Chapter 4: City Of Cape Town Coastal Set-Back Delineation: Method And Process

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ACRONYMS

BioNet:	Biodiversity Network
City:	City of Cape Town Metropolitan Municipality, established in terms of the Local Government: Municipal Structures Act, 1998 read with the Province of the Western Cape: Provincial Gazette 558 dated 22 September 2000
city:	Cape Town
CPZ:	Coastal Protection Zone
CT:SDF:	City of Cape Town Spatial Development Framework
DEA:	Department of Environmental Affairs
DEA&DP:	Department of Environmental Affairs and Development Planning
EGS:	Ecosystems Goods and Services
GIS:	Geographic Information System
HWM:	High-Water Mark
ICMA:	Integrated Coastal Management Act

ICM Bill:	Integrated Coastal Management Bill
I & APs:	Interested and Affected Parties
LLD:	Land Levelling Datum
MCMP:	Municipal Coastal Management Programme
ODM:	Overberg District Municipality
POS:	Public Open Space
PPP:	Public Participation Process
PSE:	Participatory Stakeholder Engagement
SDE:	Scenic Drive Envelope
SDNMP:	Scenic Drives Network Management Plan
SEMA:	Specific Environmental Management Act
SLRRA:	Sea-Level Rise Risk Assessment
TMNP:	Table Mountain National Park
TEV:	Total Economic Value

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1. EXECUTIVE SUMMARY

The City of Cape Town's (the City) coastline is a complex space - it is a nexus of social, economic, ecological and legislative systems managed by three different tiers of government often with overlapping roles and responsibilities. Although the coastline is one of Cape Town's most important socio-economic and environmental assets, paradoxically, the coastline is also a source of risk to the City. This coastal risk is currently being compounded by the absence of a city-wide strategic decision support framework required to promote informed and risk averse coastal planning decisions. Historically decisions relating to the coast have by enlarge been ad hoc, piecemeal and reactive. Climate change is expected to heighten the challenge of risk governance at the municipal level into the future. In responding to these challenges, the City commenced with the delineation of a set-back in 2007. The primary intent of the City's set-back is to guide and shape municipal decision making that is consistent, strategic, promotes sustainable coastal development and ultimately retains the coast as an asset in the interests of the broader public.

It is well known that set-backs have a range of significant socio-economic implications. As risk is essentially a human value, the City considered it non-negotiable to apply a multidisciplinary and iterative approach that considered a range of socio-economic and biophysical elements in defining its set-back. Through broad scale engagement and the required deliberation with interested and affected parties since 2007, the City has determined a set-back that is based on scientific, practitioner and community based knowledge and as such is grounded within the realities of a developing city scale context. Most importantly this approach has produced a set-back that achieves a balance between socio-economic imperatives whilst simultaneously installing risk averse principles in City planning.

A critical component in developing a set-back is the recognition that there is neither legislation nor planning mechanisms in South Africa designed to resolve and to manage existing infrastructure at risk. Further to this, set-backs are not designed nor equipped to manage risk retrospectively. The City is therefore in the process of developing a range of supportive planning and land use regulatory mechanisms, notable the overlay zone and the by-law, designed to both give regulatory support to City's set-back as well as address the much neglected matter of existing property and infrastructure at risk to coastal hazards.

2. INTRODUCTION

The City commenced work on delineating its coastal set-back in 2007. The City realised the importance of undertaking proactive measures with the intent to address a multitude of growing pressures along the City's coastline[1]. The determination of a coastal set-back that considered the connections between socio-economic and environmental systems was identified as the most appropriate and effective approach towards managing these pressures within a complex and dynamic space. This approach was used with the intent of achieving five primary objectives, namely to promote access to the coast, to promote increased degrees of Integrated Coastal Management (ICM) within the City, to reduce risk to the City, to ensure that the socio-economic opportunities the coast currently provides are retained and enhanced into the future in perpetuity and to ensure the conservation of remaining functional coastal ecosystems.

[1] The coastline in terms of this report is defined as the dynamic interface between land and sea masses where this dyanmic space contributes both directly and indirectly to the livelihoods of the residents of Cape Town.

