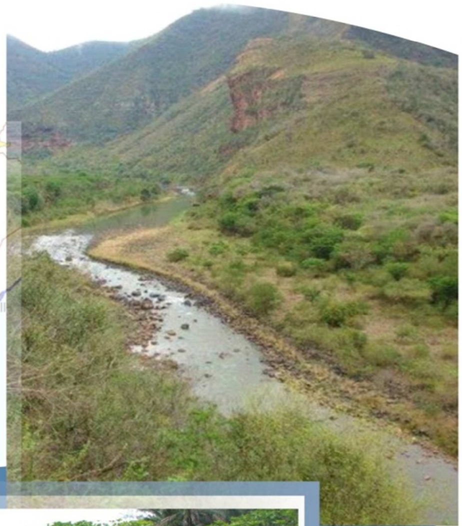
REPORT NUMBER: RDM/WMA11/00/CON/CLA/0115

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

PROJECT NUMBER: WP 10679



VOLUME 2D: SUPPORTING INFORMATION ON THE DETERMINATION OF WATER RESOURCE CLASSES - ECOLOGICAL CONSEQUENCES OF ESTUARIES IN T4, U2, U3, U5, U6, U7 AND U8 OF OPERATIONAL SCENARIOS

SEPTEMBER 2015

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

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DOCUMENT INDEX

Index Number	DWS Report Number	Report Title
1	Report Number: RDM/WMA11/00/CON/CLA/0112	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Inception Report**
2	Report Number: RDM/WMA11/00/CON/CLA/0113	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Status Quo assessment, IUA delineation and Biophysical Node identification**
3	Report Number: RDM/WMA11/00/CON/CLA/0213	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **River Resource Units and EWR sites**
4	Report Number: RDM/WMA11/00/CON/CLA/0313	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Desktop Estuary EcoClassification and EWR**
5	**Rivers EWR report volumes**	
5.1	Report Number: RDM/WMA11/00/CON/CLA/0114	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: EWR estimates of the River Desktop Biophysical Nodes**
5.2	Report Number: RDM/WMA11/00/CON/CLA/0214	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2: EcoClassification and EWR assessment on the Mtamvuna, Lovu, uMngeni, Karkloof and uMnsunduze Rivers**
5.3	Report Number: RDM/WMA11/00/CON/CLA/0314	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3: EcoClassification and EWR assessment on the uMkhomazi, uMngeni and Mvoti Rivers**
6	Report Number: RDM/WMA11/00/CON/CLA/0212	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **BHNR**
7	Report Number: RDM/WMA11/00/CON/CLA/0414	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Water Resource Analysis Report**
8	**Operational Scenario and Management Class report volumes**	
8.1	Report Number: RDM/WMA11/00/CON/CLA/0514	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: Supporting Information on the Determination of Water Resource Classes – River Ecological Consequences of Operational Scenarios**
8.2	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2a: Supporting Information on the Determination of Water Resource Classes – Mvoti (U4) Estuary EWR and Ecological Consequences of Operational Scenarios**

Index Number	DWS Report Number	Report Title
	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2b: Supporting Information on the Determination of Water Resource Classes – uMkhomazi (U1) Estuary EWR and Ecological Consequences of Operational Scenarios**
	Report Number: RDM/WMA11/00/CON/CLA/0614	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2c: Supporting Information on the Determination of Water Resource Classes –Mhlali (U30E) Estuary EWR and Ecological Consequences of Operational Scenarios**
	Report Number: RDM/WMA11/00/CON/CLA/0115	**Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: Volume 2d: Supporting Information on the Determination of Water Resource Classes –Ecological Consequences of Estuaries in T4, U2, U3, U5, U6, U7 and U8 of Operational Scenarios**
8.3	Report Number: RDM/WMA11/00/CON/CLA/0714	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3 Supporting Information on the Determination of Water Resource Classes – Estuary specialist appendices (electronic information only)**
8.4	Report Number: RDM/WMA11/00/CON/CLA/0814	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 4: Supporting Information on the Determination of Water Resource Classes - Economic Consequences of Operational Scenarios**
8.5	Report Number: RDM/WMA11/00/CON/CLA/0914	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 5: Supporting Information on the Determination of Water Resource Classes - Ecosystem Services Consequences of Operational Scenarios**
8.6	Report Number: RDM/WMA11/00/CON/CLA/1014	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 6: Supporting Information on the Determination of Water Resource Classes – User Water Quality Consequences of Operational Scenarios**
8.7	Report Number: RDM/WMA11/00/CON/CLA/1114	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 7a: Recommended Water Resource Classes for the uMkhomazi (U1) and Mvoti (U4) River Systems**
	Report Number: RDM/WMA11/00/CON/CLA/0215	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 7b: Recommended Water Resource Classes for the T4, T5, U2, U3, U5, U6, U7 and U8 secondary catchments**
9	**Resource Quality Objectives report volumes**	
9.1	Report Number: RDM/WMA11/00/CON/CLA/0315	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 1: River RQOs**

Index Number	DWS Report Number	Report Title
9.2	Report Number: RDM/WMA11/00/CON/CLA/0415	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 2: Wetland RQOs**
9.3	Report Number: RDM/WMA11/00/CON/CLA/0515	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 3: Groundwater RQOs**
9.4	Report Number: RDM/WMA11/00/CON/CLA/0615	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Volume 4: Estuary RQOs**
10	Report Number: RDM/WMA11/00/CON/CLA/0715	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Implementation Report**
11	Report Number: RDM/WMA11/00/CON/CLA/0815	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Main Report**
12	Report Number: RDM/WMA11/00/CON/CLA/0116	Classification of Water Resources and Determination of the Comprehensive Reserve and Resource Quality Objectives in the Mvoti to Umzimkulu Water Management Area: **Closing Report**

DEPARTMENT OF WATER AFFAIRS

CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE COMPREHENSIVE RESERVE AND RESOURCE QUALITY OBJECTIVES IN THE MVOTI TO UMZIMKULU WATER MANAGEMENT AREA

VOLUME 2D: SUPPORTING INFORMATION ON THE DETERMINATION OF WATER RESOURCE CLASSES –ECOLOGICAL CONSEQUENCES ON ESTUARIES IN T4, U2, U3, U5, U6, U7 AND U8 OF OPERATIONAL SCENARIOS

Approved for RFA by:

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Delana Louw Project Manager	Date

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Approved for DWS by:

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REPORT SCHEDULE

Version	Date
First draft	September 2015
Final	November 2015

EXECUTIVE SUMMARY

This report summarises the ecological consequences of a range of flow and water quality scenarios that are based on projected future development in the Water Management Area (WMA 11). The report is aimed at the strategic level and strives to assist with narrowing down future options of use (e.g. responsible disposal from Waste Water Treatment Works (WWTW)), while simultaneously identifying the consequences to the estuarine ecosystems. For reporting purposes, the estuaries of the Mvoti to Umzimkulu WMA were subdivided into three clusters:

- Northern Cluster (iLembe District Municipality).
- Central Cluster (eThekwini Municipality).
- Southern Cluster (Ugu District Municipality).

PRESSURES

The overall assessment of the Present Ecological State (PES) of estuaries in this WMA clearly shows the impact of urbanisation on these sensitive systems. For most systems, river inflows still resemble that of the reference condition (hydrology), with exceptions occurring in the urbanised systems where discharges from WWTWs have significantly elevated base flows. Therefore, the hydrodynamic processes which influence mouth states and salinity distributions are mostly similar to the natural state.

In contrast to the hydrology, the water quality in a large number of estuaries in this WMA has been modified significantly. This is attributed to diffuse agricultural runoff in rural areas (e.g. introducing fertilizer, herbicides and pesticides) and contaminated stormwater runoff from urban development (delivering nutrients and toxic substances). In 25 estuaries of the 64 estuaries water quality has been compromised by point source discharges from WWTWs, either directly into the estuaries or into rivers just upstream of the head of the estuaries. In the Ugu District Municipality 21 such WWTW discharges were identified which discharge a total volume of 26.7 Ml/day (9.8 x 10^6 m^3/annum). Seven (7) WWTW discharges were listed for the iLembe District Municipality with a total volume of 25.8 Ml/day (9.4 x 10^6 m^3/annum) (Figure 2.2) and 17 WWTW discharges in the eThekwini municipality total a volume of 440 Ml/day (Figure 2.3).

With the exception of the larger fast-flowing estuaries (e.g. the Mtamvuna, uMkhomazi, uMngeni and Umzimkulu) most systems along this stretch of coast are relatively small with very little assimilative capacity for nutrient or organic loading. Of note also is that while the overall condition of water quality for Durban Bay is regarded to be fair (Category C) this is largely attributed to tidal flushing of the extensive lower reaches of this system. Important remaining estuarine habitats (mangroves, mud and sand banks) in the upper reaches of this system are not well flushed and are subject to extensive contaminated run-off from urban surrounds. The historic and on going physical alteration and destruction of habitat for port development, together with poor water quality in the ecologically important upper reaches significantly threatens ecological integrity of Durban Bay. Although now an operational port and highly transformed, the size of this system and its remaining diversity of habitat still render it important as an estuarine resource.

Urbanisation has led to significant habitat modification in estuaries along this coast. For example, road and rail infrastructure affect nearly every estuary in the WMA. In addition, most estuaries have one or two large bridges crossing them. Bridge foundations and abutments, road and rail berms have led to infilling of systems and consequential habitat destruction. Development across floodplains and channel stabilisation has impacted natural flow patterns and resulted in localised scour and deposition. Sugar cane farming along the banks of a large number of systems has led to infilling of floodplains, general constriction of tidal flows and large-scale losses of marginal vegetation and natural vegetation buffers around the estuaries. Poor agricultural practises and overstocking has increased sediment input from catchments in Tribal Trust areas, contributing to sedimentation in the downstream estuaries.

Macrophytes, in most cases, also reflect the effect of urbanisation, with a significant number of systems showing severe degradation of floodplain vegetation. In several systems a significant loss of habitat due to the presence of bridge abutments and berms is evident. Disturbed floodplain areas and riparian zones have been invaded by Brazilian pepper tree (*Schinus terebinthifolia*) and *Lantana camara*. In many areas, aquatic habitats have been drained to cultivate the floodplain. Overall, this has resulted in woodier vegetation, encroachment by terrestrial vegetation and a loss of aquatic habitat. Reduction in freshwater inflow to estuaries and an increase in the frequency and duration of closed mouth conditions is also a threat to macrophytes. Reed encroachment in a number of systems is clear evidence of nutrient enrichment. Increased nutrient input from wastewater treatment and stormwater has caused eutrophication. Emergent species thrive under nutrient-rich conditions and invasive aquatic macrophytes such as water hyacinth (*Eicchornia crassipes*) and water cabbage (*Pistia stratiotes*) outcompete indigenous plants.

Microalgae also reflect increased production because of increased nutrient loading and concomitant increase in reed habitat (providing additional habitat for epiphytes). However, these effects are somewhat buffered by effective regular flushing of these smaller systems during their open states.

Estuarine invertebrate communities have been impacted by alteration and destruction of habitat in the systems of this study area. These have arisen mostly due to development around (and in some case over) estuarine systems resulting in loss of structural habitat as well as water column habitat. In some cases changes in river inflow have had impacts, especially on invertebrates with marine associations, both through reduced connectivity (increased mouth closure and therefore reduced opportunity to recruit into estuaries) and through changes to the salinity regimes in some systems. The alien invasive snail *Tarebia granifera* has established large populations in many systems and proliferates at the expense of indigenous gastropods. Although unstudied in South Africa, ecosystem impacts (such as loss of indigenous species, introduction of liver flukes, loss of food for higher trophic levels), are highly likely to occur because of the proliferation of this alien species. Water quality impacts are likely to have played a role in reduced invertebrate abundance in many systems, and certainly to have done so in most estuaries in densely populated urban areas. Small Temporarily open /closed estuaries (which are characteristic of this WMA) are especially prone to deterioration in water quality when they close. Although most of the systems in the WMA exhibit some natural tendency towards depressed DO levels in deeper waters, this has been exacerbated and extends into surface waters in some instances as a result of increased nutrient and organic loading from surrounding land use and WWTW discharges.

Fish communities have responded to changes in river inflow in some systems, as a result of their sensitivity to changes in mouth conditions. Most, if not all of the systems in the study area have experienced loss of estuarine habitat and loss of natural buffers on their perimeters and the inflowing rivers. Critical fish habitat has been lost in some cases, which has resulted in marked reductions in fish diversity and nursery function. The loss of submerged aquatic vegetation, especially in eelgrass *Zostera capensis* from systems like the Sandlundlu, Umgababa, Sipingo, and Durban Bay (and very likely several others) has undoubtedly played a significant role. As with estuarine invertebrates, deterioration in water quality (specifically nutrient enrichment resulting in eutrophication and subsequent reduction in DO concentrations) is increasing becoming a threat to fish health in these systems, especially those adjacent to densely populated urban areas. In recent years fish kills have occurred in 18 estuaries in the WMA (Ugu = 5, eThekwini = 9, iLembe = 4). These have been attributed to eutrophication and associated low oxygen events. In many cases these events have been triggered by malfunctioning WWTWs (due to infrastructure failure and/or overloading). The high number of fish kills recorded in the Mvoti to Umzimkulu WMA represents about 40% of all recorded fish kills in South Africa, indicating that many estuaries on this coastline are at ecological tipping points. In some cases trophic impacts are likely to have manifested with favoured prey items (e.g. sandprawn *Callichirus kraussi*) either lost or reduced in systems due to habitat loss and alteration, and water quality impacts.

Birds in these estuaries are mostly affected by human disturbance with systems in urban areas showing the most suppressed bird abundances. In some systems, the pressure is further exasperated by a reduction in suitable habitat and food availability.

RESULTS

Southern Cluster

In this cluster ten estuaries are of conservation importance: the Mtamvuna, Mpenjati, Zotsha, Umzimkulu, Damba, Koshwana, Intshambili, Mhlabatshane, Mfazazana and the Kwa-Makosi. The following overall responses were noted for systems were waste water may be discharges in the future:

- **Mpambanyoni:** All the scenarios maintain the current state (PES = C), with a slight decline under the worst case scenario (Sc) (Sc 2).
- **Sezela:** Most of the scenarios maintain the current condition (PES = C), but the removal of the wastewater inputs (Sc A1) will improve the system's condition. Under the worst case scenarios (e.g. Sc D4, Sc 2) the estuary declines significantly further in condition to a C/D and D.
- **Koshwana:** Most of the scenarios maintain the present state (PES = C/D). While Sc A1 shows an improvement (Category C) and the worst case scenarios (e.g. Sc 2) results in a significant decline in health to a Category D. The recent fish kill in this estuary shows that it is already at a tipping point.
- **Mbango:** Most of the scenarios maintain the current state (PES = E). Under Sc A1 (reduction in wastewater inputs) the systems shows a significant improvement in condition (Category D/E), while under the worst case scenarios (e.g. Sc A1a, Sc 2) it shows a further decline.
- **Boboyi** and **Mhlangeni:** Most of the scenarios result in these systems maintaining their current health (PES = B/C and C, respectively). However, declines in state will occur under the worst case waste water scenarios (Sc 2).
- **Vungu:** The system will decline in health from the current state (PES = B) to Category B/C and C under the future conditions Sc C3, Sc D4, Sc A1a and Sc 2.
- **Kongweni:** The system is at present in a degraded condition (D/E category). Most of the scenarios will result in further significant decline in health to an E Category. A significant reduction in the WWTW effluent discharge will achieve the REC of Category D. This can also be achieved by a smaller reduction in WWTW effluent, together with other (non-flow related) interventions.
- **Mvutshini:** Most of the scenarios show a significant decline in health from the present condition (PES = B/C) as this estuary is sensitive to flow.
- **Mpenjati:** The scenarios maintain the current state (PES = B/C).
- **Tongazi:** While the scenarios maintain the PES = B/C, the estuary is sensitive to the increase in WWTW effluent discharge and will decrease in condition under Sc C3, Sc D4 and Sc 2.
- **Zolwane:** The system is still in a good condition (PES = B). The estuary is sensitive to increases in WWTW effluent. About half of the scenarios, Sc E5, Sc A1a and Sc 2, will result

in a (significant) decline in condition to Category B/C or C. Other scenarios will maintain or improve the present state.

Central Cluster

In this cluster nine systems are of conservation importance: the Mahlongwa, Mahlongwane, uMkhomazi, Umgababa, Msimbazi, Lovu, Durban Bay, Mgeni and the Mhlanga. On a national and regional scale, estuary health is in a very poor state along this coast, with five systems in a degraded condition (< D/E): Little Manzimtoti, aManzimtoti, Mbokodweni, Sipingo, Durban Bay, Mgeni. Average WWTW effluent concentrations for the present and three levels of future treatment options were assessed.

Summary of average WWTW effluent concentrations for the future treatment options

Parameter	Level 1	Level 2	Level 2a
Ammonia-N (free) (µg/l)	<3 000	<1 500	<500
Nitrate/Nitrite-N (µg/l)	<8 000	<4 500	<2 500
DIN (µg/l)	**11 000**	**6 000**	**3 000**
DIP (µg/l)	**1 000**	**100**	**20**
COD (mg/l O_2)	**75**	**50**	**30**
Suspended solids (mg/l)	25	15	5
Estimated turbidity (NTU)	**40**	**30**	**20**

Small systems in this cluster were also relative insensitive to level of waste water treatment as they have very little assimilative capacity and therefore go eutrophic very easily.

The following overall responses were noted for systems were water resource development may occur or waste water may be discharges in the future:

- **Thonghati:** The estuary is at present in fair state (PES = D). The estuary showed some sensitivity to the level of treatment, with Level 1 treatment generally being much worse than Level 2 and Level 2a treatment. Under Sc A1 (no WWTW discharges) the estuary increases in condition to a Category C/D. Under the Sc 2 (treatment level 1 and 2) the estuary degrades to a Category D/E, but it maintains the PES at treatment level 2a. Significant further deterioration in condition to Categories E to E/F is anticipated under the Sc 3 to Sc 6 as a result of the substantial increase in WWTW volume and nutrient loading to the system.
- **uMdloti:** The estuary is at present in fair state (PES = D). This system has a relatively small open water area with a low assimilative capacity and therefore sensitive to increases in WWTW discharges. Water quality in river inflows is very poor (Table 7.11). Therefore, future scenarios that result in more frequent mouth closure (i.e. in which flow is significantly reduced) will lead to deterioration in water quality and reduction in DO levels unless the water quality inflow from the catchment is improved. Examples of such scenarios are Sc H6_1o, Sc A1, Sc H6_1p, and Sc A1a (L1). The estuary remained in a Category D under scenarios Sc C3 (l1), Sc C3 (L2), Sc 23_2 (L2), Sc 23_2 (L2a) irrespective of the treatment level. Significant further deterioration in condition to Categories D/E and E is anticipated under Sc D4 (L2a), Sc 2 (L1) and Sc 2 (L2a) as a result of the substantial increase in WWTW volumes and nutrient loading to the system.
- **Mbokodweni:** The system is at present in a poor condition (PES = Category E). The system improves significantly to a Category D if WWTW effluent is reduced and/or removed from the system. Under Sc 2 (55 Ml/d) at all three levels of effluent treatment, the system will

maintain PES. Under Sc 3 (30 Ml/d) the estuary show a severe decline in condition to a Category E/F.

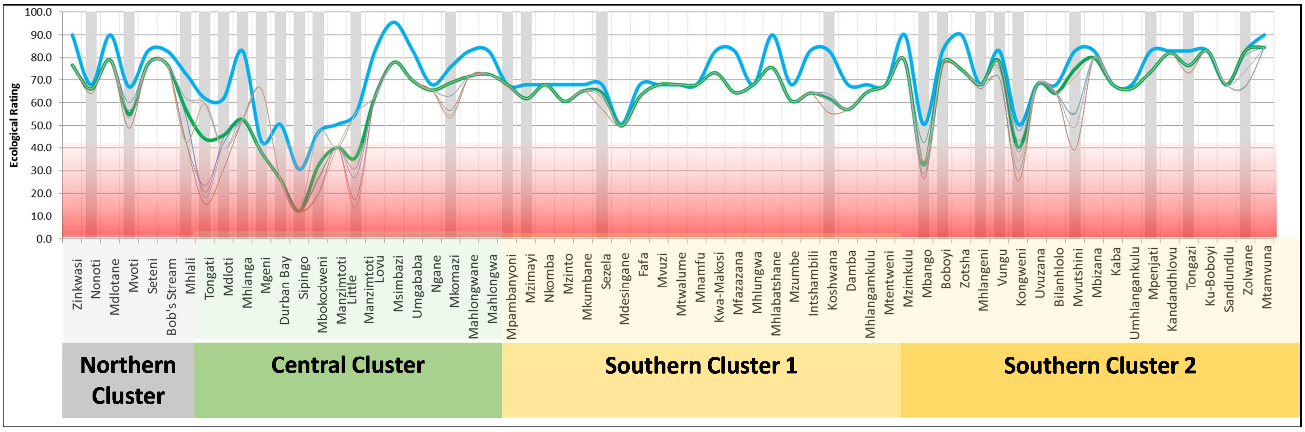
- **Little Manzintoti:** The system is at present in a poor condition (PES = E). The system improves significantly to a Category D if WWT effluent is reduced and/or removed. Under Sc 2a (8 Ml/d) at all three levels of effluent treatment, the system will maintain the PES. Under Sc 3 (30 Ml/d) the estuary shows a severe decline in condition to Category E/F and F.
- **uMkhomazi:** The estuary is of high ecological importance. All "flow" scenarios maintained the current state (PES = C). This system will require other (non-flow) interventions to attain the REC. Most of the future scenarios including WWTW discharges degrade the condition of this ecologically important estuary to a Category C/D or D. Even Sc MK1 (5 Ml/d), which potentially under average flow condition will maintain the PES, poses a risk of eutrophication and fish kills during low flow periods and droughts when the system closes.

Northern Cluster

In this cluster four systems are of conservation importance: the Mhlali, Mvoti, Mdlotane and the Zinkwasi. The following overall responses were noted for systems were waste water may be discharges in the future:

- **Mhlali:** The PES is a Category C/D. Most of the future scenarios will result in a further decline in ecological health due to excessive nutrient loading from WWTW discharges into this small estuary. The only scenario that showed some improvement in condition is Sc 1 (no WWTW discharges) taking the system to a Category B/C.
- **Mvoti:** Under most flow scenarios the system maintains the PES (Category D). The system requires other (non-flow related) interventions to attain the REC. Additional WWTW discharge will reduce the current condition, but the estuary is likely to maintain the present condition category.
- **Nonoti:** All the waste water scenarios maintain the current condition (PES = C). Scenario A1 will result in an improvement in condition from Present and the worst case scenario (Sc 2) will cause a decline in health.

Summary of the PES, REC and scenario consequences for the estuaries of the Mvoti to Umzimkulu WMA



INTEGRATING ECOLOGICAL RESPONSES INTO OPERATIONAL SCENARIOS ASSESSMENT

Based on the preceding ecological results and the engineering feasibility assessment a number of operational scenario permutations was developed incorporating local constraints into a range of catchment scale alternative. The grouped summaries are provided.

Label	Scenario description
A	Ecological protection is priority (minimum discharge to estuaries)
B	Minimum costs scenario (highest flow through estuaries)
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.
E	Indirect re-use (consider volume and practicalities) Remainder According to Scenario C.
F	Direct re-use (consider volume and practicalities) Remainder According to Scenario C.
X	Alternative scenarios (combinations of alternative)

SUMMARY OF OPERATIONAL SCENARIO RESULTS

The following was concluded from the catchment-scale operational scenario assessment for the Southern Cluster (See Appendix A):

- Overall, the scenario configuration Ai maintains the PES, while Sc C, D, E, F, Di, Ei and Ci reduce the Southern Cluster estuaries conditions.
- Scenario Aii, Aiii Aiv, Av, Bi, Bii and Biii further degrade the ecological condition of the systems. In addition, this group of scenarios increases the risk of eutrophication developing and fish kills occurring during low flows and droughts.

