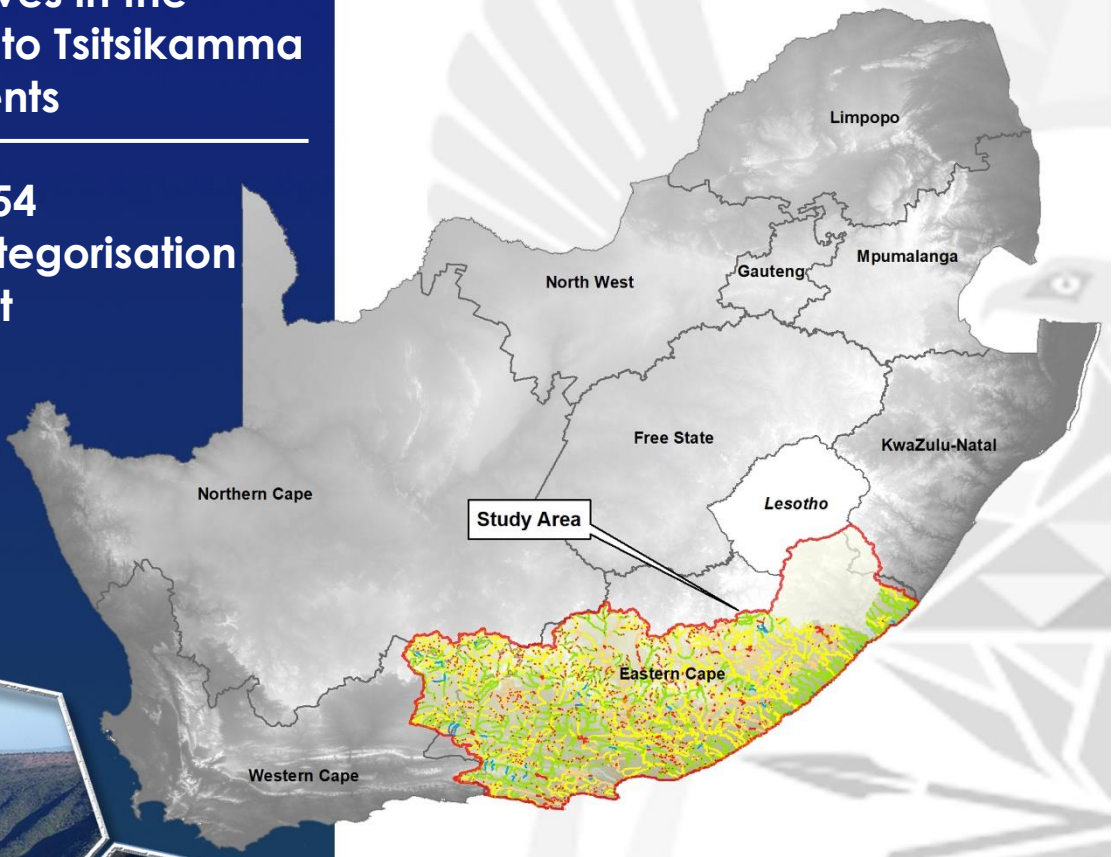
DEPARTMENT OF WATER AND SANITATION

Determination of Water Resource Classes, Reserve and the Resource Quality Objectives in the Keiskamma and Fish to Tsitsikamma Catchments

WP11354
Estuaries Eco-categorisation Report



REPORT NO.:
WEM/WMA7/00/CON/RDM/2024

October 2024

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Published by

Department of Water and Sanitation
Private Bag X313
Pretoria, 0001
Republic of South Africa

Tel: (012) 336 7500/ +27 12 336 7500
Fax: (012) 336 6731/ +27 12 336 6731

Copyright reserved

No part of this publication may be reproduced in any manner
without full acknowledgement of the source.

This report is to be cited as:

Department of Water and Sanitation, South Africa. October 2024. Determination of Water Resource Classes, Reserve and RQOs in the Keiskamma and Fish to Tsitsikamma catchment: Estuaries Eco-categorisation Report Volume 1. Report No: WEM/WMA7/00/CON/RDM/2024.

Prepared by:

Council for Scientific and Industrial Research (CSIR), Nelson Mandela University (NMU), South African Institute for Aquatic Biodiversity (SAIAB), Department of Forestry, Fisheries & the Environment (DFFE)

GroundTruth

Title:	*Estuaries Eco-Categorisation Report*
Authors:	*Van Niekerk L, Taljaard S, Adams JB, Lemley D, James N, Lamberth SJ, Rishworth G, Riddin T*
Project Name:	*Determination of Water Resource Classes, Reserve and RQOs in the Keiskamma and Fish to Tsitsikamma catchment: WP11354*
DWS Report No.:	WEM/WMA7/00/CON/RDM/2024
Status of Report	*Final*
First Issue:	*6 September 2024*
Final Issue:	*8 October 2024*

Approved for Groundtruth: Environment and Engineering

…… …….

Dr Mark Graham *Date*

Director, GroundTruth

Supported by:

…… ……

Project Manager *Scientific Manager*

Approved for the Department of Water and Sanitation by:

……..

Director: Reserve Determination

DOCUMENT INDEX

Reports as part of this project:

Bold type indicates this report

INDEX	REPORT NUMBER	REPORT TITLE
1.0	WEM/WMA7/00/CON/RDM/0121	Inception Report
2.0	WEM/WMA7/00/CON/RDM/0222	Water Resources Information, Gap Analysis and Models Report
3.0	WEM/WMA7/00/CON/RDM/0322	Status quo and delineation of Integrated Units of Analysis Report
4.0	WEM/WMA7/00/CON/RDM/0422	Resource Units Prioritisation Report
5.0	WEM/WMA7/00/CON/RDM/0522	Wetland Survey Report
6.0	WEM/WMA7/00/CON/RDM/0622	Groundwater Survey Report
7.0	WEM/WMA7/00/CON/RDM/0722	River Site Verification and Survey Report 1
8.0	WEM/WMA7/00/CON/RDM/0822	Linking the Socio-Economic and Ecological Value and Condition of the Water Resource/s
9.0	WEM/WMA7/00/CON/RDM/0922	Basic Human Needs Report
10.0	WEM/WMA7/00/CON/RDM/1022	Estuary Site Verification and Survey Report 1
11.0	WEM/WMA7/00/CON/RDM/1122	Groundwater PES and Quantification of the Reserve Report
12.0	WEM/WMA7/00/CON/RDM/1223	Wetland Eco-categorisation Report
13.0	WEM/WMA7/00/CON/RDM/1323	Final Groundwater Report
14.0	WEM/WMA7/00/CON/RDM/1423	River Site Verification and Survey Report 2
15.0	WEM/WMA7/00/CON/RDM/1523	Estuary Site Verification and Survey Report 2
16.0	WEM/WMA7/00/CON/RDM/1623	Final Wetland Report
17.0	WEM/WMA7/00/CON/RDM/1723	River's Eco-categorisation Report – Volume 1
18.0	WEM/WMA7/00/CON/RDM/1823	River's Eco-categorisation Report – Volume 2
19.0	WEM/WMA7/00/CON/RDM/1923	Ecological Water Requirements quantification for rivers Report
20.0	**WEM/WMA7/00/CON/RDM/2024**	**Estuaries Eco-categorisation Report**

ACKNOWLEDGMENTS

The project team would like to acknowledge the following people (in no particular order) for their contributions towards the overall project but especially during the estuary surveys programmes held in April and May/June 2024:

Department of Water and Sanitation (DWS):

- Lawrence Mulangaphuma
- Rendani Mudzanani
- Ncamile Dweni
- Elliot Weni
- Barbara Weston

Nelson Mandela University (NMU):

- Rachel Kibble – Bird counts and data collation
- Riaan Weitz - Soil Carbon, aerial photographs, field assistance
- Priscah Lakane - Microalagae, macrophytes, alien invasive plants
- Julia Penaluna - Literature review, physical processes, invertebrates
- Anesu Machite - Mangroves and saltmarshes

South African Institute for Aquatic Biodiversity (SAIAB):

- Thembani Mkhize - field assistance, fish identification and data collation

Fisheries and the Environment (DFFE):

- Corne Erasmus - field assistance, fish identification and data collation
- Carlo Williamson - field assistance, fish identification and data collation

Groundtruth:

- Catherine Meyer – Land-use change spatial analysis

LIST OF ACRONYMS

BAS	Best Attainable State
BHN	Basic Human Needs
CD: WEM	Chief Directorate: Water Ecosystems Management
DFFE	Department of Forestry, Fisheries and the Environment
DIN	Dissolved Inorganic Nitrate
DIP	Dissolved Inorganic Phosphate
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EFR	Environmental flow requirements
EFZ	Estuary Functional Zone
EHI	Estuarine Health Index
EI	Ecological importance
EIS	Estuary Importance Score
ES	Ecological Sensitivity
EWR	Ecological Water Requirements
GBF	2030 Global Biodiversity Framework
HABs	Harmful algal blooms
ICM	Integrated Coastal Management
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
MAR	Mean Annual Runoff
MPA	Marine protection area
MSL	Mean Sea Level
NWA	National Water Act
N SWSA	National Strategic Water Source Areas
NWRCS	National Water Resource Classification System
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RQO	Resource Quality Objectives
Snc	Scenario
WRCS	Water Resource Classification System
WWTW	Waste Water Treatment Works

EXECUTIVE SUMMARY

Background and Purpose

This phase forms part of the following study: Determination of Water Resource Classes, Reserve and the Resource Quality Objectives in the Keiskamma and Fish to Tsitsikamma Catchments. The purpose of this study is to determine appropriate Water Resource Classes, the Reserve and associated Resource Quality Objectives (RQOs) for all significant water resources in the study area to facilitate sustainable use of the water resources while maintaining ecological integrity. The aim is to implement the Water Resource Classification System (WRCS) (as per Regulation 810, 2010) to determine the Water Resource Classes, following the integrated framework (DWS, 2017), undertake the 7-step process to determine and set RQOs, and determine the Reserve for the water resources of the study area. This will ultimately assist the DWS in the management of the water resources in the study area and making informed decisions regarding the authorisation of future water use and the magnitude of the impacts of proposed developments.

The initial phase of this study included the identification of integrated Units of Analysis (IUAs), of which 19 were identified, followed by identifying “hotspots” which indicated the areas where EWR sites would be required to be quantified for the rivers. Consequently, the main rivers within these areas were selected and delineated in Management Resource Units (RU) (Report No. WEM/WMA7/00/CON/RDM/0422). It was these RU’s for where the required Ecological Water Requirements (EWRs) would be quantified. The primary focus of *this report* is the ecological categorisation (eco-categorisation) of all identified priority estuaries within the RUs.

Scientific data was collected on both the driver components (abiotic and water quality) and the response components (fish, aquatic macroinvertebrates, macrophytes, birds and microalgae). This data was collected during three (3) estuary surveys conducted in December 2023, April and May/June 2024. The use of this present data, concerning reference data was subsequently analysed, for the purpose of conducting the eco-categorisation process on all prioritised estuaries, to determine the ecological categories at these sites. The next report will then be the EWR quantification, setting of flow regimes to maintain different ecological states.

STUDY AREA AND LOCATION OF PRIORITY ESTUARIES

Overall, there are 155 estuaries in the study area. Ten of the estuaries in the WMA have been the focus of previous Environmental Flow Requirement or EWR studies, albeit it is of low confidence in some cases. An additional seven estuaries are being assessed in more detail as part of this study to address gaps in the water resources classification process, with the selection influenced by identified water resources pressure (current or future), estuary ecological importance, requests from other sectors of government, and available study resources. The seven priority estuaries for rapid/comprehensive EWR assessments that will be done in more detail include:

- Mngazi
- Mbashe
- Great Kei
- Keiskamma
- Kariega

- Gamtoos
- Kabeljous

See **Figure 1** for the location and relative catchment size of the 7 priority estuaries.

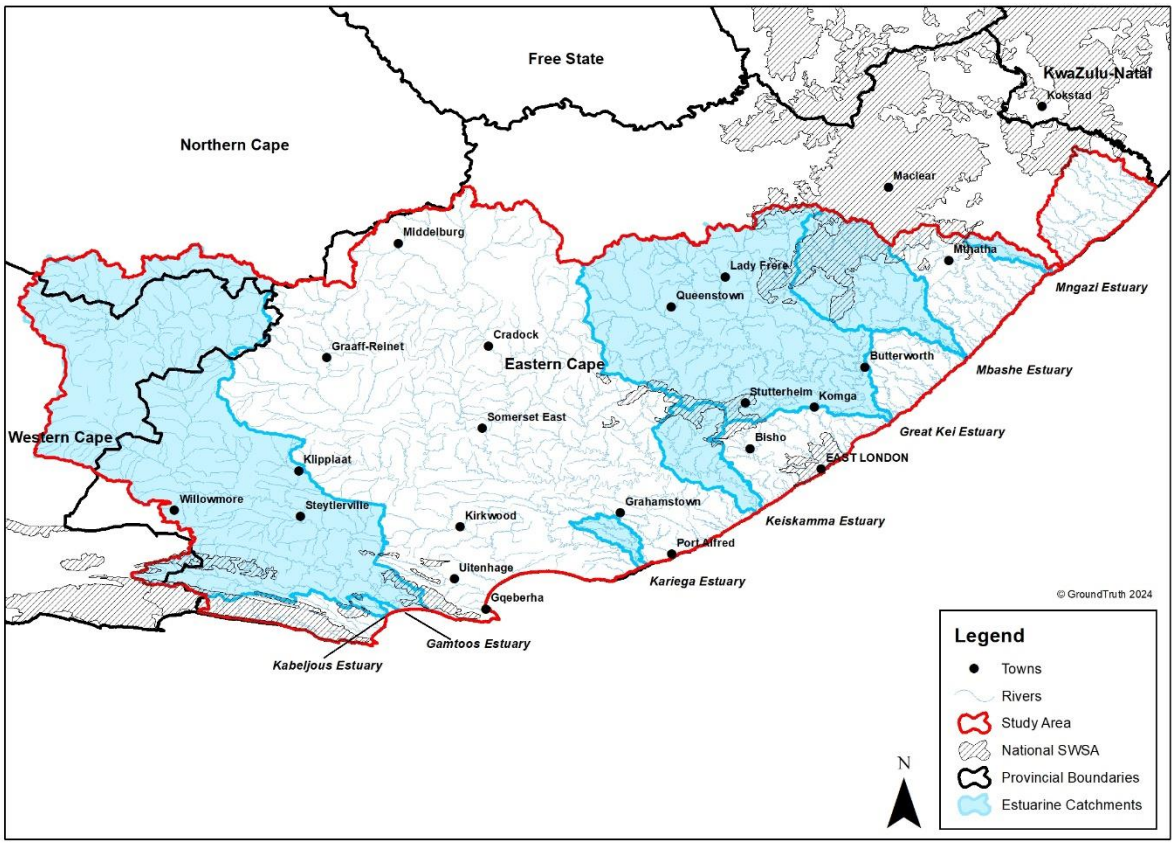


Figure 1: *Overview of the priority estuary catchments.*

Approach and Methodology

Methods to determine the ecological water requirement for estuaries were established soon after the promulgation of the National Water Act (NWA) in 1998. The "Preliminary Reserve Method" involves setting a Recommended Ecological Category (REC) (i.e. desired state), recommended Ecological Reserve (i.e. flow allocation to achieve the REC) and recommended RQOs for a resource on the basis of its present health status and its ecological importance. The official method for estuaries (Version 2), is documented in DWA (2008). In 2013, an unofficial Version 3 of the method was published, as part of a Water Research Commission study (Turpie *et al*., 2012a,b). The study uses Version 2 of the methodology (DWA, 2008), but with consideration of obvious improvements proposed in Version 3 (Turpie *et al*., 2012a,b) and Taljaard *et al*. (2022). The generic steps of the official "Ecological Reserve Method" for estuaries were applied as follows:

- Step 1: Initiate a study defining the study area, project team and level of study (confirmed in the **inception report** of this study).

- Step 2: Delineate the geographical boundaries of the resource units (confirmed in the **delineation report** of this study).

- Step 3a: Determine the **Present Ecological State** (PES) of resource health (water quantity, water quality, habitat and biota) assessed in terms of the degree of similarity to the reference condition (referring to natural, unimpacted characteristics of a water resource, and must represent a stable baseline based on expert judgement in conjunction with local knowledge and historical data). An Estuarine Health Index (EHI) is used to evaluate the current condition of the estuary. The EHI scoring of the various variables is based on a review of historical data, as well as data collected during a field monitoring programme in 2023/4. Both abiotic and biotic variables are included as the relationships between the abiotic and biotic variables are often not well understood and because the biotic response to certain abiotic variables can be lagging. The estuarine health score is translated into one of six Ecological Categories (ECs) from A to F.

- Step 3b: Determine the **Estuary Importance Score (EIS)** that takes into account the size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account rating an estuary from low to high importance as below:

EIS	Importance rating
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

- Step 3c: Set the **Recommended Ecological Category (REC)** which is derived from the PES and EIS (or the protection status allocated to a specific estuary) following the guidelines listed below:

Protection Status and Importance	REC	Policy basis
Protected area	**A or BAS***	Protected and desired protected areas should be restored to and maintained in the best possible state of health.
Desired Protected Area (based on complementarity)		
Highly important	**PES + 1, min B**	Highly important estuaries should be in an A or B Category.
Important	**PES + 1, min C**	Important estuaries should be in an A, B or C Category.
Of low to average importance	**PES, min D**	The remaining estuaries can be allowed to remain in a D Category.