The City's Spatial Development Framework (CT:SDF) was approved on the 8th of May 2012 under two different sets of legislation. It was approved as a component of the City's Integrated Development Plan in terms of the Municipal Systems Act (Act No 32 of 2000, section 34) as well as the Land Use Planning Ordinance (No. 15 of 1985, section 4(6)). The CT:SDF, together with the Provincial Spatial Development Framework forms the spatial planning document applicable to the municipal area of the City. The CT:SDF defines and spatially demarcates the City's Coastal Urban Edge. This report therefore represents the City's formal submission to the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) to formalise the City's Coastal Urban Edge as the set-back line in terms of the Integrated Coastal Management Act (ICMA) (Act 24 of 2008). As the City views the Coastal Urban Edge and draft set-back line as one and the same, for purposes of clarity this line will be referred to throughout as the draft set-back line. In addition to this numerous references are made to the Coastal Protection Zone (CPZ) and Coastal Protection Zone by-law in the various annexures. The CPZ in the annexures refers to the space between the draft set-back and High-Water Mark (HWM). The City acknowledges that this is different to the definition and intention given to the CPZ in the ICMA. In light of this, and as per the City's Integrated Coastal Management By-law, will rename the space between the HWM and the draft set-back as the "Coastal Environment" to avoid confusion. The City will in turn define a new CPZ in accordance with the requirements of ICMA.

2.1 Background and context

Cape Town's coastline is approximately 307km in length, making it the largest coastal metropolis in South Africa. The coastline of Cape Town extends from Silwerstroomstrand (18˚20'34.959"E and 33˚34'14.994"S) on the west coast to just south of Koggelbaai (18˚50'44.905"E and 34˚16'10.554"S) on the east coast. Cape Town is renowned for its beaches and coastal beauty which are arguably its greatest socio-economic and environmental asset, providing a support base, both directly and indirectly, to a coastal population with vast socio-economic inequalities. Value from the coast is derived from a multiplicity of ecosystems goods and services (EGS) as a consequence of the coast's unique biophysical attributes. Ecosystems goods and services may be broadly categorised as cultural, regulatory, supportive and provisional. Reflecting the value of the coastline, and based on cultural services alone, it is estimated that the city's beaches can be valued at approximately R77 million per annum. This figure reflects only a fraction of the Total Economic Value (TEV) as it is based purely on the cultural value of beaches alone in Cape Town. It does not reflect the regulatory, provisional and support value (de Wit *et al*, 2009).

Paradoxically, however, the coastline also contributes to the City's risk profile. The coastline of the city is a harsh and highly dynamic environment, where the biophysical attributes of the coastline are in a constant state of flux. Some of this change is cyclical and predictable, taking place over relatively short (seasonal) temporal scales, whilst other change is unseasonable and unpredictable[2]. Reflecting seasonal dynamics at a broad scale is the accretion of beaches within False Bay (on the eastern side of the city) in winter and the erosion of these beaches in summer. The opposite pattern occurs on the west coast where beaches generally erode in winter and accrete in summer. These seasonal cycles in coastal dynamics are primarily driven by two major atmospheric systems. These include the periodic mid-latitude cyclones (storms) that occur during the winter months which typically result in higher seas, and the south Atlantic high pressure system that results in south easterlies during the summer months, and subsequently calmer seas (Tadross *et al,* 2012). Examples of less predictable coastal dynamics include migrating estuary mouths, localised beach regression and accretion events as well as storm surges. These unpredictable examples often result in abrupt changes in coastal

[2] Less predictable change may still be cyclic, but just over longer and less defined periods of time. Such change may also be a result of climate variation as opposed to human induced climate change.

geomorphology. Both of these abrupt changes, and to a lesser extent, the predicted seasonal dynamics, impact on coastal infrastructure and ultimately the City's ability to maintain effective service delivery.

