt marsh and seagrass area in South Africa
Regulating	
Carbon storage	Climate regulation as a CO_2 sink
Flood regulation	Protection from natural disasters such as floods and coastal storms
Bank protection	Protection to low lying developments, infrastructure & adjacent communities
Cultural	
Aesthetics	Good living status, connection to nature, sense of place, scenic views and vistas, waterfront properties and their value, measured as existence value
Spiritual, religious, cultural fulfilment	Spiritual includes including baptism sites, cleansing sites for traditional healers (sangomas), medicinal plant collection
Recreation & tourism	Job creation, life satisfaction and happiness. Cultural heritage. Contact recreation. Bird watching, fishing, canoeing, boating, picnicking
Education & training	Opportunities for study, environmental education such as the education programmes run by Zwartkops Conservancy, student research, transdisciplinary research opportunities

WATER QUANTITY & QUANTITY REQUIREMENTS

The Nelson Mandela Bay Municipality (NMBM) is served by the Algoa Water Supply System, with a secondary system comprising the Uitenhage aquifers and dams on several rivers, including the Swartkops River, Bulk River and Sand River. While the Swartkops Estuary is considered well mixed during low rainfall periods, it may become stratified during high flow periods, and it is a shallow estuary. Salinity varies from 35 at the mouth to approximately 10 near the head of the estuary, indicating the importance of freshwater inflows to the system. The estuary experiences significant tidal water exchange and the tidal prism during spring tides is on average $3 \times 10^6 m^3$ and the average flushing time during spring tides about 22 hours. A significant impact on water quality comes from upstream river reaches and catchment activities such as land-use, urban and rural developments and associated activities, point and

non-point pollution events, water abstractions, dams, weirs, and streamflow reduction activities such as forestry.

Three important pollution point sources into the Swartkops Estuary are the Motherwell and Markman Canals, and the Chatty River that flows into the estuary. The Kariega (previously Uitenhage)/Despatch Sewage Treatment Works, Kwanobuhle and Kelvin Jones WWTW are also located in the upstream catchment. Consistent nutrient rich baseflow into the estuary from these upstream works has resulted in eutrophic estuary conditions characterised by harmful algal blooms (HABs) species in the middle-upper reaches and dense stands of invasive alien aquatic plants (e.g. water hyacinth) in the freshwater reaches (Adams et al. 2021). Informal settlements occur in places on the banks of the estuary. There are also elevated levels of heavy metals in estuarine sediments where runoff from industrial or informal residential areas, enter the system. The water quality of the Swartkops Estuary was typically mesotrophic or eutrophic from the middle to the upper reaches (Adams et al., 2019).

Analysis of historical water quality data from the DWS showed that 52% of DIN measurements were classified as either mesotrophic or eutrophic and all DIP measurements exceeded the guideline value of 0.05 mg $P \cdot \ell^{-1}$ (DWAF, 1996). Minimum WWTW discharge standards required by legislation stipulate effluent limits of 21 mg l^{-1} (1 500 µM) and 10 mg l^{-1} (320 µM) for inorganic nitrogen (DIN) and phosphorus (DIP), respectively. Unfortunately these concentrations are too high for estuaries and cause downstream eutrophication (Adams et al. 2019). Studies by Gyedu-Ababio (2011), Nel et al. (2015), Phillips et al. (2015) and Van Aswegen et al. (2019) have shown that invertebrates, fish, kelp gull eggs and plants at the Swartkops Estuary have bioaccumulated heavy metals (Cd, Cu, Pb and Zn). Metal concentrations were notably higher in sediments adjacent to stormwater canals.

Table 4: Estimated (present) inflow, as well as DIN and DIP concentrations in various sources to the Swartkops Estuary (Adams et al., 2019; Lemley et al., 2019)

Source	Average daily flow (m^3/day)	DIN (mg/ℓ)	DIP (mg/ℓ)
River	Flow varies	2.31	0.20
Motherwell	Flow varies	4.19	0.09
Chatty River	Flow varies	2.75	0.34
Markman Canal	Flow varies	5.16	0.15
Kelvin Jones WWTW (1)	21120	11.26	5.24
Kwanobuhle WWTW (2)	1980	24	4.93
Despatch WWTW 3 (3)	4410	7.84	2.21

BIOTIC CHARACTERISTICS

1. Phytoplankton

The middle to upper reaches of the Swartkops Estuary are persistently eutrophic with phytoplankton blooms. The phytoplankton in the Swartkops Estuary comprises 18 species that are found in the water column and at least 40 others that reside in the sediment. Of these, the dominant size-group is the microplankton (> 12 µm), accounting for more than 60% of total production, which has been estimated at 93.3 mgC/m^2. Production increases during and immediately after flooding due the introduction of freshwater phytoplankton species into the system. In 2020 and 2021 extensive blooms of the HAB-forming species *Heterosigma akashiwo* has been documented in the middle-upper reaches of the estuary. In January 2021 this bloom caused a massive fish kill in the mid- to upper estuary reaches (Adams et al., 2021).

2. Macrophytes

The Swartkops Estuary supports six different plant community types, namely supra- and intertidal salt marsh, submerged macrophytes, reeds, sedges, phytoplankton and benthic microalgae. Eelgrass (*Zostera capensis*) used to be the only major aquatic macrophyte in the system, prior to its complete disappearance from the system by 1984. Partial recovery was evident by 1988 and by 1996 the community appeared to be well on its way to full recovery. It now occurs in the lower intertidal zone and is abundant in the middle and lower estuary reaches, occupying a total area of 54 ha. Several other species of macrophytes appear to bloom under certain high nutrient conditions, e.g. dense mats of *Ruppia cirrhosa* in the Chatty River; infestation of water hyacinth in the lower reaches of the Swartkops River; and the brown seaweed *Enteromorpha* spp. is recorded occasionally. Both salt marsh and seagrass beds act as carbon sinks as well as nutrient filters. Reeds and sedges mainly occur in the upper reaches and at freshwater seepage sites but are not extensive due to the disturbance of the banks.

3. Benthic Macrofauna

A total of 122 species of benthic macrofauna have been recorded in the system; 78% of biomass located within the intertidal region and 22% subtidally. Within the soft sediments of non-marshland regions, the dominant forms are the *Upogebia africana*, *Callianassa kraussi*, *Cleistostoma* spp. and *Solen* spp. Substrate type and competition for space limit the distribution of the various species. Two detritivores crab species, *Sesarma catenata* and *Cleistostoma edwardsii* and the gastropod *Assiminea* sp. are the dominant macrobenthic fauna of the salt marsh habitat.

4. Ichthyoplankton

Fish larvae are present all year round, but highest abundance is recorded in summer. Diversity is low and density fluctuates considerably from a low of 0.028 larvae/m^3 to a high of 24 728 larvae/m^3 in summer. The dominant groups are the Gobiidae (predominantly *Caffrogobius nudiceps*) and *Gilchristella aestuaria*. Larvae of *Rhabdosargus holubi, Hepsetia breviceps* and *Monodactylus falciformis* have been frequently caught but in low numbers.

5. Juvenile and adult fish

There is rich and diverse ichthyofaunal community that displays an even distribution throughout the Swartkops system. This is most likely due to the well mixed water body that ensures high saline waters as far as the head of the estuary except during floods. A series of surveys dating back to the late 1970s have accounted for 86 species of fish that commonly occur in the system. The majority are marine migrants, such as *Argyrosomus japonicus*, *Pomadasys commersonnii*, *Lithognathus lithognathus*, *Rhabdosargus holubi*, *Lichia amia* and a host of mullet species. *P. commersonnii* is the most abundant of the large fish species, comprising 29 and 17% by mass and numbers respectively, followed by mullet.

6. Meiofauna

The meiofauna community occurs in the muddy and sandy sediments of the estuary and has a mean standing crop of 0.6 gC/m^2. Nematodes account for as much as 84% of the total meiofauna biomass followed by harpacticoid copepods, with the remaining components comprising oligochaetes, polychaetes, flatworms and gastrotrichs.

7. Zooplankton

A total of 54 species of zooplankton have been identified, with 24 remaining unidentified. Zooplankton is dominated by copepods and mysids; whose distribution appears to be mainly determined by salinity. Of these, mysids are the dominant group in terms of biomass, with two species, *Mesopodopsis slabberi* and *Gastrosaccus brevifissura* comprising most of the community.

8. Birds

Of the 195 bird species identified in the Swartkops Valley between Perseverance and Algoa Bay in the mid-1980s, 53 were regularly associated with the estuary and 61 were recorded on the Redhouse saltpans above Brickfields. A total of 145 species were listed as being found within the proposed Aloe Nature Reserve, most of which were associated with the Redhouse saltpans. Nine species are listed as being rare, vulnerable or threatened, namely *Spheniscus demersus*, *Ardea goliath*, *Ciconia nigra*, *Mycteria ibis*, *Phoenicopterus rubber*, *Phoeniconaias minor*, *Hieraaetus pennatus*, *Haliaeetus vocifer* and *Hydroprogne caspia*. The most significant change in the bird community of the Swartkops Estuary over the last century is the total disappearance of freshwater species due to the destruction of freshwater habitats through industrial development and the drying off saltpans on the floodplain. The estuary supports up to 20,000 birds, with in excess of 3,000 of these being annual Palearctic migrant species (BirdLife International, 2021). Cerebos discontinued their saltpan operations in 2018 resulting in the loss of approximately 10 000 birds from the Redhouse and Bar None salt pan areas due to the drying out of habitats and loss of protected islands surrounded by water.

9. Alien vegetation

Due to disturbance of the banks and estuary habitat terrestrial invasive plants are abundant and common species are *Spergularia media*, *Opuntia ficus-indica*, *Opuntia aurantiaca, Senna didymobotyra, Acacia cyclops*, *Atriplex lindleyi* subsp. *inflata* and *Lantana camara*. Invasive alien aquatic plants are also abundant and occur from the tidal limit at Perseverance upstream. These species thrive in nutrient rich systems becoming highly invasive. Dominant species are *Eichhornia crassipes* (water hyacinth), *Azolla filiculoides* (water fern), *Ceratophyllum demersum* (Coontail) and *Salvinia molesta* (Kariba weed) (Adams et al., 2019). During high flows water hyacinth is washed downstream into the estuary. These invasive plants displace the local species. In the middle and upper reaches of the Swartkops Estuary *Zostera capensis* is displaced by *Eichhornia crassipes* due to reduced light penetration and smothering (Adams, 2016). This can cause significant changes in invertebrate and fish assemblage structures.

RESEARCH OPPORTUNITIES:

The Swartkops Estuary provides several research opportunities that cover a broad range of topics. Examples of these research topics include water quality, estuarine and marine ecology. The Swartkops Estuary Research Symposium took place on 19 March 2019. It brought together over 40 researchers and stakeholders from different government departments and universities (Nelson Mandela University, Rhodes University, University of Western Cape and Wits University). The theme was improving estuary health for the delivery of multiple ecosystem services. It was hosted by the National Research Foundation (NRF)/Department of Science & Technology (DST) South African Research Chair Initiative (SARChI) in Shallow Water Ecosystems and the Institute for Coastal and Marine Research (CMR) with logistical support from the Benguela Current Large Marine Ecosystem (BCLME) III project and the Department of Environmental Affairs.