The following was concluded from the operational scenario assessment for the Central Cluster:

- Scenario configurations Ai, Aii, AiV and Av, as well as Ei improve the ecological condition of the Central Cluster estuaries.
- Scenario E and F maintain the PES, while Sc Aiii, Bii, C D Ci and Di reduce the estuaries conditions.
- Scenario Bi further degrades the ecological condition of these systems significantly.
- The latter two groups of scenarios (Aiii, Bii, C, D, Ci, D and Bi) increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

The following was concluded from the operational scenario assessment for the Northern Cluster:

- Scenario configurations Ai, E, F and Ei improve the ecological condition of the Northern Cluster estuaries.
- Scenario C and D represent a slight decline in ecological health from present.
- Scenario Aii, Aiii, Aiv, Av, Ci and Di show a further decline in ecological health.
- Scenario Bi, Bii and Biii degrade the ecological condition of these systems the most.
- The A, C, D and B groups of scenarios all increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

BAS	Best Attainable State
CD: WE	Chief Directorate: Water Ecosystems
CSIR	Centre of Scientific and Industrial Research
DEA	Department of Environmental Affairs
DIN	Dissolved Inorganic Nitrogen
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphate
DIP	Dissolved Inorganic Phosphate
DO	Dissolved Oxygen
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EC	Ecological Category
EFZ	Estuary Functional Zone
EHI	Estuarine Health Index
EWR	Ecological Water Requirement
KZN	KwaZulu-Natal
MAR	Mean Annual Runoff
MMTS2	Mooi-UMngeni Transfer Scheme Phase 2
MRDP	Mvoti River Development Project
MSL	Mean Sea Level
MWP	uMkhomazi Water Project
NBA	National Biodiversity Assessment
PES	Present Ecological State
REC	Recommended Ecological Category
RQO	Resource Quality Objective
Sc	Scenario
WMA	Water Management Area
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

There is an urgency to ensure that water resources in the Mvoti to Umzimkulu Water Management Area (WMA) are able to sustain their level of uses and maintained at their desired states. The determination of the Water Resource Classes of the significant water resources in Mvoti to Umzimkulu WMA will ensure that the desired condition of the water resources, and conversely, the degree to which they can be utilised are maintained and adequately managed within the economic, social and ecological goals of the water users (DWA, 2011). The Chief Directorate: Water Ecosystems (CD: WE) of the Department of Water and Sanitation (DWS) initiated a study during 2012 for the provision of professional services to undertake the Comprehensive Reserve, classify all significant water resources and determine the Resource Quality Objectives (RQOs) in the Mvoti to Umzimkulu WMA.

The objective of this task was to describe and document the ecological consequences of a range of waste water management options on various estuaries. The output of this task will serve as input to the process to derive Water Resource Classes.

1.2 INTEGRATED STEPS APPLIED IN THIS STUDY

The integrated steps for the National Water Classification System, the Reserve and RQOs (DWA, 2012) are supplied in Table 1.1.

Table 1.1 Integrated study steps

Step	Description
1	Delineate the units of analysis and Resource Units, and describe the status quo of the water resource(s) (completed).
2	Initiation of stakeholder process and catchment visioning (on-going).
3	Quantify the Ecological Water Requirements and changes in non-water quality ecosystem.
4	**Identification and evaluate scenarios within the Integrated Water Resource Management process.**
5	Evaluate the scenarios with stakeholders and determine Water Resource Classes.
6	Develop draft RQOs and numerical limits.
7	Gazette and implement the class configuration and RQOs.

This report forms ***part*** of the outcomes of Step 4 (highlighted above) within the integrated approach. The objective of this task was to provide the scenario analysis, assumptions and results, and to document the consequences of the scenarios for the various components. The latter are provided as seven report volumes under Report 8. These report volumes provide supporting information that feeds into Report 8.7. Thus Report 8.7 integrates all the supporting information to derive Water Resource Classes for the various scenarios.

The purpose of this report is to describe and to document the estuary ecological consequences of the operational scenarios by evaluating and determining the impact of these scenarios on the Ecological Category (EC). Note that as described above, this report (volume 2d) only provides supporting information for Report 8.7.

The report is aimed at the strategic level and strives to assist with narrowing down future options of use (e.g. responsible disposal from Waste Water Treatment Works (WWTW)),

while simultaneously identifying the consequences to the estuarine ecosystems. It is not meant to replace the need for future Environmental Impact Assessment or more detail investigations once a scenario have been identified as a viable option for future use by the relevant regulators.

1.3 DEFINITION OF CONFIDENCE LEVELS

The level of available historical data in combination with the level of effort expended during the assessment determines the level of confidence of a study. In this study, effort lays between the intermediate and comprehensive confidence levels for the priority systems (Mvoti and uMkhomazi) and the Rapid to Desktop level for the smaller systems. Criteria for the confidence limits attached to statements in this study are:

Confidence level	Situation
Low	Limited data available and/or high uncertainty in the ecological response
Medium	Reasonable data available and/or medium certainty in the ecological response
High	Good data available and/or high certainty in the ecological response

The accuracy and confidence of an estuarine Ecological Water Requirement (EWR) study is strongly dependent on the available long term monitoring information and the quality of the hydrology data. For most of the systems in this WMA no, or very little, long term data was available on river inflow, mouth behaviour, water quality and sediment dynamics. The overall confidence in the hydrology supplied to the estuarine study team is therefore of a low to medium level, with a particular concern regarding the accuracy of the simulated base flows during low flow periods.

1.4 NAMING OF RIVERS AND ESTUARIES

Names of the rivers and estuaries used in this report are according to the Government Gazette No. 848 (1 October 2010). All other names are according to what is used in the existing databases. For reference, the Ezemvelo KwaZulu-Natal (KZN) Wildlife list of names or synonyms for KZN estuaries is included as Appendix C.

1.5 STUDY AREA

Consequences of the scenarios were evaluated at various estuaries in each of the three estuary Integrated Units of Analysis (IUAs). The relevant estuaries for which assessments were undertaken, grouped into the IUAs are listed below and illustrated in Appendix E.

- Southern Cluster 1 IUA: Zolwane, Tongazi, Mpenjati, Mvutshini, Kongweni, Vungu, Mhlangeni, Boboyi, and Mbango.
- Southern Cluster 2 IUA: Koshwana, Sezela, and Mpambanyoni.
- Central Cluster IUA: uMkhomazi, Little Manzimtoti, Mbokodweni, uMdloti, and uThongathi.
- Northern Cluster IUA: Nonoti, and Mvoti.

1.6 STRUCTURE OF THIS REPORT

The report is structured as follows:

Chapter 1: Introduction
This chapter provides an overview of Classification process and confidence of the study.

Chapter 2: Condition and pressures on the Estuaries

A summary of important background information on the pressures affecting the estuaries in the WMA is provided.

Chapter 3: Method for assessing Ecological Condition and Recommended Ecological Condition

The detailed approach followed in evaluating the estuaries responses to future conditions is provided.

Chapter 4: Description of scenarios

A description of the scenarios is presented in this Chapter.

Chapter 5: Assessment of the Southern and Northern Cluster IUA

A summary of the findings of the Desktop assessment of the Southern and Northern Clusters, indicating the ecological consequences of the various future scenarios and the ECs associated with each of these, are provided.

Chapter 6: Assessment of the Central Cluster

Reporting on the more detailed assessments of the Central Cluster scenario evaluation process and the estuaries responses to the scenarios are provided.

Chapter 7: Conclusion

Discussion on the study confidence and what can be done to improve on the confidence in future studies are provided.

Chapter 8: Ranking of scenarios per IUA

A summary of the overall findings of the study and the integration into the catchment scale operational scenario assessment is provided.

Chapter 9: References

Report references are listed.

Chapter 10: Appendix A: Operational Scenario Description

This appendix provides the definitions of all scenarios with the identification labels referenced in the main sections of this report and serves as a lookup reference.

Chapter 11: Appendix B: Central Cluster Estuary Health Index Scores

The Estuary Health Index Scores and corresponding ECs under the different scenarios for estuaries assessed in the Central Cluster IUA are provided.

Chapter 12: Appendix C: Estuary Synonym List for KwaZulu-Natal Estuaries

The Ezimvelo KZN Wildlife list of names or synonyms for KZN estuaries is included.

Chapter 13: Appendix D: Estuary Pressure Table

All the pressures on the estuaries are summarised

Chapter 14: Appendix E: Estuary IUAs

The relevant estuaries for which assessments were undertaken were grouped into the IUAs and illustrated in Appendix E.

Chapter 15: Report Comments

Comments from reviewers are listed.

2 CONDITION AND PRESSURES ON THE ESTUARIES

The overall assessment of the Present Ecological State (PES) of estuaries in this WMA clearly shows the footprint of urbanisation on these systems (Figure 2.1 to 2.3). For most systems river inflow still resemble that of the reference condition (hydrology), with exceptions being the urbanised systems where discharges from WWTWs have elevated base flows significantly. Therefore, the hydrodynamic processes (influencing mouth state) and salinity distributions are mostly similar to the natural states.

In contrast to the hydrology, the water quality in a large number of estuaries in this WMA has been modified significantly. This is attributed to diffuse agricultural runoff in rural areas (e.g. introducing fertilizer, herbicides and pesticides) and contaminated stormwater runoff from urban development (e.g. nutrients and toxic substances). Furthermore, in the case of 25 (see Appendix A, B and C) of the 64 estuaries studied, water quality has been compromised by point source discharges from WWTWs, either directly into the estuaries or into rivers just upstream of the head of the estuaries.

In the Ugu District Municipality 21 such WWTW discharges were identified. Discharge from these systems totals 26.7 Ml/day (9.8 x 10^6 m^3/annum) (Figure 2.1). Seven WWTW discharges were listed in the iLembe District Municipality with a total volume of 25.8 Ml/day (9.4 x 10^6 m^3/annum) (Figure 2.2). Seventeen WWTW discharges are located in the eThekwini municipality totalling a volume of 440 Ml/day (Figure 2.3).

With the exception of the larger fast-flowing estuaries (e.g. the Mtamvuna, uMkhomazi, uMngeni and Umzimkulu) most systems along this stretch of coast are relatively small with very little assimilative capacity for nutrient or organic loading. Of note also is that while the overall water quality condition score for Durban Bay is reflected to be fair (Category C) this is largely because of tidal flushing of the extensive lower reaches of this system. The important remaining estuarine habitats (mangroves, mudflats and sand banks) in the upper reaches of this system are not well flushed and are subject to poor water quality from contaminated urban run-off. The historic and on going physical alteration and destruction of habitat for port development, together with poor water quality in the remaining ecologically important upper reaches significantly threatens ecological integrity of Durban Bay. Although now an operational port and highly transformed, the size of this system and its remaining diversity of habitat still renders it an important estuarine resource.

Urbanisation and development has also led to significant habitat modification in other estuaries along this coast. Road and rail infrastructure negatively affects nearly every estuary in the WMA. In addition, most estuaries have one or two large bridges crossing them. Bridge foundations and abutments, and road and rail berms have led to infilling of systems and consequential habitat destruction. Development across floodplains and channel stabilisation has affected natural flow patterns resulting in localised scour and deposition. Sugar cane farming along the banks of a large number of systems has led to infilling of floodplains, general constriction of tidal flows and large-scale loss of marginal vegetation and natural vegetation buffers around the estuaries. Poor agricultural practises and overstocking has increased sediment input from catchments in Tribal Trust areas contributing to sedimentation in the estuaries downstream.

All the pressures on the estuaries are summarised in a table in Appendix D.

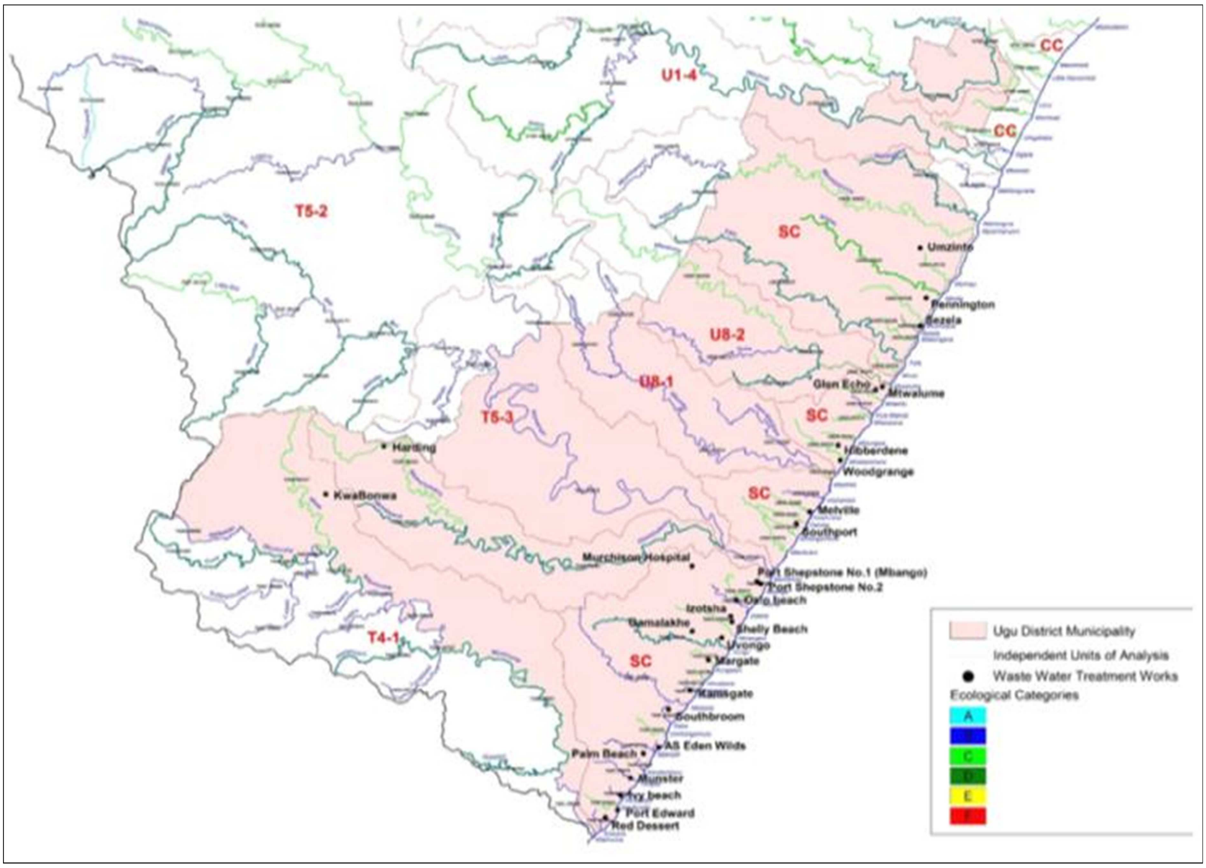


Figure 2.1 Map showing the location of WWTW discharges in Ugu District municipality

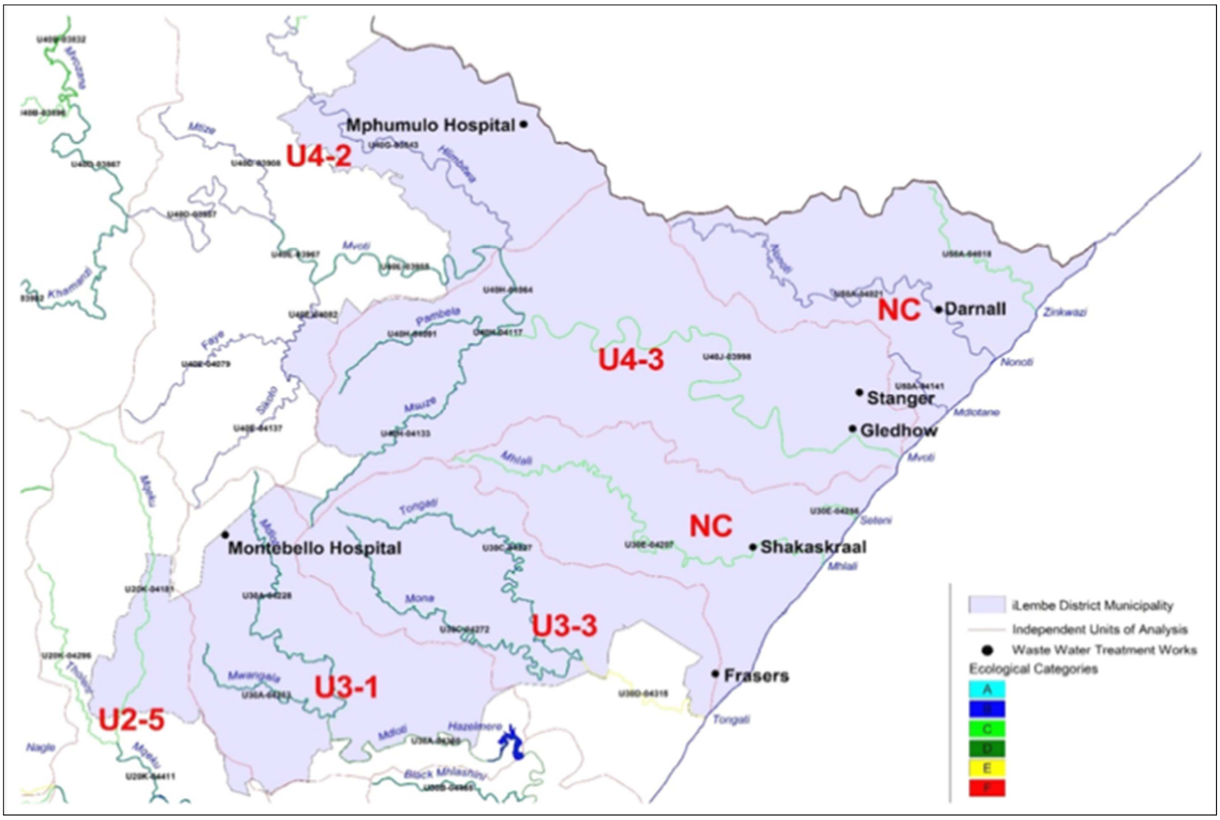


Figure 2.2 Map showing the location of WWTW discharges in iLembe District municipality

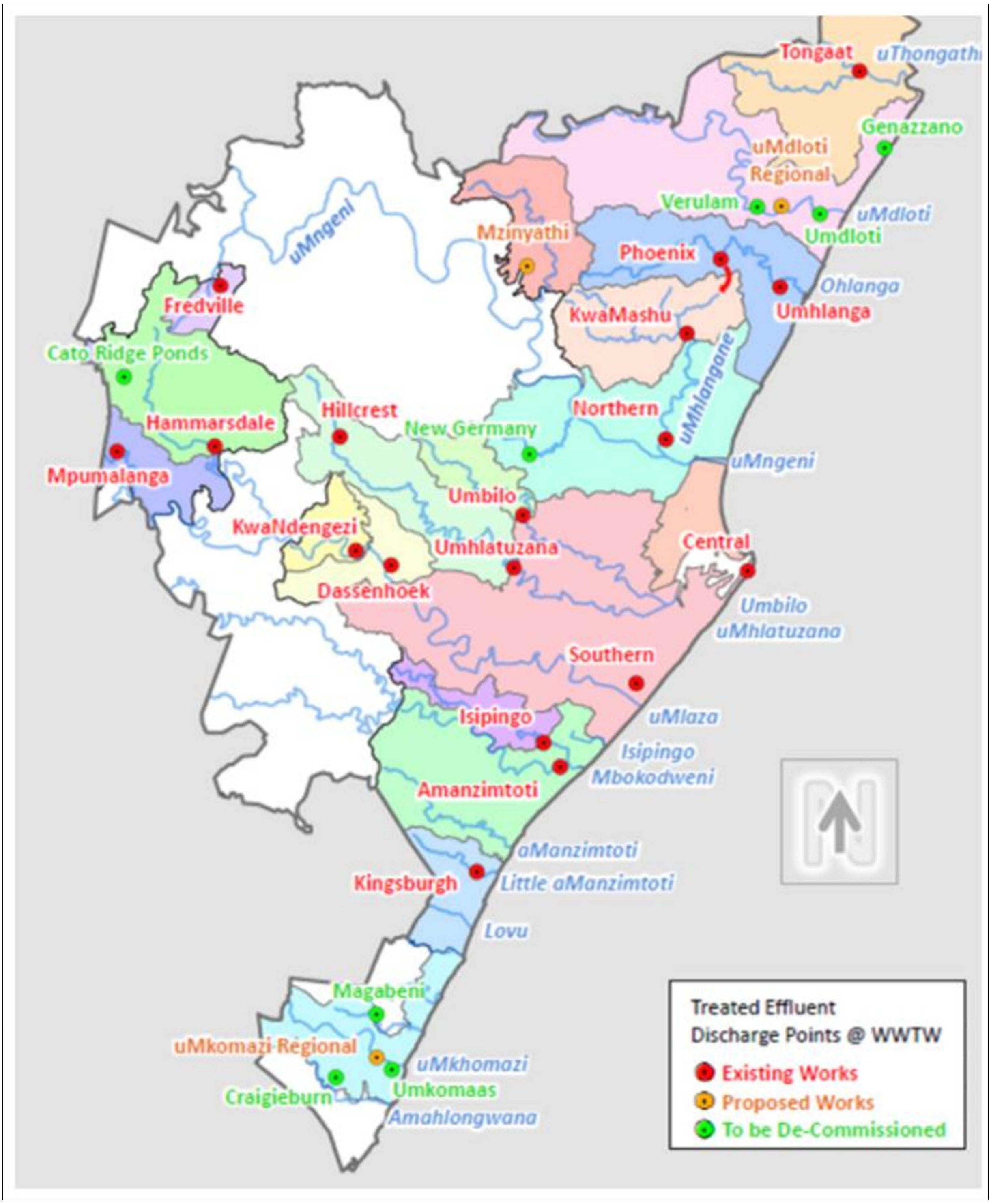


Figure 2.3 Map showing present and planned locations of WWTW discharges in eThekwini Municipality

Macrophytes, in most cases, also reflect the impacts of urbanisation, with a significant number of systems showing severe degradation of floodplain vegetation. In several systems a significant loss of habitat due to the presence of bridge abutments and berms is also evident. Disturbed floodplain areas and riparian zones have been invaded by Brazilian pepper tree (*Schinus terebinthifolia*) and *Lantana camara*. In many areas, aquatic habitats have been drained for crop cultivation on the floodplain. Overall, this has resulted in woodier vegetation, encroachment by terrestrial vegetation and a loss of aquatic habitat. Reduction in freshwater inflow to estuaries and an increase in the frequency and duration of closed mouth conditions is also a threat to macrophytes. Reed encroachment in a number of systems is clear evidence of nutrient enrichment. Increased nutrient input from WWTW and stormwater inflows has caused eutrophication. Emergent species thrive under nutrient-rich conditions and invasive aquatic macrophytes such as water hyacinth (*Eicchornia crassipes*) and water cabbage (*Pistia stratiotes*) outcompete indigenous plants and choke several smaller estuaries.

The analysis also showed that microalgae have increased production because of increased nutrient loading and a related increase in reed habitat (providing additional habitat for epiphytes). However, these effects were somewhat buffered by regular effective flushing of smaller estuaries during their open states.

Estuarine invertebrate communities have been impacted by alteration and destruction of habitat in the systems across the study area. These have arisen mostly due to development around (and in some cases over) estuarine systems resulting in loss of structural habitat as well as water column habitat. In some cases changes in river inflow have had impacts, especially on marine associated invertebrate communities, through increased mouth closure and therefore reduced opportunity to recruit into estuaries and through changes to salinity regimes. The alien invasive snail *Tarebia granifera* has established populations in many systems and proliferates at the expense of indigenous gastropods and other invertebrate species. Although unstudied in South Africa, ecosystem impacts are highly likely to occur because of the proliferation of this invasive species. Water quality impacts are likely to have played a role in reduced invertebrate abundance in many systems, and certainly to have done so in most estuaries in densely populated urban areas. Small temporarily open/close estuaries, which are characteristic of this WMA, are prone to deterioration in water quality, especially when they close. Although most of the systems in the WMA exhibit some natural tendency towards depressed Dissolved Oxygen (DO) levels in deeper waters, this has been exacerbated (and has extended into surface waters in some instances) due to increased nutrient and organic loading from surrounding land use and WWTW discharges.

Fish communities have responded to changes in river inflow in some systems, being sensitive to changes in mouth conditions. Most, if not all of the systems in the study area have experienced loss of estuarine habitat and loss of natural buffer on their perimeters and the inflowing rivers. Critical habitat has been lost in some cases, which has resulted in marked reductions in fish diversity and as well as fish nursery function. The loss of submerged aquatic vegetation, especially *Zostera capensis* (from systems such as Sandlundlu, Umgababa, Sipingo, Durban Bay, and probably others) has undoubtedly played a significant role. As with estuarine invertebrates, deterioration in water quality (specifically nutrient enrichment resulting in eutrophication and subsequent reduction in DO concentrations) is increasing becoming a threat to fish health in these systems, especially those adjacent to densely populated urban areas. In recent years fish kills have occurred in 18 estuaries in the WMA (Ugu = 5, eThekwini = 9, iLembe = 4) (Table 2.1). These have been attributed to eutrophication and/or associated low oxygen events. In many cases these events were triggered by malfunctioning sewerage systems (due to infrastructure failure and/or overloading). The high number of fish kills recorded in the Mvoti to Umzimkulu WMA represents about 40% of all recorded fish kills in South Africa, indicating that many estuaries on this coastline are at tipping points. In some cases trophic impacts are likely to have manifest with favoured prey items (e.g. sandprawn *Callichirus kraussi*) either lost or reduced in some systems due to habitat loss, modification, or water quality impacts.

