CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Diep River Estuarine Management Plan

2022

DEPARTMENT: Environmental Management, Coastal Management Branch

VERSION: FINAL

DATE: OCTOBER 2022

DOCUMENT DETAILS

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Contact

Coastal Management Branch | Environmental Management Directorate | City of Cape Town
Gregg Oelofse (Manager: Coastal Management)
Gregg.Oelofse@capetown.gov.za

Darryl Colenbrander (Head: Coastal Policy Development and Management Programmes)
Darryl.Colenbrander@capetown.gov.za

Curtis Grootboom
Curtis.Grootboom@capetown.gov.za

Elena Piller
Elena.Piller@capetown.gov.za

Infinity Environmental (Pty) Ltd
Jeremy Rose (E.A.P.)
jeremy@infinityenv.co.za

Kakale Munamati
kakale@infinityenv.co.za

Versions

Title: Diep River Estuarine Management Plan, 2021
Version 1: Peak Practice (2008)
Version 2: Coastal and Environmental Consulting (2011)
Version 3: City of Cape Town (2016)
This version: City of Cape Town and Infinity Environmental (October 2022)

2021 Review of the Diep River Estuarine Management Plan

The Diep River Estuarine Management Plan was prepared in 2008 by Peak Practice and reviewed in 2011 by Coastal and Environmental Consulting and again in 2016 by the City of Cape Town with support from RHDHV and the provincial Department of Environmental Affairs and Development Planning (DEA&DP). This review was prepared by the City of Cape Town's Coastal Management Branch with support from Infinity Environmental and based on inputs and guidance received from a number of external experts and specialists in estuarine and freshwater management. In this regard the City would like to acknowledge and thank the following:

Dr Lara van Niekerk	CSIR	Dr Gerhard Cilliers	DFFE
Dr Susan Taljaard	CSIR	Dr Stephen Lamberth	DFFE
Dr Brent Newman	CSIR	Candice Bouland	Independent consultant
Prof Janine Adams	NMU	Dr Barry Clark	Anchor Environmental
Dr Daniel Lemley	NMU	Prof Neil Armitage	UCT
Dr Liz Day	Liz Day Consulting		

The work of the authors of the 2008, 2011 and 2016 versions of the Estuarine Management Plan has been drawn on and their contribution, as well as those of individuals and organisations who participated in the various stakeholder reviews, are acknowledged. The 2018 RDM Assessment (Clark et al., 2018) was an invaluable source of data and analysis. This amendment includes an assessment undertaken between September and October 2021 to consider the continued applicability of the 2016 plan, incorporate significant new information deriving from monitoring and studies undertaken in the intervening period, and make recommendations for implementation based on a workshop with external experts. It is also an opportunity to align the EMP with the National Estuarine Management Protocol, June 2021.

EXECUTIVE SUMMARY

Introduction

The Diep River estuary in Milnerton, Cape Town, is the point at which the Diep River meets the sea. The river originates in the Riebeek Kasteel Mountains north-east of Malmesbury, and flows for about 65 km south-west towards Cape Town, before entering the sea some 5 km north of the Port of Cape Town. As it flows towards the sea, the Diep River flows through the Rietvlei wetland and Milnerton Lagoon which form part of the Diep River Estuary covering an area approximately 900 hectares in extent.

The Diep River estuary is a highly modified estuarine system occurring entirely within South Africa's oldest and most populous city. In this context the persistence of estuarine processes and habitat and the management of the estuary for biodiversity, recreation and functionality, are beset by several challenges. It is surrounded by the urban areas of Table View, Montague Gardens and Milnerton, receives treated effluent from the Potsdam Wastewater Treatment Works, and drains a river catchment of which more than half is under agriculture and a significant proportion of which falls outside the City's area of jurisdiction.

The City of Cape Town is the Responsible Management Authority for the Diep River Estuary in terms of the National Estuarine Management Protocol, 2021, and must develop an Estuarine Management Plan (EMP) that assesses the current state of the estuary and determines the management and monitoring actions required.

Figure 1. Location of the Diep River estuary within the City of Cape Town municipal area

Situation Assessment

The Diep Estuary is a permanently open estuary located in the cool temperate region of the Western Cape, entirely within the City of Cape Town and has a catchment area of 1 495 km^2 which spans four municipalities. The geographical boundaries of the estuary are defined as follows:

Downstream boundary:	Estuary mouth 33°53'23.65"S; 18°28'55.72"E
Upstream boundary:	33°48'08.83"S; 18°32'03.95"E (below Malibongwe Drive)
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank, or 1:100 year flood line, whichever is greater

The Diep River enters the estuary below Malibongwe Boulevard, with its floodplain constricting southward to its narrowest point at the Blaauwberg Road bridge. From here it widens again, the main channel skirting the eastern edge of the floodplain and a large area of salt marsh and wetland to the west making up the triangular-shaped Rietvlei. The 'triangle' measures 2 km across from east to west and 1.5 km from north to south. Two interconnected deep-water lakes (known as Flamingo Vlei) are evident at the north-western side of Rietvlei. The channelised eastern edge of the estuary receives flows from the Potsdam Wastewater Treatment Works before entering the Milnerton Lagoon downstream of the Otto du Plessis Drive bridge.

Hydrology of the Diep River Estuary is determined by the river inflows entering the catchment upstream and by the treated effluent entering the system from the Potsdam Wastewater Treatment Works. Hydrology of the Diep River itself is driven by seasonal changes with significantly reduced flows in summer and relatively increased flows in winter. The effluent discharge is more constant and supplies the majority of flows during the drier summer months. A climate change induced drier and warmer climate is likely to cause a reduction in flows in the catchment over time.

Historically the mouth closed periodically during the summer months of low-rainfall years. More recently, the discharge of treated wastewater effluent into the system has maintained flows at levels, which have resulted in an almost-permanently open mouth. The likelihood of mouth closure is elevated during drought conditions and is a concern under climate change predictions for Cape Town. Under current water quality conditions, a permanently open mouth state is preferred to avoid accumulation of nutrients and pathogens in the estuary. Regular bathymetric transects of the estuary indicate siltation of the lower reaches of the estuary channel since 1993. Particle size analysis of sediments in the Diep River estuary in 2021 indicated that sand was the main component of sediments in the system, with the proportion of mud increasing with distance upstream from the mouth.

Water quality in the Diep River Estuary is highly modified compared with its historic state. Water quality throughout the system has declined over time, with total dissolved salts, nutrients and suspended solids increasing consistently. The water quality of the estuary is impacted on by a variety of factors and potential pollutants including agricultural runoff, effluent from the Potsdam wastewater treatment works, illegal disposal of substances into the stormwater system from formal and informal residential areas, stormwater runoff from industrial facilities, powerboats and litter from recreational users. In 2020, the City experienced 122 000 sewer spills, 75% of which were caused by foreign items being placed into the sewage system (see the City's Know Your Coast Report, 2020 for more information on the various pollution sources that impact Cape Town's rivers and coasts).

E. coli levels – indicative of the level of pollution by faecal matter and of the risk posed to users – in the Diep River Estuary are very high and increasing. This is from multiple pollution sources, including treated effluent entering the Diep River, sewer spill, failures and overflows, general urban run-off via stormwater discharges as well as significant growth in informal and underserviced areas in the catchment and floodplain of the river.

Dissolved oxygen in the Diep River Estuary is relatively low across the entire spatial profile of the estuary. Incidents of supersaturation occur in Flamingo Vlei and Milnerton Lagoon, both indications of increased photosynthesis emanating from algal blooms.

Nitrate and phosphate levels in the estuary are high, with marked increases directly below the Potsdam WWTW outflow. In 2020 to 2021, nitrate and phosphate levels across the estuarine system exceeded the Resource Quality Objectives for the Diep Estuary except in the Flamingo Vlei.

There has been a clear shift in the fish community of the Diep estuary, from a largely estuarine and marine fauna documented in the historical data, to one dominated by harders, two estuary residents and a largely alien freshwater fish community. Harders are able to survive in both freshwater and marine environments, explaining their presence in the system.

The invertebrate community has also shifted from an estuarine system to a now predominantly freshwater system with very limited sea water input. As such, the invertebrate community has suffered significant decreases in species richness/diversity, abundance and biomass.

Current habitats in the estuary include open water, reeds and sedges, salt marsh, coastal vegetation, disturbed reeds and grasses, disturbed wetland vegetation, and grassed recreational areas. Development has removed natural salt marsh habitat, with small pockets still evident near Woodbridge Island and Milnerton Golf course. Approximately 33% of the estuarine functional zone is in effect developed land i.e. Woodbridge Island. The channel has also been stabilised by roads and embankments reducing the natural ability of the estuary to meander.

The estuary is an important habitat for waterbirds and its proximity to the coastline allows for both freshwater and coastal species to utilise the system. It is designated an Important Bird and Biodiversity Area by Birdlife South Africa.

The 2018 National Biodiversity Assessment (van Niekerk et al, 2019) assesses the Present Ecological State (PES) as D and proposes a Recommended Ecological Category (REC) of D (Largely modified). It is likely that the system's ecological state has declined further since the 2018 assessment.

Vision and Objectives

***Vision*: The Diep River, Rietvlei and Milnerton Lagoon are important societal and ecological assets that support biodiversity and provide a wide range of ecosystem services to a growing metropolis. The Diep River Estuary should be managed and protected for sustainable use by current and future generations.**

***Overall Objective*: To manage the Diep River Estuary- an ecosystem of significance for biological diversity - in a manner that ensures its sustainability and is compatible with pragmatic conservation goals set within the context of a heavily altered and rapidly changing urban ecosystem.**

The following key objectives inform the overall objective:

- Compliance with the resource quality objectives defined for the estuary, by mitigating the point and non-point source pollution inflows from the urban catchment.
- Retention of estuarine function and protection of biodiversity within the Rietvlei and adjacent terrestrial and wetland areas while working to re-establish biodiversity and sense of place in the Milnerton Lagoon.
- Sustainability of ecosystem services including recreation, management of stormwater flows, and management of treated wastewater from a rapidly growing urban area.
- Improvement of communication and education regarding the current and achievable future state of the estuary.

Spatial Zonation

For the purposes of this EMP, the estuary is divided into six distinct zones, based on water quality and hydrology, habitat, and management priorities (See Figure 23. Estuarine Zonation Plan). The zones are as follows:

1. **Upper channel**: This zone extends from the upper extent of the Estuarine Functional Zone (EFZ) to Blaauwberg Road Bridge above the discharge point for the Potsdam WWTW.
2. **Middle channel**: The zone extends from the Blaauwberg Road Bridge to the Otto du Plessis Road Bridge including the discharge point for the Potsdam WWTW.
3. **Rietvlei zone**: The zone is located west of the middle channel and comprises a mosaic of open water and seasonal wetland habitats including salt marsh.

4. **Flamingo Vlei zone**: This zone includes the deep North and South interconnected artificial lakes north-west of the Rietvlei zone. The Bayside canal discharges in the north-western corner of Flamingo Vlei. The Dolphin Beach detention ponds also drain into this zone.
5. **Milnerton Lagoon**: This zone consists of the lower part of the estuary between the Otto du Plessis Road Bride and the mouth of Lagoon Beach. The Zoarvlei wetland is connected to the estuary in this zone via a box culvert under Marine Drive.
6. **Developed zone**: This zone consists of the transformed and developed section which comprises 33% of the EFZ. The zone consists of residential, infrastructure, industrial, WWTW, grassed public spaces and a golf course.

It is proposed that these zones be further defined and their present ecological status and target ecological category be better defined in order to guide estuarine management actions that occur within the estuary (i.e. as opposed to those which are catchment-scale, such as stormwater management) acknowledging that broader catchment issues require urgent attention.

Management Priorities and Actions

The Diep River estuary is impacted and influenced by significant pressures from outside of the estuarine functional zone. The following table presents management priorities and actions for the Diep River Estuary.

Table 1: Priority management objectives and associated action items and timeframes

Management objective	Action *High priority actions are indicated **in blue**.*	Timeframe 1-2 years	2-5 years	5+ years
CONSERVATION OBJECTIVES (C1 to C11)	1. Define and maintain zonation, access management, and enforcement within the Table Bay Nature Reserve commensurate with necessary and appropriate signage and fencing where required.	Ongoing		
	2. **Reinforce the separation of nutrient-rich Potsdam discharge from the salt marshes fringing the Rietvlei system.** See also 28.		✓	
	3. Restore and rehabilitate sand fynbos and locally indigenous vegetation types in areas of the reserve requiring rehabilitation and which align with the approved IRMP for the TBNR. Restoration plans to be first approved by the Biodiversity Management Branch.	Ongoing		
	4. Prepare and implement an invasive species monitoring, control and eradication plan for invasive alien plant and animal species	Ongoing		
	5. Monitor the overall Present Ecological State; invertebrate diversity and distribution; fish; bird; and phytoplankton in accordance with the Monitoring Plan (section 8).	Ongoing		
	6. Implement law enforcement patrols to reduce illegal fishing and/or any other illegal activity.	Ongoing		
WATER QUANTITY OBJECTIVES (H1 to H5)	7. **Determine the minimum required daily flow from the Potsdam WWTW to achieve the required similarity with a natural flow regime, manage water quality, and manage the mouth state.**	✓		
	8. Ensure that any commitments in respect of the supply of treated effluent from the WWTW are consistent with the requirement to maintain discharge volumes meeting special limits.	✓		
	9. Provide a report indicating how the Potsdam upgrades will result in the resource quality objectives for the estuary being met.	✓		
	10. Remove and dispose of water hyacinth present in the estuary and Diep River. Limit, as practically as possible, biomass washing downstream into the estuary after clearing.	Ongoing		
	11. Develop a Mouth Management Plan and accompanying Maintenance Management Plan for the manipulation of the estuary mouth in	✓		

Management objective	Action *High priority actions are indicated* ***in blue***.	Timeframe		
		1-2 years	2-5 years	5+ years
	situations where upstream flooding or other circumstances require it.			
	12. **Assess the possible cost and benefit of dredging the lower lagoon to facilitate the release of sediments and nutrient loads and emulate natural scour. Implement dredging if a significant benefit is anticipated.**		✓	
	13. Investigate the feasibility of dredging the Rietvlei section of the Diep River Estuary.	✓		
	14. Establish a hydrological monitoring programme which considers the impacts/influence of abstraction.		✓	
WATER QUALITY OBJECTIVES (WQ1 to WQ6)	15. **Implement upgrades to the Potsdam WWTW to improve the quality of treated effluent.**		✓	
	16. Re-evaluate the RQOs and present ecological status of the estuary per estuarine zone and determine 'tipping points' for PES in the various parameters. Propose amendments to the RQOs and recommended ecological category per zone to the responsible authority based on the findings thereof.		✓	
	17. Montague Gardens bulk sewer upgrade to reduce sewage spill events due to capacity constraints and aged infrastructure – reduce current spills into the Theo Marais Canal.			✓
	18. Cleaning, according to a defined cleaning regime, of maturation and ancillary ponds.	✓		
	19. Dredging of sludge at WWTW discharge point for offsite disposal.	✓		
	20. Seal off historical outlets and maturation ponds from the Diep River.			✓
	21. Conduct investigations and enforcement of illicit industrial discharges into the stormwater system in Montague Gardens and apply at a catchment-wide scale	Ongoing		
	22. Conduct investigations and enforcement of residential and commercial compliance with the stormwater by-law and apply at a catchment-wide scale.	Ongoing		
	23. **Plan, Design & Construct stormwater to sewer diversion/s at Du Noon and Doornbach**		✓	
	24. **Implement the recommendations of the Erika Road Stormwater study.**			✓
	25. **Construct the planned treatment wetland at the Bayside Canal outfall.**		✓	
	26. **Develop a sewer pump station protocol to manage surcharge and failure events at each**			

Management objective	Action *High priority actions are indicated **in blue**.*	Timeframe 1-2 years	2-5 years	5+ years
	pump station impacting on the estuary, based on the Valyland (Fish Hoek) Pump Station Response Protocol.	✓	✓	
	27. **Complete upgrades to the Koeberg Pump Station and ensure standby generators and mobile pumps are installed at the Koeberg Pump Station. Ensure all pump stations within the Diep River catchment function optimally and that each has a backup generator.**		✓	
	28. **Investigate the potential to construct a low-flow vegetated channel east of the existing channel in the estuary, to mitigate the quality of discharge from the WWTW, with the current channel remaining in place as a high-flow bypass.**		✓	
	29. Make data publicly available with comparisons to relevant guidelines or standards as applicable, updated at least once per week.	Ongoing		
	30. Communicate clearly and effectively on current water quality and challenges.	Ongoing		
	31. Investigate the feasibility and value of pumping seawater into the system to improve habitat for estuarine species.		✓	
	32. Investigate commissioning of the old wastewater treatment works 'long pond' to act as an additional filter to improve the quality of effluent.		✓	
	33. **Test and pilot innovative ideas that may lead to improved water quality in the Diep River.**	Ongoing		
LAND USE, INFRASTRUCTURE AND DEVELOPMENT OBJECTIVES (LU1 to LU6)	34. Ensure the District Spatial Development Framework specifies mechanisms to limit the impacts of development and land use applications that fall within the catchment of the Diep River Estuary.	✓		
	35. Ensure the District Plan incorporates the Coastal Management Line determined for the estuary area.	✓		
	36. Increase the rate of upgrading of informal settlements and strictly manage land invasions within the EFZ and floodplain.	Ongoing		
	37. Utilise the land use planning and development management system to restrict new developments in the EFZ.	Ongoing		
	38. Incorporate Management of Urban Stormwater Impacts Policy into land use and development proposals.	Ongoing		
	39. Conduct a survey of legacy infrastructure within the estuary to establish potential impacts on hydrodynamics and sediment movement. Assess, obtain authorisation for, and remove any	✓		

Management objective	Action *High priority actions are indicated* ***in blue***.	Timeframe		
		1-2 years	**2-5 years**	**5+ years**
	unneeded infrastructure having a negative effect on the estuary (including any remaining parts of the 1928 weir near the mouth of the lagoon).			
SOCIAL OBJECTIVES (SO1)	40. Maintain and ensure the public's right of access and enjoyment of publicly accessible areas within the estuary in accordance with the TBNR management plan.	Ongoing		
	41. **Improve communication on current water quality, risks, and challenges.**	✓		
	42. Collate and provide information to recreational users on reducing risk when recreational water quality guidelines cannot be met within the estuary.	Ongoing		
CLIMATE CHANGE OBJECTIVES (CC1 to CC2)	43. Enforce the coastal urban edge / coastal management line and ensure relevant environmental authorisatoins are obtained for new development, infrastructure, or densification that may be exposed to risk from coastal hazards.	Ongoing		
	44. Determine the effect of sea level rise, a drier climate, and other impacts of climate change on the EFZ and 1:100 year floodline and where applicable include necessary interventions into City planning and management strategies.		✓	
EDUCATION AND AWARENESS OBJECTIVES (EA1 to EA2)	45. Develop material that explains in simple terms the pressures on the Diep River estuary system, places it in its urban context and demonstrates the links between activities in the catchment and the state of the estuary.	✓		
	46. Involve stakeholders and interested members of the public in the review of the EMP to build awareness, engagement, and participation.	✓		
	47. Formalise the estuary advisory forum as a working group of the Protected Area Advisory Committee and allow for estuarine experts or stakeholders to join this group.	Ongoing		

Implementation

The updated situation assessment shows that the Resource Quality Objectives for the Diep River Estuary defined in November 2020 are not being met. This ongoing decline in water quality and associated decline in the ecological state of the estuary can be attributed to a range of contributing factors both within and outside of the EFZ and include aspects such as:

- Poor effluent quality from Potsdam WWTW.
- A high number of failures in the sewerage system resulting in spills and discharges into the different zones of the estuary. Failures are typically caused by:
  - Aging infrastructure
  - Power outages
  - Blockages caused by foreign objects
  - Illegal stormwater to sewer connections.
- Ongoing uncontrolled inflows of untreated wastewater/pollution from multiple sources via the stormwater system, specifically the Bayside, Theo Marais and Erica Rd canals.
- Urban development and densification in the catchment, leading to increased runoff and decreased stormwater quality as well as increased pressure on wastewater infrastructure and capacity deficits in key sewerage infrastructure.
- An increase in informality in the estuary and surrounds resulting in discharge of untreated sewage and solid waste to the estuary.
- A constrained estuary mouth and reduced freshwater inflows from the upper catchment, reducing the ability of the system to flush out accumulated sediment, nutrients, and pollutants and leading to a build-up of these aspects in the estuary.

A number of capital-intensive projects intended to address the current challenges are currently in the planning phase (see **Annexure C**: Water Quality Improvement Program Transversal Action Plan). These include an upgrade of the Potsdam WWTW to improve the quality of the effluent, upgrades to bulk sewerage infrastructure, and construction of treatment wetlands. These projects have long planning and construction timeframes and are planned for completion by 2025. Though critical to the improvement of the state of the estuary, they are therefore unlikely to contribute to any improvement of the current situation within the next five years. The rapid densification and expansion of informal settlement in the catchment and in the EFZ is realistically unlikely to be addressed in this timeframe.

It is very unlikely that those parts of the Diep River estuary which are most impacted by the discharge of effluent from the Potsdam WWTW will meet the defined resource quality objectives within the 5-year period covered by this EMP. It is therefore proposed that the Rietvlei and Flamingo Vlei section of Rietvlei, which are not as strongly affected by the poor quality of effluent from Potsdam, be prioritised for short-term compliance with the resource quality objectives and other standards consistent with conservation and recreational uses, respectively. The Middle Channel zones and the Milnerton Lagoon / Zoarvlei zone are expected to attain significantly improved water quality only in the longer term (5+ years) when the planned capital-intensive upgrades to wastewater infrastructure have been fully implemented.

Priority Actions

It is recommended that the following aspects of the EMP be initiated as a matter of priority within the first year for completion within the timeframes as allocated in Table 1. All other aspects listed in the management action plans should start as soon as practicably possible as their outcomes are likely to be longer-term.

- **Action 2:** Reinforce the separation of nutrient-rich Potsdam WWTW discharge from the salt marshes fringing the Rietvlei system.
- **Action 7**: Determine the minimum required daily flow from the Potsdam WWTW to achieve the required similarity with a natural flow regime, manage water quality, and manage the mouth state.
- **Action 12:** Assess the possible cost and benefit of dredging the lower lagoon to facilitate the release of sediments and nutrient loads and emulate natural scour. Implement dredging if a significant benefit is anticipated.
- **Action 15:** Implement upgrades to the Potsdam WWTW to improve the quality of treated effluent.
- **Action 23:** Plan, Design & Construct stormwater to sewer diversion/s at Du Noon and Doornbach.
- **Action 24:** Implement the recommendations of the Erika Road Stormwater study.
- **Action 25:** Construct the planned treatment wetland at the Bayside Canal outfall.
- **Action 26:** Develop a sewer pump station protocol to manage surcharge and failure events at each pump station impacting on the estuary, based on the Valyland (Fish Hoek) Pump Station Response Protocol.
- **Action 27:** Complete upgrades to the Koeberg Pump Station and ensure standby generators and mobile pumps are installed at the Koeberg Pump Station. Ensure all pump stations within the Diep River catchment function optimally and that each has a backup generator.
- **Action 28:** Investigate the potential to construct a low-flow vegetated channel east of the existing channel in the estuary, to mitigate the quality of discharge from the WWTW, with the current channel remaining in place as a high-flow bypass.
- **Action 33:** Test and pilot innovative ideas that may lead to improved water quality in the Diep River.
- **Action 41:** Improve communication on current water quality, risks, and challenges.

CONTENTS

Tables and Figures

Abbreviations

CWAC	Coordinated Waterbird Counts
DE	Developed Zone
DEA&DP:	Provincial Department of Environmental Affairs and Development Planning
DFFE:	National Department of Forestry, Fisheries and the Environment (previously the Department of Environmental Affairs – DEA)
DO	Dissolved Oxygen
DWS:	National Department of Water and Sanitation (previously the Department of Water Affairs and Forestry – DWAF)
EFZ	Estuarine Functional Zone

EMP:	Estuarine Management Plan
FV	Flamingo Vlei
ICMA:	Integrated Coastal Management Act
IDP	Integrated Development Plan
IRMP	Integrated Reserve Management Plan
MC	Middle Channel
ML	Milnerton Lagoon
MLRA	Marine Living Resources Act (18 of 1998)
MMP:	Maintenance Management Plan
NEMA:	National Environmental Management Act (107 of 1998)
NEMBA	National Environmental Management Biodiversity Act (10 of 2004)
NEMP	National Estuarine Management Protocol
NEMPAA	National Environmental Management Protected Areas Act (57 of 2003)
NWA	National Water Act (36 of 1998)
PES	Present Ecological State
REC	Recommended Ecological Category
RQOs	Resource Quality Objectives
RV	Rietvlei
SDF	Spatial Development Framework
TBNR	Table Bay Nature Reserve
TEC	Target Ecological Category
TPC	Thresholds of Probable Concern
UC	Upper Channel
WWTW	Wastewater Treatment Works

1. INTRODUCTION

1.1. Estuaries and estuary management

An estuary is the interface between a river and the sea, defined in the 2018 National Biodiversity Assessment (van Niekerk et al., 2019) as 'a partially enclosed permanent water body, either continuously or periodically open to the sea on decadal time scales, extending as far as the upper limit of tidal action, salinity penetration or back-flooding under closed mouth conditions. During floods an estuary can become a river mouth with no seawater entering the formerly estuarine area or, when there is little or no fluvial input, an estuary can be isolated from the sea by a sandbar and become fresh or even hypersaline'.

Estuaries are generally highly productive ecosystems and provide a range of goods and services that include nursery areas for juvenile fish to stopovers for migrant birds and recreational opportunities for people. Their productivity, combined with their natural beauty and the shelter they provide also means they are highly sensitive and vulnerable to development, especially as many urban areas are deliberately located in and around them. As a result, many estuaries have been seriously degraded.

Estuaries require particular care in the planning and implementation of activities related to their use and management. Although their value – particularly from a biodiversity perspective – has long been recognized, they do not fit clearly within the regulatory mandate of any one government department. For this reason, the National Environmental Management: Integrated Coastal Management Act (No. 24 of 2008, as amended) (ICMA) establishes a system of Estuarine Management Plans, which must be consistent with the prescriptions of the National Estuarine Management Protocol (the Protocol, first published in 2013 and updated by GN 533 of 2021) and must align and coordinate the management of estuaries at a local level.

One of the pillars of integrated coastal (including estuarine) management is the establishment of effective institutional arrangements to underpin cooperative governance. The ICM Act details the institutional arrangements for cooperative coastal management in South Africa, including arrangements at national, provincial and municipal government levels. The lowest tier of institutional arrangements for estuarine management comprises the Responsible Management Authority and the estuary advisory forum. The role of the estuary advisory forum is to act as the hub which links all stakeholders, including both organs of state and civil society, to facilitate cooperative management and effective governance in terms of an Estuarine Management Plan (EMP), as well as facilitate and monitor implementation of an EMP. The role of the responsible management authority is to develop and co-ordinate implementation of EMPs.

1.2. The Diep River Estuary

The Diep River (Figure 1) has its origins in the Riebeek Kasteel Mountains north-east of Malmesbury, and flows for about 65 km south-west towards Cape Town, before entering the sea at Milnerton, some 5 km north of the Port of Cape Town. It has one major tributary – the Mosselbank – which drains the northern slopes of the Durbanville Hills. Other tributaries include the Swart, Groen, Klein, and Riebeek, with the Klapmuts being a major tributary of the Mosselbank. The total size of the catchment is 1,495 km^2.

Before entering the sea, the Diep River flows through the Rietvlei wetland and Milnerton Lagoon, which together cover an area of approximately 900 hectares (ha). These two features together have generally been considered to comprise the "estuary". However, for the purposes of the EMP the estuary is defined as the Estuarine Functional Zone (EFZ), which encompasses the Paarden Eiland wetlands (Zoarvlei), the estuary mouth, to north of the railway bridge between the Blaauwberg Road bridge and the N7 Bridge. The EFZ corresponds largely with the 5-metre contour above mean sea level (AMSL). The EFZ boundary is shown by the yellow line in Figure 1 below.

Figure 1. Location of the Diep River estuary within the City of Cape Town municipal area

1.3. Mandate and responsibilities of the Responsible Management Authority

The National Estuarine Management Protocol, 2021 (NEMP) identifies the management authority responsible for the Diep River estuary as the City of Cape Town. The estuary is within a protected area (the Table Bay Nature Reserve) and the management authority responsible for the protected area (the City of Cape Town), must therefore develop the EMP in consultation with relevant government departments and other key stakeholder and interest groups.

The responsible management authority is responsible for the development of the EMP and the overall co-ordination of the actions of other implementing agencies. Specifically, its responsibilities are described by the NEMP as:

Section 5 (e):	*"…authorities are **responsible for the development of EMPs** and **coordination of the implementation process**…"*
Section 8(1):	*"The identified responsible management authority to develop the EMP needs to **budget accordingly for the development of these plans**."*
Section 9.1(1) and 9.2:	*"The responsible management authority developing an EMP must **actively engage all the relevant stakeholders** including government departments, non-government organisations and civil society in the development and implementation of the EMP."* *"…it **must obtain formal approval** for the EMP…" and "Once approved…the EMP shall be… **Integrated**.." and "**incorporated** into the Provincial Coastal Management Programme".*

The responsible management authority that develops an EMP must, in terms of section 34 of the ICMA:

a) follow a public participation process in accordance with Part 5 of Chapter 6 of the ICMA;
b) ensure that the EMP and the process by which it is developed are consistent with:
  i) the Protocol
  ii) the national and provincial coastal management programmes
c) If applicable, ensure that relevant legislation is enacted to implement the EMP; and
d) Submit a bi-annual report to the Minister on the implementation of the EMP, the legislation and any other matter.

1.4. Legal framework for the development and review of an EMP

The NEMP is a national policy for estuarine management and guides the development of individual EMPs. The Protocol sets out the following:

a) The strategic vision and objectives for achieving effective integrated management of estuaries in South Africa;
b) The standards for the management of estuaries;
c) The procedures regarding how estuaries must be managed and how the management responsibilities are to be exercised by different organs of state and other parties;
d) The minimum requirements for EMPs;
e) Who must prepare EMPs and the process to be followed in doing so; and
f) The process for reviewing EMPs to ensure that they comply with the requirements of the ICMA.

The Diep River EMP was initially developed in 2008 by Peak Practice based on the key components of the generic framework for EMPs, as proposed in Van Niekerk & Taljaard (2007). Reviews in 2011 by Coastal and Environmental Consulting and in 2016 by the City of Cape Town with support from RHDHV and the provincial Department of Environmental Affairs and Development Planning (DEA&DP) brought the plan into alignment with the 2013 Estuarine Management Protocol.

According to the NEMP, EMPs must be reviewed by the responsible management authority at least every 5 years but may also be reviewed at any other time. Such review must include assessment of:

(a) The effectiveness of the EMP and success with meeting its objectives, taking into consideration information from monitoring during the preceding years;

(b) Environmental changes (if any) at a local or a wider scale that could affect the estuarine resources or the implementation of the EMP; or

(c) Changes (if any) to legislation, land-use planning, goals, or policies that may require the EMP to be amended.

Based on the review, it may be necessary to amend an EMP, even to the extent of revising its objectives. Following such review, the responsible management authority shall either modify or re-endorse the EMP and shall engage in public participation before the amended EMP can be approved and adopted.

This amended Diep River EMP is the outcome of the five-yearly review of the EMP, conducted by the City of Cape Town as the responsible management authority. It incorporates significant amendments compared to the 2016 version, intended both to update the situation assessment and to reorient it to an objectives-based action-oriented plan. The objectives have been substantially amended due to the determination in 2020 of resource quality objectives for the estuary.

1.5. Approach

The 2021 review was prepared by the City of Cape Town's Coastal Management Branch with support from Infinity Environmental (Pty) Ltd. It includes a rapid reassessment (undertaken in less than two months between September and October 2021) to consider the continued applicability of the 2016 plan, incorporate significant new information deriving from monitoring and studies undertaken in the intervening period, and make recommendations for implementation based on a workshop with external experts. It is also an opportunity to align the EMP with the NEMP as updated in June 2021. A workshop involving specialists in estuarine and freshwater management was coordinated in late September 2021, to consider the current state of the estuary and make recommendations for its management.

This EMP is a strategic planning document, and as such does not provide detailed, routine planning for the management of the estuary. It should be recognised as a dynamic document, in which components may be revised as new information becomes available and management priorities change. A formal review must take place at least once every five years.

2. SUMMARY OF THE SITUATION ASSESSMENT

2.1. Introduction

The initial Situation Assessment Report for the Diep River estuary, completed by Peak Practice in 2008, formed the basis for the first EMP. The situation assessment has been reviewed and updated based on more recent data and new information, to reflect the significant changes in the estuary and its catchment over the intervening 13 years. The situation assessment describes the current situation of the Diep River estuary and provides an overview of the legal requirements, biophysical environment, land use patterns, water use and discharge, environmental goods and services, use of living resources, economic and social contexts, conservation priorities, and institutional arrangements.

This assessment is heavily reliant on work completed as part of the Reserve Determination and Resource Quality Objectives process for the Berg Water Management Area, and specifically on the RDM Study for the Rietvlei/Diep Estuary (Clark et al., 2018). It also incorporates monitoring data collected by the City of Cape Town, bathymetry study by Christie-Smith (2021), sediment study by Gihwala & Hutchings (2020), and information garnered from aerial imagery and other sources.

2.2. Legislation and planning instruments applicable to the estuary

This section provides an overview of key legislative and policy instruments that may have an impact on the formulation of the EMP and the management of the Diep River estuary. It is not a full legal review but focuses primarily on legislation and policy implemented since the initial preparation of the EMP, and which affects the Diep River estuary specifically.

2.2.1. ICMA

The National Environmental Management: Integrated Coastal Management Act (ICMA) provides for the protection and management of coastal systems, including estuaries. It makes provision for the NEMP to be prepared to guide the management of estuaries and requires that EMPs be prepared for certain estuaries.

The 2016 version of this EMP was amended to bring it into line with the requirements of the NEMA and was adopted accordingly. The current version incorporates amendments based on the five-yearly review of the EMP conducted in 2021 as required by the NEMA.

2.2.2. National Environmental Management Act, 1998

The NEMA and the Environmental Impact Assessment Regulations, 2014 (as amended by GNR 324 to 327 of 2017) define several activities that require prior environmental impact assessment and authorisation from the competent authority. These include listed development and maintenance activities specifically where they occur within estuaries, giving a measure of control over new development within the defined EFZ.

The City of Cape Town has developed a Maintenance Management Plan (MMP) for maintenance activities in the Diep River estuary. The MMP for the Diep River estuary, adopted by the Department of Environmental Affairs and Development Planning in terms of the Environmental Impact Assessment Regulations, 2014 (as amended), is included as **Annexure A**. The City, and its appointed contractors are thereby authorised to undertake a range of routine stormwater maintenance tasks within the EFZ, including opening of the estuary mouth.

2.2.3. National Water Act, 1998

The National Water Act, 36 of 1998 governs the use of water and the management of water resources nationally. The Minister of Water and Sanitation in November 2020 (GN No. 1179 in GG 43872) determined Resource Quality Objectives (RQOs) and classes of water resources for the Berg catchment in the Western Cape, in terms of section 13(1) of the National Water Act. This gives legal effect to a set of standards for rivers and estuaries, including the Diep River and its estuary.

The Diep River (catchment D10) is assigned Class III, indicating that the water resource has undergone significant change from its natural state due to human activity. RQOs are defined for water quantity, habitat and biota, and water quality, for prioritised river reaches and estuaries.

The estuary is assigned a Target Ecological Category (TEC) of **D**, where categories range from Category A (unmodified, natural) to Category D (largely modified). The TEC reflects the ecological condition of the resource in terms of the deviation of its biophysical components from the natural reference condition before human influence.

2.2.4. Integrated Development Plan and Spatial Development Framework

The City of Cape Town is guided by the Integrated Development Plan (IDP), which is reviewed every five years. The current IDP cycle for the City has been in place since 2017 and ends June 2022. Defining the City's governance goals, the IDP forms the City of Cape Town's overarching masterplan that provides a vision and defines priorities from which to achieve its five strategic focus areas (CCT, 2011). The revision of the Diep River EMP is in alignment with a number of strategic focus areas, namely the City's resilience and climate change programmes, human settlements programmes, and resource efficiency and security. "Resource efficiency" in relation to the management of the Diep River estuary, includes the harnessing, and improvement of, ecological services such as water purification, flood prevention and mitigation, coastal buffers, and absorption of waste and pollution. The City recognises that Cape Town's natural resources are increasingly under pressure due to developmental and climate change induced pressures and require dedicated, yet realistic, management approaches and interventions tailored to addressing these pressures. The revised Diep River EMP is one such tool that the City will use in its efforts towards achieving this, and which aligns with the overarching aims and objectives of the IDP.

A key tool in the achievement of the governance goals of the IDP is the Municipal Spatial Development Framework (CT: MSDF). The role of the CT: MSDF is to spatially coordinate and align public investment in accordance with the priorities identified in the IDP. Contained within the overarching CT: MSDF there are eight district-level plans (each containing an environmental framework - EMF) which provide more detailed direction for the nature and form of development in each district and which guides land use and environmental decisions in each of the districts. The detail of the district plan and EMF is important to the management the Diep River estuary on the basis that it regularises land use activities that may have an impact on the Diep River estuary system, especially considering that there are a number of land use activities outside of the Diep River EFZ which impact on the estuary. The current review process of the district plans and EMFs for the CCT have been cross-pollinated with management requirements for the Diep River estuary and as such the CT: MSDF and district plans are key planning mechanisms to mitigate against land-based pressures impacting on the estuary.

2.2.5. Coastal Policy

The City's Integrated Coastal Management Policy was formally adopted by Council in 2014 and was the City's first dedicated coastal policy. The intent of the ICM Policy is to set strategic level prescripts in response to particular coastal governance challenges within the City. Considering the socio-economic* and environmental importance of the City's coastline, and anticipated climate change induced impacts and pressures on the coastline, the ICM Policy provides a vital framework from which to enable and guide effective governance of the City's coastal resources. The ICM Policy makes specific reference to the importance developing and implementing EMPs that recognise and manage the vital contribution of estuaries to supporting the health of coastal ecosystems, water quality maintenance, the provision of marine species nurseries, and the provision of valuable natural assets from a recreational use perspective.

2.2.6. Coastal Management Programme

In accordance with the requirements of the Integrated Coastal Management Act (Act 36 of 2014 as amended), the City established its Integrated Coastal Management Programme (CMP) in 2014. In addition to providing an operational level tool from which to affect the principles contained in the ICM Policy, the intention of the CMP is to:

- Entrench a range of management protocols as it relates to the City's coastal management responsibilities;
- Enhance the socio-economic and environmental potential of Cape Town's coastline and to mainstream the benefits of coastal resources into the local economy on a sustainable basis;
- Promote strategic, informed, consistent and proactive decision making across the City's 240km of coastline, and
- To ensure that such decision-making is integrated and supports a collaborative approach to coastal management across all line departments that have an impact on Cape Town's coastline.

The CMP comprises 31 chapters. A key chapter in the CMP is Chapter 23, which provides previous EMPs for the City's larger estuaries, namely the Diep River and Zandvlei, as well as for the City's smaller estuaries, namely the Eerste River, Disa River, Lourens River, Silvermine River, Sir Lowry's Pass River, and the Zeekoevlei River. In terms of the NEMP, the City will seek to consolidate the smaller estuaries into a single estuary EMP and will need to enter into a formal agreement with the Provincial Department of Environmental Affairs and Development Planning as per the requirements of the NEMP to do so.

2.2.7. Coastal By-law

The City of Cape Town Coastal By-law was promulgated in 2020. The intention of the Coastal By-law is to provide a regulatory framework to enable more effective governance and law enforcement of any activities that may negatively impact on Cape Town's coastal environment, and which may compromise the socio-economic and environmental value it currently provides to the City. The establishment of the Coastal By-law is in accordance with the requirements of the National Integrated Coastal Management Act which enables municipalities to establish coastal by-laws. The City of Cape Town Coastal By-law aligns with the principals and intent of the Integrated Coastal Management Act and contains a number of provisions dedicated to regulating any activities that may impact on estuarine systems.

2.2.8. Coastal Edge and Coastal Management Line

The City's Coastal Edge was formally approved in the Spatial Development Framework (CT: MSDF) on the 8th of May 2012. It was approved as a component of the City's IDP in terms of the Municipal Systems Act (Act No 32 of 2000, section 34) and the Land Use Planning Ordinance (No. 15 of 1985,

* An economic assessment of the contribution of Cape Town's coastline to its GDP estimates the value to be approximately R40 billion per annum (±10.7% to GDP/annum) (Urban-Econ, 2017).

section 4(6)). The CT:SDF, together with the Provincial Spatial Development Framework forms the spatial planning framework applicable to the municipal area of the City. In March 2021, the Coastal Edge was gazetted as the Coastal Management Line (CML) in terms of the requirements of the Integrated Coastal Management Act. The greater Diep River estuary falls within the Coastal Edge/CML, thereby linking its management to the regulatory and spatial planning framework contained in the CT: MSDF and to provisions contained in the Integrated Coastal Management Act.

2.2.9. Protected Areas

The Table Bay Nature Reserve was submitted for proclamation in terms of section 23 of the National Environmental Management: Protected Areas Act (57 of 2003) in 2018, replacing the Rietvlei Protected Natural Environment designation under the Environment Conservation Act, 1989. The Nature Reserve encompasses the Diep River, Rietvlei coastal section and wetlands, Milnerton Lagoon and other surrounding areas, and is managed by the City of Cape Town Biodiversity Management Branch. An Integrated Reserve Management Plan (IRMP) in in place for the reserve and incorporates this EMP. While the primary purpose of many nature reserves is to conserve biodiversity and ecosystem functioning, other important purposes are to create a welcoming place for visitors and to promote environmental education and experiences. The IRMP outlines that community participation, safety and security, cultural, historical, archaeological and paleontological management, tourism development and recreational management, infrastructure management, biodiversity conservation management and strategic research form the guiding principles of the protected-area management policy framework. Refer to the IRMP (**Annexure B**) for further details.

2.3. Diep River Catchment characteristics and land use

The catchment of the Diep River lies mainly within the City of Cape Town and Swartland Local Municipality (West Coast District), but also extends into the Drakenstein and Stellenbosch Municipalities (Cape Winelands District) (Figure 2).

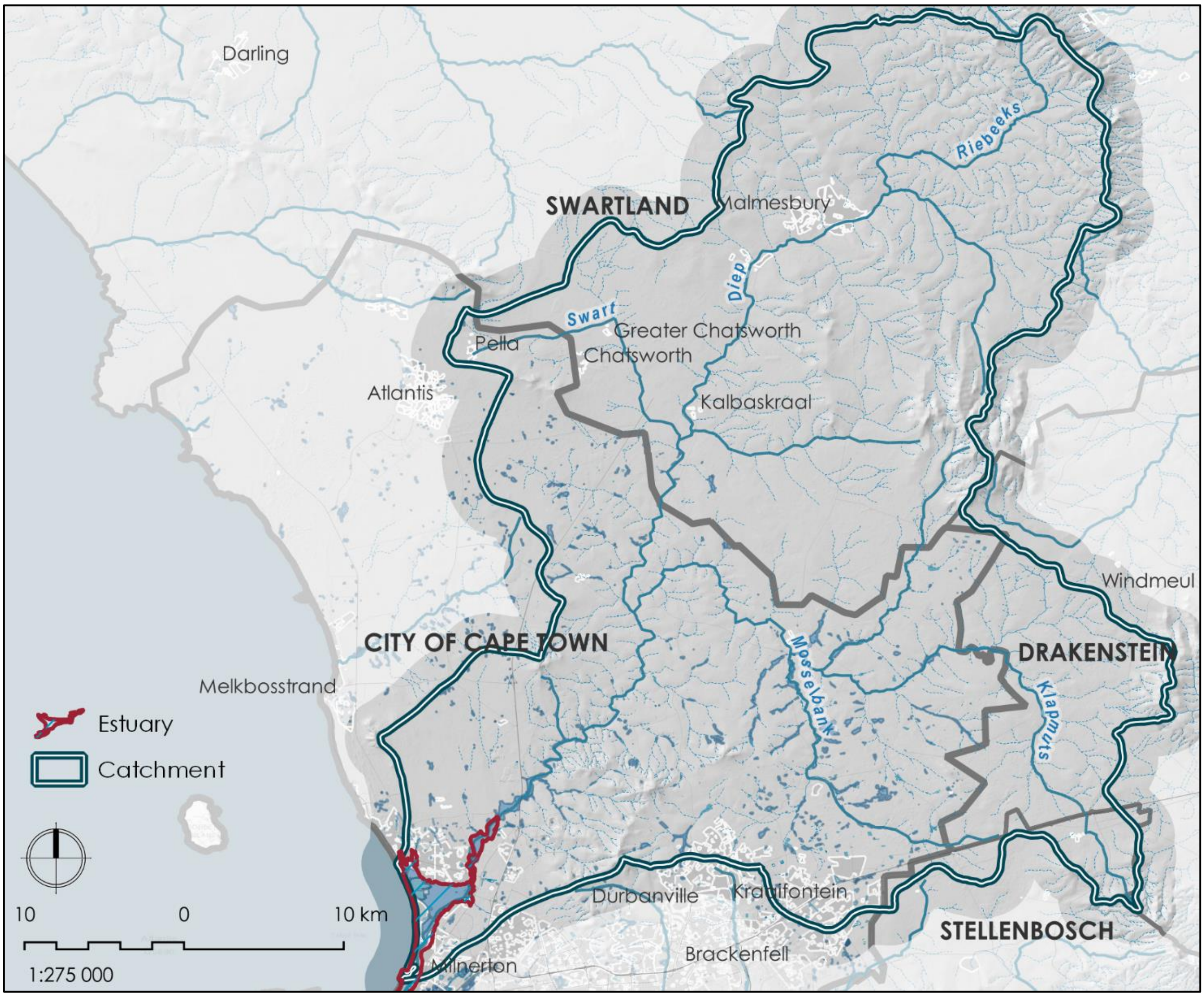


Figure 2. Diep River Catchment

Shales and phyllites of the Tygerberg and Mooreesburg Formations, with deep fertile soils and a low undulating topography suitable for both agriculture and urban development, underlie the upper catchment. The lower catchment is in quartzose sands of the Sandveld Group. The catchment is in the winter rainfall region of the Western Cape. Mean annual runoff is relatively low and the Diep River can at times dry up completely in the summer months.

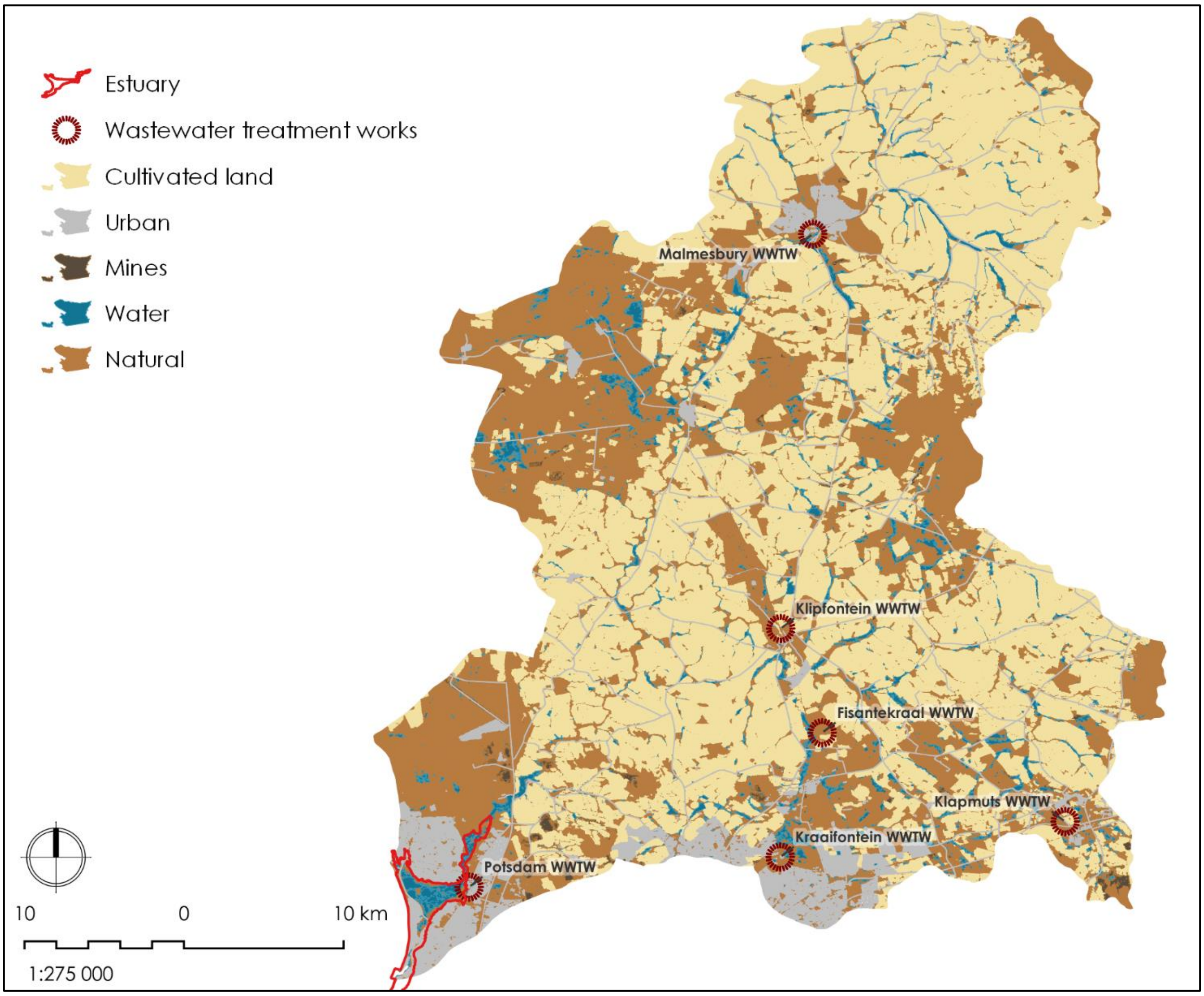


Figure 3. Land uses in the Diep River catchment, showing urban areas, agricultural lands and wastewater treatment works (WWTW)

2.4. Delineation of Estuary

The Diep River estuary, save for a few occasions during Cape Town's recent "Day Zero" drought, is permanently open to the sea and is located in the cool temperate region of the Western Cape, entirely within the City of Cape Town but with a catchment area of 1 495 km^2 in four municipalities. The geographical boundaries of the estuary are defined as follows:

Table 2: Boundaries of the estuary and its functional zone

Downstream boundary:	Estuary mouth 33º53'23.65"S; 18º28'55.72"E
Upstream boundary:	33°48'08.83"S; 18°32'03.95"E (below Malibongwe Drive)
Lateral boundaries:	5 m contour above Mean Sea Level (MSL) along each bank, or 1:100 year flood line, whichever is wider

Before entering the sea, the Diep River flows through the Rietvlei wetland and the Milnerton Lagoon, which together cover an area of approximately 900 ha. The EFZ is defined as the area encompassing the estuary waterbody itself, as well as those surrounding areas necessary for estuarine function and health (van Niekerk et al., 2019). The EFZ captures the natural, historical estuarine extent and should not be confused with setback/management lines that often exclude developed areas. For the Diep River estuary, the EFZ begins about 150 m below the Malibongwe Boulevard bridge and extends 11.3 km to the mouth at Lagoon Beach. It incorporates lateral areas below the 5 m contour including the Rietvlei, the Flamingo Vlei section to the north-west Rietvlei, and the Zoarvlei wetlands to the south. The coastal dunes west of Marine Drive, as well as the beach around the mouth, are also included for a total area of 1 250 hectares. Clark et al. (2018) estimate that the estuary, excluding urban development, covers 834 ha, with a total open water area of approximately 229 ha.

The Diep River enters the estuary below Malibongwe Boulevard, with its floodplain constricting southward to its narrowest point (130 m) at the Blaauwberg Road bridge. From here it widens again, the main channel skirting the eastern edge of the floodplain and a large area of salt marsh and wetland to the west making up the triangular-shaped Rietvlei. The 'triangle' measures 2 km across from east to west and 1.5 km from north to south. The two deep-water lakes (known as Flamingo Vlei) form the north-western side of Rietvlei. The canalised eastern edge of the estuary receives flows from the Potsdam Wastewater Treatment Works (WWTW) before entering the Milnerton Lagoon downstream of the Otto du Plessis Drive bridge. The lagoon, in a confined channel stabilised by road embankments and bridges, has a maximum width of 150 m. The mouth naturally migrates between a gabion structure and concrete wall to the south and a natural raised area about 250 m to the north.

The 2018 National Biodiversity Assessment (van Niekerk et al., 2019) assesses the Present Ecological State (PES) as D and proposes a Recommended Ecological Category (REC) of D (Largely modified).

2.5. Biophysical Description

2.5.1. Hydrology

The Diep River Estuary lies in an area of the Western Cape characterised by winter rainfall and dry summers, which results in rapid evaporation during the summer. Mean annual precipitation for the entire catchment is approximately 500 to 600 mm (Jackson et al., 2008).

The hydrological functioning within the catchment has been subject to significant human-induced change. Flows entering the estuary from the catchment are presently 37.3 million cubic metres per year (Mm^3/a), significantly reduced from natural levels of 60.8 Mm^3/a (a 39% reduction) due mainly to agricultural abstraction of water (Clark et al., 2018). However, the estuary receives supplementary flows in the form of treated wastewater from the Potsdam WWTW, totalling 20.7 Mm^3/a. Total freshwater inputs are, therefore, similar to pre-development levels at 95% of the reference flow. The Potsdam WWTW has obtained environmental authorisation to increase its treatment capacity from 47 000 m^3 per day to 100 000 m^3 per day. If fully utilised, this additional discharge would increase supplementary flows by a further 19.3 Mm^3/a.

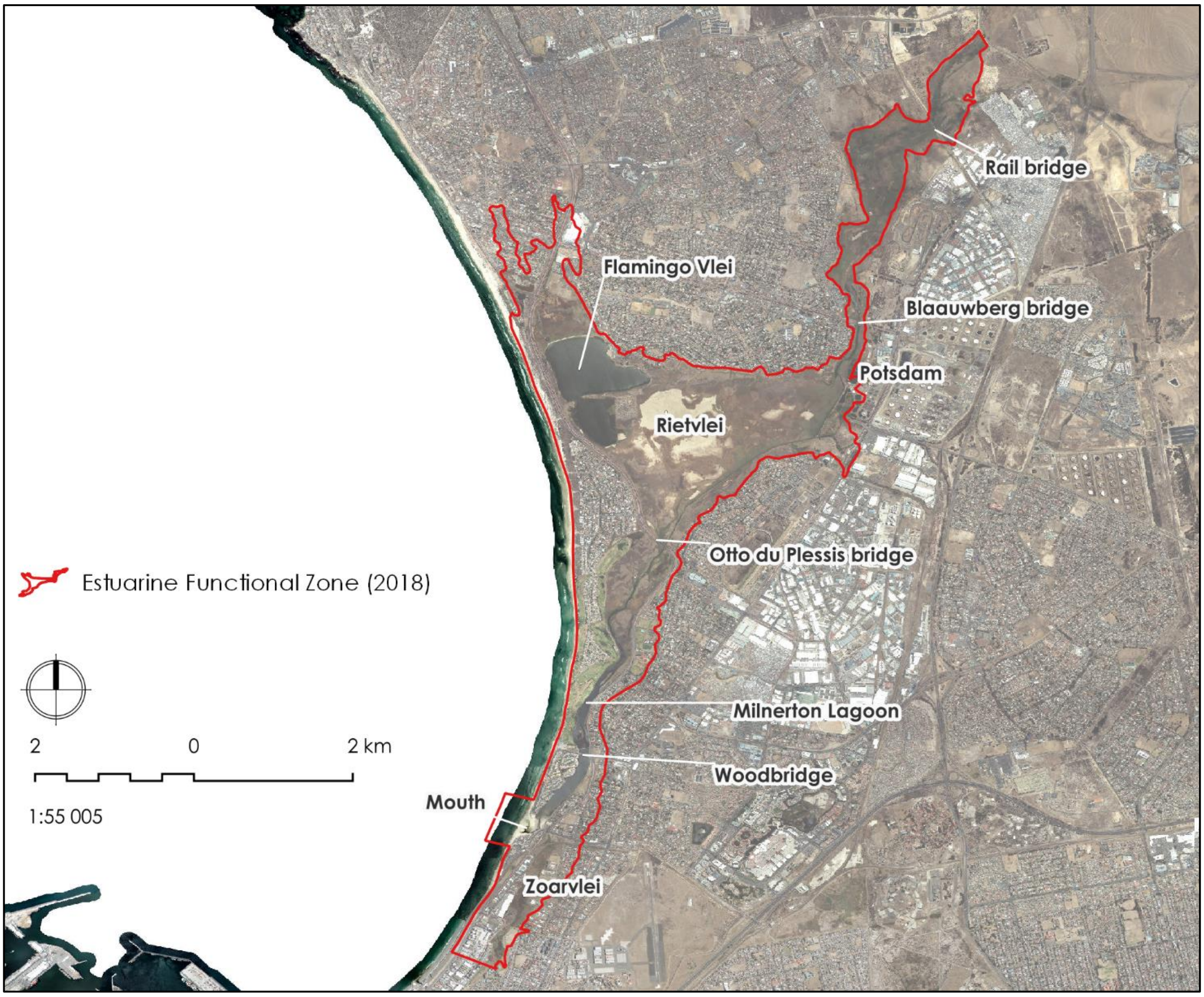


Figure 4. Estuarine Functional Zone of the Diep River Estuary (NBA 2018)

Hydrology in the catchment is strongly seasonal, with flow in the river reducing to zero in summer months. Hydrology in the estuary in the summer months is driven, therefore, primarily by the effluent discharge rather than inflows from the river.

The Diep River estuary is fed by flows entering at different points. These include:

1. The river itself, at the northeastern part of the estuary.
2. Treated effluent from the Potsdam WWTW is discharged into an earth channel along the eastern boundary of the Rietvlei. The channel conveys flows to the lagoon at the Otto du Plessis bridge. In high flow events, the channel overtops into Rietvlei.

3. The Bayside Canal, which discharges stormwater from the Table View area into the north-western part of Flamingo Vlei (flows from this canal vary and are significantly lower in summer).
4. Stomrwater discharged via culvert from the south detention pond into Flamingo Vlei.
5. The Theo Marais Canal, which discharges just downstream of the Potsdam outfall and carries stormwater flows from the Montague Gardens area.
6. The Erica Road outfall, which carries stormwater from Phoenix and Joe Slovo Park and discharges on the left (eastern) bank of the estuary.
7. Various more minor stormwater conduits and outfalls.
8. Sea water flows when the mouth is open.

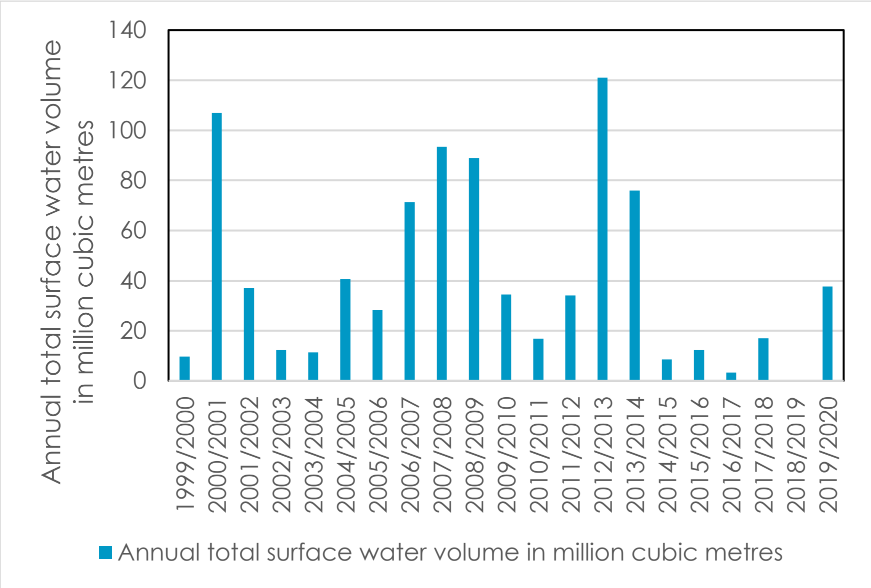


Figure 5. Mean annual runoff variation at the Adderley gauging station on the Diep River (-33.72277, 18.61666) 1999 to 2020. Data not available for 2018/19. Source: DWS Hydrological Services: Station G2H042

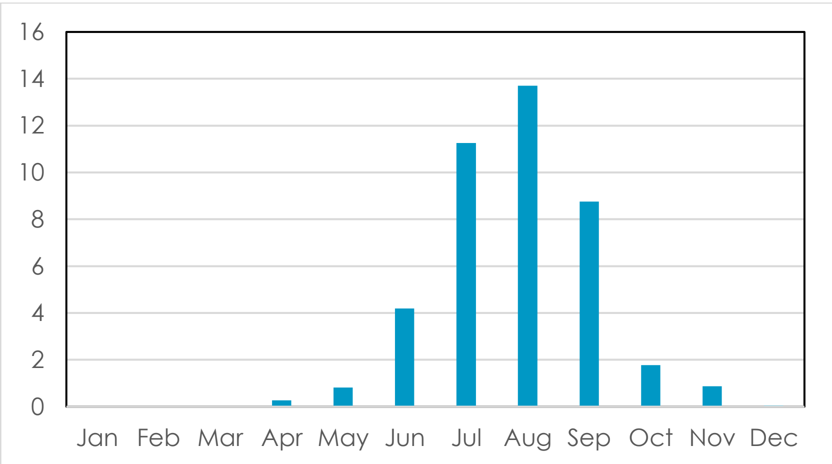


Figure 6. Average monthly flow volumes at the Adderley gauging station on the Diep River (-33.72277, 18.61666) 1999 to 2020. Data not available for 2018/19. Source: DWS Hydrological Services - Surface Water: Station G2H042

2.6. Physical characteristics

Historically, the mouth closed periodically during the summer months in low-rainfall years. More recently, the discharge of treated effluent into the system has maintained flows at levels that have resulted in a predominantly open mouth. The likelihood of mouth closure is elevated during drought conditions and is a concern under climate change predictions for Cape Town. It closed on one occasion during a drought in 2016 when flows from both the catchment and the WWTW were significantly reduced. Under current water quality conditions, a permanently open mouth state is preferred to avoid accumulation of nutrients and pathogens in the estuary.

Bathymetric transects of the estuary, most recently by Tritan (Christie-Smith, 2021), indicate siltation of the lower reaches of the estuary channel since 1993. As the lower channel was dredged for the construction of the Woodbridge Island development in the late 1980s, this may be a reestablishment of the previous depth. The bathymetric profile of an estuarine system is an important determinant of the hydrodynamic interactions in the catchment and in the surrounding coastal area where the water discharges into the sea (Gihwala and Hutchings, 2021).

Particle size analysis of sediments in the Diep River estuary in 2021 indicated that sand was the main component of sediments in the system, with the proportion of mud increasing with distance upstream from the mouth.

2.7. Water quality

The water quality in the Diep River estuary is highly modified compared with its historic state. Water quality throughout the system has declined over time, with total dissolved salts, nutrients and suspended solids increasing consistently. The water quality of the estuary is impacted on by a variety of factors and potential pollutants including:

- Run-off from agricultural areas in the catchment, containing nutrients, sediment and pesticides.
- Effluent from the Potsdam WWTW, which discharges 47 000 m^3 per day of treated effluent and will expand this capacity to 100 000 m^3 per day.
- Stormwater from residential areas containing pathogens, nutrients, and solid waste; this includes both formal residential areas where stormwater runoff may contain fertilisers, salts, pesticides, etc. and informal residential areas where untreated sewage may enter the stormwater system.
- Stormwater runoff from industrial facilities in Montague Gardens and Killarney Gardens, including a refinery whose stormwater runoff is directed to the estuary.
- Power boats and litter from recreational users.

Water quality in the Diep River is monitored by the City of Cape Town at several sampling points in the catchment and estuary (Figure 8). The water quality characteristics at the monitoring points are discussed below. Data analysed was for the period 2016 to 2021.

2.7.1. *Escherichia coli (E. coli)*

Faecal coliforms, and more specifically *Escherichia coli* (*E. coli*), can be used as a bacterial indicator of faecal pollution arising from sewage as well as from livestock and domestic animals. *E. coli* is used to evaluate the quality of effluent, river water, seawater at bathing beaches, raw water for drinking-water supply, treated drinking water, water used for irrigation and aquaculture, and recreational waters. The presence of faecal pollution by warm-blooded animals may indicate the presence of pathogens responsible for infectious diseases such as gastroenteritis, salmonellosis, dysentery, cholera and typhoid fever.

<u>Recreational guidelines</u>

The DWAF 1996 South African Water Quality Guideline series for Recreational Use (in inland water resources) is used to evaluate the ambient water quality in the estuary upstream of the Otto du Plessis Drive bridge; this guideline indicates the public health risks associated with different levels of contact with recreational waters. The "Intermediate Contact" guideline (which relates to activities such as sailing, canoeing, and paddling, but excludes full body immersion by swimming and diving) provides an indication of increasing public health risk associated with progressively high levels of faecal contamination. Downstream of the bridge where the salinity is much higher due to inflows from the sea, the DEA Guideline for Coastal Marine Waters: Guidelines for Recreational Use (2012) is used.

E. coli levels in the Diep River estuary are high and increasing . This is a result of the treated effluent entering the Diep River from the WWTW upstream and may point to inadequate treatment of effluent before it is discharged. This is likely also the result of legacy infrastructure facilitating discharge of untreated effluent during surcharges, as well as informal and underserviced areas in the catchment.

Bacterial pollution increases downstream of Du Noon / Doornbach, where flow in the canalized outlets from the stormwater system is visibly polluted. Water quality improves further downstream largely due to the river's passage through reeds areas that likely assist with water quality improvement. Below the WWTW discharge location the bacterial levels again increase significantly (Figure 7) due to incompletely treated effluent and to discharge from the Theo Marais Canal, which enters the system approximately 750 m downstream of the WWTW. Water quality in the canal is severely compromised due to frequent overflows from this pump station and sewage spills, and overflows and illicit discharges that enter the stormwater culvert from Montague Gardens and Bothasig areas.

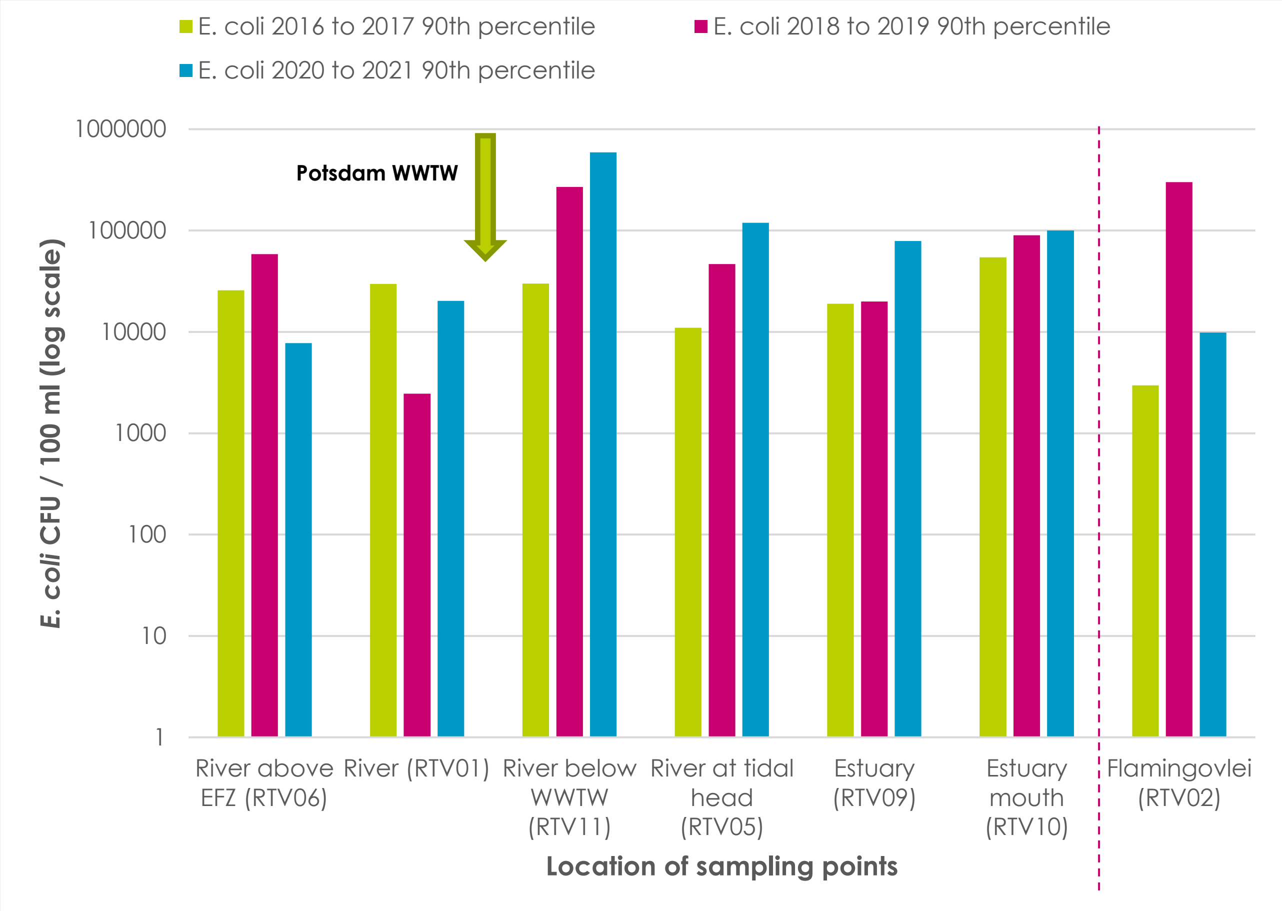


Figure 7: *E. coli* counts in the Diep River estuary between 2016 and 2021. Note that the vertical axis is logarithmic and that Flamingo Vlei is separated from the main flow, as indicated by the dashed line.

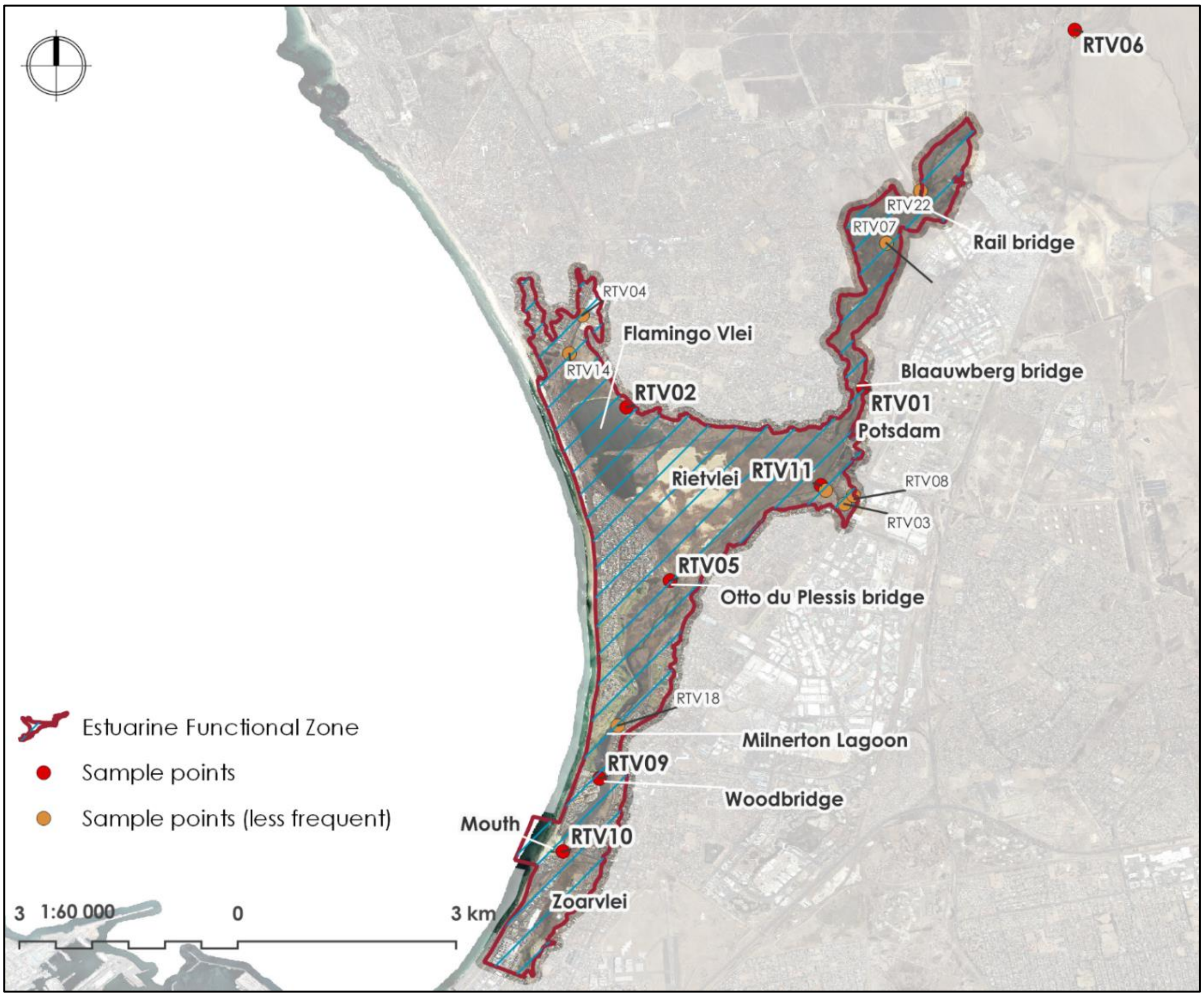


Figure 8. Sampling points in the Diep River estuarine system

E. coli levels remain high in the Milnerton Lagoon, due to the upstream influences and to numerous stormwater outlets that enter the system along Marine Drive conveying pollutants from Milnerton, Joe Slovo Park, Phoenix and Marconi Beam. *E. coli* entering the stormwater network is a likely result of sewer spills, overflows and illicit discharges into the stormwater system. *E. coli* levels in the Flamingo Vlei recreational area are relatively low, and until 2020 generally met the intermediate contact guideline for inland waters. In 2020-2021, they exceeded these guidelines and the RQO by an order of magnitude.

2.7.2. Dissolved oxygen

Dissolved oxygen is a measure of the amount of oxygen in waterbodies that is available to aquatic life. Dissolved oxygen is often used to indicate the health of a waterbody and is often inversely associated with temperature. Levels of dissolved oxygen in the Diep River estuary (Figure 9) are higher at Woodbridge Island, Flamingo Vlei, and the closest measuring station to the estuary mouth. Supersaturation is apparent in data from Flamingo Vlei (for instance, a value of 9.0 mg/ℓ was recorded in June 2021) and the Milnerton Lagoon (a value of 20.8 mg/ℓ recorded in February 2021) which may be attributed to high photosynthetic rates associated with algal production. However, such supersaturation (associated with photosynthesis during the day) hints at an equally marked reduction of oxygen resulting in hypoxia as a result of algal respiration at night. Thus, under the present state, high fluctuation in dissolved oxygen is expected in the Flamingo Vlei, ranging from supersaturation during the day to hypoxia/anoxia at night.

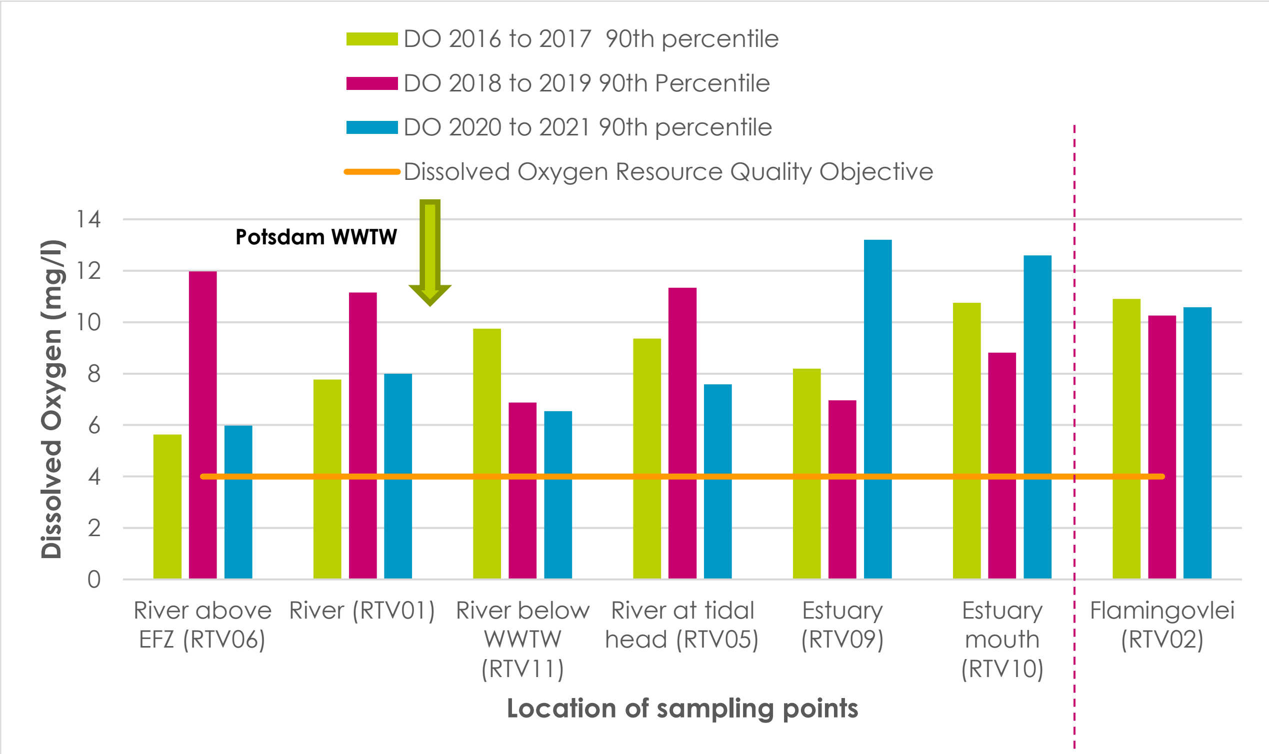


Figure 9: Dissolved Oxygen levels in the Diep River estuary between 2016 and 2021 at different monitoring points. Note that the RQO for oxygen is a minimum and that Flamingo Vlei is separated from the main flow, as indicated by the dashed line.

2.7.3. Nutrients: inorganic nitrogen and phosphorus

Phosphorus and nitrogen from various sources can contribute to nutrient enrichment and eutrophication of water resources. Sources of excess nutrients include fertilisers, livestock and domestic animal waste, sewage, and treated effluent.

Total Inorganic Nitrogen (TIN) comprises nitrate, nitrite and ammonium in water. Nitrogen levels exceed the RQO (Figure 10), even at the top of the estuary, and increase to their highest levels below the WWTW discharge point. From the WWTW, nitrogen levels increase significantly before reducing slightly at the tidal head. They decrease gradually downstream toward the mouth, but in 2020-2021 remained high at all sampling points except Flamingo Vlei (RTV02). Nitrogen levels exceeded the Resource Quality Objectives for the Diep River estuary for the full period of assessment except in 2020/21 in Flamingo Vlei (RTV02).

Spatial variation of phosphates in the system points to relatively high levels of phosphates above the EFZ and then decreasing levels until the WWTW. Phosphate levels increase again after the WWTW and at Otto du Plessis Bridge (RTV05 in Figure 11), and generally decrease towards the mouth. Phosphate levels exceeded the Resource Quality Objectives for the Diep River estuary for the full period of assessment except in Flamingo Vlei (RTV02). Phosphate also increases immediately below the WWTW but decreases at two sampling points downstream, suggesting that some of the nutrients reaching the Otto du Plessis Bridge are being retained due to sediment retention.

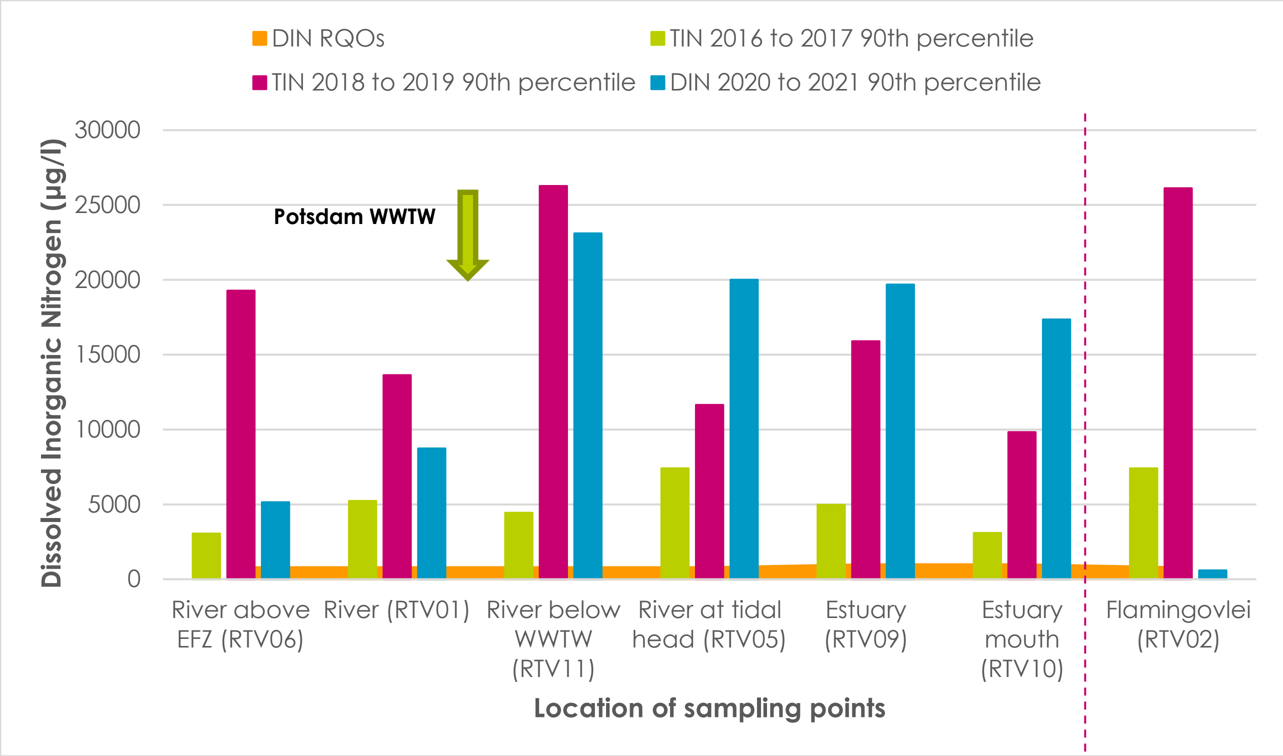


Figure 10: Total Inorganic Nitrogen (TIN) levels in the Diep River estuary between 2016 and 2021. Note that total inorganic nitrogen values for 2020/21 in the City's data are reflected as Dissolved Inorganic Nitrogen (DIN) rather than Total Inorganic Nitrogen (TIN). The RQOs are also expressed as DIN. Note that Flamingo Vlei is separated from the main flow, as indicated by the dashed line.

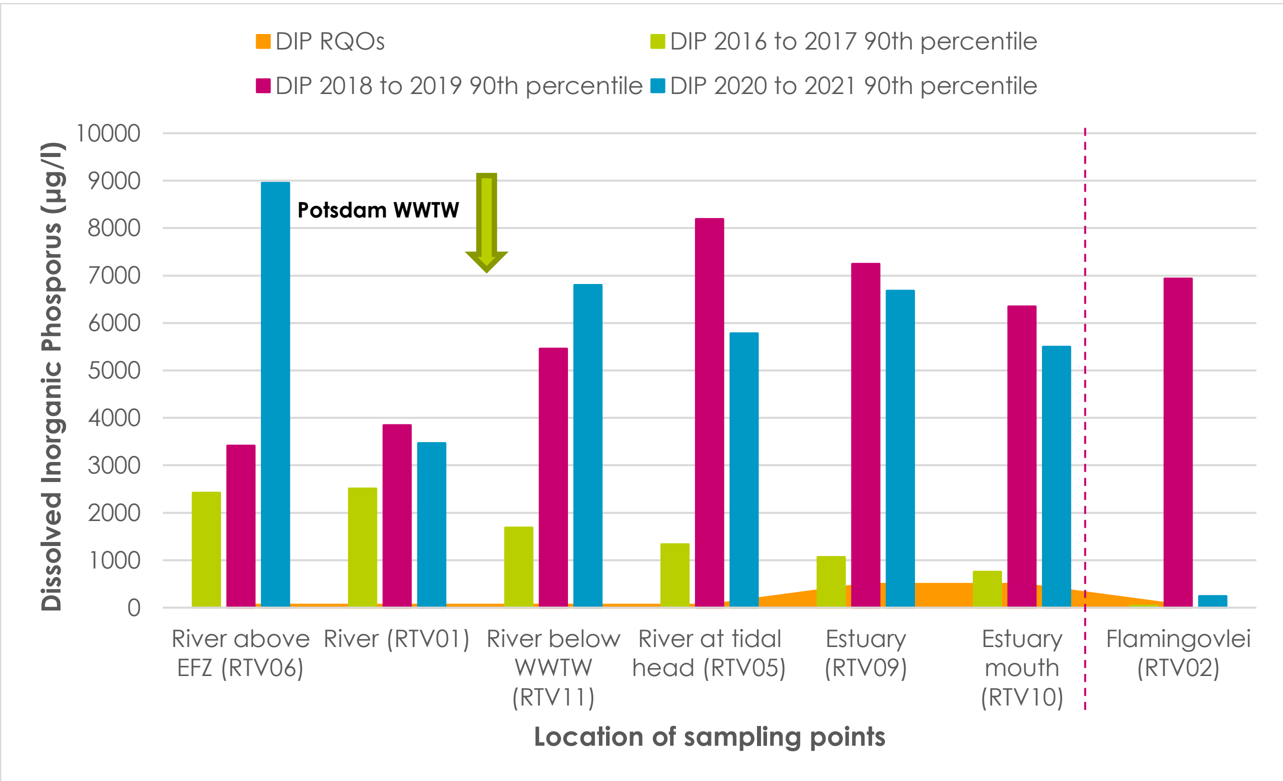


Figure 11: Dissolved Inorganic Phosphorus levels in the Diep River estuary between 2016 and 2021. Note that Flamingo Vlei is separated from the main flow, as indicated by the dashed line.

2.8. Microalgae

Microalgae are an important source of food for fish and microfauna and occur as phytoplankton in the water column, as benthic microalgae on sediment surfaces, and attached to macrophytes as epiphytes. Cyanophytes (blue green algae) are non-flagellated photosynthetic bacteria that are often abundant under freshwater nutrient rich conditions. Some species produce toxins that can be harmful if present in high concentration.

There is little information on the microalgae of the Diep River estuary and thus it is difficult to compare recent findings to historical data. However, harmful microalgal blooms appear to be less common than for other estuary/vlei systems, possibly as a result of periodic drying of some of the shallow areas.

The main groups of phytoplankton found in the different zones of the system are *Bacillariophyceae, Chlorophyceae, Cryptophyceae, Cyanophyceae* and *Euglenophyceae* (CCT Scientific Services data 2019-2021). *Bacillariophyceae* and *Chlorophyceae* seemed to be the most prevalent amongst the zones.

Changes in salinity, nutrient concentrations and the bathymetry of the estuary have all influenced the microalgae. Anthropogenic inputs from urban development and WWTW effluent have increased inorganic nutrient concentrations which would increase the biomass, decrease the species richness, and change the community composition of microalgae. The continual inflow of nutrient rich water has likely increased phytoplankton biomass (abundance). However, blooms will only occur if there is water retention. In the ephemeral pan areas, benthic microalgal and epiphyte biomass may be high. The decrease in open water surface area has reduced the available habitat for phytoplankton and changes in the subtidal and intertidal habitat have influenced benthic microalgae.