** Best Attainable State*

An estuary cannot be allocated a REC below a Category “D”. Therefore, systems with a PES in Categories ‘E’ or ‘F’ need to be managed towards achieving at least a REC of “D”.

- Step 4: **Quantify the ecological consequences of various runoff scenarios** (including proposed operational scenarios) where the predicted future condition of the estuary is assessed under each scenario. As with the determination of the PES, the Estuarine Health Index (EHI) is used to assess the predicted condition in terms of the degree of similarity to the reference condition.

- Step 5: Quantify the (recommended) **Ecological Water Requirements (EWR)**, which represent the lowest flow scenario that will maintain the resource in the REC.

- Step 6: Estimate (recommended) **Resource Quality Objectives (Ecological Specification)** for the REC, as well as future monitoring requirements to improve the confidence of the EWR.

- The locality of all prioritised estuaries within the RU as identified during this study, is provided in **Figure 4-1.**

Eco-categorisation results summary

Table 1 provides a detailed summary of the Present Ecological State scores for priority estuaries. Only two estuaries were in relatively good condition, Mngazi and Kabeljous. The highly important Great Kei, Keiskamma and Kariega were in a C Category, while the Mbashe were in a B/C Category. Gamtoos Estuary was the most degraded system in Category D.

Table 1: Summary of Present Ecological State scores for priority estuaries

Component	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Hydrology	92	68	52	46	38	36	80
Hydrodynamics and mouth condition	94	78	79	81	62	68	84
Water quality	80	63	71	77	86	51	87
Physical habitat alteration	85	80	75	70	75	70	76
Habitat health score	**88**	**72**	**69**	**68**	**65**	**56**	**82**
Microalgae	82	80	74	79	83	51	76
Macrophytes	87	80	80	73	65	52	80
Invertebrates	80	76	54	55	60	46	71
Fish	75	60	70	60	70	55	70
Birds	81	79	58	59	72	53	77
Biotic health score	**81**	**75**	**67**	**65**	**70**	**51**	**75**
ESTUARINE HEALTH SCORE	**84**	**74**	**68**	**67**	**68**	**54**	**78**
PRESENT ECOLOGICAL STATUS	B	B/C	C	C	C	D	B

Most of the priority estuaries were of high biodiversity importance due to their size, habitat diversity, overall biodiversity importance and/or functional importance. Mbashe, Great Kei, Keiskamma and Kariega all rated as ‘Highly Important’, while Kabeljous rated as ‘Important’ (see **Table 2**). The Mbashe and Great Kei estuaries support large stands of mangroves, while the Kariega and Keiskamma estuaries support large meadows for the endangered seagrass *Zostera capensis*. In addition, the Keiskamma and Gamtoos estuaries are also highly important systems for saltmarsh. Even though the Kabeljous estuary has a small open water area it supports a surprisingly large, vegetated wetland between the Kabeljous and Gamtoos estuaries.

Table 2: Summary of Estuarine Importance Scores for priority estuaries

Estuarine Importance	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Size	50	90	100	100	90	100	90
Zonal Type Rarity	10	50	50	20	20	20	10
Habitat diversity	20	90	90	100	80	100	80
Biodiversity Importance (plants, Inverbrates, fish and birds)	76	86	83	97	97	99	85
Functional importance	50	100	100	100	100	90	80
ESTUARINE IMPORTANCE SCORE	**45**	**88**	**88**	**91**	**85**	**89**	**76**
ESTUARINE IMPORTANCE RATINGRATING	**Low to average**	**Highly Important**	**Highly Important**	**Highly Important**	**Highly Important**	**Highly Important**	**Important**

The Mbashe, Great Kei, Keiskamma and Gamtoos Estuaries are all rated as critically important fish nursery systems (Van Niekerk et al. 2019) (**Table 3 and Table 4**). These estuaries serve as important nurseries for Dusky kob *Argyrosomus japonicus* (overexploited & collapsed, IUCN Red List endangered), White steenbras *Lithognathus lithognathus* (overexploited & collapsed), spotted grunter *Pomadasys commersonnii* (overexploited & collapsed) and Zambezi sharks *Carcharhinus leucas* (IUCN Red List Near threatened). The Mbashe and Great Kei catchments also export large volumes of sediments, detritus and nutrients to the nearshore marine environment, thus responsible for maintaining the very rare subtidal deltas outside the estuary mouths (< 5% of habitat in South Africa) that serve as spawning habitats for White steenbras. These systems also serve as important movement corridors for fish breeding in the sea, specifically three species of catadromous eels (Anguillidae). These eels recruit as glass eels, moving high up into the catchments where they may spend 8-30 years before returning to spawn and die at abyssal depths in the sea.

The Kariega Estuary supports the Critically Endangered estuarine pipefish *Syngnathus watermeyeri* (only recorded at present in two estuaries, Kariega & adjacent Bushman's Estuary, globally) and important line-fish species such as Cape stumpnose *Rhabdosargus holubi*, Blacktail *Diplodus sargus*, and Strepie *Sarpa salpa*. The Kariega Estuary is also important from a blue carbon perspective as it supports large strands of the endangered seagrass *Zostera capensis* that occurs throughout the system and provides an important habitat for invertebrate and juvenile fish species.

The Kabeljous Estuary is of high importance from a botanical (large wetland between it and the Gamtoos estuary) and bird perspective.

Table 3: Summary of functional importance scores for priority estuaries

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
a) Export of organic material generated in the estuary (regional scale)	40	50	70	80	40	80	20

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
b) Nursery function for fish and crustaceans (marine /riverine)	50	100	100	100	100	90	40
c) Movement corridor for river invertebrates and fish breeding in sea	40	70	80	80	30	80	20
d) Roosting, foraging and/or nesting area for marine and coastal birds	50	60	60	70	40	80	80
e) Catchment detritus, nutrients and sediments to sea	40	90	100	90	20	80	20
Functional importance score - Max (a to e)	**50**	**100**	**100**	**100**	**100**	**90**	**80**

Table 4: Summary of key ecosystem services that are of regional/national or global importance and need to be maintained/protected

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Nursery function	Medium	High	High	High	High	High	Medium
Blue Carbon sequestration	Low	High	High	High	High	High	High

The Mbashe Estuary is formally protected and is situated within the Dwesa-Cwebe Marine Protected Area (**Table 5**). In addition, the Great Kei, Keiskamma, Kariega, and Gamtoos estuaries are all desired protected areas to meet national and international conservation obligations. They form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie et al., 2012c) and for the 2030 Global Biodiversity Framework (South Africa's 30 x 30 protection targets). The National Estuaries Biodiversity Plan (Van Niekerk and Turpie, 2012) recommended that the minimum Category for conservation priorities be an A or BAS as set out in the methods above.

Table 5: Summary of protected /desired protected area status

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Marine Protected Area / Protected Area		Dwesa-Cwebe MPA					
Desired PA/MPA needed to make Conservation targets			-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	

Table 6 summarises the PES and REC for the priority estuaries. The smaller Mngazi, Kariega and Kabeljous estuaries meet their conservation targets and only require non-interventions to maintain the PES. However, the larger Mbashe, Great Kei, Keiskamma and Gamtoos estuaries require flow and non-flow interventions to meet the RECs and restore critical

ecosystem services (e.g. blue carbon and nursery function) and meet conservation obligations.

Table 6: Summary of PES and RECs of priority estuaries

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
PES	B	B/C	C	C	C	D	B
REC	B	B	B/C	B	C	C	B

Table 7 provides an overview of key flow and non-flow interventions required to maintain/ restore estuary conditions and key ecosystem services to coastal communities. In many cases, these do not require new management action but more an intensifying of existing mandates. In addition, the Gamtoos and Keiskamma estuaries have degraded saltmarsh areas in need of active restoration to improve the ability of these systems to contribute to carbon sequestration, a climate regulatory service provided by blue carbon habitats.

Table 7: Restoration interventions required to address trajectory of change and achieving the REC (Priority = ●, Action reguired= •)

Estuary	PES (Trajectory of change)	REC	Flow			Water Quality			Non-flow intervention												
			Restore/protect base flows	Maintain/protect floods	Protect/restore groundwater	Manage/reduce stormwater & drainage from floodplain	Improve river water quality	Monitor & reduce/reuse WW	Restore connectivity/ hydrodynamic functioning	Improve mouth management	Rehabilitate riparian areas/ and birds	Remove alien vegetation*	Reduce grazing (sheep, cattle, goats)	Manage browsing/ implement cattle exclusion zone	Control mangrove harvesting	Control boating activities impacting on seagrass and birds	Control recreational activities impacting saltmarsh and birds	Control/reduce fishing pressure	Manage/reduce bait collection	Investigate eradication of alien fish	Restore/protect against impact of mining
Kabeljous	B ↓	B	•	•	●		Agric		•			•					●	●	•	•	
Gamtoos	D ↓	C	•	●		Agric	Agric				●	•	•			•		●	•	•	
Kariega	C ↓	C	•					•	●			•	•			●		●	●		
Keiskamma	C ↓	B	•	●			Urban				●	•	●			●		●	●	•	
Great Kei	C ↓	B/C	•	●				•			•	•	•	●	●	•	•	●	•	•	
Mbashe	B/C ↓	B	•	●								●	•	●	●	•	•	●	•	•	
Mngazi	B ↓	B									•	•				•		●	•		●

* Mbashe Estuary: *Tamarix ramosissima*, Great Kei: Spanish reeds

Climate Change

Most of the estuaries in the study area showed a negative trajectory of change. Climate change with predicted increases in drought, floods, and hotter temperatures will only accelerate these trajectories. Maintaining a degree of natural hydrodynamic variability and estuarine abiotic configuration, together with preventing catchment degradation (e.g., erosion, nutrient enrichment), is particularly critical in the face of climate change where predicted increases in temperature, drought, and storminess are likely to confound biotic responses. For example, a 2°C increase in water temperature can increase the distribution and frequency of problematic and fast-growing primary producer communities (i.e., HABs, invasive alien aquatic plants, and filamentous/floating macroalgae) leading to a rapid decline in estuary conditions.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background

The National Water Act, 1998 (No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility for and authority over water resource management for the benefit of the public without affecting the functioning of water resource systems. To achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through the implementation of Resource Directed Measures (RDM). These measures are protection-based and include Water Resource Classification, determination of the Reserve and setting the associated Resource Quality Objectives (RQOs). These measures collectively aim to ensure that a balance is reached between the need to protect and sustain water resources, while allowing socio-economic development.

The provision of water required for the maintenance of the natural functionality of the ecosystem and provision of Basic Human Needs (BHN) is the only right to water in the National Water Act (No. 36 of 1998) (NWA). The other water users from a strategic use who are second in line to other water users are subject to formal gazetted General Authorization and water use authorization as per Section 21 of the NWA.

The Department of Water and Sanitation, through the Chief Directorate: Water Ecosystems Management (CD: WEM), has initiated a study for the determination of Water Resource Classes, Reserve and associated Resource Quality Objectives for the identified significant water resources in the Keiskamma and Fish to Tsitsikamma catchments. The water resource components included for this study are rivers, wetlands, groundwater and estuaries. The Reserve determination include both the water quantity and quality of the Ecological Water Requirements (EWR) and Basic Human Needs (BHN). This will ensure the availability of water required to protect aquatic systems (i.e. the EWR) and that the essential needs of individuals that are directly dependent on these water resources (i.e. BHN) are met.

1.2 Purpose of this study

The Keiskamma and Fish to Tsitsikamma catchments within the Mzimvubu to Tsitsikamma Water Management Area (WMA 7) are amongst many waters stressed catchments in South Africa. These areas are important for conservation and have recognisable protected areas, natural heritage, cultural and historical sites that require protection. However, water use from surface as well as groundwater for agricultural and domestic purposes are high, especially in the more arid catchments, impacting on the availability of water resources for the protection of the aquatic ecosystems. Industrial practices and domestic water use are on the rise in some of these catchments, especially around the major towns and cities. Water transfers into the study area from adjacent WMAs and within the study area and numerous storage dams changes the natural flow patterns, impacting on the aquatic biota.

Thus, the main purpose of the study is to determine, appropriate Water Resource Classes, the Reserve and set associated RQOs for all significant water resources in the study area to facilitate sustainable use of the water resources while maintaining ecological integrity.

The aim is to:

- implement the Water Resource Classification System (WRCS) (Regulation 810, 2010) to determine the Water Resource Classes (classes ranging from 1 – 3);
- follow the integrated framework (DWS, 2017);
- undertake the 7-step process to determine and set RQOs; and
- determine the Reserve for the significant water resources in the study area.

This will ultimately assist the DWS in the management of the water resources in the study area and aid in the making of informed decisions regarding the authorisation of future water use and the magnitude of the impacts of proposed developments. It must be noted that the protection and management of water resources should be done in an integrated manner, hence from source to sea. This illustrates the importance of realising that IWRM requires the co-operation and buy-in of stakeholders in the catchment and hence the forming of partnerships is essential i.e. water forums, catchment management agencies (CMA), Integrated Development Management Plans, Estuarine Management plans etc. The IWRM also relies heavily on co-operative governance. Representative participation on the platforms that the Department creates through studies such as this, is in the form of Project Steering Committees, but the latter is but one example, of inviting integrated participation.

1.3 Purpose of this report

The purpose of this report is to document the results of the Ecological Categorisation (determination of the overall PES Eco-Categorisation) of all identified priority estuaries within the Keiskamma and Fish to Tsitsikamma catchment areas, based on the information and data that is currently available through various previous studies undertaken and the observed data that is to be obtained during the scheduled estuary surveys.

1.4 Approach for the Eco-Categorisation Phase

The full project approach and methodology will be in accordance with the process as outlined in Regulation 810 (Government Gazette 33541) dated 17 September 2010, **as well as the methodologies as prescribed by the DWS for Reserve determinations of rivers, wetlands, groundwater and estuaries and the determination of Resource Quality Objectives (RQO).** The integrated steps as developed through the 'Development of Procedures to operationalise Resource Directed Measures (DWS, 2017)' will be used to guide the various activities (**Figure 1-1**).

The Eco-Categorisation forms part of Step 3 of Figure 1-1 and Step 3 of the integrated steps for the determination of the Reserve (**Figure 1-2**).

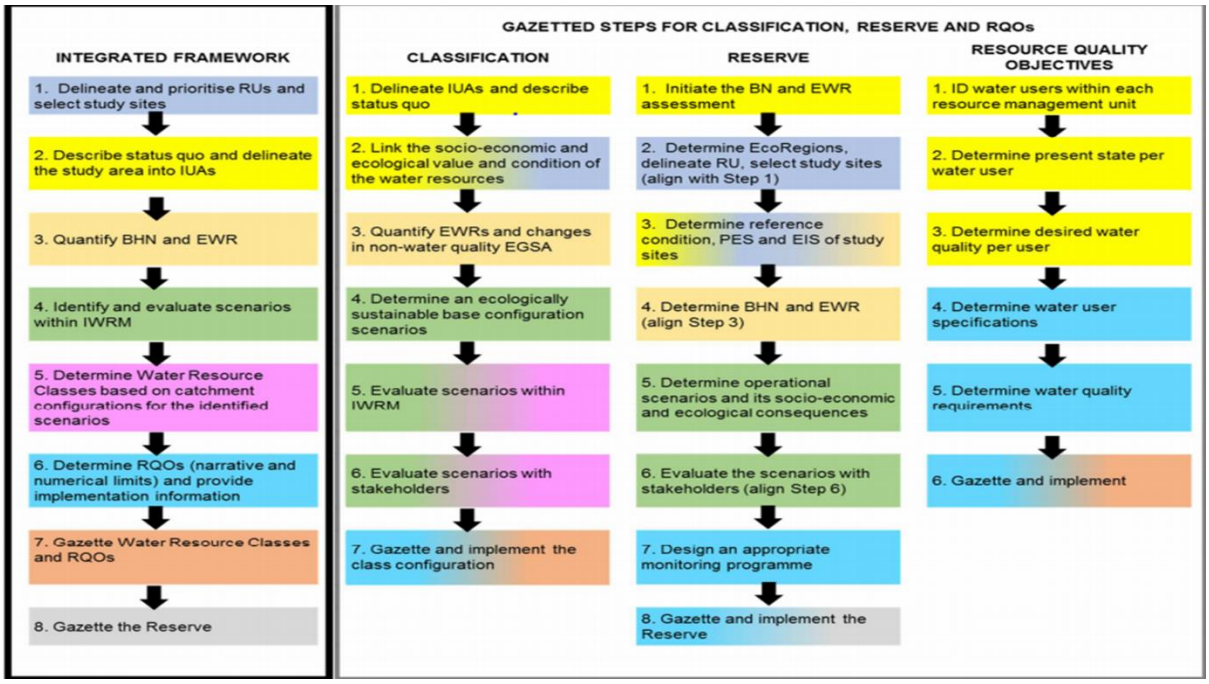


Figure 1-1: Integrated framework for determination of Water Resource Classes, Reserve and RQOs