Birds in these estuaries are mostly affected by human disturbance with systems in urban areas showing highest suppression of bird abundance. In some systems, the pressure is further exasperated by a reduction in food availability and suitable habitat.

Table 2.1 Recently recorded fish and invertebrate kills in WMA11

Estuary	District	Confirmed fish kill
Mbango	Ugu	Aug-14
Koshwana	Ugu	Jul-14
Intshambili	Ugu	Jul-14
Sezela	Ugu	Mar-15
Nkomba,	Ugu	Jul-14
Little Manzimtoti	eThekwini	Sep-13
aManzimtoti	eThekwini	Aug-15
Mbokodweni	eThekwini	Estuary Technical Working Group confirmed
Sipingo	eThekwini	Jul-14
Durban Bay	eThekwini	Estuary Technical Working Group confirmed
uMngeni	eThekwini	Estuary Technical Working Group confirmed
Mhlanga	eThekwini	Aug -14, Feb-15, Mar-15
uMdloti	eThekwini	Estuary Technical Working Group confirmed
uThonghati	eThekwini	Nov-14
uMhlali	iLembe	Estuary Technical Working Group confirmed
Mvoti	iLembe	Invertebrate kill
Mdlotane	iLembe	May-13, Nov-13, Jul-14
Nonoti	iLembe	Dec-11

Over longer time scales, the total area occupied by the various estuarine habitat types remains more or less constant, but the actual spatial location of the various estuarine habitats is highly likely to change between resetting events (e.g. larger floods). This relatively ephemeral nature of estuarine habitat presents an assessment and planning challenge. However, water resource protection requires the delineation of the geographical boundaries of the resource. In order to do this it is important to define the space within which estuaries function to ensure their present and future health.

As part of the 2011 National Biodiversity Assessment (NBA - Van Niekerk and Turpie, 2012), the estuarine functional zones (estuarine ecosystem areas) and open water areas were digitized for nearly 300 functional estuarine systems along the South African coastline using SPOT 5 imagery (2008) and Google Earth. Most SPOT 5 images were relatively cloud free, but where cloudy conditions occurred, Google images were used. The estuary mouth was taken as the downstream boundary of an estuary or, where the mouth was closed, the middle of the sand berm between the open water and the sea. The upstream boundary was determined as the limit of tidal variation or salinity penetration, whichever was furthest up the system. This approach is in line with recent scientific studies and the administrative definition of a South African estuary (DWAF, 2008). Wherever possible the upstream boundary was derived from the literature, expert judgment or field observations. In a number of systems no data were available and the upper boundary was taken as the 5 m topographical contour (bearing in mind that South African coast is microtidal (the tidal range is < 2 m)) and sand bars at closed estuary mouths can sometimes build up as high as + 4.5 m Mean Sea Level (MSL)). The upper boundaries were also screened against other existing spatial delineations, e.g. the KwaZulu-Natal Estuaries database (Version 1.00.02) and the delineation developed for eThekwini (Durban) estuaries (Forbes and Demetriades, 2008) with preference given to data from the larger scale studies. Spatially, files were converted to Google Earth (KMZ formats) and reviewed during the desktop health for comment. Systems that need additional ground truthing were identified.

The lateral boundaries of estuaries included all the associated wetlands, intertidal mud and sand flats, beaches and foreshore environments that may be affected by riverine or tidal flood events (Edgar, 2000). The 5 m topographical contour (obtained from Chief Directorate Surveys and Mapping) was used as the lateral boundary to delineate the estuarine functional zone. Where the 5 m contour was not available in digital format, orthophotos (1:10 000) were scanned, georeferenced and the 5 m contour was digitized. From the Estuarine Functional Zone (EFZ) delineation, spatial data such as area, length and perimeter (estuary shoreline) and distance to the next system could be inferred.

For reporting purposes, the estuaries were subdivided into three clusters:

- Northern Cluster (iLembe)
- Central Cluster (eThekwini)
- Southern Cluster (Ugu).

3 METHOD FOR ASSESSING ECOLOGICAL CONDITION AND RECOMMENDED ECOLOGICAL CONDITION

3.1 ESTIMATING ECOLOGICAL CONDITION

The consequences of the various flow and water quality scenarios for the estuaries were conducted at a Desktop to Intermediate level depending on data availability.

The health condition (also called the PES) of an estuary is typically defined as the extent to which the present condition differs from a defined reference (or natural) condition. Based on the above, the PES is described using six EC), ranging from natural (A) to critically modified (F) (Table 4.1). 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.

Table 3.1 Ecological Categories (DWAF, 2008)

Health Condition	Description
A	Unmodified, natural.
B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions and processes are essentially unchanged.
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions and processes are still predominantly unchanged.
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions and processes have occurred.
E	Seriously modified. The loss of natural habitat, biota and basic ecosystem functions and processes are extensive.
F	Critically/Extremely modified. Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions and processes have been destroyed and the changes are irreversible.

Estuarine Health Index (EHI) applied in EWR studies includes the following components (DWAF 2008):

Abiotic	Biotic
▪ Hydrology (% change in Mean Annual Runoff - MAR) ▪ Hydrodynamics and mouth condition ▪ Water chemistry (salinity and combined score for other variables) ▪ Sediment processes	▪ Microalgae ▪ Macrophytes ▪ Invertebrates ▪ Fish ▪ Birds

The EHI is applied to all levels of ecological water requirement studies (Comprehensive to Desktop), 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 reflect the present health of the estuary as a percentage of the pristine state (Figure 3.1). 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 this study, the assessment was undertaken by a multidisciplinary group of estuarine scientists in a workshop setting, based on their collective understanding of the likely pressures affecting each system. Expert knowledge and available information was used to derive a probable reference condition (or pristine state) of each estuary and the changes that resulted in the present state (or current condition).

For reasons of compatibility and comparison with previous assessments, the individual health scores were aggregated as illustrated in Figure 3.2 and Table 3.2. In estuaries degradation or loss of habitat seldom means a complete loss of system health or function. 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 functionally happens on a continuum, with estuaries which retain more than 90% of their natural processes and patterns being rated as Excellent and estuaries degraded to less of 40% of natural functionality rated as Poor.

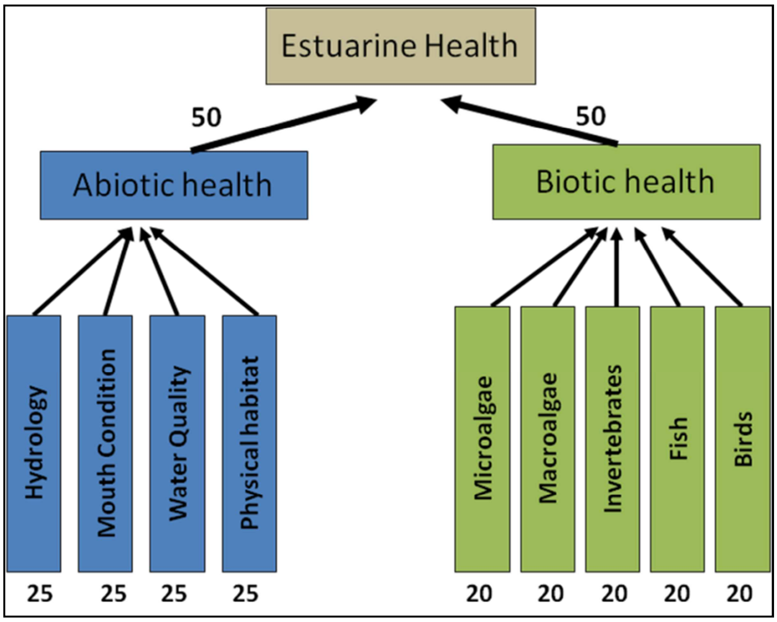


Figure 3.1 Components and weightings of the EHI (DWAF, 2008)

Table 3.2 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	

It must be emphasised that the A to F scale represents a continuum, and that the boundaries between categories are conceptual points along the continuum. There may therefore be cases where there is uncertainty as to which category a particular estuary belongs, potentially having components that have membership in two categories. **To provide resolution and reflect this, straddling categories (±3 from the category scoring range) were therefore introduced, denoted by A/B, B/C, C/D, etc.** The B/C boundary category, for example, is indicated as the light blue to dark green area in Table 4.2. Smaller, more sensitive estuaries tend to degrade rapidly to the lower health (Categories C to F), while the larger, permanently open estuaries demonstrate a degree of resilience and can generally maintain a boundary category as long as pressures are not increased.

3.2 RECOMMENDED ECOLOGICAL CATEGORY

The Recommended Ecological Category (REC) represents the recommended level of protection assigned to an estuary. The first step is to determine the 'minimum' EC, based on its PES. The relationships between EHI scores, PES and minimum REC are provided in Table 3.3.

Table 3.3 Relationship between the EHI, PES and minimum ERC

EHI score	PES	Description	Minimum REC
91 – 100	A	Unmodified, natural	A
76 – 90	B	Largely natural with few modifications	B
61 – 75	C	Moderately modified	C
41 – 60	D	Largely modified	D
21 – 40	E	Highly degraded	-
0 – 20	F	Extremely degraded	-

Thus, the PES determines 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 (Table 3.4).

Table 3.4 Estuary protection status and importance, and the basis for assigning a recommended ecological reserve category (modified from DWAF, 2008)

Protection status and importance	REC	Policy basis
Protected area Desired Protected Area	A or BAS*	Protected and desired protected areas should be restored to and maintained in the best possible state of health.
Extremely important (Ranked as 1)	PES + 1, min B	Highly important estuaries should be in an A or B Category.
Very Important (Ranked as 2)	PES + 1, min C	Important estuaries should be in an A, B or C Category.
Of low to average importance (Ranked as 3-1)	PES, min D	Estuaries to remain in a D Category.

* Best Attainable State

4 DESCRIPTION OF SCENARIOS

Please note: Appendix A provides a total summary of all scenarios evaluated in this study.

A key pressure that influenced the ecological health of several estuaries in the study area was discharge for WWTWs that service the extensive development along this stretch of coast. In collaboration with key stakeholders in the region (e.g. local authorities) the status of existing WWTW discharges, as well as potential future WWTWs was summarised. As part of this assessment possible alternative wastewater disposal options to manage current and future wastewater due to urban expansions were also investigated. From this a core set of flow and water quality scenarios was formulated along selected themes as indicated in Table 4.1, for inclusion in this assessment.

Table 4.1 Broad themes describing the core set of flow and water quality scenarios

Label	Scenario Description
A	A1 Ecological protection is priority (minimum discharge to estuaries), while in Ai to Av iterations of inflow configurations is considered.
B	Minimum costs scenario (highest flow through estuaries).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.
E	Indirect re-use (consider volume and practicalities). Remainder according to Scenario C.
F	Direct re-use (consider volume and practicalities). Remainder according to Scenario C.
"X"	Alternative scenarios (variations and combinations of alternative)

Currently 25 of the 64 estuaries in the WMA are affected by WWTW discharges. The future scenarios focussed on a subset of systems for which alternative wastewater management measures are being considered, resulting in a range of volumes discharged into the estuaries:

- Additional treatment processes to reduce the current nutrient loading discharged to estuaries.
- Transferring current WWTW discharges from a sensitive estuary to a river or estuarine system with better assimilative capacity.
- Reducing or eliminating WWTW discharges to estuaries by re-routing to the sea via marine outfalls.
- Re-use (both direct and indirect) of treated wastewater from WWTWs.

All the scenarios were formulated to handle the ultimate future wastewater volumes for each urban area. The selected range of scenarios was then evaluated by ecological specialists to determine the various estuaries responses. This report documents the predicted ecological responses to the scenarios. In addition, the costs of the alternative management measures were determined and applied in the macro-economic assessment to estimate the socio-economic implication of each scenario.

The proposed scenarios and total WWTW discharge volumes are summarised in Table 4.2. Detailed scenario descriptions are provided in DWS (2015).

Table 4.2 Summary of the current and future WWTW discharge volume as well as the percentage of total daily inflow

Municipality	Current WWTW Discharge Volumes (Ml/day)	Percentage of total (%)	Future WWTW Discharge Volumes (Ml/day)	Percentage of total (%)
Ugu	26.7	5.4%	44.9	3.5%
iLembe	25.8	5.2%	63.9	4.9%
eThekwini	440	89.4%	1 188	91.6%
Total	**492.5**		**1 296.8**	

5 ASSESSMENT OF THE SOUTHERN AND NORTHERN CLUSTER IUA

For the purposes of strategic assessment a range of scenarios including current and future WWTW discharges were evaluated at a desktop level for the following estuaries:

Southern Cluster		Northern Cluster
Zolwane	Mbango	Nonoti
Tongazi	Koshwana	
Mpenjati	Sezela	
Mvutshini	Mpambanyoni	
Kongweni	Mbango	
Vungu	Koshwana	
Mhlangeni	Sezela	
Boboyi		

In these desktop level assessments, General Standards as per the General Authorisation Regulations (2004) of the DWS were assumed as the treatment level for WWTWs.

These desktop assessments by no means replace the need for more detailed studies (e.g. environmental impact assessment) if the strategic assessment indicate that if may be viable to increase the waste water volumes to these estuaries without compromising their function.

For such more detailed assessments extensive long term data on river inflow and quality, WWTW volumes and composition, as well as improved understanding of mouth state, nutrient processes, microalgae and macrophyte abundance, invertebrate and fish responses in the estuaries remains a crucial requirement to improve confidence.

5.1 SOUTHERN CLUSTER IUA

5.1.1 Zolwane Estuary

The Zolwane Estuary is currently in a B Category (Table 5.1). From a biodiversity perspective, the estuary is of "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Given the current condition (PES = B), the reversibility of the impacts, the ecological importance and the conservation requirements of the Zolwane Estuary, the REC for the system is a B Category.

Table 5.1 Zolwane Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	**B**
REC	**B**
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	1
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Zolwane Estuary under different scenarios (Sc) are provided in Table 5.2. An evaluation of the scenarios provided the following insights:

- This system currently receives no WWTW effluent.
- The estuary is sensitive to wastewater input because of its small size and low assimilative capacity.
- Increase in reed growth is expected in response to changes in inflow and nutrient input. Under Sc E5, Sc A1a and Sc 2 increased freshwater inflow (resulting in fresher conditions in the estuary) and nutrient loading (from WWTW discharges) will stimulate reed encroachment, and favour invasive aquatic macrophytes and macroalgae.
- Invertebrates and fish will respond to the system's eutrophic conditions in the low flow periods, the generally fresher conditions in the system, the loss of habitat, and habitat degradation through macrophytes growth.
- Die-off of excessive vegetation can cause high detrital loads, which in turn will reduce DO levels resulting in possible fish kills.
- Birds, in turn, will respond negatively to the loss of invertebrate and fish prey and loss of foraging habitat through reed encroachment.

Table 5.2 Zolwane Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total WQ Score	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	2.31	0	A	A	A	B	B	B	A	B	B	B	C	B	B	B
Sc A1	2.39	0.2	B	B	B	B	B	B	B	B	B	D	D	B	C	B
Sc A1a	2.53	0.6	B	C	C	B	B	B	B	B	C	E	E	D	D	C
Sc 2	2.56	0.66	C	C	C	B	B	B	B	B	C	E	E	D	D	C
Sc C3	2.33	0.03	A	A	A	B	B	B	A	B	B	B	C	B	B	B
Sc D4	2.34	0.06	A	A	A	B	B	B	A	B	B	C	C	B	B	B
Sc E5	2.44	0.33	B	B	B	B	B	B	B	B	C	D	D	C	C	B/C

HIGH RISK FOR FISH KILLS: This is an incised estuary with limited opportunity for wind mixing and the water column is likely to stratify easily. High nutrient and organic loading are likely to reduce the DO levels in the water during low flow and drought periods when the mouth closes. For these reasons, there is a high risk that increased nutrient and organic loading will result in fish kills in the Zolwane Estuary.

5.1.2 Tongazi Estuary

The Tongazi Estuary is currently in a B/C Category (Table 5.3). From a biodiversity perspective the estuary is "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = B/C), the reversibility of the impacts, the ecological importance and the conservation requirements of the Tongazi Estuary the REC for the system is a B Category.

Table 5.3 Tongazi Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	B/C
REC	B/C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Tongazi Estuary under different scenarios are provided in Table 5.4. An evaluation of the scenarios provided the following insights:

- This system currently receives WWTW effluent (0.25 Ml/d).
- This system has very little assimilative capacity for nutrient or organic loading during low flows and drought conditions when the moth closes.
- Persistent nutrient input (especially during the closed phase) will result in eutrophication (increased primary production) potentially causing a reduction in DO concentrations when the excessive algal matter decomposes.
- Under Sc C3, Sc D4 and Sc 2 the macrophyte health condition decreases due to increased nutrient loading and microalgae blooms, particularly at the WWTW discharge location.
- Invertebrates and fish will respond to the system's eutrophic conditions in low flow periods; (especially during the closed state), low oxygen, and habitat degradation through macrophytes growth.
- Die-off of excessive vegetation can cause high detrital loads, which in turn will reduce DO levels resulting in possible fish kills. Birds, in turn, will respond negatively to the loss of invertebrate and fish prey and loss of foraging habitat through encroachment.

Table 5.4 Tongazi Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total WQ Score	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	7.3	0.3	A	B	A	C	B	B	B	B	C	C	D	C	C	B/C
Sc A1	7.3	0.1	A	B	A	C	B	B	B	B	C	C	D	C	C	B/C
Sc A1a	7.3	0.2	A	B	A	C	B	B	B	B	C	C	D	C	C	B/C
Sc E5	7.3	0.2	A	B	A	C	B	B	B	B	C	C	D	C	C	B/C
Sc C3	7.3	0.3	A	B	A	C	B	B	B	B	C	D	D	D	C	B/C
Sc D4	7.3	0.3	A	B	A	C	B	B	B	B	C	D	D	D	C	B/C
Sc 2	7.4	0.4	B	B	A	C	B	B	B	B	C	D	D	D	C	B/C

HIGH RISK FOR FISH KILLS: This is an incised estuary with limited opportunity for wind mixing and the water column is likely to stratify easily. High nutrient and organic loading are likely to reduce the DO levels in the water during low flow and drought periods when the mouth closes. For these reasons, there is a high risk that increased nutrient and organic loading will result in fish kills in the Tongazi Estuary.

5.1.3 Mpenjati Estuary

The Mpenjati Estuary is currently in a B/C Category (Table 5.5). From a biodiversity perspective the estuary is "low to average importance" (DWAF, 2008). The estuary forms part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of high conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = B/C), the reversibility of the impacts, the ecological importance and the conservation requirements of the Mpenjati Estuary the REC for the system is a B Category.

Table 5.5 Mpenjati Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	**B/C**
REC	**B**
Importance	
Conservation (5 = NBA priority list)	5
Estuary (Biodiversity) (5 = High)	3
Fish Nursery (5 = High nursery value)	3

The predicted ECs for the Mpenjati Estuary under different scenarios are provided in Table 5.6. An evaluation of the scenarios provided the following insights:

- This estuary currently receives WWTW effluent (0.6 Ml/d).
- Future WWTW discharge volumes vary between 4 - 11% of the MAR.
- The larger volume of the estuary and greater marine flushing provide a relative higher assimilative capacity for WWTW input compared with many smaller systems, but localised modification of biota can be expected near the discharge location. These may include, for example, algal blooms and excessive reed growth.
- Despite higher assimilative capacity and being more exposed to wind mixing, prolonged closures (e.g. during low flow periods and droughts) will present a risk for eutrophication, with associated reduction in DO levels raising the risk of fish kills.
- None of the scenarios achieves the REC. The following management interventions are recommended to improve the health of this system to a B Category:
  - Terminate the sandmining in the estuary and its environs (including lower river reaches) to improve the structural habitat.
  - Restore riparian habitat to improve estuary functionality, and
  - Improve the water quality (e.g. by improving the quality of WWTW input) of the system to allow for improvement of higher biotic component.

Table 5.6 Mpenjati Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total WQ Score	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	23.77	0.6	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc A1	23.64	0.27	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc A1a	23.80	0.70	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc 2	23.87	0.89	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc C3	23.78	0.64	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc D4	23.80	0.68	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc E5	23.71	0.44	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C
Sc C3a	23.78	0.64	A	B	A	C	B	D	B	B	D	D	D	B	C	B/C

5.1.4 Mvutshini Estuary

The Mvutshini Estuary is currently in a B/C Category (Table 5.7). From a biodiversity perspective the estuary is of "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking the into account current condition (PES = B/C), the reversibility of the impacts, the ecological importance and the conservation requirements of the Mvutshini Estuary the REC for the system is a B/C Category (i.e. maintain the PES).

Table 5.7 Mvutshini Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	B/C
REC	B/C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	1
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Mvutshini Estuary under different scenarios are provided in Table 5.8. An evaluation of the scenarios provided the following insights:

- This system currently receives no WWTW effluent, but this will change under the future scenarios.
- The MAR increases under Sc C3 and Sc D4 to levels well above the present MAR as a result in WWTW discharges with baseflows increasing by 10% and 20 %, respectively.
- Under Sc E5 the MAR increases by 20% as a result of WWTW discharges with half of the baseflow consisting of WWTW effluent.
- Under Sc 2 the MAR increases by 150% as a result of WWTW discharges with baseflows increasing by 320%.

- In Sc 1A, Sc 2 and Sc 5 the water quality conditions in the estuary degrade to an E Category because of increased WWTW discharges.
- The higher WWTW volumes in several scenarios increase nutrient loading, decrease salinity in the estuary and result of more open mouth conditions.
- Higher nutrient input may cause reed encroachment, algal blooms and proliferation of invasive floating aquatic macrophytes.
- Note, that while the Category for Sc C3 is similar to the present, this scenario increases the risk of the system going eutrophic when closed during low flows and drought conditions.
- In most future scenarios WWTW disposal, resultant eutrophic conditions and subsequent die-off of algae and vegetation will cause reduced oxygen levels resulting in possible invertebrate and fish kills. This is especially of concern during the closed phase when long residence times and nutrient accumulation will markedly reduce the estuary's assimilative capacity.
- Invertebrates and fish will respond to the system's eutrophic conditions in the low flow periods; (especially during the closed state); low oxygen; and habitat degradation through macrophytes growth.
- Birds, in turn, will respond negatively to the loss of invertebrate and fish prey and loss of foraging habitat through encroachment.

HIGH RISK FOR FISH KILLS: This is an incised estuary with limited opportunity for wind mixing and the water column is likely to stratify easily. High nutrient and organic loading are likely to reduce the DO levels in the water during low flow and drought periods when the mouth closes. For these reasons, there is a high risk that increased nutrient and organic loading will result in fish kills in the Mvutshini Estuary.

Table 5.8 Mvutshini Estuary: ECs associated with selected scenarios

Scenario	MAR	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	1.63	0	A	B	B	D	C	B	B	C	C	C	C	C	C	B/C
Sc C3	1.67	0.11	A	B	B	D	C	B	B	C	C	C	C	C	C	B/C
Sc D4	1.72	0.23	B	B	B	D	C	B	B	C	C	C	D	C	C	C
Sc A1	1.86	0.63	C	D	C	E	D	B	C	D	D	D	E	D	D	D
Sc A1a	1.89	0.70	C	D	C	E	D	B	C	D	D	D	E	D	D	D
Sc E5	2.02	1.05	C	D	D	E	E	B	D	D	D	E	E	E	D	D
Sc 2	2.40	2.10	D	E	E	E	E	B	D	E	E	E	E	E	E	D/E

5.1.5 Kongweni Estuary

The Kongweni Estuary is currently in a D/E Category (Table 5.9). From a biodiversity perspective the estuary is of "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = D/E), the reversibility of the impacts, the ecological importance and the conservation requirements of the Kongweni Estuary the REC for the system is a D Category.

Table 5.9 Kongweni Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	D/E
REC	D
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	3

The predicted ECs for the Kongweni Estuary under different scenarios are provided in Table 5.10. An evaluation of the scenarios provided the following insights:

- This system currently receives WWTW effluent (4.64 Ml/d) and is currently in a degraded condition - D/E Category.
- Under scenario Sc A1a and Sc E5 the estuary improves to a D.
- Sc C3 maintains the PES.
- Under Sc D4, Sc A1a, Sc 2 the estuary degrades further to a Category E.
- Under all future scenarios, the water quality maintains a Category F due to nutrient enrichment associated wastewater input and the system's limited assimilative capacity.
- Nutrient enrichment is associated with possible reed encroachment, algal blooms and invasive floating aquatic macrophytes Invertebrates and fish will respond to the system's eutrophic conditions in the low flow periods; (especially during the closed state); low oxygen; and habitat degradation through macrophytes growth.
- Birds, in turn, will respond negatively to the loss of invertebrate and fish prey and loss of foraging habitat through encroachment.