OPPORTUNITIES AND CONSTRAINTS

The objective of an EMP is to maintain an estuary in its functional condition as possible. Where there is some degradation or potentially degrading influence, this needs to be removed if possible or managed within acceptable limits. The Situation Assessment Report (SAR) suggests several opportunities for improving functioning of the estuary as well as improving management and governance of activities within and around the Swartkops Estuary. Similarly, there are several constraints identified. Due to the high human density and variety of human activities in the vicinity of the Swartkops Estuary, a wide range of man-made threats to sustainable development and conservation exist in the area.

In addition to these, the geology and geomorphology of the area also present certain risks to development and potential future land use. While some of the pressures, threats and risks in the area are generic to both the terrestrial and aquatic wetland habitats, many of these are specific to the different environments. The following pressures, threats and risks highlighted include loss of natural habitat, pollution due to poor service delivery, improper sanitation, illegal dumping, domestic waste disposal and littering leading to land and water pollution.

Destruction of estuary, floodplain and salt marsh caused by flow constriction due to causeways, roads, railway lines and pipelines is widespread. Large areas of supratidal salt marsh habitat have been removed by development. Low lying properties are under risk of damage during flooding events. Discharge of polluted runoff and stormwater from industrial and residential areas, as well as contaminated process water e.g. industrial sewage effluent

is an issue. Poor land use practices occur in the catchment resulting in increased sediment input, nutrient enrichment and pollution. Uncontrolled water abstraction and impoundment resulting in altered flow regime, i.e. reduced base flow required for ecological functioning, and insufficient freshwater pulses for mouth maintenance. The exploitation of living resources, such as bait collection, fish harvesting using gill nets has been identified as a challenge in the system.

GOVERNANCE

There is a need to improve management of those activities that impact negatively on estuarine functioning. An overview of the governance context highlights, however, that this will need to happen within an extraordinarily complex legal framework and institutional arrangement. Prior to the Integrated Coastal Management Act (No 24 of 2008) and National Estuarine Management Protocol (2013), there were number of different laws and policies that were used to manage estuaries. The ICM Act and the Protocol became handy to promote integration and cooperative governance. In the past, there has not always been co-operation between the various role-players involved in the management of the Bay, now there are signs of improvement in this regard. Improved communication and co-ordination between authorities has largely taken place through Estuary Management Forum, Municipal Coastal Committee and the Provincial Coastal Committee.

The legal requirement to preserve the functioning of the ecosystem requires that active measures be put in place to first prevent further deterioration and subsequently to restore functioning. It has been suggested that this will require not only addressing those negative influences that can be addressed, but also that active and positive interventions be considered, e.g. habitat restoration and rehabilitation. The integrity of the system can be preserved, and the estuarine functioning be improved, by putting more efforts to reverse the current trajectory.

The following management opportunities exist that would result in improved estuarine functioning:

- ❖ Managing the functioning of waste-water treatment works facilities that have direct impact on the water quality of the estuary, for example interventions by Nelson Mandela Metro Municipality in managing challenges associated with power failures. The Municipality also has a responsibility of managing land-based pollution, and the catchments which will result in the improvement of water quality.
- ❖ There is also a need to explore positive opportunities associated with community involvement, including community awareness by all spheres of government.

RECOMMENDATIONS

Although current water quality data for waste-water treatment work effluent discharges has been provided by Institutions of Higher learning (NMU), DHSWS and monitoring done by DFFE, current water quality data for the tributaries feeding into the estuary must be obtainable from the Nelson Mandela Metro Municipality. Municipality should consider having its own scientific unit to do continuous monitoring. Strengthening partnerships with academic, research and scientific institutions to identify biotic research opportunities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS & ACRONYMS

C.A.P.E	Cape Action for People and the Environment
CARA	Conservation of Agricultural Resources Act (Act No. 43 of 1983)
CBA	Critical Biodiversity Area
CBO	Community Based Organization
CMA	Catchment Management Agency
CML	Coastal Management Lines
CMS	Catchment Management Strategy
CPUE	Catch Per Unit Effort
CPZ	Coastal Protection Zone
CSIR	Council for Scientific & Industrial Research
DEDEAT	Department of Economic Development, Environmental Affairs & Tourism
DFFE	Department of Forestry, Fisheries & Environment
DHSWS	Department of Human Settlements, Water and Sanitation
ECPHRA	Eastern Cape Provincial Heritage Resources Authority
EFZ	Estuary Functional Zone
EIA	Environmental Impact Assessment
EIS	Ecological Importance and Sensitivity
EMP	Estuarine Management Plan
EWR	Environmental Water Requirements
EZP	Estuarine Zonation Plan
IAAP	Invasive Alien Aquatic Plants
ICM Act / ICMA	National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008)
IDP	Integrated Development Plan
MAP	Management Action Plan
MLRA	Marine Living Resources Act (Act No. 18 of 1998)
MSL	Mean Sea Level
NEMA	National Environmental Management Act (Act No. 107 of 1998)
NEMBA	National Environmental Management: Biodiversity Act (Act No. 10 of 2004)
NEMPAA	National Environmental Management: Protected Areas Act (Act No. 57 of 2003)
NEMP	National Estuarine Management Protocol
NFA	National Forest Act (Act No. 84 of 1998)
NGO	Non-Government Organization
NHRA	National Heritage Resources Act (Act No. 25 of 1999)
NMBM	Nelson Mandela Bay Municipality
NRF	National Research Foundation
ORV Regs.	Control of Vehicle Use in the Coastal Area Regulations
PES	Present Ecological State
PHRA	Provincial Heritage Resources Agency
PLS Regs	Public Launch Sites Regulations
PPP	Public Participation Process
REC	Recommended Ecological Category

REI	River Estuary Interface
RQO	Resource Quality Objectives
RSET	Rod Sediment Elevation Table
SSA	Sea Shore Act (Act No. 21 of 1935)
SAHRA	South African Heritage Resource Agency
SAIAB	South African Institute for Aquatic Biodiversity
SANCOR	South African Network for Coastal & Oceanic Research
SDF	Spatial Development Framework
SEMAB	Swartkops Estuary Management Advisory Body
WUA	Water Use Association

CHAPTER 1- INTRODUCTION

Estuarine ecosystems are not isolated systems. They form an interface between marine and freshwater systems and are part of regional, national and global ecosystems either directly via water flows or indirectly through the movement of fauna. In addition to the biota that these estuaries support, they provide a range of goods and services. Disturbances in one estuary can influence a wide variety of habitats and organisms in the broader freshwater or marine ecosystem. Thus, the interaction between the systems and users creates a delicate balance, the sustainability of which needs to be addressed by some form of management plan.

Estuaries are important for fisheries reproduction by providing a nursery function for several juvenile fish species. Fishing is a crucial socio-economic activity for the local communities as it plays a key role in livelihood activities and sustenance. The Swartkops Estuary has a permanently open mouth, thus plays a continual nursery role for replenishing fish stocks, which are key for ecological functioning, over and above the socio-economic factors.

The urgent need for Estuary Management Plans (EMPs) became apparent during the development of the Integrated Coastal Management Act (Act 24 of 2008; ICM Act). Prior to the ICM Act, estuaries and the management thereof were not adequately addressed by past marine, freshwater and biodiversity conservation Acts. Estuaries and the management thereof now form an integral part of the ICM Act, which identifies the need for the development of EMPs, as these would help to align and coordinate estuary management. The National Minister responsible for Environmental Affairs, has adopted a National Estuary Management Protocol (the Protocol) in terms of Section 33(2) of the ICM Act. The Protocol provides a framework for development of EMPs for the country.

It is essential to understand that the EMP developed within this framework is a living document that can be adapted according to the changing requirements of the system itself and its users. Review of the EMP after five years allows for continual improvement through feedback and coordinated monitoring. However, in order for this system to function, an institutional arrangement for management of the estuary, comprising representatives of all relevant stakeholders must be formed. This institutional arrangement serves to focus and coordinate management efforts and facilitate communication between users and managers in order to achieve a common goal.

The Swartkops Estuary (and River) together with the adjacent Swartkops Valley Nature Reserve and the Aloe Open Space have been designated as Critical Biodiversity Areas (CBA) that need to be protected. Within this category, the Swartkops River/Estuary has been

assigned a category of Critical Biodiversity Area (CBA) with the recommendation that it should form part of the formal protected area system (NMBM Bioregional; 2014).

The Swartkops Valley Nature Reserve adjoins the estuary on its northern bank (see Figure 1). The Aloes Open Space area is located in close proximity to the estuary but does not share a common boundary with the estuary. The EMP therefore recognized the important role that these two green areas play on the estuary and as such they are considered to be some of the key zones of influence for the estuary.

CHAPTER 2: GEOGRAPHICAL BOUNDARY OF THE STUDY AREA

The ICM Act defines the estuary as a body of surface water that is permanently or periodically open to the sea; in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water;

For the purpose of effective and holistic estuarine management, this EMP will consider the geographical boundaries of the Estuary Functional Zone (EFZ) as shown in Figure 1 below. Listing Notice 3 (GNR 324: 2017) of the National Environmental Management: Environmental Impact Assessment Regulations defines the EFZ as "the area in and around an estuary which includes the open water area, estuarine habitat (such as sand and mudflats, rock and plant communities) and the surrounding floodplain area, as defined by the area below the 5 m topographical contour". Historically, the full extent of the tidal influence extended as far as the causeway at Perseverance. However, since the removal of the causeway, tidal waters now push further upstream. For the purposes of this EMP, the upper limit of the estuary is the area slightly below the Perseverance abattoir.

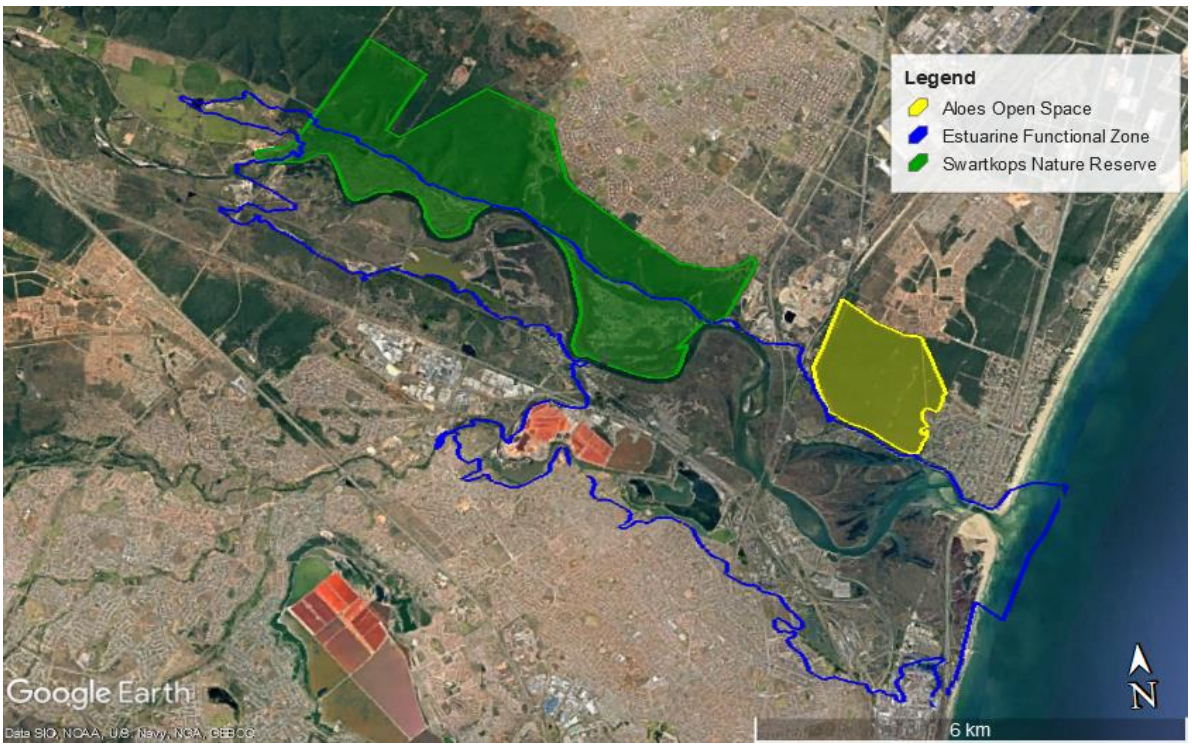

Figure 1: The Swartkops Estuary, with the Estuary Functional Zone and the zones of influence (Swartkops Valley Nature Reserve and Aloes Open Space) indicated

CHAPTER 3 – VISION & OBJECTIVES

3.1 VISION

The vision for the Swartkops Estuary presents the desired state in which the estuary should be managed, and this is done through a stakeholder consultation process.