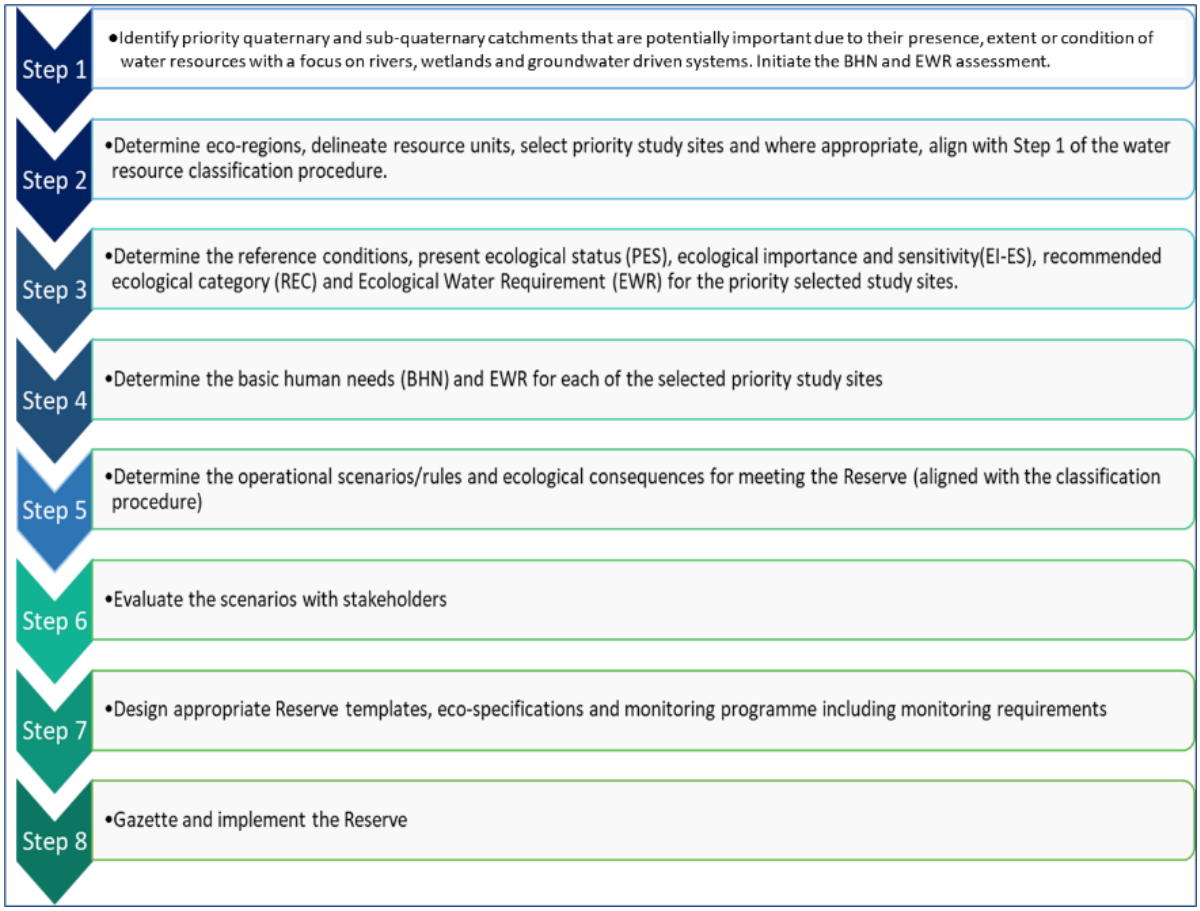


Figure 1-2: Integrated steps for the determination of the Reserve (DWS, 2017)

2. ECOLOGICAL WATER REQUIREMENT METHOD FOR ESTUARIES

Methods to determine the environmental flow requirement of estuaries were established soon after the promulgation of the National Water Act (NWA) in 1998. The "Preliminary Reserve Method" involves setting a REC (i.e. desired state), recommended Ecological Reserve (i.e. flow allocation to achieve the desired state) and recommended RQOs for a resource based on its present health status and its ecological importance.

The approach follows a generic methodology that can be carried out at different levels of effort (e.g. rapid, intermediate or comprehensive). The official method for estuaries (Version 2), is documented in DWA (2008). In 2013, an unofficial Version 3 of the method was published, as part of a Water Research Commission study (Turpie *et al*., 2012a,b). This study uses the official Version 2 of the methodology (DWA, 2008), but with consideration of obvious improvements proposed in Version 3 (Turpie *et al*., 2012a,b) and Taljaard *et al*. (2022).

The generic steps of the official "Ecological Reserve Method" for estuaries were applied as follows:

- Step 1: Initiate study defining the study area, project team and level of study (confirmed in the **inception report** of this study).

- Step 2: Delineate the geographical boundaries of the resource units (confirmed in the **delineation report** of this study).

- Step 3a: Determine the **Present Ecological State** (PES) of resource health (water quantity, water quality, habitat and biota) assessed in terms of the degree of similarity to the reference condition (referring to natural, unimpacted characteristics of a water resource, and must represent a stable baseline based on expert judgement in conjunction with local knowledge and historical data). An Estuarine Health Index (EHI) is used to evaluate the current condition of the estuary (**Table 2-1**). The fact that the physical conditions in estuarine systems are more dynamic than those of other aquatic ecosystems means that severe degradation of an estuary may involve a shift from a dynamic to a more stable, or unidirectional, system. This means that the loss of dynamic function *per se* is an important indication of declining estuarine health (DWAF, 2008). Thus, in an estuarine health assessment, measures of these different states need to be sufficiently robust so that different practitioners/disciplines will arrive at the same categorisation.

  In the case of this assessment, the EHI scoring of the various variables is based on a review of historical data, as well as data collected during a field monitoring programme in 2022. The assessment was undertaken by a multidisciplinary group of estuarine scientists in a workshop setting, based on their collective understanding of the likely impacts affecting each system. Expert knowledge and available information were all used to build up a "picture" of the probable pristine state of each estuary and the changes under current conditions.

Table 2-1: Estuarine Health Index scoring system

Variable	Score	Weight	Weighted score
Hydrology	…	25	…
Hydrodynamics and mouth condition	…	25	…
Water quality	…	25	…
Physical habitat alteration	…	25	…
Habitat health score			**…**
Microalgae	…	20	…
Macrophytes	…	20	…
Invertebrates	…	20	…
Fish	…	20	…
Birds	…	20	…
Biotic health score			**…**
Estuary Health Score Mean (Habitat health, Biological health)			**…**

The EHI is applied to all levels of ecological water requirement studies (comprehensive, intermediate or rapid), with only the level of information supporting the study and level of confidence varying. For each variable, the conditions are estimated as a percentage (0 – 100%) of the pristine health. Scores are then weighted and aggregated so that the final score reflects the present health of the estuary as a percentage of the pristine state (**Table 2-1**). Both abiotic and biotic variables are included as the relationships between the abiotic and biotic variables are often not well understood and because the biotic response to certain abiotic variables can be lagging.

For comparative reasons (with previous assessments) the individual health scores were aggregated as illustrated in **Figure 2-1** and **Table 2-2.**

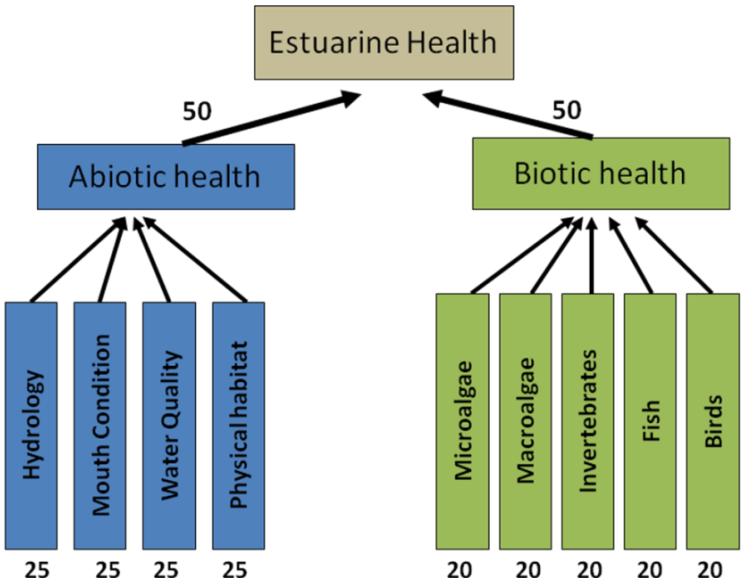


Figure 2-1: Components and weightings of the Estuarine Health Index (DWAF, 2008)

Table 2-2: Schematic illustration of the relationship between loss of ecosystem condition and functionality

Condition	≥91%	90-75	75 - 61	60 - 41	40-21	≤20
Category	A Natural	B Largely natural with few changes	C Moderately modified	D Largely modified	E Highly degraded	F Extremely degraded
State	Excellent	Good	Fair		Poor	
Functionality	Retain Process & Pattern (representation)		Loss of Process or Pattern		No Process & Pattern	

In estuaries, unlike in the terrestrial environment, degradation or loss of habitat seldom means a complete loss of an estuary. This can only happen if an estuary becomes completely degraded, e.g. changed into a parking lot or golf course. In most cases, degradation means loss of processes or loss of biological functionality, e.g. the estuarine space is filled with a different salinity condition or different species composition. This loss of functionality happens on a continuum, with estuaries which retain more than 90% of their natural processes and pattern being rated as Excellent and estuaries degraded to less than 40% of natural functionality rated as Poor.

The estuarine health score is translated into one of six Ecological Categories (ECs) provided below in **Table 2-3**.

Table 2-3: Translation of EHI score into Ecological Categories

EHI score	PES	General Description
91 – 100	A	Unmodified, or approximates natural condition; the natural abiotic template should not be modified. The characteristics of the resource should be determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic maintenance of the resource. The supply capacity of the resource will not be used.
76 – 90	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged. Only a small risk of modifying the natural abiotic template and exceeding the resource base should not be allowed. Although the risk to the well-being and survival of especially intolerant biota (depending on the nature of the disturbance) at a very limited number of localities may be slightly higher than expected under natural conditions, the resilience and adaptability of biota must not be compromised. The impact of acute disturbances must be totally mitigated by the presence of sufficient refuge areas.
61 – 75	C	Moderately modified. A loss and change of natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged. A moderate risk of modifying the abiotic template and exceeding the resource base may be allowed. Risks to the wellbeing and survival of intolerant biota (depending on the nature of the disturbance) may generally be increased with some reduction of resilience and adaptability at a small number of localities. However, the impact of local and acute disturbances must at least partly be mitigated by the presence of sufficient refuge areas.
41 – 60	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred. Large risk of modifying the abiotic template and exceeding the resource base may be allowed. Risk to the well-being and survival of intolerant biota depending on (the nature of the disturbance) may be allowed to generally increase substantially with resulting low abundances and frequency of occurrence, and a reduction of resilience and adaptability at

EHI score	PES	General Description
		a large number of localities. However, the associated increase in the abundance of tolerant species must not be allowed to assume pest proportions. The impact of local and acute disturbances must at least to some extent be mitigated by refuge areas.
21 – 40	**E**	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions is extensive.
0 – 20	**F**	Critically modified. Modifications have reached a critical level and the lotic system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances, the basic ecosystem functions have been destroyed and the changes are irreversible.

- Step 3b: Determine the **Estuary Importance Score (EIS[1])** that takes account the size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account (**Table 2-4 and Table 2-5**).

Table 2-4: Estuary Importance scoring system

Criterion	Score	Weight	Weighted Score
Estuary Size	…	15	…
Zonal Rarity Type	…	10	…
Habitat Diversity	…	25	…
Biodiversity Importance	…	25	…
Functional Importance	…	25	…
Weighted Estuary Importance Score			…

Table 2-5: Estuarine Importance rating system

EIS	Importance rating
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

- Step 3c: Set the **Recommended Ecological Category (REC)** which is derived from the PES and EIS (or the protection status allocated to a specific estuary) following the guidelines listed in Table 2-6.

[1] Note that EIS does not have the same meaning as EIS for rivers, which refer to Ecological Importance and Sensitivity.

Table 2-6: Guidelines to assign REC, based on protection status and importance, and PES of an estuary

Protection Status and Importance	REC	Policy basis
Protected area	A or BAS*	Protected and desired protected areas should be restored to and maintained in the best possible state of health.
Desired Protected Area (based on complementarity)		
Highly important	PES + 1, min B	Highly important estuaries should be in an A or B Category.
Important	PES + 1, min C	Important estuaries should be in an A, B or C Category.
Of low to average importance	PES, min D	The remaining estuaries can be allowed to remain in a D Category.

* Best Attainable State

An estuary cannot be allocated a REC below a Category "D". Therefore systems with a PES in Categories 'E' or 'F' needs to be managed towards achieving at least a REC of "D".

- Step 4: **Quantify the ecological consequences of various runoff scenarios** (including proposed operational scenarios) where the predicted future condition of the estuary is assessed under each scenario. As with the determination of the PES, the EHI is used to assess the predicted condition in terms of the degree of similarity to the reference condition.

- Step 5: Quantify the (recommended) **Ecological Water Requirements (EWR)**, which represent the lowest flow scenario that will maintain the resource in the REC.

- Step 6: Estimate (recommended) Resource Quality Objectives (Ecological Specification) for the REC, as well as future monitoring requirements to improve the confidence of the EWR.

Steps 1 to 6 is an integrated approach for estuaries, with results provided in detailed estuary EWR reports. Eco-Categorisation borrows from Steps 1 to 3 but requires Step 4 and 5 to be determined as it is an iterative process before PES and REC are determined. The integrated report will be captured per estuary in an appendix to reflect the flow of information.

3. OVERVIEW OF STUDY AREA

The study area forms part of the Mzimvubu to Tsitsikamma WMA7 as indicated in **Table 3-1** and **Figure 3-1**. The water resources of the Mzimvubu River (T31 – T36) are not included as part of the study. Secondary catchments T40 (Mtamvuna) and T50 (Mzimkhulu) form part of WMA 4. A detailed overview and status quo of the study area in terms of the rivers, wetlands, estuaries and groundwater, water resource infrastructure and socio-economics has been presented in the delineation of IUAs Report (Report Number: WEM/WMA7/00/CON/RDM/0322).

Table 3-1: Main catchments and rivers in the study area

Catchment	Major Rivers
K80	Tsitsikamma and small coastal rivers
K90	Krom, Seekoei rivers and small coastal rivers, also part of Algoa System
L10 - L90	Gamtoos with main tributaries Groot, Baviaanskloof and Kouga
M10 - M30	Koega, Swartkops and small coastal rivers, part of the Algoa System
N10 - N40	Sundays
P10 - P40	Kowie, Kariega, Boesmans and small coastal rivers (or Albany Coast)
Q10 - Q90	Fish River with main tributaries of Little Fish, Koonap and Kat
R10 - R50	Keiskamma, Buffalo, Nahoon and Gqunube Rivers (also known as the Amatole System)
S10 - S70	Great Kei River with main tributaries of Klipplaats, Indwe, White Kei, Black Kei
T10	Mbhashe
T20	Mthatha
T60	Small coastal rivers (Mtentu, Msikaba, Mzintlava), including estuaries of high conservation value
T70	Small coastal rivers (Mtakatye, Mngazi), including estuaries of high conservation value
T80 & T90	Small coastal rivers, including estuaries of high conservation value

The topography of the study area is hilly to mountainous with plains and hills of the Groot Karoo, with the Drakensberg Mountains along the north-eastern boundary of the study area. The rivers are deeply incised in the coastal strip.

The study area consists of 345 quaternary catchments (**Figure 3-3**), covering a total catchment area of more than 143 000 km^2.