Currently the City's Catchment Management Branch in conjunction with the Scientific Services Branch undertakes twice monthly routine sampling of Chl A counts, as well as the identification and count of other algal species. If results of these routine sampling efforts indicate raised levels of Chl A and species counts indicate elevated Cyanophyta counts, toxin tests are undertaken. For Microcystin, test results below 10 µg/L are not considered cause for alarm, however monitoring does continue. Results above 10 µg/L triggers re-sampling and testing on a more regular basis in addition to regular visual monitoring. A number of critical considerations will ultimately inform the closure of areas of high recreational use when readings start exceeding 20 µg/L.

2.9. Macrophytes and terrestrial vegetation

2.9.1. Main groupings and baseline description

Macroalgae and submerged macrophytes have been recorded as common in the wetlands and vlei, especially in summer, autumn and spring (Grindley and Dudley, 1988; Haskins, 2013). In the most recent reports (Haskins, 2013) it appears that a number of species that were identified in previous studies (Grindley and Dudley, 1988) were not recorded again. This may be a result of decreasing salinity in the system or differing sampling aims/methods. Filamentous algae (*Cladophora*/*Enteromorpha*) are common in wetlands and vlei ecosystems (Haskins, 2013) and "thick blankets" of it were recorded by Grindley and Dudley (1988) and highlighted as prevalent sightings by Haskins (2013).

The entire system has a diversity of macrophyte habitats consisting of pans and islands (Clark et al, 2018). The banks of Rietvlei are flat and marshy and have three vegetation zones that are not well distinguished. Open pans occur amongst sedge and salt marsh habitats that are flooded in winter but dry up in summer. There are a number of invasive species present. Thick *Typha capensis* blocked the open water present at the vlei at Dolphin Beach and the invasive waterfern *Azolla filiculoides* covers sections of open water. In January 2017, water hyacinth *Eichornia crassipes* was dominant in inlet/stormwater input areas and thick beds of the submerged macrophyte *Potamogeton pectinatus* occurred in the southern deep vlei area.

2.9.2. Macrophyte health

Cultivation on the banks of the Diep River removed riparian vegetation and poor land management resulted in extensive erosion of surrounding farmland, causing siltation of the river, vlei and lagoon. *Typha* and *Phragmites*, which only occurred in localised areas prior to 1967, have significantly expanded their distribution due to increased nutrient levels. Invasive plant eradication programmes have removed many of the invasive terrestrial plants occurring around the estuary. At least nine aquatic and semi-aquatic invasive species are thought to occur in the system and five invasive grass species. *P. vaginatum* was first recorded in 1985, and Withers *et al.* (2002) recorded 78.54 ha of this grass in Rietvlei. These grasses outcompete indigenous sedgeland species and encroach onto the open water, reducing habitat for wading birds.

Presently it is estimated that 33% of the EFZ is under development (roads, residential, holiday accommodation, golf course and coastal amenities), particularly close to the estuary mouth. Residential and commercial developments also surround most of the riparian habitat.

Development has removed natural salt marsh habitat, with small pockets still evident near Woodbridge Island and Milnerton Golf course. These too are however also showing signs of adapting to an increasingly freshwater system. The channel has also been stabilised by roads and embankments, reducing the natural ability of the estuary to meander. Extensive sedimentation from erosion upstream in the catchment and dust pollution has potentially led to an increase in reeds and sedges, which proliferate in the nutrient-rich conditions. Bulrush *Typha capensis* has encroached into the ephemeral pans and is mechanically and chemically controlled. Dredging of the estuary to increase its depth would have disturbed shallow saline habitats. It appears from comparison of aerial photographs that open water area has decreased over time. Invasive terrestrial and aquatic species would also displace natural vegetation.

The main habitats and macrophyte groups present in the Diep River Estuary are listed in Table 3 and shown in Figure 12.

Table 3. Macrophyte habitats and functional groups recorded in the estuary (with species examples)

Habitat type	Defining features, typical/dominant species	Area (ha)
Open surface water area	Serves as habitat for phytoplankton.	205.1
Submerged macrophytes & macroalgae	*Ruppia spp*, *Potamogeton pectinatus* are the dominant submerged macrophytes while filamentous green macroalgae are also prolific.	Cannot distinguish

Habitat type	Defining features, typical/dominant species	Area (ha)
Reeds and sedges	Common reed *Phragmites australis* and bulrush *Typha capensis* are dominant. There is a diversity of pans and islands with important sedge habitats (*Bolboschoenus* spp.)	212.89 + 105.7
Salt marsh	Low-lying wetter areas with *Juncus kraussii* and *Salicornia meyeriana*. Areas mapped north of Otto Du Plessis bridge that dry up. Includes sand and mudflat habitat that was difficult to distinguish from salt marsh.	53
Coastal vegetation	Fringes the open water of the ephemeral pans dominated by *Oesteospermum moniliferum* with arum lilies and invasive species prominent.	70.2
Disturbed reeds and grasses	The upper reaches of the vlei consisted of disturbed areas dominated by *Stenotaphrum secundatum* and *Typha capensis*	18.6
Disturbed wetland vegetation	This is a mixture of sedges, coastal vegetation and invasive species.	46.7
Grassed recreational	This area separates the vlei from the surrounding neighbourhoods that is used by the community for walking and that is frequently mowed.	18.6
Development	Housing, hotels, roads, bridge, golf course	424.7

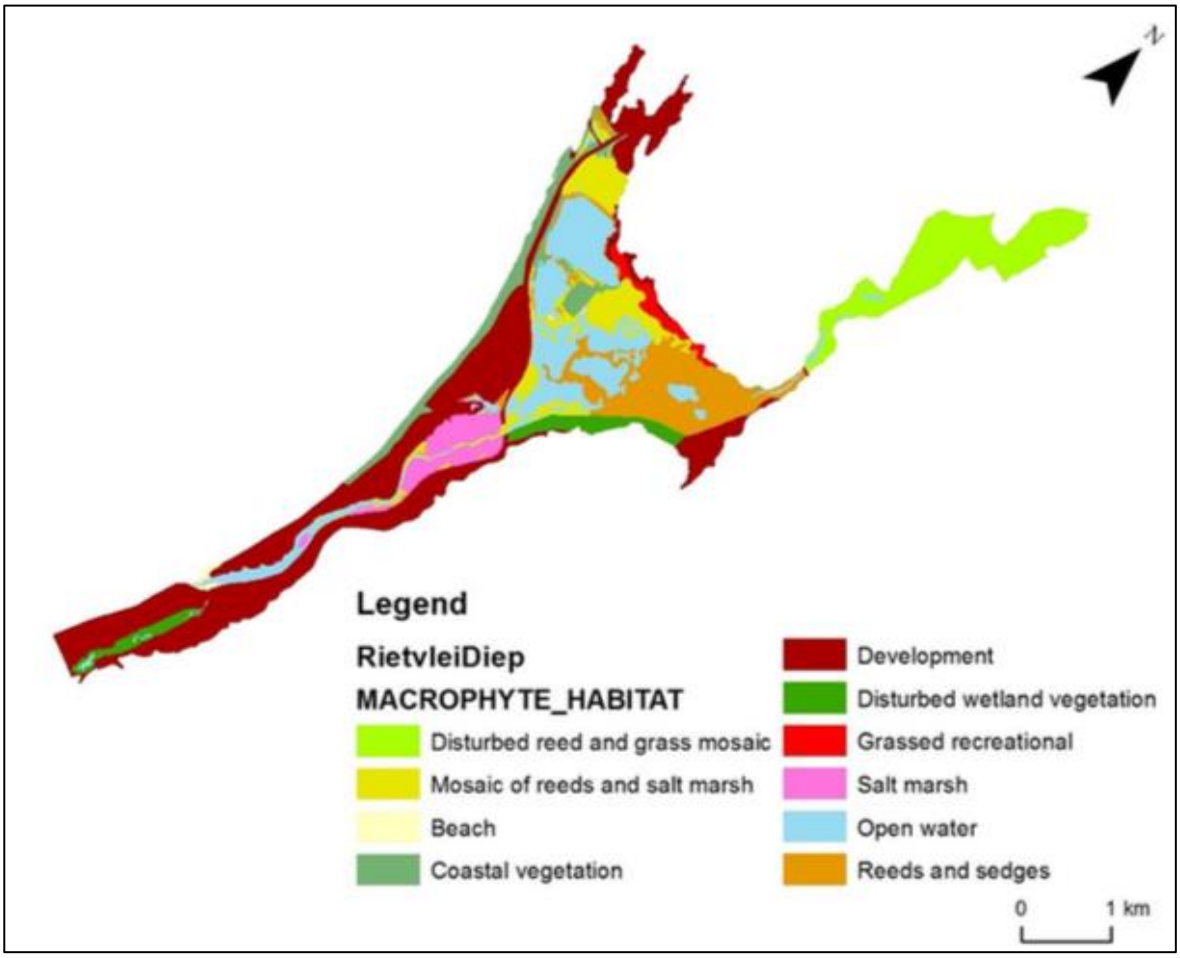


Figure 12. Distribution of macrophyte habitats in the Diep River estuary based on 2014 aerial photographs and a field survey in 2016 (excerpted from Clark et al, 2018)

2.10. Alien Invasive Species

The Table Bay Nature Reserve (TBNR) Invasive Alien Species Monitoring, Control and Eradication Plan (IAS control plan – **Annexure E**) (Stafford and Rhoda, 2016) applies to 966 ha of the TBNR with a specific focus on invasive plant species. The City's Invasive Species Unit is responsible for providing invasive species strategic and operation support to ensure the objectives of the plan are achieved. Invasive plants impact negatively on biodiversity, as they can often outcompete indigenous vegetation for space and resources. In the context of the Diep River estuary, the most significant alien invasion has been through *Eichhornia crassipes* (Water hyacinth). This vegetation forms a mat-like layer over the water surface, preventing waterbirds that require open water for feeding, roosting and nesting from utilising the river. In the riparian area, alien invasive vegetation negatively impacts on streamflow and water availability. The natural vegetation is also heavily invaded in many areas by a woody overstorey of alien species, mainly *Acacia cyclops* (wattle/rooikrans) and *Acacia saligna* (Port Jackson). In a recent assessment, a total area of 274 ha in TBNR was found to be invaded by terrestrial and aquatic invasive plant species. For more information refer to the IAS control plan (**Annexure E**). An updated version of the plan is in development.

2.11. Aquatic invertebrates/benthic macrofauna

There have been a number of studies examining the aquatic invertebrate fauna of the Rietvlei/Diep system dating back to 1954 and as recently as 2021 (Clark et al, 2018; Gihwala et al., 2021). While some species occur throughout the estuary, in general there is a predominance of freshwater species in the vleis, and more marine species in the lagoon. Invertebrates are important as food for fish and wading birds.

2.11.1. Benthic macrofauna

Sampling conducted in 2021 resulted in a total of 728 macrofaunal organisms from six different species from sampling transects between the mouth of the lagoon up until the Otto du Plessis Bridge (Gihwala et al., 2021). This represents a dramatic decline in diversity since the earliest survey by Millard & Scott (1954). The authors recorded 47 species within Milnerton Lagoon in 1954, and this dropped to 23 in 1974 by Weil (unpublished data provided in Viskich et al. 2016) and in 2014 (Viskich *et al.* 2016). Interestingly, only six of the 69 species identified in total were recorded in all three surveys between 1954 and 2014 (Viskich *et al.* 2016). From these, only the polychaete *C. capitata* and the brachyuran *H. orbiculare* were observed in the most recent study (Gihwala et al., 2021).

Considering that 13 of 28 samples contained macrofaunal organisms and that only six taxa were identified in the most recent study (Gihwala et al., 2021), the presence of benthic macrofaunal communities is likely minimal. Whilst species of amphipods and isopods were recorded in previous surveys (Millard & Scott 1954, Viskich *et al.* 2016), none were reported in the most recent study (Gihwala et al., 2021). Nonetheless, the polychaete *C. capitata* dominated all samples and constituted 79% of the abundance, followed by spionid *Prionospio sexoculata.* The latter species was not reported again after 1954 in the 1974 and 2014 surveys and appears to be re-introduced to the system. Despite the substantial absence of taxa, one must be cognizant that seasonality will likely influence species richness within the system; as species richness was previously reported to be considerably higher during summer than winter surveys (Viskich *et al.* 2016). The majority of the new species recorded in the more recent surveys are that of insect groups which primarily inhabit freshwater environments. The 2021 study aimed to determine whether trace metals found in the system were affecting the macrofauna. The results indicated that the three main benthic macrofauna species do not appear to be negatively impacted by trace metal concentrations (Gihwala et al., 2021).

The abundance of sandprawns, *Kraussillichirus kraussi*, in the Milnerton Lagoon has declined dramatically and has shifted distribution between 1998 and 2014 (Viskich *et al.* 2016). In 1998, sampling by Clark (1998) indicated that the density of sandprawns was highest approximately 1100-1200 m from the mouth, with a population of over 8 x 10^6 prawns per 100 m block of estuary. Sampling in 2014 indicated that the peak density of sandprawns had moved closer to the mouth of the lagoon and did not extend as far into the estuary any longer, and the overall standing stock had more than halved (Viskich *et al.* 2016). This shift in distribution places a higher proportion of the already depleted population at risk from bait-collecting, which is limited to the below 1000 m from the mouth. It is possible the current population represents a recovery rather than a declining population as sampling in the early 2000s failed to find any sandprawns (Viskich *et al.* 2016).

Changes in the invertebrate component of the Diep River estuary are almost entirely attributable to habitat degradation as a result of various anthropogenic activities (Viskich *et al.* 2016). The most significant of these activities is the discharge of treated wastewater into the estuary from the Potsdam WWTW. This has resulted in a shift from a once estuarine system to a now predominantly freshwater system with very limited seawater input. Eutrophication is in all likelihood a key driver behind the significant increase in the total organic carbon content of sediment, leading to porewater anoxia. As such, the invertebrate community has suffered significant decreases in all indices (species richness/diversity, abundance and biomass).

2.12. Fish

2.12.1. Baseline description

Available data on the ichthyofauna of the Diep River estuary and Rietvlei include the early surveys of Millard & Scott (1954), summer and winter surveys conducted by Weil in 1974 (unpublished data provided in Viskich *et al.* 2016); 1976 (Bell 1976), a survey by Harrison in 1994, and 197 hauls conducted between May 2003 and April 2021 (S.J. Lamberth, DFFE unpublished data) (Clark et al., 2018). Sixteen indigenous, marine or estuarine species and two indigenous freshwater fish were recorded in the 1954, 1974 & 1976 surveys. Despite the high intensity of sampling post 2003, only 13 indigenous fish species were recorded. Several formerly abundant marine or estuarine species, such as white steenbras *Lithognathus lithognathus*, white stumpnose *Rhabdosargus globiceps*, Cape silverside *Atherina breviceps*, and Cape sole *Heteromycteris capensis* were either absent in the later samples, or only represented by a few individuals (<5). One indigenous freshwater fish, Cape galaxias *Galaxius zebratus* was found in the recent surveys, whilst a number of alien invasive or extralimital freshwater species, such as carp *Cyprinius carpio*, tilapia *Oreochromis mossambicus* and *Tilapia sparmanii*, were abundant.

The fish community in the Diep River estuary based on the most recent surveys conducted over the period 2003-2021 was dominated by harders *Chelon richardsonii* (previously known as *Liza richardsonii*) that contributed 77% numerically to the total average fish abundance. A further five taxa, estuarine round herring *Gilchristella aestuaria* (22%), barehead goby *Caffrogobius nudiceps* (0.6%), Mozambique tilapia *O. mossambicus* (0.4%), flathead grey mullet *Mugil cephalus* (0.2%), and banded tilapia *T. sparrmanii* (0.2%) comprised most of the remaining fish caught over the period 2003-2021 (five taxa accounting for 99.77% of the overall catch). A further seven species were represented by more than 10 individuals, three of which are estuarine associated marine species (*Pomatomus saltatrix*) or estuarine residents with marine populations (*A. breviceps* and *Clinus superciliosus*), whilst the remaining four species, *Pseudomyxus capensis, Galaxius zebratus, Gambusia affinis* and *Cyprinus carpio*, are freshwater or catadromous species.

There has been a clear shift in the Diep River estuary ichthyofauna from a largely estuarine and marine fauna documented in the historical data, to one dominated by harders, two estuary residents and a largely alien freshwater fish community. Harders are able to survive in both freshwater and marine environments, allowing their success in the system.

2.12.2. Fish health

The changes in the ichthyofauna (and other components of the ecology) of the Diep River estuary were attributed to habitat degradation by anthropogenic activities by Viskich *et al.* (2016). The major anthropogenic influence on the Diep River estuary is the discharge of treated wastewater from the Potsdam WWTW since 1960 (Viskich *et al.* 2016). This input has changed the estuary to a freshwater dominated system and has severely limited seawater ingress. The percentage of change in the fish community attributable to anthropogenic activities is estimated to be about 95%.

Despite the above, the Rietvlei/Diep system, which represents 10% of the available estuarine nursery area for fish on the west coast, has the potential to make a significant contribution to fish recruitment into the marine commercial and recreational line and beach-seine and gillnet fisheries for harders *Liza richardsonii*.

2.13. Birds

The regional importance of Rietvlei as a temporary vlei for waterbirds has contributed to the fact that of all the faunal groups, birds have been the most intensively studied, with research going back to 1938, and counts by the Cape Bird Club to 1947.

Within the Table Bay Nature Reserve there have been 201 bird species recorded in total, of which 102 species are waterbirds and 76 are regularly present (Marnewick et al., 2015). A progressive increase in overall abundance of water birds was reported between the 1950s and 1990s (Kalatja-Summers et al., 2001). Analysis from 2001-2003 indicated a decline (Keyser, 2003), likely correlated with changes in bird habitat, extensive development, and expansion of certain types of vegetation, including alien invasives (Jackson et al., 2008). However, the vlei supports an average of 5 550 birds and as many as 15 000 birds in summer. Citizen data from iNaturalist indicates that 127 bird species have been observed within the reserve in recent years.

The reserve is important for birds and its proximity to the coastline means both freshwater and coastal species utilise the system (Marnewick et al., 2015). Threatened and near-threatened species found in the reserve include Greater Flamingo, Lesser Flamingo, Great White Pelican, African Marsh Harrier, African Black Oystercatcher and Chestnut-banded Plover (Marnewick et al., 2015). More information can be found in Important Bird and Biodiversity Areas of South Africa (https://www.cepf.net/resources/documents/south-africas-important-bird-and-biodiversity-areas-status-report-2015).

In a synthesis report compiled in 2001 (Kalatja-Summers et al., 2001), the Curlew Sandpiper was reported as the most abundant species, with the maximum count exceeding 7000. However, records from citizen data (CWAC) indicate that the last time the bird was observed in the area was 2007, when 27 individuals were recorded in the Central Pans of the Rietvlei Wetland Reserve. The Curlew Sandpiper is categorised as near threatened on the IUCN list. The 2001 analysis also indicated that a number of species were decreasing in numbers (Yellow-billed Egret, South African Shelduck and Greenshank). According to CWAC data, the last time a South African Shelduck was observed was in 2005, when three individuals were seen in the Central Pans of the Rietvlei Wetland Reserve. It is, however, suggested that more concerted effort be placed on monitoring threatened species to more accurately determine their numbers.

Kaletja-Summers et al. (2001) noted that there were some new species recorded in the area, such as kingfishers and cormorants, and it is fortunate to note that these species are still present in the area (CWAC, nd; iNaturalist, nd).

The TBNR area is still rich in bird life and there is still a draw to the area for birders. An observation session for CWAC on 18 February 2018 yielded a reported 15 species and a total count of 1182 birds along 90 m of the shoreline of the south vlei section of Rietvlei. Another observation session on 20 November 2020 yielded a reported 18 species and total count of 281 birds along 100 m of the Diep River. The iNaturalist and CWAC data is not official nor completely standardised sampling, so the results should be assessed with caution. However, they are the most recent surveys done in the area.

2.14. Other fauna

There has not been a detailed study of mammals in the Rietvlei area, but the TBNR IRMP identified 31 mammals which are likely to occur there. This includes a number of rodents and small mammals including duiker, cape clawless otter, steenbok, hares, mongooses, and genet, but most are threatened by encroaching development (Retief, 2011). Data from iNaturalist indicates that Cape dune molerat, Cape grysbok, caracal, marsh mongoose, brown rat, brown fur seal, steenbok, four-striped grass mouse and Cape molerat have been spotted in recent years.

2.15. Climate Change Impacts and Risks

Climate change is likely to affect change in global estuaries. The effect will likely occur as a result of changes in oceanic circulation, modifying terrestrial climate and hydrology, ocean acidification, sea level rise, and increased intensity of weather (heat, storms and rainfall etc.; Day et al. 2008; Day et al. 2011; Gillanders et al. 2011; Newton et al. 2014; Robins et al. 2016, cited in van Niekerk et al, 2019). Determining the more specific quantified effect of climate change on Cape Town's estuaries and the Diep River estuary in particular is difficult as global change models do not cater for site specific systems with limited data (van Niekerk et al., 2019).

2.15.1. Floodplains

Wetlands and estuaries are crucial in mitigating the impact of flooding from high rainfall events. They are able to absorb large volumes of water and divert water from homes and infrastructure. Climate change is predicted to increase the intensity and frequency of storms, which are associated with high rainfall and wave surges. A *Floodplain and River Corridor Management Policy* is in place to ensure sustainable development and activities within or adjacent to watercourses or wetlands. The policy aims to reduce exposure to flooding by avoiding risky or unwise use of floodplains. Generally, development is only permitted in zones with a flood risk of one in greater than 100 years. The 1:100 year floodplain of the Diep River extends beyond the currently defined EFZ to the north of Flamingo Vlei and in the upper channel (Figure 13). The floodlines were determined in 2000 and are unlikely to have considered sea level rise or other climate change impacts, or the extent of upstream development which has occurred in the past 20 years.

2.15.2. Hydrological change

It is predicted that the Western Cape will experience a decrease in rainfall, resulting in less fresh water entering the system. All estuaries are sensitive to changes in freshwater inflow, as it affects mouth closure, the extent of saline intrusion from coastal seawater, concentrations of land-derived biogeochemical inputs, sediment dynamics and contaminant behaviour and accumulation. Decreased freshwater inflow would also intensify the wet-dry cycles and potentially cause detrimental damage to the functioning of the system. It is, therefore, imperative to monitor freshwater inflow from rainfall and the Potsdam WWTW.

The effect of sea level rise (SLR) is challenging to quantify, however estimates place rises between 0.5 m (best case) and 2 m (worst case) by the year 2100 (Pfeffer et al. 2008; Milne et al. 2009; Rossouw and Theron 2009; Nicholls and Cazenave 2010; AMAP 2011; Theron et al. 2012; Church et al. 2013). It is predicted that there will be an increase in frequency and intensity of sea storms, coinciding with increased wind stress, rainfall intensity and wave height and power (Theron, 2007), but exact values for potential changes are lacking, not to mention the constantly evolving science in the domain of oceanographic processes. There are uncertainties surrounding the effects of SLR coupled with intensified storms and the associated challenges. Efforts should be made to protect the integrity of the watercourses to allow them to absorb and redirect water safely.

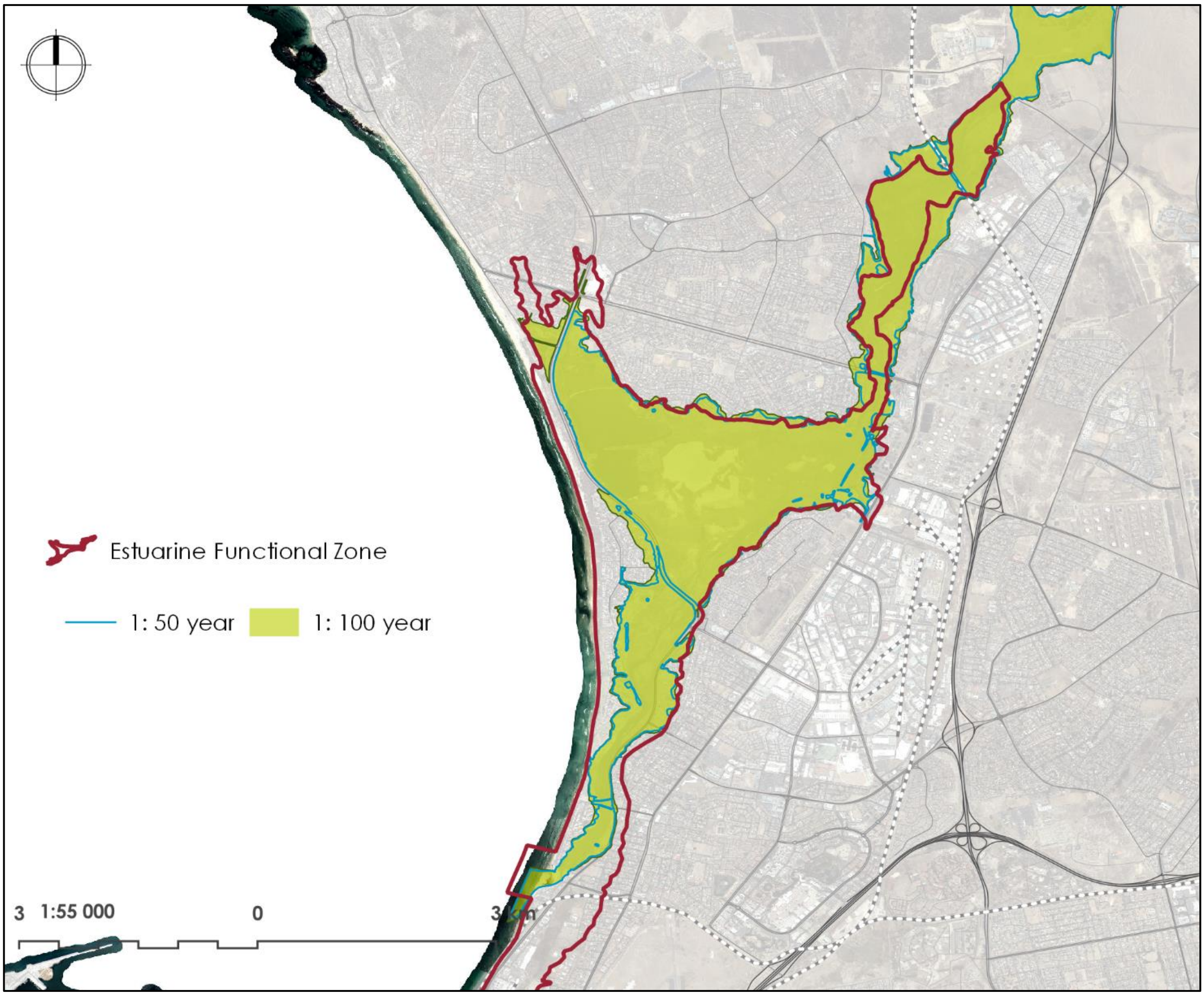


Figure 13. Floodplain of the Diep River

2.15.3. Carbon sequestration and loss

Estuarine habitats that exist within the Diep River system, such as salt marsh and submerged macrophytes, are highly productive systems that have the capacity to sequester carbon at a rapid rate (Barbier *et al.* 2011; Beaumont *et al.* 2014). It is now widely acknowledged that the regulation of both local and global climate through the potential carbon storage of estuarine habitats is significant (Beaumont *et al.* 2014; Sidder 2018). Recent research by Krauss *et al.* (2018) has shown that even upper estuary habitats, such as tidal freshwater forested wetlands and low-salinity marshes, store significant amounts of carbon, in some instances even exceeding those of seagrass and salt marsh ecosystems. In South Africa, the role of estuarine habitats as a source and sink of greenhouse gases is comparatively unknown (Van Niekerk et al., 2019).

Carbon stored within coastal and marine ecosystems is termed 'blue carbon' (Siikamäki *et al.* 2013). Carbon is sequestered from the atmosphere and stored in the soil where it can stay for millennia (Van Niekerk et al., 2019). However, many of these coastal habitats are threatened. Estuarine habitats are detrimentally affected by freshwater reduction, habitat destruction, nutrient pollution, and overexploitation of living resources. These pressures affect the capacity of estuaries to buffer against natural or anthropogenic change (Van Niekerk et al., 2019).

2.15.4. Impacts of waterbody health and biodiversity

Another impact of climate change is coastal acidification. The effects may only be felt in the very long term but will ultimately result in pH and oxygen changes in estuaries (Caldeira and Wicket, 2003). This will have effects on biotic processes such as community composition, nursery function and behavioural responses. It is important to note that as there is a natural variability in the pH of estuaries the biotic communities may already have some resilience to change. However, the variable pH levels may be amplified by ocean acidification, resulting in more extreme conditions with further detrimental impact (Hofmann et al., 2011).

It is generally accepted that there will be a shift in global temperatures and that estuaries, especially those with sections of shallow water, will be affected by increases in land temperatures. Higher land temperatures are likely to influence community composition and species distribution, reproduction, growth, behaviour, mortality, predator-prey and parasite host relationships as well as competition for resources (Van Niekerk et al., 2019). As species experience temperature changes and associated effects, their distribution may increase or decrease, leading to potentially unpredicted species interactions (Murawski, 1993; Perry *et al.,* 2005; Clark 2006; Harley, *et al.,* 2006; USEPA 2009, James *et al.,* 2013 <u>cited in</u> Van Niekerk *et al.,* 2019)).

A potentially less considered effect of climate change is the change in biochemical inputs – suspended solids, particulate organic matter (POM) and dissolved oxygen – which are generally linked to freshwater inflow (Van Niekerk et al., 2019). Suspended solids and POM usually enter an estuary via rivers and therefore it is likely that the Diep River Estuary will become less turbid and have decreased POM input as river inflow is expected to decrease in the Western Cape (Van Niekerk et al., 2019). Another factor which is important is nutrient inputs, which usually also enter the system via river inflow, upwelling and processes occurring within the system such as primary production (e.g. De Villiers and Thiart 2007; Taljaard et al. 2009; Gillanders et al. 2011). However, the nutrient loads entering estuaries have been increased by anthropogenic sources (Van Niekerk et al., 2019), sometimes to a level where the ecosystem is unable to process the nutrients and return the system to a healthy state. This can lead to eutrophication (Van Niekerk *et al*., 2019).

2.15.5. Climate change induced coastal pressures

Climate change is projected to have a range of negative impacts on the coastline. These impacts might include increased coastal erosion because of sea-level rise, shifting wind regimes and ocean currents, warming temperatures, and reduced freshwater input into estuarine systems. While sea level rise is seen as a long-term risk, coastal erosion is already happening in several coastal zones along the city's coastline. A notable 'hotspot' is located immediately north and south of the Diep River estuary mouth. See the Milnerton Erosion Response Guideline and the Dune and Beach Maintenance Management Plan, which provide a user friendly guideline to both the City and affected residents in responding to coastal erosion as well as an operational guideline that the City uses for dune and beach rehabilitation and management respectively. The Climate Change Action Plan provides more information on the City's goals and actions in achieving a sustainable and climate resilient city.

The City's Integrated Coastal Management Policy (2014) recognises climate change as a risk, and commits to ensuring the following:

- That coastal development takes place in a way that does not compromise the coastal environment's ability to buffer against climate change-induced risks and hazards.
- That decision-making related to the coastline considers the need to respond to climate change and climate induced coastal risk over the short, medium and long term.
- The implementation of proactive and progressive measures, including socio-institutional responses, to reduce coastal risk from climate change, sea level rise and storm surge events.
- Where natural systems still exist, ensuring the protection and maintenance of these natural systems to preserve their integrity and therefore their ability to respond to climate risk.

Requiring all new coastal developments and changes to existing developments to incorporate mitigation of and/or adaptation to the impacts of coastal climate change as part of the approval process.

2.16. Socio-economic context

The Diep River estuary is situated in the City of Cape Town with the river catchment extending into the Drakenstein, Stellenbosch, and Swartland municipalities. The immediate context is characterised by increasing densification and a wide range of land uses including heavy industry, residential, commercial, and informal settlements. Natural systems such as estuaries and rivers provide ecosystem services in the areas in which they occur. The Diep River Estuary catchment covers a large area and thus offers a varied number of services along different points in the catchment. Some of the socioeconomic services that the Diep River estuary provides are:

- Wastewater management – the estuary is the discharge point for a significant and growing portion of Cape Town's treated sewage and stormwater. The system is under significant stress from the decreasing quality and increasing quantity of this effluent.
- Removal of excess nutrients from inflows to the estuary, both in the Diep River itself and in the urban discharge.
- Higher property values and municipal rates in residential areas close to the estuary.
- Recreation and tourism
- Nursery areas for juvenile fish forming part of commercial fisheries.

2.16.1. Demographic and economic profile

The socio-economic context of the areas around the Diep River Estuary system is varied. The area is characterised by informal settlement and rapid greenfield residential development in the north and established, slow growing suburbs in the middle and lower reaches of the estuary. The StatsSA 2011 census data as well as the Blaauwberg District Plan's 2018 State of the Population Report were utilised to contextualise the demographics within the system. Figure 14 summarises some of the key socio-economic indicators of the Diep River Estuary catchment area per ward (Figure 15).

Ward 104

Ward 104, which includes the Du Noon informal settlement, grew significantly between 2011 and 2018, and now has the highest population density in the Blaauwberg District of the City of Cape Town (City of Cape Town, 2019). Du Noon informal settlement is densely populated and has poor access to sanitation and stormwater services. In addition to Du Noon, an informal settlement has more recently been established in the flood plain adjacent to Malibongwe Drive. Solid waste and grey water are discarded onto the ground surface, into stormwater drains, as well as directly into the Diep River (Gqomfa, 2020). Only 34% of households in this ward lived in formal dwellings in 2011, a proportion that is likely to be even lower today. Nearly 80% of residents were below the poverty line of R 3 200 monthly household income in 2011, and only 60% had access to a flush toilet. Located at the upper end of the Diep River estuary, the lack of services in this area impacts on the estuary downstream.

Figure 14. Key socioeconomic indicators for wards located in the Diep River Estuarine Functional Zone (2011 demarcation in line with most recent census data).

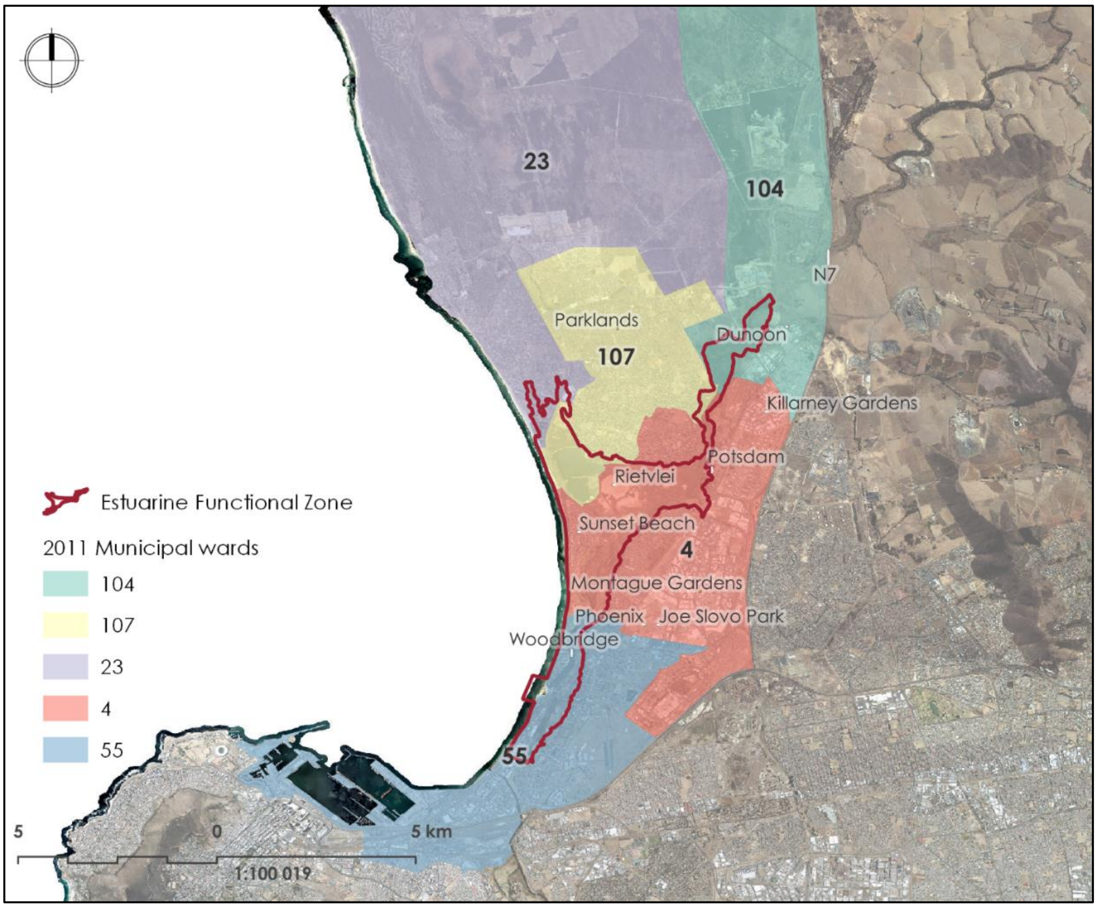


Figure 15. Municipal wards (2011 demarcation) in and around the estuary

Ward 107

Ward 107 includes the suburbs of Parklands, Sunningdale, and Table View, surrounding the Flamingo Vlei section of the estuary. The population of this area grew by nearly 200% between 2001 and 2011, and Parklands grew by more than 100% between 2011 and 2018 (City of Cape Town, 2018). In 2011, more than 99% of the population lived in formal dwellings and had access to basic services. Ward 107 remains a key growth area with new developments ongoing to the north of Sandown Road since the completion of key transport infrastructure links in this area.

Ward 4 (split into wards 113 and 4 in 2016)

Ward 4 includes Century City, Killarney Gardens, Milnerton, Montague Gardens, Summer Greens, Table View, Brooklyn, Marconi Beam, Milnerton South, Paarden Eiland, Rugby, and parts of Salt River, Woodstock and Ysterplaat. These suburbs are older, well-established and located close to the Cape Town CBD. The population growth of the area between 2011 and 2018 was relatively low (0 to 25%) except in the Sandrift and Marconi Beams areas which grew more rapidly (City of Cape Town, 2018). Ward 4 includes significant industrial areas, and the middle reaches of the estuary are impacted by runoff from these areas as well as the Potsdam WWTW, also in Ward 4. Ward 113 has approximately 39 000 inhabitants which live in close proximity to the Diep River and Rietvlei.

Ward 55

Ward 55 includes the lower reaches of the Diep River Estuary, incorporating the suburbs of Woodbridge, Lagoon Beach, and Milnerton. The population growth in this area has been relatively low as most of the suburbs in this ward are established with little space for expansion.

2.17. Human activities affecting the estuary

2.17.1. Physical changes

The banks of the Diep River were cultivated by Dutch settlers as early as 1690 (Clark et al. 2018), and the fertile soils of the catchment lent themselves to expanded agricultural use with more than half the surface area of the catchment now under cultivation, primarily for grains. Early maps (Figure 16) show that the Diep River estuary in the 18th century shared a mouth with the Liesbeek and Black Rivers 3 km to the south, separated from the coast by a line of dunes and following the alignment of the present-day Zoarvlei.

By the middle of the 19th century, the Rietvlei had silted up and a new mouth had opened close to its present-day position (Clark et al, 2018). In 1905, steam dredgers were used to deepen parts of the Diep River estuary for rowing regattas. By 1920, a sandbar had developed that closed the mouth. Boating activities were seriously curtailed by the shallowing of the system and in 1928 attempts were made to address the problem by building a weir across the river mouth to increase water levels. The weir caused floodwaters to back up and flood the adjacent residential areas, and it was eventually demolished after being damaged during floods in the 1940s.

Rietvlei originally comprised a series of seasonally flooded pans. These were inundated during the early winter when the Diep River would break its banks. Water and silt that had washed into the pans, gradually dried up through evaporation. The pans generally stood empty for several months in late summer before the return of the winter floods. Silt deposited during the wet phase was removed during the dry phase through strong winds lifting dust and sand from the dry pans. In the early 1970s, five million cubic metres of sand and soil was dredged from Rietvlei and pumped across Table Bay to provide fill for an extension of the Cape Town Docks. This left a nine-metre-deep lake now known as Flamingo Vlei (which comprises North Vlei and South Vlei) located on the north-western section of Rietvlei, and which has become an important water-sport recreational area.

Figure 16. Excerpt from an early map of the Cape Town area showing the confluence of the Diep River with the Black River at what is now Paarden Eiland (ACO Collection).

Residential development around the estuary started in 1897 with the first subdivisions for the Milnerton Estates Limited and has continued ever since, with the Sandown and Parklands areas remaining among the fastest-growing parts of Cape Town. The Woodbridge Island development constructed in 1985 at the mouth of the Milnerton Lagoon raised the ground level between the lagoon and the sea using material dredged from the estuary.

2.17.2. Agriculture

Intensive agriculture in the catchment has led to high levels of erosion, which has in turn caused siltation within the Diep River and estuary. Although no water is abstracted directly from the estuary, water abstraction within the catchment for agriculture has decreased the amount of runoff, contributing to a considerable reduction in the flows reaching the estuary from the catchment. Under natural conditions the inflow from the river would be 60.8 million cubic metres per annum (Mm^3/a); present-day inflows are reduced to 37.3 Mm^3/a (Clark et al., 2018).

2.17.3. Potsdam Wastewater Treatment Works

The Potsdam WWTW, constructed in 1960, is located on the eastern edge of the estuary. It receives sewage from the Milnerton, Century City, and Montague Gardens areas (Figure 17) and discharges treated effluent directly to the estuary. A channel to bypass flows around Rietvlei itself was constructed in 1991/92 and the treatment works was expanded and upgraded in 2004.

In 2020/21, the WWTW discharged a daily average of 25.9 megalitres (Ml) of treated effluent to the estuary (Figure 18). There is significant seasonal variation, however, with winter discharges rising to as high as 55.9Ml on one day in July 2020. Peaks in discharge correlate with higher rainfall, due presumably to stormwater ingress into the sewer system.

During the summer months, when there is little or no flow from the river or stormwater drains, Potsdam WWTW is the primary source of freshwater to the estuary. This input has changed the estuary to a freshwater dominated system and has severely limited seawater ingress. However, a high proportion of effluent is now reused for irrigation, particularly during the summer months (Figure 18). At these times discharge to the estuary drops to as low as 4.1 Ml per day.

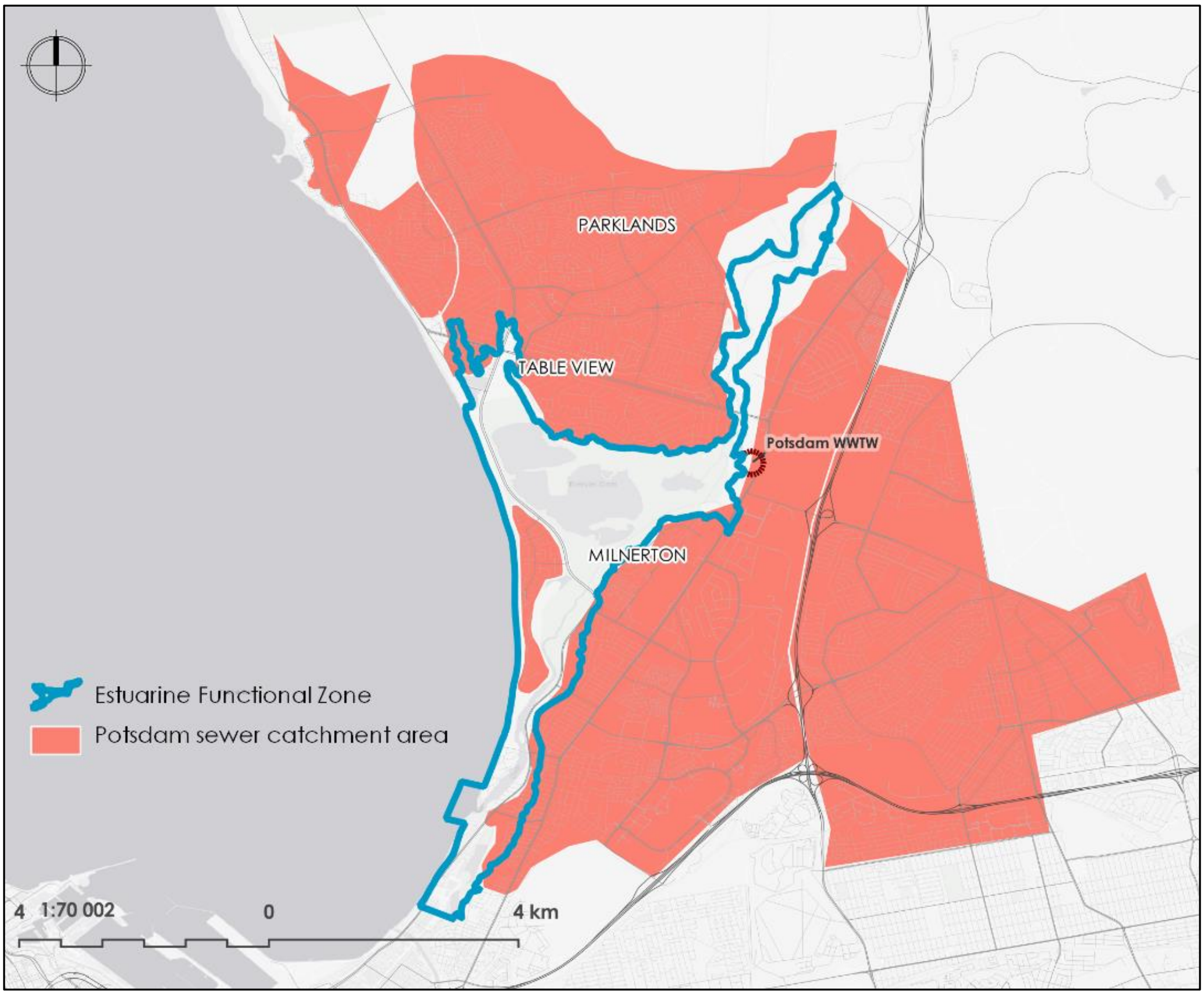


Figure 17. Catchment area for the Potsdam WWTW. Sewage from Parklands, Table View, Milnerton, Century City, Edgemead and other areas is discharged, after treatment, to the estuary

The quality of the Potsdam WWTW effluent has a significant influence on water quality in the estuary during summer, if not the whole year round. For *E. coli* and nutrients, for example, the estuary downstream of the outflow regularly exceeds the RQOs (see section 2.7).

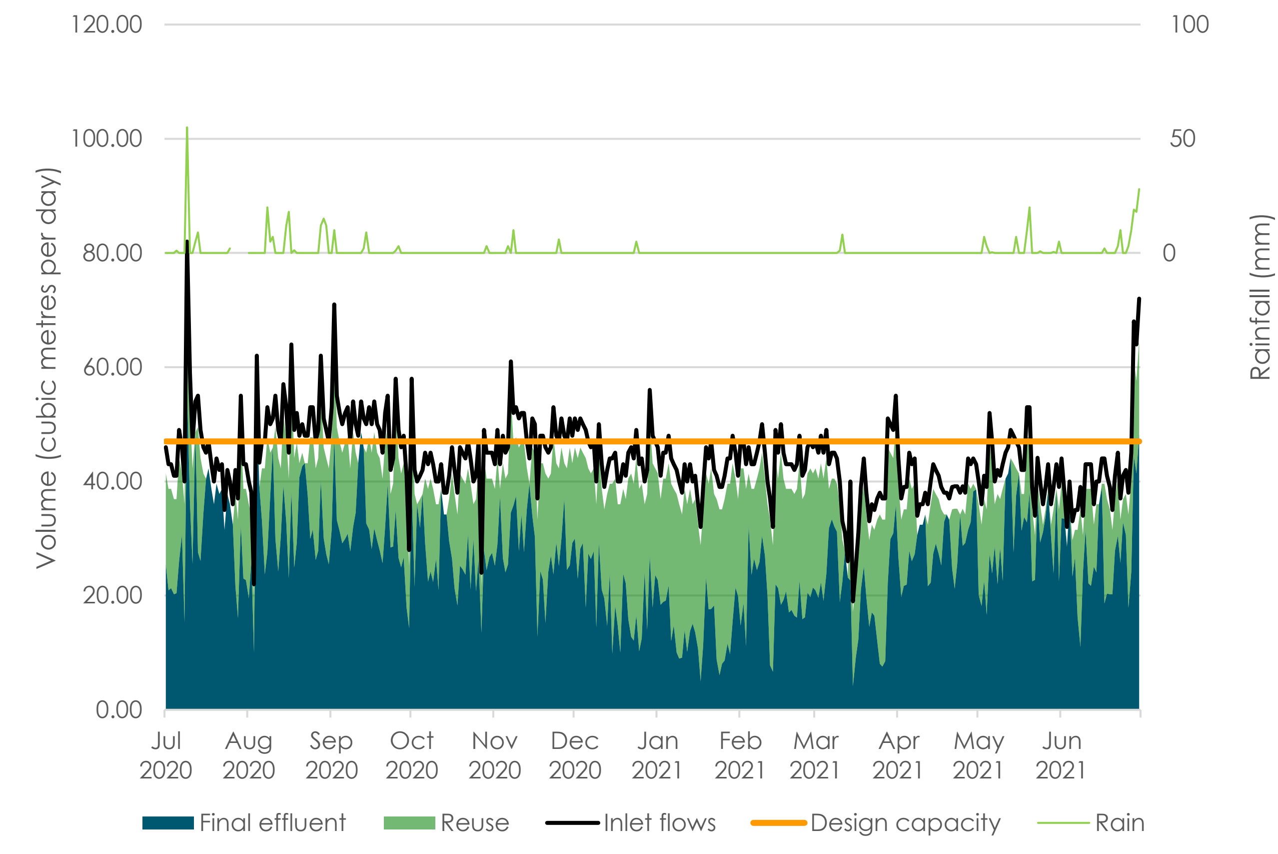


Figure 18. Daily intake, reuse and discharge volumes at the Potsdam WWTW in 2020/2021

2.17.4. Stormwater runoff from residential and industrial areas

Stormwater runoff from the urban areas surrounding the estuary is directed via the stormwater system of conduits, open channels, and attenuation facilities. Stormwater from residential areas contains pathogens, nutrients and solid waste; this includes both formal residential areas where stormwater runoff may contain fertilisers, salts, and pathogens, and informal residential areas where untreated sewage and solid waste may enter the stormwater system. Unless treated at source or before entering the estuary, these pollutants enter the estuary.

2.17.5. Sewerage infrastructure in the Milnerton/Blaauberg area

Overflows and spills of raw sewage into the estuary via the stormwater system occur frequently as a result either of blockages in the sewer infrastructure in the catchment or malfunctions of sewer pump stations. Between 2015 and 2020, nearly 35 000 sewer spills or blockages were reported in the catchment on the City's C3 electronic reporting system (Figure 19 and Figure 20). More spills occur in winter than in summer, due to capacity constraints and stormwater ingress into the sewer system. Areas of higher frequency of spill events include Du Noon, Brooklyn, Joe Slovo Park, and Phoenix.

The C3 data may include both under- and over reporting – multiple complaints may be received about a single event while if a spill goes unnoticed by the public it may not be reported on this system at all. Reports where geographic coordinates were not accurate or not provided will have been excluded.

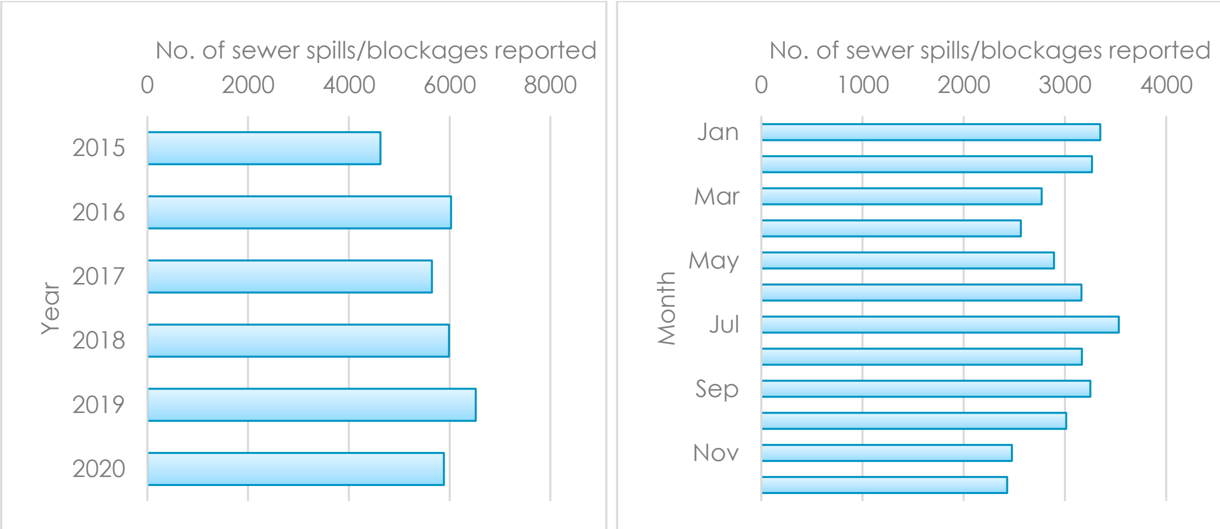


Figure 19. Total number of sewer spills/blockages reported via the City's C3 system within the catchment of the Diep River between 1 January 2015 and 22 October 2020, by month and by year

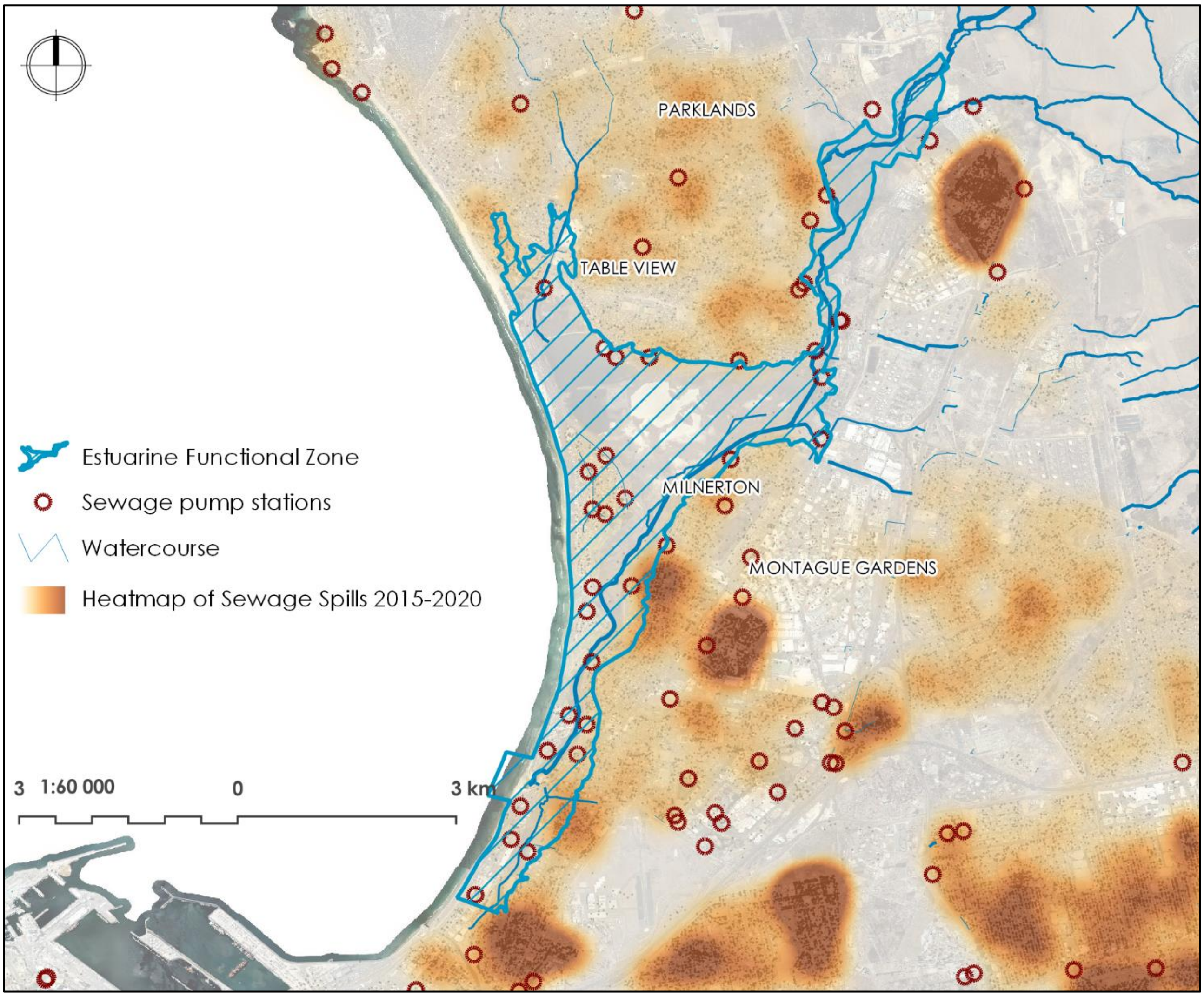


Figure 20. Heatmap of sewer spills/blockages reported via the City's C3 system within the catchment of the Diep River between 1 January 2015 and 22 October 2020

2.17.6. Development and land use change

Significant new residential, commercial, and industrial development has occurred in the area surrounding the estuary over the past three decades (Figure 21), with over 2 800 hectares of new urban development since 1988. This implies an increase in stormwater runoff due to new hardened surfaces, a decrease in stormwater quality, and an increase in sewage. Parklands remains one of the fastest-growing suburbs in Cape Town, and Du Noon has also expanded rapidly in the past five years.

2.17.7. Informal settlements and underserviced areas

There are a number of informal settlements in the area that impact on water quality via stormwater and or surface runoff. These include Doornbach and Du Noon at the upper end of the estuary. Other areas, such as Joe Slovo Park and Phoenix, have formal housing but may be considered underserviced given the high prevalence of backyard shacks. Stormwater from the Du Noon area discharges directly to the river above the Blaauwberg Road bridge, while Joe Slovo Park and Phoenix drain via the Erica Road stormwater drain, reaching the estuary opposite the tennis courts at Milnerton High School.

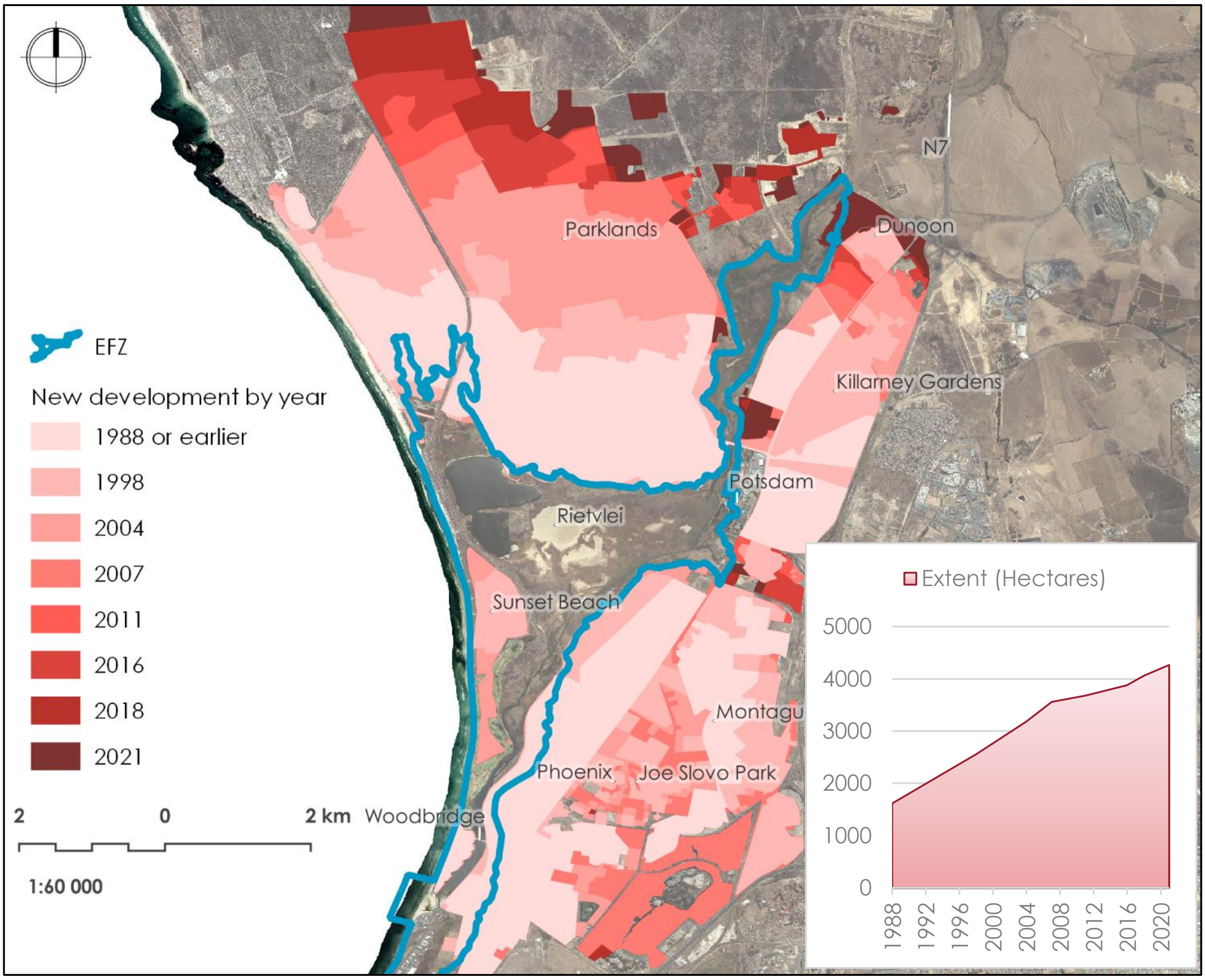


Figure 21. Extent of new development adjacent to Rietvlei and the Diep River estuary over the past three decades

2.17.8. Recreation

The Flamingo Vlei section (north lake) of Rietvlei is popular with recreational users for sailing, canoeing, water-skiing, wakeboarding, and windsurfing. The Milnerton Lagoon section is also used by canoeists and kayakers. Other recreational uses of the estuary include walking, birding, picnicking, fishing, and bait collection. An environmental education centre provides a range of environmental education programmes and includes two bird hides. Milnerton Golf Course is located within the EFZ and includes an extensive landscaped area directly abutting the adjacent estuarine habitat.

2.18. Summary

The Diep River estuary is a thoroughly modified estuarine system occurring entirely within South Africa's oldest and most populous city. In this context the persistence of estuarine processes and habitat, and the management of the estuary for biodiversity, recreation and functionality, are beset by several challenges (Figure 17).

2.18.1. Catchment-scale issues

As for any estuary, the quality and quantity of inflows from the river catchment is a major determinant of estuarine health and function. These are often beyond the control or mandate of the management authority responsible for the estuary itself.

In the Diep River catchment, extensive **agriculture** covers more than half the land surface. This increases siltation in the river, contributes to high nutrient loads, and lowers the flow due to abstraction for irrigation purposes.

Urban areas in the broader catchment, including Malmesbury and Klapmuts, are a source of runoff to the river. The latter includes stormwater runoff with contaminant loads from roads, gardens, and industrial areas, but also sewage where failing or blocked sewer pipes spill into the stormwater system. The Diep River estuary receives runoff from at least 4 140 hectares of urban areas in its immediate surroundings, including industrial areas, informal settlements and a golf course.

The estuary is also the discharge point for **treated effluent** from more than 75 000 households and significant industrial areas. An increasing number of residents depend on the sewer system in the catchment and the effluent cannot feasibly be treated or discharged elsewhere than at Potsdam.

2.18.2. Estuary-scale issues

The estuary is in an urban area and surrounded by development. **Infrastructure**, particularly roads and rail, crosses the estuary. Four road bridges, a pedestrian bridge and a rail bridge cross the EFZ, and various legacy infrastructure may also remain in place, including remnants of weirs, pipelines, and other structures. The estuary mouth is constrained by development on both sides and can no longer migrate north and south as was historically the case. These factors constrain flow in the estuary and alter the movement of sediment, reducing the ability of the system to flush accumulated sediments, nutrients, and contaminants during high flow periods.

The low-lying and flat topography of the surrounding urban areas mean that sewage is not conveyed entirely by gravity but must be pumped under pressure to the WWTW. No fewer than 38 **sewer pump stations** are located within the catchment of the Diep River within the City's area of jurisdiction. The City is in the process of developing sewer pumpstation failure protocols for pumpstations across the City. An example of such a protocol for a pumpstation falling within the Diep River catchment is included as **Annexure F**. During power failures, blockages, or equipment breakdowns, the sewer system surcharges and spills either at the pump stations or at manholes in their vicinity.

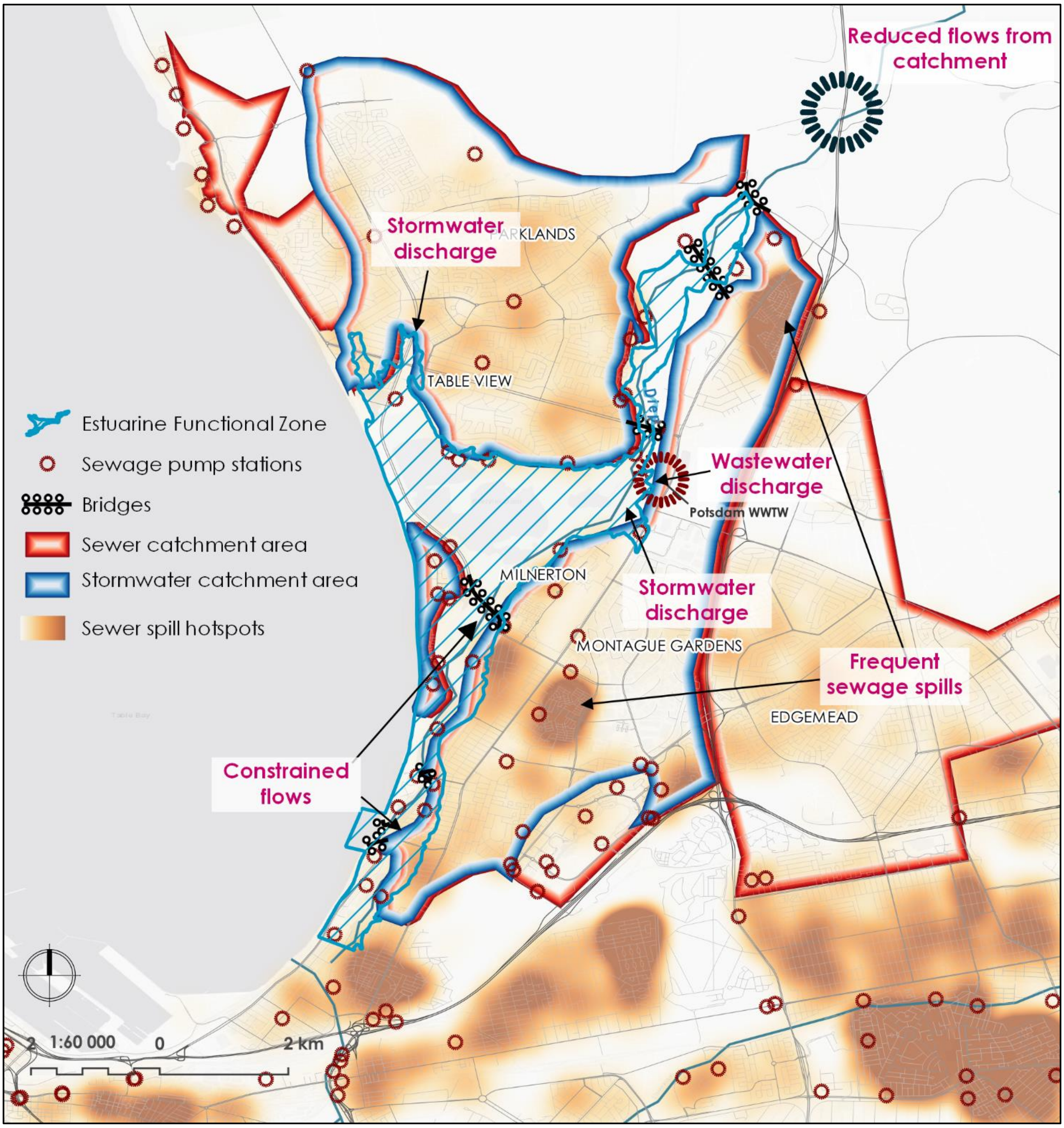


Figure 22. Pressures on the estuary

3. VISION AND KEY OBJECTIVES

3.1. Overarching vision

The following vision and overall objective for the Diep River estuary were adopted in 2008 through a public process forming part of the first EMP:

> ***Vision**: The Diep River, Rietvlei and Milnerton Lagoon are natural assets, beautiful and rich in biodiversity, and a part of our heritage. They should be restored, enhanced and protected for sustainable use and appreciation by current and future generations.*

> ***Overall Objective**: To manage the Diep River Estuary in a manner that ensures its sustainability compatible with the ideals of conservation of a heavily altered and rapidly changing urban ecosystem of significance for biological diversity.*

This vision and objective must be reassessed in the context of an estuary under extreme and increasing pressure from urban impacts, as set out in the updated situation assessment above. It is suggested that they be amended as follows:

> ***Vision**: The Diep River, Rietvlei and Milnerton Lagoon are important societal, cultural and ecological assets that support biodiversity and provide a wide range of ecosystem services to a growing metropolis. They should be managed, enhanced and protected for sustainable use by current and future generations.*

***Overall Objective**: To manage the Diep River Estuary and associated waterbodies - an ecosystem of significance for biological diversity - in a manner that ensures its sustainability, and is compatible with pragmatic conservation goals set within the context of a heavily altered and rapidly changing urban ecosystem.*

This draft amended vision and objective should be tested in public engagements during the formal review of the EMP.

3.2. Key objectives

Management objectives for the Diep River estuary include the following broad focus areas:

- Compliance with the resource quality objectives defined for the estuary, by mitigating the point and non-point source pollution inflows from the urban catchment.
- Retention of estuarine function and protection of biodiversity within the Rietvlei and adjacent terrestrial and wetland areas while working to re-establish biodiversity in Milnerton Lagoon.
- Sustainability of ecosystem services, including recreation, management of stormwater flows, and management of treated effluent from a rapidly growing urban area.
- Improvement of communication and education regarding the current and achievable future state of the estuary.

4. MANAGEMENT OBJECTIVES

The objectives set out in this section are based partly on legislated requirements set in the Resource Quality Objectives determined by the Department of Water and Sanitation in November 2020. They should be read together with section 7 of this report, which speaks to the feasibility of and timeframes for compliance, and with section 6, which sets out actions and responsibilities. It must be emphasised that the nature of current and ongoing impacts on the estuary are such that these objectives may not be achievable within the 5-year timeframe of this EMP. See section 7 for further details.

4.1. Conservation objectives

The following objectives relate to the protection of fish, invertebrate, vegetation, and avian biodiversity in the Rietvlei and Milnerton Lagoon, as well as the protection of habitats and ecosystems to meet national targets. Objectives marked *(RQO)* are gazetted resource quality objectives, while *(RQO-S)* denotes 'supplementary information' published with but not forming part of the gazetted RQOs. Thresholds of probable concern (TPCs) are also provided based on the RQO Report (2018) or other factors where no RQOs are applicable.

Table 4: Conservation objectives based on legislated requirements

#	CONSERVATION OBJECTIVE	THRESHOLD OF PROBABLE CONCERN (TPC)
C1	**Maintain and improve the overall present ecological status of D.** ***(RQO)***	Present Ecological Status score of 42% (D/E) in any one zone or overall
C2	**Maintain and restore areas of critically endangered Cape Flats Sand Fynbos within the EFZ.** ***(RQO-S)***	n/a
C3	**Maintain the distribution and area cover of macrophyte habitats, particularly the salt marsh.** ***(RQO)***	10% decrease in the area covered by different plant community types
C4	**Restore and maintain species richness, distribution of species, and mix (currently low species abundance, high dominance) of invertebrate macrofauna. Indicator species such as *Capitella capitata* should not dominate benthic communities at any site;** *Krausillichirus* ***kraussi*** **and** ***Upogebia africana*** **distribution patterns similar to reference state.** ***(RQO)***	Species richness decreases by more than 25% in any of the invertebrate categories (zooplankton, subtidal zoobenthos or intertidal benthos)
C5	**Restore and maintain the full complement of estuarine resident and estuary-associated marine fish present in the estuary with population sizes sufficient to ensure their persistence in perpetuity; ensure that exotic freshwater species do not increase to levels where they can exclude indigenous species through predation or competitive interactions; Maintain recruitment of adult and juvenile fish at present levels.** ***(RQO)***	Community composition (representation by estuarine resident, marine migrant or freshwater species) decrease by >25%
C6	**Retain at least 90% of the baseline species richness, abundance and diversity of the bird community determined using regression slope based on a 3-year running average.** ***(RQO)***	The number of non-passerine waterbird species recorded in counts decreases by >20% across five or more annual surveys
		The overall numbers of any of the defined groups decreases relative to the baseline average by >20% over a five-year period, after correcting for regional/global population changes.

#	CONSERVATION OBJECTIVE	THRESHOLD OF PROBABLE CONCERN (TPC)
		The numbers of any species decrease relative to the baseline average by >20% over a five-year period, after correcting for regional/global population changes.
C7	**Maintain low phytoplankton biomass (chlorophyll-a < 50 µg/l) and a diversity of phytoplankton groups, such that phytoplankton biomass and composition are suitable for invertebrates, fish, birds and recreational use.** *(RQO)*	Phytoplankton biomass >50 µg/l
C8	**Reduce illegal fishing by recreational fishers and by poachers using gill nets.** *(RQO-S)*	n/a
C9	**Prevent any further development in open space in the EFZ other than for conservation-related purposes.**	Any new development in open space within the EFZ.
C10	**Control alien and invasive species within the EFZ and the catchment; maintain or increase the extent of natural vegetation versus invasive vegetation in the EFZ.** *(RQO-S)*	5% increase in cover of alien and invasive vegetation
C11	**Promote recreational uses that do not compromise the biological integrity of the system.**	n/a

4.2. Water quantity objectives

The following objectives relate to hydrology, flows and hydrodynamics in the estuary, and are based on the Reserve Determination undertaken by Clark et al. in 2018. Objectives marked *(RQO)* are gazetted resource quality objectives, while *(RQO-S)* denotes 'supplementary information' published with but not forming part of the gazetted RQOs. Thresholds of probable concern (TPCs) are also provided based on the RQO Report (2018) or other factors where no RQOs are applicable.

Table 5: Water quantity objectives

<table>
<tr><th>#</th><th>WATER QUANTITY OBJECTIVE</th><th>TPC</th></tr>
<tr><td>H1</td><td>Maintain freshwater inflow adequate to maintain water quality and habitat suitable for flora and fauna. Specifically, ensure that Mean Monthly Runoff (MMR) and Mean Annual Runoff (MAR) meet the following parameters as a percentage of natural / reference values: (RQO)
<table>
<tr><th>Month</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Annual</th></tr>
<tr><td>MMR/ MAR as % of natural</td><td>80 %</td><td>80 %</td><td>80 %</td><td>93 %</td><td>100 %</td><td>100 %</td><td>80 %</td><td>80 %</td><td>80 %</td><td>80 %</td><td>80 %</td><td>80 %</td><td>80 %</td></tr>
</table></td><td>Total freshwater inflow should not drop below 0.3 m^3/s or 0.8 Mm^3 / month.</td></tr>
<tr><td>H2</td><td>Maintain the seasonality of the Rietvlei wetlands, with inundation / saturation occurring only in winter. (RQO-S)</td><td>n/a Clear interruption of/ deviation from seasonal trends i.e. longer or shorter inundation periods</td></tr>
</table>

#	WATER QUANTITY OBJECTIVE	TPC
		as compared to the baseline.
H3	**Maintain sufficient flow to retain a permanently open mouth state for habitat health and recreational use.** *(RQO)*	Estuary mouth closes
H4	**Maintain sufficient flow to maintain current median sediment grain diameter.** *(RQO)*	Median bed sediment diameter changes by >10%
H5	**Tidal amplitude remains within 10% of present state.** *(RQO)*	Tidal amplitude should not change more than 10% of present state

4.3. Water quality objectives

The following objectives relate to water quality in terms of physico-chemical parameters as well as bacteria and phytoplankton. Objectives marked *(RQO)* are gazetted resource quality objectives, while *(RQO-S)* denotes 'supplementary information' published with but not forming part of the gazetted RQOs.

Table 6: Water quality objectives

#	WATER QUALITY OBJECTIVE				TPC
WQ1	**Maintain water quality within appropriate limits for microalgae, macrophytes, invertebrates, fish, birds and recreational use. Specifically, ensure that water quality in the estuary meets the following parameters:** *(RQO)*				
	Sub-component	**Indicator**	**RQO narrative**	**RQO**	
	Nutrients	**Dissolved inorganic nitrogen**	Inorganic nutrient concentrations not to exceed thresholds of potential concern (TPCs) for macrophytes and microalgae	River inflow: **< 800 $\mu g.l^{-1}$**	River inflow: **>800 $\mu g.l^{-1}$**
				Lower estuary (Milnerton Lagoon): **< 1000 $\mu g.l^{-1}$**	Lower estuary (Milnerton lagoon): **>1000 $\mu g.l^{-1}$**
		Dissolved inorganic phosphorus		River inflow: **< 60 $\mu g.l^{-1}$**	River inflow: **>60 $\mu g.l^{-1}$**
				Lower estuary (Milnerton Lagoon): **< 500 $\mu g.l^{-1}$**	Lower estuary (Milnerton lagoon): **>500 $\mu g.l^{-1}$**
	Salinity	**Salinity**	Salinity distribution not to exceed TPCs for fish, invertebrates, macrophytes and microalgae	Average salinity in lower estuary (Milnerton Lagoon) = **20**, maximum = **35**	Average salinity <15 Maximum salinity >35
	System variables	**Dissolved oxygen**	System variables (temperature, pH, dissolved oxygen, suspended solids and turbidity) not to exceed TPCs for biota	> **4 $mg.l^{-1}$**	**≤ 4 $mg.l^{-1}$**

#	WATER QUALITY OBJECTIVE				TPC
	Pathogens*	**Enterococci**	Concentrations of waterborne pathogens not to exceed limits considered suitable for recreational use	**≤ 185** Enterococci/100 ml (90^{th} percentile, Hazen system)	**185** Enterococci/100 ml (90^{th} percentile, Hazen system)
		Escherichia coli		**≤ 500** E. coli/100 ml (90^{th} percentile, Hazen system)	**500** E. coli/100 ml (90^{th} percentile, Hazen system)
WQ2	**Ensure that the appropriate recreational guidelines are met for areas of recreational use**. Specifically, meet the recreational guidelines for intermediate contact recreation -** • Using the Coastal Waters guidelines (DEA 2012 or as updated) in the Milnerton Lagoon south of the Otto du Plessis bridge. • Using the Inland Waters guidelines (DWAF 1996 or as updated) in the Milnerton Lagoon north of the Otto du Plessis bridge and in Flamingo Vlei.				Recreational guidelines exceeded in more than 5% of sampling events
WQ3	**Improve communication and information regarding current water quality in recreational areas of the estuary, including making data publicly available with comparisons to relevant guidelines or standards as applicable.**				Recent water quality data not publicly available for key recreational areas.
WQ4	**Reduce the frequency and impacts of sewer spill and overflow incidents on the estuary.**				Frequency of sewer blockage / spill reports in the catchment increases year on year.
WQ5	**Reduce the impact of un-serviced and underserviced urban areas on the estuary.**				Informal and underserviced areas in the catchment increase in scale or density without new infrastructure to mitigate the impacts.
WQ6	**Establish specific quality objectives for each zone within the estuary, within the general parameters set in the RQOs, to allow for adaptive management.**				N/a

* Applicable to inland waters: water bodies landward of the Otto Du Plessis bridge.
** Applicable to coastal waters: Diep River estuary lagoon to the Otto Du Plessis bridge.

4.4. Land use, infrastructure and development objectives

The following objectives relate to the management of land use, infrastructure and development within the EFZ and more broadly within the catchment. The management authority is the metropolitan municipality responsible for both infrastructure provision and the evaluation of development applications, enabling it to manage land use beyond the EFZ. RQOs are not specifically determined for these objectives.

Table 7: Land use, infrastructure, development objectives

#	LAND USE, INFRASTRUCTURE, DEVELOPMENT OBJECTIVE	TPC
LU1	**Integrate the Diep River Estuarine Functional Zone into the Local Area Spatial Development**	EFZ not integrated into the District Plan

#	LAND USE, INFRASTRUCTURE, DEVELOPMENT OBJECTIVE	TPC
	Framework (District Plan) for the Blaauwberg District.	
LU2	**Prevent further development within the EFZ and 1:100 year floodplain.**	New development on vacant land within the EFZ other than for conservation purposes.
LU3	**Ensure the establishment of adequate riparian buffers as a condition of development approval where new development or redevelopment is proposed in the catchment.**	Any new development in within the City of Cape Town authorised without sufficient buffers on watercourses flowing into the Diep River catchment.
LU4	**Require the implementation of stormwater management measures in the catchment to improve stormwater quality.**	Any new or re-development approved in the catchment without a stormwater management plan demonstrating compliance with the Management of Urban Stormwater Impacts Policy, 2009.
LU5	**Determine the extent to which legacy infrastructure in the estuary is impacting on sediment movement and flow. Remove unneeded infrastructure having a negative effect on hydrodynamics and sediment movement.**	n/a
LU6	**Restrict new infrastructure development within the EFZ where incompatible with the objectives of this EMP.**	New infrastructure development within the undeveloped parts of the EFZ not specifically contributing toward the objectives of the EMP.

4.5. Social objectives

The following objectives relate to the social importance and amenity value of the estuary. RQOs are not specifically determined for these objectives.

Table 8: Social objective

#	SOCIAL OBJECTIVE	TPC
SO1	**Maintain or enhance the amenity value of the Milnerton Lagoon and Rietvlei (inclusive of Flamingo Vlei).**	Recreational areas are closed for more than one calendar month (cumulative) per year.

4.6. Climate change objectives

The following objectives relate to the effects of climate change on the estuary and EFZ. RQOs are not specifically determined for these objectives.

Table 9: Climate change objectives

#	CLIMATE CHANGE OBJECTIVE	TPC
CC1	**Maximise the potential climate change adaptation and mitigation opportunities offered by the estuary through maintenance of a functioning ecosystem.**	n/a – addressed in other objective classes
CC2	**No densification or new development in areas of coastal risk.**	New development is approved within areas of coastal risk in the EFZ

4.7. Education and awareness objectives

The following objectives relate to education and awareness of the importance of the estuary and EFZ. RQOs are not specifically determined for these objectives.

Table 10: Education and awareness objectives

#	EDUCATION AND AWARENESS OBJECTIVE	TPC
EA1	**Improve awareness of the ecological, social and economic value of the Diep River estuary and the role it plays in the City's infrastructure.**	n/a
EA2	**Improve public understanding of the source and causes of pressures and impacts on the estuary.**	n/a

4.8. Cultural importance and heritage resources of significance

The following objective relates to cultural and heritage awareness and preservation.

Table 11: Cultural and heritage objectives

#	CULTURAL AND HERITAGE OBJECTIVE	TPC
CH1	Maintain or enhance identified heritage resources within the estuary.	Any activity which may negatively impact cultural or heritage resources.

5. SPATIAL ZONATION

5.1. Zonation Plan

For the purposes of this plan, the estuary is divided into six distinct zones, based on water quality and hydrology, habitat, and management priorities.

These zones are as follows:

1. **Upper Channel**
2. **Middle Channel**
3. **Rietvlei zone**
4. **Flamingo Vlei zone**
5. **Milnerton Lagoon and Zoarvlei**
6. **Developed area:**

The EFZ also includes areas of beach and shoreline, which are separately managed under the City's Coastal Management Programme.

5.1.1. Upper Channel

The **Upper Channel** zone extends from the upper extent of the EFZ to Blaauwberg Road bridge, above the discharge point for the Potsdam WWTW. The primary drivers in this zone are inflows from the river itself and from stormwater runoff, including from the Du Noon informal settlement. The zone comprises a broad floodplain with a mosaic of reeds and grasses. There is no tidal influence or seawater intrusion in this zone. No significant recreational uses take place in this zone.

5.1.2. Middle Channel

The **Middle Channel** zone extends from the Blaauwberg Road bridge to the Otto du Plessis Drive bridge. It includes the discharge point for the Potsdam WWTW and the outflow of the Theo Marais Canal, both significant sources of poor-quality freshwater inflow. Occasionally, salinities may be higher in this zone, but it is primarily a freshwater system. Flows are conveyed in a defined channel constructed to reduce impacts of effluent on Rietvlei to the west. No significant recreational uses take place in this zone.

5.1.3. Rietvlei zone

The **Rietvlei** zone is located west of the Middle Channel and comprises a mosaic of open water and seasonal wetland habitats, including areas of salt marsh. It is bounded to the west by the deep-water lakes and to the north and south by residential suburbs. Use of and access to this zone is limited as it is managed primarily for biodiversity conservation.

5.1.4. Flamingo Vlei zone

The **Flamingo Vlei** zone includes the deep North and South interconnected artificial lakes northwest of the Rietvlei zone. The Bayside canal discharges in the north-western corner of Flamingo Vlei. The Dolphin Beach detention ponds also drain into this zone. The Flamingo Vlei zone is a popular recreational area for water sports and requires management of water quality to meet the relevant recreational water quality guidelines for inland waters (DWAF 1996 or as updated).

5.1.5. Milnerton Lagoon (including Zoarvlei)

The **Milnerton Lagoon** is the lower part of the estuary, between the Otto du Plessis Drive bridge and the mouth at Lagoon Beach. It is subject to tidal influences and has the highest salinities in the estuary. The lagoon itself is used for recreational boating and requires management of water quality to meet the relevant recreational water quality guidelines for coastal waters. The lagoon is surrounded by residential developments and hotels. Zoarvlei is a wetland to the south, historically part of the Diep River channel, and linked to the estuary via a box culvert under Marine Drive.

5.1.6. Developed zone

The remainder of the EFZ, some 33%, is transformed for urban development in the form of residential areas, infrastructure, industry, the WWTW, grassed public spaces, and a golf course. Though not a part of the estuarine habitat this area is included in the EFZ, as the latter captures the natural, historical estuarine extent and the space within which estuarine functions take place over long timescales.