The Vision for the Swartkops Estuary is as follows:

> ***The Swartkops Estuary along with its zone of influence are a unique national asset that is rich in biodiversity and must be restored and protected to a level that will attract visitors, uplift our spirits, sustain our livelihoods, and preserve our natural, cultural and recreational heritage.***

3.2 MANAGEMENT OBJECTIVES

Management Objectives are generally qualitative statements of the values defined in the Vision and should be statements of outcomes rather than means of achievement. The following key result areas need to be specifically addressed in terms of Strategic Objectives:

- Water quality & quantity
- Biodiversity conservation
- Land use & infrastructure
- Sustainable livelihoods
- Tourism and recreational use
- Education and awareness
- Climate change
- Compliance and enforcement

3.2.1 WATER QUALITY & QUANTITY

Resource Quality Objectives and the Ecological Reserve requirements must be implemented to ensure that all ecological processes and livelihoods are sustained.

3.2.2 LIVING RESOURCES & CONSERVATION

Ensure a sustainable balance between the conservation, protection and exploitation of living and heritage resources.

3.2.3 LAND USE & INFRASTRUCTURE

Development and associated activities within the designated management area are controlled via legislation in such a way as to sustain existing livelihoods and ensure the maintenance of ecosystem functioning and services.

3.2.4 SUSTAINABLE USE AND PROMOTION OF SOCIO-ECONOMIC ACTIVITIES

Manage existing activities and promote additional opportunities in a way that ensures compliance with legislation and the maintenance of ecosystem functioning and services.

3.2.5 EDUCATION & AWARENESS

To create an awareness, through research and education, of the value of the management area, a sense of ownership and the need for integrated, informed and cooperative management that will ensure the maintenance of ecosystem functioning and services.

3.2.6. CLIMATE CHANGE

To ensure effective management of the Swartkops estuarine system so to adapt to climate change impacts and develop resilience.

3.2.7. COMPLIANCE AND ENFORCEMENT

To monitor compliance with the provisions of the EMP and applicable legislation.

CHAPTER 4 MANAGEMENT STRATEGIES AND ACTION PLANS

4.1. INTRODUCTION

The Vision and Management Objectives may be achievable through various Management Strategies and Action Plans. These should be investigated and evaluated so as to optimally utilize financial and human resources that are detailed in the Management Action Plans. The Management Strategies are necessary to achieve the Strategic Objectives for the various key result areas.

Several National legislative frameworks contain provisions that dictate to authorities (includes managers), landowners and recreational users with regards to activities that are allowed or at least should be regulated within estuaries or within prescribed distances from estuaries. It must be clearly understood that all management recommendations (including aspects of the Zonation Plan) made in this EMP are based on this existing legislation. As such, all existing activities, whether within urban, rural, estuarine or protected areas, should already conform to these recommendations. This EMP merely serves to create an awareness of what activities should be considered according to the existing legislation. In so doing, the sustainable use of land and resources should be optimized to benefit all users, the terrestrial and estuarine ecosystem itself.

A full range of management actions has been identified in order to facilitate the achievement of the objectives within the eight key result areas (water quantity & quality, biodiversity conservation, land-use & infrastructure, sustainable use and promotion of socio-economic activities, education and awareness, sustainable livelihoods, compliance enforcement and climate change).

4.2. WATER QUALITY & QUANTITY

The National Water Resource Strategy provides a framework for the protection, use, development, conservation, management and control of water resources for the country as a whole and within defined water management areas such as specific catchments. This strategy is given effect by a water management institution such as a catchment management agency (CMA) or water user association (WUA), neither of which currently exist.

A Catchment Management Strategy (CMS) developed by the CMA in accordance with the NWA (Chapter 2, Part 2) for the protection, use, development, conservation, management and control of water resources within its water management area. Specifically, this includes the classification of the water resource and the resource quality objectives aligned with that particular classification, i.e. Reserve Study. This latter aspect should incorporate a Comprehensive Reserve Study that will validate/substantiate the Desktop and Intermediate Studies that has already been done. The National Biodiversity Assessment (2018) recommends the Ecological Category of D for the estuary. However, stakeholders want to see the system achieve a better status. Therefore, in line with the Vision, the desired classification of the resource is Category C. This EMP should be implemented in conjunction with the National Water Resource Strategy.

Table 5: Water quality and quantity

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Undertake comprehensive Reserve Determination assessment on the estuary	National Water Act (NWA)	Reserve Determination study	DHSWS	**H (within 3 Years)**
Manage water abstraction and discharge activities in the catchment and within the EFZ to ensure sustainable water quality and quantity levels.	NWA & ICMA	Water Use Licences, Coastal Discharge Permits issued	DHSWS; DFFE; NMBM	**M (ongoing)**
Develop a list with coordinates of existing abstraction points	NWA	Database of current abstraction points	DHSWS	**M (within 1 Year)**
Ensure reduction in vandalism of infrastructure resulting in spillages into the estuary.	Municipal Systems Act	Reduced incidents of vandalism	NMBM	**H (2 years)**
Manage and control pollution from waste-water treatment works and urban runoff via the Motherwell, Markman Canals and Chatty River and Fishwater Flats.	NWA; ICMA (Section 69); Municipal Systems Act	Water Quality Standards Implemented	NMBM; DHSWS; DFFE	**H (within 1 Year)**
Identify and manage other sources of pollution (including solid waste; effluent and hazardous waste, leaching via groundwater; contaminated stormwater; agricultural and industrial run-off).	NWA; ICMA (Section 69); Municipal Systems Act	Database of new pollution sources and types of pollution	NMBM, DHSWS, DFFE	**H (1-3 years)**
Resuscitate Catchment Management Agency	NWA	Terms of Reference Minutes of meetings	DHSWS	**H (1-3 years)**
Undertake a study to understand and assess the conservation value of salt pans and economic opportunities.	ICMA; Sea-shore Act; Municipal By-laws	Study on salt pans Environmental Authorization for restoration of the salt pans	DEDEAT, NMBM, Academic Institutions; and Expert Groups	**M (1-3 years)**
Take appropriate steps to restore and manage salt pans from potential impacts.				**M (3-5 years)**
Establish a Scientific unit within the Municipality to conduct continuous monitoring of estuaries.	Municipal Systems Act	An established and resourced Scientific Services.	NBM	**M (3-5 years)**

4.3. BIODIVERSITY CONSERVATION

Estuary Protected Zone (as demarcated in the zonation map) incorporate a variety of habitats (e.g. wetland, inter- and supra-tidal salt marsh, sandbanks and mudbanks) and species and which would be closed to all forms of human disturbance. In the case of the Swartkops Estuary, the proposed protected zone will afford protection to the intertidal and supratidal salt marsh habitat and all their associated fauna & flora. This will include many of the targeted bait organisms as well as feeding (wading), breeding and roosting birds.

Municipal by-laws may be applied to protect habitats or resources, e.g. restriction of bait collection to daylight hours to avoid trampling of substrate at night when larval release and post-larval settlement are at a peak (mudprawns); restrict number of boats according to carrying capacity within designated zones; and no-wake zones.

Table 6: Biodiversity conservation

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Review and implement appropriate controls to manage boat wakes, propeller- wash and trampling to prevent undue disturbance on plant community, water birds and other associated impacts.	NEMBA Municipal By-laws	Updated municipal by-laws addressing the identified issued	NMBM & DEDEAT	**M** **(3-5 years)**
Map, monitor and manage illegal clearing and harvesting of indigenous bush/thicket, riparian vegetation and damage to salt marsh.	NEMBA; NFA	Maps and survey reports	NMBM, DEDEAT & DFFE: Forestry	**M** **(3-5 years)**

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Survey and manage alien and invasive vegetation within the EFZ	NEMBA; NWA; NFA	Reports and survey and management actions taken.	NMBM; DFFE, HSWS & SANBI	**M (Ongoing)**
Implement appropriate controls for bait collection (invertebrate species) to ensure no disturbance on recruitment of estuarine invertebrates.	MLRA Municipal By-law	Reports on compliance monitoring and enforcement undertaken	DFFE: Fisheries & NMBM	**M (Ongoing)**
Conduct bird surveys and develop bird species list, including species of special concern for the estuary.	NEMBA	Survey report,	Bird clubs, NMBM, SANBI, DEDEAT	**M (3-5 years)**
Ensure the effective management and conservation of waterbird species.		Reports on waterbird monitoring.		**Annually**
Investigate opportunities to protect key habitats including proclamation of Ramsar site	NEMPAA, Provincial legislation	Feasibility study,	NMBM, DEDEAT	**M (3-5 years)**
Investigate the feasibility of proclamation of the Aloes Nature Reserve;	NEMPAA EC Expansion Strategy	Feasibility study,	NMBM, DEDEAT	**M (1-3 years)**

4.4. LAND USE & INFRASTRUCTURE

Table 7: Land use and infrastructure

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Ensure that existing and future development (including slipways, jetties, bridges) and land uses in and around the catchment area, EFZ complies with applicable environmental legislation and municipal land-use plans and by-laws	NEMBA, NEMA, ICMA; NWA; SPLUMA; Sea Shore Act; Municipal Systems Act; Municipal By-law	Number of future developments with relevant environmental authorizations, permits and leases.	DEDEAT, NMBM, DFFE	**M (Ongoing)**
Restrict additional development in the EFZ	NEMA; ICMA; SSA; By Laws	No additional development within the EFZ	DEDEAT & NMBM	**H (Ongoing)**
Ensure incorporation of the Swartkops EMP into all development planning and land use management framework	NEMA; SPLUMA; Municipal Systems Act & tools	Zonation plan incorporated into all plans & tools developed in terms of NEMA, ICMA, SPLUMA, Municipal Systems Act.	NMBM, DEDEAT	**H (1-2 years)**
Provision of incentives for stewardship programs	Municipal property Rates Act	Rates rebate	NMBM,	**M (Ongoing)**

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Undertake an audit of existing structures within the EFZ	Sea-shore Act; ICMA; NEMA & By-laws	DEDEAT; NMBM	Database of structures within the estuary & the EFZ	**M (1-3 years)**
Ensure appropriate management of the Aloes waste transfer station	NEMWA; By-Laws	Report on compliance audits undertaken	NMBM & DEDEAT	**H (Ongoing)**
Develop and adopt flood lines for the estuary in order to assist with infrastructure planning and climate change adaptation.	Land Survey Act	Adopted floodline by the Municipality	NMBM & DALRRD	**M (3–5 years)**
Identify and manage heritage resources in the management area	NHRA	Database of heritage resources	SAHRA; ECHRA; NMBM; DEDEAT	**L (2–3 years)**
Manage access by developing single footpaths allowing access to the water's edge in the fishing area below the Wylde Bridge.	Municipal By-law, NEMA, Sea Shore Act.	Single footpaths developed	NMBM	**M (3–5 years)**

4.5. SUSTAINABLE USE AND PROMOTION OF SOCIO-ECONOMIC ACTIVITIES

- Promote the development of new initiatives that will benefit previously disadvantaged communities and that will comply with legislation and management plans that regulate against potential impacts on the management area, its inhabitants and users. These new initiatives could represent an opportunity for alternative livelihoods for the existing subsistence fishers in order to reduce the pressure on the estuary's' living resources.
- Promote a catch-and-release format for all fishing competitions; these should be managed on a measure & release basis; no weighing of fish prior to release to reduce stress and damage.
- Promote low-impact, non-consumptive activities such as hiking (and game trails), bird watching, canoeing and sports events.