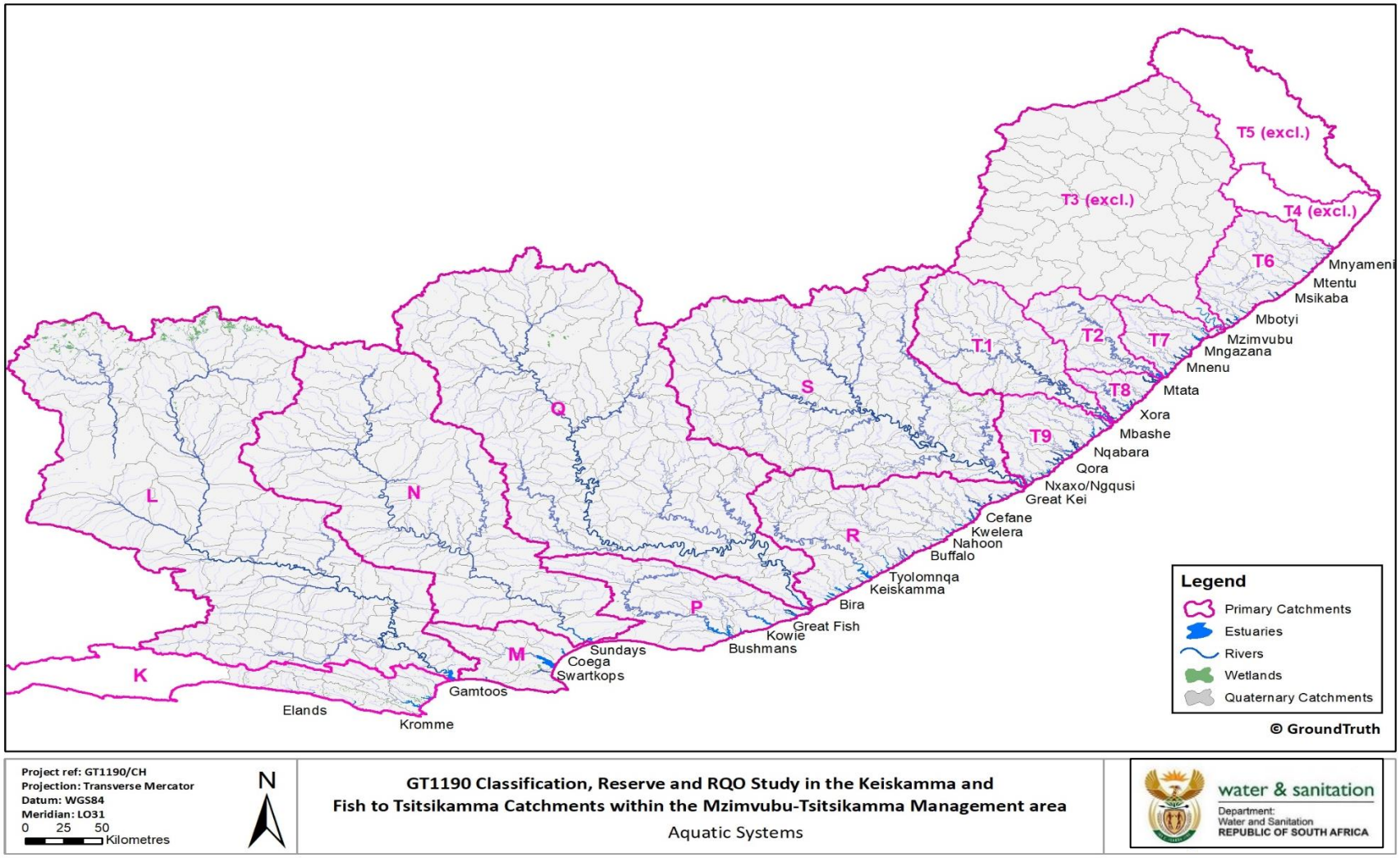


Figure 3-1: Study area of the Keiskamma, Fish to Tsitsikamma

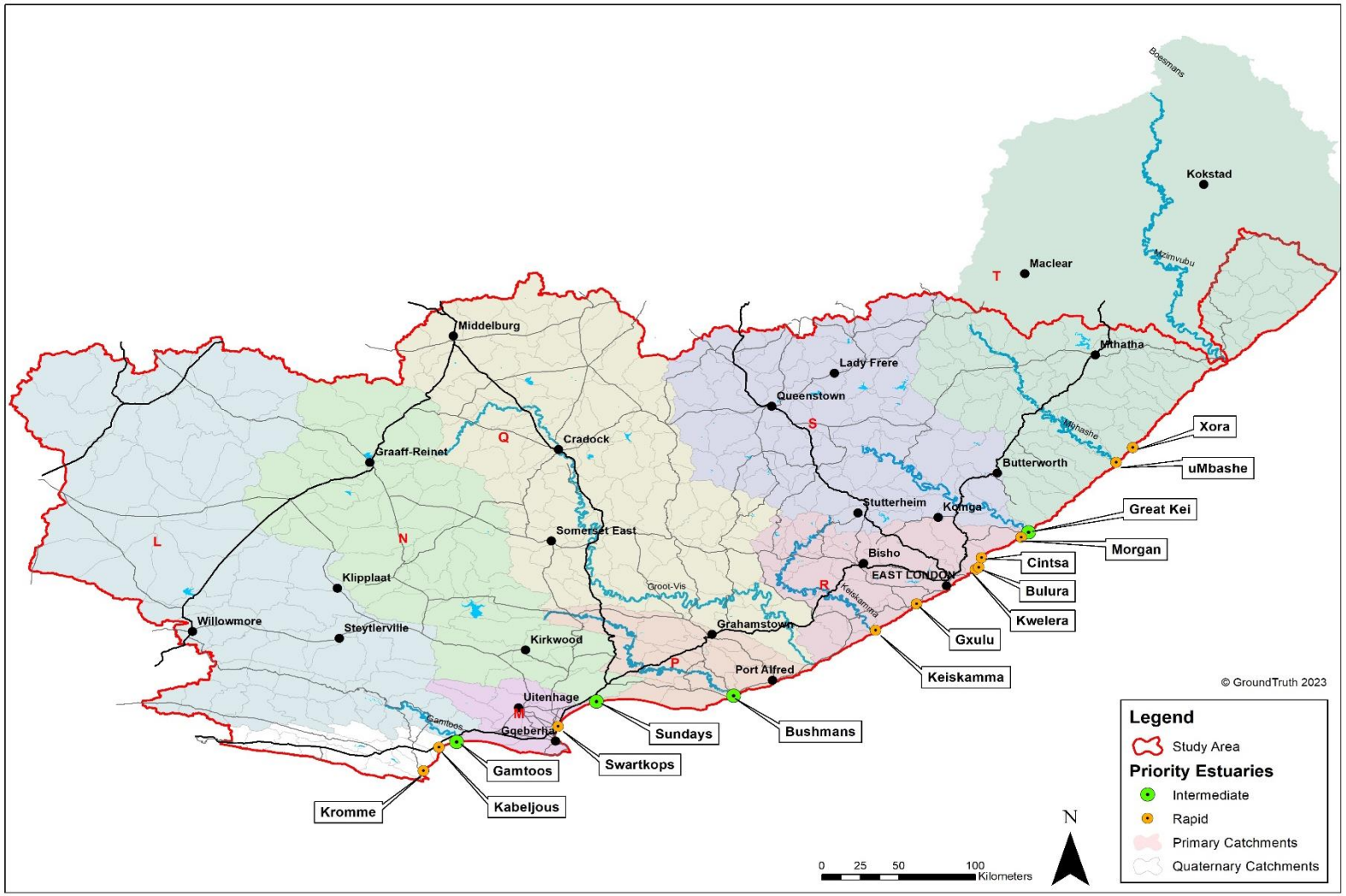


Figure 3-2: Overview of the greater study area (primary catchments)

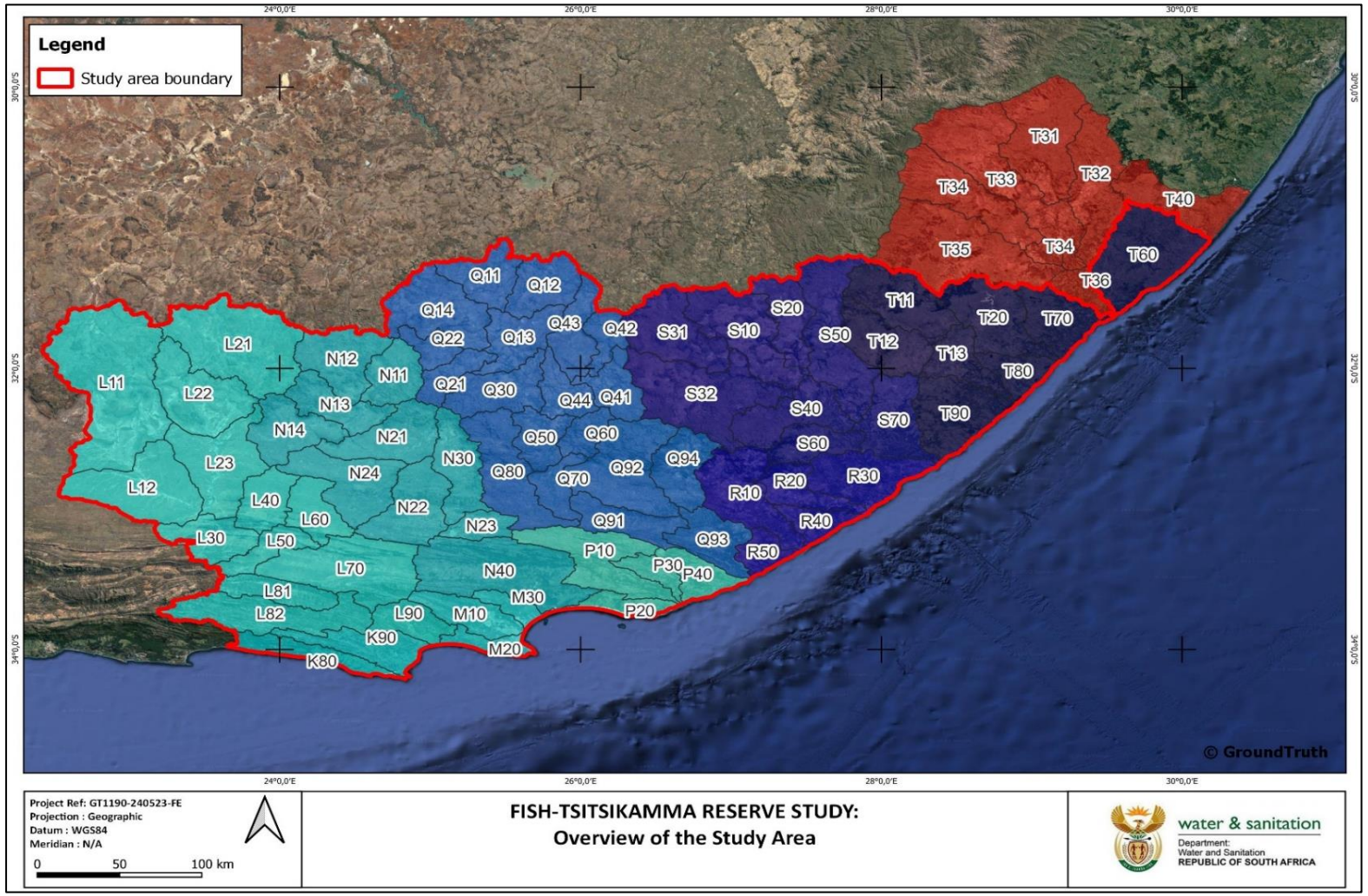


Figure 3-3: Overview of the greater study area (tertiary catchments)

4. SUMMARY OF THE ESTUARIES

Table 4-1 provides a summary of all the main estuaries in the sub-catchments within the study area, along with their catchment area sizes. Overall, there are 155 estuaries in the study area, with ten of these being the focus of previous Environmental Flow Requirement or EWR studies, albeit it is of low confidence in some cases. These are shown in **Table 4-2.**

Table 4-1: Main estuaries in the sub-catchments within the study area

Primary catchment	Sub-catchment	Main River	Associated Rivers	Main Estuaries	Catchment Area (1) (km²)
K	K80A-F	Tsitsikamma	Elandsbos, Kleinbos, Storms, Elands, Groot, Klasies, Klipdrift	Tsitsikamma, Elandsbos, Storms, Elands, Groot	1 206
	K90A-G	Krom	Seekoei, Kabeljous	Krom, Seekoei, Kabeljous	1 558
L	L11, L12, L21, L22, L23, L30, L40, L50, L60, L70, L81, L82, L90	Gamtoos	Sout, Buffels, Kariga, Plessis, Heuningklip, Groot, Baviaanskloof, Kouga	Gamtoos, Buffels, Groot	34 816
M	M10, M20, M30	Swartkops	Van Stadens, Maitland, Bakens, Papkuils, Coega	Swartkops, Van Stadens, Maitland, Coega	2 630
N	N11, N12, N13, N14, N21, N22, N23, N24, N30, N40	Sundays	Kamdeboo, Gats, Melk, Bul, Voel, Kariega	Sundays	21 248
P	P10, P20, P30, P40	Boesmans	Diepkloof, Boknes, Kariega, Kowie, Kasouga, Riet, Wes-Kleinemonde, Oos-Kleinemonde	Boesmans, Boknes, Kariega, Kowie, Kasouga, Riet, Wes-Kleinemonde, Oos-Kleinemonde	5 322
Q	Q11, Q12, Q13, Q14, Q21, Q22, Q30, Q41, Q42, Q43, Q44, Q50, Q60, Q70, Q80, Q91, Q92, Q93, Q94	Great Fish	Groot-Brak, Pauls, Tarka, Baviaans, Koonap, Little Fish, Kat	Great Fish	30 243
R	R10, R20, R30, R40, R50	Keiskamma	Tyume, Buffalo, Nahoon, Qinira, Gqunube, Kwelera, Kwenxura, Quko, Tyolomnqa, Gxulu, Bhirha, Mgwalana	Keiskamma, Buffalo, Nahoon, Qinira, Gqunube, Kwelera, Kwenxura, Quko, Tyolomnqa, Gxulu, Bhirha, Mgwalana	7 936
S	S10, S20, S31, S32, S40, S50, S60, S70	Great Kei	White-Kei, Indwe, Klipplaat, Klaas Smit, Black-Kei, Tsomo, Kubusi, Gcuwa	Great Kei	20 485

Primary catchment	Sub-catchment	Main River	Associated Rivers	Main Estuaries	Catchment Area [1] (km^2)
T	T11, T12, T13, T20, T60, T70, T80, T90	Mbashe	Xuka, Mgwali, Mthatha, Mzamba, Mtentu, Msikaba, Mzintlava, Mntafufu, Mngazi, Mngazana, Mtakatye, Mdumbi, Nenga, Mncwasa, Xora, Nqabarha, Shixini, Qhorha, Kobonqaba	Mbashe, Mgwali, Mthatha, Mzamba, Mtentu, Msikaba, Mzintlava, Mntafufu, Mngazi, Mngazana, Mtakatye, Mdumbi, Nenga, Mncwasa, Xora, Nqabarha, Shixini, Qhorha, Kobonqaba	17 938
			Total catchment area		**143 382**

[1]WR2012 Data

Table 4-2: Main estuaries in the sub-catchments within the study area

NAME	Historical Studies	Biodiversity Importance Rating
Tsitsikamma	Rapid 2003	**Low to Average Importance**
Kromme	Comprehensive 2006	**High Importance**
Seekoei	Rapid 2006	**Important**
Swartkops	Comprehensive 2021	**High Importance**
Sundays	Comprehensive 2008	**Important**
Bushmans	Intermediate 2003	**Important**
East Kleinemonde	Intermediate 2008	**Important**
Great Fish	Rapid 2013	**High Importance**
Nahoon	EFR/Intermediate 2001	**Important**
Mtata	Rapid 2002	**Important**

An additional seven estuaries are being assessed in more detail as part of this study to address gaps in the water resources classification process, with selection influenced by identified water resources pressure (current or future), estuary ecological importance, requests from other sectors of government, and available study resources.

The priority estuaries for rapid/comprehensive EWR assessments that will be done in more detail include:

- Mngazi;
- Mbashe;
- Great Kei;
- Keiskamma;
- Kariega;
- Gamtoos; and
- Kabeljous.

See **Figure 4-1** for the location and relative catchment size of the 7 priority estuaries.

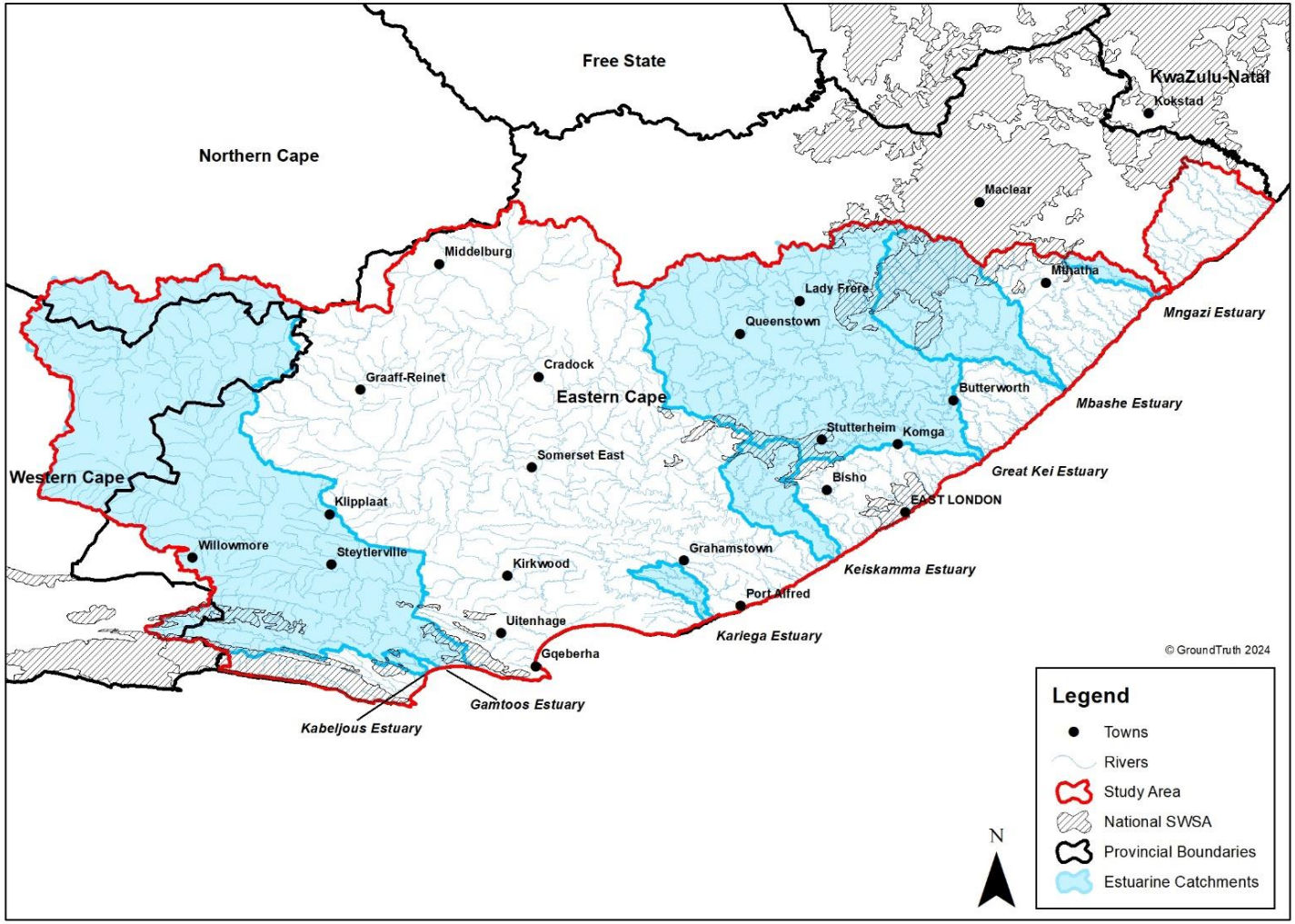


Figure 4-1: Overview of the priority estuary catchments

5. MNGAZI ESTUARY

5.1 Geographical boundaries

The temporarily open Mngazi Estuary lies just south of the coastal town of Port St Johns on the Wild Coast of the Eastern Cape. The upper reaches of the estuary are muddy with flat marshy banks. Lower down near the Mngazi Bungalows, approximately 800 m from the mouth, the banks are steeper and the bed of the estuary is a firm mixture of sand and mud. From there the estuary broadens to form a shallow lagoon behind the berm. The geographical boundaries of the Mngazi Estuary are defined as follows (**Figure 5-1**):