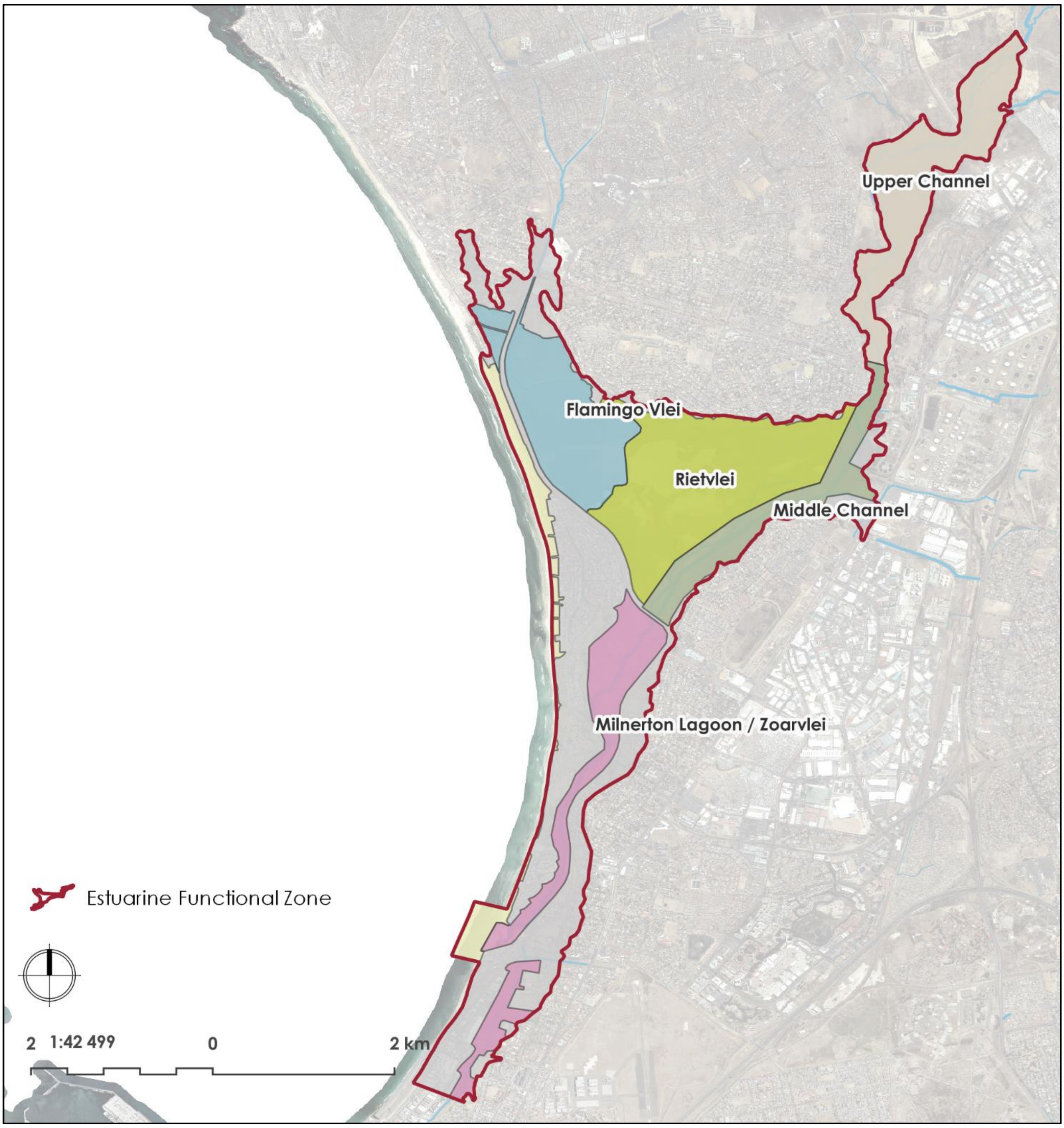


Figure 23. Estuarine Zonation Plan

5.2. Zone-specific objectives and management

It is proposed that these zones be further defined and their present ecological status and target ecological category be better understood to guide estuarine management actions that occur within the estuary (i.e. as opposed to those which are catchment-scale, such as stormwater management), acknowledging that broader catchment issues require urgent attention.

A more granular understanding of the present status and pressures will enable better management of each zone. Given the low likelihood of significant improvement in the current water quality within the Upper Channel, Middle Channel and Milnerton Lagoon zones in the short term (see section 7), it is suggested that the following high-level priorities be assigned to each zone:

- **Upper Channel**: Manage to minimise further disturbance; minimise impacts of informal settlement.
- **Middle Channel**: Manage to contain and further treat effluent from the Potsdam WWTW within the channel, preventing overspill of nutrient-rich and high-bacterial-load effluent into Rietvlei.
- **Rietvlei zone**: Manage for conservation of biodiverse seasonal wetland and terrestrial habitats; minimise disturbance and water quality impacts from neighbouring areas.
- **Flamingo Vlei zone**: Manage for recreational use and water quality consistent with the inland waters recreational use guidelines for intermediate contact.
- **Milnerton Lagoon**: Manage for estuarine function; fish and invertebrate habitat; and recreational use consistent with the coastal waters recreational use guidelines.
- **Developed zone**: Manage for improved stormwater runoff quality, manage informal/illegal structures and dwellers, litter, loss of vegetation and minimise impacts of sewage spills and other pollution sources.

A preliminary determination of priority actions applicable to each zone is included in section 6.

6. MANAGEMENT PRIORITIES AND ACTIONS

Table 12 below sets out key actions and implementation responsibilities for the 2021-2026 timeframe of this EMP.

Acronyms and abbreviations used in the table:

- Spatial zones (see section 5): **UC**: Upper Channel; **MC**: Middle Channel; **ML**: Milnerton Lagoon; **RV**: Rietvlei zone; **FV**: Flamingo Vlei zone; **DE**: Developed zone
- Legislation: **NEMPAA**: National Environmental Management: Protected Areas Act; **NWA**: National Water Act; **NEMBA:** National Environmental Management: Biodiversity Act; **RQOs:** Resource Quality Objectives; **MLRA:** Marine Living Resources Act; **ICMA:** National Environmental Management: Integrated Coastal Management Act; **NEMA**: National Environmental Management Act; **NEMP**: National Estuarine Management Protocol

Table 12. Management Actions

Management objective	Action *High priority actions are indicated* ***in blue***.	Legislation mandating this action	Responsible CCT departments branches	Designation /accountable individual	Applicable spatial zones						Timeframe		
					UC	MC	ML	RV	FV	DE	1-2 years	2-5 years	5+ years
CONSERVATION OBJECTIVES (C1 to C11)	1. Define and maintain zonation, access management, and enforcement within the Table Bay Nature Reserve commensurate with necessary and appropriate signage and fencing where required.	NEMPAA	Biodiversity Management	Biodiversity Area Manager: Table Bay Nature Reserve	✓	✓	✓	✓	✓		Ongoing		
	2. **Reinforce the separation of nutrient-rich Potsdam WWTW discharge from the salt marshes fringing the Rietvlei system.** See also 28.	NWA	Water and Sanitation[†] / Coastal Management/ Biodiversity / Management	Head: Catchments Planning, Region 1		✓						✓	
	3. Restore and rehabilitate sand fynbos and locally indigenous vegetation types in areas of the reserve requiring rehabilitation and which align with the approved IRMP for the TBNR. Restoration plans to be first approved by the Biodiversity Management Branch.	NEMBA, NEMPAA	Biodiversity Management	Biodiversity Area Manager: Table Bay Nature Reserve				✓			Ongoing		
	4. Prepare and implement an invasive species monitoring, control and eradication plan for invasive alien plant and animal species	NEMBA, AIS Regulations 2014	Biodiversity Management	Invasive Species Programme Manager	✓	✓		✓	✓		Ongoing		
	5. Monitor the overall Present Ecological State; invertebrate diversity and distribution; fish; bird; and phytoplankton in accordance with the Monitoring Plan (section 8).		Coastal Management / Biodiversity Management	Head: Coastal Conservation and Marine Monitoring / Biodiversity Area Manager: Table Bay Nature Reserve	✓	✓	✓	✓	✓		Ongoing		
	6. Implement law enforcement patrols to reduce illegal fishing and/or any other illegal activity.	MLRA, NEMPAA, Nature Conservation Ordinance	Biodiversity Management / Coastal Management and Law Enforcement	Biodiversity Area Manager: Table Bay Nature Reserve			✓	✓	✓		Ongoing		
WATER QUANTITY OBJECTIVES (H1 to H5)	7. **Determine the minimum required daily flow from the Potsdam WWTW to achieve the required similarity with a natural flow regime, manage water quality, and manage the mouth state.**	NWA and RQOs	CSRM / Water and Sanitation / Coastal Management / Biodiversity Management	Head: Catchments Planning, Region 1		✓	✓				✓		
	8. Ensure that any commitments in respect of the supply of treated effluent from the WWTW are consistent with the requirement to maintain discharge volumes meeting special limits.	NWA and RQOs	CSRM / Water and Sanitation / Wastewater	Head: Catchments Planning, Region 1		✓	✓				✓		
	9. Provide a report indicating how the Potsdam upgrades will result in the resource quality objectives for the estuary being met.	NWA and RQOs	Water and Sanitation / Wastewater	Manager: Wastewater Treatment		✓	✓	✓	✓		✓		

[†] Department listed first is the lead department with support from other departments that follow.

Management objective	Action *High priority actions are indicated **in blue**.*	Legislation mandating this action	Responsible CCT departments branches	Designation /accountable individual	Applicable spatial zones						Timeframe		
					UC	MC	ML	RV	FV	DE	1-2 years	2-5 years	5+ years
	10. Remove and dispose of water hyacinth in the estuary and Diep River. Limit as practically possible biomass washing downstream into the estuary after clearing.		Biodiversity Management (Invasive Species Unit) / CSRM	Invasive Species Programme Manager	✓	✓					Ongoing		
	11. Develop a Mouth Management Plan and accompanying Maintenance Management Plan for the manipulation of the estuary mouth in situations where upstream flooding or other circumstances require it.	ICMA and NEMA	CSRM / Coastal Management / Biodiversity Management	Head: Catchments Planning, Region 1			✓				✓		
	12. **Assess the possible cost and benefit of dredging the lower lagoon to facilitate the release of sediments and nutrient loads and emulate natural scour. Implement dredging if a significant benefit is anticipated.**		Coastal Management / CSRM / Biodiversity Management	Head: Coastal Engineering and Optimisation			✓					✓	
	13. Investigate the feasibility of dredging the Rietvlei section of the Diep River Estuary		Biodiversity Management /CSRM	Senior Environmental Professional: Conservation Services Unit				✓			✓		
	14. Establish a hydrological monitoring programme which considers the impacts/influence of abstraction.		CSRM	Head: Stormwater Planning and Development, Bulk Services	✓	✓	✓	✓	✓			✓	
WATER QUALITY OBJECTIVES (WQ1 to WQ6)	15. **Implement upgrades to the Potsdam WWTW to improve the quality of treated effluent.**	NWA and RQOs	Water and Sanitation / Wastewater	Manager: Wastewater Treatment		✓	✓	✓	✓			✓	
	16. Re-evaluate the RQOs and present ecological status of the estuary per estuarine zone and determine 'tipping points' for PES in the various parameters. Propose amendments to the RQOs and recommended ecological category per zone to the responsible authority based on the findings thereof.		Water and Sanitation / CSRM / Biodiversity Management / Environmental Management / Coastal Management	Head: Stormwater Planning and Development, Bulk Services		✓	✓	✓	✓			✓	
	17. Montague Gardens bulk sewer upgrade to reduce sewage spill events due to capacity constraints and aged infrastructure – reduce current spills into the Theo Marais Canal.		Water and Sanitation / Reticulation	Head: Planning, Design and Projects, Distribution Services		✓	✓	✓	✓				✓
	18. Cleaning, according to a defined cleaning regime, of maturation and ancillary ponds		Water and Sanitation / Wastewater	District Manager: Wastewater		✓	✓	✓	✓		✓		
	19. Dredging of sludge at WWTW discharge point for offsite disposal.		Water and Sanitation / Wastewater	District Manager: Wastewater		✓	✓	✓	✓		✓		
	20. Seal off historical outlets and maturation ponds from the Diep River.		Water and Sanitation / Wastewater	District Manager: Wastewater		✓	✓	✓	✓				✓
	21. Conduct investigations and enforcement of illicit industrial discharges into the stormwater system in Montague Gardens and Paarden Eiland industrial complex and apply at a catchment-wide scale.	Wastewater and Industrial Effluent Bylaw, NEMA S24G	Water and Sanitation (Pollution Control) / CSRM	Water Pollution Control						✓	Ongoing		
	22. Conduct investigations and enforcement of residential and commercial compliance with the stormwater by-law and apply at a catchment-wide scale.	Stormwater By - law	Water and Sanitation (Pollution Control) / CSRM	Water Pollution Control	✓					✓	Ongoing		
	23. **Plan, Design & Construct stormwater to sewer diversion/s at Du Noon and Doornbach.**		Water and Sanitation / CSRM	Senior Professional Officer: Commercial Services	✓					✓		✓	

Management objective	Action *High priority actions are indicated **in blue**.*	Legislation mandating this action	Responsible CCT departments branches	Designation /accountable individual	Applicable spatial zones						Timeframe		
					UC	MC	ML	RV	FV	DE	1-2 years	2-5 years	5+ years
	24. **Implement the recommendations of the Erica Road Stormwater Study.**		Water and Sanitation /CSRM	Head: Catchments Planning, Region 1				✓	✓				✓
	25. **Construct the planned treatment wetland at the Bayside Canal outfall.**		Water and Sanitation / CSRM	Head: Catchments Planning, Region 1				✓	✓			✓	
	26. **Develop a sewer pump station protocol to manage surcharge and failure events at each pump station impacting on the estuary, based on the Valyland (Fish Hoek) Pump Station Response Protocol.**		Water and Sanitation	Head: Technical Services, Water and Sanitation	✓	✓	✓	✓	✓		✓		
	27. **Complete upgrades to Koeberg pump station and ensure standby generators and mobile pumps are installed at the Koeberg pump station. Ensure all pump stations within the Diep River catchment function optimally and that each has a backup generator**		Water and Sanitation	Head: Wastewater Conveyance and Pump Station Operations Manager	✓	✓	✓	✓	✓	✓		✓	
	28. **Investigate the potential to construct a low-flow vegetated channel east of the existing channel in the estuary, to mitigate the quality of discharge from the Potsdam WWTW, with the current channel remaining in place as a high-flow bypass.**		CSRM / Water and Sanitation / Biodiversity Management	Head: Catchments Planning, Region 1		✓						✓	
	29. Make data publicly available with comparisons to relevant guidelines or standards as applicable, updated at least once every two weeks.		Water and Sanitation / Scientific Services / City Health / Biodiversity Management	Head: Stormwater Planning and Development, Bulk Services	✓	✓	✓	✓	✓		Ongoing		
	30. Communicate clearly and effectively on current water quality and challenges.		Water and Sanitation / City Health / Biodiversity Management	Head: Stormwater Planning and Development, Bulk Services	✓	✓	✓	✓	✓		Ongoing		
	31. Investigate the feasibility and value of pumping seawater into the system to improve habitat for estuarine species.		Coastal Management and Biodiversity Management	Head: Coastal Engineering and Optimisation			✓					✓	
	32. Investigate commissioning of the old wastewater treatment works 'long pond' to act as an additional filter to improve the quality of effluent.		CSRM / Water and Sanitation / Wastewater	Head: Catchments Planning, Region 1		✓						✓	
	33. **Test and pilot innovative ideas that may lead to improved water quality in the Diep River.**	All applicable legislation.	All relevant City departments.	City-wide	✓	✓	✓	✓	✓	✓	Ongoing		
LAND USE, INFRASTRUCTURE AND DEVELOPMENT OBJECTIVES (LU1 to LU6)	34. Ensure the District Spatial Development Framework specifies mechanisms to limit the impacts of development and land use applications that fall within the catchment of the Diep River Estuary.		Urban Planning and Design	Manager: District Planning and Mechanisms - Urban Planning and Design – Spatial Planning and Environment						✓	✓		
	35. Ensure the District Plan incorporates the Coastal Management Line determined for the estuary area.	ICMA, NEMA	Spatial Planning	Manager: District Planning and Mechanisms - Urban Planning and Design – Spatial Planning and Environment						✓	✓		

Management objective	Action *High priority actions are indicated* ***in blue****.*	Legislation mandating this action	Responsible CCT departments branches	Designation /accountable individual	Applicable spatial zones						Timeframe		
					UC	MC	ML	RV	FV	DE	1-2 years	2-5 years	5+ years
	36. Increase the rate of upgrading of informal settlements and strictly manage land invasions within the EFZ and floodplain.		Informal Settlements	Head: Planning Informal Settlements	✓					✓	Ongoing		
	37. Ensure all development and development application processes are in accordance Development Management Scheme, especially in relation to the existing zoning of the Table Bay Nature Reserve and EFZ, which forms part of the nature reserve.	Municipal Planning By-law	Land Use Management	Head: Land Use Management						✓	✓		
	38. Incorporate Management of Urban Stormwater Impacts Policy into land use and development proposals.	Management of Urban Stormwater Impacts Policy	CSRM	Head: Catchments Planning, Region 1	✓	✓	✓	✓	✓	✓	Ongoing		
	39. Conduct a survey of legacy infrastructure within the estuary to establish potential impacts on hydrodynamics and sediment movement. Assess, obtain authorisation for, and remove any unneeded infrastructure having a negative effect on the estuary (including any remaining parts of the 1928 weir near the mouth of the lagoon).		Coastal Management	Head: Coastal Conservation and Marine Monitoring	✓	✓	✓			✓	✓		
SOCIAL OBJECTIVES (SO1)	40. Maintain and ensure the public's right of access and enjoyment of publicly accessible areas within the estuary in accordance with the TBNR management plan.	ICMA	Biodiversity Management	Biodiversity Area Manager: Table Bay Nature Reserve			✓	✓	✓	✓	Ongoing		
	41. **Improve communication on current water quality, risks, and challenges.**		CSRM / Biodiversity Management /City Health	Head: Stormwater Planning and Development, Bulk Services			✓	✓	✓		✓		
	42. Collate and provide information to recreational users on reducing risk when recreational water quality guidelines cannot be met within the estuary.		City Health / Biodiversity Management / Water and Sanitation	Senior Environmental Professional: Conservation Services Unit / Head: Stormwater Planning and Development, Bulk Services			✓	✓	✓		Ongoing		
CLIMATE CHANGE OBJECTIVES (CC1 to CC2)	43. Enforce the coastal urban edge / coastal management line and ensure relevant environmental authorisatoins are obtained for new development, infrastructure, or densification that may be exposed to risk from coastal hazards.	ICMA, NEMA	Urban Planning and Design / Environmental Management Department/ CSRM / Coastal Management/ Building Development Management	Manager: District Planning and Mechanisms - Urban Planning and Design / Local EHM Manager						✓	Ongoing		
	44. Determine the effect of sea level rise, a drier climate, and other impacts of climate change on the EFZ and 1:100 year floodline, and where applicable include necessary interventions into City planning and management strategies.		Coastal Management /Spatial Planning/Climate Change Adaptation, Sustainable Energy Markets Department	Head: Coastal Policy Development and Management Programmes	✓	✓	✓	✓	✓	✓		✓	
EDUCATION AND AWARENESS	45. Develop material that explains in simple terms the pressures on the Diep River estuary, places it in its urban context and demonstrates the links between human activities in the catchment and the state of the estuary.		CSRM / Biodiversity Management/Corporate Communications	Head: Stormwater Planning and Development, Bulk Services							✓		

Management objective	Action *High priority actions are indicated* ***in blue****.*	Legislation mandating this action	Responsible CCT departments branches	Designation /accountable individual	Applicable spatial zones						Timeframe		
					UC	MC	ML	RV	FV	DE	1-2 years	2-5 years	5+ years
OBJECTIVES (EA1 to EA2)	46. Involve stakeholders and interested members of the public in the review of the EMP to build awareness, engagement and participation.	ICMA and NEMP	Coastal Management	Head: Coastal Policy Development and Management Programmes							✓		
	47. Formalise the estuary advisory forum as a working group of the Protected Area Advisory Committee and allow for estuarine experts or stakeholders to join this group.	NEMPAA	Biodiversity Management	Biodiversity Area Manager: Table Bay Nature Reserve							✓		

7. IMPLEMENTATION

7.1. Feasibility of and timeframes for implementation

The NEMP requires that the five-yearly review of an EMP must include an 'assessment of environmental changes (if any) at a local or a wider scale that could affect the estuarine resources or the implementation of the EMP'.

The most significant changes in the situation since the 2016 review of the EMP are:

- A decline in water quality and probable decline in the present ecological status; and
- The determination of RQOs, setting guidelines that must be met in the estuary.

It is apparent from the updated Situation Assessment set out in section 2 of this report that the Diep River estuary does not meet the RQOs defined in November 2020. The ongoing decline in water quality and probable decline in the ecological state of the estuary (the latter has not been reassessed as part of this review) can be attributed to a range of contributing factors both within and outside of the EFZ and include aspects such as:

- Urban development and densification in the catchment, leading to increased runoff and decreased stormwater quality as well as capacity deficits in key sewerage infrastructure.
- An increase in informality in the EFZ and surrounds resulting in discharge of untreated sewage and solid waste to the estuary.
- A high number of failures in the sewerage system resulting in spills and discharges to the estuary of untreated effluent. Failures are typically caused by:
  - Aging infrastructure
  - Power outages
  - Blockages caused by foreign objects
  - Illegal stormwater to sewer connections
- Ongoing uncontrolled inflows of untreated wastewater/pollution from multiple sources via the stormwater system specifically Bayside and Erica Rd
- A constrained estuary mouth and reduced freshwater inflows, reducing the ability of the system to flush out accumulated sediment, nutrients, and pollutants and leading to a build-up of these in the estuary.

A number of capital-intensive projects intended to address the current challenges are currently in the planning phase (see **Annexure C**: Water Quality Improvement Program Transversal Action Plan). These include an upgrade of the Potsdam WWTW to improve the quality of the effluent, upgrades to bulk sewerage infrastructure, and construction of treatment wetlands. These projects have long planning and construction timeframes and are planned for completion by 2025. They are, therefore, unlikely to contribute to any improvement of the current situation within the next five years. However, they are considered critical to the improvement of the state of the estuary. The rapid densification and expansion of informal settlements in the catchment and in the EFZ is realistically unlikely to be addressed in this timeframe.

Assuming the current infrastructure challenges can be fully addressed on schedule and have the intended outcome of improving the quality of water discharged to the estuary, there will still be a lag between their implementation and any measurable improvement in the estuary. Nutrients and sediments trapped within the estuary will remain in the system and continue to affect water quality even after the quality of inflows has been improved.

It is very unlikely that those parts of the Diep River estuary which are most impacted by the discharge of effluent from the Potsdam WWTW will meet the defined RQOs within the 5-year period covered by this EMP. It is, therefore, proposed that Rietvlei and Flamingo Vlei, which are not as strongly affected by the poor quality of effluent from the Potsdam WWTW, be prioritised for short-term compliance with the RQOs and other standards consistent with conservation and recreational uses, respectively. The Middle Channel zones and the Milnerton Lagoon / Zoarvlei zone are expected to attain significantly improved water quality only in the longer term (5+ years) when the planned capital-intensive upgrades to wastewater infrastructure have been fully implemented.

7.2. Institutional arrangements

The Diep River estuary is managed by the City of Cape Town as the Responsible Management Authority. The management of the estuary and its key drivers is not the sole responsibility of any one department within the City, however, and budgets and mandates for capital and operational costs are derived from multiple line departments that must coordinate their efforts in order to implement this EMP. In this context the implementation of this EMP requires definite allocation of responsibilities and resources. The action plan in section 6 therefore stipulates which departments, directorates or branches are **responsible** (i.e. those who must complete the actions) as well as those who are **accountable** (i.e. the single person who is the 'owner' of each task). Timeframes are stipulated for implementation based on current City budget allocations and priorities.

7.3. Priority Actions

It is recommended that the following aspects of the EMP be initiated as a matter of priority within the first year for completion within the timeframes as allocated in Table 11. All other aspects listed in the management action plans should start as soon as practicably possible as their outcomes are likely to be longer-term.

- **Action 2:** Reinforce the separation of nutrient-rich Potsdam WWTW discharge from the salt marshes fringing the Rietvlei system.
- **Action 7**: Determine the minimum required daily flow from the Potsdam WWTW to achieve the required similarity with a natural flow regime, manage water quality, and manage the mouth state.
- **Action 12:** Assess the possible cost and benefit of dredging the lower lagoon to facilitate the release of sediments and nutrient loads and emulate natural scour. Implement dredging if a significant benefit is anticipated.
- **Action 15:** Implement upgrades to the Potsdam WWTW to improve the quality of treated effluent.
- **Action 23:** Plan, Design & Construct stormwater to sewer diversion/s at Du Noon and Doornbach.
- **Action 24:** Implement the recommendations of the Erika Road Stormwater study.
- **Action 25:** Construct the planned treatment wetland at the Bayside Canal outfall.
- **Action 26:** Develop a sewer pump station protocol to manage surcharge and failure events at each pump station impacting on the estuary, based on the Valyland (Fish Hoek) Pump Station Response Protocol.
- **Action 27:** Complete upgrades to the Koeberg Pump Station and ensure standby generators and mobile pumps are installed at the Koeberg Pump Station. Ensure all pump stations within the Diep River catchment function optimally and that each has a backup generator.

- **Action 28:** Investigate the potential to construct a low-flow vegetated channel east of the existing channel in the estuary, to mitigate the quality of discharge from the WWTW, with the current channel remaining in place as a high-flow bypass.
- **Action 33:** Test and pilot innovative ideas that may lead to improved water quality in the Diep River.
- **Action 41:** Improve communication on current water quality, risks, and challenges.

8. MONITORING AND EVALUATION

An Estuarine Ecology Monitoring Plan has been prepared for the Milnerton Lagoon section of the estuary (Wright et al. 2020). The Plan is appended as **Annexure D** and summarised below.

Table 13: Overview of the method for monitoring and evaluation

Task	Approach	Frequency	Location	Priority
Mouth state	Ongoing, regular observations need to be made on the state of the estuary mouth i.e. whether the mouth is open, closed or semi-closed (waves overtopping)	Daily	Mouth	High
Bathymetry and erosion	Survey bathymetry along a series of transects (n = 10-12) aligned perpendicular to the estuary channel to understand the structure of the channel, and identify changes over time. Erosion monitoring using aerial imagery.	Every five years	Transects perpendicular to the channel	High
Granulometry	Sediment samples to be collected for grain size composition analysis at the same time as the bathymetric surveys are undertaken.	Every five years with bathymetry	Transects perpendicular to the channel	High
Sediment organics and pollutants	Analysis of sediment samples for metals (aluminium, arsenic, cadmium, chromium, iron, mercury, nickel, lead, and zinc) and particulate organic matter (total organic carbon, total organic nitrogen) and, capacity permitting, chemicals of emerging concern.	Every five years with bathymetry	3-5 samples per transect	High
Temp, salinity, DO	Deploy a moored instrument capable of measuring and recording temperature, salinity, dissolved oxygen.	Continuous	Milnerton Lagoon at Woodbridge Island	High
Bacteria (e.g. *E. coli*) and nutrients	Sampling at sampling points within the catchment and the estuary by Scientific Services. Faecal *enterococcus* to be included in the Milnerton Lagoon analyses.	Every two weeks	Various standardised sampling points in the estuary (Figure 8).	High
Microalgae biomass, growth	Chlorophyll-a should be assessed at sampling points linked to the CoCT Water Quality Monitoring of the Diep River and estuary.	Every two weeks	As above	High

Task	Approach	Frequency	Location	Priority
Vegetation cover, habitat	Estuarine associated macrophyte cover (macroalgae, *Potamogeton*, salt marsh, reeds & sedges) should be mapped and quantified using high resolution aerial photographs and/or satellite imagery.	Annually	Within the EFZ	High
Prawn monitoring	Monitoring and counts of *Krausillichirus*/*Upogebia* sand/mud prawn burrows	Once every two years	Fixed sampling points within Milnerton Lagoon	High
Benthic macrofauna	Sediment samples should be collected from within the estuary below the low water mark and analysed for benthic macrofauna and sediment characteristics.	Once every two years		Medium
Reef-building polychaete	Monitoring of the invasive reef building polychaete (or coral/tube worm) *Ficopomatus enigmaticus* should be undertaken to determine efficacy of management strategies. Three replicate artificial settling plates of a fixed size should be submerged at two different localities in the estuary. Each year, the plates should be scraped and the biofouling growth weighed.	Annually	Two locations in Milnerton Lagoon	Low
Seine net fish surveys	Seine net surveys for fish should be conducted at 4 sites up the length of the estuary to assess estuarine fish community composition and species abundance.	Annually	4 sites in the estuary	Medium
Water bird counts and identification	CWAC counts (http://cwac.birdmap.africa)	Twice per year in both the vleis and the estuary.		High

Evaluation of the above monitoring items should take the form of an annual review of compliance against the objectives of this EMP.

9. REFERENCES

AMAP. 2011. *Snow, Water, Ice and Permafrost in the Arctic (SWIPA) 2011*. Oslo: Arctic Monitoring and Assessment Programme (AMAP).

Barbier, E.B et al. 2011. *The Value of Estuarine and Ecosystem Services*. Ecological Monographs, Vol 81 (2). Pp 169-193

Beaumont, N et al. 2014. *The Value of Carbon Sequestration and Storage in Coastal Habitats*. Estuarine Coastal and Shelf Science, Vol 137 (1).

Bell, D.R. 1976. *General survey of flora and fauna in the Milnerton area*. Milnerton High School

Caldeira, K. and Wickett, M. (2003). *Anthropogenic carbon and ocean pH*. Nature, Vol 425 363. Available from: https://doi.org/10.1038/425365a

Christie-Smith, J. 2021. *Bathymetry and Granulometry of the Milnerton Lagoon (Diep River Estuary)*. Prepared by Tritan Survey for the City of Cape Town.

Church, J.A. et al. 2013. *Evaluating the Ability of Process Based Models to Project Sea-Level Change*. Environmental Research. **8** 014051

City of Cape Town (CCT) (2011). *Council Overview: a Comprehensive Guide to Council's Structures, Finance, Governance, Directorates and Planning*, Cape Town: City of Cape Town.

City of Cape Town. 2018. *Blaauwberg State of the Population.* Report prepared for as part of the Blaauwberg District Plan.

Clark, B.M. (1998). *Human Utilisation of the Diep River Estuary with an Assessment of the Intensity and Impact of Bait Collecting on the Ecology of the Estuary*. Report by Anchor Environmental Consultants for the Blaauberg Municipality, WWF-SA and Friends of Rietvlei. 36pp.

Clark BM. 2018. *RDM Study for Rietvlei/Diep Estuary*. Report prepared by Anchor Environmental Consultants as part of the Reserve Determination and Resource Quality Objectives process for the Berg Water Management Area.

CWAC, n.d., accessed 15 October 2021, https://cwac.birdmap.africa/

de Villiers, S. and Thiart, C. 2007. *The Nutrient Status of South African Rivers: Concentrations, Trends and Fluxes from the 1970s to 2005*. South African Journal of Science, Vol 103. Pp 343–349.

Department of Water and Sanitation, South Africa. 2018. Determination of Water Resources Classes and associated Resource Quality Objectives in Berg Catchment: Outline of Resource Quality Objectives Report. Project Number WP10987. DWS Report No: RDM/WMA9/00/CON/CLA/0218

Gihwala, K & Hutchings, K. 2021. *Granulometry of the Milnerton Lagoon (Diep River Estuary)*. Prepared by Anchor Research & Monitoring (Pty) Ltd for the City of Cape Town.

Gillanders, B.M., Elsdon, T.S., Halliday, I.A., Jenkins, G.P., Robins, J.B. and Valesini, F.J., 2011. *Potential Effects of Climate Change on Australian Estuaries and Fish Utilising Estuaries: A Review*. Marine and Freshwater Research, Vol 62(9), pp.1115-1131.

Gqomfa, B. 2020. *The Impact of Informal Settlements on Water Quality of Diep River in Dunoon*. Master of Environmental Management Dissertation. Cape Peninsula University of Technology.

Grindley, JR and Dudley, S. 1988. *Report 28 of the Estuaries of the Cape, Part 2: Synopses of Available Information on Individual Systems Series*, Edited by Heydorn, AEF and Grindley, JR. Stellenbosch: CSIR. (CSIR research report 427).

Harley, C.D., Randall Hughes, A., Hultgren, K.M., Miner, B.G., Sorte, C.J., Thornber, C.S., Rodriguez, L.F., Tomanek, L. and Williams, S.L., 2006. *The impacts of climate change in coastal marine systems*. Ecology letters, Vol 9(2), pp.228-241.

Harrison, T.D., (1997). A preliminary survey of coastal river systems on the South African west coast, Cape Columbine—Cape Point, with particular reference to the fish fauna, transactions of the royal society of South Africa, 52:2, 323-344, doi: 10.1080/00359199809520357

Haskins, C. 2013. Rietvlei MAC Water Quality Report. City of Cape Town. Cape Town, South Africa.

Hofmann, G.E., Smith, J.E., Johnson, K.S., Send, U., Levin, L.A., Micheli, F., Paytan, A., Price, N.N., Peterson, B., Takeshita, Y., Matson, P.G., Crook, E.D., Kroeker, K.J., Gambi, M.C., Rivest, E.B., Frieder, C.A., Yu, P.C., Martz, T.R. 2011. *High-Frequency Dynamics of Ocean pH: A Multi-Ecosystem Comparison*. PLOS ONE, Vol 6(12): e28983. Available from: https://doi.org/10.1371/journal.pone.0028983

iNaturalist, n.d., accessed 15 October 2021, https://www.inaturalist.org/projects/table-bay-nature-reserve

Jackson, L., Conrad, J., de Meyer, M., Cullinan, C., Mahomedy, L. & Dehrmann, A. 2008. *Situation Assessment for the Diep estuary*. Unpublished CAPE estuaries programme report. by Peak Practice.

James, R. and Washington, R. 2013. *Changes in African Temperature and Precipitation Associated with Degrees of Global Warming*. Climatic change, Vol *117*(4), pp.859-872.

Kaletja-Summers, B., Allan, D.G. & Longrigg, T.D. (2001). *Long-term trends, seasonal abundance and energy consumption of water birds at Rietvlei, Western Cape, South Africa*, 1950–1997. *Ostrich* 72 (1 & 2): 63–79.

Keyser, J. (2003) *Analysis of Waterbird Census Data at the Rietvlei Wetland Reserve*. Report compiled for Diploma in Nature Conservation.

Krauss, K.W., Noe, G.B., Duberstein, J.A., Conner, W.H., Stagg, C.L., Cormier, N., Jones, M.C., Bernhardt, C.E., Graeme Lockaby, B., From, A.S. and Doyle, T.W. 2018. *The Role of the Upper Tidal Estuary in Wetland Blue Carbon Storage and Flux*. Global Biogeochemical Cycles, Vol *32*(5), pp.817-839.

Lamberth, S.J. 2014. Unpublished data of ichthyological surveys conducted in the Milnerton Lagoon.

Marnewick MD, Retief EF, eron NT, Wright DR, Anderson TA. 2015. *Important Bird and Biodiversity Areas of South Africa.* Johannesburg: BirdLife South Africa.

Millard, N.A.H. and Scott, K.M.F. 1954. *The Ecology of South African Estuaries: Part VI: Milnerton Estuary and the Diep River, Cape*. Transactions of the Royal Society of South Africa, Vol 34(2), pp.279-324.

Milne, G.A., Gehrels, W.R., Hughes, C.W. and Tamisiea, M.E. 2009. *Identifying The Causes of Sea-Level Change*. Nature Geoscience, Vol 2(7), pp.471-478.

Murawski, S. A. *Climate change and marine fish distributions: forecasting from historical analogy*. Transactions of the American Fisheries Society, Vol 122.5: pp 647-658.

Newton, P. C. D., Lieffering, M., Li, F. Y., Ganesh, S., & Dodd, M. 2014. *Detection of Historical Changes in Pasture Growth and Attribution to Climate Change*. Climate Research, Vol 61(3), Pp 203–214. Available from:
https://www.jstor.org/stable/24896208

Nicholls, R.J., and Cazenave, A. 2010. *Sea Level Rise and Its Impact on Coastal Zones*. Science, Vol 328 Issue 5985, Pp 1517-1520.

Perry, A.L., Low, P.J., Ellis, J.R. and Reynolds, J.D., 2005. *Climate change and distribution shifts in marine fishes*. Science, Vol 308(5730), pp.1912-1915.

Pfeffer, W.T., Harper, J.T., and O'Neel, S. 2008. *Kinematic Constraints on Glacier Contributions to 21-st Century Sea-Level Rise*. Science, Vol 321, Issue 5894, Pp 1340-1343.

Retief, K. (2011). *Integrated Reserve Management Plan. Table Bay Nature Reserve.* Management Plan compiled by the Reserve Planning Team.

Robins, P.E., Skov, M.W., Lewis, M.J., Giménez, L., Davies, A.G., Malham, S.K., Neill, S.P., McDonald, J.E., Whitton, T.A., Jackson, S.E. and Jago, C.F., 2016. *Impact of Climate Change on UK Estuaries: A Review of Past Trends and Potential Projections*. Estuarine, Coastal and Shelf Science, Vol 169, Pp.119-135.

Rossouw, M., Theron, A.K., 2009. *Investigating Potential Climate Change Impacts on Maritime Operations Around the Southern African Coast*. 28th Annual Southern African Transport Conference, 6 – 9 July 2009. SAR, 2008

Sidder, A. 2018. *Upper Estuaries Found to be Significant Blue Carbon Sink*. EOS Science News. 29 June. Available from: Upper Estuaries Found to Be Significant Blue Carbon Sink - Eos

Siikamäki, J., Sanchirico, J.N., Jardine, S., McLaughlin, D. and Morris, D. 2013. *Blue Carbon: Coastal Ecosystems, Their Carbon Storage, and Potential for Reducing Emissions*. Environment: Science and Policy for Sustainable Development, Vol 55(6), pp.14-29.

Stafford, L & Rhoda, C (2016). *Invasive Alien Species Monitoring, Control and Eradication Plan for Table Bay Nature Reserve*. Report prepared by the Cape Town Invasive Species Unit for the City of Cape Town

Taljaard, S., Snow, G., Gama, P., van Niekerk, L. 2009. *Verification of a conceptual model of water quality for small temporarily open/closed estuaries: East Kleinmonde Estuary, South Africa*. Marine and Freshwater Research, Vol 60 (3).

Theron, A.K. and Rossouw, M. 2012. *Analysis of Potential Coastal Zone Climate Change Impacts and Possible Response Options in the Southern African Region*. Coastal Climate Change Impacts Southern Africa.

Theron, A.K. 2007. *Analysis of Potential Coastal Zone Climate Change Impacts and Possible Response Options in the Southern African Region*. Proceedings IPCC TGICA Conference: Integrating Analysis of Regional Climate Change and Response Options, Nadi, Fiji. June 2007, Pp 205 – 216.

Urban-Econ (2017). *Economic Inputs into Coastal Economic and Spatial Strategic Framework for the City of Cape Town, Final Draft Report*. Cape Town.

Van Niekerk, L., Adams, J.B., Lamberth, S.J., MacKay, C.F., Taljaard, S., Turpie, J.K., Weerts S.P. & Raimondo, D.C., 2019 (eds). *South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm*. CSIR report number CSIR/SPLA/EM/EXP/2019/0062/A. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A. http://hdl.handle.net/20.500.12143/6373

Van Niekerk, L. and Taljaard, S. 2007. *Proposed Generic Framework for Estuarine Management Plans*. Report prepared by the CSIR for the Cape Estuaries Programme.

Viskich, M., Erasmus, C., Lamberth, S., and Griffiths, C.L. 2016. *Long-term Physical, Chemical, and Biological Changes in a Small, Urban Estuary*. African Journal of Marine Science, Vol 38(1). Pp 1-15.

Withers, P.J. and Lord, E.I., 2002. *Agricultural Nutrient Inputs to Rivers and Groundwaters in the UK: Policy, Environmental Management and Research Needs*. Science of the Total Environment, Vol 282, Pp.9-24.

Wright AG, Clark BM and K. Hutchings. 2020. *Marine Ecology Monitoring Plan for the Milnerton Lagoon*. Specialist Report no. 1903/6 prepared by Anchor Research & Monitoring (Pty) Ltd for the City of Cape Town. 59pp.

10. ANNEXURES

A	Maintenance Management Plan for the Diep River estuary
B	Integrated Reserve Management Plan
C	Transversal Action Plan for the Diep River estuary
D	Marine Ecological Monitoring Plan
E	Invasive Alien Species Monitoring, Control and Eradication Plan: Table Bay Nature Reserve
F	Pumpstation Failure Sewer Response Protocol: Sandrift East Sewer Pump Station

ANNEXURE A

Maintenance Management Plan for Surface Stormwater System

System name: Diep Estuary

TCT DISTRICT: 1 Blaauwberg

ORIGINAL (version 1.0)

Prepared by: Click here to enter text.

Designation: Click here to enter text.

Contact tel: Click here to enter text.

Email: Click here to enter text.

Date: 2016/08/03

VERSION CONTROL:

Version: Rev 1.

Amended by: Click here to enter text.

Designation: Click here to enter text.

Contact tel: Click here to enter text.

Email: Click here to enter text.

Amendment date: Click here to enter a date.

This MMP has been developed with input from Anchor Environmental.
Hutchings K, Forsythe K & Clark B.M. 2016. Maintenance Management Plan, Diep Estuary. Prepared by Anchor Environmental Consultants for City of Cape Town.

APPROVED BY

Note: in terms of the Environmental Authorisation received from DEA&DP the following role players must approve (sign) this MMP: Project Manager (generally from TCT), E&HM Branch, Stormwater and Sustainability Branch and, in certain cases, Biodiversity Management Branch.

South African National Parks must also be consulted and sign off in cases when MMPs cover SANParks owned or managed land.

Document Version	*Organisation*	*Department & Branch*	*Name*	*Designation*	*Signature & Date*
V1	*City of Cape Town*	*TCT – Asset Management & Maintenance*	*Johan Massyn*	*District Manager*	
	City of Cape Town	*TCT- Asset Management & Maintenance*	*Saliem Solomon*	*Principal Prof Officer*	
	City of Cape Town	*TCT – Stormwater & Sustainability*	*Ben de Wet*	*Catchment Planner*	
	City of Cape Town	*TCT – Stormwater & Sustainability*	*Candice Haskins*	*Senior Prof Officer (Ecologist)*	
	City of Cape Town	*ERM – Environment & Heritage Management*	*Pat Titmuss*	*District Manager*	
	City of Cape Town	*ERM – Biodiversity Management*	*Koos Retief*	*Table Bay Nature Reserve Manager*	
	City of Cape Town	*Sport, Recreation and Amenities*	*Edward Knott / Helen Jordaan*	*Coastal Co-ordinator*	

CONTENTS

Contents

1 INTRODUCTION

1.1	**Purpose of this document:** The purpose of a Maintenance Management Plan (MMP) is to provide guidance to District operational staff regarding the various routine stormwater management and maintenance tasks performed on specific surface water systems such as watercourses and wetlands within the City of Cape Town's jurisdiction. The MMPs are compiled in accordance with the EIA authorisation process for the City's routine stormwater maintenance and management programme (Environmental authorisation dated 13 February 2015, EIA Reference # 16/3/1/3/1/A7/4/2031/12). In terms of the approval received from the Department of Environmental Affairs and Development Planning (DEA&DP), the City and its duly appointed and supervised contractors are authorised to undertake a range of routine stormwater maintenance tasks provided that the provisions of the Environmental Management Programme (EMPr) are adhered to, and that a site / reach specific MMP is compiled and adhered to for each work area. The MMPs are to be compiled with the multi-disciplinary inputs of key personnel from Transport for Cape Town (TCT), Environment and Heritage Management (E&HM), Biodiversity Management, City Parks, and other line departments or role players (where necessary). Once compiled, the MMP document stands as an internal record to guide all future operational maintenance activities pertinent to specific identified locations. The MMP should be updated if additional maintenance activities are identified, or amendments to e.g. the method statements are necessary. Ongoing record keeping which documents maintenance interventions as and when they take place is necessary and has been provided for towards the end of the MMP. These records are important in order to facilitate future planning & budgeting, track financial spending, capture environmental / H&S incidents and ensure that audits by the authorities can take place when required. The MMP must be provided to relevant internal or external contracted operational staff so that they can undertake stormwater maintenance interventions in a manner that is appropriate to the specific surface water system and environmentally sustainable. A leaflet entitled "Basic information for operators" is also available for dissemination. Each completed MMP must be submitted to DEA&DP for their records (email the case officer: Rondine.Isaacs@westerncape.gov.za).
1.2	**Using this document:** Sections 1 – 3 of this document provide an introduction to the surface stormwater system (e.g. watercourse or waterbody) addressed by the MMP, indicating its location, and providing a summary of the present condition of the system and any applicable engineering, environmental or heritage constraints. Section 4 presents method statements for each maintenance measure undertaken on the system. Section 5 provides key contact numbers. Section 6 provides references of reports and documentation used to inform this MMP Section 7 includes log sheets for recording the dates that various tasks (e.g. inspections and operational works) have been undertaken and other pertinent date-specific comments such as incidents.

2 LOCATION

<table>
<tr><td>2.1</td><td colspan="4">Title:

Diep Estuary Maintenance Management Plan</td></tr>
<tr><td>2.2</td><td colspan="4">TCT District:
1 Blaauwberg</td></tr>
<tr><td>2.3</td><td colspan="4">Location Description:

This MMP only covers the lower section of the Diep system which is considered to exhibit certain estuarine characteristics. The area defined for this MMP extends from the river mouth to south boundary of the Blaauwberg Road. The MMP also covers most of Zoarvlei which also drains into the Diep estuary close to the river mouth. The extent of the MMP is shown in Figure 1.</td></tr>
<tr><td>2.4</td><td colspan="4">Limits:

Starting point: Diep River Mouth (point C), including Zoarvlei (point D)
End Point: The Blaauwberg Road bridge (points A1: Bayside end and A2: Diep River end on Figure 1).
Length: Approximately 7.8 km.</td></tr>
<tr><td rowspan="2">2.5</td><td rowspan="2">Co-ordinates:</td><td>Upstream limit (1):
33°49'28.83"S
18°29'14.75"E
Point A1 on the map</td><td>Downstream limit:
33°53'30.40"S
18°28'54.80"E Point C on the map</td><td rowspan="2">Centre point:
33°51'30.99"S
18°29'53.02"E Point B on the map</td></tr>
<tr><td>Upstream limit (2):
33°50'1.22"S
18°31'18.32"E
Point A2 on the map</td><td>Zoarvlei
33°54'25.63"S
18°28'50.85"E Point D on the map</td></tr>
<tr><td>2.6</td><td colspan="4">Location Map:</td></tr>
</table>

Figure 1: Diep MMP scope . This MMP addresses the area as indicated by the yellow polygon.

2.7 **Closest Nature Reserve:**

The following reserves may be contacted for advice regarding the removal or relocation of animals from the site: Table Bay Nature Reserve 021 444 0315

Note:

- No animals may be relocated to any protected area without necessary permits and confirmation from the protected area management team.
- The City's Biodiversity Management Branch can be contacted for additional information and advice.

2.8 **Affected Landowners:**

The area included in this MMP occurs on land owned by the City. Most of the area is proclaimed in terms of NEM:BA Section 23 as a local Nature Reserve which is protected in perpetuity and managed by the City's Biodiversity Management Branch (Environmental Resource Management Department, ERM). Transport for Cape Town (TCT) is currently responsible for management of stormwater infrastructure as well as general catchment / river management. The Potsdam WWTW which is managed by Water and Sanitation is located on the eastern bank near the Blaauwberg Road bridge. A private residential development (Woodbridge Island) and the Milnerton Golf Club is located on the western edge of Milnerton Lagoon – no maintenance work however takes place in these areas.

	Indicate if land owners / managers have been consulted? Yes ☒ No ☐ Comment / land owner details: Internal City departments which have been consulted include TCT, ERM and Sport, Recreation & Amenities.
2.9	**Heritage Resources** The National Heritage Resources Act (No 25 of 1999) requires permits to be obtained for activities which will involve the alteration or demolishing of heritage resources. Please consult the **Environment & Heritage Management Branch** during the compilation of the following section. Answer the following questions, if the answer to any is "yes" consult Heritage Western Cape (HWC). • Does the activity involve the alteration or demolishing of any structures older than 60 years? Yes ☐ No ☒ • Are there are known archaeological and paleontological sites and material or meteorites within or immediately surrounding the activity area? Yes ☒ No ☐ • Are there any known burial sites or graves within or immediately surrounding the activity area? Yes ☐ No ☒ Comments: 1) A wrecked wooden hull that has tentatively been identified as that of the Commodore II ship, is located in the estuary mouth. It has been known to move during spring tides from the mouth to a corner. The remains of the ship are protected by the National Heritage Resources Act and care must be taken not to damage the wreck during maintenance activities. 2)The wooden bridge between Woodbridge Island and Marine Drive (West Coast Road) located in Milnerton was built in 1901 during the South African War. It was built by the Fortress Company of the Royal Engineers for military access to the island and it is the only surviving structure of its kind in the country. The wooden bridge is a Provincial Heritage Site (PHS) protected by the National Heritage Resources Act and must not be damaged. Section 38 (1) of The National Heritage Resource Act requires that HWC are notified if any activities trigger the following: If the answer to any statements is "Yes" a Notification of Intent to Develop (NID) must be submitted to HWC and a response on the way forward received from HWC prior to any activities commencing. • The construction of a road, wall, powerline, pipeline, canal or similar form of linear development or barrier exceeding 300m in length. Yes ☐ No ☒ • The construction of a bridge of similar structure exceeding 50 m in length. Yes ☐ No ☒ • The re-zoning of a site exceeding 10,000 m^2 in extent or Yes ☐ No ☒ • Any development or activity that will change the character of a site: ◦ Exceeding 5,000 m^2 in extent; or Yes ☐ No ☒ ◦ Involving three or more existing erven or subdivisions thereof; or Yes ☐ No ☒ ◦ Involving three or more erven or divisions thereof which have been consolidated within the past five years; or Yes ☐ No ☒ • The cost of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority. Yes ☐ No ☒ • Any other category of development provided for in regulations by SAHRA or a provincial heritage resources agency. Yes ☐ No ☒ Comments: None of the above are applicable E&HM Official that was consulted: Sonja Warnich Stemmet HWC notification details: not required

3 DESCRIPTION

3.1	**Catchment:**

	The mouth of the Diep Estuary lies approximately 5 km north of Cape Town CBD. The estuary is fed by the Diep River whose catchment size is approximately 1 495 km^2 and extends from the Riebeek Kasteel Mountains in the north-east to the Durbanville Hills in the south-west. The main tributaries of the Diep River are the Mosselbank, Swart and Riebeeks rivers; however all these tributaries merge into the Diep River before entering the top of the estuarine area at the Blaauwberg Road bridge. (Hutchings & Forsythe, 2016). The Zoarvlei area located in Paarden Eiland to the south of Milnerton Lagoon also enters the sea at the same location as the Diep and is considered to be part of the Diep estuary. The predominant land use within the broader upstream catchment area is agriculture, however the land use of the area immediately surrounding the estuary is mainly conservation, urban residential and industrial. The Diep estuary mouth remains permanently open due to freshwater input from the Potsdam Wastewater Treatment Works (WWTW) (Hutchings & Forsythe, 2016).
3.2	**Watercourse Type** This MMP covers the lower section of the Diep system (Figure 1) which has some estuarine characteristics and is a permanently open system. The Diep estuary comprises Rietvlei and Milnerton Lagoon which combined cover an area of approximately 900 ha, and the smaller Zoarvlei area to the south. Rietvlei extends from the Diep River at the Blaauwberg Bridge in the north-west and Marine Drive bridge in the south and across to the R27 in the east. The deep water lake known as Flamingovlei and numerous seasonal pans are located within the Rietvlei section. On the southern side of Marine Drive, the Milnerton Lagoon runs south alongside Woodbridge Island before discharging into the sea. (Hutchings & Forsythe, 2016). The Diep River is largely perennial although farm dams and abstraction in the upper catchment area results in the river drying up in some areas towards the end of summer/autumn. Discharge from the Potsdam WWTW and stormwater runoff augments flow in the river in the lower estuarine area.
3.3	**Watercourse Ecological Importance** In 2012 the estuaries of South Africa were assessed during a desktop health assessment to try and identify gaps in knowledge and shortcomings of previous assessments and provide a comprehensive consistent assessment of estuaries in South Africa. The assessment targeted a number of different areas, examining both the pressures and threats to each estuary as well as the current condition for a number of bio-physical parameters. The National Biodiversity Assessment (van Niekerk and Turpie 2012) rated the Diep Estuary as having a "Poor" mean Estuary Health State and an Ecological category of E. Despite being in a poor ecological condition, the Diep estuary is a sizable and important habitat for large number of waterbirds. Rietvlei is considered to be an Important Bird Area (IBA) by BirdLife International. Harebottle (2011) rated the Rietvlei area of the Diep Estuary as being in the top ten wetlands in South Africa's winter rainfall region in terms of waterbird conservation importance for both summer and winter seasons. The rest of the Diep Estuary, which was considered much less important in terms of conservation value, still falls within the boundaries of the IBA. Besides waterbirds, the Diep Estuary also houses rare ecological habitats like the sedge pans found in Rietvlei. It is also provides habitat for the threatened White Steenbras *Lithognathus lithognathus* Ongoing monitoring by the City of Cape Town has shown that water quality in the Diep River and canals draining this system is poor. In 2015 only 42% of samples collected from the river and canal sites met the intermediate contact recreational guideline (i.e. ≤ 1000 *E.coli*/100ml), this is slight improvement from 2013 and 2014 where only 36% and 41% respectively of samples met the guideline. Water quality in the Milnerton Lagoon section is similarly poor (2013 44%, 2014 35% and 2015 40%). In contrast, bacterial water quality in the Rietvlei section is excellent (2013 90%, 2014 100% and 2015 100%). Water quality in the Zoarvlei area is variable with 81%, 57% and 86% recorded over the same three years (City of Cape Town 2016).
3.4	**General Site Specific Comments (environmental / engineering / social / heritage considerations):** • The wood ship wreck near the mouth of the Milnerton Lagoon and the wooden bridge at Woodbridge Island are heritage features which must not be damaged. • The Diep estuary is recognised as an Important Bird Area. Care must be taken to avoid

	disturbing nesting, foraging and roosting birds. • The Diep estuary lies within the Table Bay Nature Reserve complex which comprises Rietvlei, Milnerton Lagoon, Zoarvlei and the Diep Fynbos Corridor all of which are managed the City's Environmental Resource Management Department. The area also forms part of the regional West Cape Biosphere Reserve which stretches northward from Diep River in Cape Town to the Berg River and covers 378000 hectares of coastal lowland plains. • PPE must be provided to persons working in potentially polluted areas (e.g. the Erica Road stormwater outlet).  ***Figure 2: Diep estuary environmental considerations***
3.5	**Photographs: Examples of some of the maintenance interventions described in this MMP.**

 Photo 1: Maintenance of the concrete walkway is required.	 Photo 2: Remnants of a ship wreck near the mouth of Milnerton Lagoon. Maintenance activities must not disturb this heritage feature. Note that the wreck is periodically buried then re-exposed due to mobile sand in the area.
 Photo 3: Maintenance of stormwater outlet headwalls and unblocking of outlets is required near the estuary mouth.	 Photo 4: Sediment removal is required at the Bayside canal. Removed sediment should not to stockpiled for periods longer than two weeks.
 Photo 5: Aquatic, reedbed and emergent vegetation needs to be managed in various locations such as upstream and downstream of the Blaauwberg road bridge.	 Photo 6: The litter trap at Erica Road stormwater outfall requires maintenance. Note: pollution from sewerage. Removal of litter and other pollution that accumulates at this stormwater outlet and litter trap is also required.

Photo 7: Weirs at the Theo Marais outlet require maintenance

Photo 8: Canals walls at Theo Marais outlet require maintenance.

Photo 9: Litter accumulation along the edge of Milnerton Lagoon

Photo 10: Litter and debris accumulation in a stormwater channel

4 STORMWATER MAINTENANCE MEASURES

4.1	**Introduction:** More detail regarding the various stormwater maintenance measures can be found in the Technical Assessment Report and Environmental Management Programme / EMPr (Appendix J and H of the Basic Assessment Report. Gibb 2014) which supported the EIA application for Environmental Authorisation of the City's stormwater maintenance programme. Ensure that all operational staff are familiarised with the contents of this MMP, environmental site constraints, best practise methods etc.
4.2	**General specifications:** Standard "best practice" mitigation measures that are broadly applicable to maintenance works undertaken in the vicinity of all watercourses including estuaries are described under "General Specifications" in the Environmental Management Programme (EMPr) (Appendix H of the Basic Assessment Report) (Gibb 2014). These include specifications on: Environmental Awareness, Vegetation Impacts, Biodiversity Impacts, Topsoil, Construction Plant and Material Management, Solid Waste Management, Washing and Wastewater Management, Sanitation, Fuels, Oil, other Hazardous Substances and Spills, Stormwater Management and Erosion, Air Quality, Noise Control, Concrete Batching, Trenching and Excavations, Access Roads, Road Reserves, Working Times, Health and Safety, Fire Prevention and Control, Works and Site Decommissioning, Rehabilitation, Monitoring and Compliance, Heritage and Archaeology.

	Specifications that are relevant to each of the stormwater maintenance measures undertaken within this particular system have been described in section 4.4 onwards.
4.3	**Typical Stormwater Maintenance Measures:** Measures typically carried out in this system include the following (refer to checked boxes ☒): **1. VEGETATION MANAGEMENT** • 1.1 Aquatic (floating) vegetation management ☒ • 1.2 Reedbed and indigenous emergent (instream) vegetation management ☒ • 1.3 Riparian/ marginal (bank) vegetation management ☒ **2. EROSION CONTORL** • 2.1 Estuary bank profile enhancement ☒ • 2.2 Construction, maintenance and expansion of erosion control infrastructure ☒ **3. SEDIMENT MANAGEMENT** • 3.1 Construction, maintenance and expansion of sediment traps / retention areas ☐ • 3.2 Manual / mechanical sediment removal from sediment traps / retention areas ☒ • 3.3 Manual / mechanical sediment removal from canals, channels and water bodies ☒ **4. CHANNEL ENCLOSURE** • 4.1 Conversion of an open channel to an enclosed pipe/ culvert system ☐ **5. LITTER AND DEBRIS REMOVAL** • 5.1 Manual / mechanical litter and debris removal ☒ • 5.2 Removal of existing structures which impede river flow ☒ • 5.3 Construction, maintenance and expansion of litter management infrastructure ☒ **6. CONSTRUCTION, MAINTENANCE AND EXPANSION OF MINOR STORMWATER INFRASTRUCTURE** • 6.1 Stormwater outlets, dam scour valves, headwalls and culverts ☒ **7. MAINTENANCE OF ATTENUATION INFRASTUCTURE** • 7.1 Weirs ☒ • 7.2 Retention/ detention ponds and dams registered in terms of the National Water Act as dams with a safety risk. ☐ • 7.3 Flood protection embankments/ berms ☒ • 7.4 SUDS facilities ☐ • 7.5 Other dams/ ponds ☐ **8. RECREATIONAL ACCESS** • 8.1 Construction, maintenance and expansion of footbridges, boardwalks or bird hides ☒ **9. MANAGEMENT OF RIVER/ ESTUARY MOUTH** • Breaching, removal of sand bars deposited in the mouth ☐ • Straightening: redirecting a meandering mouth across the shortest route directly towards the sea ☐ **Note that in terms of the Environmental Authorisation issued by DEA&DP, a suitably experienced Environmental Control Officer (ECO) or site agent is required if any of the above involve <u>construction or land clearing</u> activities. ECO involvement in other interventions at the discretion of the District team.** Construction or land clearing activities involved? Yes ☒ No ☐ If YES, indicate who the ECO is (can be internal E&HM official or external contracted ECO): Marie-Louise van den Berg Records of ECO inspections are to be kept in Section 7 of the MMP.
4.4	**Maintenance Measure:** Vegetation Management
4.4.1	**Measure Description:**

	1.1 Aquatic (submerged and floating) vegetation management 1.1.1 Manual removal 1.1.2 Mechanical removal 1.1.3 Biocontrol (see section 4.5)
4.4.2	**Location:** Removal of alien and invasive aquatic species may be required throughout the estuary if such species become problematic. Water hyacinth removal is undertaken at a number of locations across the estuary depending on where infestations have been reported such as: • Diep River in vicinity of Blaauwberg Rd bridge • Along the entire extent of the bypass canal to the Marine Drive bridge and also downstream of this bridge • Bayside canal • Zoarvlei
4.4.3	**Frequency:** Removal of alien invasive aquatic species would be required if and when the species become problematic in the estuary. Manual removal of aquatic vegetation (other than alien invasive species) is only required occasionally.
4.4.4	**Map:** The following maps indicate the position of key activities associated with this maintenance intervention. 

Figure 3: Location of aquatic vegetation management in the Diep estuary.

4.4.5 **Operational works / method statements:**

1.1.1 Manual removal of aquatic vegetation

Pre-works checklist:

- Manual methods to remove aquatic vegetation can be used in shallow areas where infestations are small. Labour intensive / job creation programmes can possibly be utilised. Ensure that manual work teams are equipped with appropriate PPE, particularly if working in potentially polluted areas.
- Removal of aquatic vegetation in deeper / inaccessible areas may require the use of machinery such as a long boom excavator. Ensure that the machinery is in good working order and that there is no leakage of hazardous substances such as fuel or oil
- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- Before vegetation is removed, the site is to be inspected to understand site constraints and to ensure that access, and vegetation stockpile locations are understood.

Works:

- Where possible use existing access routes and stockpile areas as indicated in figure 2. Take care not to trample or disturb sensitive estuarine habitats, plants or animals.
- Use appropriate tools such as rakes etc. to dislodge and draw vegetation towards

	collections point/s (could be a floating raft or identified points on the bank). If a long boom excavator is used, ensure that it is fitted with a water bucket to limit damage to banks. • If possible, clearing of vegetation should start up river and move in a downstream direction to avoid further disturbance of already cleared patches. • If feasible place nets downstream to catch fragments of plants. • Collect and remove from site as much of the targeted material as possible to prevent re-growth and blockages. • Stockpile removed material at least 10m from the High Water Mark (HWM) / water edge for no longer than two weeks. *Post-works monitoring:* • Work areas, stockpile locations and access points (especially banks) are to be monitored for erosion. Address erosion points if required. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events
4.4.6	**Labour force:** 1x foreman or supervisor, 1x truck/LDV driver, a team of workers (approx. 7 – depending on the extent of works)
4.4.7	**Tools:** Truck/LDV and trailer, long boom excavator, wheelbarrow, shovels, nets, rakes
4.4.8	**Materials:** Safety gear such as gloves, protective clothing, foot wear etc.
4.5	**Maintenance Measure:** Vegetation Management
4.5.1	**Measure Description:** **1.1 Aquatic (submerged and floating) vegetation management** 1.1.3 Biocontrol Biocontrol may be used on listed invasive aquatic species such as water hyacinth, parrots feather, Kariba weed, azolla and water lettuce. These plants can become problematic in systems where nutrient enriched inflows have resulted in eutrophication. Should any of the above listed species become problematic and biocontrol is deemed a feasible control measure, the release of suitable biocontrol agents will be guided by the City's Invasive Species Unit, (see section 5).
4.5.2	**Location:** Due to the unpredictable and transient nature of the establishment of invasive plant species, it is not possible to specify individual locations for this maintenance measure. Biocontrol agents may therefore be required at any location within the estuary where the plants have been identified as problematic.
4.5.3	**Frequency:** The release of biocontrol agents will be undertaken as and when required with guidance from the City Invasive Species Unit. If a biocontrol programme is successful there may be no need to release further biocontrol agents if a population becomes established. Biocontrol can be a slow method and it may take years for a population to become established. While a population of biocontrol agents is becoming established it may be necessary to use other methods in tandem to manage populations of the invasive aquatic plant.
4.5.4	**Map:** Locations requiring the use of biocontrol are not yet defined but these measures may occur at any location within the scope of this MMP as indicated by figure 1.

4.5.5	**Operational works / method statements:** **1.1.3 Bioncontrol** *<u>Pre-works checklist:</u>* • Consult with the CCT Invasive Species Unit prior to the release of biocontrol agents. • Use of herbicides can negatively affect biocontrol agents. Care must therefore be taken if using biocontrol and other control methods in the same area. • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. *<u>Works:</u>* *In this case the 'works' period refers to the establishment period of the biocontrol agent and can be an extended period (up to 5 years)* • Where possible use existing access routes as defined in figure 2. • Release biocontrol agents into identified target areas as per instructions of the City's Invasive Species Unit. *<u>Post-works monitoring:</u>* • The CCT Invasive Species Unit should be consulted for advice prior to large scale manual or mechanical removal of the target invasive species in areas where biocontrol agents have previously been released. • Regular inspections will be required to establish the effectiveness of biocontrol agents e.g. monitor the biocontrol agent to ensure they are still present in the system. • Care must be taken to ensure that a small controlled 'reserve' of the target plant species remains in the system (refuge for biocontrol agents) as this will reduce the requirement to repeatedly reintroduce biocontrol agents.Document the success of the use of biocontrol agents to determine if this is a viable option for the future.
4.5.6	**Labour force:** As required by the City's Invasive Species Unit
4.5.7	**Tools:** As required by the City's Invasive Species Unit
4.5.8	**Materials:** Biocontrol agents appropriate for management of the target invasive species, Safety gear such as gloves, boots, protective clothing.
4.6	**Maintenance Measure:** Vegetation Management
4.6.1	**Measure Description:** **1.2 Reedbed and indigenous emergent vegetation management** 1.2.1 Manual Removal 1.2.2 Mechanical Removal 1.2.3 Chemical Control
4.6.2	**Location:** Reedbed removal typically occurs in the same areas as aquatic vegetation removal. The removal of aquatic vegetation may also occur as a by-product of reed removal. Typha and Phragmites removal throughout the system, typically in small areas around stormwater outlets and stormwater channels and at road bridges. Larger areas of reeds within the Diep channel and around Rietvlei may also require management to ensure the hydraulic capacity of the system is maintained and to alleviate flooding. In addition,

	reed management may be required in terms of management objectives of the Table Bay Nature Reserve. Integrated management of reeds using a number of methods such as cutting, burning and herbicide application is periodically undertaken in the ponds adjacent to Waves Edge and Dolphin Beach Hotel under the supervision of reserve management.
4.6.3	**Frequency:** **1.2.1 Manual Removal** Small scale manual cutting of reeds and emergent vegetation from infrastructure such as stormwater outlets, stormwater channels and bridge crossings is undertaken as and when required, typically 1 to 2 times per year where such manual access is possible. **1.2.2 Mechanical Removal** Mechanical removal of reeds including the rhizomes from the Diep channel and other areas of dense infestation is typically required once every 3 to 5 years and is usually undertaken in conjunction with silt removal operations. These operations are required to re-instate the capacity of the system, reduce flood risk and may also be undertaken in order to achieve reserve management objectives. The need for management of extensive areas of reeds should be planned in conjunction with environmental professionals from E&HM / Biodiversity Management. **1.2.3 Chemical Control** Spraying of reeds with approved herbicides is occasionally undertaken in conjunction with controlled burns by the Biodiversity Management Branch.
4.6.4	**Map:** 

	 ***Figure 4: Location of reedbed and emergent aquatic vegetation management in the Diep estuary.***
4.6.5	**Operational works / method statements:** *<u>Pre-works checklist:</u>* • In general, do not clear purely for "aesthetic reasons" in un-channelled estuary flood plains. • Unless urgently required, do not clear emergent vegetation over the period July/August-December (this period includes the peak bird breeding period and period of juvenile marine fish recruitment to estuaries.) • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. • Before vegetation is removed, the site is to be inspected to understand site constraints and to ensure that access, and vegetation stockpile locations are understood. Sensitive areas such as salt marsh must be avoided during operations. • An environmental professional from the City's stormwater / environmental line function should assist with pre-works planning if extensive removal of reeds/emergent vegetation is required as part of bank reshaping and rehabilitation projects Such work could be planned in a phased manner according to logistical and budget considerations. *<u>Works:</u>* • Where possible use existing access routes and stockpile areas as defined in figure 2. • Regularly (see recommended frequency section 4.4.3) clear emergent and reed vegetation at stormwater outlets and channels, from sediment depositional areas and in areas where it is required to improve conveyance and flood storage capacity. . • Infrequent clearing of reed beds within the nature reserve area may also be necessary to support compatible biodiversity objectives such as encouraging establishment of a range

	of plant species and maintaining habitat diversity. Use manual removal where safe and feasible. Cut reeds close to ground at end of dry season. Note however that cutting of reeds often results in more dense and vigorous re-growth which will require attention the following year. • Where manual reed management is not feasible, and mechanical removal is required, use a long boom excavator with water bucket to avoid damage to the estuary banks and intertidal zone. Such removal will take place from the banks as the machinery cannot manoeuvre into the water. • If possible, clearing of vegetation should start up river and move in a downstream direction to avoid further disturbance of already cleared patches. • Collect and remove from site as much of the targeted and cut material as possible to prevent re-growth and blockages. • Stockpile excavated / cut material at least 10m from the High Water Mark (HWM) / water edge for no longer than two weeks. • Strictly follow EMPr guidelines for chemical control of vegetation in the estuarine functional zone. Only apply approved herbicides to the target species (use of trained operators is essential). *Post-works monitoring:* • Work areas, stockpile locations and access routes (especially banks) are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events
4.6.6	**Labour force:** 1x foreman or supervisor, 1x long boom excavator operator, 1x truck/LDV driver, a team of workers (approx. 7)
4.6.7	**Tools:** Longboom exacavtor, truck/LDV and trailer, wheelbarrow, chainsaw, saw, panga, brush-cutter, bush pick, hedge trimmer, sickles, herbicide applicators.
4.6.8	**Materials:** Safety gear such as gloves, protective clothing, safety harness, approved herbicides
4.7	**Maintenance Measure:** Vegetation Management
4.7.1	**Measure Description:** **1.3 Riparian/ marginal vegetation management** 1.3.1 Manual removal 1.3.2 Mechanical removal 1.3.4 Chemical control
4.7.2	**Location:** Clearing terrestrial vegetation from walkways and boardwalks in order to ensure the safety of pedestrians. Removal of alien riparian / marginal vegetation will be undertaken at any location around the estuary area where such species are problematic (e.g. as part of an alien species management programme).
4.7.3	**Frequency:** Clearing of vegetation to be done as and when required.
4.7.4	**Map:** Riparian / marginal vegetation is removed throughout the estuary from various locations. The estuarine area is defined in Figure 1.
4.7.5	**Operational works / method statements:** *Pre-works Checklist*

	• Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. • Identify specific plants requiring removal and/or demarcate areas requiring management. The Invasive Species Unit and/or Biodiversity Management can be consulted for advice if required. • If clearance of <u>indigenous</u> riparian or marginal vegetation is being considered the Biodiversity Management Branch representative must first be consulted to determine if the clearing is necessary. • The replanting of cleared areas with appropriate indigenous vegetation should be considered if little indigenous vegetation remains. Replanting plans must be submitted to the Biodiversity Management for approval before replanting commences. • Identify access route/s. Where possible use existing access routes or when using new access routes ensure they are as direct as possible, at right angles to the channel or area to be cleared. • Strictly follow EMPr guidelines for chemical control of alien vegetation in the estuarine functional zone. Only apply approved herbicides to target species. *<u>Works Checklist</u>* • Mechanical removal of shoreline vegetation is generally not permitted unless undertaken as part of bank reshaping / rehabilitation projects (refer to section 4.7). Such removal should follow guidelines in the pre-works planning under the guidance of Biodiversity Management (e.g. the Reserve manager) / E&HM. Re-vegetation with appropriate indigenous species must take place in conjunction with such projects. • Heavily mechanised methods to remove alien vegetation such as trees (e.g. bulldozers) are not acceptable within the estuarine functional zone, manual methods or the use of chainsaws are appropriate • Fell large trees to a level as close to the ground as is practically possible (up to 10 cm), Apply herbicide, prepared as per instructions to the cut stump (the herbicide prevents a coppicing species from re-sprouting, and the dye shows that a stump has been treated. If the herbicide is dissolved in diesel, apply to the whole stump and any exposed roots. If the herbicide is dissolved in water, apply to the cut area. Applications should be by means of a low pressure, coarse droplet spray from a narrow cone nozzle). Extreme care should be taken when using such herbicides in the vicinity of the water body. • Leave large tree stumps in place as this minimises post-clearing erosion. Do not disturb the river bed or banks by digging up large tree stumps. • For alien seedlings or saplings, either: a) Hand-pull, ensuring that the root stock is removed (use a lopper to dislodge the root before hand-pulling and dig out roots that break off); or b) Use a bow saw to cut young stems off at the base of the plant, as close to the ground as possible, and apply herbicide. • Limit workforce size when removing vegetation on banks or in muddy areas to reduce habitat degradation by trampling. • Stockpile cut material at least 10m from the HWM / water edge for no longer than two weeks. *<u>Post Works Monitoring</u>* • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events • Implement erosion control measures if bank stability is compromised by removal of marginal vegetation. • Conduct follow up operations timeously to prevent re-infestation.
4.7.6	**Labour force:** 1x foreman or supervisor, 1x truck driver, team of workers
4.7.7	**Tools:**

	Truck and trailer, wheelbarrow, chainsaw, saw, panga, brush-cutter, lopper, headge trimmer, bush pick, sickles, herbide applicators.
4.7.8	**Materials:** Safety gear such as gloves, goggles, protective clothing, safety harness, approved herbicides, wetting agents and dyes (consult the City's Invasive Species Control Unit regarding approved herbicides - this Unit keeps up to date on the latest appropriate invasive species control methods which are permissible in terms of national guidelines).
4.8	**Maintenance Measure:** Erosion Control
4.8.1	**Measure Description:** 2.1 Estuary bank profile enhancement 2.2 Construction, maintenance and expansion of erosion control structures.
4.8.2	**Location:** **2.1 Estuary bank profile enhancement** May be used to address erosion at various locations (where space and resources allow) as an alternative to the installation of erosion control structures and as part of reserve management to improve the condition of instream and bank habitats. Maintenance of an existing rehabilitation area on the banks of Zoarvlei near Wemmys Road may be required. **2.2 Construction maintenance and expansion of erosion control structures** • Maintenance of existing gabions on up and downstream sides of the wooden bridge (western bank). • Maintenance of existing gabions located at the Marine Drive bridge crossings. • Maintenance of concrete revetments along the eastern bank between the estuary mouth and Loxton Road. • Maintenance of rock revetment which support concrete walkway on the southern bank of the mouth (near Wang Thai). • New erosion control structures will be installed in areas affected by erosion (e.g. soft banks) as the need arises.
4.8.3	**Frequency:** **2.1 Estuary bank profile enhancement.** This would be undertaken to improve habitats affected by historical infilling along estuary banks as a once-off activity. Thereafter maintenance would be undertaken as and when required. Such pro-active rehabilitation measures would be implemented as funding becomes available and will most likely be done in phases. The proposed rehabilitation would only take place where the intervention will not compromise the existing level of bank stability. **2.2 Construction, maintenance and expansion of erosion control structures.** Maintenance of existing erosion control structures will be undertaken as and when required (depending on the condition of such infrastructure). The construction of new erosion control structures would be undertaken as a once-off intervention (the feasibility of re-profiling eroding / steep banks should however be investigated as a first option before erosion control structures are installed). Thereafter maintenance would be undertaken as and when required.
4.8.4	**Map:**


Diep
N
W
E
S
0
500 m
Diep (North) Erosion Control Measures
Erosion control - maintenance of stabilised bank
Erosion control - maintenance of gabion
Estuary boundary

Figure 5: Location of erosion control maintenance and management activities in the Diep estuary

4.8.5 **Operational works / method statements:**

2.1 Estuary Bank Profile Enhancement

Pre-works checklist:

- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- The environmental professionals from Biodiversity Management and/or Environmental and Heritage Management Branches should be contacted to determine if a re-vegetation plan is required as part of estuary bank profile enhancement. Indigenous species that are appropriate to the Diep estuarine environment should preferably be used.
- Determine desired slope / gradient of bank and demarcate work area and identify required materials during pre-works planning.
- Do not undertake bank profile enhancement over the period July/August - December (this period includes the peak bird breeding period and peak period of juvenile marine fish recruitment to estuaries)

Works:

- Use manual methods to re-profile banks and undertake associated earth works where possible.
- If manual labour is not feasible, limit access points of heavy machinery. An environmental professional should be present on site to assist with guiding earth works and ensuring that work is undertaken in terms of the pre-works planning.
- Make use of existing in situ earth material to re-profile the banks (do not introduce additional media unless in accordance with the bank re-profile plan and deemed appropriate for the environment).
- Replant modified bank with suitable, indigenous vegetation as soon as possible.
- Implement temporary erosion control measures in areas where tidal or flood water may erode banks prior to establishment of planted vegetation.

Post-works monitoring:

- Monitor disturbed areas to determine if sufficient indigenous vegetation growth has been achieved. Manage weed infestations if required.
- Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.

2.2 Construction, Maintenance and Expansion of Erosion Control Structures

Pre-works checklist:

- The feasibility of re-profiling eroding / steep banks should be investigated as a first option before new erosion control structures are installed (see previous section).
- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- Erosion control structures should only be installed in areas where there is a direct risk to built infrastructure or recreational / conservation amenities or potential erosion of soft estuary banks.
- The City's Stormwater engineers must provide guidance on appropriate erosion control siting, measures, materials and design during pre-works planning.
- The Woodbridge Island Body Corporate should be consulted prior to any works which may affect the private residential development.
- Do not undertake construction or repairs during peak bird breeding period July/August - December).

Works:

- Use manual construction and repair methods if appropriate (i.e. teams on foot rather than heavy machinery).
- Maintain or reduce footprint of existing hard structures across the estuary mouth channel, do not create additional barriers to the movement of biota into or out of the estuary.
- Make use of materials that are appropriate for the coastal environment (wet, high salt content environment) e.g. galvanised gabion baskets, pre-cast and cured cement elements (see materials list).
- Repair gabion wire baskets and/or reno mattress in situ if possible using appropriate materials. Repack rocks if required ensuring that the shape and dimensions of the original gabion / reno mattress structure is maintained. Ensure gabions and reno mattress are correctly positioned and anchored.
- Repairs to concrete revetments should preferably be done when the water level is low. A coffer dam can be built for repairs that are situated below the water level. A pump can be used to lower the water sufficiently for this repair. Cement with a quickset agent must be used in this instance.
- With regard to concrete batching the following must be adhered to as a minimum:
- Where possible, concrete required for maintenance activities shall be sourced from a

	recognised service provider. • Batching areas shall not be located within 150 m of any water body or any "No-Go" areas, unless written approval has been granted by the ECO. • Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used. • The Contractor shall ensure that minimal water is used for washing of concrete batching equipment. • Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement. • All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage. • Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment. • Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site. *Post-works monitoring:* • Monitor disturbed areas to determine if sufficient indigenous vegetation growth has been achieved. • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.
4.8.6	**Labour force:** 1x foreman/ supervisor, truck driver, team of labourers (number and mix of skills will depend on the extent of the works), ecologist/environmental professional and/or engineer where required for detailed planning.
4.8.7	**Tools:** 1 to 3 ton truck and/or trailer for labour and materials, rock delivery in 6 to 12 ton truck, shovels, pliers and wheelbarrow.
4.8.8	**Materials:** Various, depending on structure type, including: Premixed concrete, precast sections of concrete revetments, galvanised plastic coated wire for gabion baskets / pre-constructed gabion frame/basket, 100 and 150mm river stones, reno matress materials (120mm thick, galvanised plastic coated, length as required), galvanised plastic coated binding wire for patch and stitch work, indigenous seeds/plants, stakes and tape to demarcate work area if required.
4.9	**Maintenance Measure:** Sediment Management
4.9.1	**Measure Description:** 3.2 Manual/ mechanical sediment removal from sediment traps/ retention areas 3.3 Manual/ mechanical sediment removal from canals, channels and waterbodies.
4.9.2	**Location:** Note that sandy characteristics of this catchment result in rapid sediment accumulation in some areas. • Removal of sediment from blocked stormwater outlets and various stormwater channels and canals located around the estuary, including the Bayside canal and Theo Marais canal. • Removal of sediment from the vicinity of bridges (e.g. Marine Drive, Blaauwberg Road)

	• Removal of sediment from main Diep channel south of Blaauwberg Road bridge • Removal of Australian tube worm (*Ficopomatus enigmaticus*) starting approximately 550m upstream of the estuary to approximately 1.5km in upstream of the estuary mouth (location of this invasive alien species as per H. Pentz, 2015). Refer to Figure 7. *Note: Sediment removal may also occur as a by-product of reed removal.*
4.9.3	**Frequency:** • Removal of sediment from stormwater outlets, stormwater channels and canals such as Bayside Canal and Theo Marais Canal is required 1 to 2 times per year depending on the rate of deposition. • Removal of sediment in channel from the area downstream of the Blaauwberg Road bridge is infrequently required (once per 3 to 5 years). • Sediment removal may also occur as a result of vegetation removal (in particular the removal of reedbeds). • Tube worms deposits are removed infrequently from infested areas.
4.9.4	**Map:**

Figure 6: Location of sediment management activities in the Diep estuary

Figure 7: Location of tube worm deposits in the Diep estuary (Tube worm distribution based on data sourced from H. Pentz, 2015).

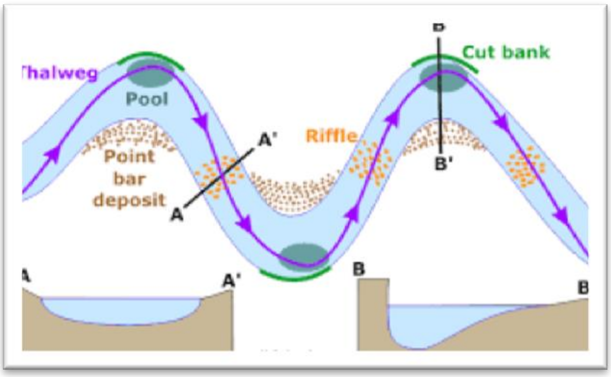
4.9.5 **Operational works / method statements:**

Note: as a general guide, on completion of the maintenance activity, the topography of the site should be similar to the pre-damage condition (i.e. the bank shape should be similar to the condition it was in prior to the sedimentation event/s that are being remedied). This means that the channel or banks cannot be made narrower, berms higher or the river channel deeper than before.

<u>*Pre-works checklist:*</u>

- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- Before work begins, the site is to be inspected to understand site constraints.
- Due to the depth of the river, machine access into the river is generally not possible. Sediment removal will therefore need to take place from the bankside.
- Spatially define limits of the sediment removal area and install marked stakes to indicate the appropriate depth to which sediments should be removed (this is to avoid over-excavation and the creation of artificial channels).
- When undertaking sediment removal from the channel section downstream of Blaauwberg Road do not deepen beyond the original (pre-damage condition) “thalweg” (definition: point of lowest elevation in the channel / the line that connects the lowest points in a

valley or river channel, and thus the line of fastest flow along a river's course; see Figure below). If possible, do not disturb the sediments for 2 m on either side of the thalweg. It is important from an ecological perspective that the natural low-flow channel be allowed to re-establish, and any marginal vegetation that establishes there remain intact as it provides cover, habitat and food for the riverine biota (Reinecke et al. 2013).



- Removal of sediments from the artificial Bayside and Theo Marais canals should aim to reinstate the design depth of the canals. Care should be taken to ensure that banks are not destabilised by operations.
- For mechanical removal of silt (and associated vegetation), temporary access routes should be as direct as possible, at right angles to the channel or area to be cleared.
- Identify and mark temporary storage/stockpile areas for dewatering of sediments at least 5m from the estuary water edge. Ensure no infrastructure or sensitive vegetation is damaged during storage.
- Truck access roads should only extend to temporary storage areas.
- Avoid sediment removal during peak bird breeding period (July/August-December) and during peak fish recruitment period (September- December).
- To minimise the duration and extent of disturbance to the estuary water body, start upstream and work downstream, preferably during the dry period.
- Take care not to damage infrastructure such as the stormwater outlets, gabions, bridge support etc. Report any damage to the project manager and/or District Manager immediately.

Works:

- Where feasible remove sediment using manual methods. This may however only be possible in small areas such as in the case of blocked stormwater outlets.
- Where manual labour cannot be used, remove the accumulated sediment from the target area with a tracked long boom excavator equipped with a water bucket or floating dredger, as appropriate. The former is generally used for small areas, while the latter may be more cost effective for larger areas.
- Due to the depth of the river, machine access into the river is generally not possible. Sediment removal will therefore need to take place from the bankside.
- Store removed sediments for dewatering in the assigned stockpile area. The Reserve manager will assist with determining an appropriate site which should be located away from sensitive areas.
- Remove stockpiled sediment within two weeks of completion of the operation. This should be an adequate period to allow for dewatering.
- Load dewatered sediments into trucks using the front end loader. If possible, cover trucks transporting sediment from the site.
- If contamination of sediment is suspected they should be tested prior to re-use.
- If possible re-use clean sediments (no vegetation) or dispose of mixed sediment and vegetation at Vissershok landfill site. Note that the sediment removed from the Diep system may be contaminated.
- If required, rehabilitate any temporary access routes prior to winter.

	Post-works monitoring: • Monitor disturbed areas (access routes, stockpile locations etc.) to determine if sufficient indigenous vegetation regrowth has been achieved. • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. • Inspections are to be undertaken prior to the onset of the winter rainfall period, and after the initial rainfall events.
4.9.6	**Labour force:** 1x foreman/ supervisor, long boom excavator/dredger and front end loader operators, truck/LDV driver, labourers (number will depend on the extent of the works).
4.9.7	**Tools:** Front end loader, long boom excavator/dredger, 12 ton truck/LDV and trailer, shovels, wheelbarrows. *Range of tools depends on extent of sediment removal and whether manual / mechanical*.
4.9.8	**Materials:** Wader/ gumboots, safety boots, work clothes, gloves. Marked stakes and tape (to define work area if required).
4.10	**Maintenance Measure:** Litter and Debris Management
4.10.1	**Measure Description:** 5.1 Litter and debris removal using either mechanical or manual methods. 5.2 Removal of structures to reduce water obstruction. 5.3 Construction, maintenance and expansion of litter management infrastructure.
4.10.2	**Location:** **5.1 Litter and debris removal using either mechanical or manual methods.** Litter and debris must be removed from many locations throughout the estuary e.g. numerous stormwater channels (particularly the Erica Rd stormwater channel and litter trap), outlets and culverts. Areas frequented by the public such as the nature reserve and the lagoon area down to the beach also require attention. **5.2 Removal of structures to reduce water obstruction.** Removal of rubble from the Theo Marais canal. **5.3 Construction, maintenance and expansion of litter management infrastructure.** Existing litter traps (e.g. Erica road outlet) and floating litter/oil booms (e.g. Theo Marias canal) will be repaired and maintained as required. New litter traps will be installed across the estuary as the need arises.
4.10.3	**Frequency:** **5.1 Litter and debris removal using either mechanical or manual methods**. Litter and debris needs to be removed particularly after rain events. Removal of litter and debris from the Erica Rd stormwater channel and litter trap in particular is regularly required. Windblown litter and litter washed down from the catchment or in from the sea may also need to be removed when required. Operations are however likely to be constrained by available resources. Use of labour intensive methods or partnerships with local interest groups can be helpful. **5.2 Removal of structures to reduce water obstruction.** Removal of rubble in the Theo Marais canal would be undertaken as a once off intervention. **5.3 Construction, maintenance and expansion of litter management infrastructure.** The frequency of maintenance of existing litter traps is determined by the condition of the infrastructure and whether the traps have been vandalised or damaged.

	Construction and expansion of litter traps will be undertaken once-off. This MMP must be amended to include the details of any planned new litter traps (i.e. locations, method statements, future maintenance needs etc.). Maintenance of any new infrastructure would thereafter be undertaken as required.
4.10.4	**Map:**  ***Figure 8: Location of litter and debris management activities in the Diep estuary***
4.10.5	**Operational works / method statements:** **5.1 Litter and debris removal using either mechanical or manual methods.** *Pre-works checklist:* • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work methods. • Before work begins, the site is to be inspected to understand safety risks and other site constraints such as presence and location of sensitive species. • It will generally be feasible to make use of hand labour to collect litter and other small debris items that are located along the edges of the estuary and inflowing stormwater channels / canal, but hand labour teams should be equipped with appropriate personal protective equipment, particularly when working is potentially polluted areas. • Manual work teams should be cautioned about not trampling vegetation excessively and to make use of the established walkways where possible • If litter and debris cannot be removed manually and the use of heavy machinery is required access routes should be determined in consultation with ERM. *Works:* • Clear litter from the inflowing river and stormwater channels and the estuary waterbody by moving systematically in a downstream direction to ensure that any litter that floats away will be collected further downstream. • If feasible, install temporary nets or canvas screens across stormwater pipe outlets when cleaning using “jetting” methods to catch any dislodged litter or debris.