Table 8: Sustainable use and promotion of socio-economic activities

MANAGEMENT ACTIONS	LEGAL REQUIREMENTS	PERFORMANCE INDICATOR	RESPONSIBLE AUTHORITY	PRIORITY
Consider a study to look at economic opportunities (e.g. day visitor facilities, boat tours, bird hides, tourism, bait selling outlets, small scale fishing, etc.) of the Swartkops Estuary.	Applicable National & Provincial legislation including Municipal by-laws	Permits issued for such activities	NMBM	**H (Ongoing)**
Regulate fishing competitions and partnerships.	MLRA; ICMA; By-laws	Permits issued to organizers of competitions	NMBM	**M (Ongoing)**
Ensure compliance of boat launch site	ICMA,	OEMP's	DEDEAT	**M (Ongoing)**

4.6. EDUCATION & AWARENESS

- Research projects (tertiary institutions) aimed at enhancing our existing knowledge and filling in knowledge gaps of the Swartkops Estuary and the Nature Reserves and thus the efficacy of the EMP through amended MAPs and monitoring programmes.

Table 9: Education and awareness

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Initiate series of workshops with relevant sectors and institutions	All relevant legislation	Keep records of number of workshops and attendance register	DFFE, DHSWS, NMBM, DEDEAT	**H (Ongoing)**
Ensure signage and notice boards are erected at access points (launch sites)	Municipal by-laws; ICM Act; NWA, Seashore Act; NEM:BA	Signage erected at key points	NMBM, DEDEAT, NGOs, DWS, DFFE, WESSA	**H (1-3 years)**
Host school group interactive tours	All relevant legislation	School awareness programmes conducted, and reports produced.	Zwartkops Conservancy, DEDEAT, Bay world	**M (Ongoing)**
Initiate awareness sessions and clean-up operations on a regular basis	NEM: WA	Records clean-up operations undertaken	DEDEAT; NMBM; NGOs & CBOs	**M (Ongoing)**
Identify key areas where research efforts should be concentrated (water quality, fishery surveys; sediments)		Research gaps identified and project proposals developed Partnerships and collaborations established- MoU and SLA developed	DEDEAT, DFFE, NMBM, DSI, academic and research institutions	**H (1-2 year)**

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Strengthen collaborations and partnerships with academic and research institutions for estuary projects		Research gaps identified and project proposals developed	DEDEAT, NMBM, Academic institutions	**H (1-3 years)**
Facilitate process for appointment and training of Honorary Fishery Control Officers (HFCO) and Voluntary Coastal Officers (VCO)	MLRA & ICMA	Number of HFCOs and VCOs appointed and trained	DEDEAT & DFFE	**M (3-5 years)**

4.8. CLIMATE CHANGE

- Planning should allow for the maintenance of a riparian zone along the length of the estuary where sensitive habitats (e.g. supratidal salt marsh and indigenous vegetation) occur. The inclusion of coastal management lines and Critical Biodiversity Areas in all planning schemes.
- No additional development (structures) on the floodplain (coastal protection zone; 1:100-year flood line) for safety reasons and sense of place.
- Developments and land use in the catchment and estuarine area should not lower water quality or interfere with normal hydrodynamic or sedimentary processes and cycles.
- Gradual retreat of existing structures from areas vulnerable to dynamic coastal processes.
- Ensure alignment and compliance with all climate change strategy documents available.
- Data from long-term monitoring programmes are needed to establish realistic climate change trends.

CHAPTER 5 - ZONATION PLANS

5.1 INTRODUCTION

The study area must be determined in terms of the Protocol and be depicted graphically on a map. Management objectives must be given effect through zoning the estuary for different purposes. Estuary spatial planning is critical in identifying sensitive areas and protecting them from activities that may have a significant impact on such areas. This ensures that there is no conflict between activities that take place within the study area and synergy amongst adjoining activities.

5.2 ESTUARY ZONATION PLAN

The estuary as defined in the ICM Act is as a body of surface water that is permanently or periodically open to the sea; in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water;

Further, the EFZ is defined in Listing Notice 3 (GNR 324: 2017) of the National Environmental Management: Environmental Impact Assessment Regulations defines the EFZ as “the area in and around an estuary which includes the open water area, estuarine habitat (such as sand and mudflats, rock and plant communities) and the surrounding floodplain area, as defined by the area below the 5 m topographical contour”. Therefore, the Estuary Zonation Plan (EZP) for this EMP covers the entire EFZ.

The EZP for the Swartkops Estuary is represented visually in Figures 2 to 8. The two broad zonation categories in this EMP are Protected & Conservation Zones as well as Habitat/Ecosystem Rehabilitation Zones. Within each of these categories, there are various sub-categories with specific management guidelines.

5.2.1 PROTECTED ZONES

The Protected Zones are established in order to protect the sensitive ecosystems within the Swartkops Estuary. No human activities may take place within the designated Protected Zones. This includes walking (also includes dogs), fishing, development, bait collecting and mooring of boats. Exemption may be obtained for *bona fide* scientific research.

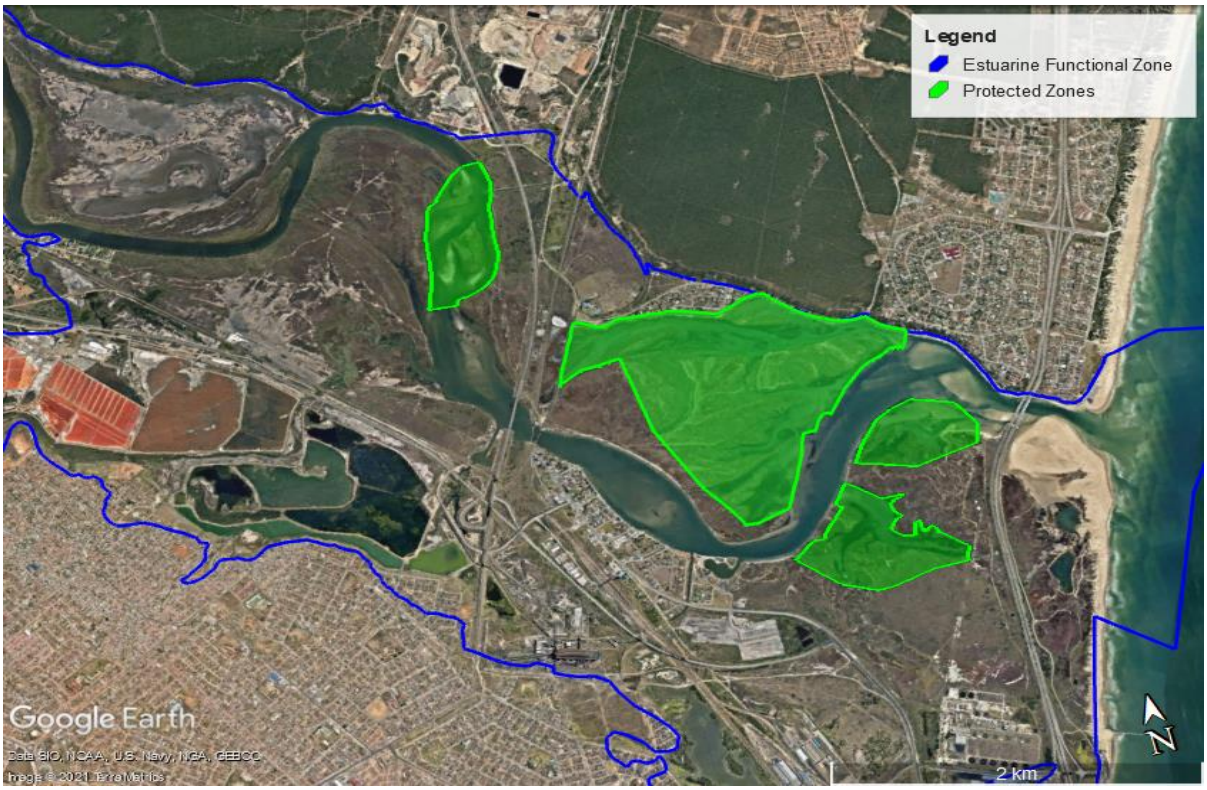

Figure 2: Designated Protected Zones

The Protected Zones were selected for the following reasons:

a. They include large intertidal salt marsh areas and considering that Swartkops has the third largest area of salt marsh in the country, it is important to protect some of this habitat. When inundated at high tides, these habitats also provide refuge and feeding areas for numerous organisms and contribute significantly to the organic and inorganic inputs into the system. The dominant species are *Spartina maritima,* with *Sarcocornia perennis, Chenolea diffusa* and *Limonium linifolium* accounting for the majority of the remaining cover. The area covered by intertidal salt marsh prior to any development has been estimated at 215 hectares (Colloty et al., 2000), but by 1939 approximately

45 hectares were lost when the Swartkops and Redhouse Villages were developed. By 1957 additional areas were lost to developments and salt marsh covered an area of 168 hectares. Since then, the area covered appears to have stayed fairly constant. The most recent assessment determined intertidal salt marsh to cover an area of 192.6 ha (Adams et al., 2021).

b. They include large sections of intertidal habitat that are heavily exploited by bait collectors. A survey by Fielding (2009) compared bait organism density in the intertidal areas below the railway bridge to density from a study in late 1970s (Hanekom 1980). Most of the collecting activity occurs in these lower reaches and in areas that are heavily exploited, mudprawns were on average at 50% of the density in 1980. Within the Protected Zones, mudprawn will be the principal bait organism that will be protected, but the other target organisms such as bloodworm, pencilbait, tapeworm, coralworm and tongueworm will also be protected.

c. The lower reaches of the Protected Zone are very important feeding areas for birds, particularly waders, with up to 40% of the estuarine associated bird species being concentrated in this area. Amongst these are the rare Terek and Curlew sandpipers and the Bartail Godwit.

d. The smaller supratidal Brickfields Island located above the Wylde Bridge has been proposed because it is an important breeding and roosting area for Kelp Gulls, Sacred Ibis and several pairs of African Black Oystercatchers. This small island is isolated in the middle of the channel and therefore easy to demarcate and monitor.

e. The submerged macrophyte *Zostera capensis* is found along the lower part of the tidal gradient and within the Northwest passage and contributes to the nutrient cycle and affords small and juvenile fish species a feeding and refuge habitat.