The dynamic and at times unpredictable nature of the coastline is a source of risk to the City. Exposure to this risk is set to be compounded considering the warming of the earth's atmosphere. Global warming is expected to have a significant impact on coastal dynamics, where fluctuations in environmental systems are set to become more pronounced. This is a key concern to the City considering the value of the coastline from an EGS perspective, but also due to the amount of critical infrastructure located along the coastline. The City's Sea-Level Rise Risk Assessment (SLRRA) identified an area totalling 25km² that is highly vulnerable to the expected impacts of sea-level rise, storm surges and subsequent coastal erosion (Cartwright, 2008). Within this area, it is estimated that there is approximately R5 billion[3] worth of City infrastructure that is at risk (Cartwright, 2008).

Considering globalisation, market driven economies and the priority of promoting economic growth through development[4], it is expected that growth in the city (as in the case of many world cities) is set to increase significantly into the future (Figure 1) (CCT, 2012). With the perception that coastal frontage property equates to economic wealth and gain, much of this growth is expected to have an impact on the coast.

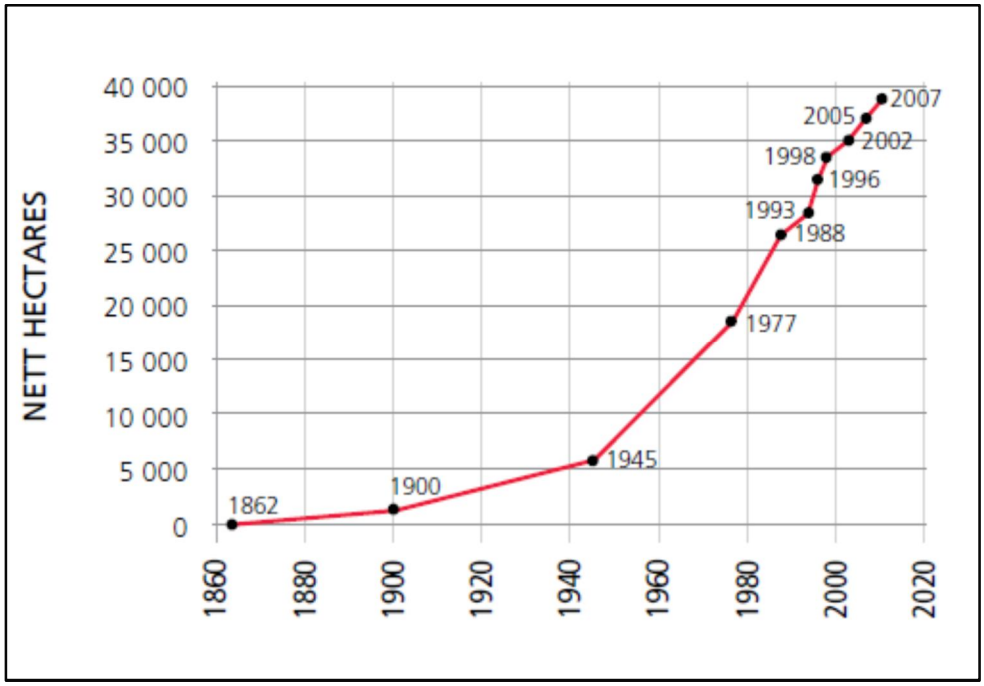


Figure 1: City of Cape Town growth from 1860 to 2007

(Source: CCT, 2012).

[3] This value reflects the cumulative value of infrastructure at risk at all points along the coastline over the next 25 years. Considering that the coastline of the city is not a homogenous environment, this risk zone will not be impacted upon uniformly.

[4] The approach of using development as a means to address poverty and unemployment is formally represented by the Accelerated and Shared Growth Initiative of South Africa. This initiative has set a target of achieving an average growth rate of 6% in GDP per annum. Added to this, 5 of the 8 Spatial Development Initiatives identified by the South African Government occur within coastal regions (South African Info, 2008).

Considering these factors of expected growth, increased pressure, value of the coast, coastal dynamic processes, the presence of critical infrastructure, the expected impacts of climate change, and the potential the coast has of becoming a source of risk to the City, it is imperative that appropriate regulatory mechanisms are developed to facilitate more effective governance and management of the coast. This will be critical towards ensuring the sustainability of the coast, ensuring the socio-economic potential of the coast is optimised and ultimately contributes to the prosperity of the city.