Table 5.10 Ecological Categories associated with Scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biological CONDITION	ESTUARY HEALTH (EC)
PES	4.77	4.97	E	D	D	F	E	D	D	E	E	D	E	D	D	D/E
Sc A1	3.83	2.40	E	C	C	F	E	D	D	E	D	D	D	D	D	D
Sc E5	4.41	4.00	E	D	C	F	E	D	D	E	D	D	E	D	D	D
Sc C3	4.93	5.40	E	D	D	F	E	D	E	E	E	D	E	E	E	D/E
Sc D4	5.09	5.84	E	D	D	F	E	D	E	E	E	E	E	E	E	E
Sc A1a	5.51	7.00	E	E	D	F	E	D	E	E	E	E	E	E	E	E
Sc 2	5.88	8.00	F	E	E	F	F	D	E	F	E	E	F	E	E	E

5.1.6 Vungu Estuary

The Vungu Estuary is currently in a B Category (Table 5.11). From a biodiversity perspective the estuary is "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = B), the reversibility of the impacts, the ecological importance and the conservation requirements of the Vungu Estuary the REC for the system is a B Category.

Table 5.11 Vungu Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	**B**
REC	**B**
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Vungu Estuary under different scenarios are provided in Table 5.12. An evaluation of the scenarios provided the following insights:

- The estuary currently receives WWTW effluent (2.74 Ml/d).
- In most of the scenarios baseflow to the estuary will increase as a result of increase in WWTW inflow.
- Although small, the system's ability to resist marked reduction in oxygen levels is good because of the waterfall assisting with water aeration and significant overtopping from the sea.
- However, due to the depth of this estuary it is likely to be sensitive to changes in stratification in relation to flow changes.
- There will also be water quality impacts associated with increase nutrient inflows and organic loading.
- Increased WWTW discharges will increase nutrient loading resulting in potential in algal blooms and invasive floating aquatic macrophytes (these invasive plants already occur above the waterfall).
- Abiotic and biotic changes will ripple through the invertebrate and fish health because of increase WWTW effluent disposal.
- The system showed a decline in health from the PES of a B to a B/C and a C under the future conditions Sc C3, Sc D4, Sc A1a and Sc 2.
- The system is a very important recreational/swimming area, well used by residents and holidaymakers alike. A vibrant informal (curio and craft trading) and formal (restaurants and shopping) commercial sector has developed and depends on the use of the beach at the estuary. Human health and economic issues will need to be considered in plans involving wastewater inputs into this estuary and upstream of it.

Table 5.12 Vungu Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	28.9	2.74	B	B	B	D	C	B	B	C	B	C	C	C	C	B
Sc A1	28.5	1.69	A	B	B	D	C	B	B	C	B	C	C	C	C	B
Sc E5	28.9	2.82	B	B	B	D	C	B	B	C	B	C	C	C	C	B
Sc C3	29.3	3.81	B	B	B	D	C	B	B	C	C	C	C	D	C	B/C
Sc D4	29.4	4.12	B	B	B	D	C	B	B	C	C	C	C	D	C	B/C
Sc A1a	29.8	5.13	B	B	B	D	C	B	B	C	C	D	C	D	C	C
Sc 2	29.9	5.64	B	B	B	D	C	B	B	C	C	D	C	D	C	C

5.1.7 Mhlangeni Estuary

The Mhlangeni Estuary is currently in a C Category (Table 5.13). From a biodiversity perspective, the estuary is of "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition of the system (PES = C), the reversibility of the impacts, the ecological importance and the conservation requirements of the Mhlangeni Estuary the REC for the system is a C Category (i.e. maintain the PES).

Table 5.13 Mhlangeni Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Mhlangeni Estuary under different scenarios are provided in Table 5.14. An evaluation of the scenarios provided the following insights:

- The Mhlangeni Estuary presently receives WWTW effluent (0.7 Ml/day).
- Under most of the future scenarios estuary will remain in a similar category to the present, with some components (e.g. macrophytes) even improving under Sc A1. However under Sc 2 a number of the components (e.g. mouth state) will degrade compared with the present condition.
- While most of the future scenarios will maintain the system in its PES, algal blooms and filamentous algae have been reported in this system, as well as expansion of reeds and sedges which are associated with nutrient loading from the WWTW.
- The invertebrates and fish will respond to these changes.

Table 5.14 Mhlangeni Estuary: ECs associated with selected scenarios

Scenario	MAR	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biological CONDITION	ESTUARY HEALTH (EC)
PES	9.82	0.70	B	B	B	C	C	D	C	C	D	D	D	C	C	C
Sc A1	9.68	0.33	B	B	B	C	C	D	B	B	C	D	D	C	C	C
Sc E5	9.76	0.55	B	B	B	C	C	D	B	B	D	D	D	C	C	C
Sc A1a	9.84	0.75	B	B	B	C	C	D	C	C	D	D	D	C	C	C
Sc C3	9.84	0.76	B	B	B	C	C	D	C	C	D	D	D	C	C	C
Sc D4	9.86	0.81	B	B	B	C	C	D	C	C	D	D	D	C	C	C
Sc 2	9.96	1.10	B	C	C	C	C	D	C	C	D	D	D	C	C	C

5.1.8 Boboyi Estuary

The Boboyi Estuary is currently in a B/C Category (Table 5.15). From a biodiversity perspective the estuary is "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = B/C), the reversibility of the impacts, the ecological importance and the conservation requirements of the Boboyi Estuary the REC for the system is a B/C Category (i.e. maintain the PES).

Table 5.15 Boboyi Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	B/C
REC	B/C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Boboyi Estuary under different scenarios are provided in Table 5.16. An evaluation of the scenarios provided the following insights:

- The Boboyi Estuary presently receives WWTW effluent (0.12 Ml/day).
- The systems remains within the PES under all future scenarios, but under Sc 2 a number of the components (e.g. macrophytes, invertebrates, fish and birds) will degrade further in condition from present.

Table 5.16 Boboyi Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total WQ Score	Physical habitat	Habitat Score	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological Score	EHI SCORE (Mean) [EC]
PES	8.073	0.12	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc A1a	8.044	0.04	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc A1	8.049	0.06	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc E5	8.064	0.10	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc F6	8.064	0.10	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc C3	8.076	0.13	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc C3a	8.076	0.13	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc D4	8.080	0.14	B	A	A	C	B	C	B	B	C	B	C	C	C	B/C
Sc 2	8.100	0.20	B	A	A	C	B	C	B	B	C	C	C	C	C	B/C

5.1.9 Mbango Estuary

The ecological categories under different scenarios are provided in Table 5.17. The estuary is currently in an E Category. From a biodiversity perspective, the estuary is "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current poor condition (PES = E) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Mbango Estuary the REC for the system is a D Category (i.e. improve the PES).

Table 5.17 Mbango Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	E
REC	D
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Mbango Estuary under different scenarios are provided in Table 5.18. An evaluation of the scenarios provided the following insights:

- The Mbango Estuary presently receives WWTW effluent (9.0 Ml/day).
- The estuary will improve in condition under Scenario Sc A1 to a D/E Category, with a number of the components improving to a D Category.
- The estuary will maintain the PES under Sc A1, Sc E5, Sc F6, Sc C3, Sc C3a and Sc D4.
- Under Sc A1a and Sc 2 further degradation of the physical and biotic processes are expected.

- Fisk kills have been recorded for this system (e.g. August 2014) which is indicative that this estuary is already under severe threat from nutrient and organic loading from wastewater input.

Table 5.18 Mbango Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	7.30	9.0	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc A1	5.43	3.88	D	D	D	D	D	D	D	D	D	F	F	E	E	D/E
Sc E5	6.38	6.47	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc F6	6.38	6.47	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc C3	7.21	8.74	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc C3a	7.21	8.74	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc D4	7.46	9.44	E	D	D	E	E	D	D	E	E	F	F	E	E	E
Sc A1a	8.40	12.0	E	E	E	E	E	D	E	E	E	F	F	E	E	E
Sc 2	8.74	12.94	E	E	E	E	E	D	E	E	E	F	F	E	E	E

5.1.10 Koshwana Estuary

The Koshwana Estuary is currently in a C/D Category (Table 5.19). From a biodiversity perspective the estuary is of "average importance" (DWAF, 2008). However, the estuary form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of high conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = C/D), the reversibility of the impacts, the ecological importance and the conservation requirements of the Koshwana Estuary the REC for the system is a B Category.

Table 5.19 Koshwana Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C/D
REC	B
Importance	
Conservation (5 = NBA priority list)	5
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Koshwana Estuary under different scenarios are provided in (Table 5.20). An evaluation of the scenarios provided the following insights:

- The estuary presently receives WWTW effluent (0.25 Ml/day).
- Reduced base flow and nutrient enrichment form WWTW discharges have already resulted in reed encroachment. Recent Google Earth images indicate that algal blooms and possible proliferation of floating aquatic invasive species already occur, which is indicative of eutrophication.
- Further WWTW discharges will lead to further deterioration in the estuary health.

- There is an improvement in conditions under Sc A1, E5 and F6, with a C Category being achieved under Scenario A1.
- Under Sc 2 the estuary health declines to a D Category.
- A fish kill was reported in this estuary in 2014, indicating that eutrophic conditions are already posing a serious threat.

Table 5.20 Koshwana Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	2.05	0.25	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc A1a	1.99	0.09	B	C	C	E	D	D	C	D	D	C	C	C	C	C
Sc A1	2.00	0.12	B	C	C	E	D	D	C	D	D	D	D	D	D	C/D
Sc E5	2.03	0.20	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc F6	2.03	0.20	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc C3	2.06	0.27	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc C3a	2.06	0.27	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc D4	2.07	0.30	B	B	B	E	D	D	C	D	D	D	D	D	D	C/D
Sc 2	2.11	0.41	B	C	C	E	D	D	C	D	E	E	E	D	D	D

5.1.11 Sezela Estuary

The Sezela Estuary is currently in a C Category (Table 5.21). From a biodiversity perspective the estuary is of "average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = C) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Sezela Estuary the REC for the system is a C Category (i.e. maintain the PES).

Table 5.21 Sezela Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	3
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Sezela Estuary under different scenarios are provided in Table 5.22. An evaluation of the scenarios provided the following insights:

- The system is nearly permanently closed.
- The estuary at present receives WWTW effluent (0.7 Ml/day).

- The system is possibly more eutrophic than previously estimated. Algal blooms and reed expansion have occurred and will increase with higher wastewater inputs.
- This in turn, will negatively affect invertebrates, fish and birds.
- There is an improvement under Sc A1, i.e. macrophytes improve in conditions.
- Under Sc D4 and Sc 2 the estuary degrades in condition to Categories C/D and D respectively.
- Fisk kills have been recoded for this system (e.g. March 2014) indicating that it is at already threatened by nutrient and organic loading.

Table 5.22 Sezela Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	3.893	0.70	B	B	B	E	D	D	C	C	D	D	D	D	D	C
Sc A1	3.794	0.43	B	B	B	E	D	D	C	C	C	D	D	D	D	C
Sc E5	3.898	0.71	B	B	B	E	D	D	C	C	D	D	D	D	D	C
Sc A1a	3.912	0.75	B	B	B	E	D	D	C	C	D	D	D	D	D	C
Sc C3	3.931	0.80	B	B	B	E	D	D	C	C	D	D	D	D	D	C
Sc D4	3.968	0.90	B	B	B	E	D	D	C	C	D	D	D	D	D	C/D
Sc 2	4.157	1.42	B	C	C	E	D	D	C	D	D	D	D	D	D	D

5.1.12 Mpambanyoni Estuary

The Mpambanyoni Estuary is currently in a C Category (Table 5.23). From a biodiversity perspective the estuary is of “average importance” (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = C) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Mpambanyoni Estuary the REC for the system is a C Category (i.e. maintain the PES).

Table 5.23 Mpambanyoni Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

The predicted ECs for the Mpambanyoni Estuary under different scenarios are provided in Table 5.24. An evaluation of the scenarios provided the following insights:

- The system at present received WWTW effluent (1.61 Ml/d).

- In addition, sugarcane in close proximity to the estuary results in a deterioration of habitat and water quality (e.g. nutrient enriched agricultural return flow).
- Most of the future scenarios will maintain the PES.
- Under Sc 2 WWTW input will increase significantly resulting in reed expansion into the open water areas, as well as algal blooms.
- This will have related negative impacts on invertebrates, fish and birds.
- This is an important site for swimming and recreational activities (Scottburgh).

Table 5.24 Mpambanyoni Estuary: ECs associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	55.53	1.61	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc A1	55.30	0.98	B	B	A	D	C	D	B	C	C	D	C	D	C	C
Sc A1a	55.49	1.50	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc E5	55.54	1.63	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc F6	55.54	1.63	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc C3	55.61	1.84	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc C3a	55.61	1.84	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc D4	55.70	2.08	B	B	A	D	C	D	B	C	D	D	C	D	C	C
Sc 2	56.13	3.27	A	B	A	D	C	D	B	C	D	D	C	D	D	C

5.2 NORTHERN CLUSTER

5.2.1 Nonoti Estuary

The Nonoti Estuary is currently in a C Category (Table 5.25). From a biodiversity perspective the estuary is of “average importance” (DWAF, 2008). The estuary does not from part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = C) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Nonoti Estuary the REC for the system is a C Category (i.e. maintain the PES).

Table 5.25 Nonoti Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	3
Fish Nursery (5 = High nursery value)	1

The ECs for the Nonoti Estuary under different scenarios are provided in Table 5.26. An evaluation of the scenarios provided the following insights:

- The system at present received WWTW effluent (0.33 Ml/d).
- Recent Google images indicate algal blooms and eutrophication, as well as the presence of rafting and floating grasses such as *Echinochloa* species.
- All the future scenarios will maintain the PES.
- Under Sc A1 WWTW input reduced nutrient loading will occur with a related improvement in all the biotic components.
- Under Sc 2, WWTW input increases significantly resulting in a marked increase in nutrient loading causing increased reed expansion, algal blooms and floating aquatic invasive macrophytes.
- This in turn will negatively impact invertebrates, fish and birds.
- Fisk kills have been recorded for this system (e.g. December 2011), showing that current nutrient and organic loading are already threatening the system.

Table 5.26 Nonoti Estuary: ECs Categories associated with selected scenarios

Scenario	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Salinity	Other Water quality	Total Water quality	Physical habitat	HABITAT CONDITION	Microalgae	Macrophytes	Invertebrates	Fish	Birds	BIOLOGICAL CONDITION	ESTUARY HEALTH (EC)
PES	34.74	0.33	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc A1	34.68	0.16	B	B	B	D	C	C	B	C	D	C	E	C	C	C
Sc A1a	34.74	0.33	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc C3	34.74	0.36	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc D4	34.74	0.39	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc E5	34.74	0.27	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc F6	34.74	0.27	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc C3a	34.75	0.36	B	B	B	D	C	C	B	C	D	C	E	D	D	C
Sc 2	34.81	0.53	B	B	B	D	C	C	B	C	D	D	F	D	D	C

6 ASSESSMENT OF THE CENTRAL CLUSTER

The following estuaries were assessed in the Central Cluster at a higher level of detail, depending on the available data and the complexity of the system (eThekwini Municipality, 2015):

- uMkhomazi Estuary.
- Little Manzimtoti Estuary.
- Mbokodweni Estuary.
- uMdloti Estuary.
- uThongathi Estuary.

The impact of WWTW discharges on the systems was also evaluated under a range of levels of effluent treatment (levels 1, 2 and 2a), discussed in more detail in the sections below and in eThekwini Metropolitan Municipality (2015).

Proportional contributions of WWTW inflow and catchment inflow were used to calculate resultant concentrations in freshwater inflow under the various flow conditions, scenarios and treatment levels. For Dissolved Inorganic Nitrogen (DIN), Dissolved Inorganic Phosphate (DIP) and turbidity, salinity was used as proxy to calculate the resultant concentrations in each of the zones under various scenarios and treatment levels, assuming mixing as the dominant driver. DO, however, being a strongly non-conservative parameter, could not be estimated in this manner. DO concentrations, therefore, were derived from available data. For this study, concentrations in seawater were assumed as follows:

- DIN: 50 µg/l,
- DIP: 10 µg/l,
- Turbidity: 10 NTU,
- DO: 8 mg/l.

6.1 uMKHOMAZI ESTUARY

6.1.1 Estuary condition, REC and Importance

The uMkhomazi Estuary is currently in a C Category (Table 6.1). From a biodiversity perspective the estuary is of "high importance" (DWAF, 2008). The estuary also forms part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of high conservation importance (Van Niekerk and Turpie, 2012). The estuary also serves as a highly important nursery for estuarine associated and estuarine dependant fish along this coastline. Taking into account the current condition (PES = C) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the uMkhomazi Estuary the REC for the system is a B Category (i.e. improve its condition).

Table 6.1 uMkhomazi Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	C
REC	B
Importance	
Conservation (5 = NBA priority list)	5
Estuary (Biodiversity) (5 = High)	4
Fish Nursery (5 = High nursery value)	5

6.1.2 Operational scenario evaluation

The average WWTW effluent concentrations for the various future treatment options, as well as estimated water quality concentrations in river inflow (i.e. without WWTW inputs) are presented in Table 6.2 below. WWTW concentrations were supplied to the CSIR, while estimated concentrations in river inflow were derived from available data and a review of relevant literature.

Table 6.2 uMkhomazi Estuary: Summary of average WWTW effluent concentrations for the future treatment options and nutrient concentrations in river inflow

Parameter	Level 1	Level 2	Level 2a	River inflow	
				Low	High
Ammonia-N (free) (µg/l)	<3 000	<1 500	<500		
Nitrate/Nitrite-N (µg/l)	<8 000	<4 500	<2 500		
DIN (µg/l)	**11 000**	**6 000**	**3 000**	**200**	**250**
DIP (µg/l)	**1 000**	**100**	**20**	**10**	**20**
COD (mg/l O_2)	**75**	**50**	**30**		
Suspended solids (mg/l)	25	15	5		
Estimated turbidity (NTU)	**40**	**30**	**20**	**10**	**200**

The predicted ECs for the uMkhomazi Estuary under different scenarios are provided in Table 6.3. An evaluation of the scenarios provided the following insights:

- The natural MAR was 1077.74 x 10^6 m^3/a, while the present MAR is 943.39 x 10^6 m^3/a (88% of reference).
- The estuary is at present in a Category C.
- As the system has a large volume and is subject to tidal flushing in the lower reaches when the mouth is open, it has a relatively higher assimilative capacity compared with smaller systems in the study area.
- However, in all instances Sc 1MKn (including 5 ML/day WWTW effluent), Sc 2Mkn (including 16 Ml/d WWTW effluent), Sc 3MKn (including 21 ML/d WWTW effluent) and Sc 4MKn (including 50 Ml/d WWTW effluent), Level 1 treatment will be insufficient to maintain water quality in its present state. Deterioration in the water quality from Category C to D, and even E is probable.
- While the system is likely to remain in the PES under Sc 1MKn under average flows, deterioration in water quality and associated fish kills are likely during periods of mouth closure when residence time and accumulation of nutrients increases. Under Sc 2MKn, Sc 3MKn and Sc 4MKn, Level 1 treatment will be insufficient to maintain the PES and the system will deteriorate to Category D.
- Under Sc 2MKn, 3MKn and Sc 4MKn despite Level 2 and 2a treatment of WWTW effluent, the system will decline to a C/D category and even Category D (4Mkn) as a result of higher wastewater volumes increasing nutrient loading to unacceptable levels.

Table 6.3 uMkhomazi Estuary: ECs associated with selected scenarios

Scenario (waste water treatment level)	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Water quality	Physical habitat alteration	Habitat health score	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biotic health score	Ecological category
Present	943.39		C	A	C	B	B	B	E	C	D	D	C	C
Sc 1MKn1 (L1)	945.22	5	C	A	D	B	C	B	F	C	D	D	D	C
Sc 1MKn (L2)	945.22	5	C	A	C	B	B	B	F	C	D	D	D	C
Sc 1MKn (L2a)	945.22	5	C	A	C	B	B	B	F	C	D	D	D	C
Sc 2MKn (L1)	777.27	16	C	A	E	C	C	C	F	D	D	D	D	D
Sc 2MKn (L2)	777.27	16	C	A	D	C	C	C	F	D	D	D	D	C/D
Sc 2MKn (L2a)	777.27	16	C	A	D	C	C	C	F	D	D	D	D	C/D
Sc 3MKn (L1)	779.09	21	C	A	E	C	C	C	F	D	D	D	D	D
Sc 3MKn (L2)	779.09	21	C	A	D	C	C	C	F	D	D	D	D	C/D
Sc 3MKn (L2a)	779.09	21	C	A	D	C	C	C	F	D	D	D	D	C/D
Sc 4MKn (L1)	789.69	50	C	A	E	C	C	D	F	E	E	E	E	D
Sc 4MKn (L2)	789.69	50	C	A	D	C	C	C	F	E	E	E	E	D
Sc 4MKn (L2a)	789.69	50	C	A	D	C	C	C	F	D	E	E	D	D

Recommendation:

- It is recommended that Department of Environmental Affairs (DEA), DWS, SAPPI, and eThekwini Municipality liaise regarding recycling, reuse and/or alternative disposal of WWTW effluent in the area. For example, the option of using the existing SAPPI marine outfall to dispose of effluent to sea should be investigated. Note that numerical modelling and more detailed environmental studies will be required to assess the implications of combining WWTW effluent with the existing SAPPI effluent.
- Under Sc 1MKn there will be a low occurrence of mouth closure, but significant risk that if closure does occur during low flow and drought conditions. Nutrient enrichment and organic loading under these conditions may reduce DO levels below 4 mg/l putting the estuary's nursery function for high value recreational angling fish species (dusky cob, estuarine bream, spotted grunter) at high risk.

Note this assessment does not include detailed numerical modelling and assumes that the proposed WWTW discharges enter the estuary at the head. Therefore this assessment did not consider a WWTW discharge in the middle or lower estuary near the mouth (this will required more detailed numerical modelling studies).

It is likely that WWTW effluent discharged in the middle or lower reaches of the estuary will cause disruption of the salinity gradient and cause deterioration of water quality, especially during low flow periods when assimilative capacity reduces markedly.

6.2 LITTLE MANZIMTOTI ESTUARY

6.2.1 Estuary condition, REC and Importance

The Little Manzimtoti Estuary is currently in an E Category (Table 6.4). From a biodiversity perspective the estuary is of "low to average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = E) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Little Manzimtoti Estuary the REC for the system is a D Category (i.e. minimum allowable category to achieve biodiversity targets and ensure functionality).

Table 6.4 Little Manzimtoti Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	**E**
REC	**D**
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	2
Fish Nursery (5 = High nursery value)	1

6.2.2 Operational scenario evaluation

Average WWTW effluent concentrations for the present and various future treatment options, as well as estimated concentrations in river inflow (i.e. without WWTW inputs) are presented in Table 6.5 below. WWTW concentrations were supplied to the CSIR, while estimated concentrations in river inflow were derived from available data and literature.

Table 6.5 Little Manzimtoti Estuary: Summary of average WWTW effluent concentrations for the future treatment options and nutrient concentrations in river inflow

Parameter	Present WWTW (average)	Level 1	Level 2	Level 2a	River Inflow	
					Low	High
Ammonia-N (free) (µg/l)	1219	<3 000	<1 500	<500		
Nitrate/Nitrite-N (µg/l)	8333	<8 000	<4 500	<2 500		
DIN (µg/l)	9552	**11 000**	**6 000**	**3 000**	**200**	**500**
DIP (µg/l)	379	**1 000**	**100**	**20**	**20**	**30**
COD (mg/l O_2)	52	**75**	**50**	**30**		
Suspended solids (mg/l)	11	25	15	5		
Estimated turbidity (NTU)	20	**40**	**30**	**20**	**20**	**40**

The predicted ECs for the Little Manzimtoti Estuary under different scenarios are provided in Table 6.6. An evaluation of the scenarios provided the following insights:

- The natural MAR was 2.84 x 10^6 m^3/a, while the present MAR is 6.62 x 10^6 m^3/a (233% of reference).
- The estuary is at present non-functional, i.e. Category E.
- Fish kills have been recorded for this system, showing that nutrient and organic loading are already threatening the system.