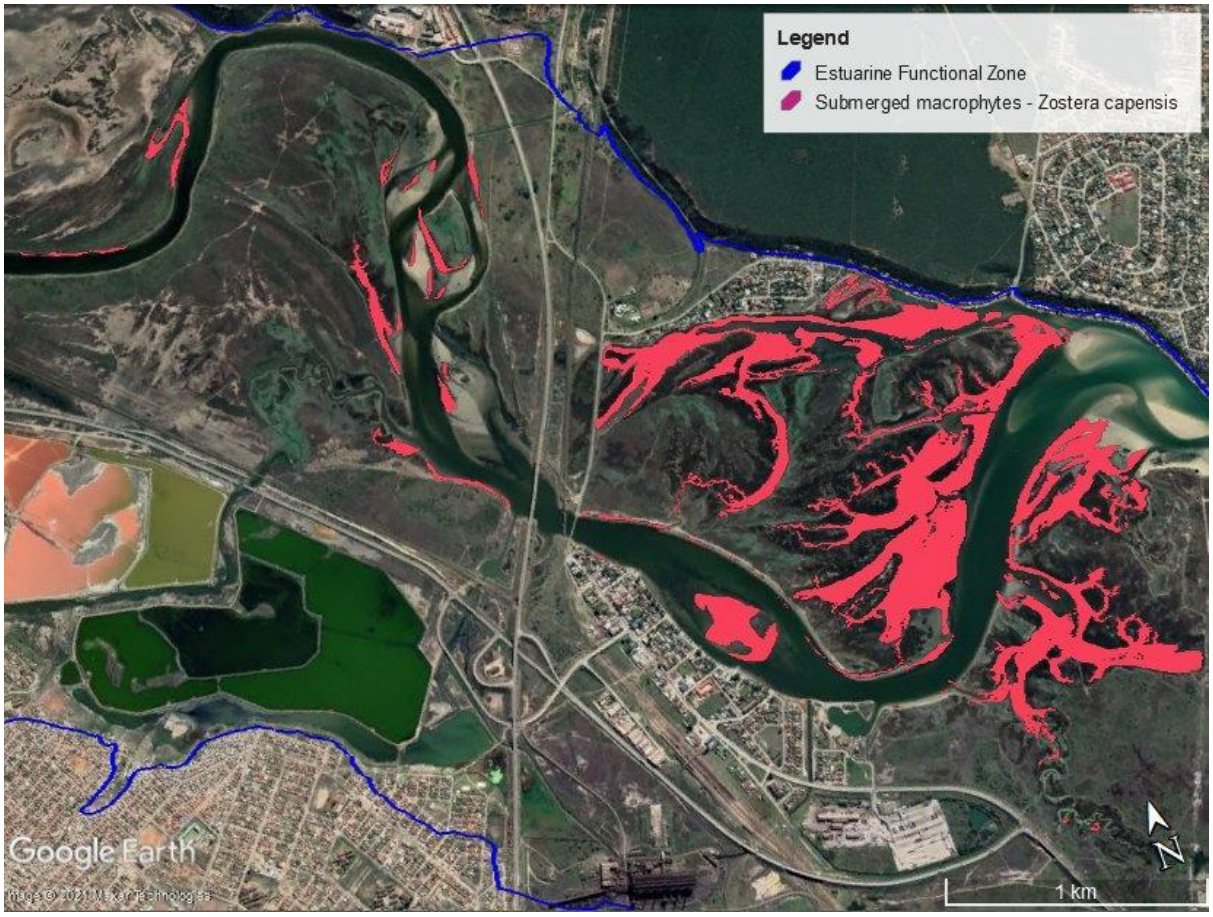

Figure 3: Distribution of *Zostera capensis* within the Swartkops EFZ

5.2.2. CONSERVATION OR MULTI-USE MANAGEMENT ZONES

The remaining zones or sections of the estuary water body, its associated habitats and the EFZ have been proposed as conservation areas. This does not mean that activities within these conservation zones are not allowed, but they will need to be regulated according to legislation, e.g. the Seashore Act (SA; Act 21 of 1935; and the associated EIA Regulations, NEMPAA, NEMA, ICM Act, MLRA, CARA, and Municipal by-laws, to ensure sound environmental practices that benefit the users and estuary. The 1:100-year flood line, which can also be used as a guideline to limit activities will also need to be considered.

Activities that would need to be controlled or restricted to specific areas include no fishing zones, freshwater fishing zones, no-wake zones.

No fishing zone

The no fishing zone is established to protect fish stocks by providing sanctuary areas to allow for the protection of the reproductive phase of fish and bait species.

The following activities **are prohibited** within this zone:

a) Fishing;
b) Bait collection;

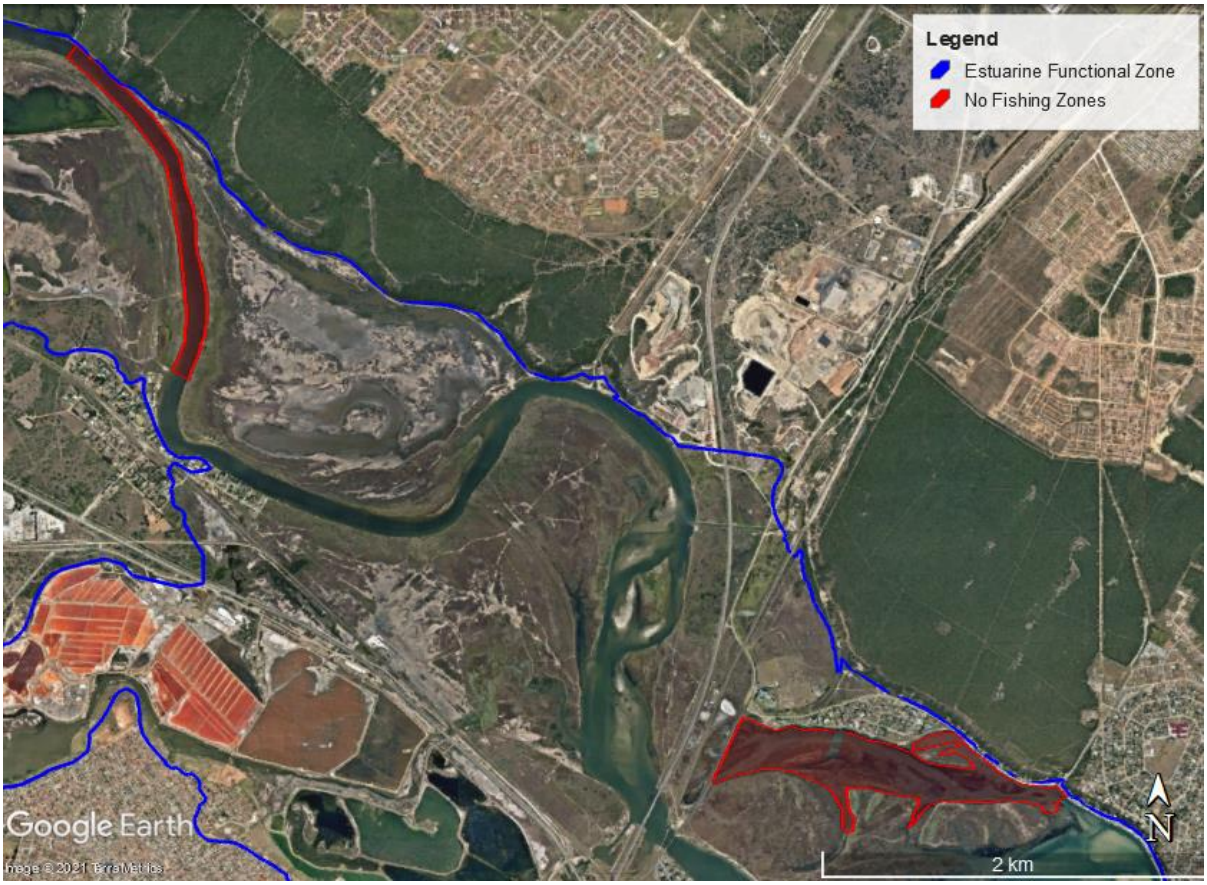

Figure 4: Areas zoned as no fishing zones

Freshwater fishing zone

The freshwater fish zone is established in order to allow for collection of **freshwater fish species only**. This zone is located close to the upper limit of the estuary. Collection of marine species is strictly prohibited in this zone.

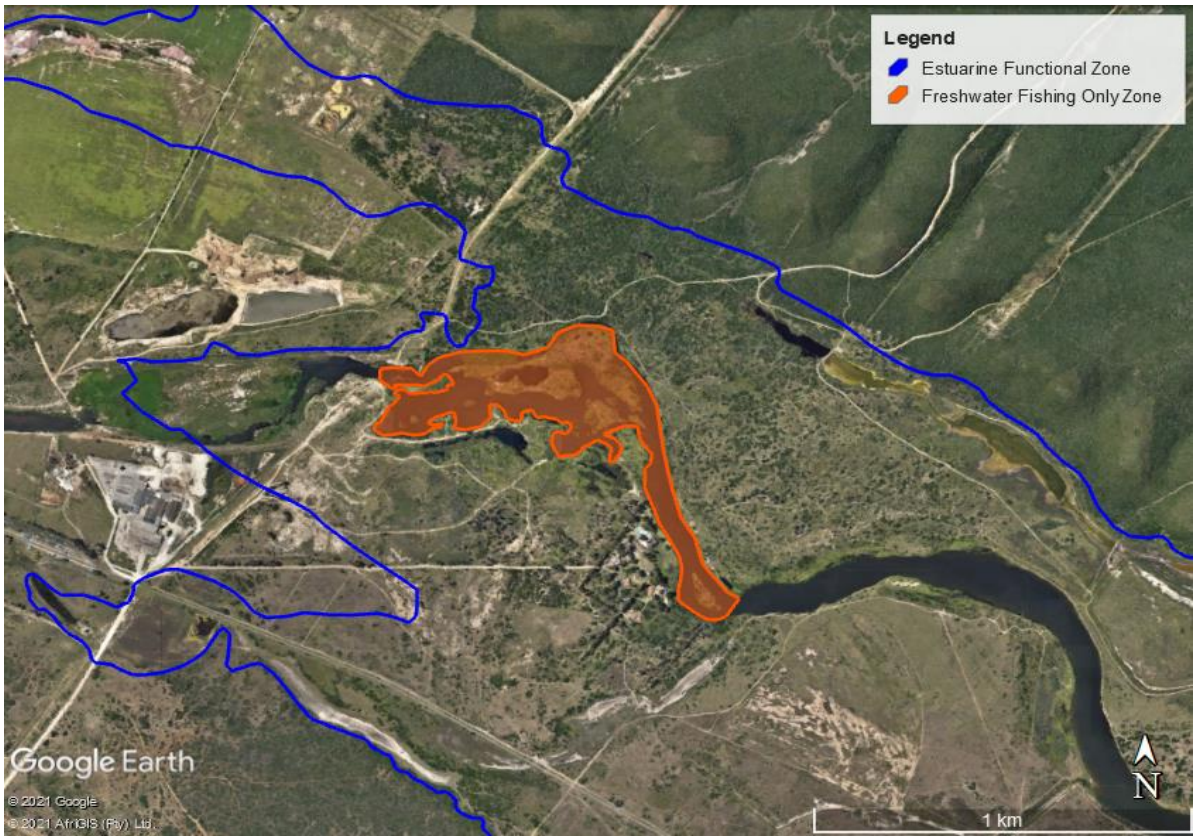

Figure 5: Areas zoned as freshwater fishing zones

No-wake zones

No-wake zones are established to protect the banks and the benthic habitat of the estuary. A vessel traversing a no wake zone must have engines at idle speed and not create a wake or waves behind.

Notwithstanding the above, the skipper of the vessel is required to comply with the Nelson Mandela Bay Municipality's Public Amenities By-Law.