Downstream boundary:	31°40'34.12"S, 29°27'40.15"E(estuary mouth)
Upstream boundary:	31°37'27.80"S; 29°24'52.96"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

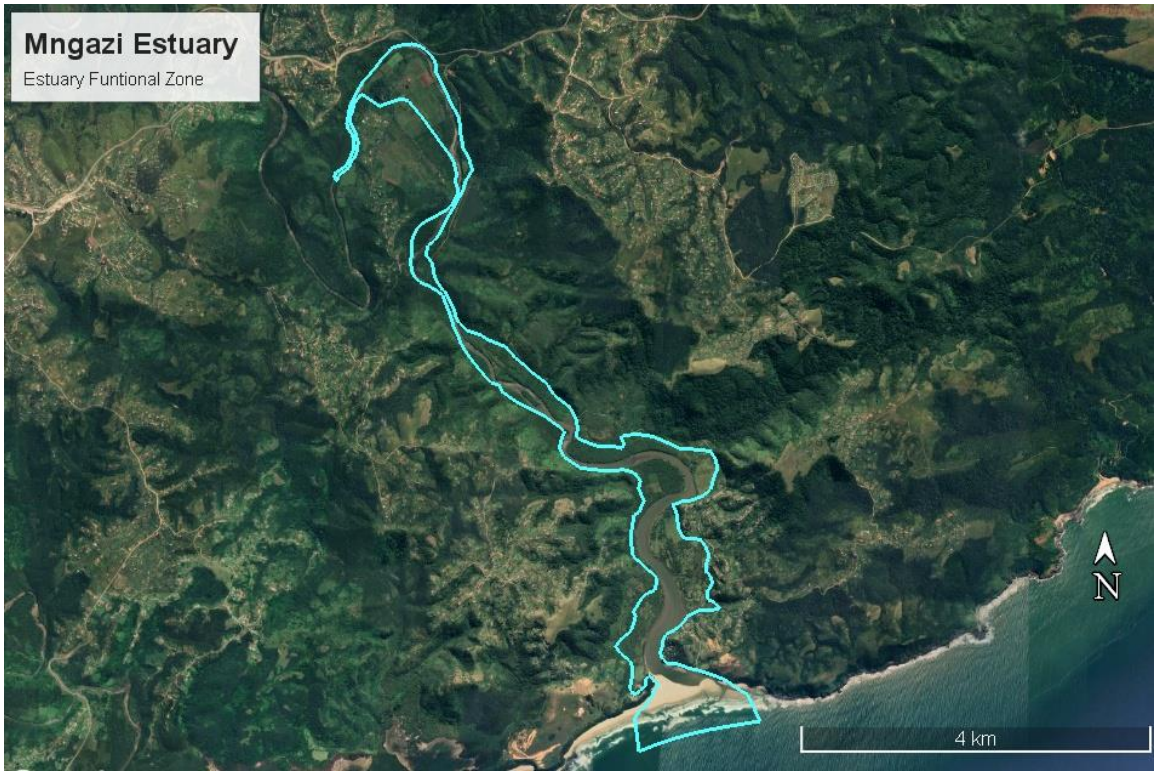


Figure 5-1: Geographical boundaries of the Mngazi Estuary based on the Estuary Functional Zone.

5.2 Present Ecological Status

According to the hydrological data provided for this study, the present MAR into the Mngazi Estuary is 83.52 Million m^3. This is a decrease of 4.3% compared to the natural MAR of 87.31 Million m^3.

The Mngazi Estuary in its present state is estimated to be 84% similar to natural conditions, which translates into a PES of a B Category. This is mostly attributed to the following factors:

- Flow reduction with a focus on baseflow reduction in the low flow period increasing mouth closure;
- A decline in water quality due to agricultural activities;
- Over-exploitation of living resources (e.g. recreational fishing, small-scale fishing and illegal gill netting);
- Overgrazing of saltmarsh by cattle.
- Agricultural activities in the EFZ cause loss of estuarine habitat; and
- Recreational activities in the lower reaches affect bird abundance.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 5-1** below.

Table 5-1: Mngazi: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	92	-*	M
Hydrodynamics and mouth condition	94	0%	M
Water quality	80	90%	M
Physical habitat alteration	85	95%	L - M
Habitat health score	88		
Microalgae	82	50%	L - M
Macrophytes	87	80%	M
Invertebrates	80	10%	L
Fish	75	15%	M
Birds	81	11%	L
Biotic health score	81		
ESTUARY HEALTH SCORE	84		**L/M**
PRESENT ECOLOGICAL STATUS (PES)	**B**		

**- Not applicable*
*** Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

5.3 Biodiversity and conservation importance

The Estuary Importance Score (EIS) takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account (**Table 5-2**) (Turpie *et al*., 2002). Biodiversity importance, in turn, is based on the assessment of the importance of the estuary for plants, invertebrates, fish and birds, using rarity indices. The scores have been determined for all South African estuaries (DWAF 2008, Turpie *et. al.,* 2012b), apart from functional importance, which was scored by the specialists during the workshop.

The Estuary Importance Score for five components and the importance rating are presented in **Table 5-2** and **Table 5-3**, respectively.

Table 5-2: Mngazi: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	50
Zonal Rarity Type	10	10
Habitat Diversity	25	20
Biodiversity Importance	25	76
Functional Importance	25	50
Estuary Importance Score		**45**
Calculation of the functional importance score		**Low to Average important**

The functional importance **(Table 5-3)** of Mngazi Estuary is of average to low importance with a score of 50.

Table 5-3: Mngazi: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	40
b) Nursery function for fish and crustaceans (marine /riverine)	50
c) Movement corridor for river invertebrates and fish breeding in sea	40
d) Roosting and/or foraging area for marine or coastal birds	50
e) Catchment detritus, nutrients and sediments to sea	40
Functional importance score - Max (a to e)	**50**

The EIS (**Table 5-4**) for the Mngazi Estuary, is 45, indicating that the estuary is rated as of "Low to Average Importance". The estuary serves as a relatively important fish nursery for marine fish and as a roosting/foraging area for coastal birds.

Table 5-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Mngazi Estuary is not in a formally protected area. The estuary also does not form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c). The NBA 2011 (van Niekerk and Turpie, 2012) recommended that the minimum category for the Mngazi be a C.

5.4 Recommended Ecological Category

The REC represents the level of protection assigned to an estuary. The PES sets the minimum REC. The degree to which the REC needs to be elevated above the PES depends on the level of importance and level of protection or desired protection of a particular estuary (See **Table 2-3**). The PES and REC for the Mngazi Estuary is a B Category as it is not a conservation priority.

5.5 Recommendations to maintain or improve estuary condition

Key interventions required to improve the condition of the Mngazi Estuary (on the edge of a B/C Category) include:

- Develop an Estuary Management Plan for the Mngazi Estuary to identify key actions required to arrest the downward trajectory and coordinate restoration efforts if required.
- Ensure maintenance of low-flow conditions to prevent prolonged periods of mouth closure that promote microalgal accumulation and the severity of bottom-water hypoxia.
- Manage nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and irrigation) and restoring riparian vegetation (buffer zones).
- Manage/reduce fishing pressure by managing access, increased compliance and improved community awareness.
- Prevent disturbance of riparian vegetation, including trampling by cattle, fire, and remove alien vegetation from the EFZ.

6. MBASHE ESTUARY

6.1 Geographical boundaries

The 8 km long Mbashe Estuary is a permanently open, turbid and channel-like estuary located approximately 70 km north of the Kei Estuary, the nearest estuary of similar size and configuration.

The geographical boundaries of the Mbashe Estuary are defined as follows (**Figure 6-1**):

Downstream boundary:	31°40'34.12"S, 29°27'40.15"E (estuary mouth)
Upstream boundary	31°37'27.80"S; 29°24'52.96"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

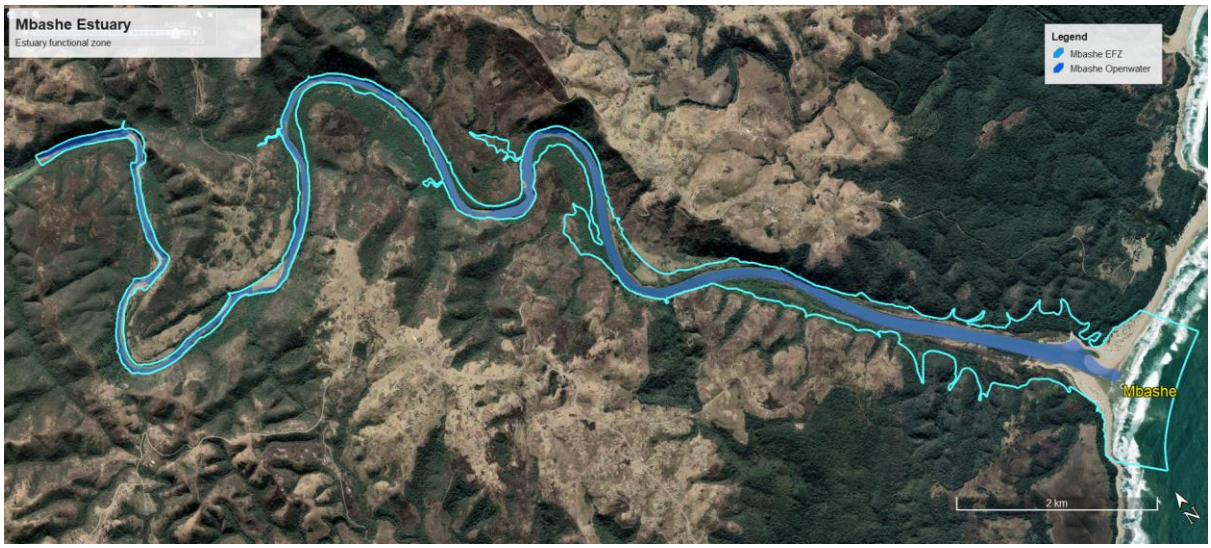


Figure 6-1: Geographical boundaries of the Mbashe Estuary based on the Estuary Functional Zone.

6.2 Present Ecological State

The present MAR into the Mbashe Estuary is 861.16 Million m^3. This is an increase of 9.4% compared to the natural MAR of 786.88 Million m^3. The Mbashe Estuary in its present state is estimated to be 74% similar to natural conditions, which indicates a PES of a B/C Category. This is for the most part attributed to the following factors:

- Flow alterations with a focus on an increase in baseflow in the low flow period resulting in a decrease in salinity and a less constricted mouth;
- Severe over-exploitation of living resources (e.g. recreational fishing, small-scale fishing, and illegal gillnetting);
- A decline in water quality due to agricultural activities in catchment and estuary environs;
- Overgrazing of saltmarsh and degradation of mangroves as a result of cattle browsing. Trampling by cattle also compacts sediment which hinders the germination of plants.

- Agricultural activities in the EFZ cause loss of estuarine habitat; and
- Recreational activities in the lower and middle reaches affect bird abundance.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 6-1** below.

Table 6-1: Mbashe: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence*
Hydrology	68	0 %	H
Hydrodynamics and mouth condition	78	0 %	L-M
Water quality	63	90 %	M
Physical habitat alteration	80	100 %	H-L
Habitat health score	**72**		
Microalgae	80	50 %	L-M
Macrophytes	80	20 %	M
Invertebrates	76	17 %	L
Fish	60	25 %	M
Birds	79	20 %	M
Biotic health score	**75**		
ESTUARY HEALTH SCORE	**74**		**M**
PRESENT ECOLOGICAL STATUS (PES)	**B/C**		

**Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

6.3 Biodiversity and conservation importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 6-2 and Table 6-3**, respectively.

Table 6-2: Mbashe: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	90
Zonal Rarity Type	10	50
Habitat Diversity	25	90
Biodiversity Importance	25	86
Functional Importance	25	100
Estuary Importance Score		**86**
Calculation of the functional importance score		**Highly important**

The functional importance (**Table 6-3**) of Mbashe Estuary is very high with a score of 100.

Table 6-3: Mbashe: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	80
b) Nursery function for fish and crustaceans (marine /riverine)	100
c) Movement corridor for river invertebrates and fish breeding in sea	80
d) Roosting area for marine or coastal birds	60
e) Catchment detritus, nutrients and sediments to sea	100
Functional importance score - Max (a to e)	

The EIS (**Table 6-4**) for the Mbashe Estuary, is 86, highlithing that the estuary is rated as "Highly Important". The estuary serves as a critically important nursery for Dusky Kob (Endangered), White steenbras (Endangered). Grunter and Zambezi Sharks. The Catchment also exports large volumes of sediments, detritus and nutrients to the nearshore marine environment, thus responsible for maintaining the very rare subtidal deltas outside the mouth (< 5% of habitat in South Africa) that serves as spawns area for White steenbras. It is also an important movement corridor for fish breeding in the sea as it serves as a conduit for three species of eels to the large Mbashe Catchment.

Table 6-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Mbashe Estuary is in the Dwesa-Cwebe Marine Protected Area. The estuary also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) and for the 2030 Global Biodiversity Framework (South Africa's 30 x 30 protection targets). The National Estuary Biodiversity Plan (van Niekerk and Turpie, 2012) recommended that the minimum Category for the Mbashe be an A or BAS, that the system be granted partial no-take protection, and that 75 % of the estuary margin be undeveloped (**Table 6-5**).

Table 6-5: Mbashe: National Estuary Biodiversity Plan requirements

Estuary Requirements	Mbashe
National and/or Regional Priority set	SA/Regional
Recommended extent of protection	Partial
Recommended extent of undeveloped margin	75%
Provisional NBA estimate of Recommended Ecological Category	A or BAS

6.4 Recommended Ecological Category

The PES for the Mbashe Estuary is a B/C Category, however, as the estuary is degraded and of high biodiversity and conservation importance it should be in an A Category or BAS.

Given the level of land-use change in the Mbashe Catchment; the impact of the interbasin transfer scheme; and the present high level of natural resource utilisation (fishing and grazing) of the Mbashe Estuary the REC is a B Category (BAS).

6.5 Recommendations to maintain or improve estuary condition

Key interventions required to improve the condition of the Mbashe Estuary include:

- Develop an Estuary Management Plan to identify key management actions required to achieve the REC and coordinate restoration efforts.
- Significantly reduce fishing pressure by managing access, increased compliance and community interactions to achieve MPA protection objectives and REC.
- Manage nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and irrigation) and restoring riparian vegetation.
- Prevent disturbance of riparian vegetation, including cattle trampling, occurrence of fire, and removal of alien vegetation in the EFZ.
- Limit trampling and browsing of salt marsh and browsing and harvesting of mangroves. Mangroves are legally protected by two separate pieces of legislation: National Forests Act (84 of 1998) and the Marine Resources Act (18 of 1998). The species *Bruguiera gymnorrhiza* and *Rhizophora mucronata* are further protected by the Protected Tree list (DWAF, 2010). All these would be addressed through an Estuary Management Plan. The sustainable use of mangroves should be encouraged with the harvesting of mangroves.