- The estuary is small with very little assimilative capacity and therefore sensitive to enrichment for WWTW discharges (i.e. no level of treatment was sufficient to reduce nutrient enrichment in the system to levels that would not risk eutrophication).
- Under Sc A1 (with no WWTW discharge), the estuary condition improves to Category D.
- Under Sc 2, irrespective of the treatment level, the estuary will remain in an E Category.
- Significant further deterioration in condition to Category F and E/F is anticipated under Sc3 due to substantial increase in WWTW volume and nutrient loading to the system.

Table 6.6 Little Manzimtoti Estuary: ECs associated with selected scenarios

Scenario (waste water treatment level)	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Water quality	Physical habitat alteration	Habitat health score	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biotic health score	ESTUARINE HEALTH SCORE
Present	6.62	4.76	D	E	E	D	E	E	D	F	F	F	E	E
Sc 1	4.88	0	C	D	C	C	C	D	E	D	D	E	D	D
Sc 2a (L1)	7.80	8	E	F	E	D	E	F	E	F	F	F	F	E
Sc 2b (L2)	7.80	8	E	F	E	D	E	E	E	F	F	F	F	E
Sc 2ca	7.80	8	E	F	D	D	E	E	E	F	F	F	F	E
Sc 3a (L1)	15.83	30	E	F	F	D	F	F	F	F	F	F	F	F
Sc 3b (l2)	15.83	30	E	F	F	D	E	F	F	F	F	F	F	F
Sc 3c (L2a)	15.83	30	E	F	E	D	E	E	F	F	F	F	F	E/F

6.3 MBOKODWENI ESTUARY

6.3.1 Estuary condition, REC and Importance

The Mbokodweni Estuary is currently in an E Category (Table 7.7). From a biodiversity perspective the estuary is of "average importance" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking the current condition (PES = E) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the Mbokodweni Estuary the REC for the system is a D Category (i.e. minimum allowable category to achieve biodiversity targets and ensure functionality).

Table 6.7 Mbokodweni Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	E
REC	D
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	3
Fish Nursery (5 = High nursery value)	1

6.3.2 Operational scenario evaluation

Average WWTW effluent concentrations for the present and various future treatment options, as well as estimated concentrations in river inflow (i.e. without WWTW discharge) are presented in

Table 6.8 below. WWTW concentrations were supplied to the CSIR, while concentrations in river inflow were derived from available data and literature.

Table 6.8 Mbokodweni Estuary: Summary of average WWTW effluent concentrations for the future treatment options and nutrient concentrations in river inflow

Parameter	Present WWTW (average)	Level 1	Level 2	Level 2a	In-stream	
					Low flow	High flow
Ammonia-N (free) (µg/l)	6614	<3 000	<1 500	<500		
Nitrate/Nitrite-N (µg/l)	4729	<8 000	<4 500	<2 500		
DIN (µg/l)	**11343**	**11 000**	**6 000**	**3 000**	**2000[1]**	
DIP (µg/l)	**389**	**1 000**	**100**	**20**	**1000[2]**	
COD (mg/l O_2)	**38**	**75**	**50**	**30**		
Suspended solids (mg/l)	7	25	15	5		
Estimated turbidity (NTU)	20	**40**	**30**	**20**	**40[3]**	**50**

1 Derived from eThekwini data above WWTW (NH_4-N); DWS data (U2H3:Kwa-Dabeka Richmond) for NOx-N.
2 Derived from eThekwini data above WWTW.
3 Derived from eThekwini data above WWTW.

The predicted ECs for the Mbokodweni Estuary ecological categories under different scenarios are provided in Table 6.9. An evaluation of the scenarios provided the following insights:

- The natural MAR was 31.5 x 10^6 m^3/a, while the present MAR is 53.54 x 10^6 m^3/a (170% of reference).
- The estuary is at present a non-functional system, i.e. Category E.
- Fish kills have been recorded for this system, showing that nutrient and organic loading are already threatening the system.
- The estuary is small with very little assimilative capacity and therefore sensitive to enrichment for WWTW discharges (i.e. no level of treatment was sufficient to reduce nutrient enrichment in the system to levels that would not risk eutrophication).
- Under Sc A1 (no WWTW discharge), the estuary increases in condition to a D Category.
- While under the Sc 3 (A1a), irrespective of the treatment level, the estuary remains in Category E.
- Significant further deterioration in condition, Category E/F is anticipated under Sc B (at all levels of treatment) due to substantial increase in WWTW volume and nutrient loading.

Table 6.9 Mbokodweni Estuary: ECs associated with selected scenarios

Scenario (waste water treatment level)	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Water quality	Physical habitat alteration	Habitat health score	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biotic health score	ECOLOGICAL CATEGORY
Present	53.54	33.6	D	E	E	D	D	F	E	F	E	F	E	E
Sc A1	41.26	0	B	B	D	D	C	E	E	E	D	F	E	D
Sc C (A1a) (L1)	61.34	55	D	F	E	D	E	F	E	F	E	F	F	E
Sc C A1a (L2)	61.34	55	D	F	E	D	E	F	E	F	E	F	F	E
Sc C A1a (L2a)	61.34	55	D	F	E	D	E	F	E	F	E	F	F	E
Sc B (L1)	72.30	85	D	F	E	D	E	F	E	F	F	F	F	E/F
Sc B (L2)	72.30	85	D	F	E	D	E	F	E	F	F	F	F	E/F
Sc B (L2a)	72.30	85	D	F	E	D	E	F	E	F	F	F	F	E/F

6.4 uMDLOTI ESTUARY

6.4.1 Estuary condition, REC and Importance

The uMdloti Estuary is currently in a D Category (Table 6.10). From a biodiversity perspective the estuary is an "important estuary" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). The estuary also serves as a relatively important nursery for estuarine associated and estuarine dependant fish along this coastline. Taking into account the current condition (PES = D) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the uMdloti Estuary the REC for the system is a C Category (i.e. minimum allowable category to achieve biodiversity targets and ensure functionality and protection of nursery function).

Table 6.10 uMdloti Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	D
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	4
Fish Nursery (5 = High nursery value)	3

6.4.2 Operational scenario evaluation

Average WWTW effluent concentrations for the present and various future treatment options, as well as estimated concentrations in river inflow (i.e. without WWTW inputs) are presented in Table 6.11. WWTW concentrations and river inflow concentrations were derived from available data and literature.

Table 6.11 uMdloti Estuary: Summary of average WWTW effluent concentrations for the future treatment options and nutrient concentrations in river inflow

Parameter	Present (Verulam) (average)	Level 1	Level 2	Level 2a	River inflow	
					Low	High
Ammonia-N (free) (µg/l)	1980	<3 000	<1 500	<500		
Nitrate/Nitrite-N (µg/l)	1096	<8 000	<4 500	<2 500		
DIN (µg/l)	**3076**	**11 000**	**6 000**	**3 000**	**2200**	
DIP (µg/l)	**1085**	**1 000**	**100**	**20**	**350**	
COD (mg/l O_2)	**113**	**75**	**50**	**30**		
Suspended solids (mg/l)	57	25	15	5		
Estimated turbidity (NTU)	**20**	**40**	**30**	**20**	**15**	**40**

The predicted ECs for the uMdloti Estuary under different scenarios are provided in Table 6.12. An evaluation of the scenarios provided the following insights:

- The natural MAR was 100.18 x 10^6 m^3/a, while the present MAR is 85.03 x 10^6 m^3/a (85% of reference).
- The estuary is at present in a Category D.
- Fish kills have been recorded for this system, showing that it is already threatened by nutrient and organic loading.
- The estuary is has small open water body area with very little assimilative capacity and therefore sensitive to enrichment for WWTW discharges (i.e. no level of treatment was

sufficient to reduce nutrient enrichment in the system to levels that would not risk eutrophication).

- Water quality in river inflow is very poor (Table 6.11). Therefore any future scenarios that will result in more frequent mouth closure than at present (i.e. if flow is significantly reduced) will lead to deterioration in water quality and reduction in DO levels unless the water quality inflow from the catchment is improved, for example under Sc H6_1o, Sc A1, H 6_1p, Sc A1a (L1).
- The estuary remains in a Category D under scenarios Sc C3 (l1), Sc C3 (L2), Sc 23_2 (L2), Sc 23_2 (L2a) irrespective of the level of wastewater treatment.
- Significant further deterioration in condition to Category D/E and E is anticipated under the Scenario Sc D4 (L2a), Sc 2 (L1) and Sc 2 (L2a) as a result of the substantial increase in WWTW volume and nutrient loading.

Table 6.12 uMdloti Estuary: ECs associated with selected scenarios

Scenario (waste water treatment level)	MAR (x 10^6 m/a)	WWTW volume (Ml/d)	Hydrology	Hydrodynamics	Water quality	Physical habitat alteration	Habitat health score	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biotic health score	ECOLOGICAL CATEGORY
Present	85.03	7.53	D	D	E	C	D	E	D	D	D	F	E	D
Sc H6_1o	67.02	7.53	D	E	E	D	D	E	E	D	D	F	E	D/E
Sc A1	68.02	0	D	E	E	D	D	E	E	D	D	F	E	D/E
Sc H6_1p	70.12	7.53	D	D	E	D	D	E	D	D	D	F	E	D/E
Sc A1a (L1)	72.40	12	C	D	E	D	D	E	E	D	D	F	E	D/E
Sc C3 (l1)	77.88	27	B	D	E	D	D	E	E	D	D	F	E	D
Sc C3 (L2)	77.88	27	B	D	E	D	D	E	E	D	D	F	E	D
Sc 23_2 (L2)	78.97	30	B	D	E	D	D	E	E	D	D	F	E	D
Sc 23_2 (L2a)	78.97	30	B	D	E	D	D	E	E	D	D	F	E	D
Sc D4 (L2a)	89.93	60	B	F	E	C	D	E	F	E	E	E	E	D/E
Sc2 (L1)	113.68	12)	C	F	E	C	D	F	F	F	E	E	E	E
Sc2 (L2a)	113.68	125	C	F	E	C	D	F	F	F	E	F	E	E

6.5 uTHONGATHI ESTUARY

6.5.1 Estuary condition, REC and Importance

The uThongathi Estuary is currently in a D Category (Table 6.13). From a biodiversity perspective the estuary is an "important estuary" (DWAF, 2008). The estuary does not form part of the core set of priority estuaries in need of protection to achieve national biodiversity targets, i.e. it is of low conservation importance (Van Niekerk and Turpie, 2012). Taking into account the current condition (PES = D) of the estuary, the reversibility of the impacts, the ecological importance and the conservation requirements of the uThongathi Estuary the REC for the system is a C Category (i.e. minimum allowable category to achieve biodiversity targets and ensure functionality).

Table 6.13 uThongathi Estuary: Summary of PES, REC and estuary Importance

Ecological Condition	
PES	D
REC	C
Importance	
Conservation (5 = NBA priority list)	1
Estuary (Biodiversity) (5 = High)	4
Fish Nursery (5 = High nursery value)	1

6.5.2 Operational scenario evaluation

Average WWTW effluent concentrations for the present and various future treatment options, as well as estimated concentrations in river inflow (i.e. without WWTW) are presented in Table 6.14 below. WWTW concentrations and river inflow concentrations were derived from available data and literature.

Table 6.14 uThongathi Estuary: Summary of average WWTW effluent concentrations for the future treatment options and nutrient concentrations in river inflow

Parameter	Present WWTW (average)	Level 1	Level 2	Level 2a	Inflow	
					Low	High
Ammonia-N (free) (µg/l)	5419	<3 000	<1 500	<500		
Nitrate/Nitrite-N (µg/l)	597	<8 000	<4 500	<2 500		
DIN (µg/l)	**6016**	**11 000**	**6 000**	**3 000**	**600**[1]	
DIP (µg/l)	**942**	**1 000**	**100**	**20**	**120**[2]	
COD (mg/l O_2)	**50**	**75**	**50**	**30**		
Suspended solids (mg/l)	12	25	15	5		
Estimated turbidity (NTU)	20	**40**	**30**	**20**	**303**	**40**

1 Based on NH_4-N and NOx-N data from DWS monitoring station U3H1.
2 Based on data from eThekwini data above WWTW (R-TONGATI_03).
3 Based on data from eThekwini data above WWTW (R-TONGATI_03).

The predicted ECs for the uThonghati Estuary under different scenarios are provided in Table 6.15. An evaluation of the scenarios provided the following insights:

- The natural MAR was 70.8 x 10^6 m/a, while the present MAR is 79.2 x 10^6 m/a (112% of reference).
- The estuary is at present in a Category D.
- Fish kills have been recorded for this system, showing that it already threatened by nutrient and organic loading.
- Under Sc A1 (no WWTW discharges), the estuary increases in condition to Category C/D.
- Under the Sc 2 (treatment level 1 and 2), the estuary will degrade to Category D/E, but will maintain the PES at treatment level 2a.
- Significant further deterioration in condition to Categories E and E/F, is anticipated under the Sc 3 to Sc 6 as a result of the substantial increase in WWTW volume and nutrient loading.

Table 6.15 uThonghati Estuary: ECs associated with selected scenarios

Scenario (waste water treatment level)	MAR (x 10^6 m/a)	WWTW Volume (Ml/d)	Hydrology	Hydrodynamics	Water quality	Physical habitat alteration	Habitat health score	Microalgae	Macrophytes	Invertebrates	Fish	Birds	Biotic health score	ECOLOGICAL CATEGORY
Present	79.2	12.4	C	B	E	D	D	E	D	E	E	F	E	D
Sc 1	74.7	0	C	A	D	D	C	D	D	C	D	E	D	C/D
Sc 2 (L1)	81.2	18	D	C	E	D	D	E	D	E	E	F	E	D/E
Sc 2 (L2)	81.2	18	D	C	D	D	D	E	D	E	E	F	E	D/E
Sc 2 (L2a)	81.2	18	D	C	D	D	D	E	D	E	E	F	E	D
Sc 3 (L1)	84.9	28	D	F	E	E	E	F	E	F	E	F	E	E
Sc 3 (L2)	84.9	28	D	F	E	E	E	E	E	F	E	F	E	E
Sc 3 (L2a)	84.9	28	D	F	E	E	E	E	E	F	E	F	E	E
Sc 4 (L1)	92.2	48	D	F	E	E	E	F	E	F	F	F	F	E/F
Sc 4 (L2)	92.2	48	D	F	E	E	E	E	E	F	F	F	F	E
Sc 4 (L2a)	92.2	48	D	F	E	E	E	E	E	F	F	F	F	E
Sc 5 (L1)	103.2	78	D	F	E	E	E	F	E	F	F	F	F	E/F
Sc 5 (L2)	103.2	78	D	F	E	E	E	E	E	F	F	F	F	E
Sc 5 (L2a)	103.2	78	D	F	E	E	E	E	E	F	F	F	F	E/F
Sc 6 (L1)	132.4	158	D	F	E	E	E	F	E	F	F	F	F	E/F
Sc 6 (L2)	132.4	158	D	F	E	E	E	F	E	F	F	F	F	E/F
Sc 6 (L2b)	132.4	158	D	F	E	E	E	E	E	F	F	F	F	E/F

The removal of the weir midway up the uThonghati Estuary will restore some intertidal and water column habitat, but if the water quality conditions do not improve this is effectively "environmental accounting" in which habitat is made available, but is not viable for use. This expenditure is not recommended unless water quality is improved in the system to allow for use of the restored habitat. This is especially the case in the future scenarios where increased WWTW volume and nutrient loading will further increase eutrophication and related risk of low oxygen events.

7 CONCLUSIONS

7.1 CONFIDENCE: SOUTHERN AND NORTHERN CLUSTER IUAS

The overall confidence in the assessment conducted in the Southern and Northern Clusters is LOW, including the assessment of the future scenarios. Little to no long term data was available to determine the PES of estuaries in these areas and therefore to assess likely responses to future WWTW discharges. Of importance is that most of the systems in these clusters are small and with low assimilative capacity for nutrient and organic loading which can easily be exceeded.

The following information is needed to improve on future EWR studies on these systems:

- Acquire long term data on river inflow and water quality (i.e. gauging weirs or regular measurements), mouth state and water levels (i.e. water level recorders).
- Improve understanding on the mode of delivery of inflow (e.g. at weekly or daily time scales). Some of these systems function on daily to hourly time scales, while the existing estuary EWR methods and tools assess systems at monthly time intervals and therefore are not able to provide high confidence assessments on such systems.
- Acquire long term data at appropriate temporal scales (which will be dependent on the variability in effluent flow and compositions) on the volume and water quality of WWTW effluents discharged to these systems.
- Data to assess the reference condition of these systems (especially the physical/sedimentary processes) are lacking and processes and reference condition are not well understood. Detailed studies (e.g. PhD studies) are required to address uncertainty. Even then, it is doubtful whether confidence can be improved above Medium.
- Information on remedial measures to improve water quality in river inflow should be investigates (e.g. related to improved catchment land-use practices). These small systems are sensitive to poor water quality conditions, which imply that they will respond well to remedial actions.
- Information on the accumulation of toxic substances (e.g. metal, herbicides and pesticides), and the current impact associated with such accumulation needs investigation, especially in the urban systems or those receiving extensive runoff from agricultural areas.
- Improved understanding on the responses of microalgae and macrophytes to various nutrient loading and assimilative capacities is required, as well as the effect on DO processes.
- Long term data on the composition and functioning of invertebrates, fish and birds are also lacking and need to be improved.

7.2 CONFIDENCE: CENTRAL CLUSTER

7.2.1 Mbokodweni and Little Manzimtoti estuaries

The overall confidence that the present state (PES) of the Mbokodweni and Little Manzimtoti estuaries were in very poor condition was HIGH (Table 7.1). However, the confidence in terms of the implication on the EC of the future scenario(s) where WWTW discharges was removed and/or reduced was MEDIUM to LOW. This was due to uncertainty to the degree the system can recover from its present baseline. Overall confidence in the further deterioration of both these systems under future scenarios where additional WWTW discharges were introduced was HIGH. These systems are very small with little assimilative capacity which is easily exceeded with increases in WWTW effluent volumes.

Table 7.1 Mbokodweni and Little Manzimtoti estuaries: Data availability and Confidence levels

Component	Data availability	Confidence in the category		
		PES result	Sc A (reduced waste water)	Sc B and C
Hydrology	Low	High	Low	High
Hydrodynamics	Low	Medium-High	Low	High
Physical habitat	Low	Low-Medium	Low-Medium	Low-Medium
Water quality	Low	Medium	Low-Medium	High
Microalgae	Low	Medium	Medium	Medium
Macrophytes	Medium	High	Medium	Medium
Invertebrates	Low	Low-Medium	Low-Medium	Low-Medium
Fish	Medium	Medium	Medium	Medium
Birds	High	High	High	High
Overall confidence	Low-Medium (but abiotics low)	High	Low-Medium	High

The following information is needed to improve on future EWR studies on these systems:

- Understanding of the catchment water quality (i.e. sources of contamination, concentrations, seasonal fluctuations, potential for remedial actions to improve water quality).
- Better quantification of inflows to the estuary (river and WWTW) that drive the mouth condition, including the mode of delivery. Ideally, river inflow to these small systems needs to be resolved at daily or hourly time scales. It is not sufficient to evaluate inflows and responses at monthly intervals as required by EWR process.
- Continuous data on mouth state are lacking and need to be acquired (e.g. by installation of water level recorders near the estuary mouths).
- Information on the accumulation of toxic substances (e.g. metal, herbicides and pesticides), and the current impact associated with such accumulation needs investigation, especially in the urban systems or those receiving extensive runoff from agricultural areas.
- Improved understanding on the responses of microalgae and macrophytes to various nutrient loading and assimilative capacities is required, as well as the effect on DO processes.
- Long term data on the composition and functioning of invertebrates, fish and birds are also lacking and need to be improved.

7.2.2 uMdloti Estuary

The overall confidence in the PES of the uMdloti Estuary, as well as the confidence on the implications of future scenarios was MEDIUM (Table 7.2).

Table 7.2 uMdloti Estuary: Data availability and Confidence levels

Component	Data availability	Confidence in the category	
		PES result	Scenario interpretation
Hydrology	**High**	**High**	**High**
Hydrodynamics	**Medium**	**Low-Medium**	**Low-Medium**
Physical habitat	**Low-Medium**	**Low-Medium**	**Low-Medium**
Water quality	**Low-Medium**	**Medium-High**	**Medium**
Microalgae	Medium	Medium	Medium
Macrophytes	Medium	Medium	Medium
Fish	Medium	Medium	Medium
Invertebrates	Medium	Medium	Medium
Birds	**Low-Medium**	**High**	**Medium**
Overall confidence	**Medium**	**Medium**	**Medium**

The following information is needed to improve on future EWR studies on the uMdloti Estuary:

- The hydrodynamics/mouth processes is highly variable (daily/weekly time scales), therefore uncertainty is introduced in the current approach where monthly time steps are used. DWS is in the process of collating long term data set on flow and water levels that will allow for improved confidence with time.
- Data to assess the reference condition of this system (especially the physical/sedimentary processes) are lacking and reference state is not well understood. This will require detailed studies (e.g. PhD studies). Even with such study is doubtful whether confidence can be improved above Medium.
- Information on the quality of river inflow as well as on remedial measures to improve water quality (e.g. related to improved catchment land-use practices) is required. Improved understanding of the responses of microalgae and macrophytes to various nutrient loading scenarios and assimilative capacities is required, as well as a better understanding of the DO processes. There is a lack of bird reference data, so this component cannot improve in confidence.

7.2.3 uThonghati Estuary

The overall confidence in the PES of the uThonghati Estuary, as well as the confidence on the projected implications of future scenarios was MEDIUM (Table 7.3). The system is small and with a low assimilative capacity for nutrient and organic loading.

Table 7.3 uThonghati Estuary: Data availability and Confidence levels

Component	Data availability	Confidence in the category	
		PES result	Scenario interpretation
Hydrology	Low	Low	Low
Hydrodynamics	Medium-High	Medium-High	Medium
Physical habitat	Low	Low-Medium	Low-Medium
Water quality	Low-Medium	Low-Medium	Low-Medium
Microalgae	Low-Medium	Medium	Medium
Macrophytes	Medium	Medium	Medium
Invertebrates	L-M	Medium	Medium
Fish	Medium	Medium	Medium
Birds	L-M	Medium	Medium
Overall confidence	L-M	Medium	Medium

The following information is needed to improve on future EWR studies on the uThongathi Estuary:

- An improved understanding of the catchment water quality, i.e. sources of contamination, concentrations, seasonal fluctuations, potential for remedial actions to improve water quality.
- Better quantification of inflows to the estuary (river and WWTW) that drive the mouth condition including the mode of delivery. Ideally, river inflow to these small systems needs to be resolved at daily or hourly time scales. It is not sufficient to evaluate these on monthly time steps as required by EWR process.
- Continuous mouth state data are lacking and need to be acquired (i.e. water level recorder near the mouth).
- Information on the accumulation of toxic substances (e.g. metal, herbicides and pesticides), and the current impact associated with such accumulation needs investigation, especially in the urban systems or those receiving extensive runoff from agricultural areas.
- Improved understanding on the responses of microalgae and macrophytes to various nutrient loading and assimilative capacities is required, as well as the effect on DO processes.
- Long term data on the composition and functioning of invertebrates, fish and birds are also lacking and need to be improved.

7.2.4 uMkhomazi Estuary

Overall confidence in the PES of the uMkhomazi Estuary, as well as on the implications of future scenarios was MEDIUM (Table 7.4). The only exception was the water quality component that was LOW to MEDIUM. The water quality prediction was lower because a box model was used in this assessment rather than a quantitative approach, such as 3D numerical modelling of the hydrodynamic processes.

Table 7.4 uMkhomazi Data availability and Confidence levels

Component	Data Availability	Confidence in the category	
		PES result	Scenario interpretation
Hydrology	Low	Low	Low
Hydrodynamics	Medium-High	Medium-High	Medium
Physical habitat	Low	Low-Medium	Low-Medium
Water quality	Low-Medium	Low-Medium	Low-Medium
Macro Algae	Low-Medium	Medium	Medium
Macrophytes	Medium	Medium	Medium
Invertebrates	Low-Medium	Medium	Medium
Fish	Medium	Medium	Medium
Birds	Low-Medium	Medium	Medium
Overall confidence	Low-Medium	Medium	Medium

The following information is needed to improve on future EWR studies on the uMkhomazi Estuary:

- 3D numerical modelling will be required to acquire detailed understanding in the behaviour of WWTW effluent under various tidal, flow and mouth state conditions.
- The conditions of the system under closed mouth, risks of deterioration in water quality, and associated knock-on ecological effects should be further investigated.
- Data to assess the reference condition of this system (especially the physical/sedimentary processes) are lacking and not well understood. Detailed studies (e.g. PhD studies) are needed to address this uncertainty. Even with such studies, it is doubtful whether confidence can be improved above Medium.
- Improved understanding on the responses of microalgae and macrophytes to various nutrient loading and assimilative capacities is required, as well as the effect on DO processes.