- Remove litter from existing litter traps – this is important before winter and after major storm events.
- Avoid temporary stockpiling of litter and/or rubble, if necessary locate above tidal inundation area, cover to avoid wind redistribution and remove within 2 days of completion of the cleaning operation.
- Cover trucks used to transport wind-susceptible, light litter to disposal facility (most likely Vissershok landfill site).

Post-works monitoring:

- Work areas, litter / rubble stockpile locations and access routes (especially banks), are to be monitored for erosion.
- Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.

5.2. Removal of structures to reduce water obstruction

Pre-works checklist:

- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- Before work begins, the site is to be inspected to understand possible safety risks and other site constraints such as the presence of sensitive species.
- Avoid undertaking the clean-up operation during peak fish recruitment period (September-December).
- Ensure that any machinery to be used is in working order and that any diesel / oil leaks are fixed before work near the water commences.

Works:

- Remove rubble / obsolete structures ensuring that any required infrastructure and the banks of the system are not damaged.
- Avoid temporary stockpiling of the rubble, and, if necessary, locate above tidal inundation area.
- Dispose of rubble at an appropriate facility such as Vissershok.

Post-works monitoring:

- Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion.

5.3 Construction, maintenance and expansion of litter management infrastructure.

Pre-works checklist:

- Ensure operational staff / contractors are familiar with the contents of the MMP and the required work.
- Where possible do not undertake maintenance or construction over the period July/August - December (this period includes the peak bird breeding period and peak period of juvenile marine fish recruitment to estuaries)
- Before work begins, the site is to be inspected to understand site constraints.
- Adhere to General Specifications as described in EMPr (particularly concrete batching).
- Ensure new litter traps do no create additional barriers to the movement of biota.
- Ensure that the design of new litter traps is suitable for the intended location and can withstand floods without being damaged or dislodged. Ensure that operational capacity to empty the litter traps at the desired frequency exists.

Works:

- Adhere to General Specifications as described in EMPr (particularly concrete batching).
- If concrete works are required to repair or install litter traps the following must be adhered

	to as a minimum: • Where possible, concrete required for maintenance activities shall be sourced from a recognised service provider. • Batching areas shall not be located within 150 m of any water body or any "No-Go" areas, unless written approval has been granted by the ECO. • Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used. • The Contractor shall ensure that minimal water is used for washing of concrete batching equipment. • Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement. • All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage. • Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment. • Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site. • Rehabilitate any area negatively impacted by construction activities. *Post-works monitoring:* • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.
4.10.6	**Labour force:** 1x foreman/ supervisor, 1x truck/LDV driver, labourers (number will depend on the extent of the works).
4.10.7	**Tools:** Wheelbarrows, spades, LDV / truck and trailer.
4.10.8	**Materials:** Wader/ gumboots, gloves, canvas, nets, refuse bags to hold litter items, litter trap baskets, concrete, sand.
4.11	**Maintenance Measure:** Construction, Maintenance and Expansion of Minor Stormwater Infrastructure
4.11.1	**Measure Description:** 6.1 Construction, Maintenance and Expansion of e.g. stormwater outlets, headwalls and culverts
4.11.2	**Location:** Numerous stormwater outlets, headwalls and culverts throughout the system.
4.11.3	**Frequency:** Maintenance of existing minor stormwater infrastructure is relatively infrequent and largely determined by the condition of the infrastructure and whether it has been vandalised or damaged. Construction and expansion of minor stormwater infrastructure will be undertaken as once-off interventions as the need arises. Care should be taken to avoid creating hard structures in the estuary channel; i.e. do no create additional barriers to the movement of biota. This MMP must be amended to include the details of any future planned new stormwater infrastructure (i.e. locations, method statements, future maintenance needs etc).
4.11.4	**Map:**

Figure 9: Maintenance and Management of Minor Stormwater Infrastructure in the Diep Estuary.

4.11.5	**Operational works / method statements:** *<u>Pre-works checklist:</u>* • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. • Before work begins, the site is to be inspected to understand site constraints. • Do not undertake maintenance during peak bird and estuarine fish recruitment period (July/August- December). • Limit maintenance activity to dry periods where possible. • Adhere to General Specifications as described in EMPr (particularly concrete batching). *<u>Works:</u>* • With regard to concrete batching the following must be adhered to as a minimum: • Where possible, concrete required for maintenance activities shall be sourced from a recognised service provider. • Batching areas shall not be located within 150 m of any water body or any "No-Go" areas, unless written approval has been granted by the ECO. • Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used. • The Contractor shall ensure that minimal water is used for washing of concrete batching equipment. • Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement. • All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage. • Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment. • Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site. • Rehabilitate any area negatively impacted by maintenance activities. *<u>Post-works monitoring:</u>* • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.
4.11.6	**Labour force:** 1x foreman/ supervisor, 1x truck/LDV driver, labourers (number will depend on the extent of the works).
4.11.7	**Tools:** Truck/LDV and trailer, wheelbarrows, shovels and other building tools depending on nature of works.
4.11.8	**Materials:** Wader/ gumboots, safety boots, gloves, sand, cement, rocks / bricks, other components as required (depending on the type of stormwater infrastructure).
4.12	**Maintenance Measure: Attenuation Infrastructure**
4.12.1	**Measure Description:** 7.1 Weirs

	7.3 Flood protection embankments/ berms
4.12.2	**Location:** **7.1 Weirs** Maintenance of the weir in the Theo Marais canal. Sediment and litter removal takes place in the area immediately upstream of this weir structure. **7.3 Flood protection embankments/ berms** Maintenance of earth berm in the reserve area adjacent to Hof Street to prevent flooding of residential areas.
4.12.3	**Frequency:** Maintenance of the existing weir and earth berm is undertaken infrequently, as and when required.
4.12.4	**Map:** 

	 ***Figure 10: Maintenance and Management of attenuation infrastructure in the Diep Estuary.***
4.12.5	**Operational works / method statements:** *Pre-works checklist:* • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. • Before work begins, the site is to be inspected to understand site constraints. • Refer to EMPr particularly the section on concrete batching. *Works:* • With regard to concrete batching the following must be adhered to as a minimum: ◦ Where possible, concrete required for maintenance activities shall be sourced from a recognised service provider. ◦ Batching areas shall not be located within 150 m of any water body or any "No-Go" areas, unless written approval has been granted by the ECO. ◦ Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used. ◦ The Contractor shall ensure that minimal water is used for washing of concrete batching equipment. ◦ Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement. ◦ All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage. ◦ Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment. ◦ Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site. • Maintain the existing flood protection berm near Hof Street by replacing dislodged earth material and compacting. Do not raise the height of the berm which is currently

	approximately 1m above the adjacent low lying flood prone area. • Do not undertake maintenance during peak bird and estuarine fish recruitment period (July/August- December). • Limit maintenance activity to dry periods where possible. • Rehabilitate any area negatively impacted by maintenance activities. *Post-works monitoring:* • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.
4.12.6	**Labour force:** 1x foreman/ supervisor, 1x truck/LDV driver, labourers (number will depend on the extent of the works).
4.12.7	**Tools:** Truck/LDV and trailer, wheelbarrows, shovels and other building tools depending on nature of works.
4.12.8	**Materials:** Wader/ gumboots, safety boots, gloves, sand, cement, rocks / bricks.
4.13	**Maintenance Measure: Recreational Access**
4.13.1	**Measure Description:** 8.1 Construction, maintenance and expansion of footbridges, boardwalks or bird hides.
4.13.2	**Location:** • Maintenance of a number of footpaths, bird hides, reserve signage, access roads, picnic / fishing areas, ablutions, slipways, floating jetty, controlled access gates and boardwalks within the Table Bay Nature Reserve estuarine area. If any new recreational infrastructure is required it should not be located below the High Water Mark and a setback of at least 5m from the estuary water edge must be provided. This MMP must be amended to include the details of any future planned new recreational infrastructure (i.e. locations, method statements, future maintenance needs etc.).
4.13.3	**Frequency:** Maintenance of existing recreational infrastructure is relatively infrequent and largely determined by the condition of the infrastructure and whether it has been vandalised or damaged. Construction of new / expansion of existing recreational access facilities will be undertaken as once-off interventions when required.
4.13.4	**Map:**

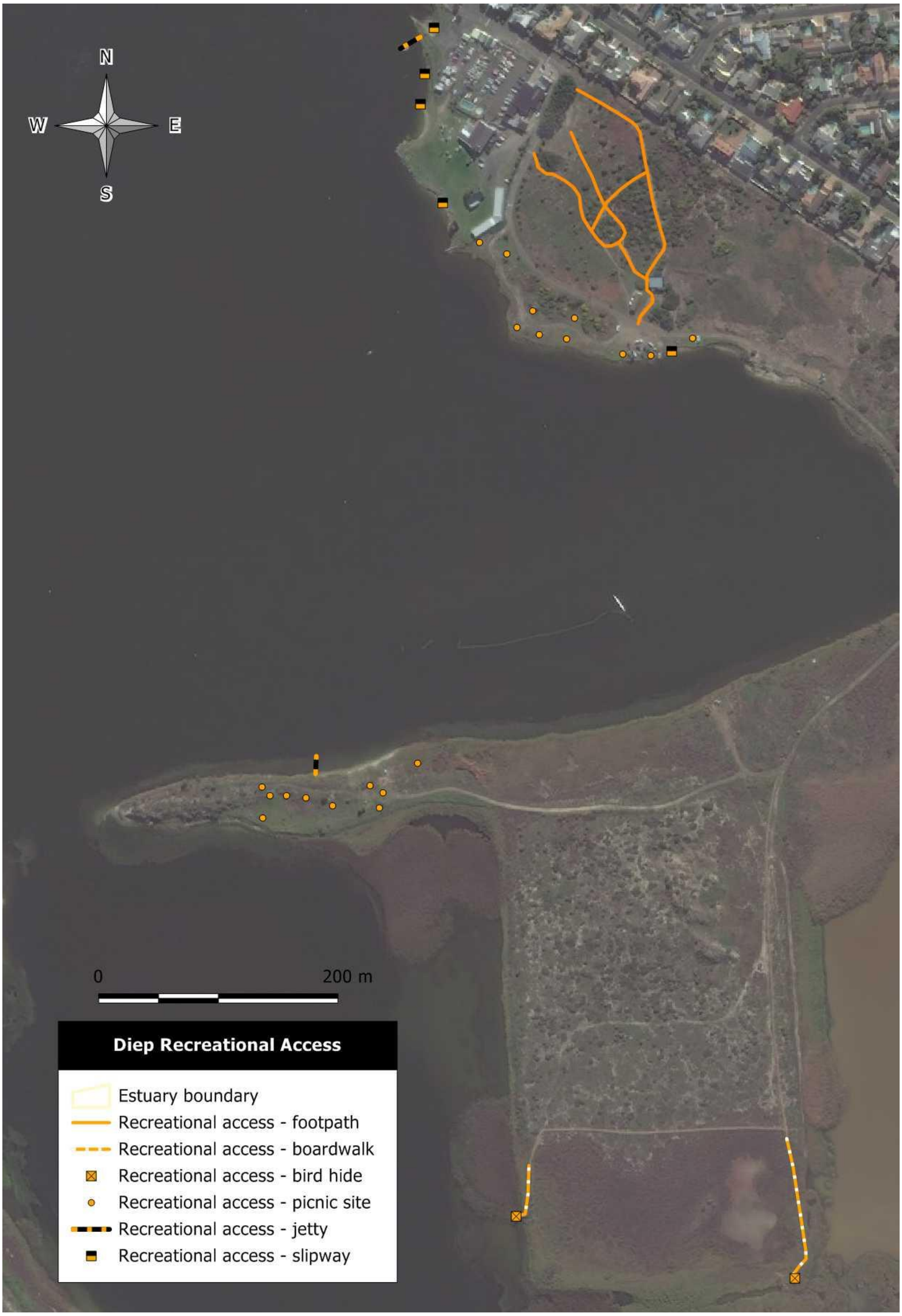


Figure 11: Maintenance and Management of recreational infrastructure in the Diep estuary.

4.13.5	**Operational works / method statements:** *<u>Pre-works checklist:</u>* • Ensure operational staff / contractors are familiar with the contents of the MMP and the required work. • Before work begins, the site is to be inspected to understand site constraints. • Refer to EMPr particularly the section on concrete batching for detailed guidance. *<u>Works:</u>* • Avoid peak bird breeding periods (September – December). • Where possible, use manual methods to carry materials onto site using existing access routes/paths. • Refill and compact uneven portions of pathway. Do not store / stockpile laterite within the estuarine zone. • Repair recreational access structures by replacing damaged components such as wooden slats, support beams, hand rails, signboards, seating, gates etc. • With regard to concrete batching the following must be adhered to as a minimum: • Where possible, concrete required for maintenance activities shall be sourced from a recognised service provider. • Batching areas shall not be located within 150 m of any water body or any “No-Go” areas, unless written approval has been granted by the ECO. • Concrete shall not be mixed directly on the ground. Mixing trays, wheelbarrows or concrete mixing machines can be used. • The Contractor shall ensure that minimal water is used for washing of concrete batching equipment. • Used cement bags must be stored tidily in weather proof containers until disposal off-site. Unused cement bags must be stored under dry conditions to prevent leaching of cement. • All reasonable measures must be taken to ensure that transportation of concrete does not result in spillage. • Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment. • Waste concrete, cement sludge and mortar leftovers shall be removed from site to an approved landfill site. *<u>Post-works monitoring:</u>* • Work areas, stockpile locations and access routes (especially banks), are to be monitored for erosion. Inspections are to be undertaken prior to the onset of the winter rainfall period, but after the initial rainfall events.
4.13.6	**Labour force:** 1x foreman/ supervisor, 1x truck driver, labourers (number will depend on the extent of the works).
4.13.7	**Tools:** LDV/truck and trailer, piling rig (optional), picks, shovels and wheel barrows.
4.13.8	**Materials:** Various, depending on structure types, including premixed concrete, boardwalk/ bridge components, pre-constructed benches, bricks, selected gravels (path base and top dressing), signage.

5 KEY CONTACT INFORMATION

Specialist / Unit	Name	Contact Details
TCT District Representative (District Manager / Project Manager)	Johann Massyn / Saliem Soloman	021 444 6053 / 5765
TCT SS Representative (Catchment Planner / Assistant Catchment Planner)	Ben de Wet	021 400 5036
TCT SS Representative (Aquatic Ecologist and Water Quality Specialist)	Candice Haskins	021 400 3088
Environmental & Heritage Management District Representative	Pat Titmuss / Morne Theron / Katy Spalding	021 444 0605 / 01
Environmental & Heritage Management District Representative (Heritage Professional)	Sonja Warnich Stemmet	021 444 0598
Environmental & Heritage Management District Representative (ECO)	Marie-Louise van den Berg	021 400 0600
City Parks District Representative	Morton Arries	021 550 7761
Sport, Recreation & Amenities	Edward Knott / Helen Jordaan	
Biodiversity Management - Table Bay Nature Reserve Area Manager	Koos Retief	021 444 0315
Biodiversity Management Representative (General)	Ian Cranna	021 514 4191
Biodiversity Management 24 hour hotline (fauna relocation)	-	083 499 1717 / 021 444 0315
Biodiversity Management Representative (Floral biodiversity)	Dr Pat Homes	021 514 4185
Biodiversity Management Representative (Faunal biodiversity / removal of snakes and dangerous fauna)	Dalton Gibbs Clifford Dorse	021 706 2404 021 514 4519
Cape Nature (General)	n/a	Switchboard at Bridgetown offices 021 483 0000
Cape Nature (Freshwater Specialist)	Dean Impson	021 414 0020
Cape Nature (Estuarine Specialist)	Pierre de Villiers	021 866 8000
SPCA Wildlife Unit	-	021 700 4158/4159
General Emergency Number (fire, police, ambulance)	n/a	107 toll free from land line OR 021 480 7700 from cell phone

6 REFERENCES

City of Cape Town. 2016. Inland and coastal water quality report: January-December 2015. City of Cape Town, South Africa

Harebottle, D.M. 2011. Seasonality and abundance of waterbirds in the winter rainfall region of South Africa. PhD thesis, University of Cape Town. Rondebosch, South Africa.

Hutchings K, Forsythe K & Clark B.M. 2016. Impact Assesment Report, Diep. Prepared by Anchor Environmental Consultants for City of Cape Town.

Pentz H, 2015. Factors affecting the distribution of *Ficopomatus enigmaticus* (Australian tube worms) in Milnerton Lagoon.

Reinecke, K., Rountree, M, Brown, C and Crowther, J. 2013. Breede River Maintenance Management Plans (MMPs) Scoping Report.Landcare Division, Cape Winelands District, Western Cape Department of Agriculture.

Van Niekerk, L. and Turpie, J.K. (eds) 2012. South African National Biodiversity Assessment 2011: Technical Report. Volume 3: Estuary Component. CSIR Report Number CSIR/NRE/ECOS/ER/2011/0045/B. Council for Scientific and Industrial Research, Stellenbosch

7 SCHEDULES AND ACTIVITY LOGS / RECORDS

7.1 General schedule

This section presents a general schedule for maintenance activities.

Approximate frequency / timing of routine operational works and inspections can be captured in this table. The table will not capture construction and expansion activities as these would be undertaken as once-off interventions.

Stormwater maintenance intervention / inspection	Frequency of intervention / inspection	Dates (approx. months)
1.1 Aquatic (floating and submerged) vegetation management		
1.2. Reedbed and indigenous emergent vegetation management		
1.3.Riparian / marginal vegetation management		
2.1 Estuary bank profile enhancement.		
2.2 Construction, maintenance and expansion of erosion control structures		
3.2 Manual/mechanical sediment removal from sediment traps/retention areas.		
3.3 Manual/mechanical sediment removal from canals, channels and waterbodies.		
5.1 Litter and debris removal using either mechanical or manual methods.		
5.2 Removal of structures to reduce water obstruction.		

5.3 Construction, maintenance and expansion of litter management infrastructure		
6.1 Stormwater outlets, dam scour valves, headwalls and culverts		
7.1 Weirs		
7.3 Flood protection embankments/ berms		
8.1 Construction, maintenance and expansion of footbridges, boardwalks or bird hides		

5.2 Operational Works Activities and Inspections

Dates and details of all planned and ad hoc activities that have been undertaken are to be recorded within 1 week of completion.

No.	Date	Measure type	Description	Location (description / co-ordinates)	Comment	Recorded by
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

5.3 Environmental Control Officer Inspections

Dates and details of inspections undertaken by the ECO to be recorded within 1 week.

No.	Date	Measure type	Description	Location	Comment	Recorded by
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

ANNEXURE B

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

INTEGRATED RESERVE MANAGEMENT PLAN

TABLE BAY NATURE RESERVE

City of Cape Town

October 2014

Making progress possible. Together.

INTEGRATED RESERVE MANAGEMENT PLAN

Compiled by

Jacobus J. Retief

Biodiversity Management Branch

Environmental Resource Management Department

City of Cape Town

Table Bay Nature Reserve

October 2014

COVER PHOTOGRAPH: BRUCE SUTHERLAND

ISBN NUMBER

TABLE OF CONTENTS

List of appendices

List of abbreviations used

APO	**annual plan of operations**
C.A.P.E	**Cape Action for People and the Environment**
CARA	**Conservation of Agricultural Resources Act**
CDF	**Conservation Development Framework**
CFR	**Cape Floristic Region**
DEA&DP	**Department of Environmental Affairs and Development Planning**
DWAF	**Department of Water Affairs and Forestry**
EIA	**environmental impact assessment**
EMP	**estuary management plan**
EMS	**environmental management system**
ERMD	**Environmental Resource Management Department**
FPA	**Fire Protection Association**
FPP	**fixed-point photography**
GIS	**geographic information system**
IBA	**important bird area**
IDP	**Integrated Development Plan**
IMEP	**Integrated Metropolitan Environmental Policy**
IRMP	**Integrated Reserve Management Plan**
LBSAP	**Local Biodiversity Strategy and Action Plan**
MAR	**mean annual runoff**
METT-SA	**Management Effectiveness Tracking Tool South Africa**
MOU	**memorandum of understanding**
MPA	**marine protected area**
NEMA	**National Environmental Management Act, Act 107 of 1998**
NGO	**non-governmental organisation**
OEMP	**operational environmental management plan**
PAR	**protected-area review**
PNE	**protected natural environment**
POS	**public open space**
ROD	**record of decision**
SAAQIS	**South African air quality information system**
SAHRA	**South African Heritage Resources Agency**
SANCCOB	**Southern African Foundation for the Conservation of Coastal Birds**
SWOT	**strengths-weaknesses-opportunities-threats analysis**
WESSA	**Wildlife and Environment Society of South Africa**
WPSP	**Workplace Skills Plan**
WWF	**Worldwide Fund for Nature**
WWTW	**wastewater treatment works**

PART 1

DESCRIPTION

1. INTRODUCTION

Table Bay Nature Reserve incorporates the protected area expansion concept for the Rietvlei Protected Natural Environment (PNE), also known as Rietvlei Wetland Reserve. The reserve consists of the seven management sections indicated in table 1 below, derived from land which had PNE status or a record of decision (ROD) ensuring their protection as part of conditions development approvals, while others were public open space (POS):

Table 1. Status of the seven management sections of the Table Bay Nature Reserve.

Management section	Status
Parklands fynbos corridor	Record of Decision
Diep River	Public Open Space
Rietvlei coastal section	Public Open Space
Rietvlei wetlands	PNE and some POS additions, important bird area (IBA), and core flora conservation site
Milnerton Lagoon	PNE and core flora conservation site
Zoarvlei (Paardeneiland wetlands)	Public Open Space
Milnerton Racecourse	Record Of Decision and core flora conservation site

The strategic management planning process for Table Bay Nature Reserve began with the definition of the vision followed by the purpose for the reserve. This purpose is then supported by desired states for the reserve. The reserve objectives contribute to realising the purpose and desired states.

For each desired state, a number of management objectives are identified, which are then implemented through the identification of outputs. Objectives for each desired state are prioritised for the five-year time horizon of the plan. Time frames, deliverables, performance indicators and targets are then allocated to each objective, or a group of linked outputs contributing to the desired state.

1.1 Aim of the Integrated Reserve Management Plan

The aim of the Integrated Reserve Management Plan (IRMP) is to ensure that Table Bay Nature Reserve has clearly defined objectives and activities to direct the protection and sustainable use of its natural, scenic and heritage resources over a five-year period.

The IRMP thus provides the medium-term operational framework for the prioritised allocation of resources and capacity in the management, use and development of the reserve. The IRMP intends to add value and continuity by clearly stating management objectives, scheduling actions, and providing management guidelines.

The reserve planning process occurs against the backdrop of the City of Cape Town's ***Integrated Development Plan*** (IDP) (Anon 2010); the City of Cape Town's ***Integrated Metropolitan Environmental Policy*** (IMEP) (Anon 2003[1]); the City of Cape Town's ***biodiversity strategy*** (Anon 2003[2]) and the ***Local Biodiversity Strategy and Action Plan*** (LBSAP) (Anon 2009[1]), and the bioregion (***Cape Action for People and the Environment, or C.A.P.E***).

The major elements of the IRMP are ***this document*** (overall strategy, vision and context); the ***detailed subsidiary plans*** (as required), and an ***annual plan of operations*** (APO). The IRMP for Table Bay Nature Reserve is supported by ***State of Biodiversity*** reports, ***operational guidelines*** and a ***monitoring and evaluation framework*** to ensure ongoing implementation and review of protected-area management activities (Figure 1).

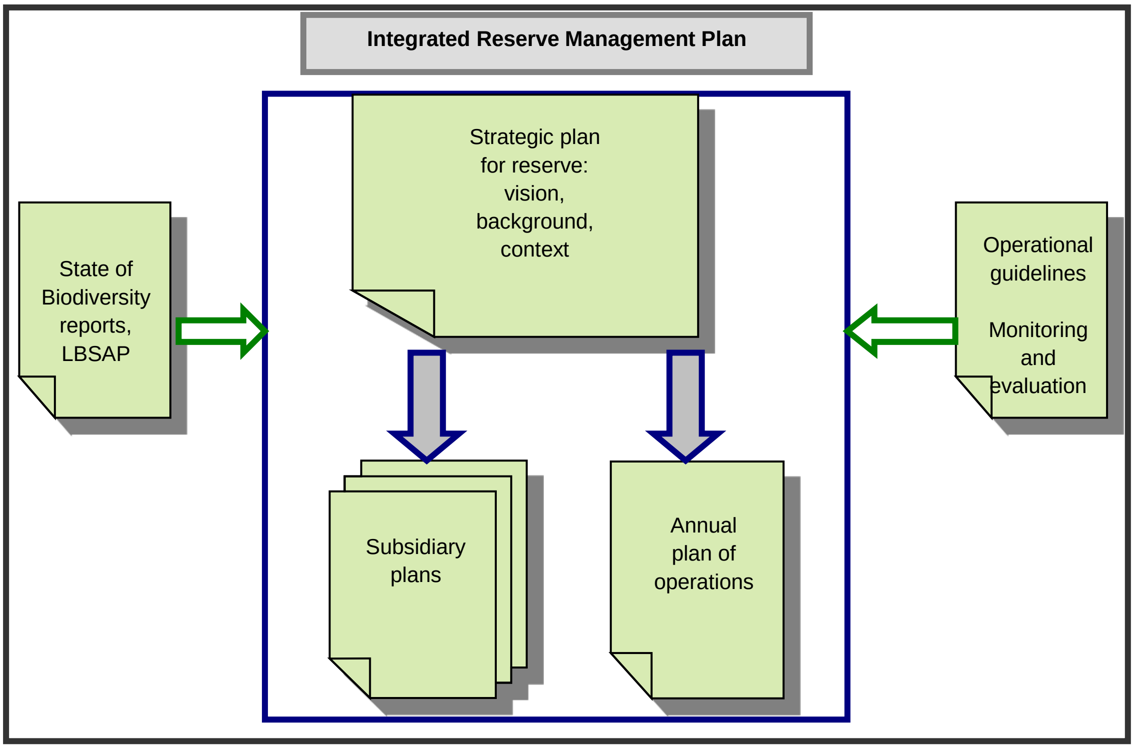


Figure 1: The elements of the IRMP

The IRMP for Table Bay Nature Reserve forms part of a tiered series of policies, legislation and related planning documents at the sector, institutional, agency and local level (see figure 2).

Where possible, emphasis has been placed on the following:

- Assigning responsibility for management interventions
- Scheduling said management interventions
- Quantifying management costs

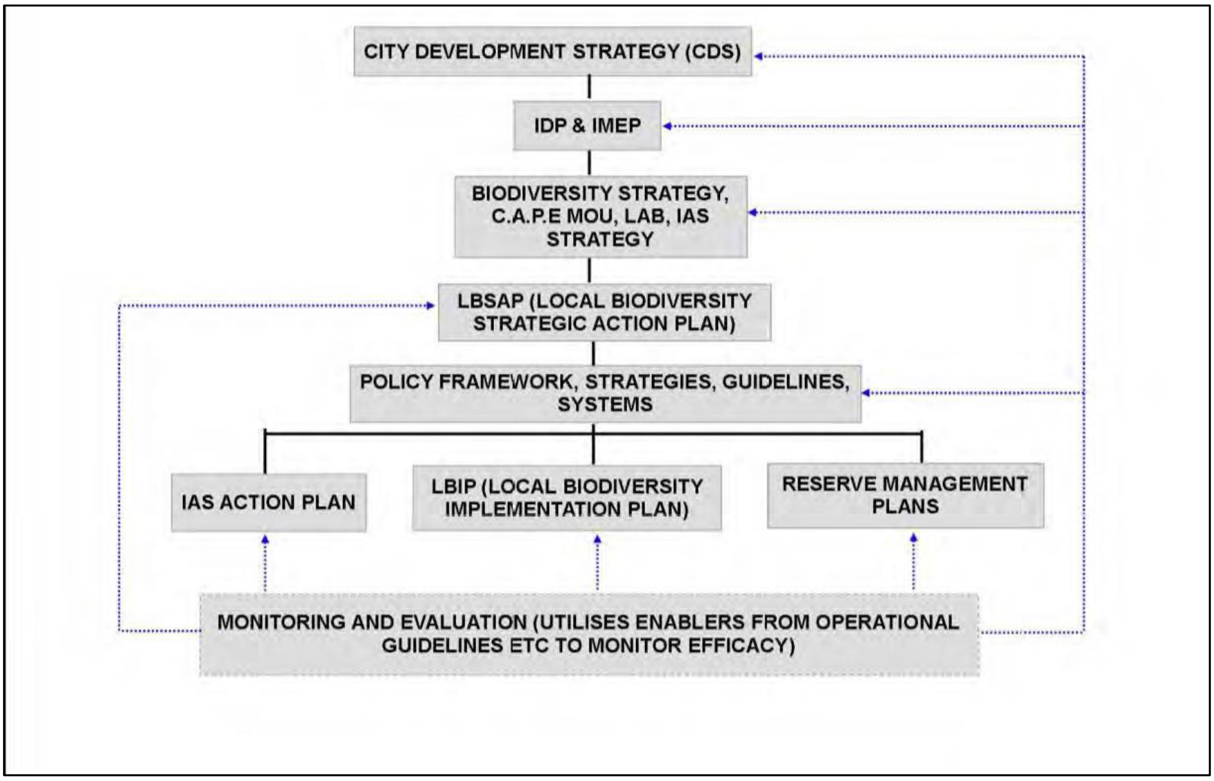


Figure 2: Legal and planning framework for the IRMP

This approach is specifically intended to create a mechanism whereby management intervention can be monitored and audited on an annual basis.

This IRMP is a dynamic document, and the detailed subsidiary plans should be updated on an annual basis or as soon as new information comes to light that may better inform decisions on responsible land management. The IRMP should be updated every five years.

The drafting of this IRMP was guided by comments received from a public participation process in the City of Cape Town during February/March 2011. The comments promoted the amalgamation of the seven management sections and their respective management plans into a single nature reserve with an overarching management plan.

The former management plan documents that are being replaced by this IRMP are listed in table 2 below:

Table 2. Schedule of management plans that are being replaced by this IRMP

Management sections	Management plans
Diep River	The Diep River corridor between Blaauwberg Road bridge and the N7 freeway management plan (Spinks & Luger 1999)
Rietvlei coastal section, Rietvlei wetlands, and Milnerton Lagoon	Caltex Rietvlei Wetland Reserve management plan report (Lochner, Barwell & Morant 1994)
Zoarvlei (Paardeneiland wetlands)	Environmental management plan – Zoarvlei (Knight Hall Hendry 1999)

Three specific management plans are presently in the implementation phases, and are therefore still valid. Two of these are implementation plans of recommendations in terms of RODs, in which provision were made for conservation areas within developments. One development is around Milnerton Racecourse (see appendix B2-1 for the ROD) and the other around the Parklands fynbos corridor (see appendix B2-2 for the ROD). A third plan was drafted for the C.A.P.E. Estuaries Programme as an estuary management plan (EMP). This EMP is also in its implementation phase, and covers the Rietvlei wetlands and the Milnerton Lagoon section.

The management plan documents that are being retained under this IRMP, and that are applicable to the various management sections, are listed in table 3 below:

Table 3: Schedule of management plans retained under this IRMP

Management sections	Management plans
Parklands fynbos corridor	Blaauwberg fynbos corridor: Operational environmental management programme (North & Mangnall 2008)
Rietvlei wetlands and Milnerton Lagoon section	Estuary management plan for the Diep River estuary (Jackson *et al*. 2011)
Milnerton Racecourse	Royal Ascot environmental management system (EMS) (Planning in Balance 2013)

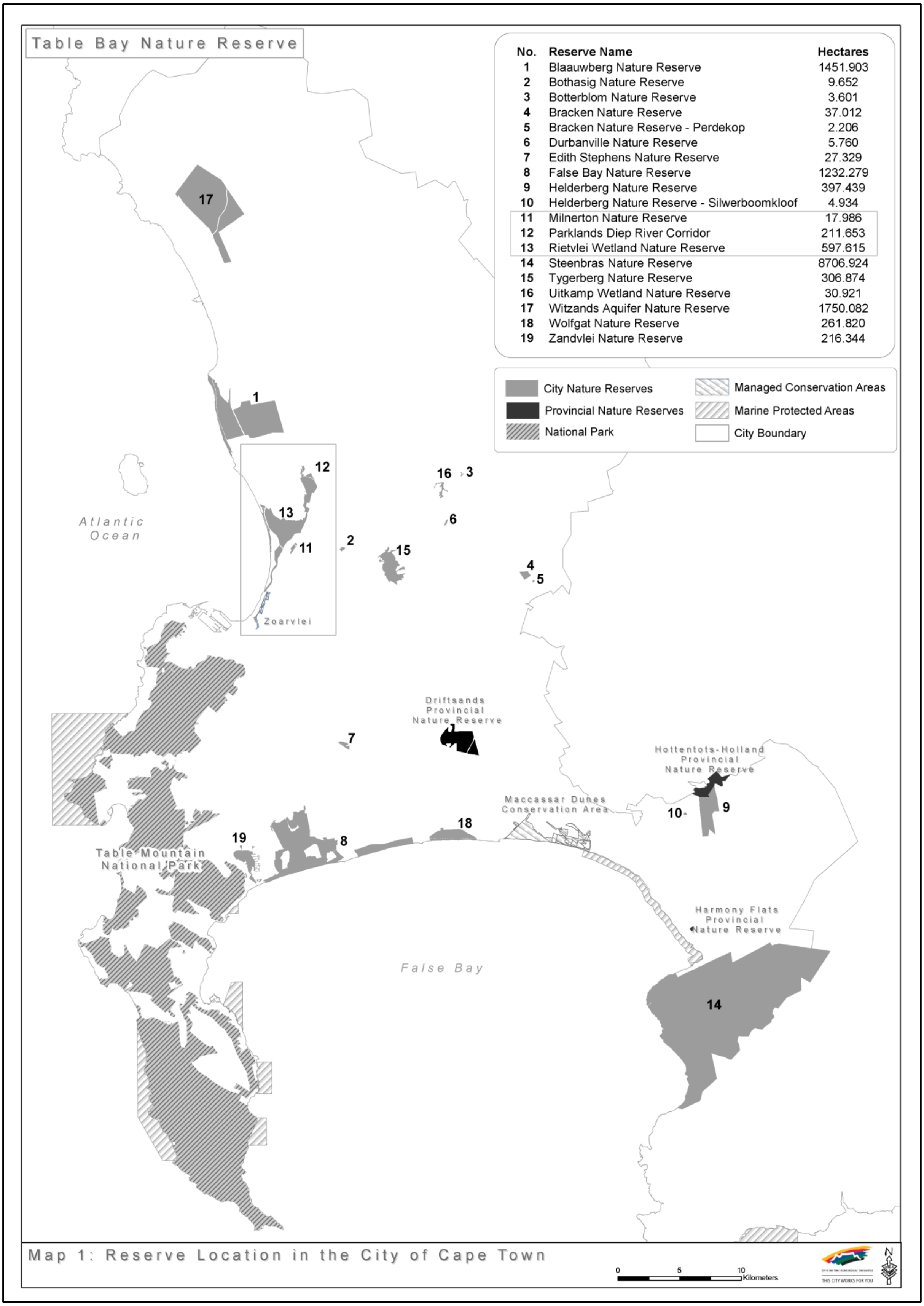
1.2 Location and extent

Table Bay Nature Reserve is situated in Milnerton, Cape Town, along the Table Bay coastline at the bottom of the Diep River catchment (map 1 and 2). It is managed by the City of Cape Town's Biodiversity Management Branch. From here, two world heritage sites, Table Mountain National Park (as part of the Cape Floral Kingdom World Heritage Site) and Robben Island, are visible.

The reserve also forms the southernmost buffer area of the Cape West Coast Biosphere Reserve, linking it to the edge of the Cape Town city centre. See map 3 for a depiction of the reserve's location in terms of the Cape West Coast Biosphere Reserve.

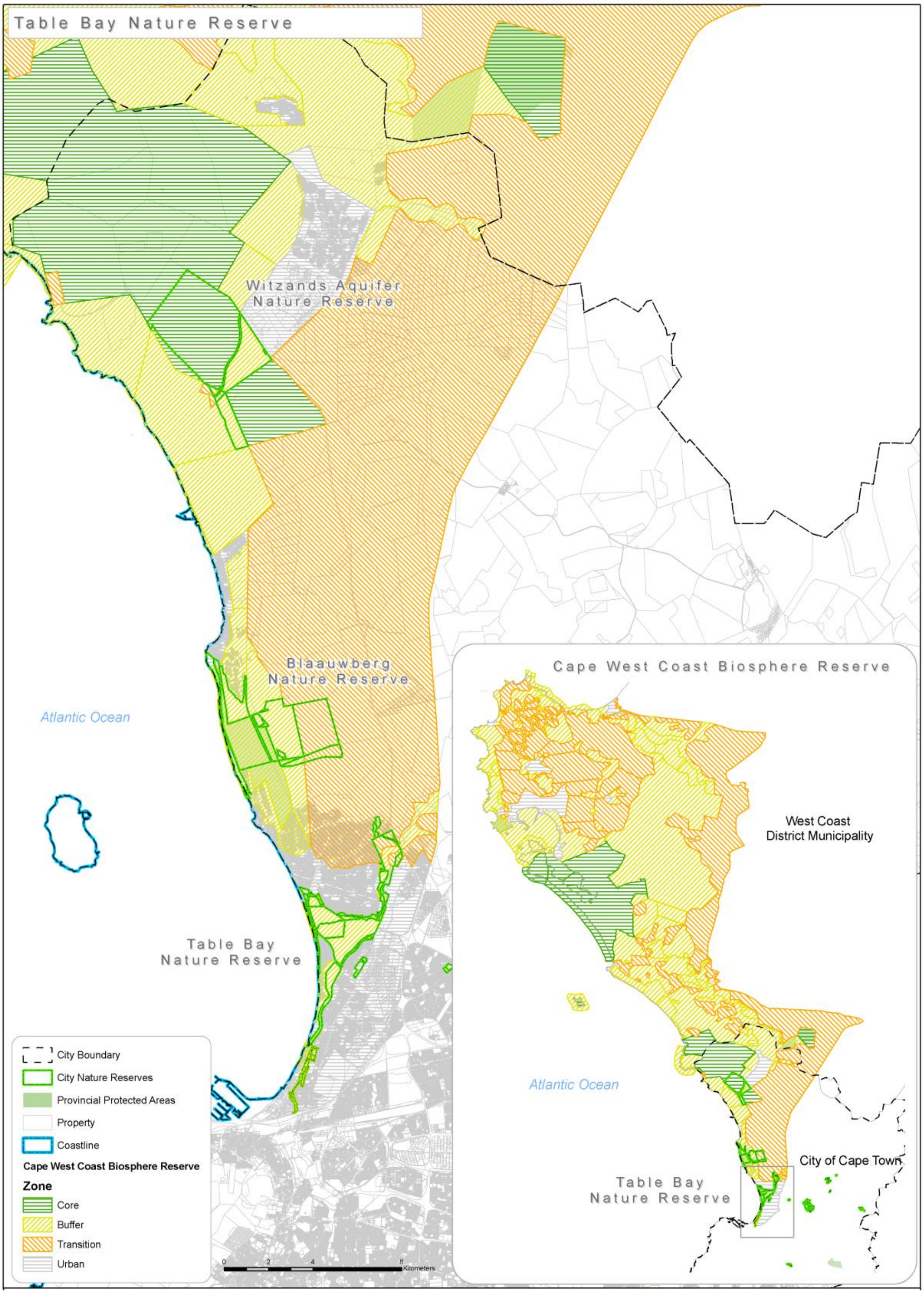
The central feature of Table Bay Nature Reserve is the Rietvlei wetland system. The Rietvlei wetlands and Milnerton Lagoon were proclaimed as a nature area on 3 August 1984 in Proclamation No. 1632, Provincial Gazette No. 9345 (see appendix B1-1). The reserve is partly owned by the City of Cape Town and the Worldwide Fund for Nature (WWF) South Africa, who owns two of the erven on the reserve. The City of Cape Town manages these two erven on a 99-year lease for the purposes of nature conservation (see appendix B5-1).

The centre of the nature reserve is approximately 10 km north-east of Cape Town city centre (see map 1 below), at the following coordinates: 33°50′45″S; 18°30′01″E. It covers an area of approximately 787 ha (see map 2 below).



Map 1: Reserve location in the City of Cape Town

Map 2: Reserve Boundary



Map 3: Reserve location in terms of Cape West Coast Biosphere Reserve

2. DESCRIPTION OF LANDHOLDINGS AND OWNERSHIP

2.1 Property details and title deed information

The City of Cape Town has submitted 615.65 ha for the initial round proclamation of Table Bay Nature Reserve. See Table 4 below for the list of these properties.

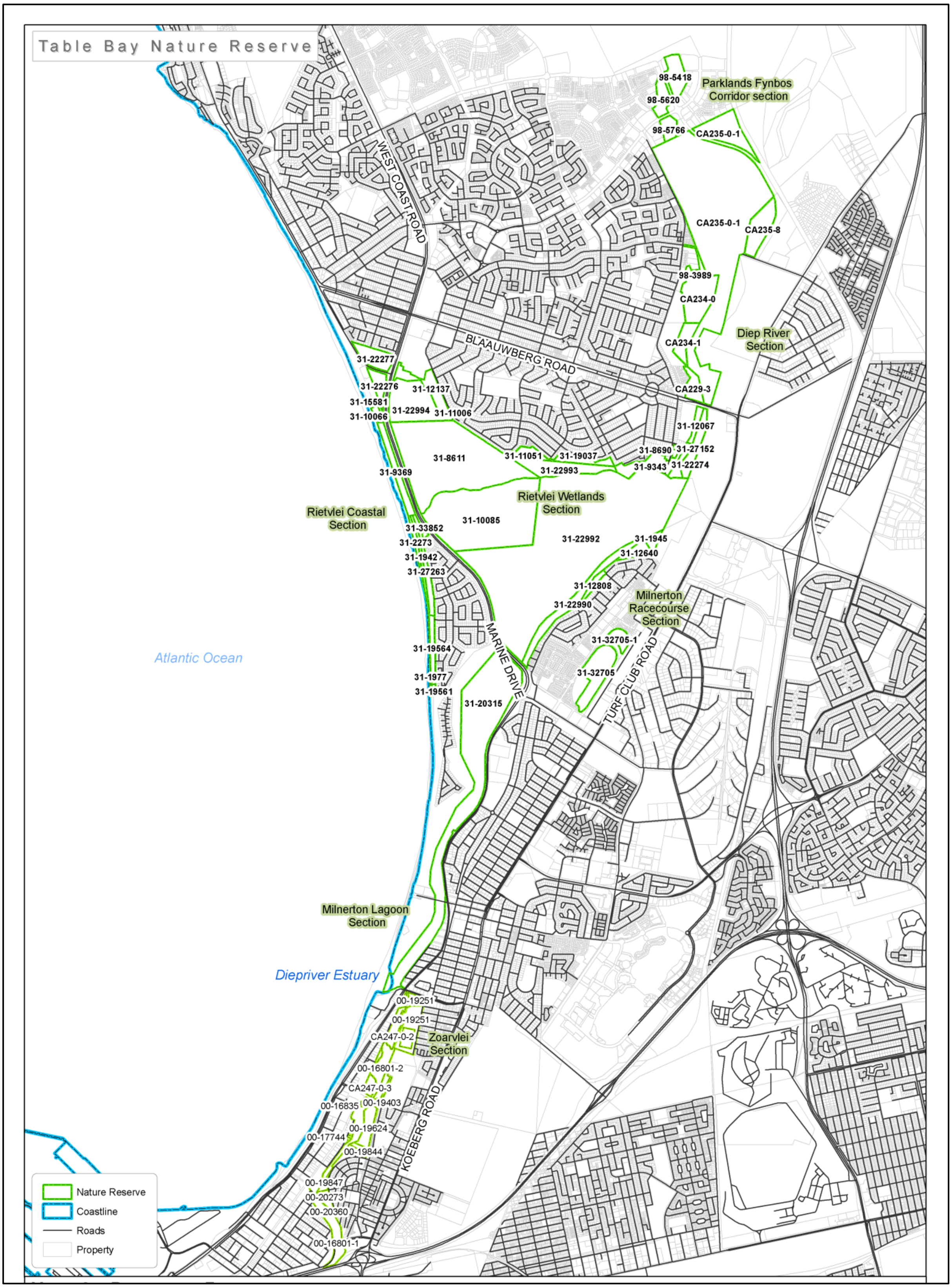
In addition, the properties owned by WWF within Table Bay Nature Reserve viz: Erf 8611 Milnerton, 84.28 ha in extent, and Erf 10085, 76.41 ha in extent, are also managed as part of TBNR. The owner is in the process of proclamation of these properties to incorporate them into TBNR (160.69 ha in total).

The northern section of the Milnerton Racecourse Conservation Area has been framed for proclamation (no: 55 in Table 4 below: 3.7 ha). The proclamation of the remainder is pending as the new boundaries need to be resurveyed based on the outcome of a development proposal (approximately 7 ha) and proposed additional land (erf 35526 Milnerton, 3.0049 ha) to be assigned for conservation. These properties are being managed for conservation under Table Bay Nature Reserve (additional 10 ha). See map 4 on page 11 for diagram.

Table 4: Erven and portions of erven of Table Bay Nature Reserve

No.	Property Name	Owner	SG Diagram	Size (ha)
1	Remainder of Farm 235 Potsdam Outspan	City of Cape Town	2963/2011 Framed	161
2	Remainder of Erf 16801 Cape Town	City of Cape Town	2428/2013 & 4362/2011 Framed	12.9
3	Remainder of Erf 19253 Cape Town	City of Cape Town	1123/1945	0.84
4	Erf 22274 Milnerton	City of Cape Town	5230/1996	3.0969
5	Erf 22990 Milnerton	City of Cape Town	1905/1994 & 8351/1997	18.6245
6	Erf 22992 Milnerton	City of Cape Town	1907/1994	217.1764
7	Erf 22994 Milnerton	City of Cape Town	1909/1994	21.9289
8	Erf 22993 Milnerton	City of Cape Town	1908/1994	11.3974
9	Remainder of Erf 19624 Cape Town	City of Cape Town	2547/2013 Framed	3
10	Remainder of Erf 19844 Cape Town	City of Cape Town	150/1813	1.2174
11	Erf 1977 Milnerton	City of Cape Town	2322/1943	0.078
12	Erf 33852 Milnerton	City of Cape Town	2830/2003	0.6139
13	Erf 20360 Cape Town	City of Cape Town	1183/1909	1.1412
14	Erf 1946 Milnerton	City of Cape Town	2588/1943	0.2966
15	Erf 19845 Cape Town	City of Cape Town	17/1948	0.3021
16	Erf 19846 Cape Towm	City of Cape Town	16/1948	0.6935
17	Erf 19847 Cape Town	City of Cape Town	15/1948	1.0137
18	Remainder of Erf 16834 Cape Town	City of Cape Town	10221/1959	0.0045
19	Erf 17744 Cape Town	City of Cape Town	10232/1959	0.1385
20	Erf 16833 Cape Town	City of Cape Town	1724/1935	0.1294
21	Erf 16837 Cape Town	City of Cape Town	1724/1935	0.1811
22	Erf 16838 Cape Town	City of Cape Town	1724/1935	0.1098
23	Erf 16839 Cape Town	City of Cape Town	1724/1935	0.1201

24	Erf 16840 Cape Town	City of Cape Town	1724/1935	0.1253
25	Erf 17741 Cape Town	City of Cape Town	10222/1959	0.0612
26	Erf 17742 Cape Town	City of Cape Town	10224/1959	0.1143
27	Erf 17743 Cape Town	City of Cape Town	10230/1959	0.1341
28	Remainder of Erf 16802 Cape Town	City of Cape Town	10238/1959	0.0124
29	Erf 20273 Cape Town	City of Cape Town	1117/1949	1.2541
30	Remainder of Erf 11051 Milnerton	City of Cape Town	3736/1999	4.5978
31	Erf 27263 Milnerton	City of Cape Town	829/1998	5.5975
32	Erf 19564 Milnerton	City of Cape Town	7689/1993	3.455
33	Remainder of Farm 247 Paarden Eiland	City of Cape Town	1661/2012 Framed	5
34	Remainder of Portion 3 of Farm 229 Riet Valley	City of Cape Town	396/1939	4.7201
35	Erf 1942 Milnerton	City of Cape Town	3984/1944	3.5634
36	Erf 12137 Milnerton	City of Cape Town	4367/2011 Framed	9
37	Erf 11006 Milnerton	City of Cape Town	8476/1983	0.0779
38	Erf 3989 Parklands	City of Cape Town	4972/2008	2.9002
39	Remainder Erf 9343 Milnerton	City of Cape Town	3609/1972	9.9305
40	Erf 19389 Milnerton	City of Cape Town	853/1993	0.0269
41	Erf 15581 Milnerton	City of Cape Town	8946/1990	0.3876
42	Remainder: Farm 234 Rosendal (Erf 38280 Milnerton)	City of Cape Town	278/1937	15.4194
43	Erf 19037 Milnerton	City of Cape Town	1630/2012 & 1633/2012 Framed	6.1958
44	Erf 10066 Milnerton	City of Cape Town	4366/2011 Framed	8.4536
45	Remainder of Erf 2273 Milnerton	City of Cape Town	3880/1966	9.6862
46	Remainder of Erf 19585 Cape Town	City of Cape Town	3903/1985	0.3817
47	Remainder of Erf 19403 Cape Town	City of Cape Town	663/1872	0.5687
48	Erf 19561 Milnerton	City of Cape Town	7689/1993	0.3915
49	Remainder of Erf 12067 Milnerton	City of Cape Town	7106/1984	2.4984
50	Erf 12808 Milnerton	City of Cape Town	1631/2012 & 1632/2012 Framed	4.3213
51	Erf 12640 Milnerton	City of Cape Town	5671/1987	3.7271
52	Erf 12945 Milnerton	City of Cape Town	6239/1993	0.0268
53	Erf 22952 Milnerton	City of Cape Town	6239/1993	0.1473
54	Erf 22965 Milnerton	City of Cape Town	6239/1993	0.262
55	Remainder of Erf 32705 Milnerton	City of Cape Town	4363/2011 Framed	3.7
56	Remainder of Erf 9369 Milnerton	City of Cape Town	6942/1972	0.1358
57	Erf 22276 Milnerton	City of Cape Town	5225/1996	4.212
58	Erf 22277 Milnerton	City of Cape Town	5226/1996	7.2132
59	Remainder: Prtn 8 of Farm 235 Potsdam Outspan	City of Cape Town	9435/1965	16.3007
60	Remainder of Erf 16835 Cape Town	City of Cape Town	3961/1985	0.0244
61	Erf 5620 Parklands	City of Cape Town	1107/2008	5.4469
62	Erf 5766 Parklands	City of Cape Town	1107/2008	3.829
63	Erf 5418 Parklands	City of Cape Town	1106/2008	7.8088
64	Remainder of Erf 1945 Milnerton	City of Cape Town	4365/2011 Framed	2
65	Remainder of Portion 1 of Farm 234 Rosendale	City of Cape Town	3920/1937	5.9444



Map 4: Reserve erven

2.2 Landscape perspective

Table Bay Nature Reserve falls within the Cape Floristic Region (CFR), the smallest yet richest of the world's six floral kingdoms, and the only one to be found entirely within one country. This rich biodiversity is under serious threat for a variety of reasons, including conversion of natural habitat to permanent agriculture land, inappropriate fire management, rapid and insensitive development, overexploitation of water resources, and infestation by alien species. The region has been identified as one of the worlds 'hottest' biodiversity hot spots, and therefore deserve prioritisation (Myers *et al* 2000).

In response to this challenge, a process of extensive consultation involving various interested parties, including local government and non-governmental organisations (NGOs), resulted in the establishment of a strategic plan (C.A.P.E Project Team 2000) referred to as Cape Action for People and the Environment (C.A.P.E), which identified the key threats and root causes of biodiversity losses that need to be addressed in order to conserve the floral kingdom. This resulted in a spatial plan identifying areas that need to be conserved and a series of broad programme activities that need to take place over a 20-year period.

Based on the situation assessment and analysis of threats, three overarching, mutually complementing and reinforcing themes were developed:

- To establish an effective reserve network, enhance off-reserve conservation, and support bioregional planning
- To strengthen and enhance institutions, policies, laws, cooperative governance and community participation
- To develop methods to ensure sustainable yields, promote compliance with laws, integrate biodiversity concerns with catchment management, and promote sustainable eco-tourism

The C.A.P.E partnership was formed to implement the C.A.P.E vision and plan by strengthening institutions, supporting conservation efforts, enhancing education, developing tourism benefits, and involving people in conservation. The City of Cape Town was one of the 19 founding signatories of the C.A.P.E memorandum of understanding (MOU).

Table Bay Nature Reserve forms an important platform and integral link within the City of Cape Town's biodiversity network, as well as a link to the Cape West Coast Biosphere Reserve.

2.3 Physical Environment

2.3.1 Climate

The climate is described as Mediterranean, characterised by warm, dry summers from November to March, and mild, rainy winters from June to August. The warm, dry and windy summers in the region also result in a mean annual evaporation rate of 1,477 mm (Department of Water Affairs and Forestry 2005).

The south-western Cape is a winter rainfall area. The catchment of the Diep River has a mean annual precipitation ranging from approximately 1 200 mm in the north-east mountain area, to 400 mm in the south-west. The Diep River has an estimated mean annual runoff (MAR) of 40 million m^3. This runoff varies not only with the seasons – with very limited flow during the summer months – but also from year to year. The runoff for 1976/77, for example, was measured at 190 million m^3, while that for 1971/72 was 2,9 million m^3 (Jackson *et al*. 2008).

The reserve is situated between the high-water mark and approximately 25 m above sea level. Rainfall varies between 273 mm and 541 mm per annum, as measured on-site. Rainfall figures have been recorded since 2000 only. Appendix A1 is a graphic representation of the mean rainfall per month since recording started.

The prevailing summer wind comes from the south-east, and the winter winds from the north and north-west. The strongest winds are those from the south-east, persisting for much of the summer season.

2.3.2 Geology, geomorphology, soils and land types

The geology of the catchment is important, as it determines the extent and nature of the groundwater as well as the characteristics of any sediment that flows down the river (Jackson *et al*. 2008). The predominant geological formation in the Diep River Quaternary catchment belongs to the ***Malmesbury group***, followed by the ***Cape granite suite*** (DWAF 2002).

Table 5 provides a summary of the geological formations. The Malmesbury group comprises dark, medium-grained, sub-greywackes, with interbedded blue, sometimes purplish, shales. The Cape granite is light grey, and is porphyritic granite, which has intruded into the Malmesbury group. The Klipheuwel formation outcrops at the village of Klipheuwel. At the contact zone of the Klipheuwel and Cape granite suite, the feldspars in the granite are highly weathered to kaolinite (Jackson *et al*. 2008).

The coastal or lower portion of the catchment comprises Quaternary alluvial deposits overlying the bedrock of the Malmesbury group. The Klipheuwel and Cape granite suite comprise only a small percentage of the area, which means that the lagoon sediments comprise mainly of weathering products of the Malmesbury group. The sediments of the Malmesbury group consist of a variety of shales, greywackes, quartzites and grits, with occasional bands of conglomerate, limestone, dolomite and chert. In the Diep River catchment, arenaceous greywackes alternate with more argillaceous shales (Jackson *et al*. 2008).

Table 5: Geological formations within the Diep River catchment

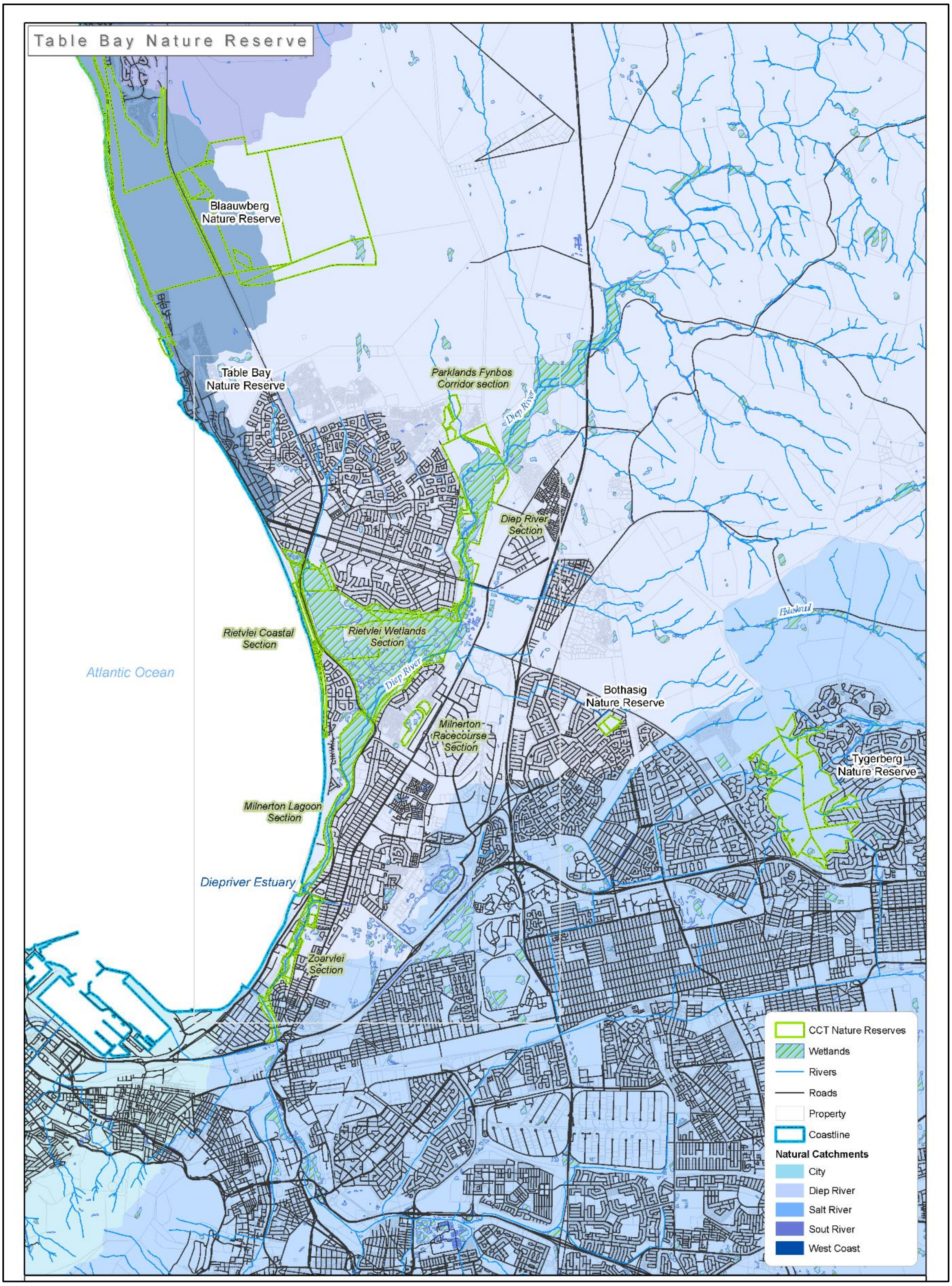
Label	Name	Hectares	%
Q	Quarternary	24 810	16,07
Ope	Peninsula formation – Table Mountain group	18	0,01
Cmk	Magrug formation – Klipheuwel group	9 911	6,42
N-Cma	Cape granite suite	22 297	14,45
Nf	Franschhoek formation – Malmesbury group	864	0,56
Nt	Tygerberg formation – Malmesbury group	41 237	26,72
Npr	Porseleinberg/Moorreesburg formation – Malmesbury group	11 130	7,21
Nmo	Moorreesburg formation – Malmesbury group	44 080	28,56
		154 347	100,00

The sediments in Milnerton Lagoon have a high percentage of clay due to the predominance of the Malmesbury group within the Diep River catchment. In other words, the clay fraction of the sediments in the lagoon is derived from the rocks in the catchment. The concentration of most elements was found to decrease from Rietvlei to the mouth of the lagoon. This is attributable to the increase of weathering of the sediments, resulting in a corresponding loss of calcium, magnesium, sodium, potassium, rubidium and strontium. A maximum thickness of 23,5 m is recorded for the Quaternary sediments overlying the basement rocks (Jackson *et al*. 2008).

2.3.3 Geohydrology, hydrology and aquatic systems

2.3.3.1 Catchments

The catchment, consisting of the Diep River and its tributaries (see map 5), lies in the south-western Cape, where climatic conditions are characterised by a winter rainfall regime, with high summer evaporation. Precipitation is of a frontal nature, with cold fronts approaching the catchment from the west (Jackson *et al*. 2008).



Map 5: Catchments, including rivers and wetlands

2.3.3.2 Aquifers

Based on the geology, this area can be divided into two distinct aquifer systems (DWAF 2002): an upper, primary aquifer and an unconfined to semi-confined deeper, secondary aquifer located in the granites and Malmesbury group rocks. In places, these two aquifers are separated by clay, which is absent when the rock strata crop out at the surface (Jackson *et al*. 2008).

The primary aquifer is situated in a 2–3 m thick surficial scree and alluvial gravel deposit located next to the Diep River. These deposits are sub-angular to angular in nature, and fairly well sorted. The rest-water level within this aquifer is shallow, about 0,5 m below the surface during the dry summer months. The secondary aquifer is located in the underlying granites and Malmesbury group rocks, which retain and transmit the groundwater in cracks, fissures, joints and faults caused by weathering, cooling and deformation (Jackson *et al*. 2008). The primary aquifer is not extensively developed in the catchment. However, the associated Quaternary deposits do occur in the area to the north-west of Kalbaskraal and along the coast in the Milnerton area. The sands are neither particularly thick nor coarse-grained (i.e. permeable), and although groundwater is present, it is not considered a major aquifer. The primary aquifer essentially provides a storage zone for groundwater, from which there may be some delayed release into Rietvlei at the onset of summer as the levels in the vlei start to drop. However, this is not considered to be a significant amount (Jackson *et al*. 2008).

The ***Malmesbury group***, within which much of the secondary aquifer is located, constitutes 63% of the Diep River catchment. The Malmesbury group comprises mainly shale, which is a rock type not conducive to producing high yields of, or good-quality, groundwater due to the mineralised nature of the rock type. Although there are exceptions to this generalisation, the Malmesbury group is considered to yield very little groundwater (Jackson *et al*. 2008).

A borehole yield analysis indicated that 32% of boreholes in this group yield less than 0,5 ℓ/s. Groundwater from the Malmesbury group is generally of a sodium-chloride-alkaline nature, and, in the more argillaceous units, sodium, magnesium, chloride and sulphate often exceed recommended allowable limits for drinking water. Springs from the Malmesbury group are very limited, although there is a thermal spring at Malmesbury (temperature is 33 ^{o}C), which circulates from a depth of approximately 1 200 m. The groundwater contribution to surface water flow (base flow) of the Diep River is therefore negligible (Meyer 2001).

The ***Cape granite suite*** comprises 14% of the Diep River catchment, and outcrops in the town of Malmesbury. The groundwater yields from granite are typically low. In this case, a borehole yield analysis indicated that 42% of boreholes in the granite yield less than 0,5 ℓ/s. Also, although water quality from the granites is typically acceptable, it is variable, and, in this area, is typically of a sodium-chloride sulphate nature. The groundwater within the granites typically occurs within the zones of weathering and at the contact zone margins between the Malmesbury group rocks and the granites. The groundwater from the granites will essentially not contribute to the Diep River base flow (Meyer 2001).

The ***Klipheuwel group*** comprises 6% of the Diep River catchment, and the more arenaceous Magrug formation can have relatively high groundwater yields (~ 2 ℓ/s), with the quality typically between 40 and 250 mS/m. However, the limited occurrence of the Klipheuwel group within the area means that it is unlikely to contribute significantly to the base flow of the Diep River (Jackson *et al*. 2008).

In conclusion, the underlying bedrock of the catchment will contribute very little toward sustaining the Diep River flow. This is supported by the fact that the Diep River to all intents and purposes does not flow during the dry summer months (Jackson *et al*. 2008).

2.3.3.3 Rivers and wetlands

The Department of Water Affairs and Forestry (DWAF) had three flow-gauging stations in operation on the Diep River for different periods of time between 1968 and 1981. They are near Malmesbury, on the Mosselbank River at Klipheuwel, and at Vissershok (Jackson *et al*. 2008).

According to the data provided, the highest MAR was recorded in 1977, while the highest monthly flow was recorded in July 1977. For all the stations, the flow reduces to zero in the summer months. The data show a gradual increase in flow between 1965 and 1988, after which there is a reduction back to previous levels (Jackson *et al*. 2008).

About 90% of the Diep River catchment is now under cultivation, meaning that the use of water for agriculture is a possible factor in the reduced runoff. The land cover classes are shown in table 6, with a list of the land cover classes and associated regional extent, relative to the total catchment area. “Cultivated: temporary – commercial dryland” (wheatfields) is the predominant land cover category within the catchment. This is based on 1996 data, and therefore does not reflect the more recent expansion of residential development in the Table View area (Jackson *et al*. 2008). The capacity of farm dams in the catchment totals 18 x 10^6

m^3, of which 15,5 x 10^6 m^3 is located in the Mosselbank catchment, the main tributary of the Diep River (Richards & Dunn 1994).

Table 6: Land cover classes for the Diep River catchment (sorted according to area)

DESCRIPTION	Sum_Hectares	%
Herbland	13	0.01
Urban / built-up land: commercial	55	0.04
Improved grassland	85	0.05
Degraded: thicket & bushland (etc)	116	0.08
Barren rock	139	0.09
Mines & quarries	313	0.20
Waterbodies	756	0.49
Wetlands	802	0.52
Urban / built-up land: industrial / transport	834	0.54
Cultivated: permanent - commercial dryland	1131	0.73
Forest plantations	2662	1.72
Unimproved grassland	2741	1.77
Degraded: shrubland and low Fynbos	3118	2.02
Thicket & bushland (etc)	4106	2.65
Urban / built-up land: residential	5618	3.63
Urban / built-up land: residential (small holdings: shrubland)	6038	3.90
Cultivated: permanent - commercial irrigated	8959	5.79
Shrubland and low Fynbos	18394	11.89
Cultivated: temporary - commercial dryland	98836	63.88
	154715	100.00

The Diep River flows into the north-eastern corner of the Rietvlei wetlands at the Blaauwberg Road bridge, and then into the Milnerton Lagoon, and finally Table Bay. The flow varies significantly from year to year as well as with the season, and often does not flow at all during the height of summer (Jackson *et al*. 2008).

Additional inflow into the Rietvlei wetlands includes flow from the stormwater drains and the sewage works. Stormwater flows are directly related to rainfall patterns. The Bayside canal, which discharges into the north-west corner of Rietvlei, varies from less than 1 000 m^3 per day in summer, to between 7 000 and 10 000 m^3 per day (Harding 2008).

The treated effluent from the Potsdam Wastewater Treatment Works (WWTW) is discharged into a channel along the eastern boundary of Rietvlei wetlands, which conveys the effluent to the head of the lagoon at the Otto du Plessis Road bridge. The channel was constructed in 1991–1992 to prevent Potsdam's effluent from polluting Rietvlei. As a result, the vlei was largely disconnected from the flow of the river, although treated effluent does still flow into the vlei when the channel overflows during winter rains. Presently, 15% of the effluent is reused (Botes 2004).

There is insufficient information available for the accurate quantification of seasonal variations in water levels of the Rietvlei wetlands. However, anecdotal data exist to suggest that in the dry summer months, the water levels in the central portion of the Rietvlei drop below ground level, causing the central pans to dry out completely – usually by January. In the wet winter months, these pans are again inundated with water (Jackson *et al*. 2008).

Freshwater flow into the lagoon comes both via the channel carrying the Potsdam effluent, and a natural channel flowing from the western side of the Rietvlei wetlands. There are also some stormwater discharges along the eastern bank. The other major source of water in the lagoon is the sea, although the extent of the saltwater intrusion is dependent on a number of factors, including whether or not the mouth is open. Other factors include siltation, water abstraction upstream, and canalisation of the river adjacent to Rietvlei. Nevertheless, a tidal range of 3,8 cm has been recorded opposite the Otto du Plessis Road bridge (Jackson *et al*. 2008).

The Diep River estuary, comprising the Rietvlei wetlands and the Milnerton Lagoon, covers an area of around 900 ha, and is the largest temporary vlei in the south-western Cape. Rietvlei is essentially triangular in shape, with the Diep River flowing in at its north-east corner. From there, it stretches for over 2 km in an east-west direction, with the southerly point of the triangle at the Otto du Plessis Road bridge marking the boundary between Rietvlei and the Milnerton Lagoon. The lagoon is a long, winding channel, bordered by a road, a golf course and the Woodbridge Island residential development, and ultimately flows into Table Bay along the west coast (Jackson *et al*. 2008).

The estuary includes a variety of habitats, from artificial deepwater lakes to shallow, seasonally inundated pans, reed beds and other estuarine habitats. Despite its history of modifications, and its location in a highly urbanised environment, it is considered to be the most important area for water birds in the region, and provides feeding, roosting and breeding habitat for migrant birds (Jackson *et al*. 2008).

Ryan *et al.* (1988) ranked this estuary sixth of the 65 coastal wetlands in the south-western Cape on the basis of the number of birds present, and sixth or seventh of all larger estuaries in the country in terms of conservation value.

At the same time, the estuary is an important recreational site, and supports some fishing and bait-collecting activities (Jackson *et al*. 2008).

2.3.3.3.1 Estuary mouth dynamics

Palaeontological evidence suggests that, in the past, the mouth of the Diep River was to the north of its current position, opposite the north-west corner of Rietvlei. During the middle of the last glacial period, the sea level was 18 m lower than its present level. In the Rietvlei basin, local erosion and deepening of the river beds was associated with the lower sea level. The sea-level rise during the latter part of the last glacial period resulted in renewed deposition of sediments, which filled the northern opening. The formation of coastal dunes started, the vegetation came to resemble the present flora, and the river outlet finally took its present position (Jackson *et al*. 2008).

Historically, the estuary mouth was almost permanently open to the sea. However, over a period of around 20 years, from the early 1970s until 1991/92 with the construction of the channel associated with the sewage works, the mouth closed on a regular basis, albeit for varying periods. It was then either breached by floods or artificially opened by the town engineers once the water level in the lagoon reached between 1,9 and 2,0 m above mean sea level. Since the construction of Woodbridge Island and the channel, the mouth has again remained open (Jackson *et al*. 2008). The periodic closure of the mouth was probably due to both reduced water flows and siltation, resulting in reduced tidal flows that were no longer strong enough to keep the mouth open (Jackson *et al*. 2008).

Prior to 1970, the Diep estuarine system was very dynamic, and this dynamism would have meant that the mouth was not always permanently open. Over the last 300 years there has been considerable movement of the mouth. The present fixed position of the mouth is the result of stabilisation by virtue of infrastructure construction and developments (Pers. comm., Neil van Wyk, 2011).

2.3.3.3.2 Water chemistry

The salinity patterns in the estuary are complicated by the fact that the salt content is derived from both seawater intrusion in the lower reaches as well as the river water, which itself is alkaline and relatively high in salt derived from the Malmesbury shales of the catchment. Nevertheless, when the river is flowing, there is a normal salinity gradient, with the upper part of the estuary being dominated by fresh water, with some saline water occurring near the mouth and in the deeper areas of the lower lagoon. In summer, the condition depends on whether the mouth is closed or open. When the mouth is closed, the high evaporation rates can lead to hyper saline conditions and a reversed salinity gradient. In the past, salinities of up to 13 parts per thousand (ppt) have been measured in the north-eastern corner of the Rietvlei wetlands (Jackson *et al*. 2008).

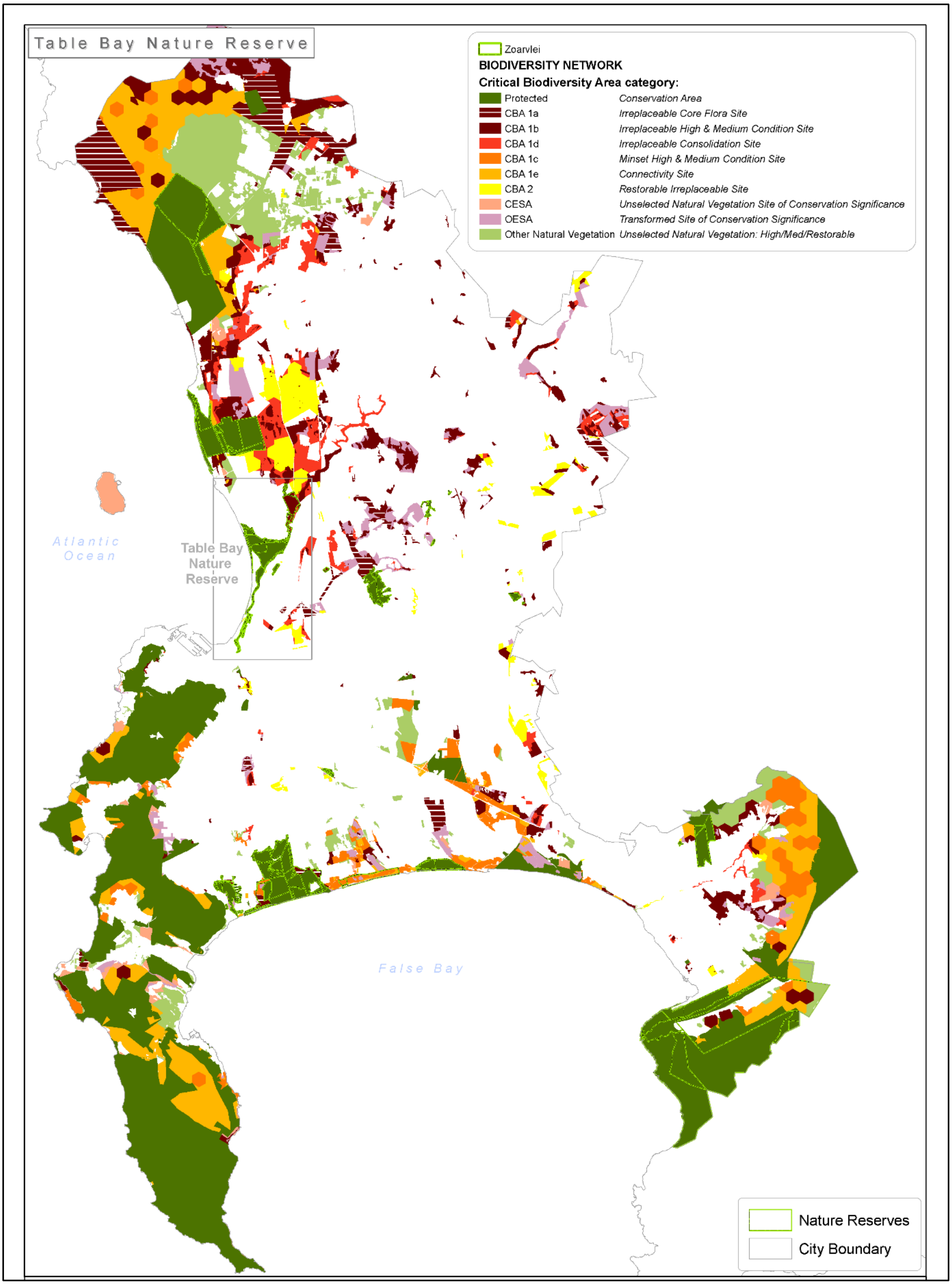
2.4 Biological environment

The biodiversity of Table Bay Nature Reserve is largely determined by the physical characteristics of the environment. These characteristics have been substantially altered as a result of various human interventions over the last two centuries. Therefore, changes in biodiversity were inevitable (Jackson *et al*. 2008). See map 6 below for a depiction of the reserve's location in terms of the City of Cape Town's biodiversity network and other nature reserves.

Appendix C contains the species lists for Table Bay Nature Reserve, drawn from the list of sightings recorded on the South African Biodiversity Database (www.biodiversity.co.za) for the four site locations on this database, namely Rietvlei, Zoarvlei, Milnerton Racecourse and Diep River. They cover the seven management sections as indicated in table 7:

Table 7: Coverage of the four biodiversity database locations over the seven management sections of Table Bay Nature Reserve

Management section	Biodiversity database locations
Parklands fynbos corridor	Diep River
Diep River	Diep River
Rietvlei coastal section	Rietvlei Wetland Reserve
Rietvlei wetlands	Rietvlei Wetland Reserve
Milnerton Lagoon	Rietvlei Wetland Reserve
Zoarvlei (Paardeneiland wetlands)	Zoarvlei
Milnerton Racecourse	Milnerton Racecourse



Map 6: Nature reserve and biodiversity network

2.4.1 Vegetation

Table Bay Nature Reserve is part of the CFR, one of six global floral kingdoms, and is characterised by high levels of endemism. The eco-region within which the reserve is situated is known as the southern coastal belt. The reserve now falls within a highly urbanised area, with only limited remaining vegetation in its surrounds (Jackson *et al*. 2008).

McDowell (1993) described the Rietvlei wetland as including five distinct wetland plant communities: perennial wetland, reed marsh, sedge marsh, open pans and sedge pans, as well as some strandveld (Jackson *et al.* 2008). A more recent survey (Withers *et al*. 2002) identified 12 different plant communities, although a number of them appear to be dominated by invasive alien species.

More recently, the natural vegetation in Table Bay Nature Reserve is delineated along six major vegetation types: Cape Flats Sand Fynbos, Cape Flats Dune Strandveld, Cape Lowland Freshwater Wetlands, Cape Estuarine Salt Marsh, Cape Inland Salt Pans, and Cape Seashore Vegetation.

Table 8 below indicates the general distribution of these vegetation types across the various management sections:

Table 8: Distribution of vegetation types over Table Bay Nature Reserve sections

Vegetation type/ management section	Cape Flats Sand Fynbos	Cape Flats Dune Strandveld	Cape Lowland Freshwater Wetlands	Cape Estuarine Salt Marshes	Cape Inland Salt Pans	Cape Seashore Vegetation
Parklands fynbos corridor	X					
Diep River	X		X			
Rietvlei coastal section		X				X
Rietvlei wetlands	X	X	X	X	X	
Milnerton Lagoon		X	X	X		
Zoarvlei (Paardeneiland wetlands)	X	X	X			
Milnerton Racecourse	X					

Figure 3 indicates the historic distribution of the three main vegetation types that occur in the reserve:

Cape Flats Sand Fynbos | **Cape Flats Dune Strandveld** | **Cape Lowlands Freshwater Wetland**

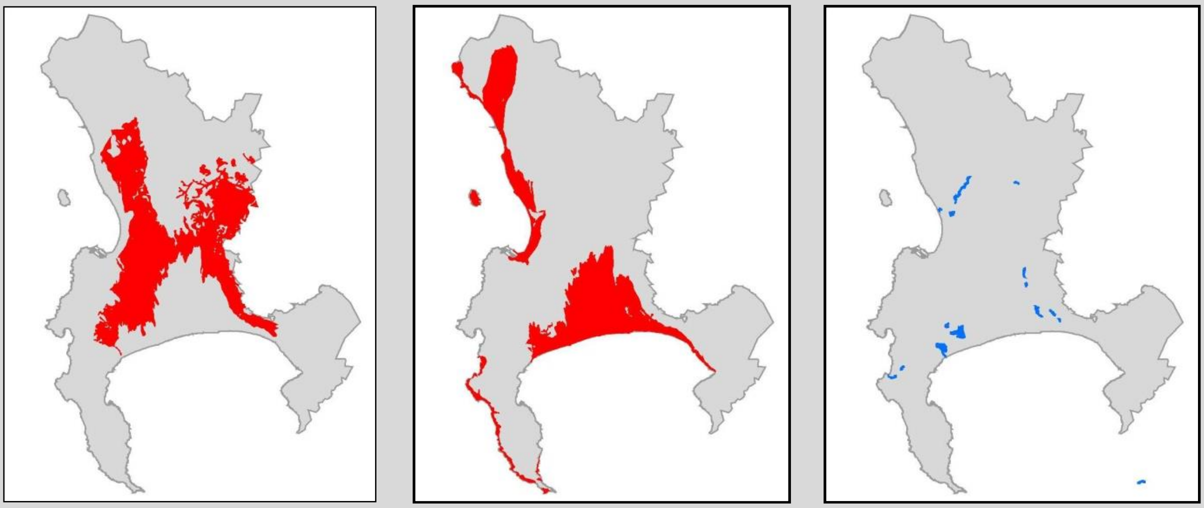


Figure 3: Historic distribution of the main vegetation types occurring in the reserve

A total of 463 plant species have been recorded within the reserve boundaries (see appendix C1 for a comprehensive plant species list as at October 2014). The 2008 ecosystem status for the vegetation types is as per table 9 below (Rebelo *et al*. 2006):

Table 9: Major national vegetation types in Cape Town, and their status

National vegetation type	Historical area in Cape Town (km^2)	% in Cape Town	Current area in Cape Town (km^2)	Conserved or managed in Cape Town (km^2)	National ecosystem status*
Cape Flats dune strandveld	401	100	180	64	EN
Cape Flats sand fynbos	547	100	77	5	CR
Azonal vegetation types					
Cape inland salt pans	2	3,0	2	2	VU
Cape Lowland Freshwater Wetlands	14	15,0	6	5	CR
Cape Seashore vegetation	3	4,0	3	2	LC

National vegetation types in* ***bold* *are confined to Cape Town.*
CR = Critically endangered, EN = endangered, VU = vulnerable, LC = least concern

2.4.1.1 Cape Flats Sand Fynbos

Cape Flats Sand Fynbos (Sand Plain Fynbos) is largely endemic to Cape Town, occurring on the Cape Flats from Blaauwberg and Koeberg hills, west of Tygerberg Hills, to Lakeside and Pelican Park in the south near False Bay, as well as from Bellville and Durbanville to Klapmuts and Joostenberg Hill in the east, and to the south-west of Bottelary Hills to Macassar and Firgrove in the south. It occurs on altitudes ranging from 20 to 200 m. Nearly 100% of this vegetation type occurs within the City of Cape Town area, and 85% is transformed. The vegetation occurs on moderately undulating and flat plains, with dense, moderately tall, ericoid shrubland containing scattered, emergent, tall shrubs. Proteoid and restioid fynbos is dominant, with asteraceous and ericaceous fynbos occurring in drier and wetter areas respectively (Rebelo *et al*. 2006).

The geology and soils are acid, tertiary, deep, grey, regic sands, sometimes white, often Lamotte form. The climate is a winter rainfall regime, with precipitation peaking from May to August. The annual precipitation ranges between 580 and 980 mm, with a mean of 575 mm. Mists occur frequently in winter. Mean daily maximum and minimum monthly temperatures range from 27,1 °C to 7,3 °C for February and July respectively, and frost occurs about three days per year. This is the wettest and the coolest of the West Coast sand fynbos types (Rebelo *et al*. 2006).

Endemic taxa include, for the low shrubs, *Cliffortia ericifolia, Leucadendron levisanus,* and the succulent shrub, *Lampranthus stenus* (Rebelo *et al*. 2006).

The vegetation type is ***Critically Endangered***, with a minimum national conservation target of 30%. However, less than 1% is statutorily conserved as small patches in Table Mountain National Park as well as some private conservation areas, such as Plattekloof and Blaauwberg Hill. This is the most transformed of the sand fynbos types, since more than 85% of the area has already been transformed by urban sprawl (Cape Town metropolitan area) and agricultural cultivation. Therefore, the conservation target remains unattainable. Most remaining patches are small pockets surrounded by urban areas, for example Rondevlei, Kenilworth, Milnerton, Fort Ikapa (6 Base ordinance), Plattekloof and Rondebosch Common. The majority of these patches have been designated as core flora conservation sites. They are mismanaged by mowing, fire protection and alien plant invasion (Rebelo *et al*. 2006).

Mowing eliminates serotinous and taller species, while fire protection results in a few common thicket species, such as *Carpobrotus edulis* and *Osteospermum moniliferum*, replacing the rich fynbos species. Alien woody species include *Acacia saligna*, *A. cyclops* and species of *Pinus* and *Eucalyptus*. Dumping and spread of alien grasses (both annual species and Kikuyu, *Pennisetum clandestinum*) are also a major problem. Alien acacias result in elevated nutrient levels and a conversion to *Eragrostis curvula* grassland and near-annual fires. Some 94 Red List sand fynbos plant species occur on the remnants within Cape Town. The endemics include six species listed as extinct in the wild, some of which are being re-introduced from botanical gardens (Rebelo *et al*. 2006).

2.4.1.2 Cape Flats Dune Strandveld

Cape Flats Dune Strandveld (Dune Thicket) is endemic to Cape Town, mainly in coastal areas at altitudes ranging from 0 to 80 m, but reaching up to 200 m in places. It occurs on flat to slightly undulating dunefield landscapes covered by tall, evergreen, hard-leaved shrubland, with abundant grasses and annual herbs in gaps. Structurally, strandveld is a tall, evergreen, hard-leaved shrubland, with abundant grasses, annual herbs and succulents in the gaps. Examples of prominent shrub species include *Euclea racemosa*, *Metalasia muricata*, *Olea exasperata*, *Osteospermum moniliferum* and *Roepera flexuosum*. Strandveld has few endemic species compared to fynbos. This vegetation type in its entirety occurs within the City of Cape Town area, and 56% is transformed (Rebelo *et al*. 2006).

The geology and soils are tertiary to recent calcareous sands of marine origin. The area has a mean annual rainfall of 350 mm in the north, and 560 mm in the south. Endemic species include *Lampranthus tenuifolius.* The vegetation type is ***Endangered***, with a minimum national conservation target of 24%, although only 6% is presently conserved (Rebelo *et al*. 2006).

2.4.1.3 Cape Lowland Freshwater Wetland

Cape Lowland Freshwater Wetland occurs throughout the Western Cape at altitudes ranging from 0 to 400 m. Some 14,7% of this vegetation type occurs within and 85,3% outside the City of Cape Town area. Transformation rates are however higher inside City of Cape Town borders (55%) than nationally (22%). The vegetation occurs on flats and in depressions, with extensive tall reeds of *Phragmites australis* and *Typha capensis*, temporarily or permanently flooded restiolands, sedgelands and rush beds as well as macrophytic vegetation embedded in permanent water bodies. Important species include *Senecio halimifolius*, *Paspalum vaginatum*, *Pennisetum macrourum*, *Triglochin bulbosa*, *Bolboschoenus maritimus* and *Juncus krausii* (Mucina *et al*. 2006).

The geology, soils and hydrology consist of substrates built of fine sandy, silty or clayey soils over young Quaternary sediments, largely derived from weathering Cape supergroup shales, granites and Table Mountain sandstones. In places, especially on shales, these wetlands can acquire a brackish character. Endemic species include the low shrub *Passerina paludosa* and, in water bodies, the aquatic herbs *Aponogeton angustifolius*, *A. distachyos* and *Cotula myriophylloides* (Mucina *et al*. 2006). The vegetation type is ***Critically Endangered***, with a minimum national conservation target of 24%, although only some 14% is conserved in the Cape Peninsula and Agulhas National Park (Mucina *et al*. 2006).

2.4.1.4 Cape Inland Salt Pans

Cape inland salt pans occur in small depressions dominated by low, succulent scrubs composed of creeping chenopods and salt-tolerant herbs and grasses. Originally, most of the saline pans were coastal lagoons, but they became dry after having been cut off from the sea. They may become temporarily flooded by winter rains, but remain mostly dry in summer (Mucina *et al*. 2006).

Important taxa in this vegetation type include *Morella cordifolia, Orphium frutescens, Senecio halimifolius, Sarcocornia capensis, S. mossiana* complex*, Atriplex cinerea* subsp*. bolusii, Lycium cinereum, Sarcocornia pillansia, Frankenia repens, Limonium equisetinum, L. kraussianum, Chironia baccifera, C. decumbens, C. tetragona, Malephra luteola, Plantago crassifolia* complex*, Sarcocornia natalensis, Halopeplis amplexicaulis, Elegia microcarpum, C. nudum, Sporobolus virginicus, Elegia verreauxii, Ficinia lateralis, F. ramosissima, Polypogon monspeliensis, Prionanthium pholiuroides* and *Tribolium hispidum* (Mucina *et al*. 2006).