7. GREAT KEI ESTUARY

7.1 Geographical boundaries

The Great Kei Estuary is a predominantly open estuary located on the southern coast of South Africa, in the transition zone between the warm temperate and subtropical biogeographic regions. The length of the estuary is 17.5 km. The geographical boundaries of the Great Kei Estuary are defined as follows (**Figure 7-1)**:

Downstream boundary:	32°40'44.39"S 28°23'12.31" E (estuary mouth)
Upstream boundary:	32°36'29.64"S; 28°17'36.45"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

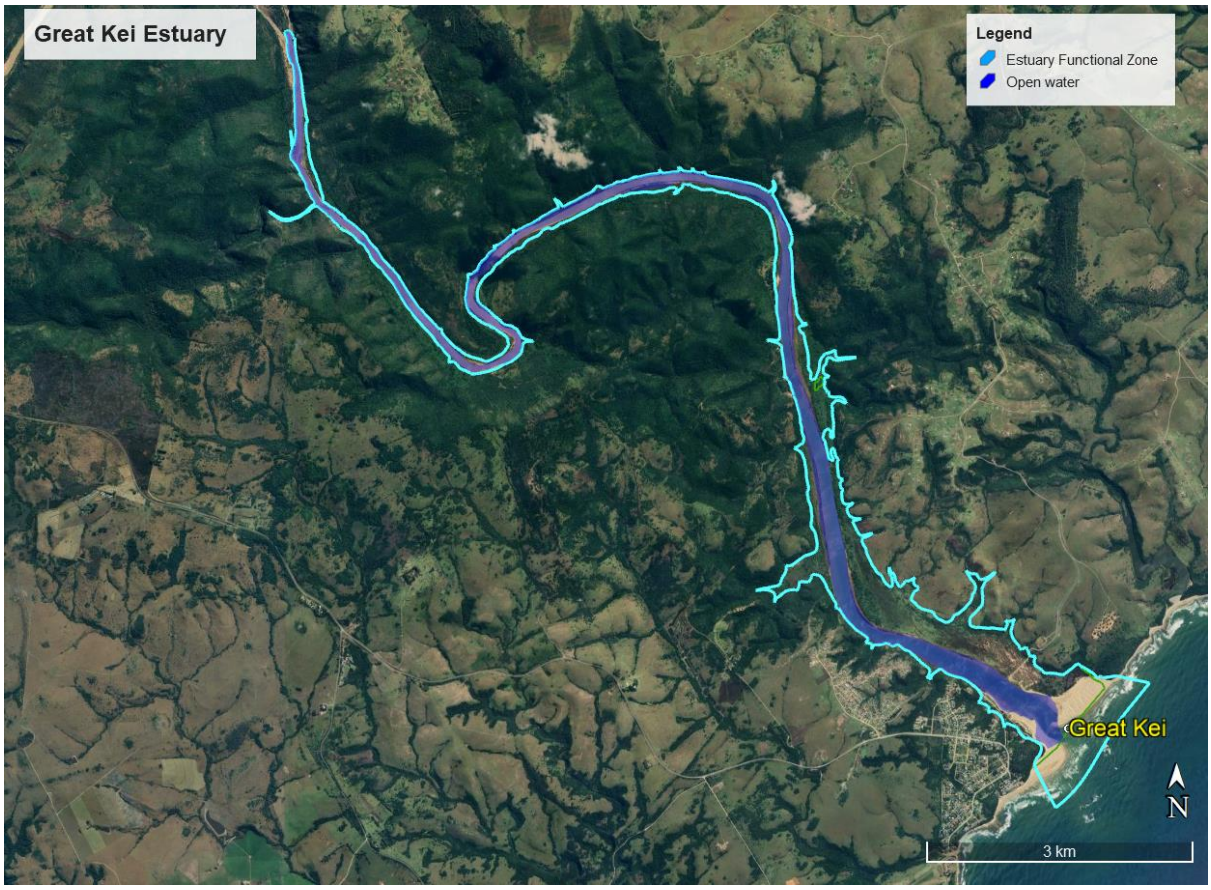


Figure 7-1: Geographical boundaries of the Great Kei Estuary based on the Estuary Functional Zone**.**

7.2 Present Ecological Status

The present MAR into the Great Kei Estuary is 742 Million m^3. This is a decrease of 29% compared to the natural MAR of 1 041 Million m^3. The Great Kei Estuary in its present state is estimated to be 68% similar to natural conditions, which translates into a PES of a C Category. This is largely attributed to the following factors:

- Flow reduction with a stress on baseflow reduction in the low flow period increasing salinity penetration;
- Severe over-exploitation of living resources (e.g. recreational fishing, small-scale fishing and illegal gill netting) impacting nursery function;
- A decline in water quality due to agricultural activities in the catchment;
- Overgrazing of saltmarsh and degradation of mangroves as a result of cattle browsing.
- Trampling by cattle of salt marsh and within mangrove stands;
- Invasive alien plants within the EFZ, especially Spanish Reed which has replaced reeds along the banks in places;
- Agricultural activities in the EFZ causing loss of estuarine habitat; and
- Recreational activities in the lower reaches, particularly along the shoreline on the seaside affect bird abundance.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 7-1** below.

Table 7-1: Great Kei: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	52	-*	H
Hydrodynamics and mouth condition	79	0%	L - H
Water quality	71	90%	M
Physical habitat alteration	75	90%	L-M
Habitat health score	69		
Microalgae	74	50%	L
Macrophytes	80	20%	M
Invertebrates	54	17%	L
Fish	70	25%	M
Birds	58	20%	M
Biotic health score	**67**		
ESTUARY HEALTH SCORE	**68**		**M**
PRESENT ECOLOGICAL STATUS (PES)	**C**		

** - Not applicable*
***Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

7.3 Biodiversity and conservation importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 7-2 and Table 7-3**, respectively.

Table 7-2: Great Kei: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	100
Zonal Rarity Type	10	50
Habitat Diversity	25	90
Biodiversity Importance	25	83
Functional Importance	25	100
Estuary Importance Score		**88**
Calculation of the functional importance score		**Highly important**

The functional importance (**Table 7-3**) of the Great Kei Estuary is very high with a score of 100.

Table 7-3: Great Kei: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	70
b) Nursery function for fish and crustaceans (marine /riverine)	100
c) Movement corridor for river invertebrates and fish breeding in sea	80
d) Roosting area for marine or coastal birds	60
e) Catchment detritus, nutrients and sediments to sea	100
Functional importance score - Max (a to e)	100

The EIS (**Table 7-4**) for the Great Kei Estuary, is 88, indicating that the estuary is rated as "Highly Important". The Great Kei Estuary is an important nursery area for a number of marine-associated fish species, including the Dusky Kob, spotted grunter. The high turbidity of the system is advantageous to juvenile fishes in avoiding predation. The Catchment also exports large volumes of sediments, detritus and nutrients to the nearshore marine environment, thus responsible for maintaining the very rare subtidal deltas outside the mouth (< 5% of habitat in South Africa) that serves as spawns area for White steenbras. It is also an important movement corridor for fish breeding in sea as it serves as a conduit for three species of eels to the larger catchment.

Table 7-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Great Kei Estuary is not in a formally protected area. However, the estuary is part of the core set of priority estuaries in need of protection to achieve South Africa's biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) and for the 2030 Global Biodiversity Framework Target 3 (South Africa's 30 x 30 Apex Target) and Target 2 (Restoration). The NBA 2011 (van Niekerk and Turpie, 2012) recommended that the minimum category for the Great Kei Estuary be a B, that the system be granted partial no-take protection

(e.g. zonation that limits use in parts of the system), and that 50 % of the estuary margin be undeveloped (**Table 7-5**).

Table 7-5: Great Kei: National Estuary Biodiversity Plan requirements

Estuary Requirements	Great Kei
National and/or Regional Priority set	South Africa/Temperate region
Recommended extent of protection	Partial
Recommended extent of undeveloped margin	50%
Provisional NBA estimate of Recommended Ecological Category	B

7.4 Recommended Ecological Category

The PES for the Great Kei Estuary is a C Category, however, as the estuary is of high biodiversity and conservation importance it should be in an A Category or BAS.

However, given the level of land use change in the catchment and the high level of resource use (fishing and grazing) in and around the Great Kei Estuary, the REC is set as a B/C (BAS).

7.5 Recommendations to maintain or improve estuary condition

Key interventions required to improve the condition of the Great Kei Estuary include:

- Develop an Estuary Management Plan for the Great Kei Estuary to identify key actions required to address the ongoing decline in condition and coordinate restoration efforts.
- Reduce fishing pressure by managing access, increased compliance and community interactions.
- Ensure maintenance of low-flow conditions to prevent prolonged periods of increased water residency that promote the accumulation of phytoplankton and benthic microalgal communities.
- Manage nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and irrigation) and restoring riparian vegetation.
- Prevent disturbance of riparian vegetation (especially mangroves), including reducing the impact of trampling and grazing/browsing by cattle and preventing the occurrence of fire.
- Remove alien vegetation within the EFZ.
- Manage/ control recreational activities (e.g. boating) in the lower and middle reaches, particularly along the shoreline affecting bird abundance.

8. KEISKAMMA ESTUARY

8.1 Geographical boundaries

The Keiskamma Estuary is located in the warm temperate region on the south coast of Southern Africa. The town of Hamburg is located on the south-west bank of the estuary (Ribbink and Ribbink, 2012). The geographical boundaries of the Keiskamma Estuary are defined as follows (**Figure 8-1**):

Downstream boundary:	33°16'52.93"S, 27°29'27.49"E (estuary mouth)
Upstream boundary	33°11'4.01"S, 27°22'38.01"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

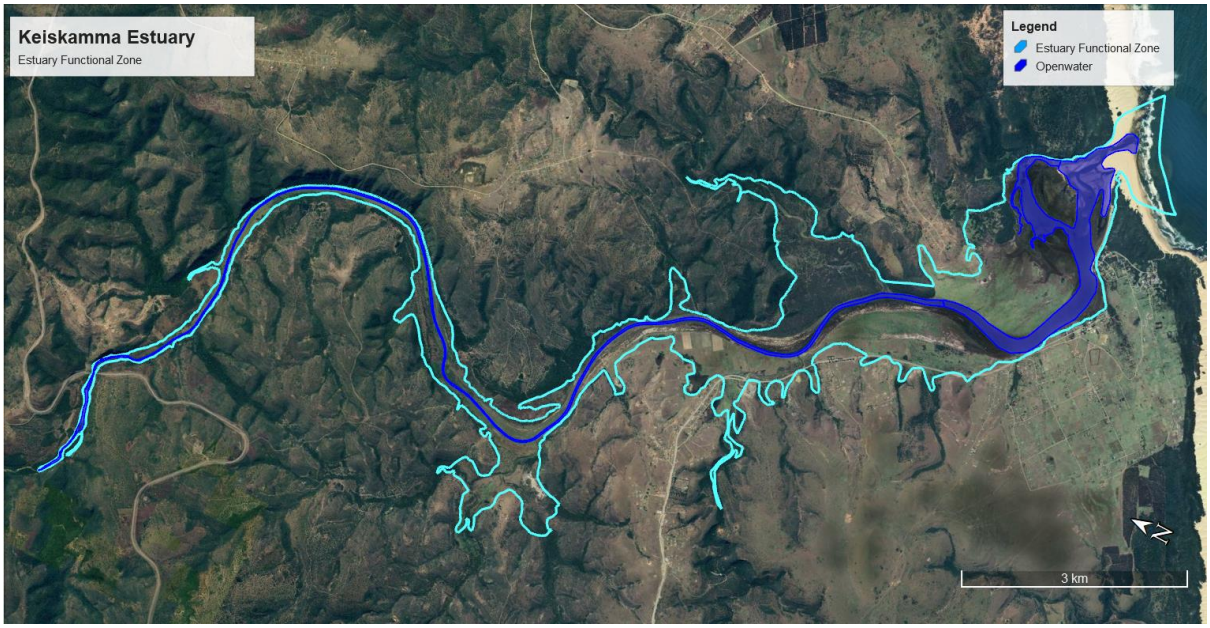


Figure 8-1: Geographical boundaries of the Keiskamma Estuary based on the Estuary Functional Zone.

8.2 Present Ecological Status

According to the hydrological data provided for this study, the present MAR into the Keiskamma Estuary is 86.4 Million m^3. This is a decrease of 33% compared to the natural MAR of 128.7 Million m^3. The Keiskamma Estuary in its present state is estimated to be 67% similar to natural conditions, which translates into a PES of a C Category. This is mostly attributed to the following factors:

- Significant flow reduction with a focus on baseflow reduction in the low flow period increasing salinity penetration;
- Severe over-exploitation of living resources (e.g. recreational fishing, small-scale fishing and illegal gill netting) impacting nursery function;
- Severe overgrazing and trampling of saltmarsh by cattle;
- A decline in water quality due to agricultural activities in the catchment;

- Bait collection and recreational activities such as boating affect bird abundance (and potentially bank stability);
- Agricultural activities in the EFZ cause loss of estuarine habitat;
- Cutting of reeds and erosion of banks; and
- Invasive alien plants within the EFZ.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 8-1** below.

Table 8-1: Keiskamma: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	46	-*	M
Hydrodynamics and mouth condition	81	0%	L - H
Water quality	77	90%	M
Physical habitat alteration	70	90%	L-M
Habitat health score	**68**		
Microalgae	79	50%	L-M
Macrophytes	73	80%	M
Invertebrates	55	17%	L
Fish	60	25%	M
Birds	**59**	20%	M
Biotic health score	**65**		
ESTUARY HEALTH SCORE	**67**		**M**
PRESENT ECOLOGICAL STATUS (PES)	**C**		

**- Not applicable*
*** Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

8.3 Biodiversity and Conservation Importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 8-2 and Table 8-3**, respectively.

Table 8-2: Keiskamma: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	100
Zonal Rarity Type	10	20
Habitat Diversity	25	100
Biodiversity Importance	25	97
Functional Importance	25	100
Estuary Importance Score		**91**
Calculation of the functional importance score		**Highly important**

The functional importance (**Table 8-3**) of Keiskamma Estuary is very high with a score of 100.

Table 8-3: Keiskamma: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	80
b) Nursery function for fish and crustaceans (marine /riverine)	100
c) Movement corridor for river invertebrates and fish breeding in sea	80
d) Roosting area for marine or coastal birds	70
e) Catchment detritus, nutrients and sediments to sea	90
Functional importance score - Max (a to e)	**100**

The EIS (**Table 8-4**) for the Keiskamma Estuary, is 91, highlighting that the estuary is rated as “Highly Important”. The Keiskamma Estuary is an important nursery area for several marine-associated fish species, including the Dusky Kob, spotted grunter (*Pomadasys commersonnii*). The high turbidity of the system is advantageous to juvenile fishes in avoiding predation. The Keiskamma catchment is also important for the delivery of sediment, nutrients and detritus to the nearshore environment.

Table 8-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Keiskamma Estuary is not in a formal protected area. However, the estuary forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) and to meet the 2030 Global Biodiversity Framework Target 3 (South Africa’s 30 x 30 Apex Target) and Target 2 (restoration) objectives. The NBA 2011 (van Niekerk and Turpie, 2012) recommended that the minimum Category for the Keiskamma be a B, that the system be granted partial no-take protection (zonation to reduce fishing effort), and that 50 % of the estuary margin be undeveloped (**Table 8-5**).

Table 8-5: Keiskamma: National Estuary Biodiversity Plan requirements

Estuary Requirements	Keiskamma
National and/or Regional Priority set	South Africa/Temperate region
Recommended extent of protection	Partial
Recommended extent of undeveloped margin	50%
Provisional NBA estimate of Recommended Ecological Category	B

8.4 Recommended Ecological Category

The PES for the Keiskamma Estuary is a C Category, however, as the estuary is degraded and of high biodiversity and conservation importance it should be in an A Category or BAS.

However, given the current degree of land-use change in the Keiskamma Catchment and estuary environs, and the present high level of natural resource utilisation (fishing and grazing pressure) of the Keiskamma Estuary the REC is set as a B Category (BAS).

8.5 Recommendations to maintain or improve estuary condition

Key interventions required to improve the condition of the Keiskamma Estuary include:

- Develop an Estuary Management Plan for the Keiskamma Estuary to identify key actions require to address the ongoing decline in condition and coordinate restoration efforts.
- Reduce fishing pressure by managing access, increase compliance and improve community interactions.
- Ensure maintenance of low-flow conditions to prevent prolonged periods of increased water residency that promote the accumulation of microalgal communities.
- Manage nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and irrigation) and restoring riparian vegetation.
- Restore saltmarsh areas that are fallow at present (see map in Adams *et al.,* 2023).
- Prevent disturbance of riparian vegetation, including trampling and severe overgrazing by cattle.
- Removal of alien vegetation from EFZ.

9. KARIEGA ESTUARY

9.1 Geographical boundaries

The Kariega Estuary is a warm temperate, predominantly open estuary situated on the east coast of South Africa. Its mouth opens just east of Kenton-on-Sea, and it is around 18 km in length and has an average midstream depth between 2.5 and 3.5 m. The Kariega Estuary is a marine-dominated system having a historical mean annual runoff of 22 x 10^6 m^6). The geographical boundaries of the Kariega Estuary are defined as follows (**Figure 9-1**):

Downstream boundary:	33°40'53.87"S, 26°41'4.23"E (estuary mouth)
Upstream boundary:	33°36'23.43"S, 26°38'17.77"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

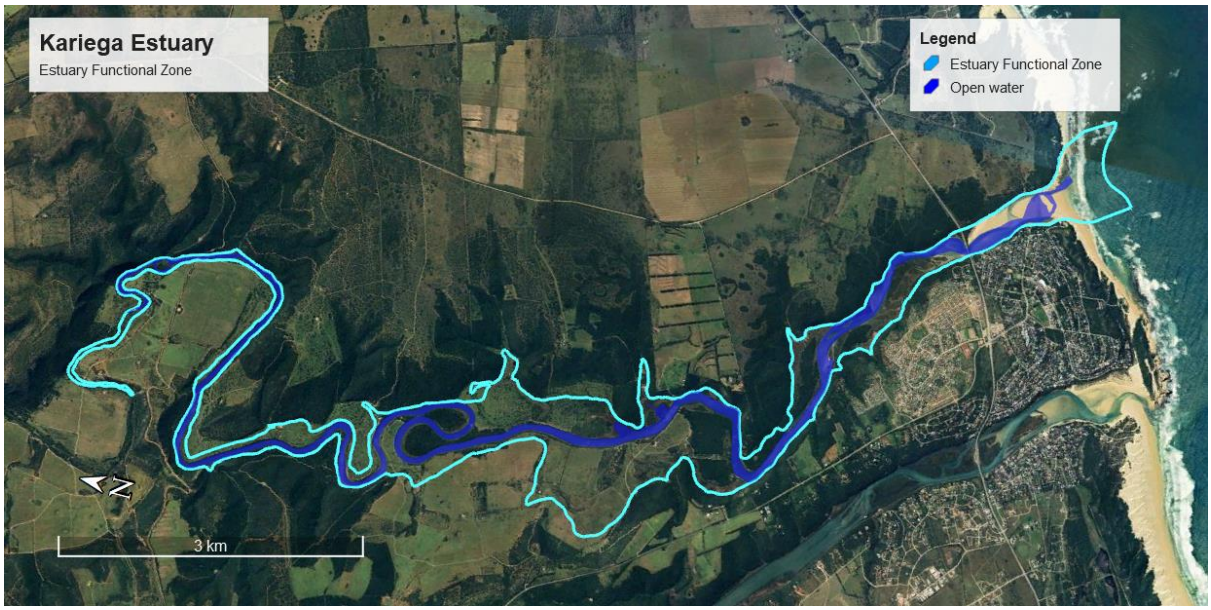


Figure 9-1: Geographical boundaries of the Kariega Estuary based on the Estuary Functional Zone.