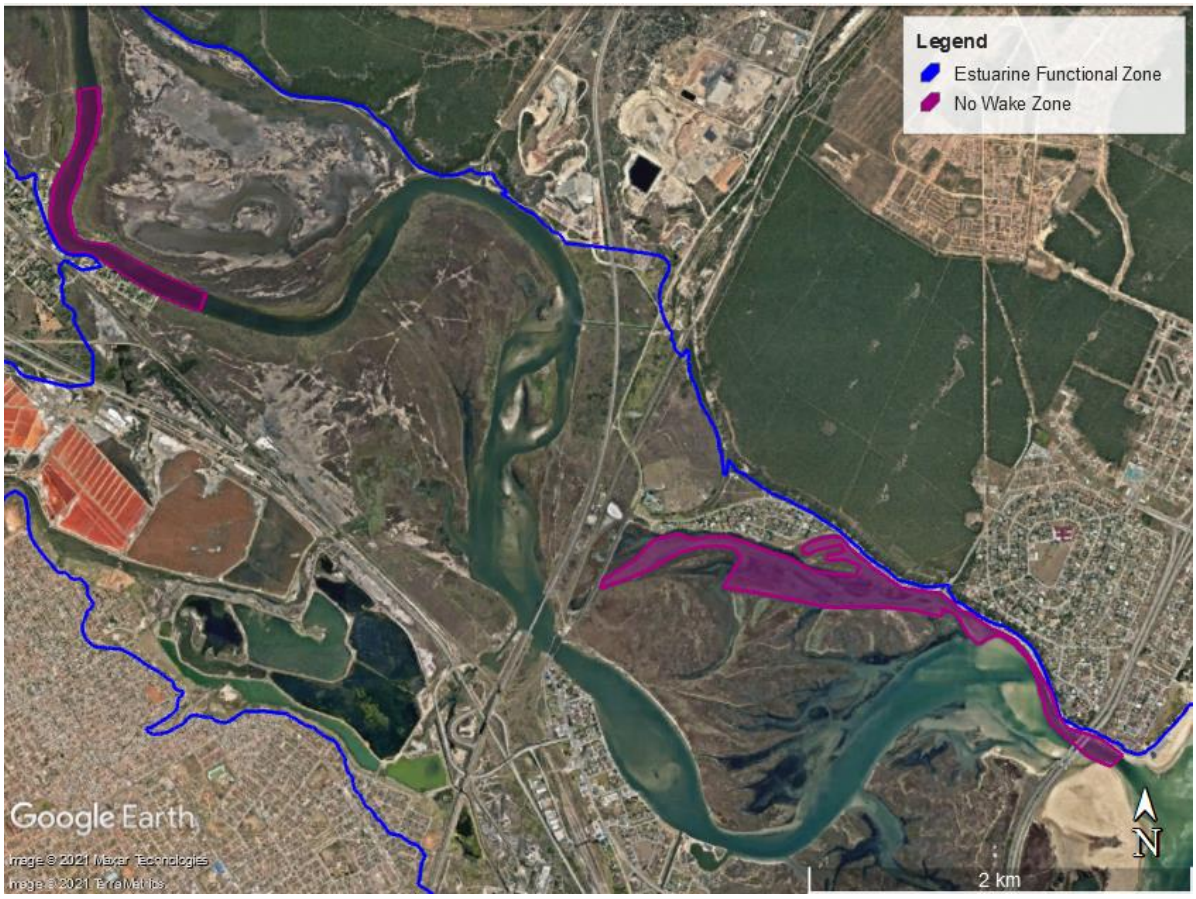

Figure 6: Areas zoned as no wake zones

5.2.3. HABITAT/ECOSYSTEM REHABILITATION ZONES

Rehabilitation, primarily in the form of alien vegetation removal, bank stabilization and improving degraded salt marsh areas will need to be addressed. However, although the removal of alien vegetation within the riparian estuarine area is seen as a priority this must not be done to the detriment of bank stability. Many sections of the estuary bank in the middle and upper reaches show signs of severe erosion and collapse. While flood waters are largely responsible for this, the situation may be exacerbated through the removal of stabilizing vegetation, structures that alter flow (e.g. Railway Bridge) and the movement of people and vehicles along the top section of the bank close to the water's edge. Tiger Bay is also in need of rehabilitation, as past attempts have not been entirely successful. Rehabilitation of the supratidal salt marshes in the Brickfields area and below the Wylde Bridge, where numerous footpaths have destroyed vegetation, needs to be prioritized.

Figure 7: Salt marsh areas that are impacted by trampling

There are also two sections of supratidal salt marsh located to the west of the R102 (south of Swartkops Village) that have been isolated from the estuary for a long period and consideration needs to be given for their rehabilitation.

Figure 8: Disturbed salt marsh areas

The effectiveness of the rehabilitation wetland project at Motherwell Canal (still at a trial phase) must be monitored and consideration given to a similar project in the vicinity of the Chatty River inlet, which is another major point source of pollution in the estuary. The EMP proposes that the Management Authority develops a rehabilitation plan for the salt pan area that falls within the protected area.

CHAPTER 6 – INSTITUTIONAL ARRANGEMENTS AND IMPLEMENTATION

6.1 INTRODUCTION

The development of this EMP is governed by the ICMA. The National Estuary Management Protocol (the Protocol) was published in terms of section 33(2) of the ICMA. Section 5 of the Protocol identifies the Provincial authority as responsible for developing the EMP for the Swartkops Estuary, which is done in consultation with the Municipality and other relevant stakeholders.

Section 34(1)(b)(ii) of the ICMA in turn requires that the EMP must be consistent with the National Coastal Management Programme and any applicable Provincial Coastal Management Programme and Municipal Coastal Management Programme. In addition, section (34)(1)(a) requires that the development of the EMP must follow the public participation process described in part 5 of chapter 6 of ICMA. Both National Coastal Management Programme (NCMP) and the Provincial Coastal Management Programmes have identified estuaries management as one of the key priorities for both spheres of government. The EMP has taken into consideration all requirements of the ICMA and the Protocol.

6.2. INSTITUTIONAL ARRANGEMENTS

The successful implementation of the EMP itself will depend on the implementation of suitable institutional arrangements and the participation of all stakeholders. DEDEAT will be the responsible management authority unless such responsibility is assigned by agreement to NMBM. Implementation is facilitated through a local management institution, which it is proposed to be called Swartkops Management Advisory Body (SEMAB). This SEMAB should be comprised of all relevant stakeholders and be headed by a Chairperson. The SEMAB will serve to keep all stakeholders informed of the progress and effectiveness of the EMP implementation, identify areas of concern and make recommendations that may need to be incorporated into later versions of the EMP, liaise with government departments to ensure that they fulfil their legal obligations and interact with tertiary & research institutions to help coordinate research programmes.

6.3 IMPLEMENTATION

The SEMAB must develop annual implementation plans that are linked to the management action plans in this EMP. The annual implementation plans must be made up of contributions from relevant stakeholders.

The SEMAB may also establish *ad hoc* technical working groups to deal with specific management issues as they arise within each of the key result areas. When a technical working group is established, it should have a representative from the relevant government department(s) which has a mandate in terms of legislation that is specific to the management issue or the relevant key result area, e.g. living resources should be represented by DFFE; conservation by DFFE and DEDEAT; land-use & infrastructure by DEDEAT, DFFE and the NMBM; and water quantity & quality by DFFE, DHSWS and NMBM. These working groups will focus on addressing issues as they arise.

The SEMAB and its members may also be directly involved with monitoring programmes by collecting data (physical measurements or visual observations) and can act as the eyes and ears for law enforcement authorities. All members of the SEMAB must be provided with a list of contact details for government department representatives who have the mandate to act so that they may be contacted whenever stakeholders observe activities that do not comply with the EMP requirements.

The monitoring and progress of the implementation of the EMP will be reported to the provincial and municipal coastal committees that were established in terms of Chapter 5 of the ICMA. Subsequent to the reporting, an annual report will be submitted to the Minister on the implementation of this EMP.

Table 10: Management strategy for institutional arrangements and implementation

Management actions	Legal requirements	Performance indicator	Responsible authority	Priority
Establish the Swartkops Estuary Management advisory body that is representative of all stakeholders, interest groups and government departments.	ICM Act	Approved TORs Minutes of meetings	Management Authority	**H** **(within 1 year)**
Ensure adoption of the EMP by the by DEDEAT	ICMA	DEDEAT Adoption	DEDEAT	**H** **(within 1 year)**
Ensure adoption of the EMP by the by NMBM for implementation	Municipal Systems Act	Council resolution adopting the EMP	NMBM & DEDEAT	**H** **(within 1 year)**
Provide annual implementation plans		Approved implementation plan	All stakeholders	**H** **(Ongoing)**
Implement zonation plan by erecting signage and physical markers (e.g. poles) demarcating different zones.	ICMA, Municipal Systems Act	Signage and/or marker erected	NMBM & DEDEAT	**H** **(1-3 years)**

CHAPTER 7 – INTEGRATED MONITORING PLAN

There are two components to monitoring, namely baseline monitoring programmes and long-term monitoring programmes, and it is important to note the difference between them in the context of the EMP framework (Taljaard and van Niekerk, 2007). Baseline monitoring programmes usually refer to short-term or once-off, intensive investigations of a wide range of parameters to obtain a better understanding of ecosystem functioning; they may also involve the investigation of non-ecological data to determine an existing situation with regards to compliance, land-use patterns, institutional & management structures, alternative livelihoods, tourism and education & awareness initiatives. These programmes would normally be a part of the Situation Assessment and the Objective-Setting Phases within the EMP framework. Knowledge gaps and programmes are also identified through the Situation Assessment process. In the context of this EMP baseline data is required in order to determine the effectiveness of the management actions described in chapter 4.

Long-term monitoring programmes refer to ongoing data-collection programmes that are done to evaluate continuously the effectiveness of management actions that are designed to maintain a desired environmental state. Long-term programmes usually involve biotic and abiotic components concerned with the biophysical aspects such as water quantity & quality, conservation and living resources. However, accumulated data from baseline programmes associated with land-use & infrastructure, management & institutional structures, sustainable use & promotion of socio-economic activities and education & awareness can be analysed over the long-term as well to ensure that the Vision for the Swartkops management area is achieved and maintained. Long-term programmes often form part of detailed scientific surveys or research projects conducted by tertiary and research institutions, but they may also take the form of less complex initiatives such as fisheries regulations compliance and activities in the context of the Zonation Plans or Municipal By-laws.

7.1. BASELINE PROGRAMMES

Baseline monitoring programmes are not required for all aspects of the EMP, e.g. establishing the SEMAB, amending the SDF to allow for a residential/conservation buffer zones, identification and evaluation of heritage resources and the Institutional & Management Structures. Some aspects of these baseline programmes, e.g. catch per unit effort (CPUE) and population (invertebrates and birds) monitoring will also form part of long-term programmes.

7.1.1. Resource Monitoring Plan

Resource monitoring refers to the monitoring of ecological indicators as measures of the general health of the estuary. It is therefore specifically aimed at establishing the effectiveness of the actions identified in the first five-year cycle of the EMP in terms of achieving the first goal of improving the ecological functioning of the estuary. This component may include water quality and quantity, sediment quality, biota, catchment condition etc. depending on the identified management actions in the EMP.