Endemic taxa in the vegetation type include *Disphyma dunsdonii, Drosanthemum salicola, Lampranthus salicola, Dymondia margaretae, Limonium anthericoides, Dorotheanthus clavatus* and *Pseudalthenia aschersoniana* (Mucina *et al*. 2006).

The vegetation type is ***Vulnerable***, with a minimum national conservation target of 24%, although only some 20% is statutorily conserved in the Agulhas and West Coast national parks as well as in the Soetendalsvlei and Rocherpan nature reserves. Only 3% enjoys protection on private land (Rietvlei, Rhenosterkop), while 20% has been transformed for cultivated land, mines or by urban sprawl. Alien Australian herbaceous *Atriplex* species show invasive behaviour in places (Mucina *et al*. 2006).

2.4.2 Mammals

The mammal fauna of Table Bay Nature Reserve comprise mostly smaller mammals, many of which are nocturnal and inconspicuous, and are therefore seldom recorded, though evidence of their occurrence in the reserve is made apparent by their middens, scat or spoor.

33 mammal species are currently confirmed for Table Bay Nature Reserve (see appendix C2). Rodents include the *Bathyergus suillus* (Cape Dune Molerat), the *Georychus capensis* (Cape Molerat), the *Tatera afra* (Cape Gerbil), the *Otomys irroratus* (Vlei Rat) and the *Rhabdomys pumilio* (Striped Field Mouse) (Lochner *et al*. 1994), as well as *Hystrix africaeaustralis* (Porcupine). Other mammals include *Raphicerus melanotis* (Cape Grysbok), *Sylvicapra grimmia* (Common Duiker), and *Raphicerus campestris* (Steenbok), but most are threatened by the encroaching development.

Recently, several sightings of *Aonyx capensis* (Cape Clawless Otter) and *Felis caracal* (Caracal) were recorded, as well as *Mellivorus capensis* (Honey Badger). Also confirmed here are *Genetta genetta* (Small Spotted Genet), *Galerella pulverulenta* and *Herpestes ichneumon* (Small and Large Grey Mongoose).

Of the mammals listed for Table Bay Nature Reserve, none is considered to be threatened. It is also possible that some of the larger endangered mammals occurred here before the area had been developed. Historical records from 1608 refer to elephant spoor in the Rietvlei area (Jackson *et al*. 2008).

2.4.3 Birds

Table Bay Nature Reserve has a rich bird fauna, and 204 species have been recorded to date (see Appendix C3). The regional importance of the reserve as a temporary wetland for water birds has contributed to the fact that, of all the faunal groups, water birds have been the most intensively studied. Research dates back to 1938, and counts by the Cape Bird Club to 1947 (Jackson *et al*. 2008).

The available information was synthesised in a report by Kaletja and Allan (1993) – an appendix to the 1994 Rietvlei management plan – which listed 100 water-bird species from the area.

Kaletja-Summers *et al*. (2001) have also published more detailed information on long-term trends and seasonal abundance of water birds at Rietvlei between 1950 and 1997 (Jackson *et al*. 2008).

Of the species listed, 64 are residents of Rietvlei, 14 are migrants, and 22 are vagrants. In terms of overall numbers, migrant birds from the northern hemisphere (Palearctic waders and terns) made up 42% of the counts during summer, which can reach around 13 000 individuals. *Calidris ferruginea* (Curlew Sandpiper) was the most abundant species, with the maximum count exceeding 7 000. In contrast, during winter, the majority of the birds are resident species, with *Fulica cristata* (Red-knobbed Coot) and *Anas undulata* (Yellow-billed Duck) being particularly common. An estimated 37 of these birds are breeding at Rietvlei (Jackson *et al*. 2008).

Apart from the seasonal variations, there have been longer-term changes in some species, with some increasing, such as *Porphyrio madagascariensis* (African Purple Swamp-hen), *Gallinula chloropus* (Common Moorhen) and various plovers. Others were decreasing, such as *Egretta intermedia* (Yellow-billed Egret), *Tadorna cana* (South African Shelduck) and *Tringa nebularia* (Greenshank). Some new species have also been recorded, such as kingfishers and cormorants, which inhabit the deep water lakes (Jackson *et al*. 2008).

Kaletja-Summers *et al*.. (2001) found that there had been a progressive increase in the overall abundance of water birds between the 1950s and 1990s, although an analysis of census data for 2001–2003 by Keyser (2003) suggested a decline. These changes are probably linked to changes in the habitat, including the expansion of certain types of vegetation, and the invasion of alien species (Jackson *et al*. 2008).

Table 10 is an excerpt from appendix C3, which indicates the bird species of Table Bay Nature Reserve that are listed as either vulnerable or near threatened.

Table 10: Table Bay Nature Reserve's bird species Red List categories

Family	Species name	Common name	Threatened status
ACCIPITRIDAE	*Circus maurus*	Black Harrier	Endangered (EN)
ACCIPITRIDAE	*Circus ranivorus*	African marsh-harrier	Vulnerable (VU)
ANATIDAE	*Oxyura maccoa*	Maccoa duck	Near threatened (NT)
CHARADRIIDAE	*Charadrius pallidus*	Chestnut-banded plover	Near threatened (NT)
CICONIIDAE	*Ciconia nigra*	Black stork	Near threatened (NT)
FALCONIDAE	*Falco biarmicus*	Lanner falcon	Near threatened (NT)
FALCONIDAE	*Falco peregrinus*	Peregrine falcon	Near threatened (NT)
GRUIDAE	*Anthropoides paradiseus*	Blue crane	Vulnerable (VU)
HAEMATOPODIDAE	*Haematopus moquini*	African black oystercatcher	Near threatened (NT)
LARIDAE	*Sterna balaenarum*	Damara tern	Near threatened (NT)
LARIDAE	*Sterna caspia*	Caspian tern	Near threatened (NT)
PELECANIDAE	*Pelecanus onocrotalus*	Great white pelican	Near threatened (NT)
PHALACROCORACIDAE	*Phalacrocorax capensis*	Cape cormorant	Near threatened (NT)
PHALACROCORACIDAE	*Phalacrocorax coronatus*	Crowned cormorant	Near threatened (NT)
PHOENICOPTERIDAE	*Phoenicopterus minor*	Lesser flamingo	Near threatened (NT)
PHOENICOPTERIDAE	*Phoenicopterus ruber*	Greater flamingo	Near threatened (NT)
ROSTRATULIDAE	*Rostratula benghalensis*	Greater painted snipe	Near threatened (NT)
SCOLOPACIDAE	*Calidrus ferruginea*	Curlew Sandpiper	Near threatened (NT)
SCOLOPACIDAE	*Limosa lapponica*	Bar-tailed Godwit	Near threatened (NT)
SCOLOPACIDAE	*Numenius phaeopus*	Eurasian Curlew	Near threatened (NT)

2.4.4 Reptiles

A total of 33 reptile species are known to occur within Table Bay Nature Reserve (see Appendix C4). The snake species occurring in the reserve include *Naja nivea* (Cape Cobra) and several non-venomous species, such as *Lamprophis aurora* (Aurora House Snake), *Duberria lufrix* (Common Slug Eater), *Lamprophis inornatus* (Olive House Snake), *Lycodonomorphus rufulus* (Common Brown Water Snake) and *Pseudaspis cana* (Mole Snake).

Of the lizard species, the most common are *Bradypodion pumilum* (Cape Dwarf Chameleon), *Meroles knoxxi* (Knox's Desert Lizard), *Afrogecko porphyreus* (Marbled Lead-toed gecko), *Acontias meleagris* (Cape Legless Skink), *Scelotes bipes* (Silvery Dwarf Burrowing Skink), *Trachylepis capensis* (Cape Skink), *Trachylepis homalocephala* (Red-sided Skink) and *Typhlosaurus caecus* (Cuvier's Blind Legless Skink). *Pelomedusa subrufa* (Marsh Terrapin) and *Chersina angulata* (Angulate Tortoise) also occur in the area.

2.4.5 Amphibians

Ten amphibian species have been recorded in Table Bay Nature Reserve (see appendix C5). The most common amphibians include *Amietia fuscigula* (Cape River Frog), *Strongylopus grayii* (Clicking Stream Frog), *Tomopterna delalandii* (Cape Sand Frog) and *Xenopus laevis* (Common Platanna).

2.4.6 Invertebrates

Though there is no official invertebrate species list for Table Bay Nature Reserve, it has been published that 84 aquatic invertebrates occur in the Rietvlei wetland section, with another 35 in the Milnerton Lagoon section (Grindley & Dudley 1988). They include examples from a wide variety of groups such as molluscs, crustaceans, polychaetes and insects, and, while some species occur across the estuary, in general there is a predominance of freshwater species in the Rietvlei wetlands and marine species in Milnerton Lagoon (Jackson *et al*. 2008).

Since many invertebrates have a relatively short life cycle, the populations can fluctuate greatly with the seasons, depending on the availability of water. Invertebrates are important as food for fish and wading birds (Jackson *et al*. 2008).

Although no detailed studies have been undertaken recently, it is likely that bottom-dwelling invertebrates in Milnerton Lagoon in particular, have suffered as a consequence of the apparent deterioration in water quality. *Callianassa kraussi* (Sand Prawn) was previously recorded as being abundant in the lower estuary between 100 m and 2,2 km upstream from the mouth. Clark (1998) estimated the standing stock at approximately 40 million and, although they were being collected for bait, the level of harvesting was considered sustainable. The sand prawn population has subsequently declined (Jackson *et al*. 2008).

Insect surveys were so far only done at the Milnerton Racecourse section, and 14 species were recorded. Additional ad hoc sightings have been added since (see appendix C6). These species are *Anax imperator* (Blue Emperor), *Cacyreus marshalli* (Common Geranium Bronze), *Colias electo electo* (African Clouded Yellow), *Crocothemis erythraea* (Broad Scarlet), *Eichochrysops messapus messapus* (Cupreous Blue), *Gegenis niso niso* (Common Hottentot), *Papilio demodocus demodocus* (Citrus Swallowtail), *Pieris brassicae* (Cabbage White), *Pontia helice helice* (Meadow white), *Pseudonympha magus* (Silver-bottom Brown), *Tarucus thespis* (Vivid Blue), *Tramea limbata* (Ferruginous Glider), *Vanessa cardui* (Painted lady) and *Macroglossum trochilus* (African Humming Bird Moth).

According to the report by Grindley and Dudley (1988), no detailed studies have been conducted on the phytoplankton, although a number of diatoms have been recorded during other studies. These include *Coscinodiscus, Rhizoselenia, Biddulphia, Thallassiosira* and *Skeletonema* species (Jackson *et al*. 2008).

Though no recent studies have been undertaken, the zooplankton in the reserve was reported as being similar to that of other temporary brackish vleis on the Cape Flats, which are characterised by species that have resistant stages, and can survive dry periods, only to re-appear and multiply once the vlei is inundated with water. Many of these are crustacean, including *Entomostraca*, *Copepoda*, *Cladocera*, *Ostracoda* and *Conchostraca* (Jackson *et al*. 2008).

In the lagoon, together with the physical conditions, the zooplankton varies from the upper reaches, which are low-saline in winter and hypersaline in summer, to the estuary mouth, where there is significant intrusion of seawater and the associated marine species. Some 28 species have been recorded, including crustaceans, foraminifera, fish eggs and larvae of ascidians and polychaetes (Jackson *et al*. 2008).

Further baseline surveys as well as research and monitoring projects need to be conducted within the reserve to obtain sufficient data for documentation purposes.

2.4.7 Fish

Fourteen fish species have been recorded within Table Bay Nature Reserve (see appendix C7). The most common fish include indigenous species, such as *Anguilla mossambica steinitzi* (Longfin Eel), *Caffrogobius nudiceps* (Barehead Goby), *Galaxias zebratus* (Cape

Galaxia), *Lithognathus lithognathus* (White Steenbras), *Liza richardsonii* (Southern Mullet), *Mugil cephalus* (Flathead Mullet) and *Rhabdosargus globiceps* (White Stumpnose). Alien fish species, including *Cyprinus carpio* (Carp) and *Gambusia affinis* (Mosquito Fish), have also invaded the reserve.

Historically, the fish assemblage in the Diep River estuary was fairly diverse, with up 28 species having been recorded, although five of these were aliens introduced over the last century (Jackson *et al*. 2008).

A number of the fish are breeding in the estuary, with some species in their juvenile stage entirely dependent on estuaries as nursery areas, such as *Lithognathus lithognathus* (White Steenbras), *Rhabdosargus globiceps* (White Stumpnose) *and Mugil cephalus* (Flathead Mullet) (Jackson *et al*. 2008). Concern over the status of both the Cape stumpnose and white steenbras – both of which are dependent on estuaries as nursery areas – has led to their inclusion on the prohibited species list for commercial line fishing, which forms part of the amended regulations published under the Marine Living Resources Act in 2005 (Jackson *et al*. 2008).

In more recent times, water quality perturbations in the Diep River estuary have seen substantial changes in the fish assemblage over short time periods. High ammonia concentrations arising from malfunctions in the Potsdam WWTW have caused the decline of benthic organisms, such as gobies and *Callianassa kraussii* (Sand Prawns), as well as other invertebrate species. A reduction in this food source has contributed to a decline in the number of important line-fish species in the estuary. As a result, the estuarine fish assemblage in the estuary is now dominated by the opportunistic *Liza richardsonii*, which is able to survive in both estuarine and marine environments (Jackson *et al*. 2008).

Table Bay Nature Reserve represents 10% of the available estuarine nursery area for fish along the west coast. The estuary could make a significant contribution to fish recruitment into the marine commercial and recreational line and beach-seine fisheries for *Liza richardsonii* (Jackson *et al*. 2008).

2.5 Socio-political context

The relatively flat topography of the catchment makes it suitable for both agriculture and urban development. This, together with its proximity to Cape Town, has meant that it has become highly developed, with agricultural activities dating back to Van Riebeeck’s time and the establishment of an outpost by the Dutch East India Company. The Diep River, particularly its lower reaches, has therefore been significantly modified over the past few centuries (Jackson *et al*. 2008).

2.5.1 History

Records and maps from the time of Van Riebeeck's arrival in the Cape in 1652 show that the Diep River mouth was originally connected to that of the Salt/Black River by a channel on the sea side of what was Paardeneiland (Jackson *et al*. 2008). During the early and middle decades of this century, this channel became known as Zoarvlei. It was formed as a blind-ending, seasonal vlei, since the channel between the two mouths was effectively cut off from tidal interchange, which used to occur as a result of its connection to the Diep River and its estuary. Zoarvlei has now lost its connection with the Salt/Black River through canalisation, and its connection to Milnerton Lagoon is now retained by culverts and a weir. It is probable that the original Paardeneiland channel began to disintegrate in the mid-1800s (Beaumont & Heydenrych 1980) as a result of sedimentation of the lower Diep River. This was exacerbated by road and rail developments in the early 1900s, and the formation of the Paardeneiland industrial area (Knight Hall Hendry 1999).

The 'Klein Zoar' cottage sits in the centre of Zoarvlei at Wemyss Road. It is said to be the only surviving example of a pioneer house, and has been dated as pre-1750. The house was declared a national monument in 1971. It is rumoured to have been Wolraad Woltemade's house, but this has not been conclusively proven. Woltemade is a well-known character in Cape history, mostly for his heroic actions in 1779, when he rescued 12 men shipwrecked on the Paardeneiland coastline, before he himself drowned (Knight Hall Hendry 1999).

The Milnerton railway line runs across the Zoarvlei northern water body, and this held the key to much of the development of the area. In 1899, the railway to Milnerton was initiated. However, it was completed in 1902 only. This transport link opened the area owned by Milnerton Estates Limited for development. The railway was closed in 1957, and the road network dominated the transport system from then onwards (Knight Hall Hendry 1999).

Otto du Plessis Road was constructed and effectively cut the Zoarvlei wetlands off from Milnerton Lagoon, as well as from the Rietvlei wetlands. These areas are still connected by means of culverts under roads and bridges. The canalisation of Black River left Zoarvlei as an isolated wetland (Knight Hall Hendry 1999). Further developments such as Milnerton Ridge and Royal Ascot also subsequently cut the Milnerton Racecourse off.

Early maps also showed that the estuary was deep enough to allow sailing and fishing boats to sail upstream for some 13 km as far as the Dutch East India Company's post at

Vissershok. Farms were established on the banks of the river in about 1690, and, from as early as 1846, there were reports that Rietvlei was silting up, with maps also showing that the mouth had separated from that of the Salt River (Jackson *et al*. 2008).

Urbanisation increased since the founding of Milnerton Estates Limited in 1897 as well as the establishment of the road and rail links. In 1904, a bridge was constructed between Milnerton and the Zonnekus Peninsula on the seaward side of the estuary. Today, the bridge is known as the Wooden Bridge, and the peninsula as Woodbridge Island. In 1905, parts of the lagoon were dredged for rowing regattas, but further siltation led to a curtailment of boating activities by the late 1920s. A weir was then built across the mouth in 1928 to control water levels, but was largely washed away by floods in 1941 and 1942 (Jackson *et al.* 2008).

Increasing development pressure saw the construction of the West Coast freeway in the 1960s and mid-1970s, including road embankments and the Otto du Plessis Road bridge, which crosses the estuary between Rietvlei and the Milnerton Lagoon. Over this period, there were proposals to develop Rietvlei as both a fishing harbour and a marina. These plans were ultimately shelved, although the north-west part of the vlei – commonly known as Flamingo Vlei – was dredged to a depth of 9–10 m to provide fill for construction in the port of Cape Town. An area of the Milnerton Lagoon below the old wooden bridge was also dredged in 1985 to provide sand for the Woodbridge Island development (Jackson *et al*. 2008).

In 1978, it was first proposed that Rietvlei be declared a nature area, with the proposal having been approved by Cabinet in 1982 and promulgated in 1984 (see appendix B1-1). In 1989, the wetland was declared a PNE under the Environmental Conservation Act (Act 73 of 1989). With the assistance of the Southern African Nature Foundation (now WWF-SA) and sponsorship from Caltex, the major part of Rietvlei and the Milnerton Lagoon was then purchased from Milnerton Estates, and the Rietvlei Wetland Reserve was established in 1993 under the auspices of the then Milnerton Municipality (now subsumed as part of the City of Cape Town) (Jackson *et al*. 2008).

The north-western part of the vlei, including the two dredged basins (Flamingo Vlei), belonged to Transnet, who subsequently donated the land to WWF-SA for incorporation into the reserve (Jackson *et al*. 2008). See appendix B4-1 for this deed of transfer.

In parallel with these developments, urbanisation of the areas surrounding Rietvlei and the Milnerton Lagoon continued. A golf course and the residential developments of Woodbridge Island and later Sunset Beach were constructed on the Zonnekus Peninsula, while the suburbs of Table View and Blouberg took shape to the north of Rietvlei. These were accompanied by the development of urban infrastructure, including stormwater drains and sewage works (Jackson *et al*. 2008).

The Milnerton sewage works was constructed on the north-east bank of Rietvlei, and, in 1991–1992, a canal was excavated to prevent the treated sewage effluent from the works from entering Rietvlei. The canal channels the effluent along the eastern boundary of Rietvlei, until it merges with Rietvlei's own outflow at the top of Milnerton Lagoon. The works – now known as the Potsdam WWTW – has subsequently been expanded and upgraded from a capacity of 32 to 47 Mℓ/day, although some of this is reused. Presently, an environmental impact assessment (EIA) is under way for further expansion, which could potentially see a discharge of up to 105 Mℓ/day (Jackson *et al*. 2008).

Stormwater from mainly residential areas enters the estuary via a number of drains, including the Bayside canal, which enters at the north-western corner of the Rietvlei wetlands, and numerous others along the northern and eastern margins. Of particular concern are those that drain areas of low-cost and informal housing, both above and below the Blaauwberg Road bridge. Industrial developments in the area included the Caltex oil refinery (now Chevron), a fertiliser factory (Kynoch) and the Montague Gardens and Killarney Gardens industrial areas. Stormwater from Chevron is discharged above the sewage works, while that from Montagu Gardens enters the estuary via an open channel near the Theo Marais sports grounds. Stormwater from the Kynoch site, which is now closed and demolished, also discharges into the Theo Marais channel via the Duikersvlei stream. This originally contained high levels of nitrates and phosphorus, but has improved somewhat since the land has been rehabilitated (Jackson *et al*. 2008).

In summary, activities in the catchment, together with the intensive urbanisation around the reserve, have over the centuries not only physically modified the area, but have brought a variety of challenges, including reduced water flows, siltation and changes in the drainage patterns, a deterioration in water quality, and changes to the biodiversity (Jackson *et al*. 2008).

2.5.2 Socio-economic context

The greater part of the Diep River catchment is dominated by dryland agricultural activities, with 90% of it under cultivation. The region accounts for about a sixth of South Africa's grain production, mainly wheat, although there are also a growing number of vineyards and orchards. Livestock includes pigs, cattle and sheep, although the most common activity is poultry production. Many of these farms have small dams to provide the water required for their activities. In addition to the agriculture, there are some quarries and informal sand works in the catchment, producing stone, gravel and sand (Jackson *et al*. 2008).

Although the catchment as a whole has a relatively low population, the lower reaches of the river where the reserve is situated fall within a highly urbanised environment. The 2001 census data put the population figure for the areas between Woodbridge Island and Sunningdale at over 55 000, and the area is one of the most rapidly growing areas of Cape Town. The residential areas are diverse, with those areas immediately adjacent to Table Bay Nature Reserve being characterised by middle to upper-income housing, with areas of low-cost and informal housing (such as Du Noon and Marconi Beam) being situated a bit further away (Jackson *et al*. 2008).

Despite the modifications that have taken place, the reserve remains highly valued for its natural attributes and the recreational opportunities it offers. A survey by Clark (1998) suggested that recreational activities are concentrated in or around the recreational deep-water lakes and the section of the Milnerton Lagoon between the mouth and the bridge. The majority (66%) of activities are land-based (picnicking, sightseeing, walking), with 34% being water-based activities, including fishing, swimming and boating. Of the boating activities, power boating, water-skiing and sailing are limited to the northern deep-water lake, while canoeing takes place primarily in the upper part of Milnerton Lagoon. The Milnerton Aquatic Club is situated on the eastern bank of the northern deep-water lake (Jackson *et al*. 2008).

Bait collection was also found to be popular, with two types occurring in the lower parts of the lagoon, namely prawn pumping for *Callianasa kraussi* (Sand Prawn) and the use of throw nets to collect *Liza richardsonii* (harders) and *Mugil cephalus* (springers). In recent years, the Sand Prawn has declined significantly. Legal fishing in the estuary is recreational, but there has been some illegal gillnetting, which could be for subsistence purposes (Jackson *et al*. 2008).

2.6 Protected-area expansion

There are several strategic future protected-area expansion plans for the reserve, and these are detailed per management section in table 11 below:

Table 11. Protected area expansion plans for the Table Bay Nature Reserve

Management section	Protected-area expansion plan(s)
Parklands fynbos corridor	Further parcels in the Parklands development must be ceded to the City of Cape Town in terms of the ROD. These blocks contain remnants of Cape Flats Sand Fynbos, and will be designated for future inclusion in Table Bay Nature Reserve to increase the size of the fynbos corridor section.
	Further parcels in the Sunningdale development must be ceded to the City of Cape Town in terms of the ROD. These blocks include remnants of Cape Flats Sand Fynbos, and will be designated for future inclusion in Table Bay Nature Reserve to increase the size of the fynbos corridor section, and ultimately

	to link to Blaauwberg Nature Reserve.
Milnerton Racecourse	The cinder running track is presently under Gold Circle ownership, but this may be ceded to the City of Cape Town for future inclusion in Table Bay Nature Reserve to increase the size of the Milnerton Racecourse section.
	The grass running track is presently under Gold Circle ownership, but a section of this may be ceded to the City of Cape Town for future inclusion in Table Bay Nature Reserve to promote connectivity between the two disjointed parts of the Milnerton Racecourse section.

3. PURPOSE, VISION/MISSION, SIGNIFICANCE/VALUE

3.1 Purpose of the protected area

Table Bay Nature Reserve is located in the CFR, which is an area of global biodiversity significance. The reserve conserves a unique combination of terrestrial and aquatic habitats, ecosystems and species, many of which are either rare or endemic to the area. Being closely associated with Table Bay, the name will be easily recognisable anywhere in the world.

The primary purpose of the reserve is the **conservation of the unique biodiversity and associated ecosystem features and functions** of the area.

In conserving this unique biodiversity, secondary objectives will be to develop high-quality visitor infrastructure, facilities and services, as well as to promote environmental education resources and experiences.

3.2 Vision and mission

The vision and mission statements below are drawn from previously published documents. It is important to note that not all the management sections in Table Bay Nature Reserve have written visions or mission statements. Therefore, the combined vision and mission statements for Table Bay Nature Reserve will encompass all the management sections.

3.2.1 Vision

<u>Integrated Development Plan vision</u>

The vision of the City of Cape Town remains as follows:

- To be a prosperous city that creates an enabling environment for shared growth and economic development
- To achieve effective and equitable service delivery
- To serve the citizens of Cape Town as a well-governed and effectively run administration

To achieve this vision, the City recognises that it must:

- actively contribute to the development of its environmental, human and social capital;
- offer high-quality services to all who live in, do business in, or visit the city as tourists; and
- be known for its efficient, effective and caring government.

<u>C.A.P.E vision</u>

We, the people of South Africa, are proud to be the custodians of our unique Cape Floral Region and share its full ecological, social and economic benefits now and in the future.

<u>Environmental Resource Management Department (ERMD) vision</u>

The Environmental Resource Management Department's vision is to ensure that sustainable and equitable development is combined with sound environmental practice for a healthy local environment, which sustains people and nature, provides protection for our unique resources, and results in an enhanced quality of life for all.

<u>Biodiversity Management Branch vision</u>

The Biodiversity Management Branch's vision is to be a City that leads by example in the protection and enhancement of biodiversity; a City within which biodiversity plays an important role, where the right of present and future generations to healthy, complete and vibrant biodiversity is entrenched; a City that actively protects its biological wealth, and prioritises long-term responsibility over short-term gains.

<u>Table Bay Nature Reserve vision</u>

The vision for Table Bay Nature Reserve is to become an internationally recognisable natural feature in Cape Town, and for the City of Cape Town to achieve this through the responsible management, monitoring and use of its natural assets, the building of partnerships with stakeholders, and the implementation of policies and legislation designed to promote its protection and sustainable use.

3.2.2 Mission

<u>Biodiversity Management Branch mission</u>

The Biodiversity Management Branch's mission is to manage biodiversity proactively and effectively, ensure an integrated approach to biodiversity between line functions and departments, actively pursue external partnerships, adopt a long-term approach to biodiversity, ensure sustainability of our rich biodiversity, adopt a holistic and multifaceted approach to biodiversity, continue to measure and monitor the City of Cape Town's performance in the protection and enhancement of biodiversity, and continue to measure and monitor the state of biodiversity in Cape Town.

Table Bay Nature Reserve mission

Table Bay Nature Reserve's mission is to restore and maintain the natural environment and its associated ecological processes and services through the implementation of the management objectives of this IRMP.

3.3 Significance of property (biodiversity, heritage and social)

Table Bay Nature Reserve is significant in many respects, as discussed below:

3.3.1 Conservation status

The reserve encompasses the **Rietvlei PNE** (also known as the Rietvlei Wetland Reserve), which is also listed as an **IBA** and a **Core Flora Conservation Site**. Furthermore, the Milnerton Racecourse section is also designated as a Core Flora Conservation Site, and is set aside for conservation in terms of the **ROD** for the Royal Ascot development. Similarly, the Parklands fynbos corridor section is designated for conservation purposes in terms of the ROD for the Parklands and Sunningdale developments.

3.3.2 Ecosystem attributes

Table Bay Nature Reserve encompasses the Diep River **estuary**, which functions as a tidal interface and fish nursery and recruitment area; the Rietvlei **seasonal wetlands**, which provide feeding grounds for migratory water birds, and the Diep River **flood plain**, which attenuates floods in the catchment. The 11 km long wetland system from the Diep River to Zoarvlei promotes **wetland linkages, connectivity and catchment-to-coast** landscapes.

3.3.3 Regional context

The reserve is closely associated with the **Table Bay coast**, and protects a significant part of the Milnerton beach. It protects the entire **lower end of the Diep River catchment**, which connects Swartland Municipality to the Table Bay coast as well as Blaauwberg Nature Reserve to the edge of the Cape Town city centre. Furthermore, it forms the southernmost buffer zone of the **Cape West Coast Biosphere Reserve**, which extends to the West Coast National Park.

3.3.4 Biodiversity conservation

Table Bay Nature Reserve protects 412 plant species, 31 mammals, 196 birds, 33 reptiles, nine amphibians and 14 fish species. It also supports yet unlisted insect, invertebrate and planktonic communities. Of the birds, two species are listed as Vulnerable, and 14 are Near Threatened.

3.3.5 Vegetation types

The reserve protects six national vegetation types, including **Cape Flats Sand Fynbos** (Critically Endangered), **Cape Flats Dune Strandveld** (Endangered), **Cape Lowland Freshwater Wetlands** (Critically Endangered), **Cape Estuarine Salt Marshes**, **Cape Inland Salt Pans** (Vulnerable) and **Cape Seashore Vegetation**.

3.3.6 Conservation planning

Table Bay Nature Reserve forms a significant part of the City of Cape Town's **biodiversity network**, and aligns with the City of Cape Town's **biodiversity strategy**. It also aligns with the vision and mission statements of **C.A.P.E**, the **C.A.P.E Estuaries Programme** as well as the City of Cape Town's ERMD and Biodiversity Management Branch.

3.3.7 Nature reserve administration

The reserve's management is guided by section-specific **management objectives**, as well as four section-specific **management committees** that encompass all seven management sections of the reserve. (This IRMP will specify the creation of an all-encompassing Table Bay Nature Reserve Forum.)

3.3.8 User opportunities

In terms of user opportunities, Table Bay Nature Reserve is utilised by schools and students for **environmental education** purposes, by Friends groups, as well by various organised **recreational** groups, including water sports, birdwatching and fishing.

3.3.9 Visual perspective

The reserve is a central feature of Cape Town, and is clearly visible from most of the major access routes to the city, including the **R27 (West Coast road)**, the maritime routes to **Cape Town Port** and the flight paths to **Cape Town International Airport**. It is also clearly visible from **Table Mountain**, **Tygerberg Hills** and **Blaauwberg Hill**.

PART 2

MANAGEMENT POLICY FRAMEWORK

4. ADMINISTRATIVE AND LEGAL FRAMEWORK FOR THE MANAGEMENT AUTHORITY

4.1 Legal framework

A range of international, national and provincial legislation potentially applies to the management of nature reserves and estuaries in South Africa. Together with relevant municipal bylaws, management policies and strategies, these pieces of legislation are summarised in the following tables. Key pieces of legislation are discussed in more detail (Jackson *et al*. 2008).

4.1.1 International obligations

4.1.1.1 Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971 (Ramsar Convention)

The mission of the Ramsar Convention is “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”.

The Convention uses a broad definition of the types of wetlands covered in its mission, including lakes and rivers, swamps and marshes, wet grasslands and peatlands, oases, estuaries, deltas and tidal flats, near-shore marine areas, mangroves and coral reefs, and human-made sites such as fish ponds, rice paddies, reservoirs, and salt pans. (Pers. comm., Niel van Wyk, 2011).

South Africa acceded to the Ramsar Convention in 1975, and has 20 designated Ramsar sites. In 1996, consideration was given to applying for Ramsar status for the Diep River estuary and Rietvlei wetlands, and a proposal to this effect was prepared. However, given the problems pertaining to the estuary, this was not submitted (Jackson *et al*. 2008).

4.1.1.2 Convention on the Conservation of Migratory Species of Wild Animals, 1979 (Bonn)

The Bonn Convention was developed to facilitate cooperation between states in the conservation of animals that migrate across their borders. Parties that are range states of a migratory species listed in appendix 1 to this convention are required to conserve and restore their habitats with a view to reducing the threat of extinction. The convention’s appendix 2 lists migratory species that require more specific agreements, such as species that have an unfavourable conservation status or require international agreements for their conservation and management. Each agreement should cover the whole range of the migratory species concerned, and should be opened to accession by all range states of that species, regardless of whether they are parties to the convention. South Africa acceded to the convention in 1991. It is particularly relevant to Table Bay Nature Reserve, which is renowned for its water birds, including 14 migrants (Jackson *et al*. 2008).

4.1.1.3 Convention on Biological Diversity, 1992

The convention establishes three main goals: (1) the conservation of biological diversity; (2) the sustainable use of its components; and (3) the fair and equitable sharing of the benefits from the use of genetic resources. Contracting parties are required to develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity. States must integrate the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies (Jackson *et al*. 2008).

The convention also provides for the establishment of a system of protected areas or areas where special measures need to be taken to conserve biological diversity. Parties are required to promote the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings. They must rehabilitate and restore degraded ecosystems and promote the recovery of threatened species through the development and implementation of plans or other strategies. Parties must also prevent the introduction, control or eradication of those alien species that threaten ecosystems, habitats or species. South Africa ratified the convention in 1995 (Jackson *et al*. 2008). Table 12 below gives a summary of a greater range of applicable international conventions:

Table 12. Summary of applicable international conventions (Jackson *et al*. 2008)

International obligations	Description	Management implications
Convention on Wetlands of International Importance, especially as Waterfowl Habitat, 1971 (Ramsar Convention)	Aims to stem the progressive encroachment on, and loss of, wetlands. Contracting parties are to designate suitable wetlands within their territory, for inclusion in a list of wetlands of international importance.	Planning must be formulated and implemented to promote not only the conservation of wetlands included in the list, but also the wise use of wetlands within the territory of contacting parties.
Convention concerning the Protection of the World Cultural and Natural Heritage, 1972 (World Heritage Convention)	Recognises that parts of the cultural and natural heritage need to be preserved. Parties are to submit an inventory of sites for inclusion on the world heritage list.	The convention is applicable not only to world heritage sites within a state's territory, but also extends to natural heritage more generally, including estuaries.
Convention on the Conservation of Migratory Species of Wild Animals, 1979 (Bonn Convention)	Recognises that states must be the protectors of migratory species of wild animals that live within, and pass through, their national jurisdictional boundaries.	Where migratory species occur, concerted action is required for their conservation and effective management.
Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981 (Abidjan Convention)	Covers the marine environment, coastal zones and related inland waters falling within the jurisdiction of the states of the West and Central African region who are contracting parties to it.	Requires parties to take all appropriate measures to prevent, reduce, combat and control pollution of the convention area caused by discharges from estuaries.
Convention on Biological Diversity, 1992	Contracting parties are to promote the protection of ecosystems, natural habitats and the maintenance of viable populations of	Requires the integration of conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral

Table 12. Summary of applicable international conventions (Jackson *et al*. 2008)

International obligations	Description	Management implications
	species in natural surroundings.	plans, programmes and policies.
United Nations Framework Convention on Climate Change, 1992	Aims to achieve stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	Requires that precautionary measures be taken to anticipate, prevent or minimise the cause of climate change, and mitigate its adverse effects (including sea-level rise).

Key national legislation

The National Biodiversity Strategy and Action Plan highlighted the lack of effective estuary management due to estuaries not fitting within the mandate of any one department. This gap was addressed through enactment of the National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008. This act introduced a requirement for estuary management plans (EMPs) and has therefore been a key driver behind the C.A.P.E Estuaries Programme (Jackson *et al*. 2008).

4.1.2.1 National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008

The Integrated Coastal Management Act is intended to:

- establish a system of integrated coastal and estuarine management in the Republic, including norms, standards and policies, in order to promote the conservation of the coastal environment, maintain the natural attributes of coastal landscapes and seascapes, and ensure that development and the use of natural resources within the coastal zone are socially and economically justifiable and ecologically sustainable;
- define rights and duties in relation to coastal areas;
- determine the responsibilities of organs of state in relation to coastal areas;
- prohibit incineration at sea;
- control dumping at sea, pollution in the coastal zone, inappropriate development of the coastal environment, and other adverse effects on the coastal environment;
- give effect to South Africa's international obligations in relation to coastal matters; and
- provide for matters connected therewith.

In terms of the Act, estuaries are to be managed in accordance with a national estuarine management protocol, to be prescribed by the ministers of Environmental Affairs and Water Affairs within four years of the commencement of the Act. The protocol must:

- determine a strategic vision and objective for achieving effective integrated management of estuaries;
- set standards for the management of estuaries;

- establish procedures and guidance regarding how estuaries must be managed, and how the management responsibilities are to be exercised by different organs of state and other parties;
- establish minimum requirements for estuarine management plans;
- identify who must prepare estuary management plans and the process to be followed; and
- specify the process for reviewing estuarine management plans to ensure that they comply with the requirements of the Act.

4.1.2.2 National Environmental Management Act, Act 107 of 1998 (NEMA)

The principles set out in NEMA serve as guidelines to organs of state when exercising any functions or taking decisions that may have a significant impact on the environment. A significant principle in NEMA, for the purposes of estuary management, provides that sensitive, vulnerable, highly dynamic or stressed ecosystems, such as estuaries, require specific attention in management and planning procedures. Pertinent regulations made in terms of NEMA include the EIA regulations and the Regulations for the Control of Vehicles in the Coastal Zone (Jackson *et al*. 2008).

4.1.2.3 National Environmental Management: Protected Areas Act, Act 57 of 2003

The Protected Areas Act provides for the protection and conservation of areas representative of South Africa's biodiversity and ecosystems, through the declaration and management of protected areas. The system of protected areas includes, among others, special nature reserves, national parks, nature reserves and protected environments. The Minister may prescribe norms and standards for the management and development of protected areas, as well as indicators to measure compliance therewith (Jackson *et al*. 2008).

Although the Rietvlei Wetland Reserve was originally declared a PNE in terms of the Environmental Conservation Act, Act 73 of 1989, section 28(7) of the Protected Areas Act provides that an area that was a protected environment before the section took effect, must be regarded as having been declared in terms of the section. Thus, the provisions of the Act are directly applicable. The responsibility for overseeing implementation of these provisions, however, lies with Province, the responsibility for PNEs having been delegated to the provinces by the Environmental Conservation Act. This oversight function has not been established as yet (Jackson *et al*. 2008).

4.1.2.4 National Environmental Management: Biodiversity Act, Act 10 of 2004

The objectives of the Biodiversity Act include:

- the management and conservation of biological diversity;
- the sustainable use of indigenous biological resources; and
- giving effect to international obligations under the Convention on Biological Diversity, and the Ramsar and Bonn conventions.

This includes the protection of threatened species and ecosystems, and the management of threats to biodiversity such as alien and invasive species. Both aspects are pertinent to Table Bay Nature Reserve in as much as the area is inhabited by a number of threatened species, and has been invaded by a number of terrestrial and aquatic alien species (Jackson *et al*. 2008).

All organs of state are required to prepare an invasive species monitoring, control and eradication plan for land under their control as part of their environmental plans in accordance with NEMA. In the case of municipalities, such plans must be part of their IDPs.

This plan must include the following (Jackson *et al*. 2008):

- A detailed list and description of any listed invasive species occurring on the land
- A description of the parts of the land that are infested with such listed invasive species
- An assessment of the extent of such infestation
- A status report on the efficacy of previous control and eradication measures
- The current measures to monitor, control and eradicate such invasive species
- Measurable indicators of progress and success, and indications of when the control plan is to be completed

Where the area is a protected area in terms of the Act, the management authority of the protected area must incorporate an invasive species control and eradication strategy into the area management plan. The management authority must also at regular intervals prepare and submit to the Minister or the provincial MEC for Environmental Affairs a report on the status of any listed species that occurs in that area (Jackson *et al*. 2008).

4.1.2.5 National Water Act, Act 36 of 1998

The purpose of the Act is to ensure that the national water resources are protected, used, developed, conserved, managed and controlled appropriately. This involves a variety of activities, two of which are of particular relevance to the management of the Diep River estuary, namely catchment management and management of the use of water (Jackson *et al*. 2008).

The Act provides for the establishment of catchment management agencies, so that water resource management may be delegated to the regional or catchment level. To date, however, only two agencies have been established, namely Inkomati and Breede-Overberg catchment management agencies. The Minister of Water Affairs assumes the powers of a catchment management agency in areas where such agencies have not been established (Jackson *et al*. 2008).

Included among the functions of a catchment management agency are (Jackson *et al*. 2008):

- investigating, and advising interested persons on, the conservation management and control of water resources in its water management area;
- promoting community participation in the conservation management and control of water resources; and
- coordinating the related activities of water users and the water management institutions.

The Act provides for the Minister to prescribe a system for classifying water resources, which may establish guidelines and procedures for determining different classes of water resources. It may also set out water uses for instream or land-based activities, which must be regulated in order to protect the water resources. Once the Minister has prescribed the system for classifying water resources, he/she must determine, for every significant water resource, quality objectives based on such classification. Such objectives may relate to the reserve, the instream flow, the water level, the presence and concentration of particular substances in the water, and the characteristics and quality of the water resource. The Minister is required to determine the reserve for all or part of that water resource. The Act provides for a preliminary determination of the reserve to be made, until a system for classifying water resources has been prescribed, or a class of a water resource has been determined (Jackson *et al*. 2008).

Section 21 sets out water uses that require a water use licence. Those significant for the purposes of the Diep River include (Jackson *et al*. 2008):

- impeding or diverting the flow of water in a watercourse;
- discharging waste, or water containing waste, into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
- disposing of waste in a matter that may detrimentally affect the water resource;
- altering the bed, banks, course or characteristics of a watercourse; or

- in any manner disposing of water that contains waste from, or has been heated in, any industrial or power-generation process.

The Potsdam WWTW is authorised to discharge effluent into the Diep River in terms of a licence issued under section 21 (Jackson *et al*. 2008).

4.1.2.6 Marine Living Resources Act, Act 18 of 1998 (amended in 2000)

The Marine Living Resources Act provides for the utilisation, conservation and management of marine living resources. In so doing, it recognises the need for the conservation of marine ecosystems, protection of marine biodiversity, and the minimisation of marine pollution. In order to accomplish this, the Minister may declare marine protected areas (MPAs), where certain activities are prohibited. These include fishing or attempting to fish, constructing or erecting any building or other structure on or over any land or water within an MPA, or discharging or depositing waste or any other polluting matter. An area may be declared an MPA for the protection of fauna and flora, to facilitate fishery management, or to diminish any conflict that may arise from competing uses in that area (Jackson *et al*. 2008).

Table 13 below lists the national legislation that applies to Table Bay Nature Reserve. Although this list is extensive, it is by no means complete, and should be updated as new legislation is gazetted.

Table 13. Summary of applicable National legislation

National legislation	Description	Management implications	Lead agent
Constitution of the Republic of South Africa Act; No 108 of 1996	Lists South African citizens' environmental rights	Chapter 2: Bill of rights assigns citizens with particular rights	N/A
Marine Living Resources Act, Act 18 of 1998	Provides for the conservation of marine ecosystems and biodiversity, and the sustainable utilisation of marine living resources	The Minister may declare certain areas as MPAs, within which permission is required to carry out certain activities, including fishing, the construction or erection of buildings, and the dredging or extracting of sand or gravel.	Department of Agriculture, Forestry and Fisheries
National Environmental Management Act, 107 of 1998 ('NEMA')	Provides for cooperative environmental governance by establishing principles for decision making, institutions to promote cooperative governance, and procedures for coordinating environmental functions	A duty of care is imposed to prevent or remedy significant pollution or degradation of the environment, especially sensitive, vulnerable, highly dynamic or stressed ecosystems, such as estuaries.	Department of Environmental Affairs
EIA regulations, 2006 (issued under NEMA)	Regulates procedures and criteria for the submission, processing, consideration and decision of applications for environmental authorisation of activities	Approval by the environmental authorities is required to carry out activities listed in the EIA regulations. This includes certain activities within the coastal zone. Approval is dependent on the findings of the EIA.	Department of Environmental Affairs / Department of Environmental Affairs and Development Planning (DEA&DP)
Regulations for the Control of Vehicles in the Coastal Zone, 2001 (issued	Provides a general prohibition on the recreational use of vehicles in the coastal zone	Vehicles may not be used in the coastal zone, unless such use is authorised in terms of a permit or exemption, or is a permissible use under the regulations.	Department of Environmental Affairs and Development Planning (DEA&DP)

Table 13. Summary of applicable National legislation

National legislation	Description	Management implications	Lead agent
under NEMA)			
National Water Act, Act 36 of 1998	Aims to ensure that water resources are protected, used, developed, conserved, managed and controlled appropriately	Water resources are defined in the Act to include estuaries. The Act sets out various water uses for which a water use licence is required, including the taking of water from a water resource.	Department of Water Affairs
National Heritage Resources Act, Act 25 of 1999	Introduces an integrated and interactive system for the management of national heritage resources. In terms of the Act, heritage resources may include landscapes and natural features of cultural significance.	The responsible heritage resources authority must be notified of certain categories of development where this may result in heritage resources being affected. The authority may then request that an impact assessment report be submitted.	South African Heritage Resources Agency (SAHRA)/Heritage Western Cape
Local Government: Municipal Systems Act, Act 32 of 2000	A municipal council must adopt a single, inclusive and strategic plan, which links, integrates and coordinates plans, and takes into account proposals for the development of the municipality.	An adopted IDP is the principal strategic planning instrument that guides and informs all planning and development and all decisions with regard to planning, management and development in the municipality.	Department of Provincial and Local Government
Mineral and Petroleum Resources Development Act, Act 28 of 2002	Aims to ensure that mineral and petroleum resources are developed in an orderly and ecologically sustainable manner, while promoting justifiable social and economic development	An application for mining requires an EIA to be conducted and an environmental management programme to be submitted, which evaluates the impact of the mining on the environment, and determines the environmental management objectives.	Department of Minerals and Energy
National Environmental Management: Protected Areas Act, Act 57 of 2003	Aims to establish a national system of protected areas as part of a strategy to manage and conserve biodiversity and ecosystems	Where a protected area is declared, restrictions may be applied to development or activities that are inappropriate for the area.	Department of Environmental Affairs / CapeNature
National Environmental Management: Biodiversity Act, Act 10 of 2004	Provides for the management and conservation of biodiversity, and of the components of such biological diversity, within the framework of NEMA. Provides for cooperative governance in biodiversity management and conservation.	Gives effect to ratified international agreements relating to biodiversity (i.e. Ramsar convention, Bonn convention and Convention on Biological Diversity). Provides for identification and listing of vulnerable and threatened ecosystems and species, and for bioregional plans.	Department of Environmental Affairs
National Environmental Management: Integrated Coastal Management Act, 2008	Establishes a system of integrated coastal and estuarine management, including norms, standards and policies, in order to promote the conservation of the coastal environment. Further aims to control dumping at sea, pollution in the coastal zone, and inappropriate development of the coastal environment. Estuaries are to be managed in accordance with a national estuarine management protocol. This must set standards for the management of estuaries, establish procedures regarding how estuaries are to be managed, and establish minimum requirements for estuarine management plans.	Estuaries would form part of 'coastal public property' and 'coastal waters', and would consequently be inalienable and under trusteeship of the state. The development of an estuarine management plan must follow a public participation process consistent with the national estuarine management protocol. Imposes a duty to avoid causing adverse effects on the coastal environment. The duty of care in NEMA applies to any impact that has an adverse effect on the coastal environment. Effluent that originates from a source on land may not be discharged into an estuary, unless authorised in terms of a general authorisation or a coastal waters discharge permit.	Department of Environmental Affairs
Conservation of Agricultural Resources Act, Act 43 of 1983 (CARA)	CARA regulations contain a list of alien invasive vegetation, categorised according to their legal status. Act regulates sale position and use of listed species.	Alien invasive plant legislation to be included under Biodiversity Act in future	

Table 13. Summary of applicable National legislation

National legislation	Description	Management implications	Lead agent
National Veld and Forest Fire Act, Act 101 of 1998	Relates to veld fire prevention, fire protection associations, fire danger indexing, enforcement of fire legislation, and the fighting of fires		
Environmental Conservation Act, Act 73 of 1989	The Environmental Conservation Act is the other law that relates specifically to the environment. Although most of this Act has been replaced by NEMA, there are still some important sections that remain in operation. These sections relate to: • protected natural environments; • littering; • special nature reserves; • waste management; • limited development areas; • regulations on noise, vibration and shock; and • EIA.		
National Environmental Management: Air Quality Act, Act 39 of 2004	To provide for enhancing the quality of ambient air for the sake of securing an environment that is not harmful to the health and well-being of the people	Promulgated to give effect to section 24(b) of the Constitution. South African air quality information system (SAAQIS) is a web-based system that provides information on the quality of ambient air across the country	
Animal Protection Act, Act 71 of 1962	To consolidate and amend the laws relating to the prevention of cruelty to animals		
Animal Diseases Act, Act 35 of 1984	Provides for control measures relating to animal diseases		
Animal Health Act, Act 7 of 2002	Regulates animal health		
Game Theft Act, Act 105 of 1991	Regulates the ownership and protection of game		
Mountain Catchment Areas Act, Act 63 of 1970	Provides for catchment conservation		

Provincial legislation

4.1.3.1 Nature and Environmental Conservation Ordinance, No. 19 of 1974 (as amended)

The Ordinance provides for the establishment of provincial, local and private nature reserves and related conservation measures, including the regulation of hunting. It also separately provides for the protection of flora, wild animals, and fish in inland waters. With respect to fishing, a permit is generally required, subject to various conditions and some exemptions. The limitations cover issues such as the type and size of fish, bag limits, season, and method of fishing and sale of fish. The Ordinance also prohibits the sale or purchase, except under permit, of bait species (Jackson *et al*. 2008).

Table 14 below summarises the relevant provincial legislation. Although this list is extensive, it is by no means complete, and should be updated as new legislation is gazetted.

Table 14: Summary of relevant provincial legislation

Provincial legislation	Description	Management implications	Lead agent
Municipal Ordinance, No. 20 of 1974	Consolidates and amends the law relating to municipalities, village management boards and local boards, and deals with municipal services	Provides for the draining of stormwater or discharge of water from any municipal service works into any natural watercourse	Municipality
CapeNature and Environmental Conservation Ordinance, No. 19 of 1974 (amended in 1999)	Deals with the establishment of nature reserves, the protection of wild animals, the protection of fish in inland waters, and the protection of flora	Prohibits the deposition of substances likely to be injurious to any fish or fish food. An angling licence is required for angling in inland waters.	CapeNature
Western Cape Nature Conservation Board Act, Act 15 of 1998	The purpose of this Act is to promote and ensure nature conservation, render services and provide facilities for research and training, and generate income.	Biodiversity agreements are signed under this Act.	CapeNature
Land Use Planning Ordinance, No. 15 of 1985	Regulates land use planning applications in the Western Cape	Applications for departure, rezoning and subdivision, where applicable, need to be submitted in terms of this Ordinance.	DEA&DP
Western Cape Planning and Development Act, Act 7 of 1999	Provides for principles, policies, guidelines and parameters for planning and sustainable development, including environmental protection and land development management.	Sets out general planning and development principles that apply throughout the province. These include principles of environmental protection, including that development in unsuitable environments, such as areas with a high water table, swamps, flood plains, steep slopes and areas sensitive to driftsands, should be discouraged. However, this Act has not yet taken effect.	DEA&DP
Problem Animal Control Ordinance, No. 26 of 1957	Regulates problem animals		CapeNature

4.1.4 Municipal bylaws (City of Cape Town)

4.1.4.1 Milnerton Municipality: Bylaw relating to the Use and Control of the Rietvlei Water Area, 1977

The Bylaw regulates the recreational water use at the Rietvlei deep-water lakes. See annexure B1-2 for the complete text. It provides for the present suite of recreational activities that take place in the Rietvlei deep-water lakes. Any activities that are not provided for may not be practised in the recreational water area. Recently, a revision of the Bylaw was requested to amalgamate similar bylaws from other former municipalities that are now subsumed into the City of Cape Town. This revision also aims to align the Bylaw with new national regulations on small vessels.

Together with this Bylaw, the Council resolution relating to fishing and boating in the Rietvlei PNE further determines the present recreational use patterns in the reserve. See appendix B3-1 for the complete resolution.

4.1.4.2 Bylaw relating to Stormwater Management, 2005

The Bylaw provides for the management of stormwater in the City of Cape Town, including the regulation of activities that may have a detrimental effect on the development, operation or maintenance of the stormwater system. The stormwater system is defined to include natural facilities, including watercourses and their associated flood plains used for the disposal of stormwater. Similarly, the definition of stormwater includes natural precipitation, groundwater and spring water conveyed by the stormwater system, as well as sea water within estuaries (Jackson *et al*. 2008). In the case of Table Bay Nature Reserve, there are numerous stormwater discharges draining both residential and industrial areas.

4.1.4.3 Wastewater and Industrial Effluent Bylaw, 2006

This Bylaw regulates the discharge of industrial effluent into municipal sewers, the protection of municipal sewers, and duties of property owners in respect of sewer installations. Its provisions should however be noted in the context of proposals to divert some of the more polluted stormwater discharges around the reserve to Potsdam WWTW, as written consent of the City of Cape Town is required to discharge stormwater into any municipal sewer (Jackson *et al*. 2008).

4.1.4.4 Dumping and Littering Bylaw, 2002

The Bylaw prohibits littering or the dumping of waste, described as any matter that is a by-product, emission, residue or remainder of any product, process or activity, and which has been discarded. Where the littering or dumping of waste takes place, the City of Cape Town may, by written notice, direct the relevant persons to cease the dumping or littering, or to prevent the continuation of the dumping or littering, and to take whatever steps the municipality considers necessary to clean up or remove the waste, to rehabilitate the affected facets of the environment, and to ensure that the waste and any contaminated material that cannot be cleaned or rehabilitated are disposed of lawfully (Jackson *et al*. 2008).

Table 15 below summarises the relevant municipal bylaws and regulations. Although this list is extensive, it is by no means complete, and should be updated as new legislation is gazetted.

Table 15. Summary of relevant municipal regulations

Municipal bylaw	Description	Management implications
Milnerton Municipality: Bylaw relating to the Use and Control of the Rietvlei Water Area, 1977	Provides for recreational activities to take place in the Rietvlei lakes. The Bylaw is presently under revision, and may be replaced with a new bylaw that would be applicable to all recreational water areas in the City.	The Bylaw regulates the recreational water use at the Rietvlei deep-water lakes, which are part of Table Bay Nature Reserve.
City of Cape Town: Dumping and Littering Bylaw, 2002	Provides that no person may litter, or permit the littering of waste, or dump or permit the dumping of waste	The depositing, discharge, spill or release of waste is prohibited.
City of Cape Town: Bylaw relating to Stormwater Management, 2005	Provides for stormwater management, and regulates activities that may have a detrimental effect on the operation of a stormwater system. Stormwater includes natural precipitation, groundwater and spring water conveyed by the stormwater system, as well as sea water within estuaries.	Written consent is required for activities affecting the stormwater system, including draining, abstracting or diverting water from the stormwater system, erecting any structure that would interfere with the stormwater system, or discharging any substance likely to damage the stormwater system or contaminate the water therein.
City of Cape Town: Wastewater and Industrial Effluent Bylaw, 2006	Deals with discharge of industrial effluent, protection of municipal sewers, and duties of property owners in respect of sewer installations. Stormwater includes sea water within estuaries.	Written consent of Council is required to discharge stormwater into any municipal sewer
City of Cape Town: Air Pollution Control Bylaw; LA 12649	The purpose of the Bylaw is to give effect to the right contained in section 24 of the Constitution of the Republic of South Africa Act, 1996 (Act 108 of 1996), by controlling air pollution within Council's area of jurisdiction; to ensure that air pollution is avoided, or where it cannot be altogether avoided, is minimised and remedied.	
Bylaw relating to Community Fire Safety; Province of the Western Cape; LA 11257	The purpose and scope of the Bylaw is to promote the achievement of a fire-safe environment for the benefit of all persons within the municipal area of jurisdiction, and to provide for procedures, methods and practices to regulate fire safety within the municipal area of jurisdiction.	
City of Cape Town: Draft Animal Bylaw, 2009	The purpose of the Bylaw is to formulate a new single bylaw, including ten different municipal bylaws on dogs as well as the Animal Protection Act of 1962. This includes chapters on dogs, cats, poultry and working equines.	

Table 16 below lists legislation that applies to human resource management and the administration of a reserve. Although this list is extensive, it is by no means complete, and should be updated as new legislation is gazetted.

Table 16: Summary of legislation applicable to human resource management and administration

Legislation	Description	Listed amendments
National legislation		
Occupational Health and Safety Act, 1993	To provide for the health and safety of persons at work, and for the health and safety of persons in connection with the use of plant and machinery;	Occupational Health and Safety Amendment Act, Act 181 of 1993

	the protection of persons other than persons at work against hazards to health and safety arising out of, or in connection with, the activities of persons at work; to establish an advisory council for occupational health and safety, and to provide for matters connected therewith.	
Basic Conditions of Employment Act, Act 3 of 1997	Provides for control measures pertaining to employment	Amendment Act 11 of 2002
Labour Relations Amendment Act, Act 66 of 1995	The labour relations act aims to promote economic development, social justice, labour peace and democracy in the work place.	Amendment Act 12 of 2002
Local Government Municipal Systems Act, Act 32 of 2000	Establishes core principles, process and mechanisms relating to local government	
Promotion of Equality/Prevention of Unfair Discrimination Act, Act 4 of 2000	Provides for the prevention of discrimination and other related matters	
Criminal Procedure Act		
Firearms Control Act		
Civil Aviation Act, Act 13 of 2009		
Fencing Act, Act 31 of 1963	Regulates all matters relating to fencing	
Hazardous Substances Act, Act 15 of 1973	Controls substances which may cause injury or ill health to, or death of, human beings by reason of their toxic nature	
Land Survey Act, Act 8 of 1997	Regulates land surveying, beacons and other related matters	
Promotion of Access to Information Act, Act 2 of 2000	Promotes access to information	
Promotion of Administrative Justice Act, Act 3 of 2000	Provides for the promotion of administrative justice	Amendment Act 53 of 2002
Regional Services Council Act, Act 109 of 1985	Regulates and controls land, land usage and other related matters	
Skills Development Act, Act 97 of 1998	Promotes the development of skills	
State Land Disposal Act, Act 48 of 1961	Regulates the disposal of state owned land	
Subdivision of Agricultural Land Act, Act 70 of 1970	Regulates the subdivision of agricultural land	
Tourism Act, Act 72 of 1993	Provides for the promotion of tourism and regulates the tourism industry	
Municipal Ordinance 20 of 1974	Regulates pollution and waste management	
South African National Road Agency Limited (SANRAL) and National Road Act, Act 7 of 1998		
Provincial legislation		
Western Cape Constitution, Act 1 of 1998	Introduces a constitutional framework for the province	
Western Cape Land Administration Act, Act 6 of 1998	Regulates land and land usage	
Western Cape Planning and Development Act, Act 7 of 1999	Regulates planning and development within the province	

Municipal legislation		
City of Cape Town: Bylaw relating to Filming	The Purpose of the By-law is to regulate and facilitate filming in the CCT	Provincial Gazette 6277, 24 June 2005
Bylaw relating to Streets, Public Places and the Prevention of Noise Nuisances, 2007	The purpose of the by-law is to regulate activities in streets and public places and prevent excessive noise nuisance	Promulgated 28 September 2007, PG 6469; LA 44559
City of Cape Town: Outdoor Advertising and Signage Bylaw, 2001	To regulate the placement of outdoor advertising and signage	Promulgated 5 December 2001, PG 5801

4.2 Administrative framework

4.2.1 Organisational structure

Table Bay Nature Reserve is managed by the ERMD's Biodiversity Management Branch in the City of Cape Town. The reserve is located within the Milnerton area of the northern region, and is the management responsibility of the area manager, assisted by nine permanent staff members, one intern and two students (see appendix A2 for the approved organogram). The operational management of the reserve is supported by various other City of Cape Town departments, including, but not limited to, City Parks, Roads & Stormwater, Law Enforcement, Water and Sanitation, Human Resources (HR) and Finance.

Table 17 below summarises various applicable organisational strategies and plans that affect and determine the operations of reserve management. Although this list is extensive, it is by no means complete, and should be updated regularly.

Table 17: Summary of relevant organisational plans and strategies

Strategy	Description	Management Implications
City of Cape Town IDP, 2007/8–2011/12	The principal strategic planning instrument that informs all planning and development within Cape Town. Recognises that the City will seek to create an environment that is conducive to growth and development, while protecting the environment to ensure sustainability.	The protection of natural aquatic environments is one of the objectives of the sustainable urban infrastructure and services strategic focus area.
iKapa Growth and Development Strategy, 2008	Serves as a White Paper for the Western Cape. It aims to guide municipal IDPs, local economic development, and district and metropolitan growth and development strategies. Recognises that water, biodiversity, and coastal and marine systems and resources have been identified as priorities.	The promotion of ecologically sustainable development is one of the five goals of the strategy to guide policy-making, programming and resource allocation. Requires sustainable resource use to respond to climate change, ecosystem degradation and threats to key strategic natural resources.
City of Cape Town Coastal Zone Management Strategy, 2003	Presents an institutional management framework that will facilitate an effective and efficient Coastal Zone Management Strategy. Recognises that estuaries play a significant role in the coastal zone as essential components to healthy ecosystems, as nurseries to many fish species and as key recreation nodes. Aims to develop and implement management plans for each of the estuaries in Cape Town by working with relevant directorates, including catchment management agencies, City Health, Scientific Services and the Wastewater Department.	Estuary management is one of the coastal management strategic objectives. Management plans for each estuary must include mechanisms for monitoring the health of the estuary, a commitment to a continual improvement, emergency response mechanisms, and clear accountability and responsibility for implementation of the management plan. The final estuary management plan must be integrated with the relevant sustainable coastal management plan for the area.
City of Cape Town IMEP, 2003	Seeks to recognise and protect Cape Town's unique coastal and marine environment and biodiversity. The City commits to the integration of environmental	A commitment by the City to apply the precautionary principle that states that, if the environmental consequences of a proposed

	considerations in all its functions and activities, including strategic planning initiatives.	activity are of significant impact or concern, and are uncertain, the activity should not be undertaken.
City of Cape Town Biodiversity Strategy	Plans to ensure conservation by mainstreaming biodiversity; identifying key areas of biodiversity, and establishing structures to manage the initiatives	Has seven strategic objectives: (1) A network of biodiversity areas and nodes (2) Use of corridors, links and mixed-use areas to connect the network (3) Conservation of biodiversity in freshwater aquatic systems (4) Invasive alien species management (5) Biodiversity legislation and enforcement (6) Biodiversity information and monitoring system (7) Biodiversity education and awareness

4.2.2 Reserve decision-making mechanisms

4.2.2.1 Reserve advisory boards

Table Bay Nature Reserve has four section-specific management and monitoring committees that track projects and discuss local issues. Table 18 represents the distribution of these management committees over the various management sections:

Table 18. Section-specific management committees of the Table Bay Nature Reserve

Management section	Section-specific management committee
Parklands fynbos corridor	Parklands Environmental Liaison Committee
Diep River	Rietvlei Management Working Group
Rietvlei coastal section	Rietvlei Management Working Group
Rietvlei wetlands	Rietvlei Management Working Group
Milnerton Lagoon	Rietvlei Management Working Group
Zoarvlei (Paardeneiland wetlands)	Zoarvlei Management Advisory Committee
Milnerton Racecourse	Milnerton Racecourse Environmental Management Committee

It is proposed, however, that these section-specific management committees be retained, but that, in addition, an overarching advisory forum be created for Table Bay Nature Reserve as a whole. The purpose of this forum would be to serve as an advisory committee, rather than a decision-making body.

It is however required that the City of Cape Town first draft a policy and guideline document for this forum and similar advisory bodies. This policy and guideline document should align with the City of Cape Town's public participation policy.

The policy and guideline document should take cognisance of the following: (1) Advisory forums must function effectively in accordance with their terms of reference and constitutions. (2) Duplication of members and discussion topics must be prevented. (3) Roles and responsibilities in terms of the accepted terms of reference and constitutions must be clarified and affirmed. (4) Local issues must be represented on the agenda, when required. (5) Ambiguities and inconsistencies must be eliminated.

A founding document with clear terms of reference must be drafted to provide clear guidelines for this board, while incorporating the requirements and individual needs of the different management committees. Special care must be taken to ensure stakeholder participation within a set of guiding principles. This forum will provide a legitimate platform to communicate management issues, and to ensure stakeholder participation.

The objectives of such an advisory forum would be to: (1) facilitate constructive interaction between the reserve and surrounding communities and stakeholders; (2) serve as a channel for communication and managing conflict; (3) assist the reserve to engage neighbouring communities and stakeholders to identify strategic issues and areas of mutual concern as well as work towards finding equitable solutions that benefit both the community and the reserve; and (4) serve as a platform for developing strategic partnerships with stakeholders.

The legislative framework for this advisory forum would be shaped by the following acts:

- The South African Constitution and the Bill of Rights
- NEMA (Act 107 of 1998)
- The National Environmental Management: Protected Areas Act (Act 57 of 2003)
- National Environmental Management: Biodiversity Act (Act 10 of 2004)

The present section-specific management committees should address local-area conservation-related issues common to that particular section and its neighbouring communities, as well as the implementation of section-specific projects. This will retain local participation in the reserve by keeping the agenda relevant to each of the management sections and their specific stakeholder interests.

Matters for consideration by the overarching advisory forum would be strategic in nature with the aim to facilitate better cooperation between the City of Cape Town, regional and national government, as well as strategic partners such as CapeNature and the Wildlife and Environment Society of South Africa (WESSA).

The representation on the advisory board and section-specific management committees must be clarified, as well as the process for the appointment of advisory forum members. In order to ensure the efficient functioning of the advisory board, the following areas require attention:

- **Stakeholder representation:** Representatives must be mandated in writing by groups whom they represent, and be appointed in terms of an appointment protocol.
- **Roles and responsibilities:** These must be underpinned by the terms of reference.

- **Information flow:** A feedback protocol must be incorporated into the agenda to facilitate communication between stakeholders.
- **Functional executive structure:** The chairman and vice-chairman must not be a reserve staff member. Subcommittees and working groups may be created. Administrative assistance can be provided by the City of Cape Town.

Table 19 below is a proposed structure for representation on this advisory forum:

Table 19. Nature Reserve Advisory Forum's proposed representation structure

Political representation	Subcouncil chairman
	Ward councillors
City line departments	Biodiversity Management
	Environment & Heritage
	City Parks
	Sport and Recreation
	Roads and Stormwater
	Catchment Management
Province	CapeNature
	DEA&DP
National Government	Department of Water Affairs
	Oceans and Coasts
NGOs	Friends group(s)
	Ratepayers'/homeowners' associations
	User groups/sports clubs
	Environmental groups (bird clubs)

5. PROTECTED-AREA POLICY FRAMEWORK & GUIDING MANAGEMENT PRINCIPLES

5.1 Management objectives

Although a broad, overarching set of management objectives for Table Bay Nature Reserve as a whole will follow in table 23 and 24, the following three management documents are currently implemented as subsidiary to this overarching IRMP:

- The Royal Ascot EMS, 2007
- The Blaauwberg fynbos corridor operational environmental management plan (OEMP), 2008
- Diep River estuary management plan, 2011

Their implementation will continue as long as the legal mechanisms that determine their existence are in place. These mechanisms are two records of decision and a City of Cape Town/C.A.P.E Estuaries Programme co-funded project.

5.1.1 Milnerton Racecourse section

The Royal Ascot Environmental Management System (Planning in Balance 2013) includes a set of management objectives for the Milnerton Racecourse Conservation Area. An overview of these objectives is given below in Table 20:

Table 20: Royal Ascot Environmental Management System objectives

ISSUE	OBJECTIVE
Contracts management	Choose suitably qualified contractors to undertake work within the conservation area
	Obtain the best value for money
	Achieve full transparency with respect to the use of funds set aside for conservation
Invasive-vegetation management	Prevent the homogenisation of the vegetation by invasive plant species (indigenous or alien)
	Limit the fuel load for fire
	Limit unnatural changes to ecosystem structure (e.g. nitrogen-fixing of the soil, changes to soil structure by roots, etc.)
Fire management	Protect human life
	Protect property
	Maintain biodiversity
	Reduce fuel load to prevent uncontrollable, catastrophic fires
	Stimulate vigorous new growth within vegetation associations
Rehabilitation	Improve biodiversity within the section
	Maintain the genetic integrity of species already occurring in the section
	Reduce negative impacts of surrounding land uses
	Maximise the conservation potential of the available area
	Increase the size of the effective natural remnant, where possible
Infrastructure management	Maintain existing infrastructure within the section
	Introduce additional infrastructure, if required (e.g. signage)
Fauna management	Minimise human and animal conflict
	Prevent alien species from outcompeting indigenous fauna
	Maintain reasonable population sizes of large animals that could affect the vegetation (grysbok and Cape hare)
	Ensure genetic viability of larger fauna, such as grysbok
	Maintain natural ecosystem function as far as possible
	Improve biodiversity by undertaking re-introductions of locally extinct fauna, where possible
Biological monitoring	Ensure collection of sound and reliable data
	Ensure that data assist with management decisions
	Monitor flora (plants), fauna (animals) and water (quality and levels)
Education and outreach	Promote understanding about the importance of preserving this section
	Foster the sense of ownership and responsibility toward the section
	Create interest about what is happening in and around this section
Review	Ensure that objectives, targets and procedures remain up to date, meaningful and implementable
	Maintain the EMS to expected relevant standards, and utilise the latest technology and accepted conservation practice norms

Similarly, the Blaauwberg fynbos corridor OEMP contains an extensive set of management objectives contained in appendix D6. An overview of these objectives is given below in table 21:

Table 21. Blaauwberg fynbos corridor operational environmental management plan objectives

ISSUE	OBJECTIVE
IMPLEMENTATION OF THE OEMP	To ensure the effective implementation of the various actions detailed in the OEMP
	To publicise the fynbos corridor
CONCEPTUALISATION AND STRATEGIC PLANNING	To ensure that the fynbos corridor is effectively utilised as both a biodiversity corridor and public amenity
MANAGEMENT OF DEVELOPMENT ABUTTING THE CORRIDOR	To ensure that abutting developments have a minimal negative impact on the fynbos corridor
	To manage the conduct of residents and landowners to facilitate environmentally sound management of the fynbos corridor and abutting areas
VEGETATION MANAGEMENT	To prevent the establishment or spread of alien vegetation, eliminate potential invasion, improve aesthetics, decrease fire risk, and avoid compromising the ecological integrity of any natural area
	To protect existing indigenous vegetation within the fynbos corridor
	To control access and movement to avoid damage to indigenous flora as well as prevent erosion within the corridor
	To enhance species diversity within the fynbos corridor
FAUNAL MANAGEMENT	To encourage habitation by wild animals as well as to monitor occurrence of animals and maintain carrying capacity of the fynbos corridor
WASTE MANAGEMENT	To control the incidence of illegal dumping and littering occurring within the fynbos corridor
STORMWATER MANAGEMENT	To reduce the negative impacts associated with stormwater
WILDFIRE PREVENTION	To prevent and control wildfires to retain the biodiversity of the area and reduce risk to residents and users
SAFETY AND SECURITY	To ensure that the fynbos corridor is safe for use by all users
INFRASTRUCTURE MAINTENANCE	To ensure that all infrastructure within the fynbos corridor and immediate surrounds is maintained and has no avoidable environmental impact associated with it
EMERGENCY PROCEDURES	To ensure an effective response to emergency situations within the fynbos corridor
REVIEW OF OEMP	To ensure that the OEMP is up to date and relevant to manage the fynbos corridor proactively and effectively

5.1.3 Diep River estuary management plan

The Diep River estuary management plan (Jackson *et al*. 2011) has an extensive set of management objectives contained in an action plan (see appendix D5 for a full breakdown of these objectives). An overview of these objectives is given below in table 22:

Table 22. Diep estuary management plan objectives

ISSUE	OBJECTIVE
WATER QUANTITY MANAGEMENT	To re-establish a regime more typical of an estuarine system
	To manage water levels, flood risk and seasonal drying
ESTUARINE ENVIRONMENTAL QUALITY MANAGEMENT	To establish binding resource quality objectives
	To meet interim and longer-term water quality objectives
	To reduce accidental discharges into the estuary
	To reduce inputs from informal settlements
	To manage short-term fluctuations in critical water quality parameters
BIODIVERSITY MANAGEMENT	To improve understanding of the ecological requirements of the central pans
	To improve knowledge of the biology of the estuary
	To manage invasive species
	To rehabilitate biodiversity
CONSERVATION AND PLANNING INITIATIVES	To develop and upgrade reserve infrastructure
	To develop conservation and eco-tourism
LEGAL/POLICY MEASURES	To formalise the expanded boundaries of the reserve
	To formalise the estuary management plan
	To improve the reserve’s protection from encroachment of gardens and invasives
EDUCATION AND AWARENESS RAISING	To improve public awareness on the importance of wetlands and the Diep River estuary
	To promote awareness of, and compliance with, the estuary zoning plan
	To document and promote awareness of the rehabilitation initiative
	To promote awareness of health and sanitation issues around the estuary
	To promote and market the reserve
RESOURCE REQUIREMENTS	To increase capacity of human resources
	To improve availability of financial resources to implement the action plan

5.1.4 Overarching biodiversity and heritage objectives

Table 23 below outlines the broad, overarching biodiversity and heritage objectives and associated plans for Table Bay Nature Reserve. These objectives feed into low-level plans, which are not contained in this IRPM, though may be compiled in the future as appendices or as separate documents.

Table 23: Biodiversity and heritage objectives of Table Bay Nature Reserve

High-level objective	Objective	Sub-objective (where required)	Initiative	Low level plan
CONSERVATION OF REPRESENTATIVE, FUNCTIONAL ECOSYSTEMS To conserve a representative sample of the region's ecosystems in a linked landscape, and maintain or restore environmental processes to enable natural spatial and temporal variation in structural, functional and compositional components of biodiversity	**Representative ecosystems** To incorporate a spectrum of viable aquatic and terrestrial ecosystems characteristic of Table Bay Nature Reserve, and to re-introduce missing elements, where possible	**Consolidation and expansion of land areas** Consolidation of protected areas, focusing on underrepresented ecosystems, functional linkages and processes	(1) Identify underrepresented habitats/ecosystems (2) Consolidate reserve boundaries (3) Incorporate untransformed vegetation (4) Establish corridors linking the reserve with catchments and neighbouring conservation areas (5) Investigate conservation stewardship options with key landowners	**Reserve expansion plan**
		Re-introduction of biota Re-establishment, where possible, of locally extinct or depleted biodiversity components and populations in accordance with International Union for Conservation of Nature principles and guidelines and the City of Cape Town's draft policy on fauna management	(1) Re-establish indigenous herbivore complement within constraints of reserve size and urban setting	**Faunal management plan**
		Fire management Apply appropriate fire regimes in fynbos areas (frequency, season, intensity, size)	(1) Implement a fire management plan in accordance with objectives of conserving biodiversity and threatened biota (2) Monitor impact of fire management regime	**Fire management plan**
		Threatened biota Maintain viable populations of threatened species in order to meet obligations in terms of international agreements and conventions	(1) Maintain viable populations of rare/threatened plant and animal species (identify, locate and monitor populations of priority species)	**Threatened biota plan**
		Monitoring plan Implement and maintain an approved monitoring plan	(1) Implement and maintain a biological monitoring programme for the reserve	**Monitoring plan**
	Rehabilitation: Rehabilitate degraded areas, incding the re-establishment of natural biodiversity patterns, and the restoration of key processes which support the long term persistence of biodiversity.	**Vegetation** Re-establish physical, chemical and biological processes in degraded vegetation areas	(1) Rehabilitate all old, degraded sites	**Vegetation rehabilitation plan**
		Alien plants and other alien biota Control and, where possible, eliminate alien biota to facilitate re-establishment of natural biodiversity patterns and processes in invaded areas	(1) Establish the distribution and density of invasive species (2) Prioritise areas and species for alien removal, focusing on biodiversity restoration (3) Implement removal programmes for	**Invasive alien plant management plan & alien biota**

			priority species and areas	**management plan**
MITIGATE INTERNAL and EXTERNAL PRESSURES To reduce threats and pressures and limit environmental impacts resulting from non-biodiversity management aspects and operations on surrounding land and resource use	**Reconciling biodiversity with other reserve objectives** To ensure that non-biodiversity management aspects of reserve operations (revenue generation, visitor, resource use, developments and management activities) are informed and constrained by biodiversity conservation objectives, and that the impacts of these activities on biodiversity are minimised	**Internal developments** Minimise the impacts associated with the development of visitor and reserve management infrastructure, and ensure that such developments do not compromise biodiversity objectives	(1) Reserve zoning (2) Develop and implement Conservation Development Framework (CDF) (3) Developments in accordance with EIA process (NEMA) and corporate policies (4) Establish visitor carrying capacities (5) Implement green standards and environmental best practice based on corporate policy	**CDF**
		Internal activities Minimise the impacts associated with visitor and reserve management activities, and ensure that such activities do not compromise biodiversity objectives		
		Extractive resource use Minimise the impacts of extractive resource use, and ensure that such activities are aligned with corporate guidelines, are within management capacity constraints, and do not compromise biodiversity objectives	(1) Quantify current extractive resource activities (2) Define opportunities and constraints in line with corporate guidelines (3) Regulate resource use according to adaptive management process	**Sustainable resource use management plan**
	Reconciling biodiversity with external threats To reduce external threats and pressures, and limit impacts of surrounding land and resource use on biodiversity conservation within the reserve	**External developments** Minimise the impacts associated with inappropriate developments outside the reserve	(1) Engage regional land management authorities, including IDPs and spatial development frameworks at local and regional level (2) Align with bioregional planning, including explicitly identified areas for the maintenance of important biodiversity patterns and processes, with appropriate land use guidelines (3) Provide input into planning and decision-making processes for external development that may compromise reserve and biodiversity network objectives (4) Negotiate to ensure that external developments are not visually obtrusive or out of character with the park	**Cooperative governance; communication plan**
		External activities Negotiate to ensure that external resource and land use does not detrimentally affect ecological processes within the reserve	(1) Mitigate or improve the management of external, potentially detrimental impacts (2) Encourage eco-friendly resource use and land management practices on adjacent properties (3) Mitigate the impacts of oil and other pollution events through appropriate contingency planning	**Contingency plan, cooperative governance; communication plan**
		Hydrological and water chemistry changes Participate in activities for the maintenance of river flow regimes and water chemistry within limits for the maintenance of ecosystem processes in aquatic ecosystems within the reserve	(1) Lobby for appropriate catchment categorisation (currently general authorisation) (2) Enforce legislation applicable to the management and protection of aquatic resources (3) Facilitate regular assessments of river health (4) Address the issue of sewage and other point-source pollution of aquatic systems	**Cooperative governance and communication plan**
		Illegal harvesting of resources	(1) Public liaison (2) Law enforcement	**Protection plan,**

		Prevent the illegal collection, removal and destruction of physical and biological resources		**security plan**
WILDNESS/ REMOTENESS To maintain and restore wildness/remoteness in the reserve so that the spiritual and experiential qualities of wildness are maintained, enhanced or, where necessary, restored	**Range of experiences** Provide a range of visitor experiences	N/A	(1) Reserve zoning (2) Develop CDF and sensitivity-value analysis	**(1) CDF** **(2) Reserve expansion plan** **(3) Invasive-alien plant management plan**
	Sense of place Maintain or restore appropriate sense of place	N/A	(1) Implement and update CDF (2) Establish and apply appropriate visitor carrying capacity (3) Negotiate to ensure that external developments are not visually obtrusive or out of character with the reserve	
CULTURAL HERITAGE MANAGEMENT To investigate and manage all cultural assets	**Conserve and manage cultural heritage assets**	N/A	(1) Develop a database of all tangible and intangible cultural assets, including inventory, maps and relevant documents (2) Develop site management plans for each cultural heritage site, with monitoring systems in place for management priorities and prescriptions (3) Facilitate appropriate interpretation of cultural heritage associated with the reserve	**Cultural heritage management plan**

5.1.5 Overarching socio-economic objectives

Table 24 below outlines the socio-economic objectives and associated plans for Table Bay Nature Reserve:

Table 24: Socio-economic objectives of Table Bay Nature Reserve

High-level objective	Objective	Sub-objective (where required)	Initiative	Low-level plan
Nurture productive and mutually beneficial partnerships that result in gains in economic and/or biodiversity equity	Enhance socio-economic benefits to local communities	N/A	(1) Contribute to local community development by supporting the Expanded Public Works Programme/poverty relief projects (2) Contribute to local skills development by supporting the skills and learnership programmes (3) Identify and facilitate the creation of business opportunities in association with the reserve (4) Support community-based social development initiatives	**Local socio-economic development plan**
	Increase environmental awareness, and encourage participation in conservation initiatives	Inspire visitors and communities to consider the environment as an interrelated and interdependent system, of which they are an integral part	(1) Develop and implement an interpretation plan that feeds into both the education and zoning plans (2) Implement environmental education and youth development programmes suited to the needs of each focus group (i.e. tailor-made	**Education development plan**

		Educate learners, educators and other community focus groups to be able to take environmental action	programmes for each focus group)	
		Support educators and community leaders with resource and information materials	(1) Establish and market the environmental education centre with a range of interpretive and information resources	
Support cooperative governance that will build custodianship	Maintain good reserve/community/stake-holder relations	N/A	(1) Identify and involve all relevant stakeholders for participation in the reserve advisory forum (2) Develop effective communication mechanisms and responsibilities for representatives	**Stakeholder relationship plan**
	Effective cooperative governance	Minimise degrading impact and consequences of inappropriate development in and around the reserve	(1) Establish and maintain good working relationship with relevant government departments as well as internal City departments	
		Ensure support/buy-in for management decisions through participatory decision-making processes	(1) Define roles and responsibilities with stakeholder groups, partnerships and government through written agreements	
Become the nature-based visitor destination of choice in the region	Develop, manage and enhance a range of sustainable visitor products	N/A	(1) Design customer satisfaction survey (2) Analysis of current product usage and identification of opportunity	**Visitor plan**
			(1) Plan for visitor infrastructure and facilities as identified by the CDF (2) Develop and implement the infrastructure management plan (in compliance with State of Infrastructure report) (3) Compile a State of Infrastructure report	**Infrastructure programme**
	Conserve and manage cultural heritage assets	N/A	(1) Develop a database of all tangible and intangible cultural assets, including inventory, maps and relevant documents (2) Develop management plans for each cultural heritage site, with monitoring systems in place for management priorities and prescriptions (3) Facilitate appropriate interpretation of cultural heritage associated with the reserve	**Cultural heritage management plan**
Grow the domestic visitor profile to be representative of South African society	Grow the domestic visitor profile of the reserve to be representative of regional demographics	N/A	(1) Promote and manage access to the reserve (2) Develop and support dedicated access programmes, or incorporate a 'dedicated access' element into existing programmes (3) Actively market reserve resources and services	**Marketing plan**
Enhance the City of Cape Town's reputation	Enhance the reserve's reputation	N/A	(1) Develop and implement a communication plan to promote reserve activities	**Communication programme**
Advance strategic human resource management	To ensure good human resource management	N/A	(1) Implement and support learnerships and volunteer programmes (2) Ensure that all staff have access to training initiatives as per the Workplace Skills Plan (WPSP)	**Staff capacity-building programme and institutional**

			(3) Ensure adherence to all corporate human resource policies	**development plan**
Financial management	Ensure sound financial management practices are applied to and underpin the reserve	N/A	Manage cost spending appropriately	**Financial sustainability programme**
Good corporate governance management	Manage risk profile effectively	N/A	Conduct legal review	**Risk management programme**

5.2 SWOT analysis

Table 25 below is a preliminary strengths-weaknesses-opportunities-threats (SWOT) analysis for Table Bay Nature Reserve:

Table 25: Preliminary SWOT analysis

STRENGTHS	WEAKNESSES
Conservation strengths: Encompassing a PNE and IBA, two core flora conservation sites and two sites protected by means of RODs	**Lack of awareness:** Vision of the reserve, information about the management sections, environmental legislation
Ecosystems strengths: Encompassing a tidal estuary, seasonal wetlands, a flood plain, a coastal system, wetland linkages, connectivity corridors and catchment-to-coast benefits	**Fragmentation of natural areas:** Bisections of roads, railways, developments, bulk services
Regional strengths: Associations with Table Bay coast, lower end of the Diep River catchment, and the Cape West Coast Biosphere Reserve	**Skills and training weaknesses:** Field-ranger skills, law enforcement
Biodiversity strengths: Protecting 412 plant, 31 mammal, 196 bird, 33 reptile, nine amphibian and 14 fish species	**Compliance management capacity weakness**
Vegetation strengths: Protecting six national vegetation types, namely Cape Flats sand fynbos, Cape Flats dune strandveld, Cape lowland freshwater wetlands, Cape estuarine salt marshes, Cape inland salt pans and Cape seashore vegetation	**Present lack of office and administrative space**
Planning strengths: Forms part of the City of Cape Town's biodiversity network, promotes the biodiversity strategy, and aligns with C.A.P.E and the C.A.P.E Estuaries Programme	**Shortage of qualified environmental and/or conservation staff in the industry**
Administrative strengths: Section-specific management objectives, management committees as well as a proposed overarching advisory board	**Shortage of public support for conservation objectives**
Usage strengths: Utilisation for **environmental education** purposes and by Friends and **recreational** groups, including water sports, birdwatching and fishing	**Discontinuity of management** of the biodiversity network
Resource strengths: Permanent staff, dedicated budget, facilities secured, fixed	**Old vlei bylaw governing water sports**

and movable assets in place, communications	**recreation**
OPPORTUNITIES	**THREATS**
Awareness-raising opportunities: Media releases, open days, public forums, informative signage, printed publications	**Impacts from bulk services on environment:** Stormwater, sanitation, wastewater treatment, road lighting
Connectivity opportunities: Corridors to Blaauwberg Hill and Tygerberg, and various wetland linkages	**Uncontrolled access:** Person, pets, domestic animals, off-road vehicles
Training opportunities: WPSP, cooperative training, internships	**Edge effects from developments:** Dumping, littering, alien plants
Partnership building with other law enforcement agencies	**Alien and invasive infestations**
On-site administrative office building in development	**Unnatural fire regime:** Either too often or complete exclusion
Career-streaming opportunities for students and interns	**Negative public perceptions:** Nuisance of dust, seeds, pollen, insects, smoke from fires
Liaison with Friends groups, and supportive relationships	**Crime and security:** Illegal occupation, theft of infrastructure, arson, break-ins at neighbouring residents
Stewardship opportunities for nearby landowners who share in the biodiversity network. Ysterplaat airforce base, Wingfield military base, Intaka Island at Century City	**Increasing development:** Population growth, more bulk services, more pressure on environment
Creation of an overarching **advisory board**	**Irregular funding:** Students, interns, operating budgets
Revision of old bylaws, and drafting of a new **Recreational Water Areas Bylaw**	**Loss of biodiversity:** Adjacent rural areas being developed
Closer **user interface and better service delivery** with new on-site office	**Changing political structures:** Discontinuity in political support

5.3 Protected-area management policy framework and guiding principles

5.3.1 Community participation

Table Bay Nature Reserve will strive to nurture productive and mutually beneficial partnerships that result in equitable access to biodiversity and natural heritage benefits. This will be achieved through the creation of job opportunities in support of Expanded Public Works Programme and poverty relief initiatives, as well as through implementing City-funded projects. Participation in skills development and learnership programmes and support of community-based social development initiatives could contribute to the development of local skills.

The reserve will contribute to raising environmental awareness and encouraging participation in conservation initiatives. This will be done through an environmental education plan that will aim to:

- inspire visitors and communities to consider the environment as an interrelated and interdependent system, of which they are an integral part;
- educate learners, educators and community focus groups, and support such groups with resource and information materials;
- develop and implement environmental education programmes suited to the needs of various focus groups; and
- develop and implement an interpretation plan that complements the environmental education plan.