9.2 Present Ecological Status

The present MAR into the Kariega Estuary is 13.1 Million m^3. This is a decrease of 40% compared to the natural MAR of 21.9 Million m^3. The Kariega Estuary in its present state is estimated to be 68% similar to natural conditions, which results in a PES of a C Category. This is mostly attributed to the following factors:

- Significant flow reduction with a focus on baseflow reduction in the low flow period resulting in an increase in salinity penetration and development of hypersalinity in the system;
- A decline in water quality due to agricultural activities and local housing development not on formal reticulation;

- Severe over-exploitation of living resources (e.g. recreational fishing, small-scale fishing and illegal gill netting) impacting nursery function;
- Agricultural activities and development in the EFZ cause loss of estuarine habitat; and
- Bait collection and recreational activities such as boating affect bird abundance (and potentially bank stability).

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 9-1** below.

Table 9-1: Kariega: Present Ecological State scores.

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	38	-*	M
Hydrodynamics and mouth condition	62	0%	L-M
Water quality	86	90%	M
Physical habitat alteration	75	80%	L
Habitat health score	**65**		
Microalgae	83	20%	L-M
Macrophytes	65	10%	M
Invertebrates	60	10%	L
Fish	70	20%	H
Birds	72	11%	M
Biotic health score	**70**		
ESTUARY HEALTH SCORE	**68**		**M**
PRESENT ECOLOGICAL STATUS (PES)	**C**		

**- Not applicable*
*** Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

9.3 Biodiversity and conservation importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 9-2 and Table 9-3**, respectively.

Table 9-2: Kariega: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	90
Zonal Rarity Type	10	20
Habitat Diversity	25	80
Biodiversity Importance	25	97
Functional Importance	25	100
Estuary Importance Score		**85**
Calculation of the functional importance score		**Highly important**

The functional importance (**Table 9-3**) of Kariega Estuary is very high with a score of 100.

Table 9-3: Kariega: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	40
b) Nursery function for fish and crustaceans (marine /riverine)	100
c) Movement corridor for river invertebrates and fish breeding in sea	30
d) Roosting area for marine or coastal birds	40
e) Catchment detritus, nutrients and sediments to sea	20
Functional importance score - Max (a to e)	**100**

The EIS (**Table 9-4**) for the Kariega Estuary, is 85, indicating that the estuary is rated as "Highly Important". The estuary's nursery function supports Critically Endangered Estuarine pipefish *Syngnathus watermeyeri* (only recorded at present in two estuaries globally) and important line fish species such as Cape stumpnose *Rhabdosargus holubi*, Blacktail *Diplodus sargus*, and Strepie *Sarpa salpa*. The endangered seagrass *Zostera capensis* that occurs throughout this estuary is also important for invertebrate species.

Table 9-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Kariega Estuary is not formally protected but is bisected by a private nature reserve in its middle and upper reaches resulting in relative pristine habitats and little disturbance. The estuary also forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) and the 2030 Global Biodiversity Framework Target 3 (30 x 30) that aims to protect indigenous endangered species such as the estuarine pipe fish and seagrass *Zostera capensis*. The NBA 2011 (van Niekerk and Turpie, 2012) recommended that the minimum Category for the Kariega is a B, that the system be granted partial no-take protection (i.e zonation), and that 50 % of the estuary margin be undeveloped (**Table 9-5**).

Table 9-5: Kariega: National Estuary Biodiversity Plan requirements

Estuary Requirements	Kariega
National and/or Regional Priority set	South Africa/Temperate region
Recommended extent of protection	Partial
Recommended extent of undeveloped margin	50%
Provisional NBA estimate of Recommended Ecological Category	B

9.4 Recommended Ecological Category

The REC represents the level of protection assigned to an estuary. The PES sets the minimum REC. The degree to which the REC needs to be elevated above the PES depends on the level of importance and level of protection or desired protection of a particular estuary.

The PES for the Kariega Estuary is a C Category, however, as the estuary is degraded and of high biodiversity and conservation importance it should be in an A Category or BAS.

Given the small size of the catchment, the degree of land-use change in the catchment and lower parts of the estuary, and the present level of natural resource utilisation of the Kariega Estuary the REC is a C Category (BAS).

9.5 Recommendations to maintain or improve estuary condition

Key interventions required to assist with species protection and to halt further decline in the condition of the Kariega Estuary include:

- Increase the protection of the estuary to ensure the protection of Estuarine pipefish and seagrass, i.e. stewardship agreements with Private Nature Reserve adjacent to the system.
- Develop an Estuary Management Plan for the Kariega Estuary to identify key actions required to improve/protect the system and coordinate restoration efforts (requirement of National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008) to coordinate management and restoration actions.
- Prevent further loss of low-flow conditions to limit the extent and duration of hypersalinity that leads to a loss of primary productivity. Increase base flows (e.g. through the removal of alien vegetation, unauthorised abstractions and/or forestry) to prevent mouth closure.
- Create interventions within the catchment and institute a buffer zone around the river and EFZ that would improve the nutrient status and help with sedimentation issues.
- Reduce fishing pressure by managing access, increase compliance and improve community interactions to restore nursery function.
- Prevent disturbance of riparian vegetation, including trampling, cattle, fire, and removal of alien vegetation.
- Undertake restoration of the estuary floodplain and reduce agriculture impacts in the supratidal area of the system.

10. GAMTOOS ESTUARY

10.1 Geographical boundaries

The Gamtoos Estuary is a permanently open estuary located on the south coast of South Africa and is approximately 24 km long. The geographical boundaries of the Gamtoos Estuary are defined as follows (**Figure 10-1**):

Downstream boundary:	33°58'8.20"S, 25° 2'30.36"E (estuary mouth - 2018)
Upstream boundary:	33°54'54.70"S, 24°56'16.56"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

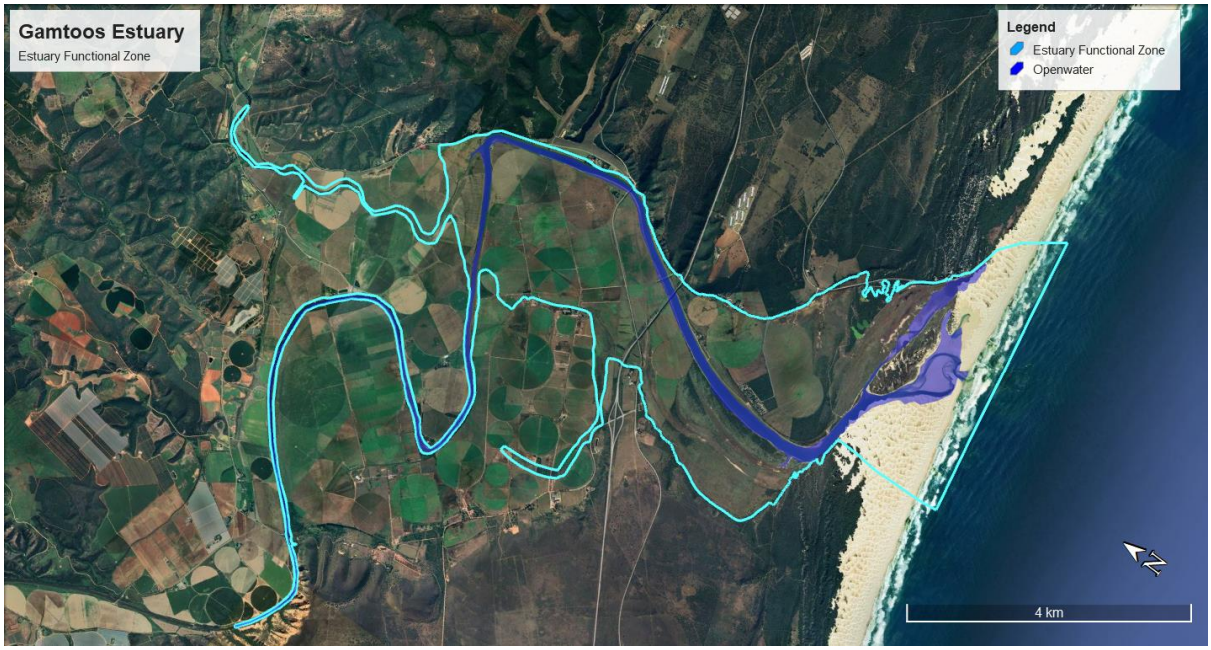


Figure 10-1: Geographical boundaries of the Gamtoos Estuary based on the Estuary Functional Zone.

10.2 Present Ecological Status

The present MAR into the Gamtoos Estuary is 195 million m^3. This is a decrease of 52% compared to the natural MAR of 404 million m^3. The Gamtoos Estuary in its present state is estimated to be 54% similar to natural conditions, which translates into a PES of a D Category. This is mostly attributed to the following factors:

- Flow reduction with a focus on baseflow reduction in the low flow period resulting in a significant increase in salinity and the occurrence of mouth closure (a rare and worrisome event for an estuary that is normally open);
- A decline in water quality due to extensive agricultural activities in the catchment and in the floodplain of the estuary;

- Severe over-exploitation of living resources (i.e recreational fishing, small scale and illegal gill netting) impacting nursery function and fisheries productivity;
- Agricultural activities in the EFZ cause loss of critical estuarine habitat;
- Overgrazing and trampling of saltmarsh on the floodplain impacting blue and teal carbon habitats and carbon sequestration;
- Bank destabilisation and bank hardening impacting coastal protection and habitat availability; and
- Bait collection and recreational activities in the lower and middle reaches affect bird abundance.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 10-1** below.

Table 10-1: Gamtoos: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	36	-*	H
Hydrodynamics and mouth condition	68	0%	L - H
Water quality	51	90%	M-H
Physical habitat alteration	70	90%	L
Habitat health score	56		
Microalgae	51	90%	L-H
Macrophytes	52	85%	M
Invertebrates	46	20%	L
Fish	55	20%	M
Birds	53	20%	M
Biotic health score	51		
ESTUARY HEALTH SCORE	**54**		**M**
PRESENT ECOLOGICAL STATUS (PES)	**D**		

**- Not applicable*
*** Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

10.3 Biodiversity and conservation importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 10-2 and Table 10-3**, respectively.

Table 10-2: Gamtoos: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	100
Zonal Rarity Type	10	20
Habitat Diversity	25	100
Biodiversity Importance	25	99

Functional Importance	25	90
Estuary Importance Score		**89**
Calculation of the functional importance score		**Highly important**

The functional importance (**Table 10-3**) of Gamtoos Estuary is very high with a score of 90.

Table 10-3: Gamtoos: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	80
b) Nursery function for fish and crustaceans (marine /riverine)	90
c) Movement corridor for river invertebrates and fish breeding in sea	80
d) Roosting area for marine or coastal birds	80
e) Catchment detritus, nutrients and sediments to sea	80
Functional importance score - Max (a to e)	**90**

The EIS (**Table 10-4**) for the Gamtoos Estuary, is 89, indicating that the estuary is rated as "Highly Important". The Gamtoos Estuary is a very important nursery for adolescents Dusky Kob and Leervis – both important line fish species that generate significant revenue for coastal communities, the system also serves as a corridor for three species of eels that migrate to the middle (Mottle eels) and upper catchment (Longfin eels). The sand spit at the mouth is also an important roosting area for Black Oystercatchers and Terns. In addition, the catchment supplies much-needed detritus and sediments to the nearshore marine environment which is linked to squid spawning habitat an important fishery along this coast. The system is also very important for blue carbon sequestration as it supports extensive saltmarshes.

Table 10-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Gamtoos Estuary is not in a formal protected area. However, the estuary forms part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) and to meet the 2030 Global Biodiversity Framework Target 3 (South Africa's 30 x 30 Apex Target) and Target 2 (Restoration) objectives. The NBA 2011 (van Niekerk and Turpie, 2012) recommended that the minimum Category for the Gamtoos be an A or BAS, that the system be granted partial no-take protection (i.e. zonation or closed areas), and that 50 % of the estuary margin be undeveloped (**Table 10-5**).

Table 10-5: Gamtoos: National Estuary Biodiversity Plan requirements

Estuary Requirements	Gamtoos
National and/or Regional Priority set	South Africa/Temperate region
Recommended extent of protection	Partial
Recommended extent of undeveloped margin	50%

Estuary Requirements	Gamtoos
Provisional NBA estimate of Recommended Ecological Category	A or BAS

10.4 Recommended Ecological Category

The PES for the Gamtoos Estuary is a D Category, however, as the estuary is in poor condition and of high biodiversity and conservation importance it should be in an A Category or BAS.

Given the degree of land-use change, specifically agriculture, in the catchment and estuary floodplain; concerns regarding water quality; and the present very high level of natural resource utilisation of the Gamtoos Estuary the REC is set as a C Category (BAS).

10.5 Recommendations to maintain or improve estuary condition

Key interventions required to improve the condition of the Gamtoos Estuary include:

- Develop an Estuary Management Plan for the Gamtoos Estuary to identify key actions required to halt the ongoing degradation of estuary condition and restore and coordinate restoration efforts (requirement of National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008).
- Increase base flows (e.g. through the removal of alien vegetation, unauthorised abstractions and/or forestry) to prevent mouth closure.
- Maintain a degree of natural hydrodynamic variability and periodic system flushing to prevent persistent eutrophic conditions (i.e., HABs, hypoxia, loss of species diversity).
- Reduce nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and irrigation) and restoring riparian vegetation.
- Institute a buffer zone around the river and EFZ that would improve the nutrient status and help with sedimentation issues.
- Develop and approve an Estuary Mouth/Maintenance Management Plan (required under the Environmental Impact Assessment regulations under the National Environmental Management Act (No. 107 of 1998)) to facilitate artificial breaching if required in future.
- Reduce fishing pressure by managing access, increase compliance and improve community interactions to restore nursery function.
- Prevent further disturbance of estuary riparian vegetation, including reducing trampling and grazing by livestock, fire, and remove alien vegetation from the EFZ.
- Undertake active restoration of the degraded estuary floodplain and reduce agriculture impacts in the supratidal area of the system (see Adams *et al.* 2023)

11. KABELJOUS ESTUARY

11.1 Geographical boundaries

The geographical boundaries of the Kabeljous Estuary are defined as follows (**Figure 11-1**):

Downstream boundary:	34° 0'17.90"S, 24°56'7.46"E (estuary mouth)
Upstream boundary:	33°59'34.78"S, 24°55'34.55"E
Lateral boundaries:	Estuary functional zone along each bank (~5 m MSL contour)

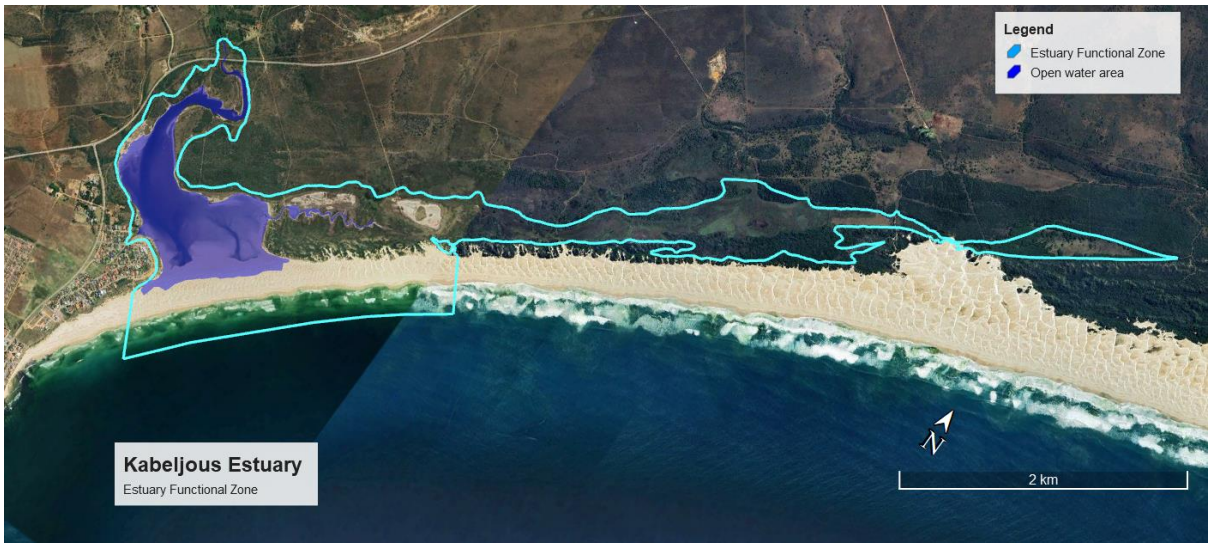


Figure 11-1: Geographical boundaries of the Kabeljous Estuary based on the Estuary Functional Zone.