Table 11: Resource monitoring plan

Ecological component	Indicator	Timing	Target	Responsible authorities
Water Quantity: Record freshwater inflow at head of estuary	Mouth dynamics and estuarine water level	Once every two weeks and daily in the case of flood events	Recommended inflows according to reserve determination	DHSWS, NMBM & Institutions of Higher Learning
Water Quality: concentrations of water quality parameters.	Levels of sediments, nutrients, metal accumulation, and pollutants	Once every two weeks and daily in the case of flood events or spillage incidents	Compliance with set guidelines by DHSWS/DFFE guidelines for Marine Environment	DHSWS, NMBM & Institutions of Higher Learning
Changes in bathymetry as a measure of long-term sedimentation processes.	Depth profile of the estuary at selected sites;	Every three years or episodic flood events	maintenance of water body EFZ	DHSWS, DFFE, Institutions of Higher Learning
Frequency and location of fish & invertebrates kills; macro and micro algal blooms; non floating objects and surface contaminants; and areas with bad smells	Observe the occurrence and location of these impacts.	Observations can be made during normal activity	Location to be recorded and investigated	DFFE, DEDEAT & NMBM
Monitor municipal industrial and agricultural effluent	Water quality monitoring results	Monthly sampling at the point source and daily in the case spillages	Compliance with DHSWS & DFFE water quality standards	NMBM, DHSWS & DFFE
Coordinate and undertake integrated water quality monitoring	Integrated water quality monitoring plan that addresses sampling points and parameters.	Quarterly reporting	Coordinated water quality sampling activities amongst institutions	NMBM, DFFE, DHSWS, Institutions of Higher Learning, Research Institutions

Ecological component	Indicator	Timing	Target	Responsible authorities
Bacterial contamination in the estuary	Total coliform (*E. coli*) counts	Weekly sampling, prior to organized sporting events and when bad odours or sewage spills are noticed	Graphical display of bacterial contaminants	NMBM, DFFE, DHSWS, Event Organizers, Institutions of Higher Learning & Research Institutions
Maintenance of fish populations	Catch per unit effort (CPUE)	Seasonally (4 time per annum)	Fish population target has not yet been determined.	DFFE
Monitor vegetation cover within EFZ	Area & type of vegetation	Satellite images every 3 years	Improved vegetation cover within the EFZ	NMBM, DEDEAT, SANBI
Alien vegetation	Area of cover and species	Satellite Imagery every 3 years	Less than 10% of the EFZ infested with alien invasive vegetation	DFFE, DEDEAT, SANBI, NBMM
Monitoring programmes for selected water birds of special concern	Monitoring programmes of selected taxa.	Summer and winter count every year.	Abundance of population of selected taxa	Bird clubs, NMBM, SANBI, DEDEAT
Maintenance of invertebrate's populations	Population density	Seasonally	Number of random quadrants above low spring tide level.	DFFE, Institutions of Higher Learning & Research Institutions.

7.1.2 Compliance Monitoring

Compliance monitoring section intends to monitor effectiveness of the implementation of the EMP by monitoring the intensity and nature of the activities taking place or conducted within the Swartkops estuary, identification of the activities that are non-compliant with the applicable legislation, policies and guidelines as identified in the EMP.

Table 12: Compliance monitoring plan

Use/activity	Indicator	Timing	Target	Responsible authority
Ensure regular presence of law enforcement personnel on the estuary to deal with various transgressions (MLRA, NEMA, SEMAs, MPRDA, SSA Regulations, By-Laws,).	Records of incidents of non-compliance.	Ongoing	Reduced incidences of non-compliances	DEDEAT; DFFE; DHSWS; NMBM
Investigate legality of structures within the estuary and feasibility of leasing public land	Numbers of enforcement actions taken, or lease applications lodged	ongoing	Reduced incidences of non-compliances	DEDEAT; NMBM; DFFE
Compliance of legalized structures and/or developments with the conditions of licenses, permits and/or environmental authorisations.	Number of compliance monitoring reports	Ongoing	Increased compliance with condition of licenses, permits and / or environmental authorizations.	DFFE, DHSWS, DEDEAT, NMBM
Reduce solid waste (litter) from the catchment and the estuary. Identify sources of pollution	Volumes of solid waste collected the EFZ	Ongoing	Reduced solid waste in the EFZ	NMBM, DEDEAT, NGO

7.1.3. Performance Monitoring

This component of the integrated monitoring plan aims to assess the effectiveness of the overall implementation of the Swartkops EMP by determining whether the actions associated with each Management Objective have been achieved or not. The performance indicator allocated to each action will form the basis of the performance monitoring component.

Table 13: Performance monitoring plan

Management output	Indicator	Timing	Target	Responsible authorities
Operation of institutional mechanisms to drive implementation of the EMP.	Agenda and Minutes of established fora	Ongoing	Coordinated implementation of the EMP	DEDEAT, NMBM, DFFE, DHSWS, DMRE, Institutions Higher Learning, Research Institutions, NGOs
Manage development within the EFZ	Spatial and development plans comply with provisions of the EMP	Ongoing	Ensure all developmental activities taking place within the EFZ are compliant with relevant/applicable legislation.	DEDEAT, NMBM, DFFE
Increase public awareness of Swartkops estuary. Initiate series of workshops with relevant sectors and institutions	Records workshops, public awareness, clean-up campaigns and other initiatives conducted.	Ongoing	Increased number awareness activities conducted	NMBM, DEDEAT, DFFE & DHSWS,
Compilation of annual EMP implementation report	Implementation report	Annually	Annual Implementation Report submitted to Minister	DEDEAT
Prioritized research initiatives implemented	List of prioritized research initiatives	3-5 years	Increased body of knowledge for informed management of the system	DFFE, DEDEAT, DHSWS, Institutions of Higher Learning & Research Institutions
Implementation of the integrated monitoring plan	Report on monitoring undertaken	Annually	Implementation of all proposed monitoring activities.	DEDEAT

7.2. LONG-TERM MONITORING

Data gathered from long term monitoring programmes can be used as indicators of other management concerns, where the ecological reserve specifically is not responsible for the observed pattern or scenario. For example, the long-term monitoring of fish could reveal a decline in biodiversity or species richness that could be due to RQO parameters but could equally be due to human activities such as fishing, episodic events causing habitat change, seasonal migrations, national trends in fish populations or large-scale fluctuations in climate. Unlike baseline programmes where data can be gathered and in many instances analysed by SEMAB members, long term monitoring programmes tend to be the responsibility of government departments such as DHSWS & DFFE who may contract the services of Institutions of Higher Learning & research institutions such as CSIR, SAIAB, SAEON and Universities. However, at all times the SEMAB should be involved so as to ensure that programmes will be beneficial to the effective implementation of the EMP.

Long-term monitoring programmes for the following components are proposed, namely hydrology, sediment dynamics, hydrodynamics, water & sediment quality, microalgae, macrophytes, terrestrial vegetation, invertebrates, fish, birds and mammals. The protocols for carrying out these programmes has been taken from Taljaard and Van Niekerk (2007) and adapted to suit the Swartkops scenario where applicable.

Table 14: Long-term monitoring programmes for water and sediment

HYDROLOGY & HYDRODYNAMICS				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TIME SCALE**	**RESPONSIBILITY**	**COMMENTS**
Simulated data for run off and flood hydrographs	Head of the estuary, tributaries & discharge points (canals, stormwater discharges etc.).	**Runoff**- average monthly flows over a 50 to 80-year period. **Flood hydrograph** – hourly flows for duration of flood	DFFE & DHSWS	Used for initial reserve determination and not ling term monitoring.
Record river inflow.	Various points within the system (head, middle reach the mouth)	Continuous		To use methods that will not impede the hydrology of the system and migratory movements of aquatic organisms. Baseline data for inflow and water level are required for initial reserve determination and a minimum 5-year data set is recommended.
Record water level	Mouth area and four stations along estuary	Continuous		
Take satellite images	Entire estuary if possible, otherwise mouth area	Annually		
				To determine high water mark and other changes over time.

SEDIMENT DYNAMICS				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TIME SCALE**	**RESPONSIBILITY**	**COMMENTS**
Sediment grabs for particle analysis (size, composition)	Entire estuary at 1000m intervals	Every 5 years and after flood events	DFFE, DHSWS & Research Institutions.	Difference between long term equilibrium patterns and short-term variations need to be determined. Sediment processes are better monitored over the long term and floods may be infrequent and their effects only recorded in the long term
Take sediment cores for historical characterizations	Entire estuary; 50m intervals at mouth and 1000m intervals elsewhere.			
Bathymetric surveys for mouth dynamics and cross-sectional profiles.	Entire estuary; 50m intervals at mouth and 1000m intervals elsewhere.			
Lidar survey to capture topographic variability with 2 cm accuracy including ground truthing	Entire estuary (EFZ)			
Sediment loads	Head of estuary and middle reaches	Bi-weekly		
Monitor and accretion at the mouth of the estuary.	Mouth and lower reaches of the estuary.	Once every 2 years	DFFE, DEDEAT, Institutions of Higher Learning & Research Institutions.	
Monitor erosion within the estuary	Monitor banks (head, middle reaches and mouth).	Once every 5 years	DFFE, DEDEAT, Institutions of Higher Learning & Research Institutions.	

WATER & SEDIMENT QUALITY				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TIME SCALE**	**RESPONSIBILITY**	**COMMENTS**
River inflows – measure system variables, nutrients & toxic substances	Head of the estuary, tributaries & discharge points (canals, stormwater discharges etc.)	Bi-weekly	DFFE & DHSWS	Water quality parameters depend on riverine and marine waters and biochemical processes. Baseline data for water quality should be obtained from a minimum 5-year data set. Toxic substances accumulate and integrate over time; therefore sediments would provide the best evidence of elevated levels or build-up. Data collection can coincide with biological monitoring programmes to help with interpretation of biotic data
Sample nearshore marine environment water quality at the mouth	Immediate vicinity of the mouth or general nearshore/surf zone conditions (within zone of influence)	Monthly		
Estuary water quality – measure conductivity, pH, salinity, temperature, system variables & inorganic nutrients	Ten stations equally spaced along the estuary and one each in river and surf zone	Seasonally and/or at times during biological surveys	DFFE; DHSWS & NMBM	
Measure parameters at effluent discharge sites	At discharge site prior to entering estuary	Every 2 weeks		
Sediment samples for toxic substances (trace metals, microplastics, hydrocarbons, pesticides & herbicides)	Head of estuary and middle reaches	Annually	DFFE; DHSWS, NMBM & Research Institutions	
Collect in situ continuous salinity data with mini Conductivity-Temperature-Depth (CTD) probe at a depth of 1 m at the mouth, Redhouse & Perseverance	Three sites – mouth, middle & supper reaches	Continuous	DFFE; DHSWS, NMBM & Research Institutions	
Collect surface and bottom water samples for inorganic nutrients (and organic nutrients) and suspended solid analysis, together the in-situ salinity, temperature, pH, dissolved oxygen and turbidity profiles	Entire estuary (6 stations, coinciding with microalgae and invert sampling sites)	Seasonally		

Table 15: Long-term monitoring programmes for plants

MICROALGAE				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Phytoplankton biomass – Chlorophyll-a measurements (proxy for phytoplankton biomass, i.e., 3 replicates each) taken at the surface (0 m, 0.5 m and/or 1 m) and bottom-water depths	Ten stations equally spaced from mouth to head of the estuary	Seasonally	DFFE; SANBI; Research Institutions; Institutions of Higher Learning	Combine sampling times when water & sediment quality studies are done; also coincide with invertebrate sampling to help with implementation of zooplankton data
Benthic microalgae – Intertidal and subtidal benthic chlorophyll-a measurements (proxy for MPB biomass, i.e., 4 replicates each)				
Measure salinity, inorganic nutrients, sediment particle size distribution & organic content and light penetration at each site				