The Rietvlei Education Centre is owned by the Friends of Rietvlei, and co-managed by the Friends and the City of Cape Town for the purposes of running environmental education programmes and hosting meetings and events relating to the environment. Presently, the Rietvlei Education Centre is expanding its environmental education programme to encompass all local schools, as well as linking with the environmental education initiative at the nearby Southern African Foundation for the Conservation of Coastal Birds (SANCCOB).

In order to develop and maintain good reserve-community-stakeholder relations, all relevant stakeholders need to be identified. The development of an effective communication system in order to address interested and affected parties is required. Where necessary, task teams and working groups may be established in order to assist the reserve with key issues.

There are currently several officially registered users that lease pieces of land, either within or directly adjacent to the reserve. The Milnerton Aquatic Club leases a piece of land on the eastern shore of the Rietvlei deep-water lake for the purposes of promoting water sports recreation. This lease is contained in appendix B5-2.

Until June this year, the Cape Radio Flyers leased a small piece of land on the seasonal pan area, east of the R27, for the purposes of promoting radio-controlled aviation. Their lease expired end of May 2014, and will most likely not be renewed. The lease of the Cape Radio Flyers is contained in appendix B5-3.

SANCCOB leases a portion of land to the north of the Rietvlei deep-water lake as a seabird rehabilitation centre. SANCCOB's lease is contained in appendix B5-4.

The Western Province Motor Club is situated at the Killarney raceway on the eastern shore of the Diep River management section. The motor club's lease of this piece of land is contained in appendix B5-5. Just south of the Killarney raceway is the Milnerton Riding Club, who leases another piece of land east of the Diep River management section. The purpose of the Milnerton Riding Club is to operate as a horse-riding estate. Their lease is contained in Appendix B5-6.

5.3.2 Safety and security

A safety and security audit aimed at completing a rapid and verifiable analysis of the current security situation, security services, infrastructure, staffing and social context has been carried out in Table Bay Nature Reserve. See appendix D1 for the audit report's executive summary.

5.3.3 Culture-historical, archaeological and paleontological management

Table Bay Nature Reserve is presently not characterised in terms of Cultural Historical attributes. City's Cultural Resources Department should review the area and a Cultural historic, archaeological and paleontological zoning should be developed.

5.3.4 Tourism development and recreational management

The reserve's tourism and recreational potential is focused around the water area. The recreational activities are regulated by the Milnerton Municipality Bylaw relating to the Use and Control of the Rietvlei Water Area (see appendix B1-2), as well as the Council resolution relating to fishing and boating in the Rietvlei PNE (see annexure B3-1).

A fully integrated Conservation Development Framework should be developed for the reserve incorporating the precinct planning completed for the Rietvlei Administration Building. This plan will indicate suitable tourism and recreational development nodes, and will be guided by the sensitivity-value analysis and zonation of the Reserve as well as infrastructure and zoning of the surrounding areas.

5.3.5 Infrastructure management

Table Bay Nature Reserve extent incorporates a large amount of infrastructure, including urban support or utility infrastructure. Various departments within the City of Cape Town share responsibility for these structures. A full reserve infrastructure audit needs to be completed, and current infrastructure uses and structural integrities should be documented. Infrastructure has to be mapped.

Infrastructure that is or could be used should be included in a five-year maintenance plan. Redundant infrastructure with no propects of future use should be demolished and the sites rehabilitated.

5.3.6 Biodiversity conservation management

5.3.6.1 Community-based natural resource management

The reserve provides a range of goods and services that contribute to the well-being of society. Turpie and Clark (2007) produced a preliminary estimate of the Diep River estuary's economic value. They identified the following values:

Direct-use values: These values comprise the use of the natural resources of the estuary for commercial or subsistence purposes. These can be consumptive uses, such as the use of fish as food, or non-consumptive, such as the use of the estuary for recreation.

Consumptive uses: Approximately 8 tons of fish are harvested from the Rietvlei wetlands and Diep River estuary system annually (Lamberth & Turpie 2003). When the monetary value of the catch is to be extrapolated from these figures, it is likely to be around R20 000. *Phragmites* reeds can be harvested for use in thatching or the production of arts and crafts, although no estimate of the value of this resource is available.

Non-consumptive uses

Property values: Turpie and Clark (2007) estimated the property value attributable to the Diep River estuary to be R657,2 million, ranking it fourth in the top 20 temperate estuaries of South Africa as far as this criterion is concerned. Using the approach adopted by the authors – based on annual turnover and associated commission – this translates into an annual income in the real-estate sector of R36,34 million. Since municipal property rates are linked to property value, the estuary could also be considered as contributing to the income of the local authority.

Recreation and tourism: Turpie and Clark (2007) estimated the tourism value of temperate estuaries to be around R2 billion a year. Although no specific value was provided for the Diep River estuary, it was stated that the majority of estuaries are worth between R10 000 and R1 million in terms of tourism value. Clark (1998) identified the activities in this reserve to be a mixture of land-based (picnicking, sightseeing, walking, etc.) and water-based activities, including fishing, swimming and boating. Clark (1998) included an assessment of the harvesting of bait species in the Diep River estuary, including *Callianassa kraussi* (Sand Prawn), *Liza richardsonii* (Harder) and *Mugil cephalus* (Springer).

The harvesting of these natural resources within Table Bay Nature Reserve is currently permitted. Research on the amount of harvesting and the species harvested across the city is currently under way. Investigations are required to determine whether current harvesting patterns are sustainable, and whether there are potential threats associated with them.

5.3.6.2 Fire management

Fire plays an essential ecological role in the life cycle of certain vegetation types. Fire is crucial to the long-term conservation of species within Table Bay Nature Reserve, and is therefore considered an important component of reserve management. Fire management involves influencing the season, frequency and intensity of fires, and reconciling ecological and practical requirements. Too frequent fires, or fires that burn out of phase with the natural burning regime, present a threat to slower-growing species, which may be entirely eliminated. However, if fire is completely excluded from the area, certain species may invade, while others never get the opportunity to germinate, resulting in species losses. Vegetation that is allowed to burn too frequently will become degraded, and alien plants, especially grasses, will invade. Grasses maintain a shorter fire cycle and permanently change the vegetation structure and biodiversity value of the area.

The fire management programme for Table Bay Nature Reserve involves the monitoring of large wildfires as well as smaller natural and unnatural fires. Historical records of fire events in the reserve area as well as post-fire monitoring records must be documented to determine veld ages. Minimal interference takes place when naturally ignited fires occur. In case of human-induced fires that would simulate a natural fire, the same management response would apply. Natural fires are limited in urban settings. All possible actions are taken to prevent the spread of fire onto the adjacent properties. All unnatural fires that threaten the reserve ecologically, or pose a threat to infrastructure and/or public safety, are controlled.

Prescribed burning of vegetation is a management option in areas where vegetation becomes senescent (old) and there is a risk of species loss. The use of prescribed burning practices would assist in maintaining a vegetation mosaic that promotes plant and animal diversity. Accurate fire records and post-fire monitoring data will inform fire planning for the reserve. The decision to administer prescribed burns is considered on an annual basis and, if required, planned and implemented accordingly.

Fire may be used to keep fuel loads low so as to reduce the risk of uncontrolled fires, particularly on the urban edge and in areas that become a potential risk to infrastructure and public safety. Firebreaks and other fire control measures required by law will be implemented where necessary and feasible.

Reasonable pre-fire season protection measures are necessary, as well as a plan of action in the event of a wildfire. Interaction with various City of Cape Town departments and independent stakeholders as well as continuous public and private landowner involvement are essential. The development of fire protection and response plans is an important component of the reserve's fire management approach. While the reserve forms part of the Fire Protection Association (FPA), it remains important and critical to develop a detailed fire management plan, which details the burning frequencies for vegetation types such as Cape Flats Sand Fynbos and Cape Flats Dune Strandveld, the resources required as well as roles and responsibilities. Currently, fire management implementation in Table Bay Nature Reserve involves the following:

- The application of guidelines on seasonal burning intervals and species requirements acquired from relevant documents and biophysical specialists
- Accurate record keeping of all fires, including details and maps
- Use of fire data and GIS for recording and mapping
- Application of post-fire monitoring programmes
- Application of fire data to determine prescribed burning needs
- Development and implementation of a fire protection and response plan, including affected stakeholders, such as additional City of Cape Town departments and private landowners neighbouring the reserve

5.3.6.3 Catchment management

Table Bay Nature Reserve falls within the Diep River catchment. The Diep River originates in Malmesbury and Riebeeck-Kasteel, outside the City of Cape Town boundary. As no cross-border catchment management forum currently exists, this needs to be set up.

5.3.6.4 Soil erosion and control

The reserve is a deposition basin for silt, and, as a result, very little soil erosion takes place. Where erosion takes place as a result of human activities, plans must be made to address this. The shoreline of the deep-water lakes is eroding due to the excessive depth of these water areas into which the shores are slowly sinking.

Soil management implementation in Table Bay Nature Reserve includes the following:

- The maintenance of all management tracks and footpaths
- Identification and recording of all soil erosion sites, including the assessment and development of restoration plans, where required
- Use of soil erosion data and GIS for recording and mapping
- Application of monitoring programmes at identified soil erosion sites
- Accurate documentation of management actions applied to restoration sites, including results from areas responding to these actions

5.3.6.5 Invasive-species management

The management of invasive species is a priority in Table Bay Nature Reserve. Alien biota need to be controlled and, where possible, eliminated in order to facilitate the re-establishment of natural biodiversity and processes in invaded areas.

Invasive-species management within the reserve is applied in accordance with the City of Cape Town's Invasive Species Strategy and in coordination with various government-funded initiatives, including Working for Water and Working for Wetlands. Invasive alien plant species could spread rapidly should management fail to continue implementing a properly planned and coordinated management programme. The emphasis on the maintenance of woody alien plant species should shift to a balanced holistic approach focusing on all invasive species, including herbaceous plants, aquatic weeds and alien fauna.

Some species that still pose a great risk to the reserve are the Australian *Acacia saligna*, *A. cyclops* and *Eucalyptus* species, as well as *Pennisetum clandestinum* (Kikuyu) and *Eichhornia crassipes* (Water Hyacinth). Several other species are also listed as such, and are being managed in terms of the City of Cape Town's Invasive Alien Species Strategy.

In order to protect indigenous species from alien invasives, the following is required:

- Prioritisation of areas for management, focusing on biodiversity restoration
- The implementation of removal programmes for priority species and areas
- The development and implementation of an invasive and alien-plant management plan and a management plan for alien fauna

5.3.6.7 Species introductions

The options of re-introducing locally extinct species must be investigated. Fauna species that previously occurred in the reserve and are no longer present or exist in low numbers only may have to be augmented by re-introductions.

For this to take place, detailed proposals are required by the City of Cape Town's Fauna Management Committee, as is an investigation into the availability of suitable habitat for the species with reference to public utilisation of areas. A full investigation needs to be done into the historical occurrence and status of the species, as well as the effect of re-introducing such species to the area. Re-introduction of potentially dangerous species as well as species may require a public participation process.

All proposed re-introductions need to be recommended and approved by the fauna and flora management committees as well as provincial authorities before implementation. The implementation of any re-introduction programme must also be specified in a plan of action, and documented accurately.

The population of *Raphicerus melanotis* (Grysbok) at Milnerton Racecourse Conservation Area requires active management to ensure the number of individuals do not exceed the carrying capacity of the site, natural dispersal of individuals from this site being near impossible and highly unlikely (Planning in Balance 2013). This provides opportunity for a source of this species if it is comfirmed require and appropriate to restock other areas of TBNR.

5.3.6.7 Strategic research

Research subjects that are required for management intervention at Table Bay Nature Reserve need to be identified. Several externally promoted research projects are presently being conducted in the reserve, and are supported by reserve management.

The use of the reserve as a study area should be encouraged. Research activities, however, should not have a negative impact on the biodiversity or other uses of the reserve. Copies need to be obtained of all data, results and published papers from previous research projects within the reserve.

5.4 Sensitivity-value analysis

The reserve is a significant asset to the City of Cape Town, and makes valuable contributions to national vegetation targets of threatened vegetation types listed in the National Spatial Biodiversity Assessment (Driver *et al*. 2005). The development of the sensitivity-value analysis and zoning plan is one of the steps required in compiling a Conservation Development Framework (CDF) for the reserve. CDFs are tools to reconcile the various land use needs, and delineate visitor user zones as well as the positioning of infrastructure, access points, roads and facilities.

CDFs are in response to the requirements of the Biodiversity Act (2004), and seeks to comply with the spatial planning requirements of the Act. The CDF will ensure that best practice and sustainable development principles are integrated with spatial planning in protected areas.

The sensitivity-value analysis is the landscape analysis portion of the broader CDF. It is a multi-criteria decision support tool for spatial planning, designed to present the best available information in a format that allows for defensible and transparent decision making. The sensitivity-value analysis process is based on the principle that the acceptability of a development (or placement of a structure) at a site is based on the site’s value (arising from the site’s biodiversity, heritage, aesthetic or other values) and its sensitivity or vulnerability to a variety of disturbance (Holness 2005). The sensitivity-value analysis, the CDF and the associated zoning plan form part of an adaptive management system. They will grow and change over time as the understanding of the landscapes and ecosystems improves. They do however not replace the need for detailed site and precinct planning and EIA compliance at site level.

At the time that the sensitivity-value analysis was undertaken, the Table Bay Nature Reserve concept did not yet exist. Initially, three separate reserves, Rietvlei Wetland Nature Reserve, Diep River Nature Reserve and Milnerton Racecourse Nature Reserve, were proposed to be proclaimed separately. Due to the Diep River and the Milnerton Racecourse being relatively small in comparison to Rietvlei, they were not covered in the sensitivity-value analysis process. As a result, the sensitivity-value analysis covers the Rietvlei wetlands only (see appendix D4). Subsequently, it was decided to amalgamate these areas, including the adjacent corridors and wetland linkages, into a combined Table Bay Nature Reserve. All geographic information work was carried out in ESRI’s ArcMap Version 9.3.1 GIS, using the ArcInfo licence level, with Spatial Analyst and 3D Analyst extensions. The methodology used for both the sensitivity-value analysis and the zoning process was adapted from Holness and Skowno (2008) and SRK Consulting (2008a; b).

5.5 Section-specific zoning plans of Table Bay Nature Reserve

A combined zoning plan for the reserve must still be compiled. However, the various management sections have been zoned separately. Figure 4–6 depict the zoning plans for the various management sections of the reserve, excluding the Zoarvlei section, which still needs to be compiled.

5.5.1 Rietvlei wetlands, Milnerton Lagoon and Milnerton Racecourse sections

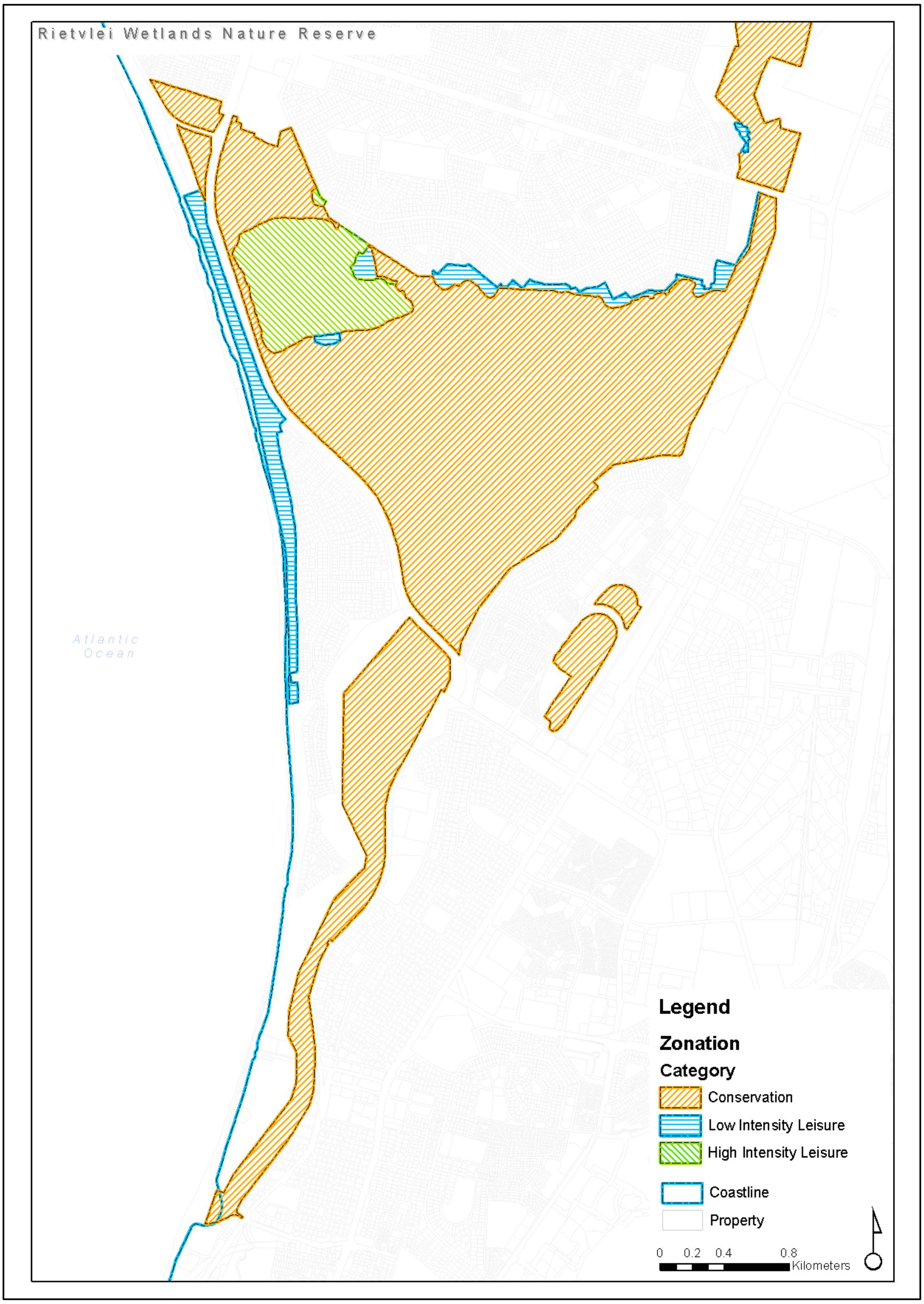


Figure 4: Zoning plan for the Rietvlei wetlands, Rietvlei coastal section, Milnerton Lagoon and Milnerton Racecourse

5.5.2 Diep River section and Parklands fynbos corridor section

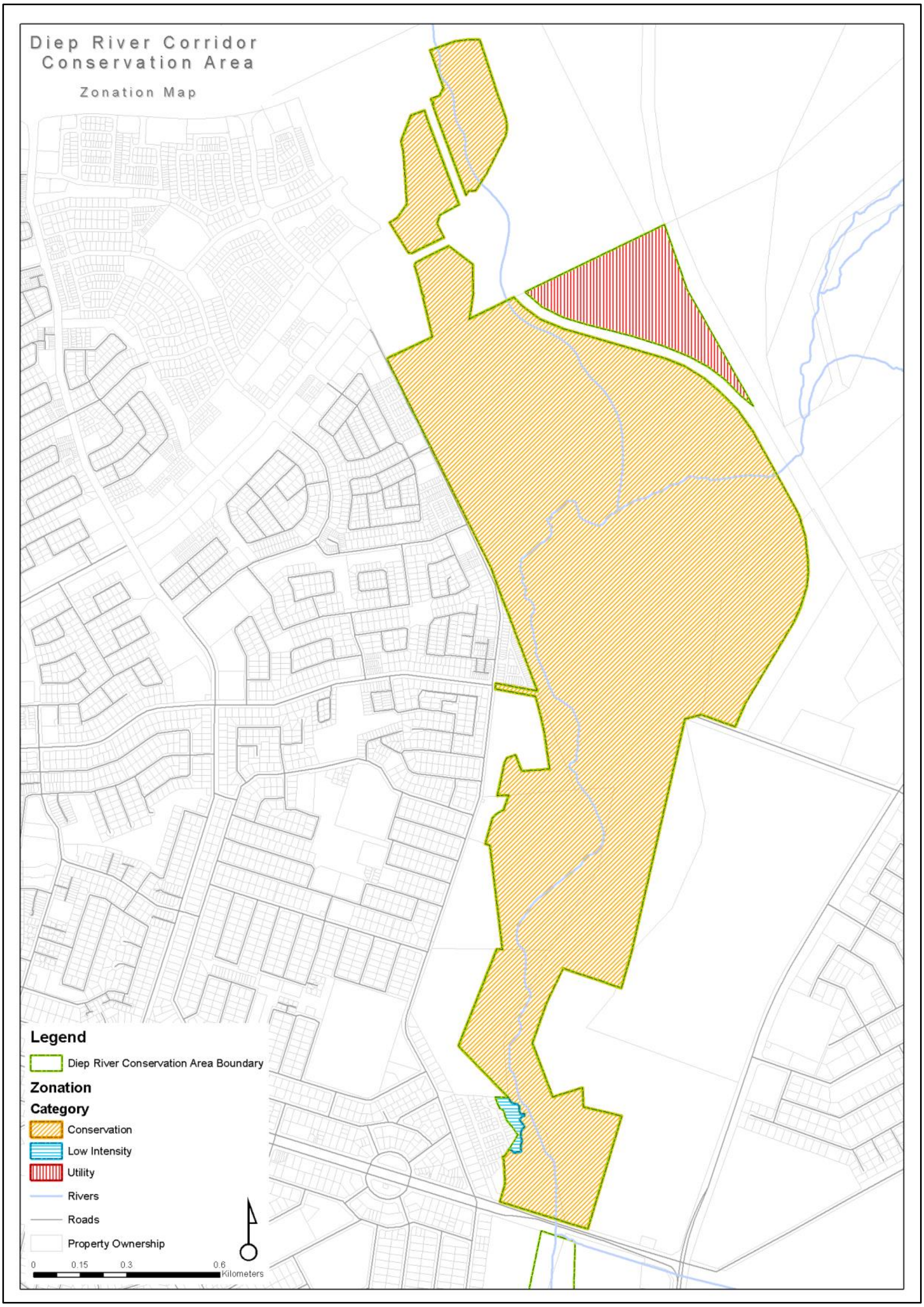


Figure 5: Zoning plan for the Diep River and Parklands fynbos corridor sections

5.5.3 Milnerton Racecourse section

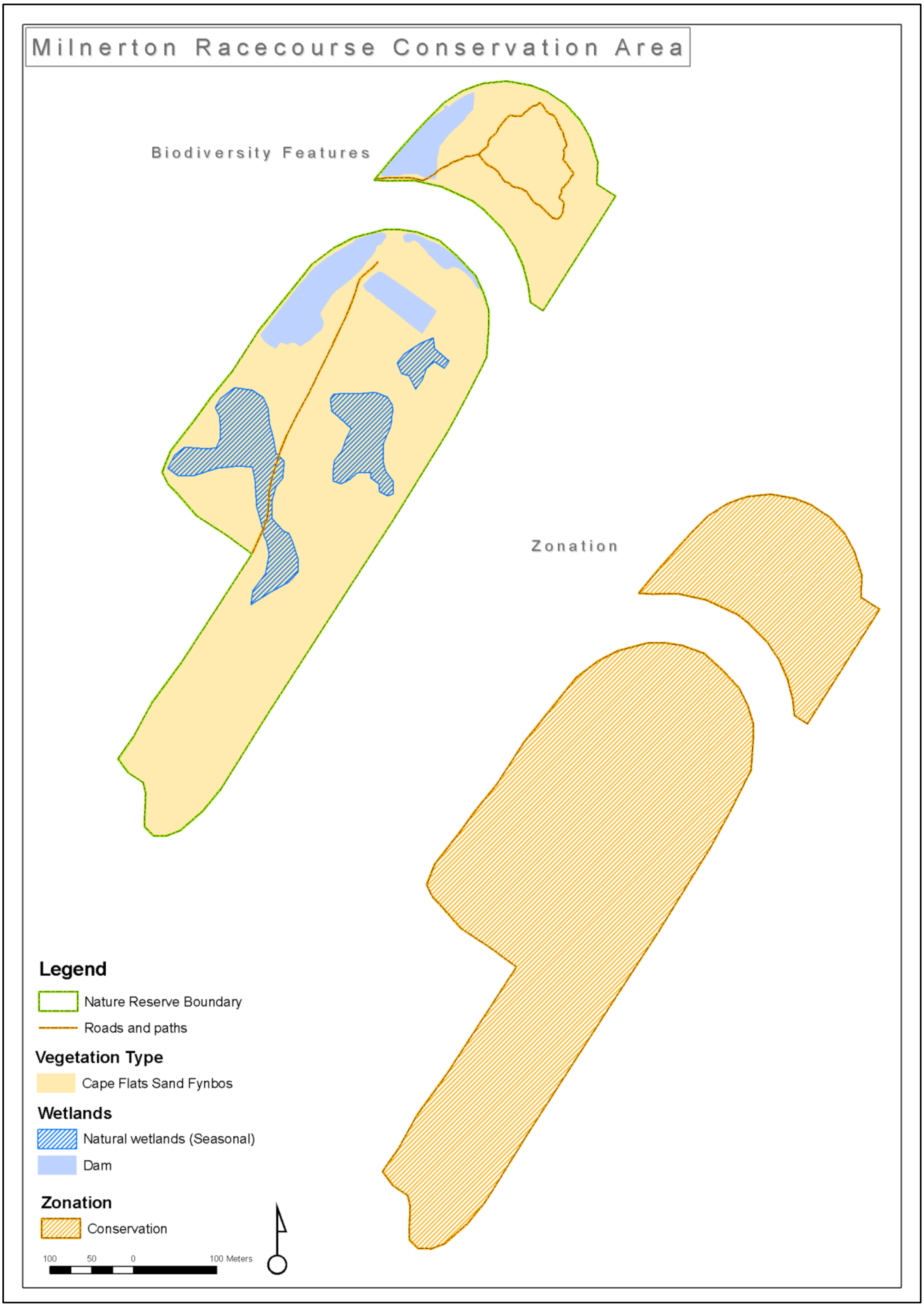


Figure 6: Zoning plan for the Milnerton Racecourse section

5.5.4 Zoning informants

The sensitivity-value analysis is but one of the values underlying the identification of broad tourism use zones. Although the biodiversity analysis is an objective scientific process, other informants to the zoning process are more subjective. Every attempt is made to place high sensitivity-value sites into stronger protected zones. The zoning process, however, is a compromise between the environment and development. The high-value biodiversity assets often need to be made available in an appropriate manner to the eco-tourism market.

Underlying decision-making rules used in the zoning planning process include the following:

- The zoning process is aimed at striking a balance between environmental protection and the development required to meet the broader economic and social objectives of the reserve.
- The zoning process takes into account existing development footprints and tourism access routes.
- An underlying principle is that, from a biodiversity perspective, for any kind of development, an existing transformed site is preferable to a greenfields site.
- Infrastructure costs are dramatically increased when developments take place away from existing infrastructure.
- Existing tourism nodes and access routes are a reality of the economic landscape, and it would not be possible to shut down existing tourism sites compromising the development objectives of the reserve.
- Where existing development nodes, tourist sites and access routes occur in areas with high sensitivity-value, the broad use zoning aims to keep the development footprint as small as possible, preferably within the existing transformed site.
- Where possible, sites with high biodiversity sensitivity-value are put into stronger protection zones.
- Peripheral development is favoured and, where possible, should be located outside the protected area.
- The designation of a broad use zone does not imply that all sites within that zone would be suitable for all the development types anticipated. Detailed site-level planning is still required, and many sites may prove unsuitable at a site level of planning, or during an EIA.
- Special management areas (overlays) need to be formalised and links made to the management plans.

5.5.5 Zoning definitions and descriptions

The zoning definitions and descriptions were workshopped with management staff, and the following five categories were determined:

- Primary conservation zone
- Conservation zone
- Low-intensity leisure zone
- High-intensity leisure zone
- Utility zone

Appendix D4 outlines the zoning and zone descriptions. These are based on the zoning used for the CapeNature reserves (Holness & Skowno 2008), as there should be general alignment of the broader use zones to enable comparison and integration if provincial conservation planning programmes so require.

6. DEVELOPMENT PLAN

A full Conservation Development Plan or Framework is still to be completed for Table Bay Nature Reserve. This plan will indicate suitable development nodes, and will be guided by the infrastructure and zoning management plans.

Some detailed precinct planning was conducted for part of the high-intensity use zone designated at the Rietvlei Wetland Section based on the Sensitivity-Value assessment and zonation (as per Appendix D4), and the CDP/CDF will need to incorporate this precinct planning. The administration offices for the Reserve was constructed in 2011 to 2012 on erf 8611, approved by WWF-SA in terms of their lease agreement with the City of Cape Town. This includes an events and meeting venue (the Rietvlei Boma). The letter of approval and site development plan can be seen in appendix D3. The approach to the office and Aquatic Club and the entry to the Reserve has been realigned and upgraded.

7. COSTING PLAN

The budget below is not a true reflection of costs, but merely a guideline for what is required to implement the management plan objectives. A true costing plan can only be drafted once the CDF has been finalised with associated building and maintenance costs. The costing plan in Table 26 details the broad-category breakdown for key management objectives and interventions for Table Bay Nature Nature Reserve for the period 2014–2019.

Table 26: Costing plan for Table Bay Nature Reserve 2014 - 2019

Management Actions	Funding source	Approximate costs 2014–2015	Approximate costs 2015–2016	Approximate costs 2016–2017	Approximate costs 2017–2018	Approximate costs 2018–2019
1. Invasive alien plant programme						
• Clearing of important alien species	Grant funds	R90 000	R94 500	R99 500	R104 500	R109 500
	Operating	R10 000	R10 500	R11 500	R12 000	R12 500
	MAOCC*	R5 000	R5 500	R6 000	R6 300	R7 000
2. Fauna Management						
• Grysbok at MRCA	Operating	R5 500	-	R6 000	-	R7 000
	MOACC*	R1 500	-	R2 000	-	R2 500
3. Fire management						
• Maintenance of fire belts	Operating	R40 000	R42 000	R44 100	R20 500	R21 500
• Planned ecological burn	Operating	-	-	-	-	-
	MOACC*	-	-	-	R20 000	-
4. Road and trail maintenance						
• Footpath maintenance	Operating	R8 000	R8 500	R9 000	R9 500	R10 000
	MAOCC*	R2 500	R3 000	R3 500	R4 000	R4 500
• Boardwalks	Operating	-	R40 000	-	R44 500	-
• Tracks and road	Operating	R15 000	R16 000	R17 000	R17 500	R18 500
5. Fencing and gates maintenance						
• Fencing	Operating	R60 000	R63 000	R66 500	R70 000	R73 500
• Gates	Operating	R6 000	R6 500	R7 000	R7 500	R8 000
	MAOCC*	R4 000	-	-	R5 500	-
6. Other Infrastructure Maintenance						
• TBNR office	Operating	R40 000	R42 000	R44 500	R46 500	R49 000
• EE building	Operating	R5 000	R5 500	R6 000	R6 500	R7 000
• Boat related infrastructure	Operating	-	R50 000	-	-	R180 000
• Other buildings	Operating	R7 000	R7 500	R8 000	R8 500	R9 000
• Signage	Operating	R40 000	-	R44 500	-	R60 000
	MAOCC*	R6 000	-	-	R7 000	-
7. Infrastructure development plans						
• EE Centre upgrade/new	Capital	-	-	-	-	R4 000 000

Management Actions (continued)	Funding source	Approximate costs 2014–2015	Approximate costs 2015–2016	Approximate costs 2016–2017	Approximate costs 2017–2018	Approximate costs 2018–2019
8. Human resources • Direct human resource costs	Operating	R975 000	R1 050 000	R1 135 000	R1 225 000	R1 325 000
9. General expenses • General operating costs	Operating	R300 000	R315 000	R331 000	R348 000	R365 000
10. Special projects • New Signage and Interpretation	Capital	-	-	R150 000	-	-
• Restoration	Operating/Grant funding	-	-	-	-	R40 000
***MAOCC: Milnerton Area Operating Cost Centre**						

PART 3

MONITORING & AUDITING

8. MONITORING & AUDITING

8.1 Annual audit procedure

8.1.1 Management Effectiveness Tracking Tool South Africa (METT-SA)

The METT-SA is a rapid, site-level assessment tool adapted from the World Bank and WWF's system (second edition 2007). The system is based on the idea that good protected area management follows a process with six distinct stages or elements.

It begins with understanding the **context** of existing values and threats, progress through **planning**, and allocation of resources (**inputs**), and, as a result of management actions (**processes**), eventually produces products and services (**outputs**), that result in impacts or **outcomes**.

METT-SA was compiled to be applied to the protected areas managed by all C.A.P.E partners. It may be necessary to adapt this system for off-reserve conservation efforts and stewardships.

When applying the METT-SA, it is important to consider that it is intended to report on progress in the reserve. The score allocation becomes the baseline against which future assessments are made to determine improvement. It is site-specific and should not be used to compare different sites. It can highlight trends in management, and gives an indication of where management practice needs to improve. It is not intended to replace more detailed assessments as part of adaptive management systems.

The METT-SA has certain limitations in the quantitative measurement of outcomes, but does adjust the overall score where certain criteria are not applicable to the site. This is not a tool for performance management of managers.

Tracking the trends of management effectiveness is a long-term process, and instant improvements are unlikely. Generally, the METT-SA is applied at three-year intervals, but the Branch applied an annual evaluation system, the Protected Area Review, to facilitate incremental improvement linked to the measures set by the METT-SA. The METT-SA was conducted every 5 years to allow for sufficient improvement between METT assessments, especially for newly established conservation sites.

METT-SA reviews were done for the Rietvlei Protected Natural Environment (see appendix D2-1) and for the Diep River fynbos corridor (see appendix D2-2) in 2007. In 2012 the

METT-SA was conducted for the entire Table Bay Nature Reserve (see appendix D2-3). The next METT assessment will be conducted in September 2017.

8.1.2 Protected-area review

The protected-area review (PAR) is an internal review conducted annually to assist managers in assessing their sites, and to allow for adaptive management actions to take place, where required. It is proposed that the PARs that were conducted for the separate management sections be combined into one PAR from the start of the implementation of this IRMP.

8.2 Management plan review

This IRMP should constantly be updated with new information, and regularly reviewed and adjusted where necessary. To achieve this, at least the following set questions should be addressed:

- Did this management plan make a meaningful contribution to the reserve?
- Were individual management objectives realistic and achievable?
- Were the objectives unambiguous, or was there room for misunderstanding?
- Were budgets for each management objective realistic?
- Were the allocated budgets too much or too little?
- Were sufficient and qualified staff members allocated to each management objective?

8.3 Biodiversity monitoring

Table 27 below indicates the current monitoring arrangements in Table Bay Nature Reserve, which are accompanied by monitoring protocols:

Table 27: Current monitoring arrangements at Table Bay Nature Reserve

Action	Responsible party	Data-collecting tool	Frequency
Avifauna census	Reserve management	Visual surveys	Quarterly
Water quality status	Reserve management and Scientific Services	Collection of samples and in-field measurement	Monthly
Weather data	Reserve management	On-site observation	Daily
Shoreline erosion	Reserve management and surveyors	Geographic positioning system surveys	Annually
Antelope surveys	Reserve management	Drive counts	Annually
Small-mammal surveys	Reserve management	Pitfall traps, Sherman traps, trap cages and collections	Annually
Reptile and amphibian surveys	Reserve management	Pitfall traps, Sherman traps, trap cages and collections	Annually
Fish surveys	Reserve management and Oceans and Coasts	Trek-net and gill-net surveys	Ad hoc

PART 4

9. ACKNOWLEDGEMENT AND REFERENCES

ACKNOWLEDGEMENTS

Acknowledgements are due to Niel van Wyk, Friends of Rietvlei Committee, for his valuable input into this management plan.

REFERENCES USED IN TEXT

Anon 2003[1]. *The Integrated Metropolitan Environmental Policy*. Unpublished report, City of Cape Town.

Anon 2003[2]. *The Biodiversity Strategy*. Unpublished report, City of Cape Town.

Anon 2009[1]. *Local Biodiversity Strategy and Action Plan 2009–2019*. Unpublished report, City of Cape Town.

Anon 2010. *City of Cape Town, Five-year Plan for Cape Town, Integrated Development Plan (IDP) 2007–2012, 2010–2011 Review*. Unpublished report, City of Cape Town.

C.A.P.E Project Team 2000. *Cape Action Plan for the Environment: Strategy*. Unpublished report, WWF (South Africa).

Beaumont, R.D. & Heydenrych, P.J. 1980. *The effects of development on the Diep River estuarine system near Cape Town*. SA Water Bulletin, April 1980.

Botes, W.A.M. 2004. *Milnerton Estuary: An assessment of the effects from reduced flows from the Potsdam WWTW*. A consultancy report compiled by WAM Technology.

Clark, B.M. 1998. *Human Utilisation of the Diep River estuary with an assessment of the intensity and impact of bait collecting on the ecology of the estuary*. Report by Anchor Environmental Consultants for the Blaauwberg Municipality, WWF-SA and Friends of Rietvlei.

Department of Water Affairs and Forestry, 2002. *Water Resources Management Plan in the Diep River Catchment: A Situation Assessment*. Institute for Water Quality Studies Report # N/G210/REQ/1200.

Department of Water Affairs and Forestry, 2005. *State of Rivers Report: Greater Cape Town's Rivers.* River Health Programme report (2005).

Driver, A., Maze, K., Rouget, M., Lombard, A. T., Nel, J., Turpie, J. K., Cowling, R.M., Desmet, P., Goodman, P., Harris, J., Jonas, Z., Reyers, B., Sink, K. & Strauss, T. 2005. *National Spatial Biodiversity Assessment 2004: Priorities for biodiversity conservation in South Africa*. Strelitzia 17. SANBI, Pretoria.

Grindley, J.R. & Dudley, S. 1988. *Estuaries of the Cape Part II: Synopses of Available Information on Individual Systems. Report No. 28: Rietvlei (CW 24) and Diep (CW 25).* CSIR Research Report 427. Stellenbosch, South Africa.

Harding, W.R. 2008. *Upgrading of the Bayside Canal (Tableview) Catchment and Water Quality Assessment.* Report to BKS (Pty) Ltd/City of Cape Town.

Holness, S. 2005. *Sensitivity Value Analysis Manual. A decision support tool, operating on the principles of systematic conservation planning, for integrating best available biodiversity knowledge into spatial planning within national parks*. SANParks Internal Report.

Holness, S. & Skowno, A. 2008. *Report on Sensitivity-Value Analysis and Zonation Process for the Boland Mountain Complex*. CapeNature conservation internal report.

Jackson, L., Conrad, J., & Carstens, M. 2011. *Estuary management plan for the Diep estuary.* Unpublished C.A.P.E. Estuaries Programme report, January 2011, by Coastal & Environmental Consulting.

Jackson, L., Conrad, J., De Meyer, M., Cullinan, C., Mahomedy, L. & Dehrmann, A. 2008. *Situation assessment for the Diep estuary*. Unpublished CAPE estuaries programme report, October 2008, by Peak Practice.

Kaletja, B. & Allan, D.G. 1993. *Avifauna specialist study*. In Lochner, P., Barwell, L. And Morant, P. *Caltex Rietvlei Wetland Reserve – Appendices Report.* CSIR Report. EMAS-C93072 (C).

Kaletja-Summers, B., Allan, D.G. & Longrigg, T.D. (2001). *Long-term trends, seasonal abundance and energy consumption of water birds at Rietvlei, Western Cape, South Africa*, 1950–1997. *Ostrich* 72 (1 & 2): 63–79.

Keyser, J. 2003. *Analysis of Waterbird Census Data at the Rietvlei Wetland Reserve*. Report compiled for Diploma in Nature Conservation. Cape Peninsula University of Technology.

Knight Hall Hendry (Pty) Ltd. 1999. *Environmental management plan – Zoarvlei.* Unpublished Knight Hall Hendry (Pty) Ltd report BLM 02C, October 1999.

Lamberth, S.J. & Turpie, J.K. 2003. *The role of estuaries in South African fisheries: economic importance and management implications*. African Journal of Marine Science 25: 131–157.

Lochner, P., Barwell, L. & Morant, P. 1994. *Caltex Rietvlei Wetland Reserve: Management Plan Report.* CSIR Report EMAS-C93072 (B) 68 pp.

McDowell, C.R. 1993. *Vegetation assessment of the Berg River estuary and floodplain with evaluation of likely impacts arising from proposed upstream water impoundment*. Water Affairs Report. Ninham Shand, Cape Town.

Meyer, S. 2001. *An explanation of the 1:500 000 general hydrogeological map – Cape Town 3317*. Department of Water Affairs and Forestry.

Mucina L., Rutherford M.C. & Powrie L.W. 2006. *Inland azonal vegetation*. In: Mucina L, Rutherford MC (Eds.) The Vegetation of South Africa, Lesotho and Swaziland: Strelitzia, 19, pp. 616–657.

Myers, N., Mittermeyer, R.A.C.G., Fonseca, G.A., & Kent, J. 2000. *Biodiversity hotspots for conservation priorities*. Nature 403:853–858.

North, T. & Mangnall, M. 2008. *Blaauwberg Fynbos corridor: Operational environmental management programme.* Unpublished report no 4716/09921~OEMP of ASKA Property Group and Milnerton Estates Property Developers, October 2008.

Planning in Balance, 2013. *Royal Ascot Environmental Management System*. An unpublished Royal Ascot report.

Rebelo A.G., Boucher C., Helme N.A., Mucina L., Rutherford M.C. *et al.*2006. *Fynbos biome*. In Mucina, L. & Rutherford, M.C. (eds). *The Vegetation of South Africa, Lesotho and Swaziland*: Strelitzia, 19, pp. 52–219.

Richards, C. & Dunn, P. 1994. *Hydrology of the Diep River basin.* Report to DWAF by Ninham Shand Inc. in association with BKS Inc. DWAF Report No. P G000/00/3593.

Ryan, P., Underhill, L.G., Cooper, J. & Waltner, M. 1988. *Waders (Charadrii) and other water birds on the coast, adjacent wetlands and offshore islands of the south-western Cape Province*, South Africa. *Bontebok* 6.

Spinks, A.C. & Luger, M.K. 1999. *The Diep River corridor between Blaauwberg Road bridge and the N7 freeway management plan.* Unpublished Ninham Shand Report no. 3005/8766, December 1999.

SRK Consulting. 2008a. *Final Conservation Development Framework for Settlers Park Nature Reserve*. Nelson Mandela Bay Municipality. Internal report.

SRK Consulting. 2008b. *Final Conservation Development Framework for Van Stadens Wildflower Nature Reserve*. Nelson Mandela Bay Municipality. Internal report.

Turpie, J. & Clark, B. 2007. *Development of a conservation plan for temperate South African estuaries on the basis of biodiversity importance, ecosystem health and economic costs and benefits*. Report prepared for the C.A.P.E Estuaries Programme.

Withers, M.J., Boucher, C. & Harding, W.R. 2002. *A management orientated vegetation survey of Rietvlei, Western Cape Province, South Africa.* Ecological Research Report No. 68. Department of Botany, University of Stellenbosch.

ADDITIONAL RESOURCES

Branch, G.M., May, J., Roberts, B., Russell, E. & Clark, B. 2002. *Case studies on the socio-economic characteristics and lifestyles of subsistence and informal fishers in South Africa*. *SA Journal of Marine Science* 24: 475–487.

Braune, M.J., Sim, M.J. & Engelsman, B. 2001. *Diep River Flood Warning System and Floodline Study.*SRK Report No. 275314/1 prepared for the Cape Metropolitan Council.

CCA Environmental and Ninham Shand, 2006. *Proposed extension and upgrading of wastewater treatment and associated infrastructure in the Blaauwberg area: Final Scoping Report.* Report prepared for the City of Cape Town.

City of Cape Town. 2001. *IMEP Integrated Metropolitan Environmental Policy: City of Cape Town – The environmental policy of the City of Cape Town.* Unpublished City of Cape Town report, October 2001.

CSIR. 1992. *Water quality status of the Rietvlei/Milnerton Lagoon System (Diep River estuary) – 1988/89.* CSIR DATA Report EMAS-D 92007, October 1992.

CSIR. 2000a. *Draft scoping report: Options for boundary management on the northern edge of the Rietvlei Wetland Reserve.* Unpublished CSIR report ENV-S C 2000-033 B, May 2000.

CSIR. 2000b. *Investigation of the dust problem from the central pan of the Rietvlei Wetland Reserve.* Unpublished report no ENV-S-C 2000-057, June 2000.

CSIR. 2001. *Solutions for the dust problem at Rietvlei.* Unpublished CSIR report ENV-S-C 2—1-045, August 2001.

Department of Water Affairs and Forestry. 1996. *South African Water Quality Guidelines: Volume 7: Aquatic Ecosystems*. DWAF, 159 pp.

Huizinga, P. 1993. *The Hydrology and Dynamics of the Rietvlei System*. Specialist Study for the Rietvlei Management Plan Report. CSIR, Stellenbosch.

Low, A.B. 1998. *Plantlife of the Potsdam Area.* Unpublished COASTEC report, March 1998.

Low, A.B. 2005. *Establishment of a Fynbos corridor between the Blaauwberg Conservation Area and Diep River – Parklands Section.* Unpublished COASTEC report, August 2005.

Maze, K.E. & Rebelo, A.G. 1999. *Core flora conservation areas on the Cape flats.* Unpublished Flora Conservation Committee report 99/2, The Botanical Society of South Africa, October 1999.

Midgley D.C., Pitman W.V. & Middleton B.J. 1994. *Surface Water Resources of South Africa 1990 – Volume IV: Drainage Regions E, G, H, J, K, L Western Cape*. Water Research Commission Report No. 298/4.1/94.

Millard, N.A.H. & Scott, K.M. 1953. *The ecology of South African estuaries*. Part VI. Milnerton estuary and the Diep River, Cape. *Transactions of the Royal Society of South Africa* 34: 279–324.

OvP Associates. 1999. *Beachfront management plan: Milnerton Lagoon mouth to Dolphin Beach – First draft report.* Unpublished OvP Associates report, September 1999.

Pitman, W.V., Potgieter, D.J., Middleton, B.J. & Midgely, D.C. 1981. *Surface water resources of South Africa Vol. IV. Drainage regions E,G,H,J,K,L: the Western Cape. Part 2 (Appendices).* Hydrological Research Unit Report 13/81.

Rietvlei Protected Natural Environment Management Advisory Committee. 1990. *Rietvlei Protected Natural Environment MASTER PLAN.* April 1990, unpublished report.

River Health Programme. 2003. *State-of-River report: Diep, Hout Bay, Lourens and Palmiet River Systems.* Department of Water Affairs and Forestry, Pretoria.

Taljaard, S., De Villiers, S., Fricke, A.H. & Kloppers, W.S. 1992. *Water quality status of the Rietvlei/Milnerton Lagoon system (Diep River Estuary) – 1988–89.* CSIR Data Report EMAS-D 92007.

Wynberg, R.P. & Branch, G.M. 1991. *An assessment of bait collecting for Callianassa kraussi Stebbing in Langebaan Lagoon, Western Cape, and of associated avian predation*. South African Journal of Marine Science 11: 141–152.

Wynberg, R.P. & Branch, G.M. 1994. *Disturbance associated with bait-collection for sand prawns (*Callianassa kraussi*) and mud prawns (*Upogebia Africana*): long term effects on the biota of intertidal sandflats*. Journal of Marine Research 52: 523–558.

PART 5

APPENDICES

APPENDIX A:	**CHARTS AND TABLES**
Appendix A1:	Average rainfall (2000–2011)
Appendix A2:	Organogram of Milnerton area staff
APPENDIX B:	**LEGAL AGREEMENTS**
Appendix B1:	Gazettes
Appendix B1-1:	Department of Constitutional Development and Planning No. 1632, 3 August 1984, Reservation of Land as a Nature Area: Rietvlei Area
Appendix B1-2:	Provincial Notice 912/1977, 2 September 1977: Milnerton Municipality: Bylaw relating to the Use and Control of the Rietvlei Water Area
Appendix B2:	Records of decision
Appendix B2-1:	Milnerton Racecourse development
Appendix B2-2:	Parklands development
Appendix B3:	Council resolutions
Appendix B3-1:	Fishing and boating in the Rietvlei protected natural environment
Appendix B4:	Deeds of transfer
Appendix B4-1	Transnet Limited to WWF South Africa
Appendix B5:	Lease agreements
Appendix B5-1	WWF South Africa with Blaauwberg Municipality
Appendix B5-2:	The Milnerton Aquatic Club
Appendix B5-3:	Cape Radio Flyers
Appendix B5-4:	Southern African Foundation for the Conservation of Coastal Birds (SANCCOB)
Appendix B5-5:	Western Province Motor Club
Appendix B5-6:	Milnerton Riding Club
Appendix B6:	Surveyor-General diagrams
APPENDIX C:	**SPECIES CHECKLISTS OF TABLE BAY NATURE RESERVE**
Appendix C1:	Plants of Table Bay Nature Reserve
Appendix C2:	Mammals of Table Bay Nature Reserve
Appendix C3:	Birds of Table Bay Nature Reserve
Appendix C4:	Reptiles of Table Bay Nature Reserve
Appendix C5:	Amphibians of Table Bay Nature Reserve
Appendix C6:	Insects of Table Bay Nature Reserve
Appendix C7:	Fish of Table Bay Nature Reserve
APPENDIX D:	**OTHER DOCUMENTS**
Appendix D1:	Security audit
Appendix D2:	Management Effectiveness Tracking Tool South Africa (METT-SA)
Appendix D2-1:	METT-SA scoresheet for Rietvlei Wetland Reserve (protected natural environment) 2007
Appendix D2-2:	METT-SA scoresheet for Diep River Fynbos Corridor 2007
Appendix D2-3:	METT-SA scoresheet for Table Bay Nature Reserve 2012
Appendix D3:	Development plans
Appendix D3-1:	Administration office development

ANNEXURE C

WATER QUALITY IMPROVEMENT PROGRAM

LOWER DIEP RIVER: TRANSVERSAL ACTION PLAN - 1 April 2021

	Ref.	Pollution Source / Problem	Cause / Effect	Catchment Receiving Water Body	Pollution Risk	Item No.	Action	Resp Dept / Branch	Time Frame	Work Stream	Baseline Start	Baseline Finish	Revised Start	Revised Finish	Progress Comments	Mitigation Action (if applicable)	DEA&DP		Directive Ref.	Modified Directive Ref.
2021-3	Diep New	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A		Maturation & Ancillary Pond Cleaning	W&S / WW	Short Term	O & M	23-Mar-21	30-Jun-21	N/A	N/A	Annual pond cleaning & maintenance commened 23 March 201.		2	2		
2021-1	Diep New	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A		Conduct a thorough clean-up of the sludge within the Diep River at the Potsdam WWTW FE discharge point.	W&S / WW W&S / CSRM	Short Term	O & M	22/01/2021			14 calendar days 5 February 2021	New Action.	Report submitted to DEA&DP on 5 February 2021.			5.4	
2021-2	Diep New	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A		Effectively seal-off historical outlets from Potsdam WWTW including the maturation ponds.	W&S / WW	Short Term	O & M	22/01/2021			30 calendar days - 21 Feb 2021 Proof 7 days after completion.	New Action.	Report submitted to DEA&DP on 21 February 2021.			5.6	
2021-4	Diep New	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A		Standby Generators to have immediate response during power outage. (Not 15 to 30 minute delay)	W&S / WW	Short Term	O & M	22/01/2021			Proof 7 days after completion.	Generator start-up time to be confirmed.	Completed - WW to furnish proof / evidence. 1 to 2 minute delay.			5.7	
106	Diep .106	Koeberg Road Pump Station	Sewer Spills into Theo Marais Canal	Theo Marais Canal	A		Koeberg Road Pump Station Operations & Spill ("Failure") Incident Response Management	W&S / Retic PS CSRM	Short to Medium Term	O & M	01-May-20	Until no longer needed			Ongoing. Environmental pollution: Root cause is foreign hard solid waste discarded into manholes upstream ending at pump station and damaging pumps. Solidified fat reducing conveyance system capacity. 1. Koeberg pump station: • All pumps x 4 are operational • Pipeline linking Rising Main chamber and wet well has been completed. Linked pipeline will allow sewer to flow back into wet well when there is leak again from the coupling in the RM. • RM isolation valve, RM spool piece and VJ coupling replaced. • Wet well was cleaned in June 2020		12	5		
101.2	Diep New	Montague Gardens Industrial Illicit Discharge	Pollution to the Theo Marais Canal via illegal point discharges into the stormwater drainage system inlets and underground pipes.	Theo Marais Canal	A	803	Investigate, educate & regulate illicit discharges from Montague Gardens Industrial Area.	W&S / WDM	Long Term	Specialized Tasks	Tactical & Reactive Function				Postponed to Summer Dry Season as winter flows hinder discharge tracing. This can only be implemented when the phreatic flow from the Tygerberg Hills has reduced sufficiently.	Investigate the source of the constant flow through the Montague Gardens area and further upstream. Continue regular incursions into Montague Gardens Industrial area. Limited action during lockdown.	26	5		
2021-5	Diep New	Montague Gardens Industrial Illicit Discharge	Pollution to the Theo Marais Canal via illegal point discharges into the stormwater drainage system inlets and underground pipes.	Theo Marais Canal	A	803	Investigate, educate & regulate illicit discharges from Montague Gardens Industrial Area.	W&S / WDM	60 calendar days 23 March 2021	Specialized Tasks	Task Completed in 2020				WPC to plan and undertake investigation. Incursion with DWS undertaken in 2020 -WPC to furnish report/detail.	Report submitted to DEA& DP on 23 March 2021				
2021-6	Diep New	Point & Diffuse Source Pollution	Pollution into the Diep River	Entire Diep river System	A		Investigate, educate & regulate illicit discharges in conjuction with DEA&DP : Environmental Law Enforcement	W&S / WDM / WPC							The City is awaiting a respose from the department, as has been requested in the monthly reports of July & august 2020.	Investigate, educate & regulate illicit discharges in conjuction with DEA&DP : Environmental Law Enforcement		6		
101.3	Diep New	Theo Marais Canal Clean-up	Koeberg Rd PS Spillage	Theo Marais Canal	A		Sewer Spill Clean Up & Sludge removal	W&S /Retic W&S Retic PS	Medium Term	O & M	Ad Hoc - as & when required.				Pump out water and remove polluted sediment.	Task Completed. Task to be repeated on and "as& when required" basis	27	6		
107	Diep.107	Pheonix / Joe Slovo	Sewerage & Greywater Pollution conveyed by the Erica Road stormwater drainage system.	Erica Rd, Milnerton Lagoon	A		Pump grey water from Erica Road stormwater outfall twice weekly	W&S / Retic	Short to Medium Term	O&M	Tactical & Reactive Maintenance & Operation Function				Pumping required when inflow at Milky Way SW tio Sewer Diversion works capacity is exceeded or pumps fail.	Currently Pumpung Bi-weekly.	39	7		
108	Diep.108	Bayside Canal	Litter and Solid Waste Pollution via Wind Dispersion, Illegal Dumping and Convieyard by Storm Water drainage system	Rietvlei	A		Twice/Monthly frequency cldeaning the Bayside canal banks in terms of litter & Solid Waste	SWM (Cleaning Branch)	Long Term	O & M					Although our Killarney Depot cleans the river/canal banks on a bi-monthly basis. However, in the months June and July 2020 the river banks were cleaned. There was a total of approximately **7,25** tons of waste removed from the cleaning initiatives along Bayside canal and disposed off. This to a total cost of **R4328,52**. In additional to the aforementioned, the total labour cost to cleaning the canal banks were a total of **R34103,04**. Whereas our vehicle cost amounted to a total of **R1252**.	1. Efforts to prevent the unlawfully occupation of the canal banks by homeless people and vagrants is required. A joint clean up with Law Enforcement was planned for the month of August 2020. 2. Our Cleansing staff are sometimes intimidated by the rudeness of the vagrants. Joint operations with Law Enforcement are necessary. 3. Transversal integrated initiatives with Storm Water Management colleagues are essential.	32	8		
109	Diep.109	Pheonix / Joe Slovo	Solid Waste Pollution conveyed by stormwater drainage system.	Erica Rd, Milnerton Lagoon	A		Remove litter from the Erica Road stormwater outfall trash rack.	RIMS	Short to Medium Term	O&M	Tactical & Reactive Maintenance & Operation Function				RIMS Catch Pit cleaning programme /Winter Readiness Programme.		40	9		
110	Diep.110	Invasive & Alien Vegetation	Water hyacinth depletes oxygen and reduces sunlight for indiginous aquatic plant & animal life. It also mats physically slows the flow of water, causing suspended particles to be precipitated, leading to silting.	Lower Diep River	A		Remove & dispose of Water Hyacinth	EMD / Invasive Species Unit	Long Term	Specialized Tasks	Tactical Maintenance				COVID-19 Lockdown regulations at various levels have prohibited work in rivers, creating a backlog.	Rainfall & River water level can delay clearing work.	45	10		
111	Diep .111	Illicit Discharge	DIEP 111 (Item No. 801 - 803): Pollution to Lower Diep River / Milnerton Lagoon via illegal point discharges into the stormwater drainage system inlets and underground pipes.				DIEP 111 comprises 4 sub-tasks as detailed individually below:	W&S / WDM / WPC	Long Term	Specialized Tasks	Tactical & Reactive Function								5.1.1	
111	Diep .111	Illicit Discharge	Pollution to Lower Diep River / Milnerton Lagoon via illegal point discharges into the stormwater drainage system inlets and underground pipes.	Catchment Wide	A	801	Investigate, educate & regulate illicit discharges into stormwater drainage systems, rivers & water bodies.	W&S / WDM / WPC	Long Term	Specialized Tasks	Tactical & Reactive Function				Monitor and schedule blitz operations when the lockdown level is relaxed.		24			
111	Diep .111	Milnerton Race Horse Precinct Illicit Discharge	Pollution to the Theo Marais Canal via illegal point discharges into the stormwater drainage system inlets and underground pipes.	Theo Marais Canal	A	802	Investigate, educate & regulate race horse facilities at Milnerton Race Horse Stables	W&S / WDM	Short Term	Specialized Tasks	01-Aug-20	01-Jan-21		60 calendar days 23 March 2021	Incursion to inspect stormwater system drainging the Milnerton Race Horse Stable precinct. Conduct full inspection to determine volume and quality of wastewater generated. Monitor the water quality in the stormwater system and downstream of the stables. Investigate best practice for stables	Task Complte - reports submitted to DEA&DP on 23 March 2021	25	12	5.1.2	
111	Diep .111	Upper Diep River	Agricultural area - illicit point & diffuse stormwate runoff discharges .	Upper Diep River, Mosselbank River tributary.	A		Investigate, educate & regulate illicit discharges in conjuction with DEA&DP : Environmental Law Enforcement	W&S / WDM	Long Term	Specialized Tasks	Operational Function				To be Planned with WPC & DEA &DP.	WQ Report updated monthly with City & OTA results.. Report submitted monthly to DEA&DP.	47	13		
113	Diep.113	Sewer Pump Stations	Pollution to Lower Diep River / Milnerton Lagoon via stormwater drainage system inlets and underground pipes or directly into the river course..	Catchment Wide	B		Pump Station Operations & Spill ("Failure") Incident Response Management	W&S / WDM / WPC / CSRM / RETIC / WW	Medium Term	Specialized Tasks	21-Apr-20	30-Oct-21		4.2.2.1. - end October 2021. 4.2.2.2. - 21 February2021. 4.2.2.3 - 23 March 2021.	Over-arching document & appendices are completed . Work in progress on specific practical implementation protocol to physically deal with spillages. Pollution incident protocols to be revised / re- drafted covering (i) sewer gravity system, (ii) sewer pump stations, & (iii) WWTW (review)	DIEP 113 Submit revised pollution incident protocols and contingency plans for Potsdam WwTW, Koeberg & Sanddreft (East) Pump Stations. 4.2.2.1 Submit by end October 2021 4.2.2.2 Overarching document within 30 calendar days & 4.2.2.3 Interim remediation / incident management response plan to deal with instantaneous pollution events / emergency incidents that may occur. Submitted to DEA&DP on 21 Feb 2021.	9	14	5.1.3	4.2.2
114	Diep.114	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A	105	Potsdam WW Treatment Works Upgrade - Design & Tender Phases 4.2.3.1 Implement by end August 2025 4.2.3.2 Monthly Progress Reporting	W&S / WW	Long Term	CAPITAL	In Progress	End August 2025			Completion date can be met if potential SCM delays do not erode time 'float' allowed. WW to Provide summary project programmes for each of the project phases.	The capacity of the Potsdam Wastewater Treatment Works will be increased from 47Ml to 100Ml/d upon completion of the upgrade works in 2025. The membrane bioreactor (MBR) will be installed with sufficient membranes to treat the projected increase in flow for the next 15 years (post completion)	5	15	5.1.4	4.2.3
114	Diep.114	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A	106	Potsdam WW Treatment Works Upgrade - Civil Works	W&S / WW	Long Term	CAPITAL	01-Jan-21	01-Dec-23			✓		6	16	5.1.5	
114	Diep.114	Potsdam Wastewater Final Effluent Quality	Pollution to Lower Diep River / Milnerton Lagoon via the treatment works outlet channel.	Lower Diep River (Milnerton Lagoon)	A	107	Potsdam WW Treatment Works Upgrade _ Mechanical & Electrical Works	W&S / EAM	Long Term	CAPITAL	01-Jan-21	01-Dec-24			✓		7	17		
116	Diep.116	Montague Gardens Sewer Gravity Reticulation Network	Sewer Network Blockages & Spillages due to capacity constraints & aged infrastructure into Theo Marais Canal.	Theo Marais Canal	C	301	Item 301 Montague Gardens Bulk Sewer Upgrade. Includes screening system. 4.2.4.1 Complete by 30 June 2025 4.2.4.2 City to indicate measures to reduce blockages in sewer retic network within 60 calendar days.	W&S / Retic	Long Term	Capital	01-Mar-20	30-Jun-25	1/03/2020	4.2.4.1. - 30/06/2025 4.2.4.2 - 23 March 2021	City programme dates: 1 March 2020 to 30 June 2025. Ph. I - New sewer and screens ends Jun 2024 Ph. 1 Lining of Montague Drive sewer - +2 years. Consultant appointment done and Section 33 process underway with a targeted completion January 2021.	4.2.4.1. Anic Smit - overall project completion is 2027, which includes the Montagu Drive pipeline. Montague Gardens sewer gravity reticulation network will be completed by 30 June 2025. 4.2.4.2. Lorraine Cleophas to furnish details of pro-active maintenance & cleaning. "Bin It, Don't Block It" Campaign to continue - pamphlets in printing & loudhailers to be used in Residential areas. Submitted to DEA&DP on 23 March 2021.	17	18		4.2.4
122	Diep.122	Koeberg Road Pump Station	Sewer Spills into Theo Marais Canal	Theo Marais Canal	A		Koeberg Road Pump Station Upgrade in concurrence with Montague Gardens Bulk Sewer Upgrade 4.2.6.1. Montague Bulk Gardens to be completed between 1 July 2022 and 1 June 2024 4.2.6.2. Monthly reporting.	W&S / Retic	Medium Term	CAPITAL	01-Jul-22	01-Jun-24	1/07/22	30/06/2024	Koeberg Road Pump Station Refurbishment - some of which has been completed (Brian Thompson) and other planned update (Anic Smit) report required. City Programme Dates: 1 July 2022 to 1 June 2024. Koeberg Road Pump Station Upgrade in concurrence with Montague Gardens Bulk Sewer Upgrade. Budget available in 2021/2022. Consultants tender 293C cancelled and planned refurbishment design to start after September 2021 when the replacement tender is awarded.		16	24	5.2	4.2.7
117	Diep.117	Dunoon & Doornbach Sewer Gravity Reticulation Network	Sewer Network Blockages & Spillages + Sewerage & Greywater into Lower Diep River via stormwater drainage system and the 2 outflow channels	Lower Diep River	A		Plan, Design & Construct stormwater to sewer diversion/s. Dunoon & Doornbach Sewer Gravity Reticulation Network: Sewer Network Blockages & Spillages + Sewerage & Greywater into Lower Diep River via stormwater drainage system and the 2 outflow channels - Plan, Design & Construct stormwater to sewer diversion/s.	W&S /Retic W&S Retic PS CSRM	Medium Term	Capital	01-Jun-20	2023		end December 2023	Electric Power Supply source investigation completed. City Programme Dates: 1 June 2020 to 2023. Designs completed by CSRM and approved by Retic. Pending budget & project implementation.	4.2.5.1. Complete by end December 2023. 4.2.5.2. Monthly progress reporting.	19	19	5.1.6	4.2.5
118	Diep.118	Pheonix / Joe Slovo	Encroachment of Stormwater Management Ponds	Erica Rd, Milnerton Lagoon	B		Investigate and possible reinstatement of Management Ponds	W&S / CSRM	Long Term	Specialized Tasks	01-Jul-21	01-Dec-23			Investigation to be carried out under W&S Consultant Framework Tender - award August 2020 (???)		43	20		
119	Diep.119	Pheonix / Joe Slovo	Sewerage, greywater & solid waste pollution.	Erica Rd, Milnerton Lagoon	B		Contstruct Treatment Wetland / Pond at Erica Rd stormwater system outfall.	W&S / CSRM	Long Term	Specialized Tasks	01-Feb-21	01-Dec-23			Investigation to be carried out under W&S Consultant Framework Tender - award August 2020 (???)	Will need EIA. Compile scope of works.	44	21		
120	Diep.120	Theo Marias Oufall Channel	Sewerage & Greywater Pollution conveyed by the Theo Marais stormwater drainage system.	Theo Marais Canal	A		Plan, Design & Construct stormwater to sewer diversion/s.	W&S /Retic W&S Retic PS CSRM	Medium Term	Capital	01-Jun-20	2023			City Programme Dates: 1 June 2020 to 2023. Project department & lead to be confirmed.	4.2.6.1. Montague Bulk Gardens to be completed between 1 July 2022 and 1 June 2024 4.2.6.2. Monthly reporting.	48	22	5.1.7	4.2.6
121	Diep.121	Sewer Pump Stations	Pollution to Lower Diep River / Milnerton Lagoon via stormwater drainage system inlets and underground pipes or directly into the river course..	Catchment Wide	A		Sewer Pump Station Audit	W&S / WDM W&S / EAM	Medium Term	Specialized Tasks	01-Mar-20	30-Sep-21		60 calendar days 23 March 2021	Physical Assessments of pump stations has been completed. Preliminary Findings reported & presented. Prioritise Diep River Catchment Pump Stations - site assessments completed.	Upon completion the plan will be workshopped with the asset owner branches to decide how to incorporate into maintenance and upgrade works as well as budget for and implementation of improvements. Assessment Report submitted to DEA&DP on 23 March 2021	10	23	5.1.8	
2021-7		Du Noon and Doornbach, Solid Waste Management (Collection and Area Cleaning (Including Joe Slovo Park)	Litter and Solid Waste Pollution via Wind Dispersion, Illegal Dumping and Conveyed by Storm Water drainage system A lack of proper waste collection service for the backyarders in the densely populated areas results to illegal dumping of household waste.	Low Diep River	A		Increased frequency of refuse Colletion and Area cleaning	SWM (Cleansing Branch)	Short Term	O & M					Eugene Hlongwane - Raised as an issue. Service is being delivered 7 days a week cannot be increased.	1. The back yarders are the missing middle with regards to the provision of the waste collection services and as a consequence, a huge amount of waste is dumped illegally because there is not alternative. These concerns were raised during the Water and Waste Portfolio Committee workshop held towards the end of July month 2020. 2. A concerted effort to address this problem must made at a strategic level of management as well as at political level. At this stage no decision has been made pertaining to the wayforward.	29	40		
2021-8		WQ Sampling	Comparable Monitoring	Diep River reach in vicinity of Potsdam Long Pond Discharge Weir			Add & monitor sampling point at Potsdam WWTW FE discharge point to monitor the water quality of the FE entering the environment.	W&S / SS	Not specified						New Action. Assuming a point coinciding with an OUTA sampling point. Exact location needs to be confirmed by DEA&DP	Scientific Services have been briefed, current problem with media for performing E.coli tests.			5.5	
2021-9		Solid Waste	Flotsam Debris	Lower Diep River (Milnerton Lagoon)			General Waste traps (nets) at all Stormwater outlets & clean regularly. Stormwater Outlet Nets at Strategic Locations. 4.2.7.1 Implement by November 2021. 4.2.7.3. Monthly progress reporting. 4.2.7.2. Interim response plan within 60 days.	W&S / CSRM		O & M					New Action. Nets have been donated.				5.8	4.2.7.
2021-10		Estuary Management	Management Options & Monitoring	Milnerton Lagoon			Submit an Estuary Management Plan for Milnerton Lagoon that must address improving the estuary water quality, marine and coastal ecosystem functions as well as the overall management of the Milnerton Lagoon Estuary for comment & DEFF approval.	SPE / Coastal Management SPE / Biodiversity Management				60 calendar days 23 March 2021			There some existing plans in place including an Estuary Maintenance Mangement Plan (Approved by DEA&DP). Estuary management & monitoring proposal submitted to DEA&DP on 3 March 2021.					
2021-11		Communication & Engagement					Continue to conduct meetings / engagements with affected groups to communicate & inform the communities of the City's short, medium & long term actions as per the Action Plan and provide them with copies of updated reports.	W&W WQIP	Not Specified						Monthly reports submitted to Sub-councils 3 & 15. Ad-hoc correspondence with MCRA representative. Engagement with OUTA / MCRA & DEA&DP held in February 2021.	Future OUTA / MCRA & DEA&DP Engagement to be planned for April 2021				

ANNEXURE D

MARINE ECOLOGICAL MONITORING OF THE MILNERTON LAGOON (DIEP RIVER ESTUARY)

July 2021

Anchor Research and Monitoring Report No. 1954/1

MARINE ECOLOGICAL MONITORING OF THE MILNERTON LAGOON (DIEP RIVER ESTUARY)

July 2021

Report prepared for:
The City of Cape Town
Environmental Management Department
Spatial Planning and Environment Directorate
44 Wale Street, Cape Town

Report Prepared by:
Anchor Research & Monitoring (Pty) Ltd
8 Steenberg House, Silverwood Close, Tokai, South Africa
www.anchorenvironmental.co.za

Authors: Kirti Gihwala, Jessica Dawson and Barry Clark

Citation: Gihwala K, Dawson J & BM Clark. 2021. *Marine ecological monitoring of the Milnerton Lagoon (Diep River Estuary).* Specialist Report no. 1954/1 prepared by Anchor Research and Monitoring (Pty) Ltd for The City of Cape Town. 49 pp.

Cover photo credit: Aiden Biccard

EXECUTIVE SUMMARY

Milnerton Lagoon is part of the Diep River Estuary and is located to the north east of Cape Town's city centre where the Diep River enters Table Bay, on the west coast of South Africa. The City of Cape Town (CoCT), as the Responsible Management Authority, has undertaken several projects aimed at identifying and reducing pollution from land-based sources to the marine environment via the Diep River Estuary. The Diep Estuary Management Plan (EMP) identifies the importance of quantifying and managing sediment quality highlighting concerns of sediments becoming a sink for contaminants, and the consequential impacts on bottom-dwelling organisms. To identify areas of potential concern, Anchor Research & Monitoring (Pty) Ltd (Anchor) was appointed by CoCT to undertake a sediment and macrofauna monitoring survey of the Milnerton Lagoon (Diep River Estuary). This report presents findings on sediment quality (granulometry, organics and trace metal concentrations) and the benthic macrofaunal community sampled from the Diep River Estuary during June 2021.

Sediment Quality

Results from the 2021 monitoring survey have highlighted sites sampled along the Diep River Estuary consisted primarily of a coarse sandy texture. Additionally, mud content was higher at three sites in the vicinity of Woodbridge Island, two sites above the Otto du Plessis Bridge and increased with distance upstream, particularly at sites close to the Blaauwberg Bridge. This is likely due to decreases in hydrodynamic flow at these sites caused by biotic e.g. marginal vegetation (*Phragmites* reeds) and alien aquatic macrophytes (water hyacinth), or anthropogenic obstructions (bridges) allowing fine-grained sediment to be deposited at a greater rate compared to sites elsewhere in the estuary where faster flowing currents disperse fine sediments. TOC/TON levels, as well as a number of trace metal concentrations (As, Cd, Cr, Ni, Al and Fe) mirrored the patterns observed for mud content and accumulated in sediments further upstream in the estuary, past the Otto du Plessis Bridge and at sites close to the Blaauwberg Bridge. Statistical tests confirmed the latter findings whereby significant differences between the two areas (Milnerton Lagoon vs Diep River) were detected for five elements (Al, As, Cr, Fe and Ni).

Furthermore, only three elements (Cr, Pb and Hg) did not exceed the South African and international sediment quality guidelines, whereas the remainder exceeded these guidelines at particular sites (past the Otto du Plessis Bridge and near the Blaauwberg Bridge). Enrichments factors indicated substantial increases in Cd, Fe and Zn concentrations within the Diep River Estuary over the past 32 years. In general, the majority of the trace metals measured in the sediments of the Diep River Estuary have become enriched compared to historical surveys. Additionally, the average trace metal concentrations for Cd, Ni and Zn within the Diep River Estuary were relatively high in comparison to other local and international estuaries. This is a reason for concern, as such elements are typically elevated by anthropogenic activities and are known to have ecotoxicological effects.

Benthic macrofauna

During the 2021 benthic macrofauna survey, a total of 728 macrofaunal organisms from six different taxa were recorded within the Milnerton Lagoon, which represents a dramatic decline in diversity compared to historical reports. A total of 28 successful macrofauna samples were collected from 11 transects, however, only 13 of these contained macrofaunal organisms. Additionally, species of bivalves, gastropods, amphipods and isopods, reported from previous surveys were not found in the present study. The polychaete *C. capitata*, a species known to occupy highly disturbed ecosystems, dominated all samples and constituted 79% of the abundance, followed by *P. sexoculata.* Univariate results indicated Shannon Weiner Diversity index and biomass were similar across all sites, while abundance and species richness differed significantly across the length of the system. Multivariate analyses revealed significant dissimilarity in macrofaunal community structure among sites. This is logical as macrofauna were absent in half of the samples located 1.5 km from the mouth and further upstream. Generally, disparity was evident between sites grouped by relative distance from river mouth as well as between replicate samples. SIMPER analyses and bubble plots demonstrated that three species were restricted to either sections of the mouth (i.e. *C. capitata*) or further upstream of the Diep River Estuary (*P. sexoculata* and *Chironomis* sp.). Additionally, the relationship between macrofaunal abundance data and abiotic data was investigated of which distance from river mouth, As and Pb explained the greatest proportion of the variation observed in the macrofauna data. However, findings presented in the present study indicated the three main species do not appear to be negatively impacted by these trace metal concentrations.

It has become apparent in the scientific community, that total metal concentration is not a good predictor of environmental effects, whereas bioavailability monitoring and use of bio-indicators have proven to be successful in determining trace metal toxicity levels among species. Very few studies have examined the toxicity of trace metals on South African estuarine biota and international literature has demonstrated high variability in trace metal toxicity both between species and aquatic systems This study measured trace metal pollution levels in the Diep River Estuary sediments but did not conduct field or laboratory ecotoxicity studies to determine toxic effects on biota found in this estuarine system. Nonetheless, the analyses of various physical and chemical parameters in sediment collected in the Diep River Estuary in June 2021 provide evidence that some trace metal elements were elevated well above levels considered to be toxic to living organisms (according to international and local quality guidelines) and highlighted sites past the Otto du Plessis Bridge and near the Blaauwberg Bridge as areas of concern. Furthermore, the large absence of benthic organisms indicates a severely degraded system and no longer pristine compared to historical surveys.

Potential sources of these trace metal pollutants need to be identified and addressed. Sources of contaminants most likely include effluent from wastewater treatment works (i.e. sewage), storm water and industrial wastewater. Thus, it is imperative that monitoring of the Diep River Estuary be continued on a regular basis, as well as the possible introduction of a more detailed approach i.e., ecotoxicity testing.

Ecological state of the estuary

In the recent National Biodiversity Assessment the Diep River Estuary's present ecological state (PES) is listed as "D" (Poor/Heavily modified) with a recommended ecological category (REC) of "D". A breakdown of the individual components assessed, and the scores given to each within the Diep River Estuary is provided in this report and shows that despite the overall ecological category being a "D" several of the individual components have lower scores and are "severely" or "critically modified, including the water quality, macrophytes and Invertebrates.

A significant impact within the estuary causing a reduction in the ecological category is poor water quality, which in turn influences biotic components of the system (such as the macrofaunal abundance and richness). The main sources of pollution include the Potsdam wastewater treatment works that discharges into the system, as well as urban and stormwater runoff adjacent to the estuary and in the river catchment which results in poor water quality for the inflowing water that reaches the head of the estuary. The recent National Biodiversity Assessment (NBA 2018) additionally lists a number of other threats acting on the system, causing it to have a 'High' overall threat status. These threats include flow modifications, habitat loss, invasive alien plants and fish, bait collection and fish kills linked to pollution. Although the City is in the process of clearing Water Hyacinth within the system this, and other species of invasive aquatic plants, pose a threat to the health of the estuary.

Recommendations for further monitoring in the Diep River Estuary include the following:

1. In order to identify and control sources of heavy metal pollution, regular, testing of trace metal content of all sewage and industrial effluent entering the Diep system should be instituted.
2. Implementing improved methods of invasive plant species prevention, such as a floating boom at the head of the estuary which restricts the distribution of the plants into the system, and more regular clearing of the invasive aquatic species (avoiding such high levels of infestation) could improve the overall health of the estuary.

TABLE OF CONTENTS

GLOSSARY

Abundance	Refers to the number of individuals of a specific species.
Aquatic	Relating to or living in water.
Benthic	Pertaining to the environment inhabited by organisms living on or in the estuary bottom.
Bio-indicators	Bioindicators are organisms or communities of organisms, which reactions are observed representatively to evaluate a situation, giving clues for the condition of the whole ecosystem.
Biomass	The mass of living biological organisms in a given area or ecosystem.
Biota	Living organisms within a habitat or region.
Contaminants	Biological or chemical substances or entities, not normally present in a system, capable of producing an adverse effect in a biological system, seriously injuring structure or function.
Diversity	The number of different species that are represented in a given community.
Estuary	An estuary is defined in terms of the National Environmental Management: Integrated Coastal Management Act (ICMA) and the NEMA 2014 EIA Regulations as "a body of surface water— a) that is permanently or periodically open to the sea; b) in which a rise and fall of the water level as a result of the tides is measurable at spring tides when the body of surface water is open to the sea; or c) in respect of which the salinity is higher than fresh water as a result of the influence of the sea, and where there is a salinity gradient between the tidal reach and the mouth of the body of surface water.''
Estuarine Functional Zone	Used to delineate the functional zone of an estuary to include functional areas of estuarine habitat (e.g. sand and mudflats, rock and plant communities and flood plain areas) as well as the open water area of the estuarine system.
Granulometry	The measurement of the size distribution in a collection of sediment grains.
Impact	A change to the existing environment, either adverse or beneficial, that is directly or indirectly due to the development of the project and its associated activities.
Macrofauna	Also termed macrobenthos, are invertebrates that live on or in sediment, or attached to hard substrata – particularly those which are retained on a 1 mm sieve.
Macrophyte	An aquatic plant large enough to be seen by the naked eye.
Polychaete (Polychaeta)	Segmented worms with many bristles (i.e. bristle worms).
Sessile	An organism that is fixed in one place (immobile)
Specialist study	A study into a particular aspect of the environment, undertaken by an expert in that discipline.
Species	A category of biological classification ranking immediately below the genus, grouping related organisms. A species is identified by a two part name; the name of the genus followed by a Latin or Latinised un-capitalised noun.
Species richness	The number of different species represented in an ecological community. It is simply a count of species and does not take into account the abundance of species.

LIST OF ABBREVIATIONS

Anchor	Anchor Research and Monitoring (a subsidiary of Anchor Environmental Consultants)
Al	Aluminium
As	Arsenic
ANOVA	Analysis of Variance
BCLME	Benguela Current Large Marine Ecosystem
Cd	Cadmium
CoCT	City of Cape Town
Cr	Chromium
DISTLM	Distance Linear Based Modelling
EF	Enrichment factor
EMP	Estuary Management Plan
ERL	Effects Range Low
ERM	Effects Range Median
Fe	Iron
Hg	Mercury
MEMP	Marine Ecology Monitoring Plan
Ni	Nickel
NOAA	National Oceanic and Atmospheric Administration
PERMANOVA	Permutational Multivariate Analysis of Variance
Pb	Lead
PNE	Protected Natural Environment
TOC	Total Organic Carbon
TON	Total Organic Nitrogen
WoRMS	World Register of Marine Species
WWTW	Waste-Water Treatment Works
Zn	Zinc

1 INTRODUCTION

Milnerton Lagoon is part of the Diep River Estuary and is located to the north east of Cape Town's city centre where it enters Table Bay, on the west coast of South Africa. Upstream of Milnerton Lagoon, low flows from the river are directed along an earth channel, which conveys river water along the eastern shore of Rietvlei (a large vlei, declared a Protected Natural Environment (PNE) in 1989, and considered of particular ecological importance in terms of its birdlife). The Potsdam Wastewater Treatment Works (WWTW) discharges treated sewage effluent into the earth channel abutting the vlei, and in summer, when upstream abstraction of Diep River flows is high, treated effluent comprises a substantial amount of water in the river channel. Milnerton Lagoon was also declared a Protected Natural Environment, recognised as one of 37 Core Flora Sites on the Cape Flats (BotSoc 1999), and is now a section of Table Bay Nature Reserve, submitted for proclamation under the National Environmental Management: Protected Areas Act (Act 57 of 2003, as amended).

The City of Cape Town (CoCT), as the Responsible Management Authority, has undertaken several projects aimed at identifying and reducing pollution from land-based sources to the marine environment via the Diep River Estuary. The Diep Estuary Management Plan (EMP) details the erosion in the catchment and siltation in the estuary; noting for example that there have been reports of significant accumulations of organic material in the bottom of watercourses (City of Cape Town 2018). As such, the EMP identifies the importance of quantifying and managing sediment quality (City of Cape Town 2018). Concerns include the potential for these sediments to become a sink for contaminants, with the consequential impacts on bottom-dwelling organisms (City of Cape Town 2018). Contaminants such as trace metals and organics accumulate in depositional areas with fine muddy sediments.

While substantial chemical and biological monitoring data is available for this system, heavy metal accumulation and its effects on the benthic faunal communities within the estuary should be assessed further and more frequently (Taljaard *et al.* 1992, Jackson *et al.* 2009, Hutchings & Clark 2010, Shuping *et al.* 2011, CSIR 2015, Hutchings *et al.* 2016, Viskich *et al.* 2016). It has been recommended that, to identify areas of potential concern, sediment samples need to be analysed to determine the levels of organics and pollutants in the sediment within the estuary (from the mouth as far as the Blaauwberg Bridge). In addition, a benthic macrofauna survey of the Milnerton Lagoon should be completed (from the mouth to the Otto du Plessis Bridge). Anchor Research & Monitoring (Pty) Ltd (Anchor) was appointed by CoCT to undertake the sediment and macrofauna monitoring survey of the Milnerton Lagoon (Figure 1). This monitoring was to be in accordance with the 2020 Marine Ecology Monitoring Plan for Milnerton Lagoon (Wright *et al*. 2020).

This report presents findings on sediment quality in the form of sediment granulometry (Gihwala & Hutchings 2021), organics and trace metal concentrations as well as the benthic macrofauna sampled from the Diep River Estuary during June 2021. These findings are discussed with reference to the earlier surveys and relevant scientific literature and recommendations for the future monitoring and management of trace metal pollution in the Diep River Estuary are provided.

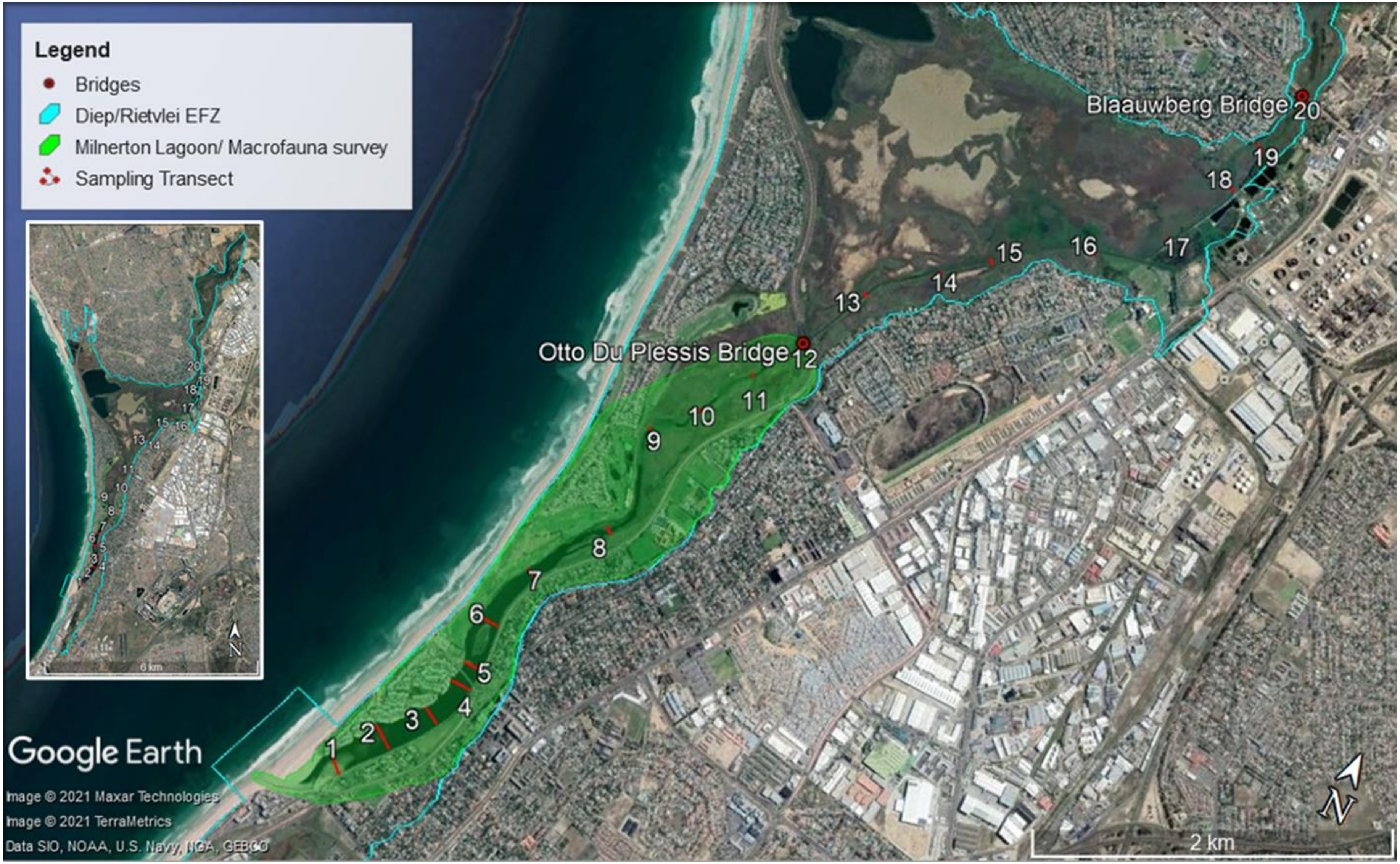


Figure 1 Milnerton Lagoon within the Diep River Estuary and the location of sediment (1-20) and macrofauna (1-12) sampling sites along system. Inset shows the full extent of Estuarine Functional Zone (EFZ)

1.1 Scope of Work

Anchor were appointed to undertake the marine ecological survey of the Milnerton (Diep River) Lagoon. The monitoring programme has three broad objectives, namely:

1. Determine the levels of organics and pollutants in the sediment of the Milnerton Lagoon;
2. Complete a benthic macrofauna survey of the Milnerton Lagoon; and
3. Complete a report that details the results, analysis and findings of the sediment and benthic macrofauna surveys.