7.3 SUMMARY OF INDIVIDUAL ESTUARY ASSESSMENT RESULTS

In summary, the fair to poor PES of most of the smaller systems in the WMA is because of poor water quality and increased frequency of opening of estuary mouths. These impacts are associated with increased volumes and nutrient loading from WWTWs, as well as poor water quality entering from the catchment of some of the systems. As a result of their small assimilative capacities these systems are at a high risk of becoming eutrophic, especially when their mouths close during low flow and drought conditions. In turn, die-off of vegetation can result in high detrital loads, causing reduced DO levels which negatively impact fish and invertebrates. Fish kills are the end result and are indicative of the ecosystems reaching ecological tipping points. The consequences are summarised in the following sections and illustrated in Figure 7.1. Note, the grey bars indicate presence of existing WWTW.

7.3.1 Southern Cluster IUA

In this cluster ten estuaries are of conservation importance: the Mtamvuna, Mpenjati, Zotsha, Umzimkulu, Domba, Koshwana, Intshambili, Mhlabatshane, Mfazazana and the Kwa-Makosi. The following overall ecological responses were noted:

- **Mpambanyoni:** All the scenarios maintain the current state (PES = C), with a slight decline under the worst case scenario (Sc 2).

- **Sezela:** Most of the scenarios maintain the current condition (PES = C), but the removal of the wastewater inputs (Sc A1) will improve the system's condition. Under the worst case scenarios (e.g. Sc D4, Sc 2) the estuary declines significantly further in condition to a C/D and D.
- **Koshwana:** Most of the scenarios maintain the present state (PES = C/D). While Sc A1 shows an improvement (Category C) and the worst case scenarios (e.g. Sc 2) results in a significant decline in health to a Category D. The recent fish kill in this estuary shows that it is already at a tipping point.
- **Mbango:** Most of the scenarios maintain the current state (PES = E). Under Sc A1 (reduction in wastewater inputs) the systems shows a significant improvement in condition (Category D/E), while under the worst case scenarios (e.g. Sc A1a, Sc 2) it shows a further decline.
- **Boboyi** and **Mhlangeni:** Most of the scenarios result in these systems maintaining their current health (PES = B/C and C, respectively). However, declines in state will occur under the worst case waste water scenarios (Sc 2).
- **Vungu:** The system will decline in health from the current state (PES = B) to Category B/C and C under the future conditions Sc C3, Sc D4, Sc A1a and Sc 2.
- **Kongweni:** The system is at present in a degraded condition (D/E category). Most of the scenarios will result in further significant decline in health to an E Category. A significant reduction in the WWTW effluent discharge will achieve the REC of Category D. This can also be achieved by a smaller reduction in WWTW effluent, together with other (non-flow related) interventions.
- **Mvutshini:** Most of the scenarios show a significant decline in health from the present condition (PES = B/C) as this estuary is sensitive to flow.
- **Mpenjati:** The scenarios maintain the current state (PES = B/C).
- **Tongazi:** While the scenarios maintain the PES = B/C, the estuary is sensitive to the increase in WWTW effluent discharge and will decrease in condition under Sc C3, D4 and Sc 2.
- **Zolwane:** The system is still in a good condition (PES = B). The estuary is sensitive to increases in WWTW effluent. About half of the scenarios, Sc E5, Sc A1a and Sc 2, will result in a (significant) decline in condition to Category B/C or C. Other scenarios will maintain or improve the present state.

7.3.2 Central Cluster

In this cluster nine systems are of conservation importance: the Mahlongwa, Mahlongwana, uMkhomazi, Umgababa, Msimbazi, Lovu, Durban Bay, uMngeni and the Mhlanga. On a national and regional scale, estuary health is in a very poor state along this coast, with five systems in a degraded condition (< E/D): Little Manzimtoti, aManzimtoti, Mbokodweni, Sipingo, Durban Bay, uMngeni. Small systems in this cluster were also relative insensitive to level of waste water treatment as they have very little assimilative capacity and therefore go eutrophic very easily.

The following overall responses were noted to the flow and waste water scenarios:

- **Thonghati:** The estuary is at present in fair state (PES = D). The estuary showed some sensitivity to the level of treatment, with Level 1 treatment generally being much worse than Level 2 and Level 2a treatment. Under Sc A1 (no WWTW discharges) the estuary increases in condition to a Category C/D. Under the Sc 2 (treatment level 1 and 2) the estuary degrades to a Category D/E, but it maintains the PES at treatment level 2a. Significant further deterioration in condition to Categories E to E/F is anticipated under the Sc 3 to Sc 6 as a result of the substantial increase in WWTW volume and nutrient loading to the system.

- **uMdloti:** The estuary is at present in fair state (PES = D). The system is small with a low assimilative capacity and therefore sensitive to increases in WWTW discharges. Water quality in river inflows is very poor (Table 7.11). Therefore, future scenarios that result in more frequent mouth closure (i.e. in which flow is significantly reduced) will lead to deterioration in water quality and reduction in DO levels unless the water quality inflow from the catchment is improved. Examples of such scenarios are Sc H6_1o, Sc A1, Sc H6_1p, and Sc A1a (L1). The estuary remained in a Category D under scenarios Sc C3 (l1), Sc C3 (L2), Sc 23_2 (L2), Sc 23_2 (L2a) irrespective of the treatment level. Significant further deterioration in condition to Categories D/E and E is anticipated under Sc D4 (L2a), Sc 2 (L1) and Sc 2 (L2a) as a result of the substantial increase in WWTW volumes and nutrient loading to the system.
- **Mbokodweni:** The system is at present in a poor condition (PES = Category E). The system improves significantly to a Category D if WWTW effluent is reduced and/or removed from the system. Under Sc 2 (55 Ml/d) at all three levels of effluent treatment, the system will maintain PES. Under Sc 3 (30 Ml/d) the estuary show a severe decline in condition to a Category E/F.
- **Little Manzintoti:** The system is at present in a poor condition (PES = E). The system improves significantly to a Category D if WWTE effluent is reduced and/or removed. Under Sc 2a (8 Ml/d) at all three levels of effluent treatment, the system will maintain the PES. Under Sc 3 (30 Ml/d) the estuary shows a severe decline in condition to Category E/F and F.
- **uMkhomazi:** The estuary is of high ecological importance. All “flow” scenarios maintained the current state (PES = C). This system will require other (non-flow) interventions to attain the REC. Most of the future scenarios including WWTW discharges degrade the condition of this ecologically important estuary to a Category C/D or D. Even scenario MK1 (5 Ml/d), which potentially under average flow condition will maintain the PES, poses a risk of eutrophication and fish kills during low flow periods and droughts when the system closes.

7.3.3 Northern Cluster

In this cluster four systems are of conservation importance: the Mhlali, Mvoti, Mdlotane and the Zinkwasi. The following overall responses were noted:

- **Mhlali:** The PES is a Category C/D. Most of the future scenarios will result in a further decline in ecological health due to excessive nutrient loading from WWTW discharges into this small estuary. The only scenario that showed some improvement in condition is Sc 1 (no WWTW discharges) taking the system to a Category B/C.
- **Mvoti:** Under most flow scenarios the system maintains the PES (Category D). The system requires other (non-flow related) interventions to attain the REC. Additional WWTW discharge will reduce the current condition, but the estuary is likely to maintain the present condition category.
- **Nonoti:** All the waste water scenarios maintain the current condition (PES = C). Scenario A1 will result in an improvement in condition from Present and the worst case scenario (Sc 2) will cause a decline in health.

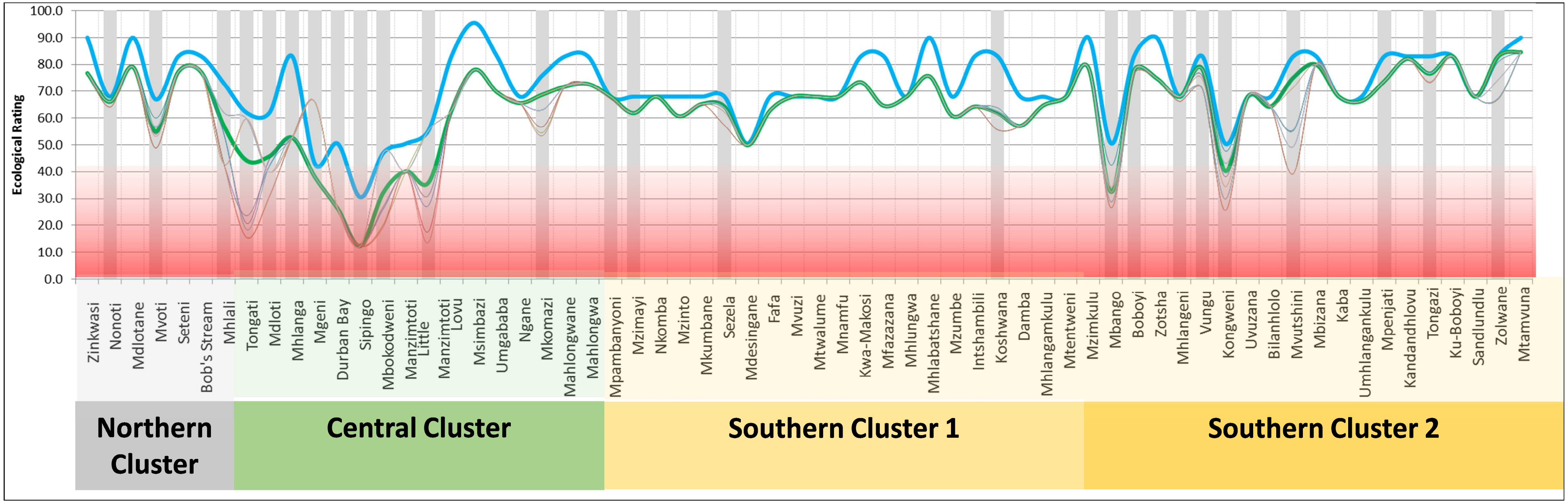


Figure 7.1 Summary of the PES, REC and scenario consequences for the estuaries of the Mvoti to Umzimkulu WMA

8 RANKING OF SCENARIOS PER IUA

8.1 SUMMARY OF OPERATIONAL SCENARIO RESULTS

8.1.1 Southern Cluster

The following was concluded from the catchment-scale operational scenario assessment for the Southern Cluster (Figure 8.1):

- Overall, the scenario configuration Ai maintains the PES, while Sc C, D, E, F, Di, Ei and Ci reduce the Southern Cluster estuaries conditions.
- Scenarios Aii, Aiii Aiv, Av, Bi, Bii and Biii further degrade the ecological condition of the systems. In addition, this group of scenarios increases the risk of eutrophication developing and fish kills occurring during low flows and droughts.

8.1.2 Central Cluster

The following was concluded from the operational scenario assessment for the Central Cluster:

- Scenario configurations Ai, Aii, AiV and Av, as well as Ei improve the ecological condition of the Central Cluster estuaries.
- Scenario E and F maintain the PES, while Sc Aiii, Bii, C D Ci and Di reduce the estuaries' condition.
- Scenario Bi further degrades the ecological condition of these systems significantly.
- The latter two groups of scenarios (Sc Aiii, Bii, C, D, Ci, D and Bi) increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

8.1.3 Northern Cluster

The following was concluded from the operational scenario assessment for the Northern Cluster:

- Scenario configurations Ai, E, F and Ei improve the ecological condition of the Northern Cluster estuaries.
- Scenario C and D represent a slight decline in ecological health from present.
- Scenario Aii, Aiii, Aiv, Av, Ci and Di show a further decline in ecological health.
- Scenario Bi, Bii and Biii degrade the ecological condition of these systems the most.
- The Sc A, C, D and B groups of scenarios all increase the risk of eutrophication developing and fish kills occurring during low flows and droughts.

8.2 RANKING OF SCENARIOS

8.2.1 Process

The ecological state (or health) rating is expressed relative to how the scenario achieves the REC. This is quantified as a numerical ratio ranging usually between 1 and 0, where a score of 1 indicates the scenario achieves the REC and zero when the scenario is typically in an F Ecological Category. This process is used to rank the scenarios at each estuary. Thereafter a weight based on various importance criteria has to be allocated to the estuaries when a ranking of scenarios have to be undertaken for more than one estuary. The process is described below:

- Deriving a single metric (one number), that reflects the ecological health relative to the REC for the estuaries, requires a number of steps. Broadly, the rationale to achieve a single rating is that each scenario at each estuary is ranked on the basis of the degree to which the scenarios meet the REC. The following approach was applied:
- Apply the EHI to each scenario that influences the flow or water quality to determine the EC for each component.

- Provide the associated percentage that represents the category.
- Calculate the degree to which the scenario meets the ecological objectives which is represented by the REC.
- The score of each scenario is then normalised to obtain a rating that is 1 if the REC is achieved, above one if the REC is exceeded (i.e. 1.1) or between 1 and zero if the score (EC) is below the REC.
- Rank the scenarios in terms of a numerical scale with values zero and one (typically, where one (1) indicates the scenario achieves the REC and a zero (0) represents the situation where the scenario results in a “F”).

A relative weighting was used on the catchment scale. Estuaries scores were normalised to their relative size, ecological importance, functional importance and present condition. Health was incorporated to ensure that good condition systems were rated higher than poor condition system, but size also plays a role. For example, a large, poor condition system such as Durban Bay still provide important functional habitats and processes, while a small, poor condition estuary, that experience regular fish kills, contribute significant less to the overall condition and resilience of the estuarine network that dots this coast.

Functional importance was based on the maximum value (High = 5, Low = 1) of: nursery function for estuarine and coastal fish; export of detritus, sediment and nutrients to the nearshore; and connectivity with the marine environment (marine linkages). This last aspect was incorporated to reflect the fact that estuaries are connected coastwise and are affected if their neighbouring systems are in a poor state. To account for this phenomena, key physical features (MAR, percentage open to the sea, distance to the next system) were normalised to ensure that isolated systems weigh more heavily that connected systems.

In addition, estuaries were also rated with regard to their recreation importance. A rating out of 5 was applied, with estuaries adjacent to Blue flag beaches and resorts were rated 5. Low use areas were rated 1.

8.2.2 Ranking results

The integrated ranking results for each IUA are illustrated in Figure 8.1. Traffic diagrams are used for the illustration. The traffic diagrams resemble traffic lights with the highest ranking scenario in the green and the lowest in the red. The importance in terms of the ranking is the order of the ranking and the relative difference between the scenarios.

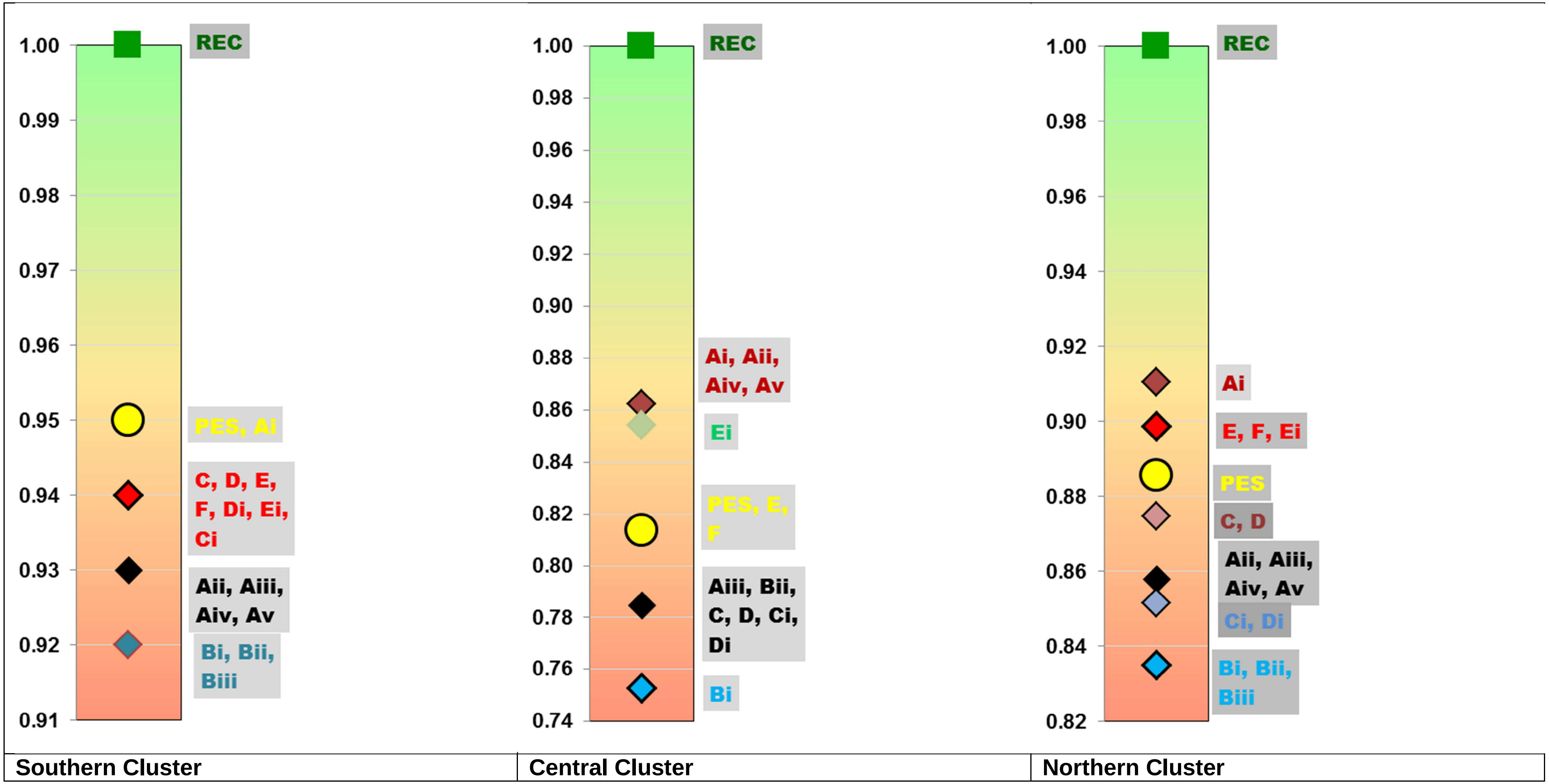


Figure 8.1 Summary of the operational scenario consequences in relation to the REC for the estuaries of the Mvoti-Umzimkulu WMA

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10 APPENDIX A: OPERATIONAL SCENARIO DESCRIPTION

This appendix provides the definitions of all scenarios with the identification labels referenced in the main sections of this report and serves as a lookup reference.

Definition of scenario applied in the comparison and evaluation process

Sc	Scenario Description	Comment
Ai	Ecological protection is priority (minimum discharge to estuaries).	NC and SC: 30% of future waste water flow to estuary, remainder through alternative means.
Aii	Ecological protection is priority (minimum discharge to estuaries).	NC and SC: Discharge current capacity, remainder disposal through alternative means.
Aiii	Ecological protection is priority (minimum discharge to estuaries).	All Clusters: Discharge current capacity, remainder disposal through alternative means.
Av	Ecological protection is priority (minimum discharge to estuaries).	As Sc Ai: Option for CC (discharge to iSipingo as an alternative option to Ai).
Bi	Minimum costs scenario (highest flow through estuaries).	Options for CC: Low nutrient discharge from (high costs).
Bii	Minimum costs scenario (highest flow through estuaries).	As Sc Bi: Different infrastructure options for Central Cluster (lower costs). uMkhomazi estuary received 50Ml/day waste water flow .
Biii	Minimum costs scenario (highest flow through estuaries).	As Sc Bi: Current treatment (high) nutrient discharge (low costs).
C	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Short term increases in discharges. CC: Short term increases in discharges with low nutrient discharge (high costs).
Ci	Current and short term (5 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Short term increases in discharges. CC: As Sc C: Current treatment (high) nutrient discharge (low costs).
D	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Medium term increases in discharges. CC: Low nutrient discharge (high costs).
Di	Current and medium term (10 year) flow discharged into river systems, remainder through alternative means.	NC and SC: Medium term increases in discharges. CC: As Sc D: Current treatment (high) nutrient discharge WWTW (low costs)
E	Indirect re-use (consider volume and practicalities). Remainder According to Scenario C.	NC and SC: Reuse 50% if future waste water flow. CC: Reuse via Hazelmere Dam.
F	Direct re-use (consider volume and practicalities). Remainder According to Scenario C.	NC and SC: Reuse 50% if future waste water flow. CC: High level of treatment (high operating costs), supply into distribution system.

Note: The grey shaded scenarios were selected for presentation to the Project Steering Committee.

uMngeni River System scenarios

Sc	Scenario Variables							
	Update Water Demands	Update Demands and Return Flows (2022)	Ultimate Development Demands and Return Flows (2040)	EWR	MMTS2[1]	MWP[2]	Darvill Re-use	eThekwini Re-use
UM1	Yes	No	No	No	No	No	No	No
UM2	No	Yes	No	No	Yes	No	No	No
UM41	Yes	No	Yes[3]	No	Yes	No	No	No
UM42	Yes	No	Yes[4]	No	Yes	No	No	No
UM51	Yes	No	Yes[3]	No	Yes	No	Yes	Yes
UM52	Yes	No	Yes[4]	No	Yes	No	Yes	Yes

1 Mooi-Mgeni Transfer Scheme Phase 2 (Spring Grove Dam).
2 Mkomazi Water Project (Smithfield Dam).
3 All future return flows from Phoenix and Mhlanga WWTW to the Mgeni System.
4 All future return flows from Phoenix, Umhlanga and Tongati WWTW to the Mgeni System.

Lovu River Scenarios

Sc	Scenario Variables			
	Update Water Demands	Ultimate Development Demands and Return Flows (2040)	EWR	Reduced Abstraction and Afforested Areas
LO1	Yes	No	No	No
LO2	Yes	Yes	No	No
LO3	Yes	Yes	No	Yes (25% reduction)
LO4	Yes	Yes	No	Yes (50% reduction)

uMkhomazi River System scenarios

Sc	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	uMWP-1	Ngwadini Off Channel Dam
MK1	Yes	No	No	No	No
MK2	Yes	Yes	No	Yes	Yes (no support)
MK21	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (no support)
MK22	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (no support)
MK23	Yes	Yes	REC low+[3] (EWR 2)	Yes	Yes (no support)
MK31	Yes	Yes	REC tot[1] (EWR 3)	Yes	Yes (no support)
MK32	Yes	Yes	REC low[2] (EWR 3)	Yes	Yes (no support)
MK33	Yes	Yes	REC low+[3] (EWR 3)	Yes	Yes (no support)
MK4	Yes	Yes	No	Yes	Yes (with support)
MK41	Yes	Yes	REC tot[1] (EWR 2)	Yes	Yes (with support)
MK42	Yes	Yes	REC low[2] (EWR 2)	Yes	Yes (with support)

1 Recommended Ecological Category (Total Flows).
2 Recommended Ecological Category (Low Flows).
3 Recommended Ecological Category (Total Flows for January, February, March and Low Flows remaining months).

Mvoti River System scenarios

Sc	Scenario Variables				
	Update water demands	Ultimate development demands and return flows (2040)	EWR	MRDP[1]	Imvutshane Dam
MV1	Yes	No	No	No	No
MV21	Yes	No	REC tot[2]	No	No
MV22	Yes	No	REC low[3]	No	No
MV3	Yes	Yes	No	Yes	Yes
MV41	Yes	Yes	REC tot[2]	Yes	Yes
MV42	Yes	Yes	REC low[3]	Yes	Yes
MV43	Yes	Yes	REC low+[4]	Yes	Yes

1 Mvoti River Development Project (Isithundu Dam). 2 Recommended Ecological Category (Total Flows)
3 Recommended Ecological Category (Low Flows).
4 Recommended Ecological Category (Total Flows for January, February, March and Low Flows for remaining months).