11.2 Present Ecological Status

The estuary is fed by the Kabeljous and Gheis Rivers, with a total length of approximately 30 km). The total catchment of the area is about 238 km^2. The Kabeljous Estuary receives a mean annual precipitation of approximately 450 mm. Historical studies have estimated the mean annual runoff of between 15 x 10^6 m^3 and 27 x 10^6 m^3 (Bickerton and Pierce, 1988; Klages, 2005), but this has recently been adjusted downwards in the Algoa Bay study. According to the hydrological data provided for this study, the present MAR into the Kabeljous Estuary is 4.7 Million m^3. This is a decrease of 11% compared to the natural MAR of 5.27 Million m^3.

The Kabeljous Estuary in its present state is estimated to be 78% similar to natural conditions, which translates into a PES of a B Category. This is mostly attributed to the following factors:

- A reduction in groundwater input that assists in moderating hypersalinity and estuary water levels;
- Flow reduction with a focus on baseflow reduction resulting in an increase in salinity and a decrease in water levels;
- A decline in water quality due to agricultural activities in the catchment;
- Agricultural activities and development (including bridges) in the EFZ cause loss of estuarine habitat;

- Over-exploitation of living resources (i.e., illegal gillnetting and line fishing) – effectively mining fish in a closed small estuary;
- Recreational activities in the lower reaches affect bird abundance;
- Trampling and footpaths through saltmarshes;
- Land invasion occurs in the important wetland area east of the mouth. This brings with it pressures such as habitat removal, nutrient and litter pollution. These freshwater wetlands contain the only viable remaining example of Humansdorp Shale Renosterveld, which has remnant Khoisan middens, and is the breeding and roosting area of the endangered black Harrier.

The overall current Estuarine Health Index (EHI) score as well as the percentage attributed to non-flow related pressures is given in **Table 11-1** below.

Table 11-1: Kabeljous: Present Ecological State scores

Variable	Estuarine health score		
	Score	% attributed to non-flow related impacts	Confidence**
Hydrology	80	-*	L
Hydrodynamics and mouth condition	84	0%	L - M
Water quality	87	90%	L
Physical habitat alteration	76	90%	L
Habitat health score	**82**		
Microalgae	76	50%	L
Macrophytes	80	40%	M
Invertebrates	71	24%	L
Fish	70	20%	M-L
Birds	77	14%	H
Biotic health score	**75**		
ESTUARY HEALTH SCORE	**78**		**L**
PRESENT ECOLOGICAL STATUS (PES)	**B**		

**- Not applicable*
*** Confidence levels: Very Low (VL), Low (L), Medium (M), High (H)*

11.3 Biodiversity and conservation importance

The Estuary Importance Score for five components and the importance rating are presented in **Table 11-2 and Table 11-3,** respectively.

Table 11-2: Kabeljous: Estuarine Importance score

Criterion	Weight	Score
Estuary Size	15	90
Zonal Rarity Type	10	10
Habitat Diversity	25	80
Biodiversity Importance	25	85
Functional Importance	25	80
Estuary Importance Score		**76**
Calculation of the functional importance score		**Important**

The functional importance (**Table 11-3**) of Kabeljous Estuary is high with a score of 80.

Table 11-3: Kabeljous: Estimation of the functional importance score

Calculation of the functional importance score	Score
a) Export of organic material generated in the estuary (regional scale)	20
b) Nursery function for fish and crustaceans (marine /riverine)	40
c) Movement corridor for river invertebrates and fish breeding in sea	20
d) Roosting area for marine or coastal birds	80
e) Catchment detritus, nutrients and sediments to sea	20
Functional importance score - Max (a to e)	**80**

The EIS (**Table 11-4**) for the Kabeljous Estuary, is 76, showing that the estuary is rated as "Important". Given its small size, long periods of closure and prevalence of developing hypersalinity Kabeljous Estuary is a surprisingly important nursery area for several economically important fish species, including Garrick *Lichia amia,* Cape stumpnose *Rhabdosargus holubi,* Southern mullet *Chelon richardsonii and* Striped mullet *Chelon tricuspidens*. The Kabeljous Estuary is also very important as a roosting area for marine or coastal birds.

Table 11-4: Ranges applied in Estuarine Importance scoring

Importance score	Description
81 – 100	Highly important
61 – 80	Important
0 – 60	Of low to average importance

The Kabeljous Estuary is not formally protected. The estuary also does not form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie *et al*., 2012c) or in the 30 x 30 Global Biodiversity Framework protection targets. The NBA 2011 biodiversity plan (van Niekerk and Turpie, 2012) recommended that the minimum Category for the Kabeljous be a C.

11.4 Recommended Ecological Category

The PES for the Kabeljous Estuary is a B Category. **Given the degree of agriculture and development in the catchment and estuary environs; concerns regarding surface water and groundwater abstraction; declining water quality; and the high level of fishing effort the REC for the Kabeljous Estuary is also set at a B Category.**

11.5 Recommendations to maintain or improve estuary condition

Key interventions required to address the ongoing decline in the condition of the Kabeljous Estuary include:

- Develop an Estuary Management Plan for the Kabejous Estuary to identify key actions needed to improve the condition and coordinate restoration efforts.
- **Ensure maintenance of low-flow conditions (including groundwater) to prevent prolonged periods of mouth closure and the development of extreme hypersalinity that promotes microalgal and macroalgal accumulations.**
- **Increase base flows (e.g. through the removal of alien vegetation, unauthorised abstractions and/or forestry).**
- Reduce nutrient inputs by implementing agricultural best management practices (e.g., prevent overfertilization and over-irrigation) and restoring riparian vegetation.
- Reduce fishing pressure by managing access, increase compliance and improve community interactions to restore nursery function.
- Prevent disturbance of riparian vegetation, including trampling by humans and cattle, fire, and removal of alien vegetation.
- Prevent artificial breaching of the mouth (currently not a concern).

12. CONCLUSION

12.1 Summary of findings

Table 12-1 provides a detailed summary of the Present Ecological State scores for priority estuaries. Only two estuaries were in relatively good condition, Mngazi and Kabeljous. The highly important Great Kei, Keiskamma and Kaiega were in a C Category, while the Mbashe were in a B/C Category. Gamtoos Estuary was the most degraded system in Category D.

Table 12-1: Summary of Present Ecological State scores for priority estuaries

12.2 Component	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Hydrology	92	68	52	46	38	36	80
Hydrodynamics and mouth condition	94	78	79	81	62	68	84
Water quality	80	63	71	77	86	51	87
Physical habitat alteration	85	80	75	70	75	70	76
Habitat health score	**88**	**72**	**69**	**68**	**65**	**56**	**82**
Microalgae	82	80	74	79	83	51	76
Macrophytes	87	80	80	73	65	52	80
Invertebrates	80	76	54	55	60	46	71
Fish	75	60	70	60	70	55	70
Birds	81	79	58	59	72	53	77
Biotic health score	**81**	**75**	**67**	**65**	**70**	**51**	**75**
ESTUARINE HEALTH SCORE	**84**	**74**	**68**	**67**	**68**	**54**	**78**
PRESENT ECOLOGICAL STATUS	B	B/C	C	C	C	D	B

Most of the priority estuaries were of high biodiversity importance due to their size, habitat diversity, overall biodiversity importance and/or functional importance. Mbashe, Great Kei, Keiskamma and Kariega all rated as 'Highly Important', while Kabeljous rated as 'Important' (see **Table 12-2)**. The Mbashe and Great Kei estuaries support large stands of mangroves, while the Kariega and Keiskamma estuaries support large meadows for the endangered seagrass *Zostera capensis*. In addition, the Keiskamma and Gamtoos estuaries are also highly important systems for saltmarsh. Even though the Kabeljous estuary has a small open water area it supports a surprisingly large, vegetated wetland between the Kabeljous and Gamtoos estuaries.

Table 12-2: Summary of Estuarine Importance Scores for priority estuaries

Estuarine Importance	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Size	50	90	100	100	90	100	90
Zonal Type Rarity	10	50	50	20	20	20	10
Habitat diversity	20	90	90	100	80	100	80
Biodiversity Importance (plants, Inverbrates, fish and birds)	76	86	83	97	97	99	85

Estuarine Importance	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Functional importance	50	100	100	100	100	90	80
ESTUARINE IMPORTANCE SCORE	**45**	**88**	**88**	**91**	**85**	**89**	**76**
ESTUARINE IMPORTANCE RATINGRATING	**Low to average**	**Highly Important**	**Highly Important**	**Highly Important**	**Highly Important**	**Highly Important**	**Important**

The Mbashe, Great Kei, Keiskamma and Gamtoos Estuaries are all rated as critically important fish nursery systems (Van Niekerk et al. 2019) **(Table 12-3 and Table 12-4**). These estuaries serve as important nurseries for Dusky kob *Argyrosomus japonicus* (overexploited & collapsed, IUCN Red List endangered), White steenbras *Lithognathus lithognathus* (overexploited & collapsed), spotted grunter *Pomadasys commersonnii* (overexploited & collapsed) and Zambezi sharks *Carcharhinus leucas* (IUCN Red List Near threatened). The Mbashe and Great Kei catchments also export large volumes of sediments, detritus and nutrients to the nearshore marine environment, thus responsible for maintaining the very rare subtidal deltas outside the estuary mouths (< 5% of habitat in South Africa) that serve as spawning habitats for White steenbras. These systems also serve as important movement corridors for fish breeding in the sea, specifically three species of catadromous eels (Anguillidae). These eels recruit as glass eels, moving high up into the catchments where they may spend 8-30 years before returning to spawn and die at abyssal depths in the sea.

The Kariega Estuary supports the Critically Endangered Estuarine pipefish *Syngnathus watermeyeri* (only recorded at present in two estuaries globally) and important line fish species such as Cape stumpnose *Rhabdosargus holubi*, Blacktail *Diplodus sargus*, and Strepie *Sarpa salpa*. The Kariega Estuary is also important from a blue carbon perspective as it supports large strands of the endangered seagrass *Zostera capensis* that occurs throughout the system and provides an important habitat for invertebrate and juvenile fish species. The Kabeljous Estuary is of high importance from a botanical (large wetland between it and the Gamtoos estuary) and bird perspective.

Table 12-3: Summary of functional importance scores for priority estuaries

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
a) Export of organic material generated in the estuary (regional scale)	40	50	70	80	40	80	20
b) Nursery function for fish and crustaceans (marine /riverine)	50	100	100	100	100	90	40
c) Movement corridor for river invertebrates and fish breeding in sea	40	70	80	80	30	80	20
d) Roosting, foraging and/or nesting area for marine and coastal birds	50	60	60	70	40	80	80
e) Catchment detritus, nutrients and sediments to sea	40	90	100	90	20	80	20
Functional importance score - Max (a to e)	**50**	**100**	**100**	**100**	**100**	**90**	**80**

Table 12-4: Summary of key ecosystem services that are of regional/national or global importance and need to be maintained/protected

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Nursery function	Medium	High	High	High	High	High	Medium
Blue Carbon sequestration	Low	High	High	High	High	High	High

The Mbashe Estuary is formally protected and is situated within the Dwesa-Cwebe Marine Protected Area (**Table 12-5**). In addition, the Great Kei, Keiskamma, Kariega, and Gamtoos estuaries are all desired protected areas to meet national and international conservation obligations. They form part of the core set of priority estuaries in need of protection to achieve biodiversity targets in the 2011 National Estuaries Biodiversity Plan (Turpie et al., 2012c) and for the 2030 Global Biodiversity Framework (South Africa's 30 x 30 Apex target). The National Estuaries Biodiversity Plan (van Niekerk and Turpie, 2012) recommended that the minimum Category for conservation priorities be an A or BAS as set out in the methods above.

Table 12-5: Summary of protected /desired protected area status

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
Marine Protected Area / Protected Area		Dwesa-Cwebe MPA					
Desired PA/MPA needed to make Conservation targets			-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	-NBA 2011 -GBF 2030	

Table 12-6 summarises the PES and REC for the priority estuaries. The smaller Mngazi, Kariega and Kabeljous estuaries meet their conservation targets and only require non-interventions to maintain the PES. However, the larger Mbashe, Great Kei, Keiskamma and Gamtoos estuaries require flow and non-flow interventions to meet the RECs and restore critical ecosystem services (e.g. blue carbon and nursery function) and meet conservation obligations.

Table 12-6: Summary of PES and RECs of priority estuaries

	Mngazi	Mbashe	Great Kei	Keiskamma	Kariega	Gamtoos	Kabeljous
PES	B	B/C	C	C	C	D	B
REC	B	B	B/C	B	C	C	B

12.3 Restoration required to address negative trajectories and achieve RECs

Table 12-7 provides an overview of key interventions required to maintain/ restore estuary conditions and key ecosystem services to coastal communities. In many cases, these do not require new management action but more an intensifying of existing mandates. In addition, the Gamtoos and Keiskamma estuaries have degraded saltmarsh areas in need of active restoration to improve the ability of these systems to contribute to carbon sequestration, a climate regulatory service provided by blue carbon habitats.

12.4 Climate Change

Most of the estuaries in the study area showed a negative trajectory of change. Climate change with predicted increases in drought, floods, and hotter temperatures will only accelerate these trajectories. Maintaining a degree of natural hydrodynamic variability and estuarine abiotic configuration, together with preventing catchment degradation (e.g., erosion, nutrient enrichment), is particularly critical in the face of climate change where predicted increases in temperature, drought, and storminess are likely to confound biotic responses. For example, a 2°C increase in water temperature can increase the distribution and frequency of problematic and fast-growing primary producer communities (i.e., HABs, invasive alien aquatic plants, and filamentous/floating macroalgae).

Table 12-7: Restoration interventions required to address trajectory of change and achieving the REC (Priority = ● Action reguired= •)

Estuary	PES (Trajectory of change)	REC	Flow			Water Quality			Non-flow intervention												
			Restore/protect base flows	Maintain/protect floods	Protect/restore groundwater	Manage/reduce stormwater & drainage from floodplain	Improve river water quality	Monitor & reduce/reuse WW	Restore connectivity/ hydrodynamic functioning	Improve mouth management	Rehabilitate riparian areas/ wetlands	Remove alien vegetation*	Reduce grazing (sheep, cattle, goats)	Manage browsing/ implement cattle exclusion zone	Control mangrove harvesting	Control boating activities impacting on seagrass and birds	Control recreational activities impacting saltmarsh and birds	Remove/reduce fishing pressure	Manage/reduce bait collection	Investigate eradication of alien fish	Restore/protect against impact of mining
Kabeljous	B ↓	B	•	•	●		Agric		•			•					●	●	•	•	
Gamtoos	D ↓	C	•	●		Agric	Agric				●	•	•			•		●	•	•	
Kariega	C ↓	C	•					•	●			•	•			●		●	●		
Keiskamma	C ↓	B	•	●			Urban				●	•	●			●		●	●	•	
Great Kei	C ↓	B/C	•	●				•			•	•	•	●	●	•	•	●	•	•	
Mbashe	B/C ↓	B	•	●								●	•	●	●	•	•	●	•	•	
Mngazi	B ↓	B									•	•				•		●	•		●

* Mbashe Estuary: *Tamarix ramosissima*, Great Kei: Spanish reeds

13. REFERENCES

BICKERTON I, PIERCE S. 1988. Part II Synopses of available information on individual systems: Report No 33 Krom (CMS45), Seekoei (CMS46) and Kabeljous (CMS 47). In: Heydorn, A., Morant, P. (Eds.), Estuaries of the Cape. Council for Scientific and Industrial Research, Stellenbosch, South Africa, p. 109.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY. 1995. South African Water Quality Guidelines for Coastal Marine Waters. Volume 1: Natural Environment.

DEPARTMENT OF WATER AFFAIRS AND FORESTRY. 2008. Resource Directed Measures for Protection of Water Resources: Methodologies for the determination of ecological water requirements for estuaries. Version 2.0 Pretoria.

KLAGES, N, 2005. Ecological Assessment of Laguna Bay (Portion 6 of the Farm 328 Kabeljouws River). Institute for Environmental and Coastal Management.

TALJAARD, S, LEMLEY DA, VAN NIEKERK, L. 2022. A method to quantify water quality change in data limiting estuaries. Estuarine Coastal and Shelf Science 272: 107888.

TURPIE, J.K., TALJAARD, S., ADAMS, J.B., VAN NIEKERK, L., FORBES, N., WESTON, B., HUIZINGA, P., & WHITFIELD, A. 2012a. Methods for the determination of the Ecological Reserve for estuaries. Version 3. Water Research Commission and Department of Water Affairs, Pretoria. WRC Report No. 1930/2/14.

TURPIE, J.K., TALJAARD, S., VAN NIEKERK, L., ADAMS, J.B., WOOLDRIDGE, T., CYRUS, D.P., CLARKE, B., FORBES, N., 2012b. The Estuary Health Index: a standardised metric for use in estuary management and determination of ecological water requirements. WRC Report No. 1930/1/12.

TURPIE, J.K., WILSON, G., VAN NIEKERK, L. 2012c. National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa. Anchor Environmental Consulting, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

UNITED NATIONS ENVIRONMENT PROGRAMME, NAIROBI CONVENTION SECRETARIAT AND COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH. 2022. Western Indian Ocean: Guidelines for Setting Water and Sediment Quality Targets for Coastal and Marine areas. UNEP, Nairobi, Kenya. XXIV + 109 pp +Appendices.