1.1.1 Sediment Quality

Estuary sediments are derived from terrestrial and marine sources; weathering, biological and marine processes interact with hydrodynamic and geomorphological processes creating distinct spatial and temporal differences in the size composition and distribution of sediments. This heterogeneous distribution of sedimentary characteristics has both ecological and physico-chemical implications in estuaries. Fine sediments tend to accumulate in regions where there is minimal hydrodynamic disturbance. Conversely, coarse sediments typically remain in high energy regions where current, tidal and wave disturbances are prevalent. Understanding sedimentary characteristics provides valuable insight into the diversity and distribution patterns of benthic macrofaunal communities. Benthic macrofauna respond to differences in sediment properties either as larvae or adults and are thus strongly associated with the sedimentary composition of their habitat (Gray 1974, Etter & Grassle 1992, Bergen *et al.* 2001, Ellingsen 2002, Anderson 2008). Apart from granulometric composition, organic content of the sediment can similarly influence macrofaunal distribution and diversity and plays a part in the accumulation of trace metals and other anthropogenic contaminants (Bolam *et al.* 2004, Austen & Widdicombe 2006, Martins *et al.* 2013). Organic matter derived from either marine or terrestrial origins is also an essential food source for benthic macrofaunal communities and excess organic matter, and the decay thereof, can negatively affect the ecological health of the estuarine ecosystem as a whole.

The concentrations of metals in sediments are affected by grain size, total organic content and mineralogy. Since these factors vary in the environment, one cannot simply use high absolute concentrations of metals as an indicator for anthropogenic metal contamination. Metals and organic toxic pollutants are predominantly associated with fine sediment particles (mud and silt). This is because fine grained particles have a relatively larger surface area for pollutants to adsorb and bind to (Clark *et al.* 2020). Metal concentrations are therefore commonly normalized to a grain-size parameter and only then can the correct interpretation of sediment metal concentrations be made (Summers *et al.* 1996). Aluminium (Al) or Iron (Fe) are commonly used as normalizers for trace metal content as they coat all sediments and occur in proportion to the surface area of the sediment (Gibbs 1994), they are abundant in the earth's crust (with relatively constant ratios of metal concentrations to Al or Fe concentrations) and are not likely to have a significant anthropogenic source (Gibbs 1994, Summers *et al.* 1996).

Normalized metal ratios can be used to estimate the extent of metal contamination within the marine and estuarine environment, and to assess whether there has been enrichment of metals from anthropogenic activities. Several studies have been conducted to determine the relative abundance of metals in crustal materials (Taylor 1964, Taylor & McLennan 1981, Martin & Whitfield 1983). The results of these analytical techniques are important for the assessment of the extent of potential contamination resulting from anthropogenic activities.

1.1.2 Benthic macrofauna

Bio-indicators are useful in monitoring ecosystems when physico-chemical and eco-toxicological variables cannot be measured or are difficult to quantify or interpret (Gerhardt 2002). These bio-indicators provide a direct spatial and temporal measure of the state of the ecosystem. Benthic macrofauna are a fundamental part of the food web and are important as processors of organic particles. These organisms are frequently monitored as bio-indicators to detect changes in the health of marine and estuarine environments (Khatri & Tyagi 2015, Parmar *et al.* 2016). This is largely because most of them are sessile and cannot avoid contaminants (as mobile biota can) nor be carried passively in ocean currents (as may happen to planktonic organisms) (Gray *et al.* 1992). Additionally, they are relatively easy to sample quantitatively, and they exhibit a range of tolerances to environmental stress and pollution (Dutertre *et al.* 2013). Furthermore, they are scientifically well-studied, compared with other sediment-dwelling components (e.g. meiofauna and microfauna) and taxonomic keys are available for most groups.

Numerous studies have documented benthic community responses to multiple anthropogenic influences (Pranovi *et al.* 2008, Borja *et al.* 2011, Hale *et al.* 2018). While these include eutrophication and hypoxia, the effects of global warming and contamination effects were identified as just as important (Ballesteros *et al.* 2007**,** Callaway *et al.* 2007, Krann *et al.* 2011, Obst *et al.* 2017, Ranasinghe *et al.* 2009**,** Reis *et al.* 2008, Shojaei *et al.* 2016). Because they are largely dependent on local circumstances for their survival and reproduction, contact with contaminated sediment can cause sensitive species to perish and allow opportunistic, pollution tolerant species to proliferate. Benthic invertebrates are also naturally abundant and diverse with only a few intentionally managed by man. The net effect in response to pollution will be a skewing of community composition and structure that will reflect the general state of the environment. Pollution is typically reflected by shifts in the abundance of component species, reduction in diversity, or a relative proliferation of pollution tolerant, opportunistic species (Pearson & Rosenberg 1978; Borja *et al.* 2000, Josefson *et al.* 2008, Ryu *et al.* 2011).

The main aim of this marine ecological survey is to determine the levels of organics and pollutants in the sediment of the Milnerton Lagoon and the subsequent effects of these contaminants on benthic macrofaunal communities within the lagoon. There are numerous indices, based on benthic invertebrate fauna information, which can be used to reveal conditions and trends in the state of ecosystems. Environmental assessments are inherently complex and to address this it is recommended that several indices be used i.e. those based on community composition, diversity, species abundance and biomass, all of which are considered in this report.

2 METHODS

2.1 Sediment sample collection

Sediment samples were collected using a stainless steel Van Veen grab (which samples an area of 0.0289 m^2) from 12 sites located between the mouth and the Otto du Plessis Bridge (Figure 1). These samples were collected along the length of cross channel transects and included 2-3 samples per transect, depending on the width of the channel at that point (Figure 2). Similarly, 16 sediment samples were collected from eight transects (two replicates per transect) between the Otto du Plessis Bridge and the Blaauwberg Bridge. Thus, a total of 44 sediment samples from 20 sites were collected for this survey. Samples were labelled and stored in clean, 250 g plastic sample jars and kept chilled until submission to laboratories for analysis.

2.2 Benthic macrofauna survey

Macrofauna samples were collected from the same sites as the sediment samples but only included the 30 sites between the mouth and the Otto du Plessis Bridge. Samples were collected with the same sampling tool used for sediment and sieved through a 1 mm mesh bag. All benthic macrofauna (>1 mm in size) retained in the bag were stored in plastic bottles, preserved with 5 % formalin, labelled and transported to the laboratory for further analysis. No sediment or macrofauna samples were collected at station 10 (Figure 1) as numerous grab attempts bought up only rocks (Figure 2 and inset).

Figure 2 **An example of sediment sample sites located along bathymetry transects within the Milnerton Lagoon. Inset shows an example of rocks found at stations on transect 10.**

2.3 Laboratory analyses

Sediment analyses were carried out by CSIR Environmental Laboratory Services and Scientific Services in Cape Town. Summaries of the method used for each analysis is provided below.

2.3.1 Organics

Total organic carbon (TOC) and total organic nitrogen (TON) in sediment samples were determined by the laboratories of the CSIR. Samples were freeze dried and homogenised by ball milling with Zirconium balls and were then acidified with 1N HCl, Milli Q rinsed and dried. TOC and TON content was then analysed by thermo-catalytic tube combustion in an oxygenated atmosphere at high temperature. The combustion gases were separated by adsorption columns and sequentially quantified by a thermal conductivity detector MALS3.1 Vario Elementar El III Elemental Analyser with Helium as a carrier gas.

2.3.2 Metals

The sediment was first freeze-dried and ball-milled. Approximately 0.5 g of dried sediment was weighed into a digestion vessel and digested in a mixture of HNO_3-HCl. This is a 'near-total' digestion method that dissolves most elements that could become 'environmentally available' but is not designed to dissolve metals tightly incorporated in silicate structures (e.g. Al and Cr). The digestate was diluted to volume with deionised water, and the concentrations of various major, minor and trace metals detected and quantified using Inductively Coupled Plasma Optical Emission (ICP-OES. Mercury was analysed using a direct mercury analyser (DMA). Precision and extraction efficiency of the digestion and metal determination procedures was evaluated by analysing marine sediment reference standard TH-2 (National Research Council of Canada) amongst other QC checks. All recoveries were within acceptable tolerance and precision limits for quality assurance and quality control purposes. Quality assurance and quality control procedures were run with batches of samples. This included the analysis of laboratory blanks, laboratory duplicates, spiked blanks, and duplicate samples.

The following trace metals were analysed from the sediment samples collected in 2021:

- Aluminium (Al)
- Arsenic (As)
- Cadmium (Cd)
- Chromium (Cr)
- Iron (Fe)
- Mercury (Hg)
- Nickel (Ni)
- Lead (Pb)
- Zinc (Zn)

2.3.3 Benthic macrofauna

In the laboratory, samples were rinsed in a 1 mm sieve to remove formalin and stained with Rose Bengal to facilitate the separation of biological and non-biological matter. All fauna were then removed and preserved in 1% phenoxytol (Ethyleneglycolmonophenyl ether) solution. Thereafter, macrofauna were identified to species level where possible, but at least to family level in all instances. The validity of each species was confirmed on The World Register of Marine Species (WoRMS, www.marinespecies.org). The biomass (blotted wet mass to four decimal places) and abundance of each species was recorded for each sample.

2.4 Statistical analysis

Univariate data were analysed using the software package, Dell Statistica version 13.5. Multivariate data were analysed using the Plymouth Routines in Multivariate Ecological Research (PRIMER) software package (version 7) with PERMANOVA+ add-on package (Anderson *et al.* 2008).

2.4.1 Sediment

Product Moment Correlations were used to determine relationships between:

1. Mud content (extracted from Gihwala & Hutchings 2021) and TOC
2. Mud content and trace metal concentrations in sediments

2.4.1.1 Sediment quality guidelines

The Benguela Current Large Marine Ecosystem (BCLME) program reviewed international sediment quality guidelines in order to develop a common set of sediment quality guidelines for the coastal zone of the BCLME (Angola, Namibia and west coast of South Africa) (Table 1). The BCLME guidelines cover a broad concentration range and still need to be refined to meet the specific requirements of each country within the BCLME region (CSIR 2006). There are thus no official sediment quality guidelines that have been published for the South African marine environment as yet, and it is necessary to adopt international guidelines when screening sediment metal concentrations. The National Oceanic and Atmospheric Administration (NOAA) have published a series of sediment screening values which cover a broad spectrum of concentrations from toxic to non-toxic levels as shown in Table 1.

The Effects Range Low (ERL) represents the concentration at which toxicity may begin to be observed in sensitive species. The ERL is calculated as the lower 10^{th} percentile of sediment concentrations reported in literature that co-occur with any biological effect. The Effects Range Median (ERM) is the median concentration of available toxicity data. It is calculated as the lower 50^{th} percentile of sediment concentrations reported in literature that co-occur with a biological effect (Buchman 1999). The ERL values represent the most conservative screening concentrations for sediment toxicity proposed by the NOAA; and ERL values have been used to screen the Diep River Estuary sediments.

Statistical significance of spatial and temporal variations in TOC, TON and trace metal concentrations in sediment between two areas of the estuary (i.e. Lagoon vs Diep River) were investigated using parametric t-tests.

Table 1 **Summary of Benguela Current Large Marine Ecosystem and National Oceanic and Atmospheric Administration metal concentrations in sediment quality guidelines**

Metal (mg/kg dry wt.)	BCLME region (South Africa. Namibia. Angola)		NOAA	
	Special care	Prohibited	ERL	ERM
As	30-150	> 150	8.2	70.0
Cr	50-500	> 500	81.0	370.0
Cd	1.5 – 10	> 10	1.2	9.6
Cu	50 – 500	>500	34.0	270.0
Hg	0.5 - 5	> 5	150.0	700.0
Pb	100 – 500	> 500	46.7	218.0
Ni	50 – 500	> 500	20.9	51.6
Zn	150 – 750	> 750	150.0	410.0

2.4.1.2 Normalization

As mentioned earlier in Section 1.1.1, normalized metal ratios can be used to estimate the extent of metal contamination within the marine environment, and to assess whether there has been enrichment of metals from anthropogenic activities.

In this study trace metal (TM) concentrations were normalized against aluminium using the equation:

$$TM_{ratio} = \frac{[\mathrm{TM}]\ \mathrm{mg.kg^{-1}}}{[\mathrm{Al}]\%}$$

2.4.1.3 Enrichment factors

Enrichment factors for six metals (Cd, Cr, Fe, Ni, Pb and Zn) were calculated for Diep River Estuary sediment samples by dividing metal concentrations obtained in 2021 by the metal concentrations recorded for sediments in two areas of the system (Milnerton Lagoon and the Diep River in the vicinity of the Potsdam sewage works) during 1988-89 (Taljaard *et al*. 1992). Enrichment factors were similarly calculated for nine metals (Al, As, Cd, Cr, Fe, Hg, Ni, Pb and Zn) using sediment data collected during 2010 by Hutchings & Clark (2010).

2.4.2 Benthic macrofauna

2.4.2.1 Diversity indices and community descriptors

Macrofaunal abundance and biomass data were converted from values within a single grab sample to values per m^2. Macrofaunal community descriptors (number of taxa, abundance, species richness, evenness and diversity) were calculated using the DIVERSE function in PRIMER V7 (Anderson *et al.*

2008). Diversity indices provide a measure of diversity, i.e. the way in which the total number of individuals are divided up among different species. Understanding changes in benthic diversity is important as increasing levels of environmental stress generally decreases diversity. Two different aspects of community structure contribute to community diversity, namely species richness and equability (evenness). Species richness refers to the total number of species present while equability or evenness expresses how evenly the individuals are distributed among different species. A sample with greater evenness is considered to be more diverse. It is important to note when interpreting diversity values that predation, competition and disturbance all play a role in shaping a community. For this reason, it is important to consider physical parameters as well as other biotic indices when drawing conclusions from a diversity index.

Shannon-Weiner diversity index (H') and Margalef's species richness (d), were calculated for each sampling location using PRIMER V7:

$$H' = -\Sigma p_i(\log p_i) \qquad d = (S-1)/\mathrm{Log}(N)$$ [1]

Taxonomic richness (alpha diversity or total number of species/taxa), total abundance, and biomass were also calculated. One-way analysis of variance (ANOVA) was employed to determine the influence of sites along the Milnerton Lagoon on community descriptors along with post-hoc Tukey tests to identify where differences between sites were found.

2.4.2.2 Community structure and composition

Using PRIMER V7, Macrofaunal abundance data were either root-root (fourth root) or square root transformed and converted to a similarity matrix, either using the Bray-Curtis similarity coefficient (for datasets where species are present across all samples) or the zero-adjusted Bray-Curtis similarity coefficient (for sparse datasets where no species were found across two or more samples). Hierarchical cluster analysis and multi-dimensional scaling plots (MDS) were constructed to identify 'natural groupings' between sites for the spatial assessment. MDS plots preserve the rank order of inter-point dissimilarities, based on a resemblance measures, within the constraints of a small number of dimensions, i.e., it is a non-parametric approach.

This routine is used to visualise patterns in a dataset in a small number of dimensions (usually two) and often the true relationship between the multivariate data points is not adequately projected. To measure how well the two-dimensional plot may represent the sample relationship, a stress value for MDS plots is given, whereby a value > 0.25 indicates that a higher dimensional projection may be more appropriate. It is important to remember that the community composition reflects not only the physico-chemical health of the environment but also the ability of communities to recover from disturbance.

[1] Where p_i is the proportion of the total count arising from the *i*th species. This is the most commonly used diversity measure and it incorporates both species richness and equability. S is total species and N is total individuals.

The PERMANOVA routine, contained in the PERMANOVA+ for PRIMER 7 software package, tests the simultaneous response of one or more variables to one or more factors in an analysis of variance (ANOVA) experimental design on the basis of a resemblance measure (e.g. Bray-Curtis similarity), using permutation methods (Anderson *et al.* 2008). In this study, this routine was applied to test for statistically significant differences of a particular variable, such as abundance among (*a priori* defined) groups of samples (e.g. sites). In essence, the routine performs a partitioning of the total sum of squares according to the specified experimental design, including appropriate treatment of factors that are fixed or random, crossed or nested, and all interaction terms. A distance-based *pseudo-F* statistic is calculated in a fashion that is analogous to the construction of the *F* statistic for multi-factorial ANOVA models. *P*-values are subsequently obtained using an appropriate permutation procedure for each term. The significance level used for the PERMANOVA routine is $p < 0.05$. The contributions of each species to the average dissimilarity between two treatment groups, and to the average similarity within a group, were assessed using a SIMPER (Similarity Percentages) analysis. This technique seeks to identify taxa that are principally responsible for differences detected in community structure between sites or groups.

The relationship between biotic (macrofaunal abundance) and abiotic variables (sediment granulometry, organics, trace metal concentrations and distance from the mouth) was investigated using a Distance Based Linear Model (DistLM) (Anderson *et al.* 2008) as previous multivariate analyses grouped similar samples together but did not relate that grouping to the environmental conditions. DistLM conducts a marginal test that determines the proportion of variance in the macrofauna distribution pattern that can be explained by each abiotic variable. DistLM then partitions the variation of the distribution data according to a multiple regression model (based on predictor variables) as selected by the user, (forward, backward, step-wise or best fit), which provides a best solution for a combination of sediment fractions. The 'step-wise' procedure and 'Adj R^2' criteria were used in this study. DistLM requires a balanced dataset with an equal number of sample replicates for all variables.

3 RESULTS AND DISCUSSION

3.1 Sediment Quality

3.1.1 Particle size and Organics

Summary results of the particle size analysis of sediments sampled from the Diep River Estuary in 2021 (Gihwala & Hutchings 2021) have been included in this report. Particle size analysis indicated that sand was the main component in the study area (Figure 3). Sediment samples could not be collected at site 10 due to the presence of rocks. Furthermore, there appears to be a greater proportion of fine sediment (i.e. mud) as opposed to gravel across all the sites (except for site 18). These results are similar to findings reported from previous studies, although, the authors did not report any gravel component in their surveys (Hutchings & Clark 2010, CSIR 2015). However, the present survey indicates that while sand appears to be the main particle size fraction, the proportion of mud increases with distance upstream in the estuary, particularly at sites close to the Blaauwberg Bridge, and at sites (3-5) in the vicinity of Woodbridge Island (Figure 3). This survey also indicated higher proportions of fine sediment as opposed to those reported in the previous surveys (Hutchings & Clark 2010, CSIR 2015).

TOC/TON levels along the Diep River Estuary in the present survey indicated low concentrations within the lagoon area (except for the sites 3-5 in the vicinity of Woodbridge Island and site 12 near the Otto du Plessis Bridge) compared to the Diep River further upstream (Figure 4). Although, TOC and TON concentrations were not significantly different between the two areas (T-tests: TOC, $t = 1.05$, $p > 0.05$; TON, $t = 0.68$, $p > 0.05$), despite the high concentrations found within the vicinity of the Woodbridge Island and Otto du Plessis Bridge. The latter organic rich samples held high inter-sample variability, with some replicates yielding exorbitant concentrations, although no laboratory analytical errors were detected. From visual inspection, it was clear that these replicate samples were finer and darker than the rest of the samples which supported the higher TOC/TON values for the organic rich samples.

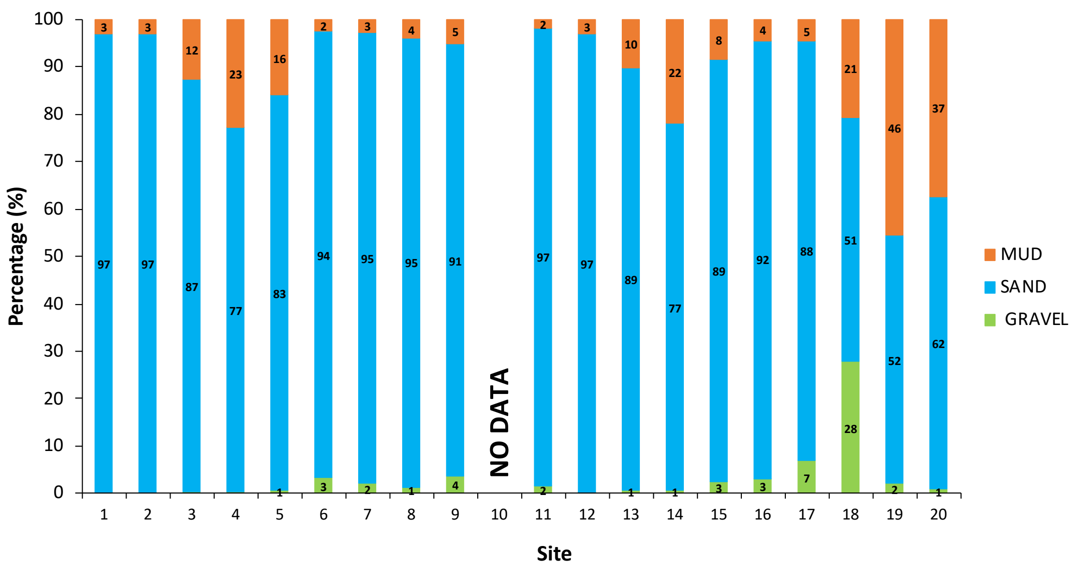


Figure 3 **Mean cumulative percentage contribution of sediment particle grain size fractions (gravel, sand and mud) sampled at 20 transects on the Diep River Estuary 10-11 June 2021 (Gihwala & Hutchings 2021).**

Furthermore, both TOC (r = 0.414) and TON (r = 0.436) was significantly ($p < 0.01$), positively correlated with the percentage mud in samples collected from the Diep River Estuary (Figure 5). The latter supports the former findings with increased proportion of fine sediment (Figure 3) and TOC/TON levels (Figure 4) with distance upstream in the estuary. These results are intuitive considering contaminants such as metals and organic toxic pollutants are predominantly associated with fine sediment particles (mud and silt). This is because fine grained particles have a relatively larger surface area for pollutants to adsorb and bind to. Higher proportions of mud, relative to sand or gravel, can thus lead to high organic loading and trace metal contamination (Clark *et al.* 2020).

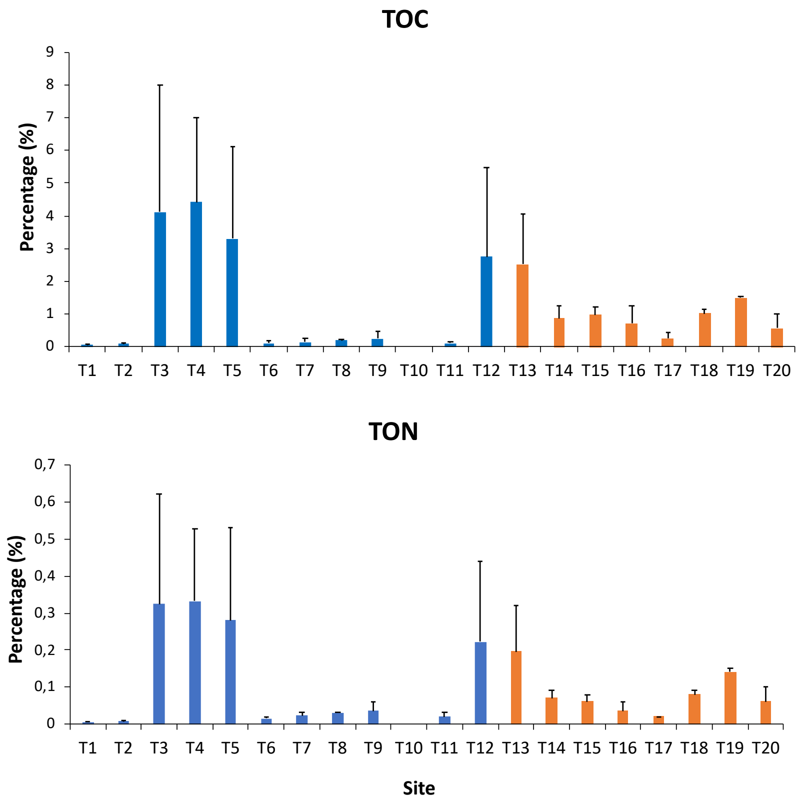


Figure 4 **Mean percentage of Total Organic Carbon (TOC) and Total Organic Nitrogen (TON) sampled at 20 transects on the Diep River Estuary 10-11 June 2021.**

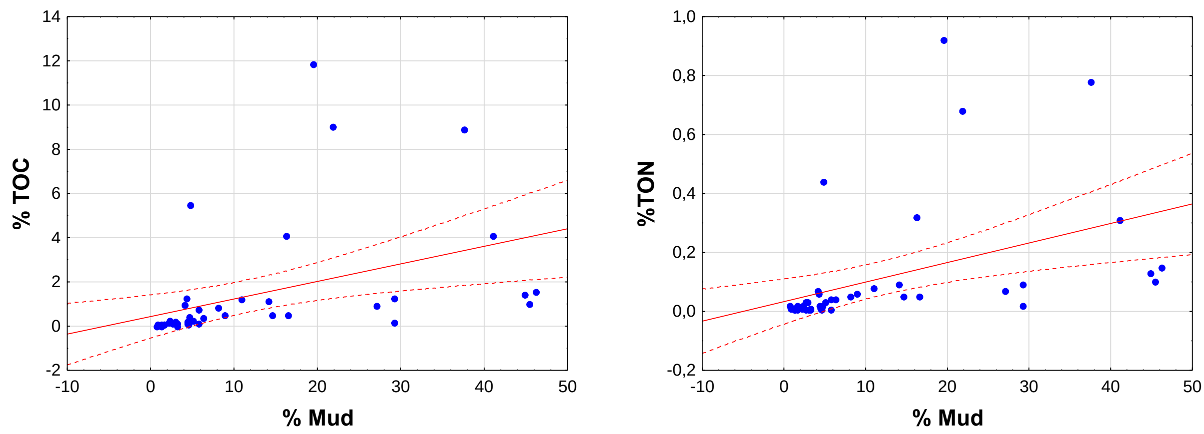


Figure 5 **Relationship of total organic carbon (TOC) and total organic nitrogen (TON) to mud content in the 44 sediment samples collected at sites on the Diep River Estuary.**

3.1.2 Trace Metal Concentrations

Trace metals occur naturally in marine and estuarine environments, and some are important in fulfilling key physiological roles. Disturbance to the natural environment by either anthropogenic or natural factors can lead to an increase in metal concentrations occurring in the environment, particularly sediments. An increase in metal concentrations above natural levels, or at least above established safety thresholds, can result in negative impacts on organisms, especially filter feeders like mussels that tend to accumulate metals in their flesh. High concentrations of metals can also render these species unsuitable for human consumption. Metals are strongly associated with the cohesive fraction of sediment (i.e. the mud component) and with Total Organic Carbon. Metals occurring in sediments are generally inert (non-threatening) when buried in the sediment but can become toxic to the environment when they are converted to the more soluble form of metal sulphides.

This section of the report focuses on the trace metals deemed to pose the greatest threat to the health of the estuarine environment, as well as those previously determined for the Diep River Estuary (Taljaard *et al.* 1992, Hutchings & Clark 2010). These selected trace metal concentrations in sediments collected from the Diep River Estuary in 2021 are illustrated in Figure 6.

Visually, there appears to be greater trace metal accumulation in sediments further upstream of the Diep River Estuary, past the Otto du Plessis Bridge (sites 13 and 14) and particularly at sites close to the Blaauwberg Bridge (sites 18-20). The latter pattern was not observed for Pb, Zn and Hg. Nonetheless, the majority of the elements mirrored the patterns observed for mud content and TOC/TON levels along the estuary. This is further supported with all trace metal concentrations being significantly ($p < 0.05$) positively correlated with percentage mud in sediment samples collected from the Diep River Estuary (Table 2 and Figure 7). In addition, t-tests indicating significant differences ($p < 0.05$) between the two areas (Milnerton Lagoon vs Diep River) were only detected for five elements (Al, As, Cr, Fe and Ni).

Cr, Pb and Hg were the only three elements sampled from the Diep River Estuary that did not exceed the South African and international sediment quality guidelines (Figure 6). At some transects, particularly sites 13-15, metal concentrations exceeded sediment quality guidelines for As, Cd, Ni and Zn. The latter patterns were also observed at sites 18-20 (close to the Blaauwberg Bridge) and sites 3-5 near Woodbridge Island, except for Zn and As, respectively. Interestingly, trace metals Cd, Zn and Pb were found to have exceeded sediment quality guidelines at some sites previously sampled in Milnerton Lagoon (Hutchings & Clark 2010).

Table 2 **Correlation coefficients between 2021 Diep River Estuary trace metal concentrations and sediment granulometry (% mud). Significant ($p < 0.05$) r values are highlighted in red.**

Metal	% Mud	Metal	% Mud
Aluminium	0.870	Nickel	0.756
Arsenic	0.802	Lead	0.335
Cadmium	0.941	Zinc	0.428
Chromium	0.850	Mercury	0.353
Iron	0.786		

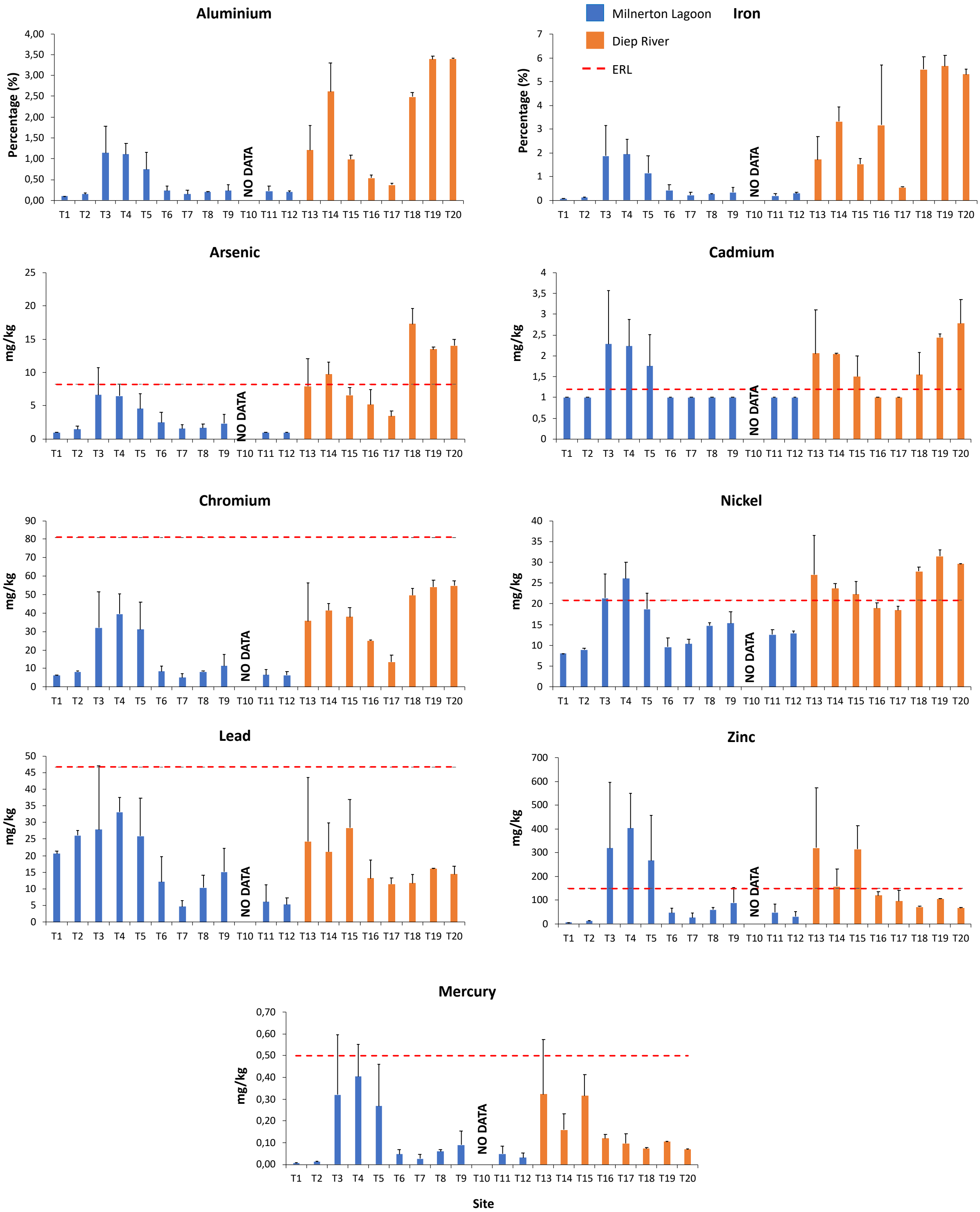


Figure 6 **Average Diep River Estuary sediment trace metal concentrations at 20 transects. Sediment quality guidelines indicated by red lines (South African special care concentrations for Mercury and NOAA ELR limits for the rest).**

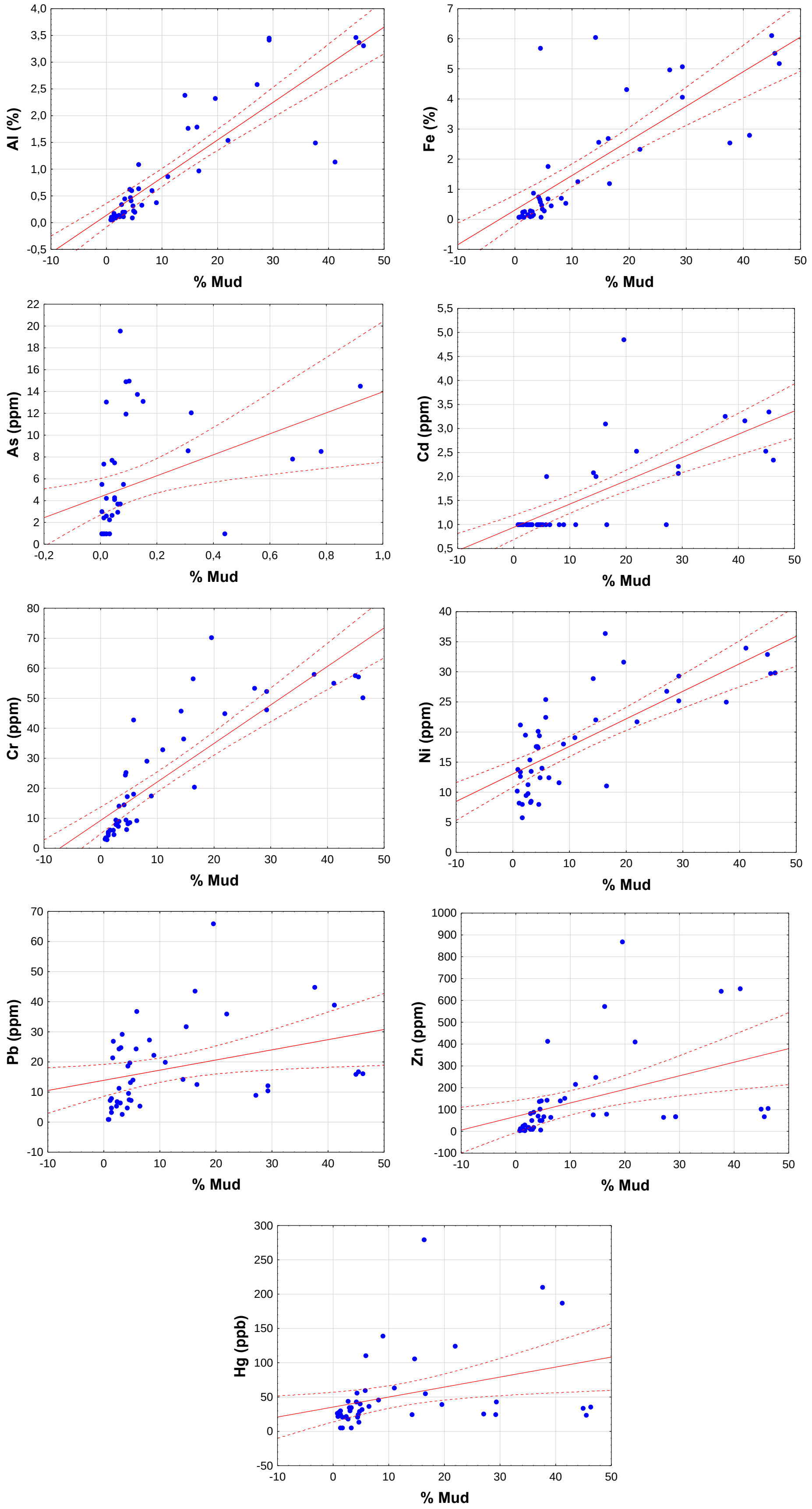


Figure 7 **Relationships between all sediment trace metal concentrations [Aluminium (Al), Iron (Fe), Arsenic (As), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Lead (Pb), Zinc (Zn) and Mercury (Hg)], and sediment mud content in the 44 sediment samples collected at sites on the Diep River Estuary.**

Trace metal concentrations in the sediments sampled in the Diep River Estuary, expressed as ratios of the concentration of Al as a percentage (refer to Section 2.4.1.2) are shown in Figure 8. Theoretically these ratios allow for comparison of trace metal concentrations between sites and give an indication of where metal concentrations are elevated by anthropogenic activities.

Remarkably, the normalized trace metal data depicted in Figure 8 illustrate sites within the Milnerton Lagoon region to be elevated compared to those further upstream of the estuary, with the exception of As:Al and Cr:Al. Sites close to the Blaauwberg Bridge previously showcased elevated trace metal accumulation in sediments, of which some elements even exceeded the guidelines (Figure 6), although, this is not the case in the data presented below. Additionally, trace metal concentrations at sites 1-2 (close to the mouth of the estuary) are higher compared to the rest of the stations, except for Zn:Al and Hg:Al. Overall, the geochemical ratios on the Diep River Estuary for four trace metals were substantially greater than those reported for Small Bay in Saldanha Bay (considered polluted) and orders of magnitude greater than the ratios naturally occurring in the earth's crust (Table 3).

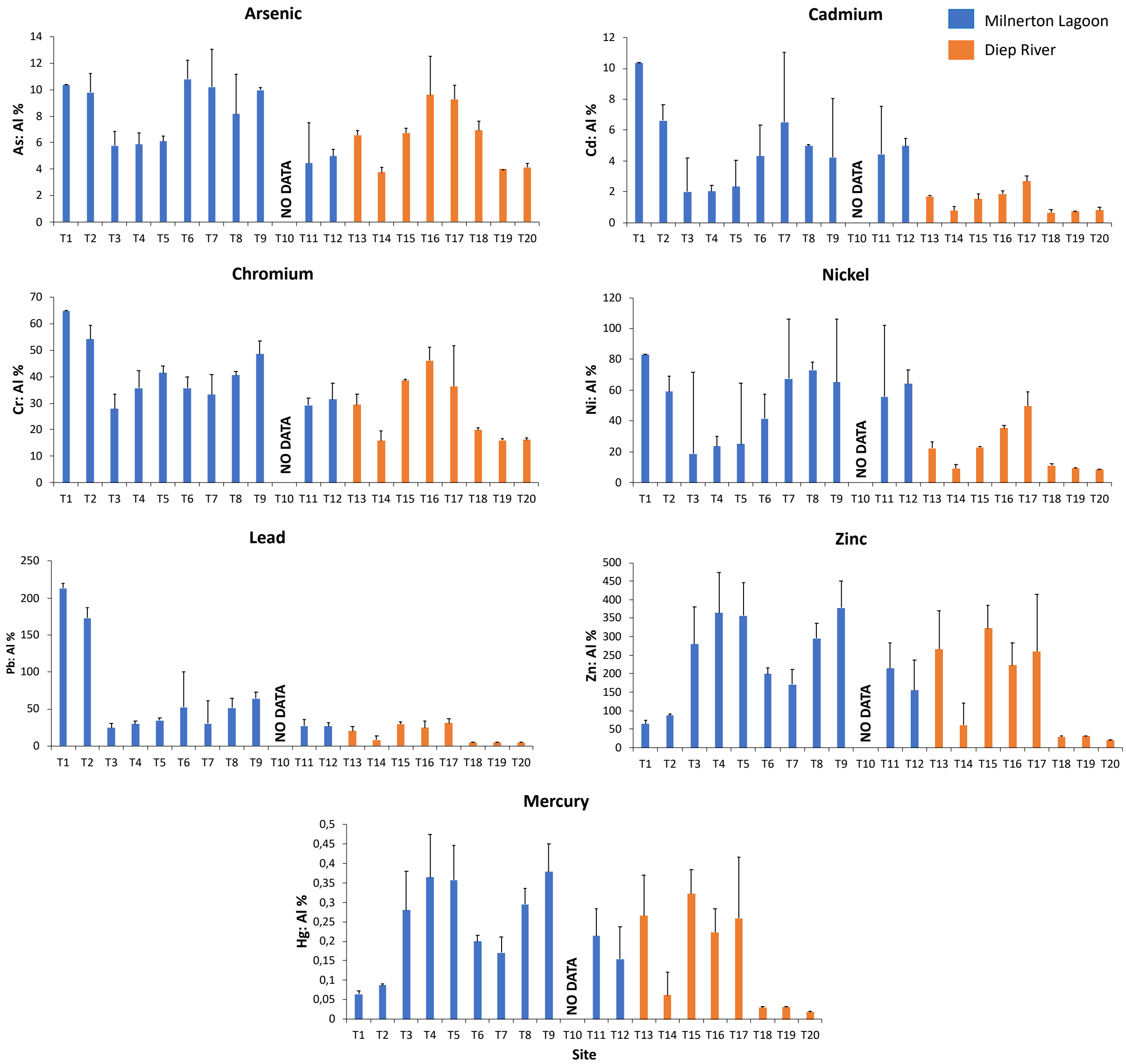


Figure 8 **Average trace metal concentrations expressed as a ratio of Aluminum in the sediments sampled in the Diep River Estuary.**

Table 3 **Average geochemical ratios of trace metals relative to aluminium. Values for Small Bay Saldanha and the earth's crust are shown for comparative purposes.**

Location	As	Cd	Cr	Ni	Pb	Zn
Diep River Estuary (This survey)	7.23	3.34	34.82	39.16	44.88	198.71
Small Bay in Saldanha (Clark *et al.* 2020)	6.40	2.19	61.52	34.18	41.20	6.40
Earth's Crust (Monteiro *et al.* 2004)	1.1	0.3	50	7.1	2.3	18.3

Enrichment factors for trace metals between Milnerton Lagoon and Diep River were calculated by dividing current concentrations by historical data measured by Taljaard *et al.* (1992) and Hutchings & Clark (2010); and are illustrated in Figure 9. Substantial increases in the concentrations of Cd, Fe and Zn were evident in the Milnerton Lagoon and Diep River sediments over the past 32 years. Interestingly, noticeable decreases in the concentrations of these same metals were observed in 2010 compared to 1989, whilst Cr and Ni concentrations have elevated over time across the Lagoon and Diep River. Furthermore, t-tests indicated significant ($p < 0.05$) elevations in Cd ($t = -2.23$), Cr ($t = -2.16$) and Ni ($t = -3.63$) concentrations within the Diep River compared to 2010. In contrast, in the Milnerton Lagoon, Cd ($t = 2.32$) and Pb ($t = 2.07$) concentrations had significantly ($p < 0.05$) declined compared to 2010. Generally, the majority of the trace metals measured in the sediments of the Diep River Estuary have increased i.e., become enriched (> 1) compared to historical surveys (Taljaard *et al.* 1992, Hutchings & Clark 2010).

Comparison of the average estuary sediment trace metal values with data available for other local and international estuaries reveal concentrations in the Diep River Estuary are amongst the highest for Cd, Ni and Zn (Table 4). It is of great concern, particularly elements like Zn that are typically elevated by anthropogenic actions and are known to have eco toxicological effects (Hutchings & Clark 2010).

Table 4 **Comparison of mean sediment metal concentrations ($mg.kg^{-1}$) in the Diep River Estuary and other estuaries in South Africa and elsewhere internationally.**

Region	Estuaries and coastal areas	Al	Fe	Cd	Cr	Pb	Ni	Zn
South Africa	Diep River Estuary[1]	9656.2	16593.1	1.51	24.4	17.9	18.4	141.2
	Mhlatuzi Estuary[2]	12668	17094	0.2	53.3	13.6	13.4	18.8
	Mhlatuzi Estuary[3]		21353		66.3	14.4		46.9
	Swartkops Estuary[4]				20.3	32.9		35.9
	Swartkops Estuary[5]		13020	0.2	3.5	16.7	7.5	35.5
	West Kleinmonde[6]		5435	0.8			11.8	21.9
International	St. Louis Estuary (Senegal)[7]	1814	1819	0.7	67.6	233	7.9	30.8
	Brisbane Estuary (Australia)[8]		15784	0.3	15	25.6	15.3	106
	Hooghly Estuary (India)[9]		28600	2.0	40.1	23.4	33.9	53.4
(1) This study (2) Izegaegbe *et al.* 2020 (3) Mzimela *et al.* 2014 (4) Binning & Baird 2001 (5) Watling 1988 (6) Orr 2008 (7) Diop *et al.* 2015 (8) Duodu *et al.* 2017 (9) Banerjee *et al.* 2012								

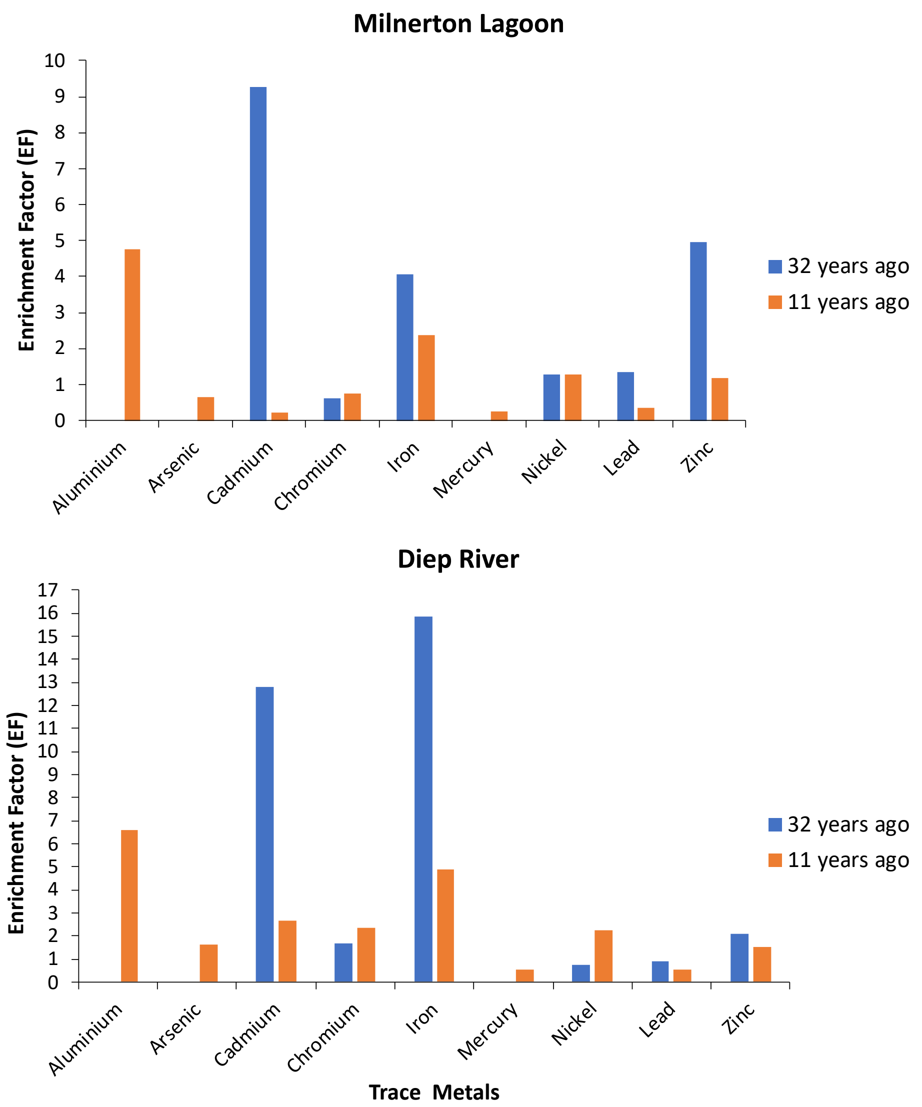


Figure 9 **Enrichment factors for present day trace metals in the Diep River Estuary sediments when compared to trace metals 32 years (Taljaard *et al.* 1992) and 11 years (Hutchings & Clark 2010) ago.**

Overall, results from this survey have highlighted that sites sampled along the Diep River Estuary consisted primarily of a coarse sandy texture. Additionally, mud content was higher at three sites in the vicinity of Woodbridge Island, two sites above the Otto du Plessis Bridge and increased with distance upstream, particularly at sites close to the Blaauwberg Bridge. This is probably due to decreases in hydrodynamic flow at these sites caused by biotic e.g. marginal vegetation (*Phragmites* reeds) and alien aquatic macrophytes (water hyacinth), or anthropogenic obstructions (bridges) allowing fine-grained sediment to be deposited at a greater rate compared to sites elsewhere in the estuary where faster flowing currents disperse fine sediments. As expected, TOC/TON levels as well as a number of trace metal concentrations mirrored the patterns observed for mud content along the Diep River Estuary; since higher proportions of mud, relative to sand or gravel, can lead to high trace metal contamination. Thus, there is a concern considering four trace metals (As, Cd, Ni and Zn) measured along the Diep River Estuary exceeded the South African and international sediment quality guidelines.

3.2 Benthic Macrofauna

3.2.1 Community descriptors and composition

A total of 728 macrofaunal organisms from six different taxa were recorded from sampling transects between the mouth of the lagoon up until the Otto du Plessis Bridge. This represents a dramatic decline in diversity since the earliest survey by Millard & Scott (1954). The authors recorded 47 species within Milnerton Lagoon, yet this reduced by half to 23 in 1974 by Weil (unpublished data) and in 2014 (Viskich *et al.* 2016). Interestingly, only six (*Capitella capitata*, *Ficopomatus enigmaticus*, *Scolelepis squamata*, *Kraussillichirus kraussi*, *Melita zeylanica* and *Hymenosoma orbiculare*) of the 69 taxa listed were recorded by all three surveys between 1954 and 2014 (Viskich *et al.* 2016). From these, only the polychaete *C. capitata* and the brachyuran *H. orbiculare* were observed in the present study.

Important to note, only 28 successful macrofauna samples were collected from 11 sites. Sampling at site 10 was not successful due to the presence of rocks. Furthermore, sample sorting indicated only 13 of the 28 samples contained macrofaunal organisms. Considering this and only six taxa identified in the present study, the presence of benthic macrofaunal communities is minimal. In support of the latter, bivalve molluscs (e.g. mussels *Choromytilus meridionalis* and oysters *Ostrea* sp) and gastropods previously reported from the Diep River Estuary (Millard & Scott 1954) were not found during the present survey, indicating a complete disappearance of bivalve and gastropod species from subsequent surveys. Similarly, whilst species of amphipods and isopods were recorded in previous surveys (Millard & Scott 1954, Viskich *et al.* 2016), none were reported in the present study. Nonetheless, the polychaete *C. capitata* dominated all samples and constituted 79% of the abundance, followed by spionid *Prionospio sexoculata.* Remarkably, the latter species was not reported again after 1954 in the 1974 and 2014 surveys and appears to be re-introduced into the system. Despite the substantial absence of taxa, one must be cognizant that seasonality will likely influence species richness within the system; as species richness was previously reported to be considerably higher during summer than winter surveys (Viskich *et al.* 2016).

A spatial comparison of univariate indices of abundance, biomass, species richness and Shannon Weiner diversity was recorded along the 11 sampling stations between the mouth of the lagoon and the Otto du Plessis Bridge (Figure 10). Abundance/biomass values were predominately recorded along the lower reaches of the estuary, near the mouth (sites 1-3). Diversity indices followed suit but were also present further upstream, near the Otto du Plessis Bridge, and were highly variable. ANOVA results only detected significant differences in abundance (F_{10} - value = 2.76, $p < 0.05$) and species richness (F_{10} - value = 3.04, $p < 0.05$). Post-hoc tests indicated that abundance (post- hoc Tukey: $p < 0.05$) and species richness (post- hoc Tukey: $p < 0.05$) at site 2 was significantly greater than sites 4 and 7 (near the Woodbridge Island). Differences in average biomass were not significant (F_{10} - value = 0.84, $p > 0.05$) – this could be explained by the high biomass of *C. capitata* present in samples collected at site 2. In summary, mean indices of Shannon Weiner Diversity and biomass were similar across the 2021 survey, while abundance and species richness differed.

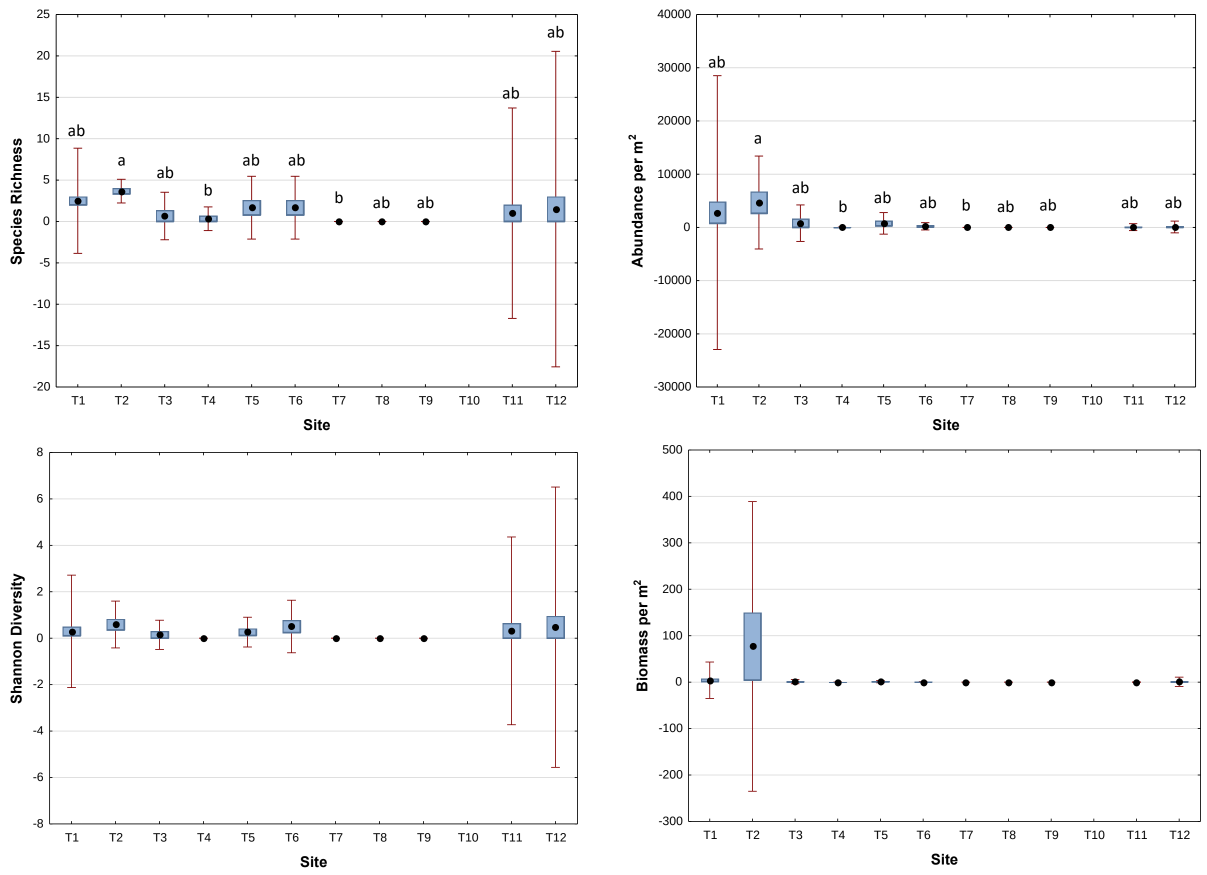


Figure 10 **Abundance (m^2), species richness, Shannon-Wiener diversity index and wet biomass (m^2) from data collected at 11 sampling station within Milnerton Lagoon in 2021. Values displayed are means, boxes are ± 1 SE and whiskers, 0.95 confidence interval.**

3.2.2 Multivariate analysis of spatial patterns in community composition

3.2.2.1 Spatial patterns in benthic macrofauna

The dissimilarity in macrofaunal community structure among samples collected during the 2021 survey is displayed in a Metric multidimensional scaling (MDS) plot (Figure 11). Visually, there is a clear spatial separation of sites grouped by relative distance from the river mouth with distinct clusters. Samples with no macrofaunal organisms are grouped together and these appear to be from sites located 1.5 km from the mouth and further upstream. Furthermore, disparity is evident between replicate samples taken along the same transect line. PERMANOVA validated these findings, and indicated significant differences in community structure among sites (Pseudo-F_{11} = 1.99, $p < 0.05$). This is expected, considering the absence of macrofauna in more than half of the samples (15 out of 28).

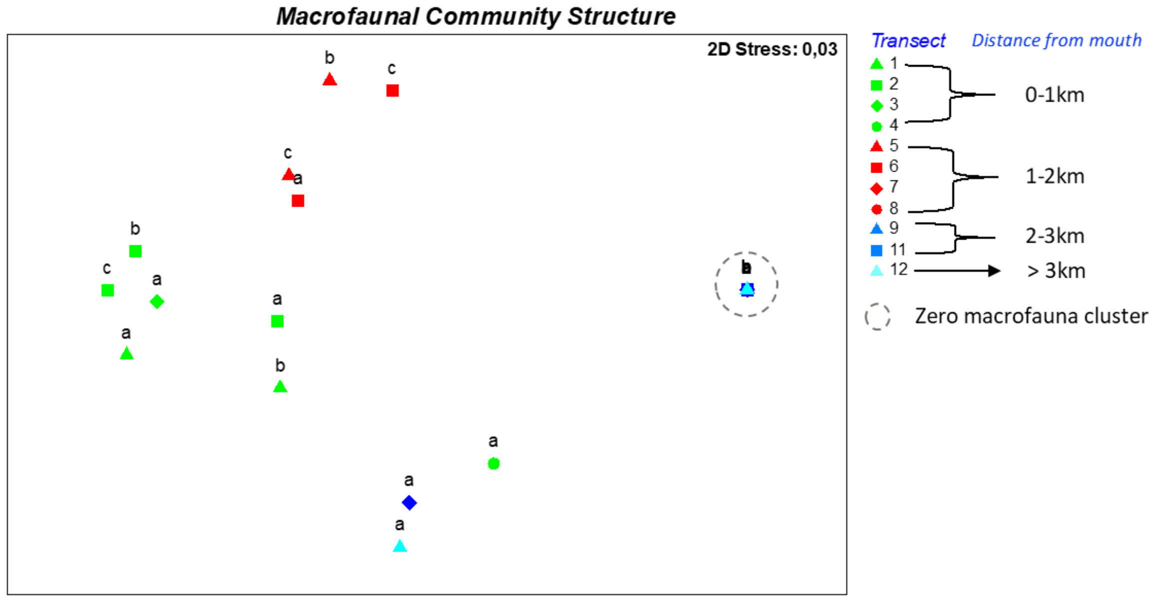


Figure 11 **Metric multidimensional scaling (MDS) plot of macrofaunal community composition at stations sampled during the 2021 Diep River Estuary survey. Colours denote the relative distance of the sites from the river mouth. The MDS plot is based on Bray-Curtis similarity (+1 dummy variable) measure.**

3.2.2.2 Indicator species

SIMPER analyses indicated which taxa contributed to the average similarity/dissimilarity between treatment groups (i.e. relative distance from the river mouth). The two most important species responsible for the dissimilarity between 0-1 km and 1-2 km distances from the river mouth (91.18% average dissimilarity) were the polychaetes *C. capitata* and *P. sexoculata*. The latter species along with insect larvae *Chironomis* sp. were the main contributors for the dissimilarity between 0-1 km and 2-3 km distances from the river mouth (95.81% average dissimilarity). Interestingly, the three aforementioned species contributed for the dissimilarity between 1-2 km and 2-3 km distances from the river mouth (98.46% average dissimilarity). Bubble plots (Figure 12) in conjunction with the latter, demonstrate that the main species contributors are evidently restricted to either sections of the mouth (i.e. *C. capitata*) or further upstream of the Diep River Estuary (*P. sexoculata* and *Chironomis* sp.).

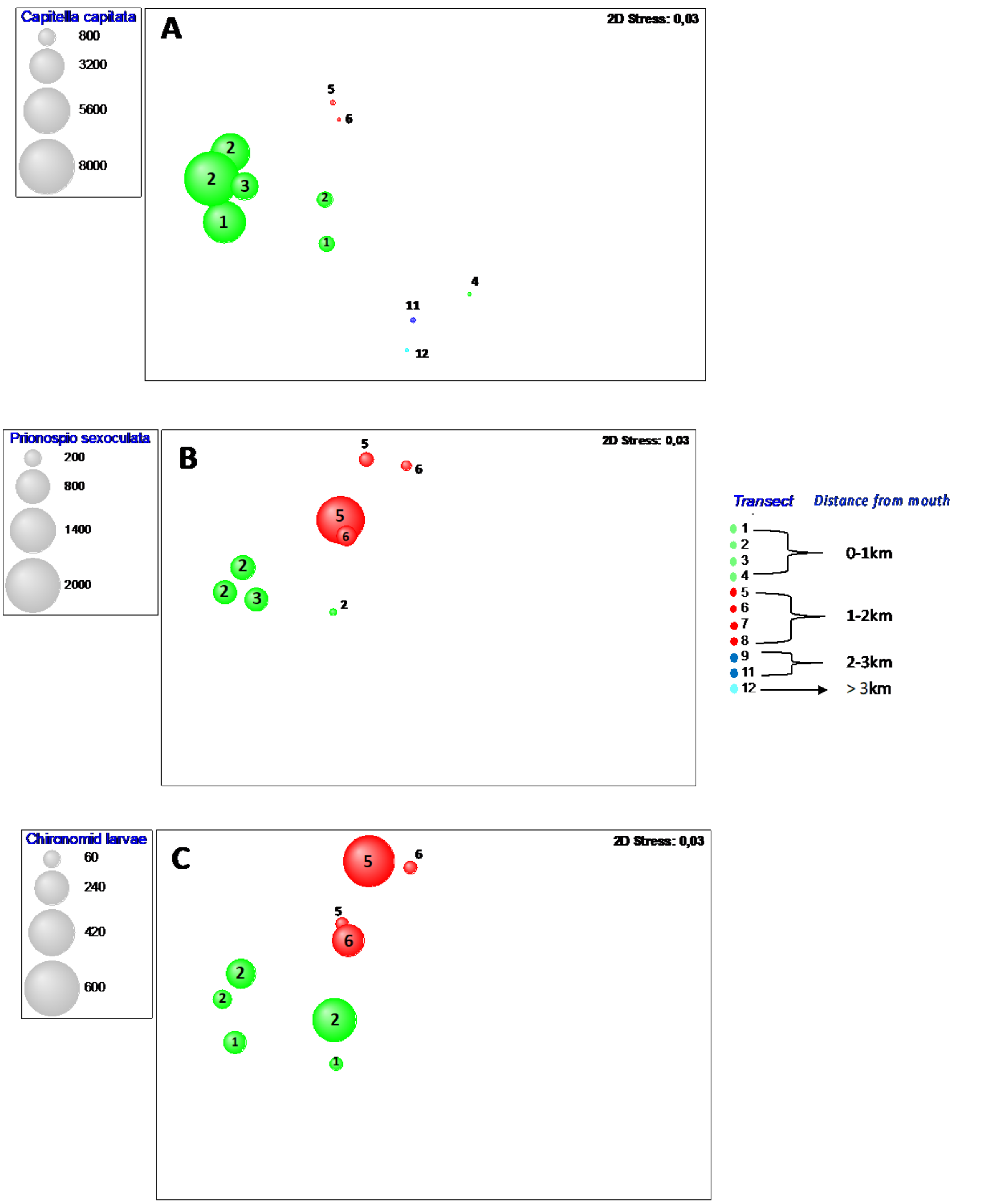


Figure 12 **Bubble plots indicating the relative abundance (m^2) of A: *C. capitata*, B: *P. sexoculata* and C: *Chironomis* sp. Colours denote the relative distance of the sites from the river mouth. The MDS plot is based on Bray-Curtis similarity (+1 dummy variable) measure.**

3.2.3 Linking relationships between macrofaunal communities and abiotic parameters

A Distance Based Linear Model (DISTLM)(Anderson *et al.* 2008) was performed to assess the relationship between the 2021 benthic macrofaunal data and various abiotic parameters (sediment granulometry, organics, trace metal concentrations and distance from the mouth).

Marginal tests indicated that gravel and distance from river mouth were the only factors that explained a significant proportion of the variation observed in macrofaunal abundance (Table 5). When considered alone, these two factors explained 11 and 14% of the variation respectively; whereas the proportion of the variation explained by the rest of the factors were low. The sequential test revealed that a combination of five input variables (i.e. distance from mouth, As, Pb, Cr and Hg) explained 45% of the variation in the data cloud, with distance from mouth, Arsenic and Lead contributing significant proportions thereof (Table 5).

Table 5 **Results of the DistLM marginal and sequential tests of macrofauna abundance data at 11 transects sampled within Milnerton Lagoon in 2021 for the predictor variables: sediment granulometry, organics, trace metal concentrations and distance from the mouth). Sequential tests are conducted using the 'step-wise' procedure and yield an adjusted R^2 value. Res. df = 26 for marginal tests. The outcome of the best model solution in the sequential tests is highlighted in bold. Statistical significance ($p < 0.05$) is shown in RED.**

MARGINAL TESTS				
Variables	**SS(trace)**	**Pseudo-F**	**P**	**Proportion**
% TOC	3377.2	1.256	0.29	0.046
% TON	3849.6	1.441	0.241	0.053
% GRAVEL	8017.2	3.192	0.031	0.109
% SAND	5664	2.177	0.11	0.077
% MUD	3815.2	1.427	0.229	0.052
Aluminium	6288.7	2.439	0.064	0.086
Arsenic	6204.5	2.404	0.079	0.085
Cadmium	3312.9	1.23	0.262	0.045
Chromium	3737.8	1.397	0.228	0.051
Iron	5763.1	2.218	0.104	0.079
Nickel	5697.6	2.191	0.106	0.078
Lead	208.76	0.074	0.988	0.003
Zinc	4806.3	1.824	0.129	0.066
Mercury	6773.5	2.647	0.067	0.092
Distance from mouth (km)	9988.9	4.101	0.015	0.136

SEQUENTIAL TESTS							
Variables	**Adj R^2**	**SS (trace)**	**Pseudo-F**	**p**	**Proportion**	**Cumul.**	**res.df**
Distance from mouth (km)	0.103	9988.9	4.1011	0.028	0.136	0.136	26
Arsenic	0.237	11503	5.549	0.007	0.157	0.293	25
Lead	0.298	6062	3.1792	0.032	0.083	0.376	24
Chromium	0.302	2185.6	1.1536	0.294	0.03	0.406	23
Mercury	0.324	3204.1	1.746	0.162	0.044	**0.449**	22

The full model can be visualised by examining the distance-based redundancy analysis (dbRDA) ordination (Figure 13). The first two axes capture 75.8% of the variability in the fitted model, and 48.8% of the total variation in the data cloud. The black lines in the dbRDA plot are category vectors, whereby the length of the vectors is a measure of the strength of the relationship between that category and the axes. It is evident that distance from the river mouth separated the various sites along the Diep River Estuary. This was coupled with As and Pb concentrations which in turn separated sample replicates among the groups of relative distance from the river mouth. The relatively medium percentage of variation explained by the model indicated that the abiotic variables measured were adequate in predicting the variation observed in the biotic data. However, it is important to note that only 28 samples were utilized in this linear regression model. To provide a true reflection of the relationship shared between biotic and abiotic parameters, a larger sample size is preferred as small numbers of observations often result in intercorrelations among parameters thereby compromising the overall statistical model (Anderson *et al.* 2008). Overall, the model has indicated that distance from river mouth, along with trace metal concentrations (i.e. As and Pb) were the most important drivers in determining benthic macrofaunal community structure. More specifically, these parameters were influencing the relative abundance of the three contributor species previous mentioned (Figure 12), considering these species were numerically dominant as opposed to the remaining taxa.

Literature has documented the effects of heavy metal exposure to various invertebrates causing physiological stress, hindering reproductive success and mortality (Peters *et al.* 1997, Nicholson 1999, Radford *et al.* 2000, Fleeger *et al.* 2003, Gagnaire *et al.* 2004). However, findings presented in this study indicate the three contributor species do not appear to be negatively impacted with current As and Pb concentrations within the sediment, despite elevated concentrations at sites 3-5 near the Woodbridge Island. This is intuitive considering both metals were below their respective ERL thresholds (Figure 6). Although, it appears that *P. sexoculata* and *Chironomis* sp. were relatively abundant further upstream (1-2 km from the estuary mouth) compared to *C. capitata*, which dominated in the lower reaches of the system (near the mouth). Similarly, levels of As were lowest in this section of the estuary as opposed to moderate Lead concentrations along the lagoon. Remarkably, numerous studies have demonstrated how opportunistic polychaetes, namely *C. capitata* (Ward & Hutchings 1996, Fukunaga *et al.* 2010, Mosbahi *et al.* 2019) as well as species of *Prionospio* (Fukunaga *et al.* 2010) exploit heavily polluted areas (observed particularly for Pb).

It has been established that benthic organisms serve as useful bio-indicators to monitor and detect changes in the health of marine and estuarine environments, particularly for pollution impacts (Khatri & Tyagi 2015, Parmar *et al.* 2016, Rodrigues *et al.* 2017, Abessa *et al.* 2019). Polychaetes have been identified as the initial macrobenthic colonists to inhabit disturbed environments with a pollution gradient (Loo 2001, Çinar *et al.* 2006, Dean 2008, Kies *et al.* 2020). Although, it has been reported that polychaete species may display great variability in their sensitivities to different pollutants (Dean 2008). For example, Reish & Gerlingher (1997) reported *Nereis virens* to be vulnerable against Hg whereas another species within the Nereididae family, namely *Nereis diversicolor* was tolerant to this metal. Nonetheless, it has become increasingly clear in recent years, that total metal concentration is not a good predictor of environmental effects (Morrisey *et al.* 1995, Wong *et al.* 1995, Pretorius *et al.* 2001). Instead, the understanding of the variation in trace metal toxicity to a variety of species has been greatly improved by the concepts of bioavailability (Rainbow 2002, Landner and Rudolf 2005); along with the development of bio-indicators as a promising alternative approach for the monitoring of environmental pollution (Holt & Miller 2010, Abdul Jaffer Ali *et al.* 2015, Mdaini *et al.* 2020, Roveta *et al.* 2021).

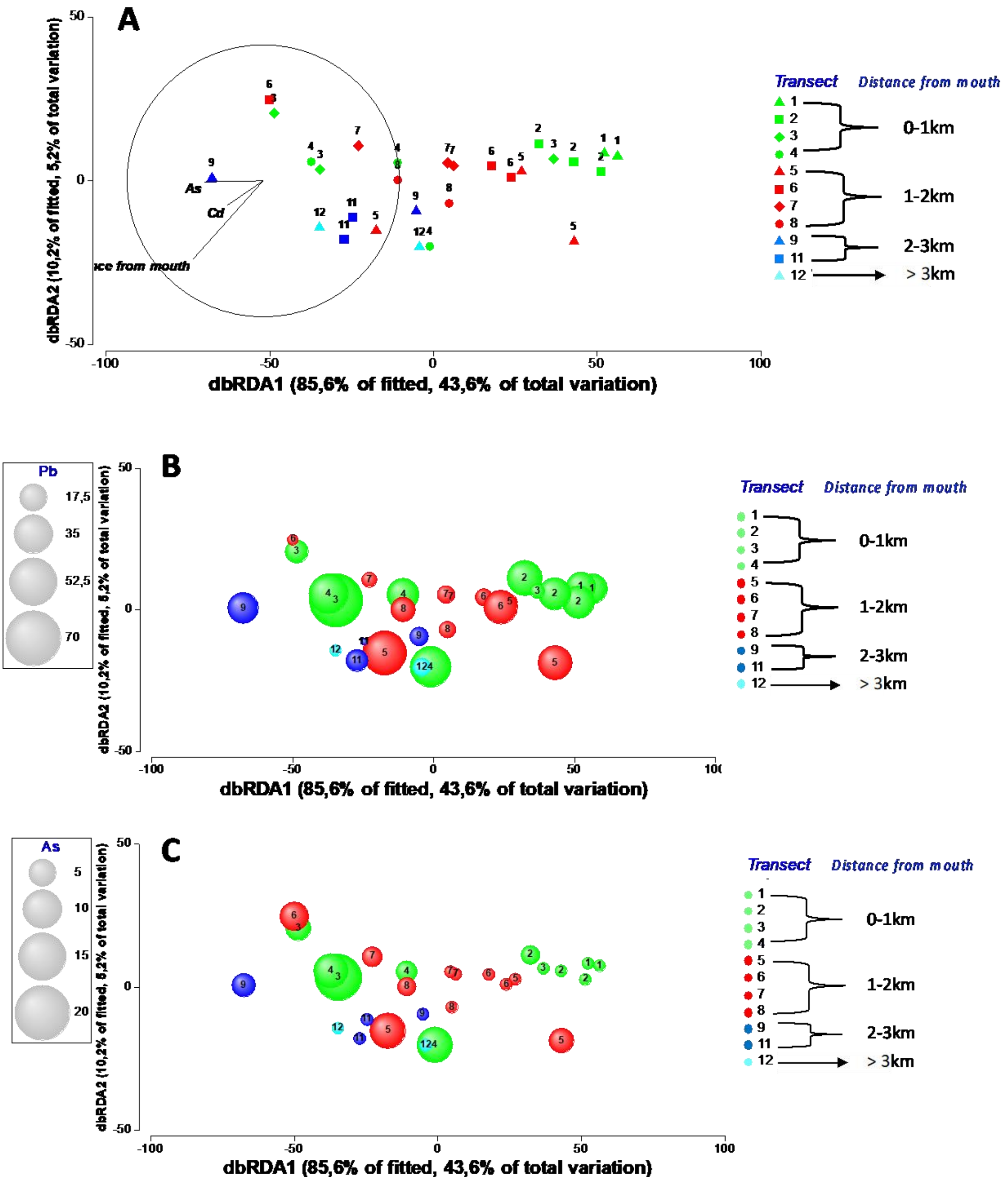


Figure 13 **(A) Results of DISTLM showing dbRDA plot of macrofaunal abundance data at 11 transects sampled within the Milnerton Lagoon from the 2021 survey. Sediment granulometry, organics, trace metal concentrations and distance from the mouth (km) were included as categorical predictors in this design. The black lines are category vectors, whereby the length of the vector is a measure of the strength of the relationship between that category and the axes. Bubble plots indicating the relative concentration (mg/kg) of B: Lead and C: Arsenic within the study area. Colours denote the relative distance of the sites from the river mouth.**

3.3 Ecological state of the estuary

The National Water Act of 1998 requires the implementation of 'Resource Directed Measures' (RDM) for the optimal use of our country's water resources while minimising ecological damage. The main focus of a RDM is the determination of the 'Reserve', which is the water quality and quantity required for the protection of both basic human needs and the needs of aquatic systems. The 'Ecological Reserve' is the quality and quantity of water required for a specific aquatic system (e.g. river reach, wetland, estuary) to maintain a desired level of structure and function, or quality. The desired quality of the water resource is defined by its 'Ecological Category' which is assigned a letter on a health scale of A to F (Table 6).

Table 6 Ecological categories for South African estuaries, the Diep River Estuary has been classified as a D status. (Van Niekerk *et al*. 2019a).

Condition (% of pristine)	Present ecological state	General Description
≥91%	A	**Unmodified, approximates natural condition:** The natural abiotic processes should not be modified. The characteristic of the resources should be determined by unmodified natural disturbance regimes. There should be no human induced risks to the abiotic and biotic processes and function.
76--90	B	**Near natural with few modifications:** A small change in the natural habitats and biota may have taken place, but the ecosystem functions are essentially unchanged
61-75	C	**Moderately modified:** A loss and change of the natural habitat and biota have occurred, but the basic ecosystem functions are still predominantly unchanged.
41-61	**D**	**Heavily modified:** A large shift in natural processes and ecosystem functions and/or loss of habitat, biota have occurred.
21-41	E	**Severely modified:** The loss of natural habitat, biota and basic ecosystem functions is extensive.
≤20	F	**Critically Modified:** Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural abiotic processes and associated biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

The Estuarine Health Index (EHI) applied in Ecological Water Requirement (EWR) studies include a number of variables/categories laid out in DWA (2008) (Table 7). For each category, the conditions are estimated as a percentage (0 – 100%) of pristine health. Scores are then weighted and aggregated so that the final score reflects the present holistic health of the estuary as a percentage of the pristine state (Turpie *et al.* 2012).

The Diep River Estuary's present ecological state (PES) is listed as "D" (Poor/Heavily modified) with a recommended ecological category (REC) of "D" (Van Niekerk *et al.* 2019b). A breakdown of the individual components assessed, and the scores given to each within the Diep River Estuary is provided below and shows that despite the overall ecological category being a "D", several of the individual components have lower scores and are "severely" or "critically modified, including the water quality, macrophytes and Invertebrates (Table 7).

Table 7 **Ecological categories associated with individual components of the estuary.**

NBA 2018 Condition Status			
Present Ecological State (2018)	D	Microalgae	D
Hydrology	C	Macrophytes	E
Hydrodynamics	B	Invertebrates	F
Water Quality	E	Fish	E
Physical habitat	E	Birds	C

The low levels of water flow and tidal influence means the system has a low assimilative capacity and is sensitive to pollution. Therefore, a significant impact within the estuary causing a reduction in the ecological category is poor water quality, which in turn influences biotic components of the system (such as the macrofaunal abundance and richness). The main sources of pollution include the Potsdam wastewater treatment works that discharges into the system, as well as urban and stormwater runoff adjacent to the estuary and in the river catchment which results in poor water quality for the inflowing water that reaches the head of the estuary (Van Niekerk *et al.* 2019c). The recent National Biodiversity Assessment (NBA 2018) additionally lists a number of other threats acting on the system, causing it to have a 'High' overall threat status. These threats include flow modifications, habitat loss, invasive alien plants and fish, bait collection and fish kills linked to pollution (Van Niekerk *et al.* 2019c).

Several estuaries, like the Diep River Estuary, which experience high nutrient pollution pressure and flow modification are vulnerable to the spread of invasive alien plant species. Additionally, increased nutrient levels associated with the wastewater discharge, agricultural run-off and persistent freshwater conditions have been shown to enhance the growth of alien aquatic plants in estuaries (Nunes 2020). The diversity and abundance of invasive alien plants within the estuarine area of the Diep River is high, with seven invasive species listed to occur within the EFZ, including two species of aquatic invasive plants i.e. Red water fern *Azolla filiculoides* and Water hyacinth *Eichhornia crassipes* (Adams *et al*. 2019). The latter, often forms a dense blanket of floating vegetation which covers/clogs the entire water channel in the middle and upper reaches. Examples are provided below from pictures taken during the monitoring survey between sites 9-12 (Figure 14).

Figure 14 **Dense blankets of water hyacinth covering the entire water surface of the estuary channel.**

The City of Cape Town has recently been working to clear and remove the Hyacinth throughout the system, with the Invasive Species Unit's hand teams and an excavator used in the upper reaches above the Otto du Plessis Bridge. However, access below the bridge is limited and only hand teams could be used in this area, which slows down the operation. The progress of the Invasive Species Unit at the time of sampling is shown in Figure 15.

Figure 15 **Progress of the Water Hyacinth clearing conducted in the Diep River Estuary by the City of Capes Town's Invasive Species Unit as of early June 2021. Image source CoCT.**

The proliferation of aquatic invasive species such as the hyacinth can restrict/obstruct the water channel thereby causing reduced flow rates and declines in the extent of light penetrating to the benthos. Additionally, when they die and decay, they can result in reduced dissolved oxygen concentrations within the water column and cause declines in the water quality of the estuary. All of which could have significant negative effects on the benthic community and provide an additionally strain on the already depleted benthic macrofauna communities. The removal of these floating macrophytes will improve flow and water quality within the estuary as well as increase light penetration to the benthos which can in turn enhanced benthic primary production. Cumulatively, these improvements to the condition of the estuary could also improve the condition of the benthic macrofaunal communities.

4 CONCLUSIONS & RECOMMENDATIONS

Anchor Research & Monitoring (Pty) Ltd (Anchor) was appointed by the CoCT to undertake the marine ecological survey of the Milnerton (Diep River) Lagoon. This report presents findings on sediment granulometry, organics and trace metal concentrations in sediments as well as the benthic macrofauna sampled from the Diep River Estuary during June 2021.

Sediment Quality

Results from the 2021 monitoring survey have highlighted sites sampled along the Diep River Estuary consisted primarily of a coarse sandy texture. Additionally, mud content was higher at three sites in the vicinity of Woodbridge Island, two sites above the Otto du Plessis Bridge and increased with distance upstream, particularly at sites close to the Blaauwberg Bridge. This is probably due to decreases in hydrodynamic flow at these sites caused by biotic e.g. marginal vegetation (*Phragmites* reeds) and alien aquatic macrophytes (water hyacinth), or anthropogenic obstructions (bridges) allowing fine-grained sediment to be deposited at a greater rate compared to sites elsewhere in the estuary where faster flowing currents disperse fine sediments. Mud content was significantly, positively correlated with TOC/TON and all trace metal elements. Given the latter, organics as well as a number of trace metal concentrations (As, Cd, Cr, Ni, Al and Fe) mirrored the patterns observed for mud content and accumulated in sediments further upstream of the estuary, past the Otto du Plessis Bridge and at sites close to the Blaauwberg Bridge. T-tests confirmed the latter findings whereby significant differences between the two areas (Milnerton Lagoon vs Diep River) were detected for five elements (Al, As, Cr, Fe and Ni).

Furthermore, only three elements (Cr, Pb and Hg) did not exceed the South African and international sediment quality guidelines, whereas the remainder exceeded these guidelines at particular sites (past the Otto du Plessis Bridge and near the Blaauwberg Bridge). Enrichments factors indicated substantial increases in Cd, Fe and Zn concentrations within the Diep River Estuary over the past 32 years. In general, the majority of the trace metals measured in the sediments of the Diep River Estuary have become enriched compared to historical surveys. Additionally, the average trace metal concentrations for Cd, Ni and Zn within the Diep River Estuary were relatively high in comparison to other local and international estuaries. This is a reason for concern, as such elements are typically elevated by anthropogenic activities and are known to have ecotoxicological effects.

Benthic macrofauna

During the 2021 benthic macrofauna survey, a total of 728 macrofaunal organisms from six different taxa were recorded within the Milnerton Lagoon, which represents a dramatic decline in diversity compared to historical reports. A total of 28 successful macrofauna samples were collected from 11 transects, however, only 13 of these contained macrofaunal organisms. Additionally, species of bivalves, gastropods, amphipods and isopods, reported from previous surveys were not found in the present study. The polychaete *C. capitata*, a species known to occupy highly disturbed ecosystems, dominated all samples and constituted 79% of the abundance, followed by *P. sexoculata.* Univariate results indicated Shannon Weiner Diversity index and biomass were similar across all sites, while abundance and species richness differed significantly across the length of the system. Multivariate analyses revealed significant dissimilarity in macrofaunal community structure among sites. This is logical as macrofauna were absent in half of the samples located 1.5 km from the mouth and further upstream. Generally, disparity was evident between sites grouped by relative distance from river mouth as well as between replicate samples. SIMPER analyses and bubble plots demonstrated that three species were restricted to either sections of the mouth (i.e. *C. capitata*) or further upstream of the Diep River Estuary (*P. sexoculata* and *Chironomis* sp.). Additionally, the relationship between macrofaunal abundance data and abiotic data was investigated of which distance from river mouth, As and Pb explained the greatest proportion of the variation observed in the macrofauna data. However, findings presented in the present study indicated the three main species do not appear to be negatively impacted by these trace metal concentrations.

It has become apparent in the scientific community, that total metal concentration is not a good predictor of environmental effects, whereas bioavailability monitoring and use of bio-indicators have proven to be successful in determining trace metal toxicity levels among species. Very few studies have examined the toxicity of trace metals on South African estuarine biota and international literature has demonstrated high variability in trace metal toxicity both between species and aquatic systems (Rainbow 1992, Brown *et al.* 2004, Landner & Rudolf 2005, Grossell *et al.* 2007, Merciai *et al.* 2014, Adams *et al.* 2020). This study measured trace metal pollution levels in the Diep River Estuary sediments but did not conduct field or laboratory ecotoxicity studies to determine toxic effects on biota found in this estuarine system. Nonetheless, the analyses of various physical and chemical parameters in sediment collected in the Diep River Estuary in June 2021 provide evidence that some trace metal elements were elevated well above levels considered to be toxic to living organisms (according to international and local quality guidelines) and highlighted sites past the Otto du Plessis Bridge and near the Blaauwberg Bridge as areas of concern. Furthermore, the large absence of benthic organisms indicates a severely degraded system and no longer pristine compared to historical surveys (Van Niekerk *et al.* 2019a).

Potential sources of these trace metal pollutants need to be identified and addressed. Sources of contaminants most likely include effluent from wastewater treatment works (i.e. sewage), storm water and industrial wastewater. Thus, it is imperative that monitoring of the Diep River Estuary be continued on a regular basis, as well as the possible introduction of a more detailed approach i.e., ecotoxicity testing.

Recommendations for further monitoring in the Diep River Estuary include the following:

1. In order to identify and control sources of heavy metal pollution, regular, testing of trace metal content of all sewage and industrial effluent entering the Diep system should be instituted.
2. Implementing improved methods of invasive plant species prevention, such as a floating boom at the head of the estuary which restricts the distribution of the plants into the system, and more regular clearing of the invasive aquatic species (avoiding such high levels of infestation) could improve the overall health of the estuary.

5 REFERENCES

Abessa DMS, Rachid BRF, Zaroni LP, Gasparro MR, Pinto YA & MC Bícego et al. (2019) Natural factors and chemical contamination control the structure of macrobenthic communities in the Santos Estuarine System (SP, Brazil). *Community Ecology* **20:** 121–137.

Abdul Jaffar Ali H, Tamilselvi M, Akram AS, Kaleem Arshan ML & V Sivakumar (2015) Comparative study on bioremediation of heavy metals by solitary ascidian, *Phallusia nigra*, between thoothukudi and vizhinjam ports of india. *Ecotoxicology and Environmental Safety* **121**: 93–99.

Adams JB, Fernandes M & Riddin T. 2019. 'Chapter 5: Estuarine Habitat extent and trend' in South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Adams W, Blust R, Dwyer R, Mount D, Nordheim E, Rodriguez PH & D Spry (2020) Bioavailability assessment of metals in freshwater environments: A historical review. *Environmental Toxicology and Chemistry* **39:** 48–59.

Anderson MJ (2008) Animal-sediment relationships re-visited: Characterising species' distributions along an environmental gradient using canonical analysis and quantile regression splines. *Journal of Experimental Marine Biology and Ecology* **366:** 16–27.

Anderson MJ, Gorley RN & KR Clarke (2008) PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PRIMER-E: Plymouth. UK.

Austen MC & S Widdicombe (2006) Comparison of the response of meio- and macrobenthos to disturbance and organic enrichment. *Journal of Experimental Marine Biology and Ecology* **330:** 96–104.

Ballesteros E, Torras X, Pinedo S, García M, Mangialajo L & M de Torres (2007) A new methodology based on littoral community cartography dominated by macroalgae for the implementation of the European Water Framework Directive. *Marine Pollution Bulletin* **55:** 172–80.

Banerjee K, Senthilkumar B, Purvaja R & R Ramesh (2012) Sedimentation and trace metal distribution in selected locations of Sundarbans mangroves and Hooghly estuary, northeast coast of India. *Environmental Geochemistry and Health* **34(1):** 27–42.

Bergen M, Weisberg SB, Smith RW, Cadien DB, Dalkey A, Montagne DE, Stull JK, Velarde RG & JA Ranasinghe (2001) Relationship between depth, sediment, latitude, and the structure of benthic infaunal assemblages on the mainland shelf of southern California. *Marine Biology* **138:** 637–647.

Binning K & D Baird D (2001) Survey of heavy metals in the sediments of the Swartkops River Estuary, Port Elizabeth South Africa. *Water SA* **27(4):** 461–466.