Scenarios of levels of wastewater treatment

PARAMETER	Level 1 (L1)	Level 2 (L2)	Level 2a (L2a)
Ammonia-N (free) (µg/l)	<3 000	<1 500	<500
Nitrate/Nitrite-N (µg/l)	<8 000	<4 500	<2 500
DIN (µg/l)	**11 000**	**6 000**	**3 000**
DIP (µg/l)	**1 000**	**100**	**20**
COD (mg/l O_2)	**75**	**50**	**30**
Suspended solids (mg/l)	25	15	5
Estimated turbidity (NTU)	**40**	**30**	**20**

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
uMkhomazi Estuary scenarios		
Present	943.39	
Sc 1MKn1 (L1)	945.22	5
Sc 1MKn (L2)	945.22	5
Sc 1MKn (L2a)	945.22	5
Sc 2MKn (L1)	777.27	16
Sc 2MKn (L2)	777.27	16
Sc 2MKn (L2a)	777.27	16
Sc 3MKn (L1)	779.09	21
Sc 3MKn (L2)	779.09	21
Sc 3MKn (L2a)	779.09	21
Sc 4MKn (L1)	789.69	50
Sc 4MKn (L2)	789.69	50
Sc 4MKn (L2a)	789.69	50

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
uMdloti Estuary scenarios		
Present	85.03	7.53
H6_1o	67.02	7.53
ScA1	68.02	0
H6_1p	70.12	7.53
ScA1a (L1)	72.40	12
ScC3 (l1)	77.88	27
ScC3 (L2)	77.88	27
Sc23_2 (L2)	78.97	30
Sc 23_2 (L2a)	78.97	30
ScD4 (L2a)	89.93	60
Sc2 (L1)	113.68	125
Sc2 (L2a)	113.68	125

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
Mbokodweni Estuary scenarios		
Present	53.54	33.6
Sc A1	41.26	0
Sc C (A1a) (L1)	61.34	55
Sc C A1a (L2)	61.34	55
Sc C A1a (L2a)	61.34	55
Sc B (L1)	72.30	85
Sc B (L2)	72.30	85
Sc B (L2a)	72.30	85
Little Manzimtoti Estuary scenarios		
Present	6.62	4.76
Sc 1	4.88	0
Sc 2a (L1)	7.80	8
Sc 2b (L2)	7.80	8
Sc 2ca	7.80	8
Sc 3a (L1)	15.83	30
Sc 3b (l2)	15.83	30
Sc 3c (L2a)	15.83	30

Scenario (waste water treatment level)	MAR (x 10^6 m^3/a)	WWTW volume (Ml/d)
uThongathi Estuary scenarios		
Present	79.2	12.4
Sc 1	74.7	0
Sc 2 (L1)	81.2	18
Sc 2 (L2)	81.2	18
Sc 2 (L2a)	81.2	18
Sc 3 (L1)	84.9	28
Sc 3 (L2)	84.9	28
Sc 3 (L2a)	84.9	28
Sc 4 (L1)	92.2	48
Sc 4 (L2)	92.2	48
Sc 4 (L2a)	92.2	48
Sc 5 (L1)	103.2	78
Sc 5 (L2)	103.2	78
Sc 5 (L2a)	103.2	78
Sc 6 (L1)	132.4	158
Sc 6 (L2)	132.4	158
Sc 6 (L2b)	132.4	158

11 APPENDIX B: CENTRAL CLUSTER ESTUARY HEALTH INDEX SCORES

11.1 uMKHOMAZI ESTUARY

Table 11.1 provides a detail summary of the uMkhomazi Estuary health score.

Table 11.1 uMkhomazi EHI score and corresponding ECs under the different scenarios

	Weight	Present	Sc 1MKn1 (L1)	Sc 1MKn (L2)	Sc 1MKn (L2a)	Sc 2MKn (L1)	Sc 2MKn (L2)	Sc 2MKn(L2a)	Sc 3MKn (L1)	Sc 3MKn (L2)	Sc 3MKn (L2a)	Sc 4MKn (L1)	Sc 4MKn (L2)	Sc 4MKn (L3)
Hydrology	25	66	67	67	67	63	63	63	63	63	63	66	66	66
Hydrodynamics	25	95	95	95	95	95	95	95	95	95	95	95	95	95
Water quality	25	67	57	67	66	39	47	47	36	47	47	35	48	48
Physical habitat	25	78	78	78	78	75	75	75	75	75	75	75	75	75
HABITAT HEALTH SCORE		**76**	**74**	**77**	**76**	**68**	**70**	**70**	**67**	**70**	**70**	**68**	**71**	**71**
Microalgae	20	90	80	90	90	70	75	75	65	75	75	60	75	75
Macrophytes	20	21	15	15	15	11	11	11	10	10	10	5	5	5
Invertebrates	20	75	70	75	75	55	60	60	55	55	55	40	40	50
Fish	20	60	50	55	55	50	55	55	45	50	50	35	35	40
Birds	20	60	55	60	60	50	55	55	45	50	50	35	40	40
BIOTIC HEALTH SCORE		**61**	**54**	**59**	**59**	**47**	**51**	**51**	**44**	**48**	**48**	**35**	**39**	**42**
ESTUARINE HEALTH SCORE		**69**	**64**	**68**	**68**	**58**	**61**	**61**	**56**	**59**	**59**	**51**	**55**	**57**
ECOLOGICAL CATEGORY		**C**	**C**	**C**	**C**	**D**	**C/D**	**C/D**	**D**	**C/D**	**C/D**	**D**	**D**	**D**

11.2 LITTLE MANZIMTOTI ESTUARY HEALTH SCORES

Table 11.2 provides a detail summary of the Little Manzimtoti Estuary health scores.

Table 11.2 Little Manzimtoti EHI score and corresponding ECs under the different scenarios

	Weight	Present	Sc 1	Sc 2a (L1)	Sc 2b (L2)	Sc 2ca	Sc 3a (L1)	Sc 3b (L2)	Sc 3c (L2a)
Hydrology	25	40	69	36	36	36	30	30	30
Hydrodynamics and mouth condition	25	24	58	20	20	20	0	0	0
Water quality	25	40	67	26	37	47	8	14	29
Physical habitat alteration	25	53	63	50	50	50	43	43	43
HABITAT HEALTH SCORE		**39**	**64**	**33**	**36**	**38**	**20**	**22**	**25**
Microalgae	20	28	55	18	25	30	8	13	22
Macrophytes	20	45	35	30	30	30	10	10	10
Invertebrates	20	5	50	5	5	5	5	5	5

	Weight	Present	Sc 1	Sc 2a (L1)	Sc 2b (L2)	Sc 2ca	Sc 3a (L1)	Sc 3b (L2)	Sc 3c (L2a)
Fish	20	15	45	15	15	15	10	10	10
Birds	20	50	50	42	42	42	35	35	35
BIOTIC HEALTH SCORE		**29**	**47**	**22**	**23**	**24**	**14**	**15**	**16**
ESTUARINE HEALTH SCORE		**34**	**56**	**28**	**30**	**31**	**17**	**18**	**21**
ECOLOGICAL CATEGORY		**E**	**D**	**E**	**E**	**E**	**F**	**E/F**	**E/F**

11.3 MBOKODWENI ESTUARY

Table 11.3 provides a detail summary of the Mbokodweni Estuary health scores.

Table 11.3 Mbokodweni EHI score and corresponding ECs under the different scenarios

	Weight	Present	Sc 1	Sc 2 (L1)	Sc 2 (L2)	Sc 2 (L2a)	Sc 3 (L1)	Sc 3 (L2)	Sc 3 (L2a)
Hydrology	25	53	79	46	46	46	41	41	41
Hydrodynamics	25	35	80	17	17	17	11	11	11
Water quality	25	39	40	33	33	35	30	30	31
Physical habitat alteration	25	45	50	45	45	45	45	45	45
HABITAT HEALTH SCORE		**43**	**62**	**35**	**35**	**36**	**32**	**32**	**32**
Microalgae	20	20	30	14	15	16	12	13	14
Macrophytes	20	30	40	25	25	25	25	25	25
Invertebrates	20	10	30	10	10	10	5	5	5
Fish	20	30	50	30	30	35	15	15	20
Birds	20	17	10	5	5	5	5	5	5
BIOTIC HEALTH SCORE		**21**	**32**	**17**	**17**	**18**	**12**	**13**	**14**
ESTUARINE HEALTH SCORE		**32**	**47**	**26**	**26**	**27**	**22**	**22**	**23**
ECOLOGICAL RESERVE CATEGORY		**E**	**D**	**E**	**E**	**E**	**E/F**	**E/F**	**E/F**

11.4 uMDLOTI ESTUARY HEALTH SCORES

Table 11.4 provides a detail summary of the uMdloti Estuary health scores.

Table 11.4 uMdloti EHI score and corresponding ECs under the different scenarios

	Weight	Present	Sc H6_1o	Sc A1	Sc H6_1p Total EWR	Sc A1a (L1)	Sc C3 (l1)	Sc C3 (L2)	23_2 (L2)	Sc 2a (L2a)	Sc D4 (L2a)	Sc 2 (L1)	Sc 2 (L2a)
Hydrology	25	57	48	46	50	63	78	78	82	82	84	63	63
Hydrodynamics	25	53	40	40	45	45	46	46	46	46	20	0	0
Water quality	25	40	37	37	39	37	37	38	38	38	39	32	35
Physical habitat	25	68	51	51	59	55	59	59	59	59	74	73	73
HABITAT HEALTH SCORE		**54**	**44**	**44**	**48**	**50**	**55**	**55**	**56**	**56**	**54**	**42**	**43**

	Weight	Present	Sc H6_1o	Sc A1	Sc H6_1p Total EWR	Sc A1a (L1)	Sc C3 (I1)	Sc C3 (L2)	23_2 (L2)	Sc 2a (L2a)	Sc D4 (L2a)	Sc 2 (L1)	Sc 2 (L2a)
Microalgae	20	31	24	25	26	28	33	34	35	35	30	17	20
Macrophytes	20	45	40	40	45	40	40	40	40	40	20	20	20
Invertebrates	20	45	45	50	45	45	45	45	45	45	25	20	20
Fish	20	45	45	45	45	45	45	45	45	45	40	35	35
Birds	20	20	15	20	15	15	15	15	15	15	40	30	20
BIOTIC HEALTH SCORE		**37**	**34**	**36**	**35**	**35**	**36**	**36**	**36**	**36**	**31**	**24**	**23**
ESTUARINE HEALTH SCORE		**46**	**39**	**40**	**42**	**42**	**45**	**46**	**46**	**46**	**43**	**33**	**33**
ECOLOGICAL CATEGORY		**D**	**D/E**	**D/E**	**D/E**	**D/E**	**D**	**D**	**D**	**D**	**D/E**	**E**	**E**

11.5 uTHONGATHI ESTUARY

Table 11.5 provides a detail summary of the uThongathi Estuary health scores.

Table 11.5 uThongathi EHI score and corresponding ECs under the different scenarios

		Present	Sc 1	Sc 2 (L1)	Sc 2 (L2)	Sc 2 (L2a)	Sc 3 (L1)	Sc 3 (L2)	Sc 3 (L2a)	Sc 4 (L1)	Sc 4 (L2)	Sc 4 (L2a)	Sc 5 (L1)	Sc 5 (L2)	Sc 5 (L2a)	Sc 6 (L1)	Sc 6 (L2)	Sc 6 (L2b)
Hydrology	25	61	72	58	44	58	55	55	55	50	50	50	47	47	47	43	43	43
Hydro-dynamics	25	81	97	69	69	69	11	11	11	0	0	0	0	0	0	0	0	0
Water quality	25	37	51	36	41	44	32	36	38	30	35	37	28	36	37	28	35	37
Physical habitat alteration	25	43	45	43	43	43	30	30	30	30	30	30	30	30	30	30	30	30
HABITAT HEALTH SCORE		**55**	**66**	**51**	**49**	**53**	**32**	**33**	**33**	**27**	**29**	**29**	**26**	**29**	**29**	**25**	**27**	**28**
Microalgae	20	35	46	32	36	38	20	24	26	17	22	23	15	21	22	0	19	21
Macrophytes	20	50	55	50	50	50	30	30	30	25	25	25	25	25	25	25	25	25
Invertebrates	20	30	70	30	30	35	20	20	20	15	15	15	10	10	10	0	10	10
Fish	20	30	55	30	30	35	25	25	25	20	20	20	15	15	15	0	15	15
Birds	20	20	40	20	20	20	15	15	15	15	15	15	10	10	10	0	10	10
BIOTIC HEALTH SCORE		**33**	**53**	**32**	**33**	**36**	**22**	**23**	**23**	**18**	**19**	**20**	**15**	**19**	**16**	**15**	**16**	**16**
ESTUARINE HEALTH SCORE		**44**	**60**	**42**	**41**	**44**	**27**	**28**	**28**	**23**	**24**	**24**	**21**	**24**	**22**	**21**	**21**	**22**
ECOLOGICAL CATEGORY		**D**	**C/D**	**D/E**	**D/E**	**D**	**E**	**E**	**E**	**E/F**	**E**	**E**	**E/F**	**E**	**E/F**	**E/F**	**E/F**	**E/F**

12 APPENDIX C: ESTUARY SYNONYM LIST FOR KWAZULU-NATAL ESTUARIES

Estuary synonym list for KZN estuaries (Source: B Escott, Ezemvelo KZN Wildlife).

Estuary Name	Synonyms
Bilanhlolo	Ibilanhlolo; Big ibilanhlolo
Bobs Stream	Sharks Bay
Boboyi	Imboyboye
Damba	Domba
Durban Bay	Durban Bayhead
Fafa	iFafa
Intshambili	Ntshambili; Injambili
Isolwane	Zolwane
Kaba	Mkobi; Mkobe; Khaba
Kandandhlovu	Khandandlovu, Kandandlovu, Umkandanhlovu
Kongweni	Inkongweni
Koshwana	Ikotshwana
Kosi	
Ku-Boboyi	
Kwa-Makosi	Makosi
Little Manzimtoti	Little Amanzimtoti
Lovu	Illovu
Mahlongwa	Amahlanga, Amahlongwa
Mahlongwana	Amahlongwana
aManzimtoti	Manzimtoti
Matigulu/Nyoni	Amatikulu, (e) Matikulu, Inyoni
Mbango	Imbonga, Imbango
Mbizane	Mbizana
Mbokodweni	Umbogintwini, umbohodweni
Mdesingane	Mdezingane
Mdlotane	Ndlotane, (u)Mhlutini
uMdloti	Umdloti; Umhloti; Mhloti; Mdhloti
Mfazazana	Mfazazaan; Umfazaan; Umfazazane; Umfazaazan
uMfolozi	Mfolozi, Mfolosi
Mgababa	Umgubaba, Umgababa
uMngeni	Mngeni
Mgobozeleni	Mgobezeleni, Ngoboseleni; Ngobeseleni; Sodwana; Sordwana
Mhlabatashane (Mzimayi2)	Mhlabatshane
Mhlali	eMhlali, uMhlali
Mhlanga	Umhlanga, Ohlanga, Umslanga
Mhlangamkulu	
Mhlangeni	
Mhlatuzane	
Mhlatuze	Mhlathuze, Umhlatuze
Mhlungwa	Umhlungwa
Mkumbane	Inkombane, Umkombana
Mlalazi	Umlalazi
Mnamfu	Unamfu
Mpambanyoni	Mpanbanyoni, Mpambonyoni, Umpambinyoni, Umpambumyani

Estuary Name	Synonyms
Mpenjati	
Msimbazi	uMzimbasi, Umzimbezi
Mtentweni	Mtentwana, Ententweni
Mtwalume	Umtwalumi, Mtwalumi
Mvoti	Umvoti
Mvutshini	Little iBilanhlolo
Mvuzi	Uvuzi
Mzimayi	Umzimai
Mzimkulu	Mzimkhulu, Umzimkulu
Mzingazi	
Mzinto	Umzinto
Ngane	Ingane, iNgane
Nhlabane	Hlobane
Nkomba	
Nonoti	
Qhubu	
Reunion (Canal)	
Richards Bay	
Sandlundlu	Inhlanhlinhlu
Seteni	
Sezela	Isizela
Shazibe	
Sipingo	Isipingo
Siyaya	Siaya, Siyani, Siyaní, Siyai
St Lucia	
uThongathi	Tongaat; Tongaati; Thongathi; Umtongate; Tongati
Tongazi	Thongazi, Intongazi
Tugela	Thukela, Tukela
Umhlangankulu (South)	Mhlangankulu
uMkhomazi	Mkomazi, Umkomaas, Mkomanzi
Umlazi	Mlazi
Umtamvuna	Mtamvuna, Mthamvuna
Umzumbe	Umzumbe, Mzumba, Mzamba, Mzumbe
Unknown	aManzimnyama canal
Uvuzana	
Vungu	Uvongo
Zinkwazi	Zinkwasi, Sinquasi; Sinkwazi
Zotsha	Izotsha

13 APPENDIX D: ESTUARY PRESSURE TABLE

Estuary Name	Type	% Mouth Open	Depth	Estuary Priority	PRESSURE ASSESSMENT: Pressures on Hydrology	Nat MAR	% Change	Dams	Pressures on Hydrodynamics	Artificial Breaching	Channalised	Pressures on Water quality	Municipal Wastewater (point disc	WW volumes (Ml/d)	Estimated WQ of Stormwater infl	Estiamted WQ of River inflow (Ra	Pressures on Physical habitat	Bridges	Mining	Impacts from Mariculture	Channalised
Mtamvuna	Temporarily closed	95	3.0	1		275	87			?					1	3		●			
Zolwane	Temporarily closed	81	1.5	2		2	106			Y				0.00	2	2					
Sandlundlu	Temporarily closed	60	1.5	1		5	98			Y	Yes				3	2	●	●	Sand?		Yes
Ku-Boboyi	Temporarily closed	53	1.0	2		1	99								3	3		●			
Tongazi	Temporarily closed	91	2.0	2		7	105					●	WWTW	0.25	5	2		●			
Kandandhlovu	Temporarily closed	54	0.5	3		2	104					●			4	3	●	●			
Mpenjati	Temporarily closed	71	1.5	2		24	101			Y		●	WWTW	0.60	4	3	●	●	Sand (2)		
Umhlangankulu	Temporarily closed	33	1.5	1		3	100			Y		●			4	4	●	●			
Kaba	Temporarily closed	27	1.0	2		3	98					●	WWTW?		4	4	●	●			
Mbizana	Temporarily closed	54	1.0	1		36	98			?					4	3	●	●	Sand (1)		
Mvutshini	Temporarily closed	42	1.0	2		2	99			Y		●	Ramsgate WWTW	1.30	3	3		●			
Bilanhlolo	Temporarily closed	47	1.0	1		5	99			Y		●	Spills		3	3	●	●			
Uvuzana	Temporarily closed	32	1.0	1		1	100			Y		●	Pump station		5	5	●	●			
Kongweni	Temporarily closed	49	1.5	1	●	2	245		●	Y		●	Margate WWTW	4.97	5	4	●	●			
Vungu	Temporarily closed	96	15.0	3		28	104					●	Uvongo WWTW	2.74	6	3		●			
Mhlangeni	Temporarily closed	55	0.5	1		9	106			Y	San	●	WWTW	0.70	3	3	●	●			Sandbag
Zotsha	Temporarily closed	76	1.5	3		16	103		●	Y			WWTW?		3	4		●	Sand (2)		
Boboyi	Temporarily closed	94	1.0	2		8	98					●	WWTW	0.12	3	3	●	●			
Mbango	Temporarily closed	86	2.0	1	●	3	244		●			●	Pump station (Mbango	9.00	4	4	●	●			
Mzimkulu	Temporarily closed	97	2.5	2		1452	81			Y			WWTW Port Shepston		2	2		●	Sand (5)		
Mtentweni	Temporarily closed	40	1.5	1		12	92								4	3	●	●			
Mhlangamkulu	Temporarily closed	19	1.5	1	●	2	84		●						3	3	●	●			
Damba	Temporarily closed	28	1.0	2	●	5	84		●	Y					3	3	●	●			
Koshwana	Temporarily closed	26	1.0	2	●	2	99		●			●	WWTW?	0.25	3	3	●	●			
Intshambili	Temporarily closed	42	1.0	2	●	6	75		●			●			2	3	●	●			
Mzumbe	Temporarily closed	74	0.5	1		59	90					●			3	2	●	●	Sand (2)		
Mhlabatshane	Temporarily closed	50	2.0	2		6	100						WWTW	0.41	4	4	●	●			
Mhlungwa	Temporarily closed	29	1.0	1		6	98					●			3	4	●	●			

Estuary Name	PRESSURE ASSESSMENT (cont.): Pressures on Macrophytes	Vegetation harvesting/Over Grazing/Trampling	Pressures on Invertebrates	Bait collection	Pressures on Fish	Fishing Effort(Catches in tons)	Fish Kills (provide date if possible	Alien Fish	Pressures on Birds	Recreation Activities (linked to bird pressures)	USERS: Contact recreation (e.g. No, Yes, Blue Flag)	Mariculture (e.g. type)	INDICATOR COMPONENT & WQ DRIVING VARIABLES: Hydrology	Habitat	Biota	Dissolved oxyxgen	Turbidity	Nutrients	Toxic Substance	E coli/Enteroccoci
Mtamvuna				Yes		2.5				Jetskis, Boating			●							●
Zolwane				Yes		0.1							●							●
Sandlundlu	●		●	Yes	●	0.2			●				●	●	●					●
Ku-Boboyi				Yes		0.2							●							●
Tongazi	●		●	Yes	●	0.0			●				●		●	●	●	●	●	●
Kandandhlovu	●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Mpenjati	●	Nce ma (Jun	●	Yes	●	0.3							●	●	●	●	●	●	●	●
Umhlangankulu	●		●	Yes	●	0.3			●				●	●	●	●	●	●	●	●
Kaba	●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Mbizana	●		●	Yes	●	0.6				Kanoes			●	●	●					●
Mvutshini	●		●	Yes	●	0.2			●				●		●	●	●	●	●	●
Bilanhlolo	●		●	Yes	●	0.2			●	Swimming, angling and boating.			●	●	●	●	●	●	●	●
Uvuzana	●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Kongweni	●		●	Yes	●	0.2			●	paddle-boating			●	●	●	●	●	●	●	●
Vungu			●	No		0.0			●	Swimming, boating and fishing			●			●	●	●	●	●
Mhlangeni	●		●	Yes	●	0.2			●	boating			●	●	●	●	●	●	●	●
Zotsha	●			Yes		0.7							●							●
Boboyi	●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Mbango	●		●	Yes	●	0.1			●				●	●	●	●	●	●	●	●
Mzimkulu			●	Yes		4.0				Jetskis			●							●
Mtentweni	●		●	Yes	●	0.2			●	Boating			●	●	●					●
Mhlangamkulu	●		●	Yes	●	0.2			●				●	●	●					●
Damba	●		●	Yes	●	0.2			●				●	●	●					●
Koshwana	●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Intshambili	●			Yes	●	0.2				ski-boat launch site			●	●	●	●	●	●	●	●
Mzumbe	●	Nce ma	●	Yes	●	0.3			●				●	●	●	●	●	●	●	●
Mhlabatshane	●		●	Yes		0.2				canoeing			●	●						●
Mhlungwa	●	ngto	●	Yes	●	0.8			●				●	●	●	●	●	●	●	●