MACROPHYTES				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Satellite Images – record number of plant community types, area covered by each, historical changes in community distribution & size and extent of anthropogenic impacts. Check fragmentation of habitats from trampling and footpaths. Check for increase in bare areas in salt marsh habitat from mapping	Estuarine Functional Zone	Summer survey every three years	SANBI; Research Institutions; Institutions of Higher Learning	The following plant habitat types are relevant to the Swartkops; open surface water, intertidal sand & mudbanks, submerged microphyte beds, microalgae, intertidal and supratidal salt marsh and reed sedges
Field data for ground truthing of satellite images – Record number of plant community types, area covered by each, particularly the seagrass (*Zostera capensis*) beds., species list within each community and extent of anthropogenic impacts. Assess extent of invasive species within the 5 m contour line and extent of Invasive alien aquatic plants (IAAPs) in the upper reaches using fixed point photography and aerial imagery..				
Permanent transacts at reference sites - record changes in plant habitat and use quadrants to determine percentage change in species composition within communities. Percentage plant cover measured in duplicate 1 m^2 quadrats along the transects and an elevation gradient from the water to the terrestrial habitat. These transects to be associated with RSET to check whether salt marshes are eroding or accreting (climate change monitoring). Specific data along transacts to include elevation and water level, salinity & turbidity, sediment salinity, composition, pH, redox potential, electrical conductivity, , organic and moisture content.	At least two transects each in lower and middle reaches covering dominant habitats, e.g. Salt marshes, *Zostera* beds and reeds/sedges. Additional transects as needed where communities sensitive to freshwater flow are located.		SANBI; Research Institutions; Institutions of Higher Learning	

TERRESTRIAL VEGETATION				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Satellite images – record of plant community types, area covered by each historical change in community distribution & size and extent of anthropogenic impacts.	EFZ	Annually	SANBI; Research Institutions; Institutions of Higher Learning	All indigenous vegetation types should be monitored. Historical records can be used as a baseline.

Table 16: Long-term monitoring programmes for invertebrates, fish, birds, amphibians and mammals

INVERTEBRATES				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Zooplankton – quantitative duplicate samples at night during neap tides using net trawls pulled diagonally across the estuary; record species composition and abundance. Collect phytoplankton and benthic microalgae at each site for chlorophyll-a analysis.	One station in the river; other stations within defined salinity zones (0 – 10ppt, 10-20ppt and 20-35ppt); minimum of ten stations long estuary length. Stations in each site should include dominant habitats, bird feeding areas and areas vulnerable to changes in river inflow.	Every two years mid-summer	SANBI; Research Institutions; Institutions of Higher Learning	High variability in invertebrate response to flow and rapid changes in community composition and species abundance requires a long-term data set for baseline data. Sampling stations should try overlap macrophyte sites to link invertebrate patterns to habitat types. Coordinate sampling with water & Sediment quality surveys for cost-effectiveness and interpretation of patterns.
Benthic invertebrates – subtidal samples collected by grab; intertidal samples using core-sampler or quadrant counts for burrow density; minimum of five replicates per site. Identify all to species level, record density and abundance and if *Zostera* is present at same sites as zooplankton. Sediment samples at each site to be analysed for particle size and organic content (at same sites as zooplankton)				
Microcrustaceans – Intertidal prawn hole counts using 0.25 m^2 grid (5 replicates per site) at the same sites used for zooplankton.. Establish the species concerned using a prawn pump. Supratidal crabs to be included.			SANBI; Research Institutions; Institutions of Higher Learning	

FISH				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Fish community- sampling gear needs to suit habitat types. Seine or sonar will be primary gear, but also otter trawls (deep channels), cast nets and Fyke nets (strong flow and dense vegetation). Seine net specifications: 30 m x 2 m, 15 mm bar mesh seine with a 5 mm bar mesh with a 5mm bar mesh 5 m either side and including the cod-end Trawl specification: 1.5 m wide by 3 m long, 14 mm bar nylon mesh in the main net body and a 6 mm bar in the cod-end Record species composition, abundance, distribution and length frequencies. Sub samples may be required for feeding, reproduction and genetic studies. Monitoring must include status of alien invasive fish species in the upper reaches of the estuary as well as in the REI zone to understand the influence of HABs.	Stations in the river, at least ten spread over representative salinity zones (0-10ppt, 10-20ppt, 20-30ppt and 30-35ppt); stations in each zone must include all the major habitats	Seasonally. Additional sampling after any fish kill.	DFFE: Fisheries, Institutions of Higher Learning & Research Institutions.	Non-destructive sampling to be carried out where possible, i.e. measure and release. Multiple gears are required to ensure the entire community is sampled. Sampling should coincide with water quality surveys. Fish are good indicator species and respond rapidly to changes in flow regime but may be more tolerant to substances that are harmful to other organisms (plants and invertebrates) and may also not be s susceptible to pollutants or other toxins as they are mobile and car swim away.

MAMMALS				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Visual census of mammals to include species richness and abundance (special note of rare or endangered species), state of habitat, level of human activity/disturbance and breeding activity/success	EFZ	Annually	Institution of Higher of Higher Learning & Research Institutions	Annual counts are necessary to account for long-term variability that may have cycles of than a year. the decline in numbers or disappearance of species listed as threatened, rare or endangered should be the priority are of concern.
BIRDS				
Divide estuary into sections based on habitat types and within each section at low tide record species and abundance (special note of rare or endangered species), state of habitat, level of human disturbance, breeding activity and nesting sites. (include upstream sites particularly to document changes in response to restoration activities).	EFZ including surf zone at mouth to beyond backline breakers and 500m either side of the mouth position.	Summer and winter count every year.	Bird clubs, NMBM, SANBI, DEDEAT	Sections where counts take place must be labelled as a “distance from mouth”; summer counts to be done outside of holiday period, preferably February/March; annual counts are required to detect cycles of variability which may have three year periodicity; seasonal counts required for migratory species. Birds are good indicators species for large permanent open estuaries.

AMPHIBIANS				
SAMPLING PROCEDURE	**SPATIAL SCALE**	**TEMPORAL SCALE**	**RESPONSIBILITY**	**COMMENTS**
Audio-visual census of amphibians as well as capture-recapture method to include species diversity and abundance (special note of rare or endangered species), state of habitat, level of human activity/disturbance and breeding activity/success	EFZ	Annually.	DEDEAT, Institutions of Higher Learning & Research Institutions.	Annual counts are necessary to account for long-term variability that may have cycles of more than a year. The decline in numbers or disappearance of species listed as threatened, rare or endangered should be the priority area of concern.

7.3 EVALUATION

Evaluation of the implementation of the EMP will become the responsibility of the SEMAB. It will be the responsibility of the SEMAB to produce an implementation report at the end of each year. The EMP in its current form will be reviewed **after five years**.

CHAPTER 8 - RESEARCH

The following research needs that should fill the knowledge gaps and provide supplementary data for monitoring programmes have been identified and should be initiated as soon as possible. Although a wealth of information is available, particularly for the Swartkops Estuary, much of it is outdated, and new research efforts are needed to update our knowledge of the system. The local management forum may approach tertiary and research institutions such as Universities, the CSIR and NRF institutions such as SANCOR, SAIAB and SAEON to create an awareness of what is required. There may be a degree of overlap with the long-term monitoring programmes defined in Section 8 above.

Sediment and hydrodynamics

- Sediment accumulation below the Wylde (Railway) Bridge.
- Tidal flows, salinity intrusion and freshwater inflow in the upper reaches (the effect of the removal of the Perseverance causeway on the extent of the REI).

Water quality

- The effects of poor water quality (sewerage and heavy metals) on ecosystem functioning including the nursery function of the estuary
- The response of salt marsh to nutrient enrichment.
- The occurrence of HABs and influence on higher trophic groups.
- Factors driving the transport and fate of plastics, particularly microplastics (< 5 mm).
- The potential role of HABs and IAAPs in trapping microplastics.
- Impact of microplastics on living organisms, including waterbirds.
- Impact of the Aloes Waste transfer station on the estuary.
- The distribution of persistent organic pollutants that include pesticides and fertilizers as well as pharmaceuticals and the influence on human health.

Rehabilitation

- The effect of the removal of the Perseverance causeway on the biological community of the estuary. This will improve the extent and influence of the REI. There should be significant impacts on the productivity, primarily in the upper reaches, which will have a knock-on effect on the entire system.

Fishing

- Fishery survey comprising bait organisms and fish. Key elements include fishing/collecting effort, catch per unit effort (CPUE), user dynamics, target fish species, catch composition, bait utilization in relation to existing regulations (waste), motivation for using resource, economic value of the fishery, degree of compliance and conflict between different fishing fraternities.

Bait exploitation

- Bait exploitation and the effect on targeted species requires ongoing investigation.
- A multi-disciplinary study aimed at resolving the issues surrounding the subsistence bait fishery; to cover social, economic and resource-based aspects and determine whether this industry is sustainable at present levels of effort (permit numbers and quotas) and with existing collecting methods (e.g. digging). The feasibility of a commercial farming venture should also be investigated. Recommendations on sustainable levels of effort and recommendations for alternate livelihoods for participants can be made.
- Invertebrate organisms - population density (in and outside protected areas and in open-access areas), recovery periods after disturbance (collecting and trampling that alter habitat), impact of various collecting methods (pumps vs. digging), community structures before and after disturbance, effect of pollutants in the sediment, mortality due to birds foraging after collection activities, effect on birds by bait collectors and larval settlement times and location along the tidal cross-section. Certain species such as pencil bait, tapeworm and bloodworm have been decimated in some areas and it appears that current levels (and methods) of exploitation are not sustainable.

Zonation and protected areas

- Effectiveness of estuary Protected Areas with regards to invertebrate populations, health of estuarine habitat and birds (species richness and breeding success).
- The importance of Tippers Creek (and the *Zostera* beds) to the overall functioning of the estuary and the effect of power-driven vessels (both at speed and at no-wake speeds) on this section of the estuary.
- A comparison between biodiversity and habitat health within the estuary protected areas compared to rest of the system.

Ecological water requirements and Resource Quality Objectives (classification)

- A Comprehensive Reserve Assessment as required by DWS to substantiate the results from the Intermediate study that has been conducted. This will be required if the Vision of a Category C/B system is to be realized.
- Long term monitoring of habitats and community structures in relation to RQOs to determine requirements and effectiveness of the ecological reserve.

Climate change

- Habitat transformation in response to climate change.
- Impacts of climate change on estuary and ecosystem-based adaptation.
- Long-term monitoring of response of salt marsh to climate change and human impacts.

Economic value

- Study on the economic value and opportunities (Salt pans, recreational activities, property value, fishing, bait collection, etc.)

Users and user conflict

- The carrying capacity of the estuary needs to be determined so that the SEMAB can make an informed decision about the numbers of users utilizing the system at any given time. Some data can be collected as part of the fishery survey, but some aspects such as sense of place, pollution due to engine emissions and incidents of confrontation between all user groups will need to be addressed by a dedicated project.

Education and awareness

- A social based project to determine the effectiveness of the education & awareness programme and the attitude toward the EMP and those management actions which have directly affected users, e.g. restricted access to sanctuary areas.

Rehabilitation / Restoration

- Rehabilitation of the abandoned salt pans including wetting with water from Motherwell Canal.
- Rehabilitation of the riparian zone including removal of invasive plants.
- Restoration research using a socio-ecological systems approach.

CHAPTER 9 - REFERENCES

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