Borja A, Belzunce MJ, Garmendia JM, Rodríguez JG, Solaun O & I Zorita (2011) Chapter 8. Impact of pollutants on coastal and benthic marine communities. In: Sanchez-Bayo F, van den Brink PJ

& RM Mann (eds.) Ecological Impacts of Toxic Chemicals. Bentham Science Publishers, pp 165–186.

Borja A, Franco J & V Perez (2000) A marine biotic index to establish the ecological quality of soft-bottom benthos within European Estuarine and Coastal Environments. *Marine Pollution Bulletin* **40:** 1100–1114.

Bolam SG, Whomersley P & M Schratzberger (2004) Macrofaunal recolonization on intertidal mudflats: effect of sediment organic and sand content. *Journal of Experimental Marine Biology and Ecology* **306(2):** 157–180.

Brown RJ, Galloway T S, Lowe D, Browne M A, Dissanayake A, Jones MB & MH Depledge (2004) Differential sensitivity of three marine invertebrates to copper assessed using multiple biomarkers. *Aquatic toxicology* **66:** 267-27.

Buchman MF (1999) NOAA screening quick reference tables. 99-1, 1–12. Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration. NOAA HAZMAT Report.

Callaway R, Engelhard GH, Dann J, Cotter J & H Rumohr (2007) A century of North Sea epibenthos and trawling: comparison between 1902–1912, 1982–1985 and 2000. *Marine Ecology Progress Series* **346:** 27–43.

Çinar ME, Katagan T, Öztürk B, Egemen Ö, Ergen Z, Kocatas A, Önen M, Kirkim F, Bakir K, Kurt G, Dagli E, Kaymakçi A, Açik S, Dogan A & T Özcan (2006) Temporal changes of soft bottom zoobenthic communities in and around Alsancak Harbor (Izmir Bay, Aegean Sea), with special attention to the autoecology of exotic species. *Marine Ecology* **27:** 229–246.

City of Cape Town (2018) https://www.westerncape.gov.za/eadp/files/atoms/files/Diep%20EMP_v4_2018.pdf

Clark BM, Hutchings K, Biccard A, Brown E, Laird M, Gihwala K, Swart C, Makhosonke A, Sedick S, Turpie J & B Mostert (2020) *The State of Saldanha Bay and Langebaan Lagoon 2020, Technical Report*. Report No. AEC 1876/1 prepared by Anchor Environmental Consultants (Pty) Ltd for the Saldanha Bay Water Quality Forum Trust, September 2020. 438pp.

CSIR (2006) The development of a common set of water and sediment quality guidelines for the coastal zone of BCLME, South Africa. Prepared for Benguela Current Large Marine Ecosystem Programme. CSIR Report No. CSIR/NRE/ECO/2006/0011/C. Stellenbosch, 164 pp.

CSIR (2015) Sediment quality in aquatic systems in the Cape Town area of South Africa. CSIR Report CSIR/NRE/ECOS/IR/2015/0046/A.

Dean HK (2008) The use of polychaetes (Annelida) as indicator species of marine pollution: A review. *Revista de Biología Tropical (International Journal of Tropical Biology and Conservation)* **56:** 11–38.

Diop C, Dewaelé D, Cazier F, Diouf A & B Ouddane (2015) Assessment of trace metals contamination level, bioavailability and toxicity in sediments from Dakar coast and Saint Louis estuary in Senegal, West Africa. *Chemosphere* **138:** 980–987.

Duodu GO, Goonetilleke A, & GA Ayoko (2017) Potential bioavailability assessment, source apportionment and ecological risk of heavy metals in the sediment of Brisbane River estuary, Australia. *Marine Pollution Bulletin* **117(1-2):** 523–531.

Dutertre M, Hamon D, Chevalierand C & A Ehrhold (2013) The use of the relationships between environmental factors and benthic macrofaunal distribution in the establishment of a baseline for coastal management. *Marine Science* **70(2):** 294–308.

Ellingsen KE (2002) Soft-sediment benthic biodiversity on the continental shelf in relation to environmental variability. *Marine Ecology Progress Series* **232:** 15–27.

Etter RJ & JF Grassle (1992) Patterns of species diversity in the deep sea as a function of sediment particle size diversity. *Nature* **360:** 576−578.

Fukunaga A, Anderson MJ, Webster-Brown JG & RB Ford (2010) Individual and combined effects of heavy metals on estuarine infaunal communities. *Marine Ecology Progress Series* **402:** 123–136.

Gerhardt A (2002) Bioindicator Species and their use in Biomonitoring. Environmental monitoring I. Encyclopedia of life support systems. UNESCO ed. Oxford (UK): Eolss Publisher.

Gibbs RJ (1994) Metals in sediments along the Hudson River Estuary. *Environmental International* **20:** 507–516.

Gihwala K and K Hutchings (2021) Granulometry of the Milnerton Lagoon (Diep River Estuary). Report no. 1968/1 prepared by Anchor Research and Monitoring (Pty) Ltd for Tritan Survey 17 pp.

Gray JS (1974) Animal-sediment relationships. *Oceanography and Marine Biology* **12:** 223–261.

Gray JS, McIntyre AD & J Stirn (1992) Manual of Methods in Aquatic Environment Research. Part II. Biological Assessment of Marine Pollution with Particular Reference to Benthos. FAO Fisheries Technical Paper Number 324. United Nations Food and Agricultural Organization, Rome.

Grosell M, Blanchard J, Brix KV & R Gerdes (2007) Physiology is pivotal for interactions between salinity and acute copper toxicity to fish and invertebrates. *Aquatic Toxicology* **84**: 162–172.

Hale SS, Buffum HW & MM Hughes (2018) Six decades of change in pollution and benthic invertebrate biodiversity in a southern New England estuary. *Marine Pollution Bulletin* **133:** 77–87.

Holt EA & SW Miller (2010) Bioindicators: using organisms to measure environmental impacts. *Nature Education Knowledge* 3:8

Hutchings K & BM Clark (2010) Assessment of the effects of heavy metal accumulation from land based sources on the Diep estuary. Unpublished report prepared for Department of Environmental Affairs and Development Planning, Western Cape Government. Anchor Environmental Consultants, Cape Town.

Hutchings K, Forsythe K & BM Clark (2016) City of Cape Town Surface Stormwater Systems, Diep Estuary Impact Assessment. Prepared by Anchor Environmental Consultants for City of Cape Town.

Izegaegbe JI, Vivier L & HMM Mzimela (2020) Trace metal contamination in sediment in the Mhlathuze Estuary, northern KwaZulu-Natal, South Africa: effects on the macrobenthic community. *Environmental Monitoring and Assessment* **192:** 1–18.

Jackson VA, Paulse AN, Odendaal JP & W Khan (2009) Investigation into metal contamination of the Plankenberg and Diep Rivers, Western Cape, South Africa. *Water SA* **35(3)**:289-29

Josefson AB, Hansen JLS, Asmund G & P Johansen (2008) Threshold response of benthic macrofauna integrity to metal contamination in West Greenland. *Marine Pollution Bulletin* **56:** 1265–1274.

Kies F, Kerfouf A, Elegbede I, Matemilola S, De Los Rios Escalante P, Khorchani A & S Savari (2020) Assessment of the coastal and estuarine environment quality of western Algeria using the bioindicator Polychaeta; the genus Nereis. *Journal of Materials and Environmental Science* **11(9):** 1472–1481.

Khatri N & S Tyagi (2015) Influences of natural and anthropogenic factors on surface and groundwater quality in rural and urban areas. *Frontiers in Life Science* **8(1):** 23–39.

Krann C, Dekinga A & T Piersma T (2011) Now an empty mudflat: past and present benthic abundances in the western Dutch Wadden Sea. *Helgoland Marine Research* **65:** 51–58.

Landner L & R Rudolf (2005) Toxic and other adverse biological effects of trace metals. In: Metals and the Environment. *Environmental Pollution* **8**: 289-389

Long ER, MacDonald DD, Smith SL & FD Calder (1995) Incidence of adverse biological effects within ranges of concentrations in marine and estuarine sediments. *Environmental Management* **19:** 81–97.

Loo MGK (2001) Effects of wastewater effluent on macrobenthic infaunal communities at Christies Beach, South Australia. PhD thesis, The University of Adelaide.

Martins R, Sampaio L, Rodrigues AM & V Quintino (2013) Soft bottom Portuguese continental shelf polychaetes: Diversity and distribution. *Journal of Marine Systems* **123–124:** 41–54.

Martin JM & M Whitfield (1983) The significance of the river inputs to the ocean. In: Wong CS, Boyle E, Bruland KW, Burton JD & ED Goldberg (eds.) Trace metals in seawater. Plenum Press, New York.

Merciai R, Guasch H, Kumar A, Sabater S & E García-Berthou (2014) Trace metal concentration and 475 fish size: Variation among fish species in a Mediterranean river. *Ecotoxicology and Environmental 476 Safety* **107:** 154-161.

Mdaini Z, El Cafsi M & JP Gangné (2020) Seasonal trace metal contents in sediments and in the polychaete annelid Marphysa sanguinea (Montagu, 1813) in Tunis Lagoon. *Cahiers de Biologie Marine* **61:** 9–24.

Millard NAH, Scott KM. 1954. The ecology of South African estuaries. Part VI. Milnerton estuary and the Diep River, Cape. Transactions of the Royal Society of South Africa 34: 279–324.

Monteiro PMS, Joubert W, Pascall A, Brown S and A. Adonis 2004. The Biogeochemical Status of Surface Sediments In Saldanha Bay And Langebaan Lagoon 2004. CSIR report *ENV-S-C 2004080*

Morrisey DJ, Underwood AJ and L Howitt 1995. Development of sediment-quality criteria – a proposal from experimental field studies of the effects of copper on benthic organisms. *Marine Pollution Bulletin* **31**: 372-377.

Mosbahi N, Serbaji MM, Pezy JP, Neifar L & JC Dauvin (2019) Response of benthic macrofauna to multiple anthropogenic pressures in the shallow coastal zone south of Sfax (Tunisia, central Mediterranean Sea). *Environmental Pollution* **253:** 474-487.

Mzimela H, Wepener V & D Cyrus (2014) Spatial and temporal variations in selected heavy metals in water and sediment from the Mhlathuze Estuary, Richards Bay. *African Journal of Environmental Science and Technology* **8(11):** 670–683.

Nunes M, Adams JB & L Van Niekerk (2020) Changes in invasive alien aquatic plants in a small closed estuary. *South African Journal of Botany.* **135 :**317-329.

Obst M, Vicario S, Lundin K, Berggren M, Karlsson A, Haines R, Williams A, Goble C, Mathew C & A Güntsch (2017) Marine long-term biodiversity assessment suggests loss of rare species in the Skagerrak and Kattegat region. *Marine Biodiversity* **48:** 2165–2176.

Orr K 2008. Spatial and temporal variations in metals in the sediment and water of selected eastern cape estuaries, South Africa. MSc. thesis, Rhodes University, Grahamstown, South Africa.

Pearson TH & R Rosenberg (1978) Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology Annual Review* **16:** 229–311.

Pranovi F, da Ponte F & P Torricelli (2008) Historical changes in the structure and functioning of the benthic community in the lagoon of Venice. *Estuarine, Coastal and Shelf Science* **76:** 753–764.

Pretorius PJ, Linder PW, Slabbert JL & PW Wade (2001) The chemical behavior of heavy metals and their bioavailability and toxicity to organisms: implications for environmental quality criteria. *South African Journal of Science* **97**:431-434.

Rainbow PS (1995) Biomonitoring of heavy metal availability in the marine environment. *Marine Pollution Bulletin* **31**: 183-192.

Ranasinghe JA, Weisberg SB, Smith RW, Montagne DE, Thompson B, Oakden JM, Huff DD, Cadien DB, Velarde RG & KJ Ritter (2009) Calibration and evaluation of five indicators of benthic community condition in two California bay and estuary habitats. *Marine Pollution Bulletin* **59:** 5–13.

Reish DJ & TV Gerlinger TV (1997) A review of the toxicological studies with polychaetous annelids. *Bulletin of Marine Science Miami* **60:** 584–607.

Reise K, Herre E & M Sturm (2008) Mudflat biota since the 1930s: change beyond return? *Helgoland Marine Research* **62:** 13–22.

Rodrigues SK, Abessa DMS, Rodrigues APC, Soares-Gomes A, Freitas CB, Santelli RE, Freire AS & W Machado (2017) Sediment quality in a metal-contaminated tropical bay assessed with a multiple lines of evidence approach. *Environmental Pollution* **228:** 265–276.

Roveta C, Annibaldi A, Afghan A, Calcinai B, Di Camillo CG, Gregorin C, Illuminati S, Pulido Mantas T, Truzzi C & S Puce (2021) Biomonitoring of Heavy Metals: The Unexplored Role of Marine Sessile Taxa. *Applied Sciences* **11:** 580.

Ryu J, Khim JS, Kang S-G, Kang D, Lee C-H & C-H Koh (2011) The impact of heavy metal pollution gradients in sediments on benthic macrofauna at population and community levels. *Environmental Pollution* **159:** 2622–2629.

Shojaei MG, Gutow L, Dannheim J, Rachor E, Schröder A & T Brey (2016) Common trends in German Bight benthic macrofaunal communities: assessing temporal variability and the relative importance of environmental variables. *Journal of Sea Research* **107:** 25–33.

Shuping LS, Snyman RG, Odendaal JP & PA Ndakidemi (2011) Accumulation and Distribution of Metals in *Bolboschoenus maritimus* (Cyperaceae), from a South African River. *Water, Air and Soil Pollution* **216:** 319-328.

Summers JK, Wade TL, Engle VW & ZA Malaeb (1996) Normalization of metal concentrations in estuarine sediments from the Gulf of Mexico. *Estuaries* **19:** 581–594.

Taljaard S, de Villiers S, Fricke AH & WS Kloppers (1992) Water quality status of the Rietvlei/Milnerton Lagoon system. CSIR Data Report EMAS-D 92007.

Taylor SR & SM McLennan (1981) The composition and evolution of the continental crust: rare earth element evidence from sedimentary rocks. *Philosophical Transactions of the Royal Society, London* **301:** 381–399.

Taylor SR (1964) Trace element abundances and the chondritic earth model. *Geochimica et Cosmochimica Acta* **28(12):** 1989–1998.

Turpie JK, Taljaard S, van Niekerk L, Adams J, Wooldridge T, Cyrus D, Clark B & N Forbes (2012) The Estuary Health Index a standardised metric for use in estuary management and the determination of ecological water requirements. WRC Report No. 1930/1/12.

Van Niekerk L, Adams JB, Lamberth SJ, MacKay CF, Taljaard S, Turpie JK, Weerts SP & Raimondo DC. (2019a) (eds). South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. CSIR report number CSIR/SPLA/EM/EXP/2019/0062/A. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Van Niekerk L, Taljaard S, Adams JB, Clark B, Lamberth SJ, MacKay CF, Weerts SP & Whitfield AK (2019b) 'Chapter 7: Condition of South Africa's estuarine ecosystems' in South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A

Van Niekerk L, Adams JB, Lamberth SJ, Taljaard S, MaKay F, Bashoo S, Parak O. & Weerts S (2019c) Chapter 6: Pressures on the Estuarine Realm in South African National Biodiversity Assessment 2018: Technical Report. Volume 3: Estuarine Realm. South African National Biodiversity Institute, Pretoria. Report Number: SANBI/NAT/NBA2018/2019/Vol3/A.

Viskich M, Griffiths CL, Erasmus C & S Lamberth (2016) Long-term physical, chemical and biological changes in a small, urban estuary. *African Journal of Marine Science* **38:** 1-15.

Ward TJ & PA Hutchings (1996) Effects of trace metals on infaunal species composition in polluted intertidal and subtidal marine sediments near a lead smelter, Spencer Gulf, South Australia. *Marine Ecology Progress Series* **135:** 123–135.

Watling RJ (1988) Metal studies in the coastal environment of the Eastern Cape: a review. In: 'Towards an environmental plan for the Eastern Cape'. Grocott and Sherry: Grahamstown, South Africa. pp. 367-377.

Wong YS, Tam NFY, Lau PS & XZ Xue (1995) The toxicity of marine sediments in Victoria Harbour, Hong Kong. *Marine Pollution Bulletin* **31:** 464-470.

Wright AG, Clark BM & K Hutchings (2020) *Marine Ecology Monitoring Plan for the Milnerton Lagoon.* Specialist Report no. 1903/6 prepared by Anchor Research & Monitoring (Pty) Ltd for the City of Cape Town. 59pp.

CITY OF CAPE TOWN
ISIXEKO SASEKAPA
STAD KAAPSTAD

Making progress possible. Together.

ANCHOR
research & monitoring

ANNEXURE E

INVASIVE ALIEN SPECIES MONITORING, CONTROL AND ERADICATION PLAN FOR TABLE BAY NATURE RESERVE

September 2016

Produced by: The Cape Town Invasive Species Unit
Author: Louise Stafford & Chandré Rhoda

Contact

Environmental Resource Management
The Cape Town Invasive Species Unit
Westlake Conservation Office
Ou Kaapse Weg, Tokai
Tel: (021) 444 2356/7
Email: invasive.species@capetown.gov.za
Website: capetowninvasives.org.za
Find us on Facebook: www.facebook.com/ctinvasives

Table of Contents

List of Figures

List of Tables

List of Acronyms

ADU - Animal Demography Unit
APO – Annual plan of operations
BM - Biodiversity Management
BIONET-Biodiversity Network
CAFDA - Cape Flats Development Association
CBC - Cape Bird Club
CFR - Cape Floristic Region
CFWWTW - Cape Flats Wastewater Treatment Works
CoCT – City of Cape Town
CTEET - Cape Town Environmental Education Trust
CWAC - Coordinated Water Avian Counts
DEA - Department of Environmental Affairs
DPR – Diep River
DRC – Diep River Corridor
EDRR - Early Detection and Rapid Response
EPWP - Expanded Public Works

ERMD – Environmental resource management department
Ha - Hectares
IAP – Invasive alien plant
IAS – Invasive alien species
IBA - Important Birding Area
IP – Invasive plant
ISC - Invasive species monitoring, control and eradication
ISU – Invasive species unit
MRC – Milnerton Race Course
NEMBA - National Environmental Biodiversity Act
PAAC – Protected Areas Advisory Committee
TBNR – Table Bay Nature Reserve
UCT - University of Cape Town
WESSA - Wildlife and Environment Society of South Africa
WFW - Working for Water
WLA – Workload assessment

Executive Summary

The Table Bay Nature Reserve invasive species monitoring, control and eradication plan (hereinafter referred to as TBNR ISC plan) is developed according to the requirements of the National Environmental Biodiversity Act, 10 of 2004, (NEMBA), the Alien and Invasive Species (AIS) Regulations and lists (Oct 2014). The plan is also aligned with the City of Cape Town Invasive Species Strategy (Aug 2016).

This TBNR ISC plan applies to the 955.54 ha of the TBNR that make up the Diepriver Corridor, Zoarvlei, Milnerton Race Course and Diep River section. Collaboration and alignment between neighbouring landowners is important to address seed pollution of cleared areas.

This plan is in effective for the period 1 July 2016 to 30 June 2021. All data is reflected on date this plan becomes effective *viz* 1 July 2016. The presence of invasive animals was not recorded during the surveys and this plan is therefore focussed mainly on invasive plants.

Governance: The responsible department for managing Table Bay Nature Reserve is the CoCT Environmental Resource Department in collaboration with the Transport of Cape Town Branch. The CoCT Invasive Species Unit is responsible for providing invasive species strategic and operational support to ensure the objectives of this plan are achieved.

The plan gives effect to the following three objectives:

- Bringing the alien plant invasion in the all the sections of TBNR in maintenance stage by 2021 through systematic mechanical, chemical and manual control;
- Preventing the introduction of new invasive species into the catchment area through identification and monitoring and management of invasive pathways;
- Detecting any new invasive plant and animal (vertebrates and invertebrates) introductions through regular surveys and responds rapidly by removing such species before they become established and form viable populations;

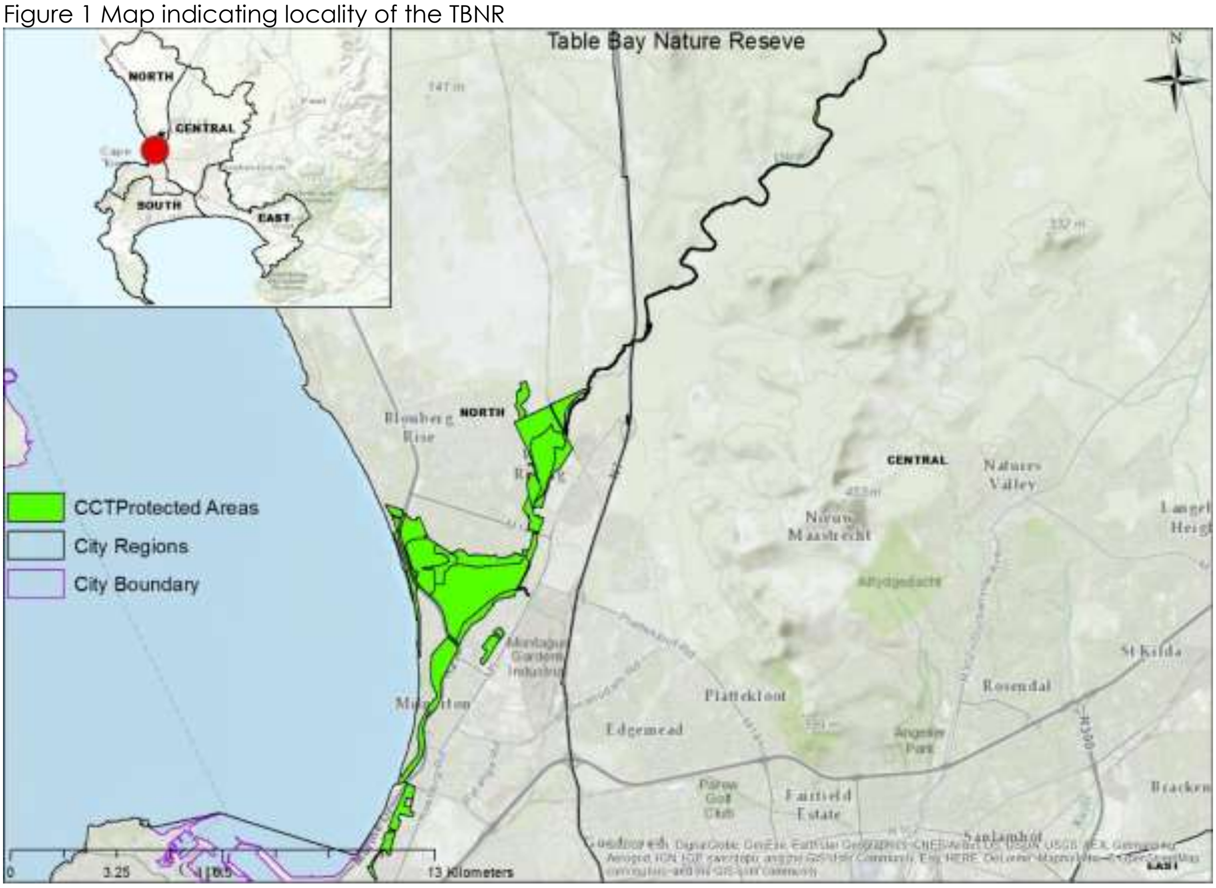
Chapter 1: Provides a description of the site and provides management history, highlights the invasive species impacts, lists the stakeholders and liaison between the stakeholders;
Chapter 2: Describes the process of dividing TBNR sections into different management units and contains the map showing the management units as well as lists and describes the invasive plant species present. Invasive animals that was recorded will be dealt with according to the specific species management plans.
Chapter 3: Discusses where previous controls were implemented and the efficacy of previous control methods;
Chapter 4: Describes prioritization and process of prioritizing;
Chapter 5: Makes provision for targets and timelines in the form of a logframe and provides the basis for monitoring and evaluation described in chapter 8;
Chapter 6: Describes the control and eradication methods to be used on the site;
Chapter 7: Outline the roles, responsibilities and reporting requirements;
Chapter 8: Makes provision for the monitoring and evaluation process including data storage and reporting

Annexure A: Lists the IAS and describes them for each management unit

1. Introduction

Table Bay Nature Reserve covers a surface area of 969.23 hectares which includes rive different sections. Table Bay Nature Reserve (TBNR) is managed by the City of Cape Town's Biodiversity Management Branch of the Environmental Resource Management Department.

Figure 1 Map indicating locality of the TBNR



The TBNR consists of the following five sections:

Diep River Corridor	244.07 ha
Diep River	47.32 ha
Zoarlei Wetland	48.56 ha
Milnerton Racecourse	17.99 ha
Rietvlei	597.60 ha

This Invasive Alien Species Monitoring, Control and Eradication plan (hereinafter called IAS control plan) is compiled according to the Department of Environmental Affairs (DEA) Guidelines for Invasive Species Monitoring, Control and Eradication Plans for Organs of State dated 1 October 2015.

1.1 Description of site

Table Bay Nature Reserve (TBNR) is situated in Milnerton, Cape Town, along the Table Bay coastline in the Diep River catchment (Figure 1) and is managed by the City of Cape Town's Biodiversity Management Branch. The centre of the nature reserve is approximately 10 km north-east of Cape Town city centre. The central feature of Table Bay Nature Reserve is the

Rietvlei wetland system. The Rietvlei wetlands and Milnerton Lagoon were proclaimed as a nature area on 3 August 1984 in Proclamation No. 1632, Provincial Gazette No. 9345. The reserve is partly owned by the City of Cape Town and the Worldwide Fund for Nature (WWF) South Africa, who owns two of the erven on the reserve. The City of Cape Town manages these two erven on a 99-year lease for the purposes of nature conservation.

Table Bay Nature Reserve encompasses the Diep River estuary, which functions as a tidal interface and fish nursery and recruitment area; the Rietvlei seasonal wetlands, which provide feeding grounds for migratory water birds, and the Diep River flood plain, which attenuates floods in the catchment. The 11 km long wetland system from the Diep River to Zoarvlei promotes wetland linkages, connectivity and catchment-to-coast landscapes. Table Bay Nature Reserve forms an important platform and integral link within the City of Cape Town's biodiversity network, as well as a link to the Cape West Coast Biosphere Reserve. See below Figure 2 indicating the Biodiversity Network (BIONET).

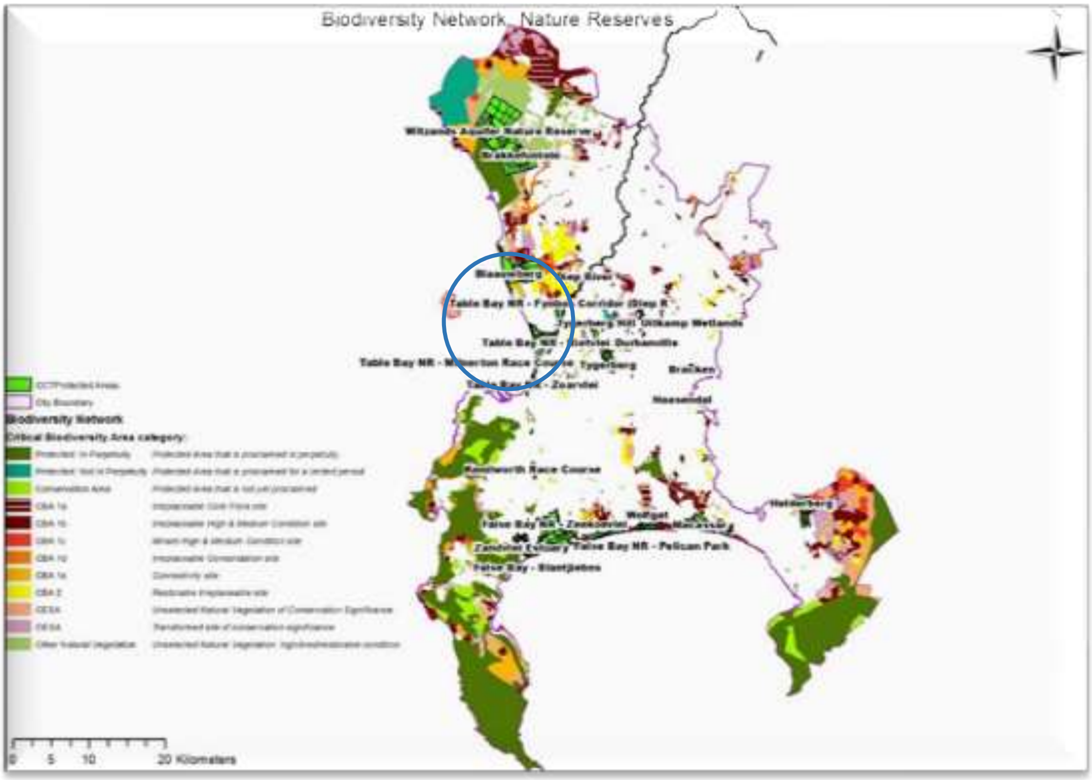


Figure 2: Map showing Biodiversity Network

The natural vegetation in Table Bay Nature Reserve include six major vegetation types: Cape Flats Sand Fynbos, Cape Flats Dune Strandveld, Cape Lowland Freshwater Wetlands, Cape Estuarine Salt Marsh, Cape Inland Salt Pans, and Cape Seashore Vegetation.

Table 1 below indicates the general distribution of these vegetation types across the various management units.

Table 1 Distribution of vegetation types over Table Bay Nature Reserve section

Vegetation type/ management section	Cape Flats Sand Fynbos	Cape Flats Dune Strandveld	Cape Lowland Freshwater Wetlands	Cape Estuarine Salt Marshes	Cape Inland Salt Pans	Cape Seashore Vegetation

Diep River corridor	X					
Diep River	X		X			
Zoarvlei Wetland	X	X	X			
Milnerton Racecourse		X				
Rietvlei	X	X	X	X	X	X

1.2 Water provision

The TBNR contains several valuable natural habitats, and important aquifers, wetlands and water bodies. About 90% of the Diep River catchment is now under cultivation, meaning that the use of water for agriculture is a possible factor in the reduced runoff.

The Diep River flows into the north-eastern corner of the Rietvlei wetlands at the Blaauwberg Road bridge, and then into the Milnerton Lagoon, and finally Table Bay. Additional inflow into the Rietvlei wetlands includes flow from the stormwater drains and the sewage works. Stormwater flows are directly related to rainfall patterns.

Freshwater flow into the lagoon comes both via the channel carrying the Potsdam effluent, and a natural channel flowing from the western side of the Rietvlei wetlands. There are also some stormwater discharges along the eastern bank. The other major source of water in the lagoon is the sea, although the extent of the saltwater intrusion is dependent on a number of factors, including whether or not the mouth is open. Other factors include siltation, water abstraction upstream, and canalisation of the river adjacent to Rietvlei.

The Diep River estuary, comprising the Rietvlei wetlands and the Milnerton Lagoon, covers an area of around 900 ha, and is the largest temporary vlei in the south-western Cape. Rietvlei is essentially triangular in shape, with the Diep River flowing in at its north-east corner. From there, it stretches for over 2 km in an east-west direction, with the southerly point of the triangle at the Otto du Plessis Road bridge marking the boundary between Rietvlei and the Milnerton Lagoon. The lagoon is a long, winding channel, bordered by a road, a golf course and the Woodbridge Island residential development, and ultimately flows into Table Bay along the west coast.

1.3 Waste water treatment

The treated effluent from the Potsdam Wastewater Treatment Works (WWTW) is discharged into a channel along the eastern boundary of Rietvlei wetlands, which conveys the effluent to the head of the lagoon at the Otto du Plessis Road bridge. The channel was constructed in 1991–1992 to prevent Potsdam's effluent from polluting Rietvlei. As a result, the vlei was largely disconnected from the flow of the river, although treated effluent does still flow into the vlei when the channel overflows during winter rains.

2 Invasive species impacts

Invasive plant impacts negatively on biodiversity. Alien vegetation, particularly *Eichhornia crassipes* (Water hyacinth), has invaded the Diep River and Zoarvlei Wetlands. This vegetation forms a mat over the water surface, preventing waterbirds that require open water for feeding, roosting and nesting from utilising the river.

In addition, the natural vegetation is heavily invaded in many areas by a woody overstorey of alien species, mainly *Acacia cyclops* and *A. saligna*. Alien plant infestations in the riparian area impacts negatively on streamflow and water yield.

2.1 Invasion pathways

The multiple landuse and activities in the TBNR makes the area vulnerable for the introduction of alien and invasive species.

- Road network
- Industrial area
- Residential area
- Agriculture
- Horticulture
- Pet trade

2.2 Fire

The most recent wild fire was in July 2016. The area affected by this fire was the Diep River Corridor (DRC) section in management unit DRC002. In addition, ecological control burn operations were conducted in management unit RTV007 and RTV013 in Rietvlei and RTV12 along the Zoarvlei Section and both management units in Milnerton Race Course. Table 2 shows the timing of fire incidences at TBNR.

Table 2 TBNR fire incidents

Area	Management Unit	Wild fire	Control burn
Diep River Corridor	DRC001	-	-
	DRC002	2011. 2015, and July 2016	-
	DRC003	Jan-16	-
	DRC004	Dec-15	-
	DRC005	Jan-16	-
	DRC006	2015, January 2016	-
	DRC007	May-16	-
Diep River	DPR01	-	-
	DPR02	-	-
	DPR03	-	-
	DPR04	-	-
	DPR05	-	-
	DPR06	-	-
	DPR07	May-16	-
Rietvlei	RTV001	-	-
	RTV002	2001	-
	RTV003	2013	-
	RTV004	2015	-

	RTV005	-	-
	RTV006	-	-
	RTV007	-	2005
	RTV008	2013	-
	RTV009	-	-
	RTV010	2015	-
	RTV011	-	-
	RTV013	-	2013
Zoarvlei	RTV012	-	2014
	RTV014	-	-
Milnerton Race Course	MRC001	-	2008 and 2010
	MRC002	-	2012

Incidences of fire usually alter the management priorities, as fire clears the area of invasive species. Accordingly, areas that were burnt in the last 12 months become a high management priority. The fire incident map (Figure 4-8) indicates the fires on TBNR in the different management sections.

Figure 3 DRC fire incident map

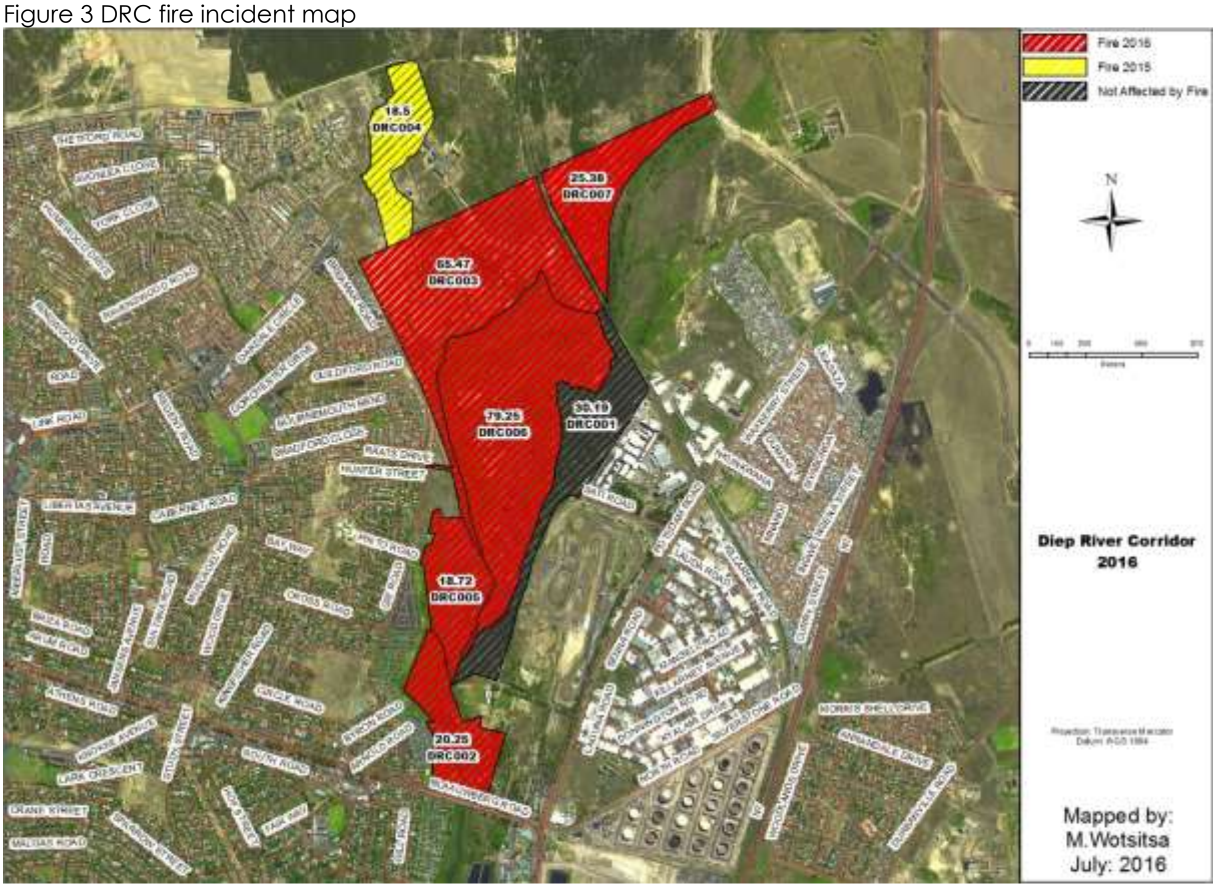


Figure 4 Diep River fire incident map

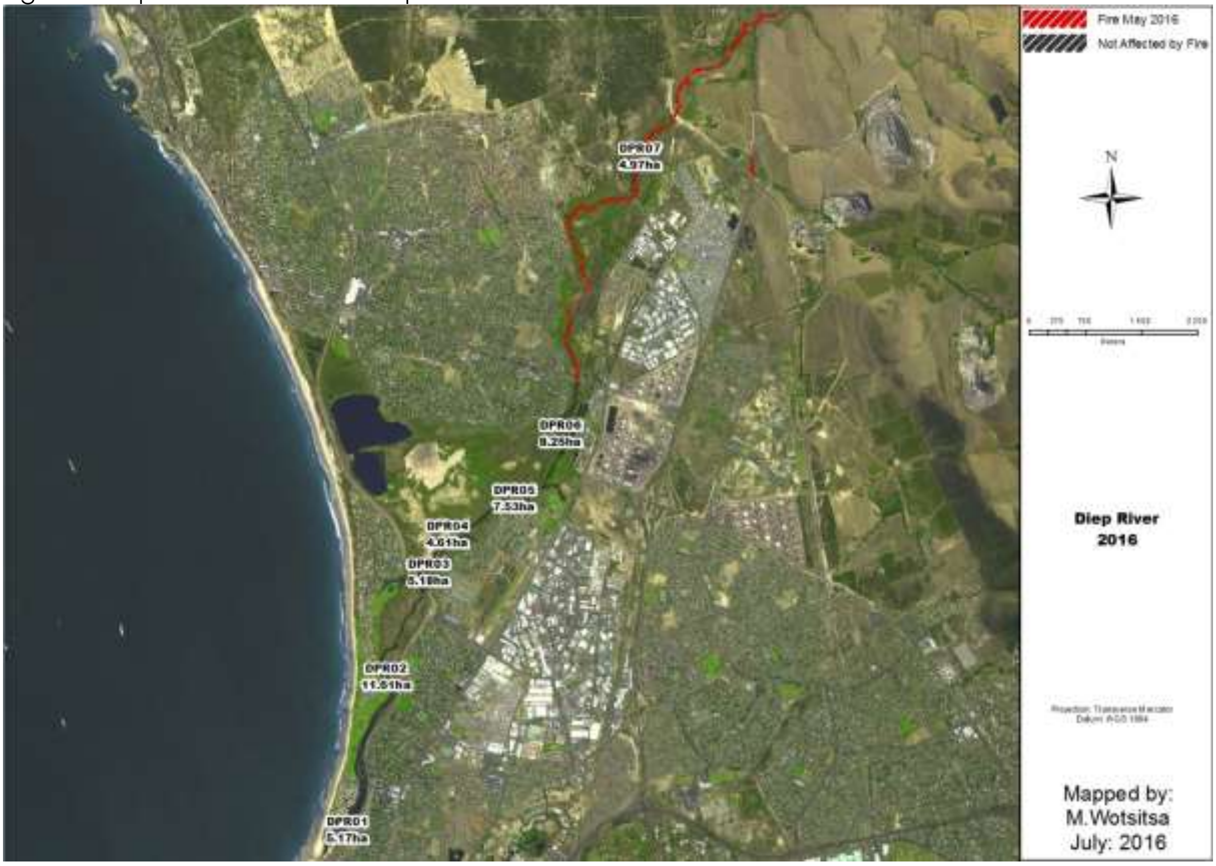


Figure 5 RTV fire incident map

Figure 6 Zoarvlei fire incident map

Figure 7 MRC fire incident map

2.3 Stakeholders

The control plan will be communicated and implemented through a process of consultation and input from the important stakeholders. The list of stakeholders and their details are summarized in Table 3.

Table 3 Contact details for the stakeholders of TBNR

Stakeholder	Contact person	Email	Phone number	Category
Area Manager / Table Bay Nature Reserve Advisory committee	Koos Retief	jacobusj.retief@capetown.gov.za	021 444 7219/0315	Core
Reserve Manager	Christopher Singo	christopher.singo@capetown.gov.za	021 444 7222/0315	Core
Milnerton Canoe Club	Gordon Laing	gordon.laing@gmail.com	(0)74 100 6081	Other
Milnerton Canoe Club	Russell Ikin	ikin2r@gmail.com	none	Other
Milnerton Riding Club	Tanya Williams	tanya@texcetera.co.za	none	Other
Roads & Stormwater Department	Johan Massyn	Johan.Massyn@capetown.gov.za	021 444 5763	Core
Parklands Home Owner's Association	Eric Basson	eric@phoa.co.za	0215566768	Other
Blaauwberg Area Development Environmental Liaison Committee	Alec Lambert	alecrlambert@gmail.com	021 526 6012	Other

2. Invasive alien species present on the site

After delineating and naming the management units, baseline data was collected as prescribed by the National Environmental Management: Biodiversity Act (NEMBA) Section 76. Invasive plant species present in each unit were listed according to their taxonomic group, scientific and common names, and described according to size classes.

The City of Cape Town adopted the following three size classes as a standard with a fourth (mixed) to indicate a site where a combination of seedlings, young and mature are present. These size classes serve as a guideline only and variations may occur.

- Seedlings - Less than 40cm in height and less than 1cm in diameter; plants can be hand-pulled or cut using a lopper
- Young - Height between 40cm and 1m and diameter between 1cm and 5cm; plants can be cut using a handsaw or silky saw; no seeds or flowers are present
- Mature - Over 1m in height and more than 5cm in diameter; plants are felled using a chainsaw; seeds and/or flowers are present during season

The extent of each species was estimated per management unit and expressed as percentage cover. Following this, the NEMBA listed category was assigned and species were prioritized according to area and species (Early Detection and Rapid Response (EDRR). Alien species that were not categorized by the NEMBA were recorded as “not listed”.

Two management approaches are followed: **Area** refers to the standard control programme and schedule per management unit. The management units are prioritized according to site level criteria (Chapter 4); **Species** refers to priority target species including EDRR target species will be dealt with through the City of Cape Town's EDRR programme.

The species control programme makes provision for target species based on their invasiveness and impact on fynbos. If a priority species is present on a site it triggers rapid response action, either by specialized species teams or by a standard teams with the required expertise.

The collected baseline data is used to determine the workload (estimated persondays and cost per hectare) and to track progress. Prior to any control intervention, a workload assessment is completed in the field. In this way, the baseline data is updated and progress at each site can be tracked. The dates of workload assessments are also captured in the City of Cape Town's invasive species central database.

According to the baseline data assessment (March 2016), the following EDRR target species are present in TBNR:

Table 4 EDRR species present at TBNR

Area	Management unit	Species name	Common name
Diep River Corridor	DRC001	*Verbesina encelioides*	Wild sunflower
	DRC005	*Anredera cordifolia*	Madeira vine
Diep River	DPR06	*Cortaderia selloana*	Pampas grass
Rietvlei	RTV005	*Anredera cordifolia*	Madeira vine
	RTV008	*Cortaderia selloana*	Pampas grass
	RTV014	*Spartium junceum*	Spanish Broom

The species approach will be followed for the species mentioned in table 4.

The updated baseline data, compiled in March 2016, is summarized in Annexure A: Table 17. This data shows that a total area of 274.40 ha is invaded by terrestrial and aquatic invasive plant species. Table five indicating the percentage invaded hectares per management unit for the five management sections.

Pennisetum clandestinum will not be controlled in this management plan at this stage. Irrespective of their NEMBA listed category, all invasive alien plant species present excluding *Pennisetum clandestinum* in TBNR area will be treated as category 1b. This is due to the fact that these species occur in a protected area. According to the NEMBA, category 1b plants are "invasive species requiring compulsory control as part of an invasive species control programme". No permits will be issued for any of these species.

The following figures 5-10, showing the management unit identity, size of each unit in hectares and as well as the density per management.

Figure 8: Map showing Invasive Plant Distribution in the Diep River section of TBNR

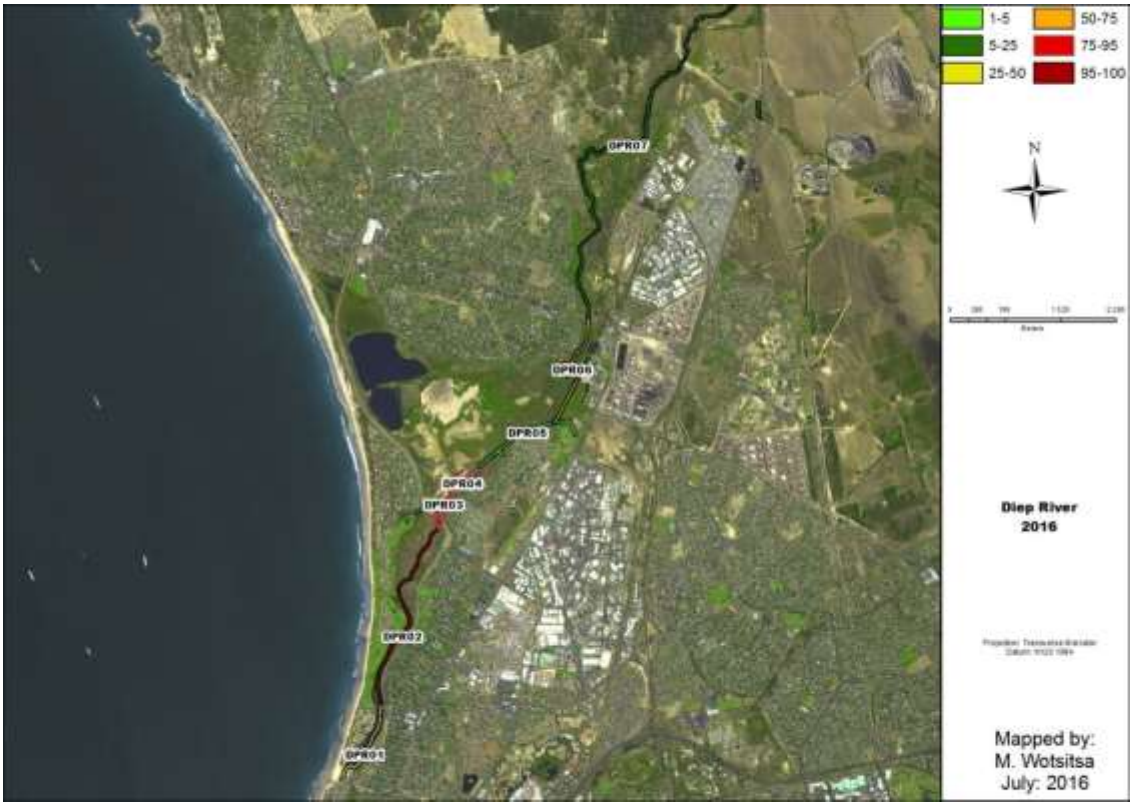


Figure 9: Map showing Diep River Reaches and extent of invasion

Figure 10: Map showing invasive plant distribution in the Rietvlei Section of TBNR

Figure 11: Map showing invasive plant distribution in Zoarvlei section of TBNR

Figure 12: Map showing invasive plant densities in the Milnerton Race Course section of TBNR

Species approach will be followed for Invasive fauna species present in TBNR. Surveys for invertebrates were not conducted and no data is available. Should any invasive fauna including invertebrate species be detected in TBNR in the future, rapid response action will be triggered.

3. Efficacy of previous control and eradication methods

The efficacy of control methods is reflected through the decrease in IAS density, cost per hectare, time and effort required (persondays and personday cost) reflected prior to every control intervention. The efficacy of control methods is determined through workload assessment before every control operation and by analysing the data to provide an annual update of infestation levels.

Since March 2010 the City of Cape Town's Environmental Resource Management Department (ERMD), Invasive Species Programme has been actively involved in the management of invasive vegetation in collaboration with Reserve Manager and deploys clearing teams according to an annual control programme. The reserve manager is actively involved in the management and prioritization of areas for control. Funding for the control programmes derives from two sources: City of Cape Town Operational funding (ERMD) and Expanded Public Works (EPWP). Table 5 indicates the previous control interventions by ERMD in each management unit.

Table 5 Summary of previous control history in TBNR

Area	Management Unit	Initial treatment	1st follow-up	2nd follow-up	3rd follow-up	4th follow-up	In maintenance since
Diep River Corridor	DRC001	2011	2012	2016	-	-	-
	DRC002	2016	-	-	-	-	-
	DRC003	2011	2012	2013	-	-	2014
	DRC004	2011	2012	-	-	-	2016
	DRC005	2011	2012	2013	-	-	2014
	DRC006	2015	-	-	-	-	-
	DRC007	2015	-	-	-	-	-
Diep River	DPR01	-	-	-	-	-	-
	DPR02	2013	2014	2015	2016	-	-
	DPR03	2013	2014	2015	2016	-	-
	DPR04	2013	2014	2015	2016	-	-
	DPR05	2013	2014	2015	2016	-	-
	DPR06	2013	2014	2015	2016	-	-
	DPR07	-	-	-	-	-	-
Rietvlei	RTV001	-	-	-	-	-	-
	RTV002	-	-	-	-	-	-
	RTV003	2004	2005	-	-	-	2015
	RTV004	2005	-	-	-	-	2015
	RTV005	-	-	-	-	-	-
	RTV006	2002, 2005	-	-	-	-	-
	RTV007	2003-2005	-	-	-	-	-
	RTV008	2003					2015
	RTV009	-	-	-	-	-	-
	RTV010	2001	-	-	-	-	2015
	RTV011	2002	-	-	-	-	-
	RTV013	2001	-	-	-	-	-
Zoarvlei	RTV012	2005	2015	-	-	-	-
	RTV014	2015	-	-	-	-	-
Milnerton Race Course	MRC001	-	-	-	-	-	2008
	MRC002	-	-	-	-	-	2008

4. Prioritization of IAS Management Units

The site-level prioritization is guided by the City of Cape Town Invasive Species Prioritization Framework (2016) based on Roura-Pascual et al. (2009[1]). The factors taken into account

[1] Roura-Pascual, N., Richardson, D.M., Krug, R.M., Brown, A., Chapman, R.A., Forsyth, G.G., Le Maitre, D.C., Robertson, M.P., Stafford, L., Van Wilgen, B.W., Wannenburgh, A. and Wessels, N. 2009. Ecology and management of alien plant invasions in South African fynbos: Accommodating key complexities in objective decision making. Biological Conservation, 142(8), pp.1595-1604.

include fire occurrence, IAP cover, locality in the catchment, fire risk, IAP size class and last clearing operation.

5. Invasive Species Management objectives

The following three management objectives were divided into Specific Measurable, Assignable, Realistic and Time bound (S.M.A.R.T) deliverables by means of an implementation programme (logframe)

- Bringing the alien plant invasion in the all the sections of TBNR in maintenance stage by 2021 through systematic mechanical, chemical and manual control;
- Preventing the introduction of new invasive species into the catchment area through identification and monitoring and management of invasive pathways;
- Detecting any new invasive plant and animal (vertebrates and invertebrates) introductions through regular surveys and responds rapidly by removing such species before they become established and form viable populations;

6. Control and eradication methods to be employed

Invasive plants will be controlled by integrating mechanical, manual and chemical control in compliance with NEMBA section 75 (1-3) Duty of Care Guidelines:

- Means and methods must be appropriate to the species
- Conducted in such a way that it causes the least harm to biodiversity and the environment
- IAS offspring will be targeted (follow-up operations)

Invasive species management plans control methods will be followed for the different species present in TBNR according to the City of Cape Town Invasive Plant Control Guidelines (2016).

7. Responsibilities and reporting requirements

Table 6: Responsibilities and reporting requirements

Department	Person	Responsible for	Frequency
ERMD – ISU	Project manager	Planning - Data management (WLA, capturing, storing of baseline data); EDRR; Costing, Scheduling; Compiling APO; reporting; monitoring progress; Quality assurance	Annually and before & after control interventions
ERMD - Reserve Management	Reserve Manager	Planning, quality assurance; input into control plan	Ongoing
ERMD - Reserve Management	Site Operational Supervisor-Driver	Quality assurance; pathway monitoring	Ongoing

8. Monitoring and evaluation

This plan aligns with the overarching City of Cape Town Invasive Species strategy (2016). The overall state of invasion reflects from March 2016 for the purpose of submitting the first IS status report on 1 October 2017 as determined by the NEMBA section 76.

The monitoring, evaluation and reporting sections of different land parcels managed by the CoCT aligns and informs the overarching state of invasion as outlined in the strategy and will be described in the plans of every parcel of land – as is the case for the TBNR plan.

Data collection and storage:
Data collection requirements, as determined by NEMBA (species, description and extent), are achieved through workload assessments completed prior to every control operation. These assessments are collated, analysed and reported on every 5 years as from 1 October 2017. Data is stored centrally on the Invasive Species Database.

Monitoring:
Monitoring of the efficacy of control methods as required by NEMBA Section 76 is achieved through analysing the extent of invasion annually over a period of 5 years, starting on 1 October 2016.

The monitoring objective for TBNR is to determine the achievement of different goals reflected in the implementation plan and presented in the form of a logframe and the implementation of the APO and schedule.

Detailed monitoring of the efficacy of control for specific species will be determined in the strategic plan as a priority and reflected in the 5-year status report.

Reporting:
Monthly reports are compiled to track implementation of APO and control schedule. Annual reports reflect the progress against targets.

Annexures

Table 7: Invasive plant species description and distribution in the five TBNR sections

Area	Management unit	Species name	Common name	Seedlings (D < 1cm; H < 40cm)	Young (D 1 - 5cm; H 40 cm - 2m)	Mature (D > 5cm; H > 2m)	Estimated % cover	NEMBA Category	Priority species
Diep River Corridor	DRC001	*Eucalyptus conferruminata*	Spider gum			X	2	1b	Area
		Verbesina encelioides	Wild sunflower	X	X		2	Not listed	X (EDRR)
		Acacia saligna	Port jackson	X	X	X	1	1b	Area
		Myoporum montanum	Manatoka	X	X	X	1	3	Area
		Echium vulgare	Blue echium	X	X	X	1	1b	Area
		Ricinus communis	Castor-oil plant	X	X	X	1	2	Area
		Xanthium spinosum	Spiny cocklebur	X	X	X	1	1b	Area
	DRC002	*Eucalyptus conferruminata*	Spider gum			X	1	1b	Area
		Acacia saligna	Port jackson	X	X	X	3	1b	Area
		Myoporum montanum	Manatoka		X	X	1	3	Area
		Ricinus communis	Castor-oil plant		X	X	6	2	Area
		Acacia cyclops	Rooikrans	X	X	X	1	1b	Area
		Melia azedarach	Syringa			X	1	1b	Area
	DRC003	*Eucalyptus conferruminata*	Spider gum			X	1	1b	Area
		Acacia saligna	Port jackson	X	X	X	6	1b	Area
		Myoporum montanum	Manatoka	X	X	X	1	3	Area
		Ricinus communis	Castor-oil plant	X	X	X	1	2	Area
		Xanthium spinosum	Spiny cocklebur	X	X	X	1	1b	Area

	Schinus terebinthifolius	Brazilian pepper tree			X	1	3	Area
	Nicotiana glauca	Willd tobacco			X	1	1b	Area
	Leptospermum laevigatum	Australian myrtle			X	2	1b	Area
DRC004	*Acacia saligna*	Port jackson	X	X	X	4	1b	Area
	Ricinus communis	Castor-oil plant	X	X	X	1	2	Area
	Eucalyptus globulus	Blue Gum	X			1	Not listed	Area
	Leptospermum laevigatum	Australian myrtle			X	2	1b	Area
DRC005	*Acacia saligna*	Port jackson	X	X	X	1	1b	Area
	Ricinus communis	Castor-oil plant	X	X	X	1	2	Area
	Opuntia stricta	Prickly pear			X	1	1b	Area
	Paraserianthes lophantha	Stinkbean			X	1	1b	Area
	Sambucus canadensis	American elderberry			X	1	1b	Area
	Anredera cordifolia	Madeira vine	X	X	X	4	1b	X (EDRR)
	Arundo donax	Giant Reed			X	1	1b	Area
	Cydonia oblonga	Quince			X	1	Not listed	Area
DRC006	*Acacia saligna*	Port jackson	X	X	X	1	1b	Area
	Paraserianthes lophantha	Stinkbean			X	1	1b	Area
	Ricinus communis	Castor-oil plant	X	X	X	1	2	Area
	Echium vulgare	Blue echium	X	X	X	1	1b	Area
	Eucalyptus conferruminata	Spider gum			X	7	1b	Area
DRC007	*Acacia saligna*	Port jackson	X	X	X	2	1b	Area
	Myoporum montanum	Manatoka	X	X	X	3	3	Area
	Nicotiana glauca	Willd tobacco	X	X	X	1	1b	Area

		Eucalyptus conferruminata	Spider gum			X	30	1b	Area
Diep River	DPR01	*Commelina benghalensis*	Wandering jew			X	5	Not listed	Area
		Eichhornia crassipes	Water hyacinth			X	40	1b	Area
		Lemna gibba	Duckweed			X	1	Not listed	Area
	DPR02	*Commelina benghalensis*	Wandering jew			X	2	Not listed	Area
		Persicaria capitata	Pink knotweed			X	1	1b	Area
		Eichhornia crassipes	Water hyacinth			X	95	1b	Area
	DPR03	*Commelina benghalensis*	Wandering jew			X	2	Not listed	Area
		Eichhornia crassipes	Water hyacinth			X	75	1b	Area
		Lemna gibba	Duckweed			X	1	Not listed	Area
	DPR04	*Commelina benghalensis*	Wandering jew			X	10	Not listed	Area
		Eichhornia crassipes	Water hyacinth			X	80	1b	Area
	DPR05	*Commelina benghalensis*	Wandering jew			X	1	Not listed	Area
		Persicaria decipiens	Slender Knotweed			X	0.5	Not listed	Area
		Eichhornia crassipes	Water hyacinth			X	2	1b	Area
		Nasturtium officinale	Watercress			X	0.5	2	Area
	DPR06	*Cortaderia selloana*	Pampas grass			X	0.01	1b	X (EDRR)
		Eichhornia crassipes	Water hyacinth			X	60	1b	Area
		Lemna gibba	Duckweed			X	0.01	Not listed	Area
	DPR07	*Acacia saligna*	Port Jackson			X	1	1b	Area
		Echium vulgare	Blue echium			X	1	1b	Area
		Lupinus angustifolius	Annual lupin			X	2	Not listed	Area
		Rapistrum rugosum	Wild Mustard			X	1	Not listed	Area
		Xanthium spinosum	Spiny cocklebur			X	0.2	1b	Area
		Schinus terebinthifolius	Brazilian pepper tree			X	1	3	Area

		Lemna gibba	Duckweed			X	1	Not listed	Area
		Myriophyllum aquaticum	Parrot's feather			X	1	1b	Area
Rietvlei	**RTV001**	*Pennisetum clandestinum*	Kikuyu grass			X	60	1b	Area
		Myoporum montanum	Manatoka			X	4	3	Area
		Eucalyptus conferruminata	Spider Gum			X	4	1b	Area
		Coprosma repens	Shiney Leaf			X	4	Not listed	Area
		Ricinus communis	Castor-oil plant			X	4	2	Area
		Schinus terebinthifolius	Brazilian pepper tree			X	4	3	Area
		Arecaceae spp.	Palm			X	1	Not listed	Area
	RTV002	*Acacia saligna*	Port jackson	X	X		5	1b	Area
		Arecaceae spp.	Palm			X	1	Not listed	Area
	RTV003	*Pennisetum clandestinum*	Kikuyu grass			X	75	1b	Area
		Acacia saligna	Port jackson	X	X		5	1b	Area
		Arecaceae spp.	Palm			X	1	Not listed	Area
	RTV004	*Pennisetum clandestinum*	Kikuyu grass			X	40	1b	Area
		Acacia saligna	Port jackson	X	X		5	1b	Area
		Anredera cordifolia	Madeira vine	X	X	X	4	1b	X (EDRR)
		Arecaceae spp.	Palm			X	1	Not listed	Area
	RTV005	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	RTV006	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	RTV007	*Pennisetum clandestinum*	Kikuyu grass			X	15	1b	Area
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	RTV008	*Acacia saligna*	Port jackson	X	X	X	1	1b	Area
		Pennisetum clandestinum	Kikuyu grass	X	X	X	75	1b	Area
		Arecaceae spp.	Palm			X	1	Not listed	Area
		Schinus terebinthifolius	Brazilian pepper tree	X	X		0.01	1b	Area
		Myoporum montanum	Manatoka	X	X		0.01	3	Area

		Acacia cyclops	Rooikrans	X	X		0.01	1b	Area
		Cortaderia selloana	Pampas grass	X	X		0.01	1b	X (EDRR)
		Vicia sativa	Broad-Leaf Purple Vetch	X	X	X	60	Not listed	Area
	RTV009	*Pennisetum clandestinum*	Kikuyu grass	X	X	X	60	1b	Area
		Acacia saligna	Port jackson		X	X	1	1b	Area
		Malva parviflora	Small Mallow		X	X	1	Not listed	Area
		Myoporum montanum	Manatoka	X	X	X	1	3	Area
		Vicia sativa	Broad-Leaf Purple Vetch			X	30	Not listed	Area
	RTV010	*Pennisetum clandestinum*	Kikuyu grass	X	X	X	50	1b	Area
		Acacia saligna	Port jackson	X	X		0.02	1b	Area
		Myoporum montanum	Manatoka	X	X	X	0.1	3	Area
		Schinus terebinthifolius	Brazilian pepper tree	X	X	X	0.1	3	Area
		Sesbania punicea	Red sesbania	X	X	X	0.1	1b	Area
		Syzygium guineense	Water Pear			X	0.1	Not listed	Area
		Lagunaria patersonii	Pyramid tree	X	X		0.02	Not listed	Area
		Acacia cyclops	Rooikrans	X	X		0.02	1b	Area
		Malva parviflora	Small Mallow	X	X	X	1	Not listed	Area
		Cirsium vulgare	Scotch thistle			X	0.1	1b	Area
		Opuntia stricta	Prickly pear	X	X		0.02	1b	Area
		Arecaceae spp.	Palm		X		0.1	Not listed	Area
		Vicia sativa	Broad-Leaf Purple Vetch			X	30	Not listed	Area
	RTV011	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	RTV013	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zoarvlei	**RTV012**	*Acacia saligna*	Port jackson	X	X	X	4	1b	Area

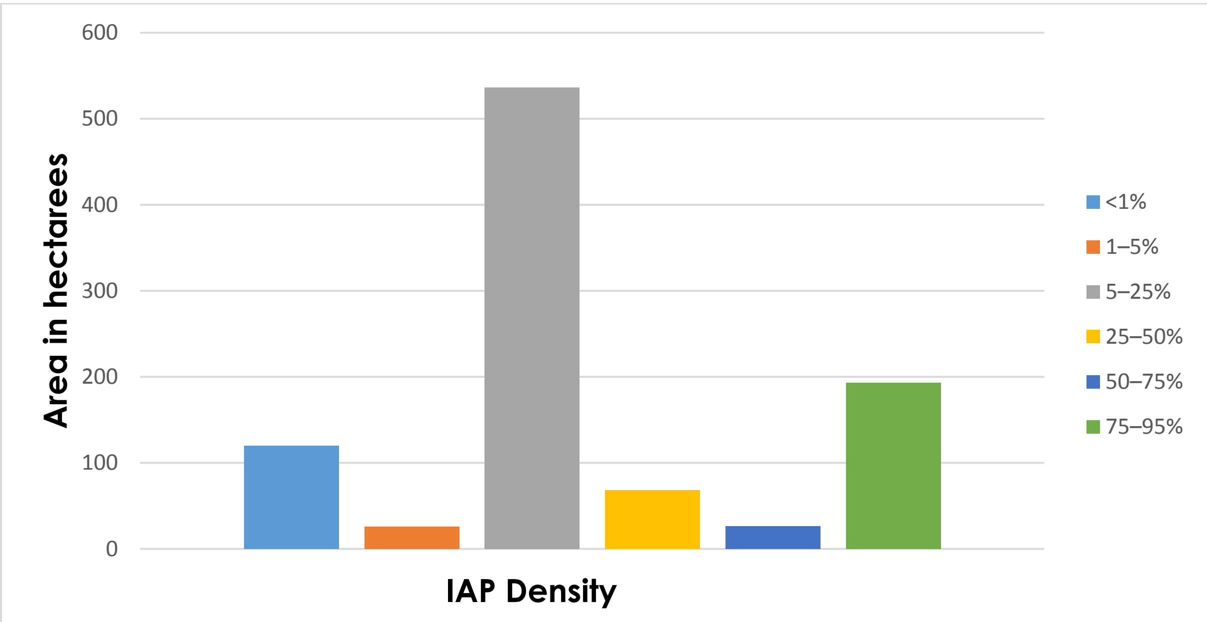
		Ricinus communis	Castor-oil plant	X	X	X	0.01	2	Area
		Schinus terebinthifolius	Brazilian pepper tree	X	X	X	0.01	3	Area
		Myoporum montanum	Manatoka	X	X	X	0.01	3	Area
		Arundo donax	Giant Reed			X	1	1b	Area
		Sesbania punicea	Red sesbania			X	1	1b	Area
		Opuntia stricta	Prickly pear			X	0.01	1b	Area
		Eucalyptus camaldulensis	River Red Gum			X	2	1b	Area
	RTV014	*Acacia saligna*	Port jackson	X	X	X	2	1b	Area
		Spartium junceum	Spanish Broom	X	X	X	0.01	1b	X (EDRR)
		Malva parviflora	Small Mallow	X	X	X	0.01	Not listed	Area
		Myoporum montanum	Manatoka	X	X	X	0.1	3	Area
Milnerton Race Course	**MRC001**	*Vicia sativa*	Broad-Leaf Purple Vetch	X	X	X	60	Not listed	Area
		Pennisetum clandestinum	Kikuyu grass	X	X		0.05	1b	Area
		Schinus terebinthifolius	Brazilian pepper tree	X			0.1	3	Area
		Acacia saligna	Port jackson	X	X		0.02	1b	Area
		Acacia cyclops	Rooikrans	X	X		0.02	1b	Area
	MRC002	*Acacia saligna*	Port jackson	X	X		0.02	1b	Area
		Acacia cyclops	Rooikrans	X	X		0.02	1b	Area
		Vicia sativa	Broad-Leaf Purple Vetch	X	X	X	60	Not listed	Area
		Pennisetum clandestinum	Kikuyu grass	X	X		0.05	1b	Area

Of the 969.23 hectares of TBNR, 55% is represented by the 5-25% density category, followed by the 75 - 95% category, which represents 20% of the area (Table 8).

Table 8 IAS density distribution for TBNR showing the area (in hectares) classified under each density category (March 2016)

<1%	1–5%	5–25%	25–50%	50–75%	75–95%	95 - 100%	Total
119.65	25.99	536.16	68.22	26.24	192.97	0	**969.23**

Figure 13 Density distribution of invasive plants in TBNR (March 2016)



Sandrift East Sewer Pump Station Failure: Operational Response Protocol

VERSION: 00, 24 NOVEMBER 2021

R6353/13/12/21

TABLE OF CONTENTS

TABLE OF FIGURES

TERMS AND ABBREVIATIONS

CCT: City of Cape Town Metropolitan Municipality
CFU: Colony Forming Units
CSRM: Catchment Stormwater River Management
EHM: Environment and Heritage Management
EMS: Environmental Management Systems
SCADA: Supervisory Control and Data Acquisition

1. INTRODUCTION

The Sandrfit East Sewer Pump Station: Operational Response Protocol (hereafter referred to as the "Protocol") is intended to facilitate a timeous, efficient, well-coordinated, site specific and environmentally sensitive response to sewer spills that may arise as consequence of the failure of the Sandrift Sewer Pump Station (hereafter referred to as the "Station"- see Figure 1).

This Protocol will be activated when there is a failure at the Station and there is a sewer spill. This Protocol has been developed to align to the overarching City SOP (Annexure 2A and Annexure 2B), namely the "Procedure for Responding to Sewage Pollution Incidents Caused by Council Services". In terms of this Protocol a sewage spill is defined as any sewage that may enter the natural or built environment as a consequence of a failure of the Station.

Figure 1: Locality Map of the Sandrift East Pump Station, City of Cape Town

2. PROBLEM STATEMENT

2.1. Causes behind pump station failures

There are a variety of reasons that may lead to the failure of the Station. These include the following:

- **Load shedding**
- **Foreign items disposed into the sewer system blocking the incoming pipeline**
- **Pump trips and overheating**
- **Delays in receiving notifications from the telemetry system**

2.2. Impact of pump station failure

When the Station fails and can no longer pump the incoming sewage then the sewage backs up in the sewer pipes and overflows out of a manholes on the corner of Koeberg and Bosmandam Road.

Sewage will exit the sewerage system and flow into a nearby stormwater catchpit. From here the sewage flows through the stormwater pipe underneath Koeberg Rd and discharges and the stormwater outfall at the Woodbridge, Milnerton.

2.3. Sewer spill classification

Not all sewage spills across the City are the same, and not all pump stations are the same, therefore it is necessary to classify spills and sites according to the following matrix.

For Sandrift East pump station the following applies:

RECEIVING ENVIRONMENT NAME	Milnerton Lagoon
SENSITIVITY ASSESSMENT	Critical Biodiversity Area Biodiversity Agreement Site Bathing Beach (Lagoon Beach) Site is subject to a Directive Overflows from s/w Outfall at the two bridges
PUMP STATION SIZE	20 kW (per pump x2)
LIKELY MAX FLOW	20l/sec @ 15m Head
LIKELY OUTCOME AFTER STATION FAILURE	The overflow is uncontrollable and likely to/will drain to a local sensitive environment Where the overflow reaches waters, the volume of sewage likely to enter the waterway is high with regard to the volume and flow of the receiving waters Where the overflow reaches land or watercourse, the public exposure risk will be high given the maximum response time
SEWER SPILL CLASSIFICATION	3. Major or 4. Catastrophic

3. CHANNELS FOR REPORTING SEWAGE SPILLS BY THE GENERAL PUBLIC

Whilst systems are now in place to ensure immediate notification of system failures at the Station, sewage spills may arise from broader sewer network failures. This is especially the case in instances of sewer pipe blockages, which may not always be immediately identified and responded to by the City of Cape Town (CCT) due to the extensive sewer network. In this regard should members of the public identify sewage spills in the Diep River Catchment, that such spills are reported to the City via the following channels:

Create a service request via the internet:
https://eservices1.capetown.gov.za/coct/wapl/zsreq_app/index.html

Create a service request telephonically:
0860 103 089: Option 2

Members of the public are encouraged to retain the reference number that will be provided upon notifying the City of the sewage spill. The reference number will allow members of the public to track progress of the City's response to the reported sewage spill.

In order to Follow-Up on your Notification please Email Water@capetown.gov.za. If your Notification is outside the Customer Service Charter SLA, a Follow-up Escalation will be triggered for the attention of the operational team.

4. SEWAGE SPILL RESPONSE PROTOCOL

4.1. General steps to follow

The following are the general steps to follow as defined in the City SOP – Procedure for Responding to Sewage Pollution Incidents Caused by Council Services Annexure 2B:

STEP No.	STEP	SUB STEP No.	SUB STEP/ACTION	ACTION OWNER/WHO
1	Made Aware of the Incident	1.1	Receiving notice/complaint	Responsible Person or Complainant
		1.2	Create C3 notice/log the complaint	
		1.3	Acknowledge complaint receipt by RP	
2	Respond	2.1	Confirm the incident	Responsible Person and First Responder
		2.2	Conduct basic/visual assessment of the nature and extent of the incident	
		2.3	Notify all relevant support line functions	
		2.4	Send an alarm report (Annexure 1)	
		2.5	Clarify the support needed	
3	Action	3.1	Cease/contain/stop pollution	Responsible Person
		3.2	When requested to do so, provide plant equipment and operators for the clean-up. Liaise and take guidance/ instructions from the Incident Coordinator for the containment and clean-up needed during the incident. Conduct the clean-up as requested and report any challenges to the Incident Coordinator. The provision of manual labour does not form part of this service	EAM
		3.3	Clean-up the affected area and remedy the effects of the incident	Responsible Person
		3.4	Coordinate the required responses	Incident Coordinator / Responsible Person
		3.5	Assess of the impact (immediate and delayed effects on the environment and public health) and confirm the classification level (this may include onsite analysis/visual inspection by relevant Support line)	WPC in consultation with relevant lines (Incident Coordinator; CSRM; EMD; Environ Health; Scientific Services etc.)
		3.6	Liaise with Scientific Services on the analysis needed, take samples at strategic points and submit to SS for analysis	WPC
		3.7	Sample analysis, provide scientific report with interpretation on impact analysis and trends (where possible). Give guidance on specific analysis and samples needed	Scientific Samples
		3.8	Environmental health impact and installation of warning signs if needed	Environmental Health Practitioner (EHP)
		3.9	Guidance on environmental compliance and advice on liaison with the authorities	EMD
		3.10	Media Statement	Communication and Stakeholder Engagement at Water and Sanitation Department

STEP No.	STEP	SUB STEP No.	SUB STEP/ACTION	ACTION OWNER/WHO
4	Review	4.1	Confirm that incident was actioned & finalized accordingly (all actions done)	Incident Coordinator/ Responsible Person and Support
		4.2	Finalize and confirm all the actions accordingly	Incident Coordinator/ Responsible Person
5	Closure	5.1	Provide relevant information to the RP/Incident Coordinator on time/as requested	All parties
		5.2	Populate the Incident Report, with inputs for all relevant	Responsible Person/ Incident Coordinator
		5.3	Consultation on the Incident report before finalizing	Responsible Person/ Incident Coordinator
		5.4	Finalize and sign the report	Responsible Person
		5.5	Feedback to all the Interested and Affected parties Including the Complainant	Responsible Person
6	Report	6.1	Submit the signed Incident Report to all	Responsible Person /Incident Coordinator
7	Evaluation	7.1	If major incident evaluation of action taken and proposals for actions to be undertaken to avoid/mitigate the reoccurrence (repeat of the incident)	CSRM as and when deemed necessary

The following sections unpack step 2 and step 3 with more detailed actions and tasks and the responsible persons.

4.2. Actions to be undertaken under Step 2: Respond

Upon receipt of notification of a pump station failure or any other reports of a sewage spill including via C3 notification lodged by the public, an immediate response will be initiated that will include the following actions and tasks:

ACTION / TASK	TIMEFRAME	RESPONSIBLE	CONSULTED	INFORMED
1. Dispatch person to pump station and another to storm water outfall at Woodbridge, Milnerton	Immediately after receipt of C3 Notification or Pump Station Alarm	TDC/ Depot Dispatch or Pump Station Standby/ Operator		
2 Network Ops 2.1 Upon arrival at the overflowing manhole identify cause (if a pump station, notify Pump Station Ops)	Within Customer Service Charter Response Times (1 Working Day)		(	CRSM/WPC/Incident Co-Ordinator/ EMD
2.2 if the sewage has entered the s/w escalate (worst case scenario) - Take immediate action to contain any escaped sewage using **sand bags and/or inflatable bunding,** else continue with applying the standard JHA's	Immediately	(Killarney Depot)	CRSM/WPC/Incident Co-Ordinator/ EMD	MayCo Member; Executive Director; Director Distribution Services; Director Bulk Services; Director Technical Services
3. Pump Station Ops 3.1 Upon arrival at the pump station determine the cause of the failure and	Within 1 working day of receipt of alarm or notification	Operational Teams (First Response)	Incident Co-Ordinator	
3.2 Determine if there is a need for over pumping at the pump station to a nearby manhole while waiting for repairs (Hiring of Mobile Pumps)		Operational Teams (First Response)	Incident Co-Ordinator	
3.2 a) If yes, request support from network ops to contain overflow/ or assist with over pumping (Dependent on resource availability at the time of incident)		Operational Teams (First Response)	Incident Co-Ordinator;	
3.2 b) If no, continue with assessing the cause of failure. Escalate to E&AM if the fault requires Electrical/ Mechanical or Instrumentation repairs/ replacement		Operational Teams (First Response)	Incident Co-Ordinator	

ACTION / TASK	TIMEFRAME	RESPONSIBLE	CONSULTED	INFORMED
Upon arrival at the outfall determine the extent of the spill and contaminated area		Water Pollution Control	Incident Co-Ordinator;	
Notify the Incident Coordinator		Water Pollution Control		
Notify all relevant line functions		Incident Co-Ordinator;		R3 WhatsApp
Notify all relevant external role-players		Incident Co-Ordinator;	Recreation and Parks Department, Biodiversity, EHM and the Coastal Management Branch	DEADP; DWS
Send an alarm report (Annexure 1)		Incident Co-Ordinator;		DEADP; DWS
Clarify the support needed		Incident Co-Ordinator;	Water Pollution Control/ EMD/ CRSM	DEADP; DWS

4.3. Actions to be undertaken under Step 3: Action

Once the incident has been assessed then the following actions and tasks will be undertaken:

ACTION / TASK	TIMEFRAME	RESPONSIBLE	CONSULTED	INFORMED
Restore pumping operations Undertake all necessary actions to get the failed pump station operational	Within 6 hrs (however dependent on severity of fault)	Pump Station Ops and EAM		
Restore operations				
If First line operations are able to resolve:	Within 6 hrs (however dependent on severity of fault)	Operational Teams (First Response)		Incident Co-Ordinator;
If EAM is required to resolve:	Within 6 hrs (however dependent on severity of fault)	Operational Teams (First Response)		Incident Co-Ordinator;
Reinstate Pump Station to normal operations				
If First line operations are able to resolve:	Within 6 hrs (however dependent on severity of fault)	Operational Teams (First Response)		Incident Co-Ordinator;
If EAM is required to resolve:	Dependent on the fault	Operational Teams (First Response)		Incident Co-Ordinator;
Contain the sewage Dispatch a vacuum tanker to the outfall and commence sucking up the sewage.		Operational Teams (First Response)	EMD	DEADP; DWS
Contain the sewage Dispatch a portable pump system/vacuum tanker to the pump station and commence sucking up the sewage from the wet well and discharge into the discharge line of the pump station		Operational Teams (First Response)	EMD	DEADP; DWS
Confirm the classification levels and extent of spill with further visual inspection, this will help inform the clean-up operations necessary		Water Pollution Control	EMD	DEADP; DWS

ACTION / TASK	TIMEFRAME	RESPONSIBLE	CONSULTED	INFORMED
Plan the clean up Upon the sewage spill being contained, engage with relevant district City Health, Rec and Parks, CSRM, Biodiversity, EHM and Coastal Management officials to determine most appropriate response to disinfect and clean the affected area		Water Pollution Control/ EMD / CRSM/ Coastal Management		DEADP; DWS
Clean up sewage on the road Clean-up the affected area using a sewage spill kit ensuring sewage does not enter the stormwater system, disinfect the area		Operational Teams (First Response) with support from Network Operations (Killarney Depot)		
Plan the water quality sampling Determine the water quality sampling required and identify the sample locations (this will be informed by the extent of the sewage spill into the wetland) At a minimum take a sample the points represented in the Figure below.		(SSB)	Liaise with Scientific Services, on the analysis needed, take samples at strategic points and submit for analysis Give guidance on specific analysis and samples needed	
Carry out the sampling and test at the labs.		Water Pollution Control (and SSB)		
Provide scientific report with interpretation on impact analysis and trends (where possible).		SSB		
Determine environmental health risk and the need for warning signage		City Health		
Erect signage at Lagoon Mouth and various points along Milnerton Lagoon		City Health		
Seek guidance on environmental compliance and advice on liaison with the authorities		Incident Co-Ordinator;	EMD	DEADP; DWS
Put together a media statement and engage with stakeholder and communication engagement office	Within 3hrs of receipt of incident classification		Incident Co-Ordinator;	

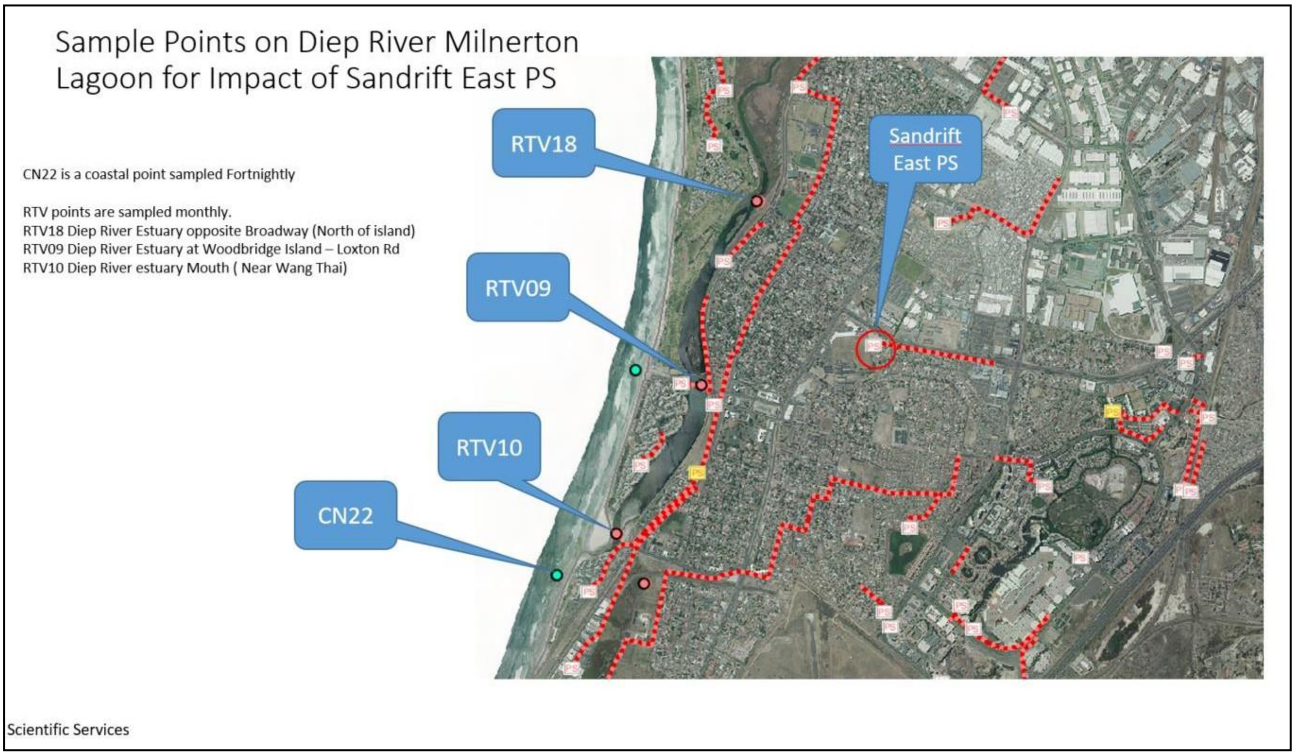


Figure 2: Sampling Points on Diep River Milnerton

4.4. Important considerations

1. Application of bio-enzymes, disinfection and anti-odor measures may be applied if the spill enters the water body. These measures must be applied on a 'top-down' basis with application commencing from the source moving downstream.
2. The application of bio-enzymes, disinfection and anti-odor measures must be undertaken in consultation with Recreation and Parks, Environment and Heritage Management, Catchment Stormwater and River Management, Biodiversity Management and Coastal Management.
3. Sewage sludge build up needs to be prevented by ensuring all sewage is removed by the vacuum tankers. Do not just remove the liquid sewage, also ensure all sludge and rag is removed.
4. City Health must request that Scientific Services take representative samples for the analysis of both *E. coli* and E*nterococci* from affected water bodies to determine the level of contamination post the sewage spill event.
5. Should raw sewage enter the ocean, City Health to request samples are collected from the sea.
6. City Health to report results to relevant line departments as soon as they are received.
7. Affected public use areas may only be re-opened to the public through the removal of public health warning signs when the following thresholds (determined in accordance with the South African National Bathing Water Quality Guidelines) are met:
    i. ***E.coli***: < 500 cfu/100ml
    ii. ***Enterococci***: < 200 cfu/100ml

5. COMMUNICATING HEALTH AND SAFETY CONCERNS

The following actions will be undertaken when communicating health and safety concerns to the public in the event of a sewage spill:

1. City Health will immediately ensure the erection of temporary public health warning signage at strategic locations in relation to the affected area.
2. To facilitate expedient erection of public health warning signs City Health to ensure that an appropriate number of signage is stored at the Station or Depot for quick access to signage.
3. If necessary, Water and Sanitation staff as first respondents may erect public health warning signs should there be a delay in City Health getting to site.
4. City Health to determine whether a media release is required with input from all relevant departments.

6. NEMA REPORTING

The City is obliged to report on significant sewage spill events in terms of the National Environmental Management Act Environmental Impact Assessment regulations. The Incident Coordinator must report the incident to Head: Environmental Compliance in accordance with the City's overarching Procedure for Responding to Sewage Pollution Incidents Caused by Council Services.

5. DEPARTMENTAL CONTACTS FOR EXECUTION OF THE PROTOCOL

5.1. INTERNAL

LINE FUNCTION	OFFICIAL	DESIGNATION	CONTACT DETAILS	
Sewer Reticulation		Head: Waste Water Conveyance		
		Regional Manager Operations		
		Pump Station Superintendent		
		Pump Station Manager		
		Superintendent		
Recreation and Parks		Coastal Coordinator		
		Principal Technical Assistant		
City Health		Head Environmental Health. Area: North.		
		Principal Environmental Health Practitioner		
Biodiversity Management		Senior Professional Officer: Biodiversity		
Biodiversity Management		Reserve Supervisor: Table Bay Nature Reserve		
Environmental Management Compliance		Head: Environmental Compliance		
Catchment Stormwater and River Management		Head: Catchment Planning		
Water Pollution Control		Senior Professional Officer: Policy and Regulation		
Scientific Services		Head: Analytical Laboratory/ Senior Professional Officer - SSB		

5.2. External Authorities:

LINE FUNCTION	OFFICIAL	DESIGNATION	EMAIL
Departmental of Environmental Affairs and Development Planning (DEADP)		Remediation and Emergency Incident Management	
		Remediation and Emergency Incident Management	
		Control Environmental Officer: Pollution Policy & Regulatory Services	
National Department of Water and Sanitation		Deputy Director: Berg-Olifants Proto CMA: Berg Area	
		Environmental Officer: Specialized Production	
Department of Forestry, Fisheries and the Environment		Environmental Management Inspector (EMI)	

6. SIGNATURES:

	Signature	Date
Mr. Sigqibo Nogaya Head: Waste Water Conveyance	Sigqibo Nogaya Digitally signed by Sigqibo Nogaya Date: 2021.12.13 09:54:52 +02'00'	

	Signature	Date
Mr. Pierre Maritz (Pr. Tech, Eng.) Branch Manager: Reticulation	Pierre Maritz Digitally signed by Pierre Maritz Date: 2021.12.13 15:24:03 +02'00'	