PRESSURE ASSESSMENT

Estuary Name	Type	% Mouth Open	Depth	Estuary Priority	Pressures on Hydrology	Nat MAR	% Change	Dams	Pressures on Hydrodynamics	Artificial Breaching	Channalised	Pressures on Water quality	Municipal Wastewater (point disc	WW volumes (Ml/d)	Estimated WQ of Stormwater infl	Estiamted WQ of River inflow (Ra	Pressures on Physical habitat	Bridges	Mining
Mfazazana	Temporarily closed	24	1.0	2		3	93		●			●			3	4	●	●	
Kwa-Makosi	Temporarily closed	37	1.0	2		3	94								3	4	●	●	
Mnamfu	Temporarily closed	42	1.0	1		3	94		●			●			4	4	●	●	
Mtwalume	Temporarily closed	71	0.5	1		58	73		●			●			3	2	●	●	Sand (2)
Mvuzi	Temporarily closed	23	1.5	2		2	94		●			●			2	3	●	●	
Fafa	Temporarily closed	45	1.0	1	●	46	81			Y		●			2	2	●	●	Sand (2)
Mdesingane	Temporarily closed	58	1.0	1		2	100					●			3	4	●	●	
Sezela	Temporarily closed	19	2.0	2		4	99			Y		●	WWTW	0.70	4	4	●	●	
Mkumbane	Temporarily closed	8	2.0	2		4	93	Mkumbane				●			3	3	●	●	
Mzinto	Temporarily closed	15	1.5	2	●	23	87			?		●			3	2	●	●	
Nkomba	Temporarily closed	10	0.5	2		1	100					●			2	2	●	●	
Mzimayi	Temporarily closed	20	0.5	1	●	6	74					●			3	4	●	●	
Mpambanyoni	Temporarily closed	78	0.5	1		60	92			?		●	Park Rynie WWTW	1.61	4	2	●	●	Sand (1)
Mahlongwa	Temporarily closed	22	1.0	1		14	96			Y		●	WWTW?		3	3	●	●	Sand (2)
Mahlongwane	Temporarily closed	13	2.0	1		3	109			?		●	WWTW	0.82	3	5	●	●	
Mkomazi	Temporarily closed	99	1.5	3	●	1078	86			Y		●	Umkomaas WWTW	1.00	3	1	●	●	Sand (6)
Ngane	Temporarily closed	54	1.0	2		4	112			?		●	??	0.82	3	3	●	●	
Umgababa	Temporarily closed	46	1.0	3	●	11	91	Umgababa		Y					3	2	●	●	
Msimbazi	Temporarily closed	36	0.5	1		10	103					●	WWTW (small)?		3	3	●	●	
Lovu	Temporarily closed	77	1.0	2	●	106	69	Beaulieu/Ri	●	Y		●			3	2	●	●	Sand (7)
Little Manzimtoti	Temporarily closed	72	1.0	1	●	3	233		●	, W(		●	Kingsborough WWTW	4.76	3	3		●	0
Manzimtoti	Temporarily closed	44	1.0	1	●	5	127		●	Y		●	Pump station?		3	3	●	●	Sand (1)
Mbokodweni	Temporarily closed	86	1.5	2	●	32	170		●	, W(	Mou		WWTW	33.62	6	5	●	●	Sand (8)
Sipingo	Permanently open	5	2.0	3	●	109	3		●		Culv	●		0.00	6	5	●		
Durban Bay	Estuarine bay	100	2.0	3	●	36	175				Mou	●	Pump station?	15.88	6	6	●		
Mgeni	Temporarily closed	95	1.5	3	●	671	31	Midmar, Alb		Y	Mou	●	WWTW, PUMP STATI(	#####	6	4	●	●	Sand (2)
Mhlanga	Temporarily closed	48	1.5	3	●	13	167		●	Y		●	Mhlanga WWTW	4.98	3	3	●	●	
Mdloti	Temporarily closed	40	1.3	3		100	85	Hazelmere	●	Y		●	Mdloti WWTW	7.53	3	5	●	●	Sand (3)
Tongati	Temporarily closed	84	1.5	3		71	112	Dudley Prin		Y		●	Tongaat WWTW	12.42	3	5	●	●	Sand (2)
Mhlali	Temporarily closed	48	1.0	3		56	95			Y		●	Ballitoville WWTW	0.79	3	3	●	●	Sand (4)
Bob's Stream	Temporarily closed	20	0.5	3		1	100					●			3	3	●		
Seteni	Temporarily closed	35	0.5	2		1	100					●			3	3	●		
Mvoti	River mouth	99	0.5	3		375	60			Y		●	Stanger WWTW	12.16	6	6	●		Sand (5)
Mdlotane	Temporarily closed	14	2.0	2		6	97					●			3	3			
Nonoti	Temporarily closed	18	1.5	1		36	96			Y		●	WWTW?	0.33	4	2	●		Sand (1)
Zinkwasi	Temporarily closed	28	0.5	2		14	97			Y		●			3	2	●		Sand (1)

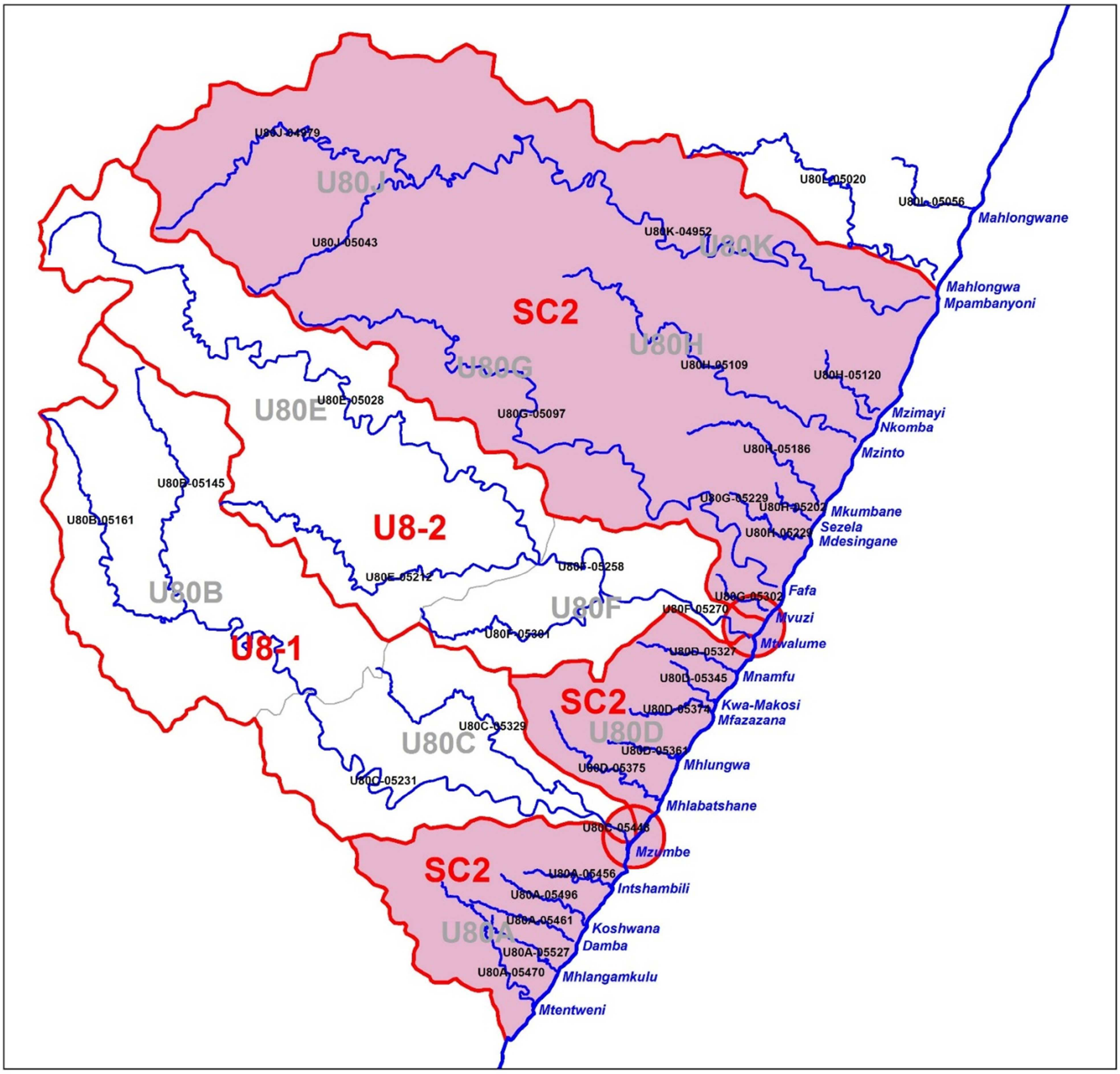
PRESSURE ASSESSMENT (continued) / USERS / INDICATOR COMPONENT & WQ DRIVING VARIABLES

Estuary Name	Impacts from Mariculture	Channalised	Pressures on Macrophytes	Vegetation harvesting/Over Grazing/Trampling	Pressures on Invertebrates	Bait collection	Pressures on Fish	Fishing Effort(Catches in tons)	Fish Kills (provide date if possible	Alien Fish	Pressures on Birds	Recreation Activities (linked to bird pressures)	Contact recreation (e.g. No, Yes, Blue Flag)	Mariculture (e.g. type)	Hydrology	Habitat	Biota	Dissolved oxyxgen	Turbidity	Nutrients	Toxic Substance	E coli/Enteroccoci
Mfazazana			●		●	Yes	●	0.5							●	●	●	●	●	●	●	●
Kwa-Makosi			●		●	Yes	●	0.4			●				●	●	●					●
Mnamfu			●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Mtwalume			●		●	Yes	●	0.2			●	ski-boat launching site			●	●	●	●	●	●	●	●
Mvuzi			●			Yes	●	0.2							●	●	●	●	●	●	●	●
Fafa			●	ncem a	●	Yes	●	0.8			●	Paddlecraft & canoes			●	●	●	●	●	●	●	●
Mdesingane			●		●	Yes	●	0.1			●				●	●	●	●	●	●	●	●
Sezela			●		●	No	●	0.0			●				●	●	●	●	●	●	●	●
Mkumbane			●		●	Yes	●	0.2			●	Skiboat launch			●	●	●	●	●	●	●	●
Mzinto			●		●	Yes	●	0.6			●				●	●	●	●	●	●	●	●
Nkomba			●			No		0.0			●				●	●		●	●	●	●	●
Mzimayi			●		●	Yes	●	0.2			●				●	●	●	●	●	●	●	●
Mpambanyoni			●		●	Yes	●	0.1			●	Scottburgh ski-boat, canoe, paddelcraft			●	●	●	●	●	●	●	●
Mahlongwa			●		●	Yes	●	7.6			●	Canoe			●	●	●	●	●	●	●	●
Mahlongwane			●			No	●	0.4			●	Canoe			●	●	●	●	●	●	●	●
Mkomazi			●	gro	●	Yes	●	7.0			●	Jetskis			●	●	●	●	●	●	●	●
Ngane			●		●	Yes	●	1.9			●				●	●	●	●	●	●	●	●
Umgababa			●		●	0	●	0.0							●	●	●	●	●	●	●	●
Msimbazi			●			0	●	0.0							●	●	●	●	●	●	●	●
Lovu			●		●	0	●	0.0			●				●	●	●	●	●	●	●	●
Little Manzimtoti			●		●	0	●	0.0	●		●				●		●	●	●	●	●	●
Manzimtoti			●		●	0	●	0.0			●				●	●	●	●	●	●	●	●
Mbokodweni		Mouth Stabilised	●		●	0	●	0.0	●		●				●	●	●	●	●	●	●	●
Sipingo		Culverts	●		●	0	●	0.0			●				●	●	●	●	●	●	●	●
Durban Bay		Mouth Stabilised	●		●	Yes	●	53.0			●				●	●	●	●	●	●	●	●
Mgeni		Mouth Stabilised	●		●	Yes	●	3.7			●				●	●	●	●	●	●	●	●
Mhlanga			●		●	Yes	●	0.1	●		●				●	●	●	●	●	●	●	●
Mdloti			●		●	Yes	●	1.0	●		●				●	●	●	●	●	●	●	●
Tongati			●		●	Yes	●	0.6			●				●	●	●	●	●	●	●	●
Mhlali			●		●	Yes	●	0.6			●				●	●	●	●	●	●	●	●
Bob's Stream			●			Yes		0.0			●				●	●		●	●	●	●	●
Seteni			●			Yes		0.1			●				●	●		●	●	●	●	●
Mvoti			●		●	Yes	●	1.0			●				●	●	●	●	●	●	●	●
Mdlotane						Yes		0.2							●			●	●	●	●	●
Nonoti			●		●	Yes	●	0.6			●				●	●	●	●	●	●	●	●
Zinkwasi			●		●	Yes		3.0			●				●	●		●	●	●	●	●

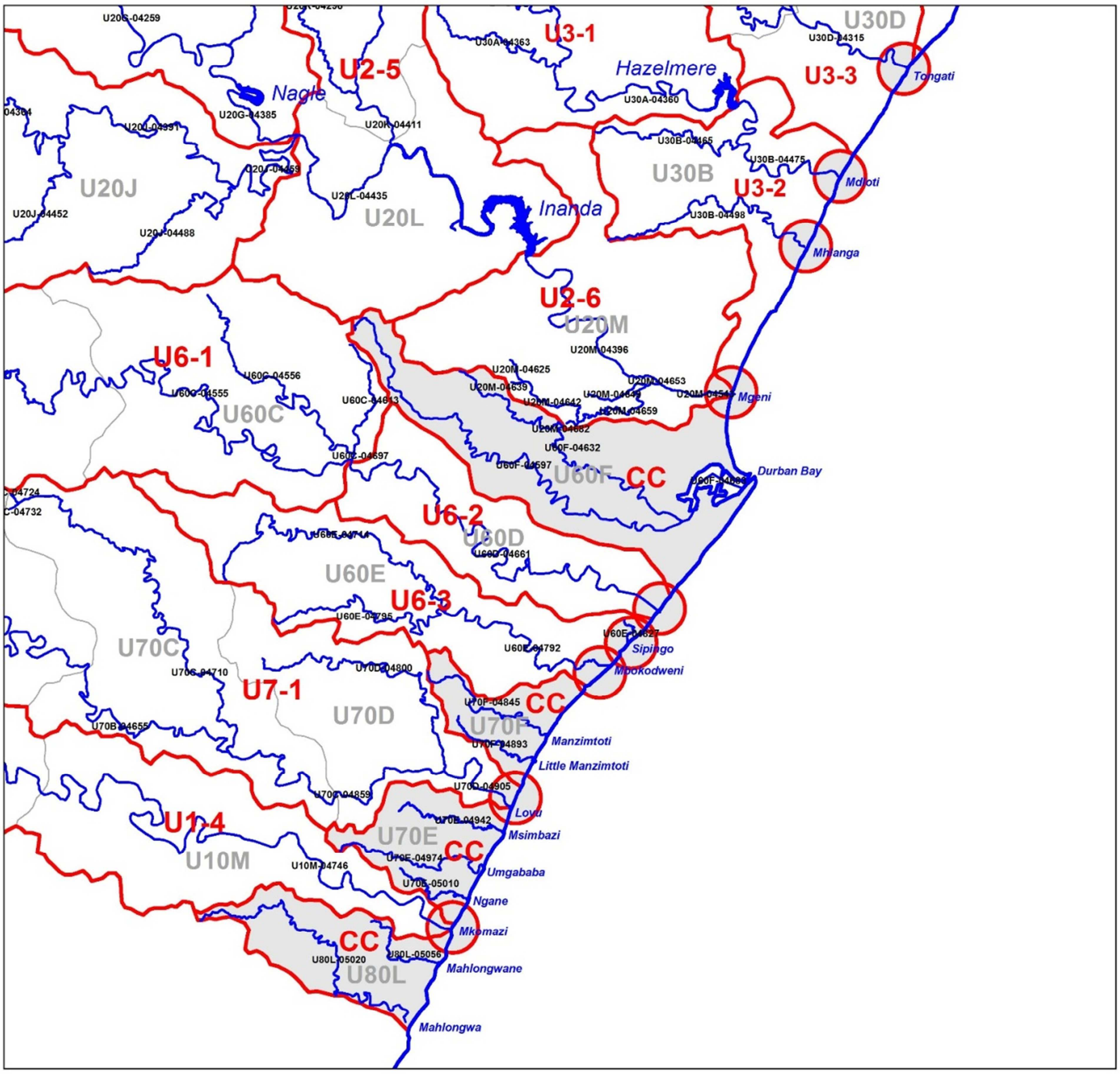
14 APPENDIX E: ESTUARY IUAS

14.1 SOUTHERN CLUSTER 1 IUA

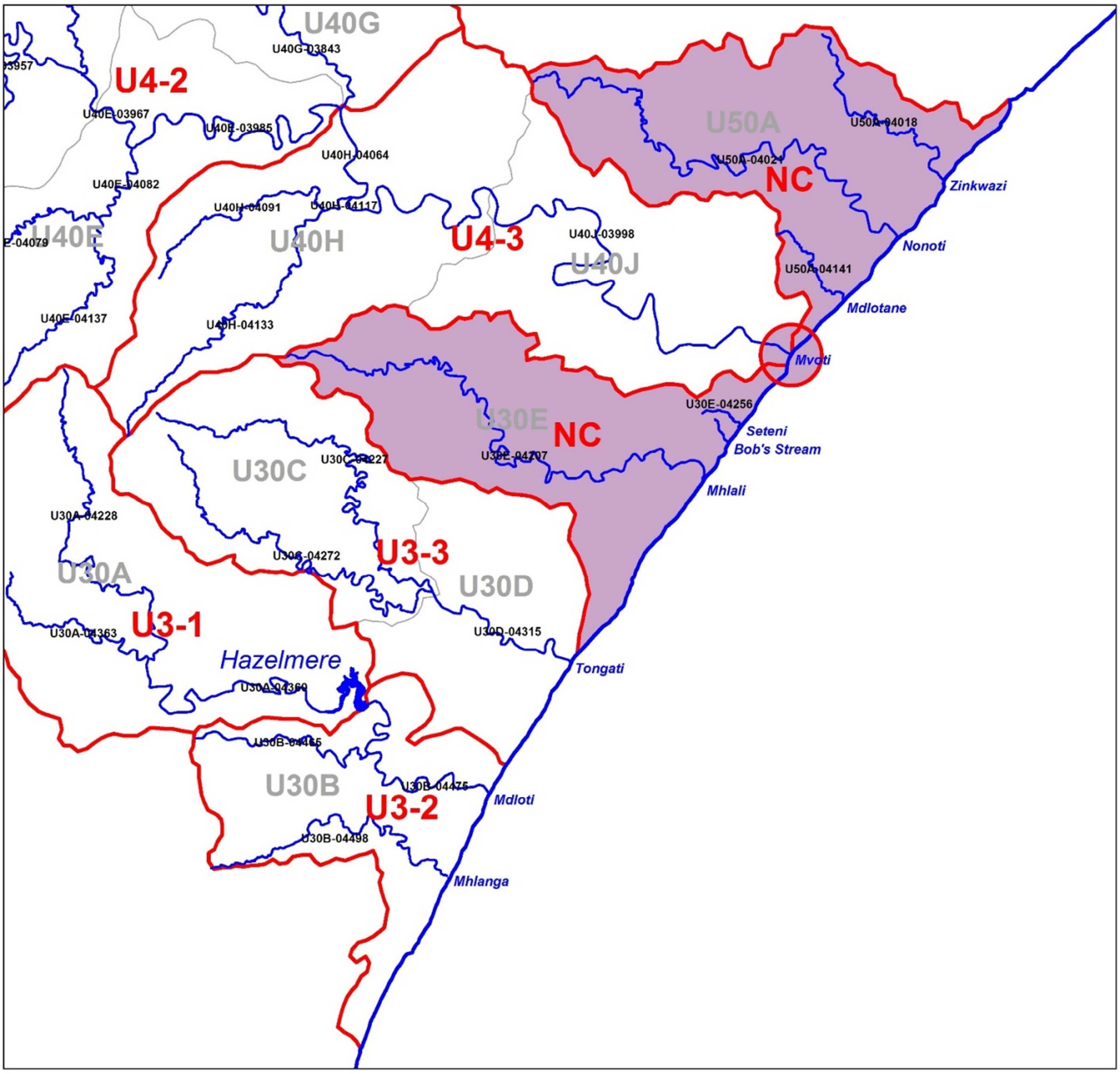
14.2 SOUTHERN CLUSTER 2 IUA



14.3 CENTRAL CLUSTER IUA



14.4 NORTHERN CLUSTER IUA



15 APPENDIX F: REPORT COMMENTS

Page / Section	Report statement	Comments	Changes made?	Author comment
Mmaphefo Thwala (DWS)				
9	Although unstudied in South Africa, ecosystem impacts are highly likely to occur because of the proliferation of this alien species.	Specify ecosystem impact of invasive invertebrates.	Yes	Although unstudied in South Africa, ecosystem impacts (such as loss of indigenous species, introduction of liver flukes, loss of food for higher trophic levels), are highly likely to occur because of the proliferation of this alien species.
9	TOCEs	What is this?	Yes	Temporarily open /closed estuaries.
10	Discusses scenarios	Add a table with the full suite of the scenarios in the annexure to remind what these were and to allow for reading this report in isolation.	Yes	Added Appendix A.
11		Briefly indicate what each level entails.	Yes	Added a table summarizing the levels of treatment.
11		What about the other estuaries in the central cluster?	No	This report only deals with the estuary responses to future pressures. Only report on the consequences of operational scenarios
12	The following overall responses were noted:	Indicate that operational scenarios only affected the below estuaries in this cluster.	Yes	The following overall responses were noted for systems were waste water may be discharges in the future.
13		Indicate which ones fall under which cluster and the critical areas.	Yes	Replaced figure
15	The following overall responses were noted:	Indicate that operational scenarios only affected the below estuaries in this cluster.	Yes	The following overall responses were noted for systems were waste water may be discharges in the future.
27		Refer or list 25 stems with waste water in them.	Yes	Added: (see Appendix D).
63	Confidence: Rapid/Intermediate level	7.2 below has categorized according to the level of assessment, rapid/intermediate regardless of the cluster.	Yes	Confidence: Central Cluster.
71		Remove all blank pages.	Yes	Done.
eThekwini Municipality				
		Although DWS were always reluctant to give this study the due recognition that eThekwini would have wanted, there does need to be an acknowledgment as and where in these reports the eThekwini data / information is now used.	Yes	

Page / Section	Report statement	Comments	Changes made?	Author comment
	Fish communities have responded to changes in river inflow in some systems, being sensitive to changes in mouth conditions. Most, if not all of the systems in the study area have experienced loss of estuarine habitat and loss of natural buffer on their perimeters and the inflowing rivers. Critical habitat has been lost in some cases, which has resulted in marked reductions in fish diversity and as well as fish nursery function. The loss of submerged aquatic vegetation, especially *Zostera capensis* (from systems such as Sandlundlu, Umgababa, Sipingo, Durban Bay, and probably others) has undoubtedly played a significant role. As with estuarine invertebrates, deterioration in water quality (specifically nutrient enrichment resulting in eutrophication and subsequent reduction in dissolved oxygen concentrations) is increasing becoming a threat to fish health in these systems, especially those adjacent to densely populated urban areas. In recent years fish kills have occurred in 18 estuaries in the WMA (Ugu = 5, eThekwini = 9, iLembe = 4) (Table 2.1). These have been attributed to eutrophication and/or associated low oxygen events. In many cases these events were triggered by malfunctioning WWTWs (due to infrastructure failure and/or overloading). The high number of fish kills recorded in the Mvoti to Umzimkulu WMA represents about 40% of all recorded fish kills in South Africa, indicating that this coastline is at a tipping point. In some cases trophic impacts are likely to have manifest with favoured prey items (e.g. sandprawn *Callichirus kraussi*) either lost or reduced in some systems due to habitat loss, modification, or water quality impacts	Fish Kills The record of fish kills is used to show that nutrient and organic loading are already threatening a system which is deemed to be at a “tipping point”. Certainly in eThekwini the majority of fish kills are associated with identified failures in the sewage reticulation system (pump station failures, pipe blockages etc.) and not the WWTWs themselves and this, and any conclusion reached on the basis of this statement needs to be corrected.	Yes	Estuary health is evaluated based on average conditions, not once off events. Water Quality was evaluated on available measured river water quality above the estuary and eThekwini measured data collected as part of this study or supplied by the city. Fish condition was derived from measured data. An initial evaluation of the fish conditions were conducted by eThekwini, which were moderated in the more recent study – with similar results indicating that both fish specialists consider the systems in poor conditions as a result of chronic water quality stress. Fish kills were observed in a number of systems along the eThekwini coast, some with and others without waste water into them. Some of the fish kills were linked to infrastructure failure during the Technical Working Group sessions (e.g. Mhlanga), while others were noted as cause unknown. In all cases the fish kills were contributed to poor water quality.
	The estuary is small with very little assimilative capacity	Report 7 B Table 3.5, gives an estuary area of 28.5 ha, although in item 6.1.2 the estuary is more correctly described as ‘small’. The area of this estuary - plus the others in the table – all need to be checked , together with the resulting ranking / rating/ weighting used in the ‘balance’ being corrected accordingly.	Yes	This was change in the Consequences report to: The estuary’s open water area is small with very little assimilative capacity.
		It further needs to be noted that predicted ECs (based on individual scoring of scenarios) were included in the scenario assessment carried out under the eThekwini contract which considered the impact of the ‘illegal / unauthorised” causeway.	Yes	Added a reference. To Estuary Consequence report.
		In item 6.2.2 vol.7 B, when considering the central cluster, the comment is made that	No	The scenarios that tested the impact of removing waste water from the individual estuaries had the

Page / Section	Report statement	Comments	Changes made?	Author comment
		scenario E and F (which are both ways in which all – or the required amount – of wastewater can be removed from the estuaries) will maintain the PES. However, the detailed ecological scenario analysis clearly shows that all the estuaries which receive wastewater will benefit (and improve the PES) if that wastewater were to be wholly or partially removed under future scenarios.		following results: • Little Manzimtoti = Improve from E to D • Mbokodweni Estuary = Improve from E to D • Mdloti Estuary = Decline from D to D/E as result of poor catchment quality and closed mouth conditions • uThongathi Estuary = Improve from D to C/D. However, in the aggregation of the overall scenario weighting this benefit is smoothed out in Scenario E and F as the systems