2.2 Report structure

This report details the City's method and process in delineating its draft coastal set-back. The report begins with determining objectives (Section 2.3) followed by a description of the City's legal mandate with respect to defining a coastal set-back in terms of the ICMA (Section 2.4). Section 3 begins with identifying and describing general principles that the City considers essential in establishing coastal set-backs. Following from this general overview, the report details a range of specific informants, based on a local level analysis, that were used to define the draft set-back for the city's entire coastline (Section 4). Section 5 details the City's methodology of delineating estuaries for inclusion within the City's set-back.

This report also details the process the City has undertaken in developing its draft coastal set-back. This primarily focuses on the stakeholder engagement process, both informally (Section 6.1) and formally (Section 6.2). Section 7 draws a comparison between the City's approach and that used in Overberg District Municipality (ODM).

Section 8 describes the 'bigger picture', providing information on the various supportive coastal regulatory mechanisms the City intends to develop in order to achieve the intent of the City's draft set-back. Section 9 outlines the implications to the City of not having a set-back in place. Section 10 concludes the report through summarising the method, process and proposed supportive coastal regulatory mechanisms outlined in Section 9. References, acknowledgment and annexures are provided in Sections 11, 12 and 13 respectively.

2.3 Objectives of the report

This report represents the City's submission to DEA&DP for the formalisation of the City's draft set-back in terms of the requirements of ICMA. The objectives of this report are therefore to:

1) Report on internal processes and consultations as well as the extensive Public Participation Process (PPP) undertaken in the formalisation of the City's draft set-back as the coastal urban edge in terms of the CT:SDF;
2) Provide a formal report to DEA&DP on the City's draft set-back delineation methodology;
3) Provide a comparison between the City's methodology, the Western Cape Methodology and the Overberg District Municipality's (ODM) Methodology,
4) Report on the City's progress and intentions with respect to the following supportive regulatory mechanisms to the coastal set-back:
    a. Municipal Coastal Management Programme
    b. Integrated Coastal Management Policy
    c. Coastal By-law

d. Coastal Protection Overlay Zones

5) Highlight the implications and risks to the City of not having a set-back line in place.

2.4 Meeting the requirements of the Integrated Coastal Management Act

The South African government in May 1997 began an extensive and integrated process of public participation research analysis to develop the White Paper for Sustainable Coastal Development in South Africa. The policy, in essence, "…aims to achieve sustainable development through a dedicated and integrated coastal management approach, in partnership with all South Africans" (DEAT, 2000: Foreword). Within this, policy provision was made for a Plan of Action which outlines in detail how the aims and objectives of the White Paper are to be met (DEAT, 2006). Resulting from this, and as a component of the *Plan of Action,* an Integrated Coastal Management Bill (ICM Bill) was made available for public comment in December 2006. In September 2008 it was accepted by the National Council of Provinces and on the 1st of December 2009, with the exception of certain sections, it became legally enforceable in South Africa. The ICMA is therefore South Africa's first legal instrument designated for promoting integrated management of the coastal zone and as such a tool towards assisting the White Paper in achieving its goals.

2.4.1 Section 25 of the ICMA: establishment of coastal set-back Lines

The establishment of a set-back for coastal municipalities is a legal requirement of the ICMA. In terms of Section 25 of the ICMA, set-backs must be established:

I. "to protect coastal public property, private property and private safety;
II. to protect the coastal protection zone;
III. to preserve the aesthetic values of the coastal zone;
IV. for any other reason consistent with the objectives of this Act; and
V. prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of that coastal set-back line" (ICMA, 2008: 42).

In general terms, a set-back is used as a planning mechanism to guide decision makers to more effectively regulate coastal development and to avoid risk from coastal hazards into the future. The focus of this regulation centres on the need to minimize the impact of development on sensitive coastal ecosystems, to retain and promote access to the coast, to prevent exposure of coastal property to risk from coastal processes, such as storm surges, coastal erosion, beach regression, migrating dune systems, and to retain the aesthetics and sense of place of the coastal space.

The City has defined its draft set-back in terms of the requirements of the ICMA. Through the application of the set-back, the City intends to manage the impact of development and activities on the coast to retain and improve the value and opportunities the coast provides. In addition to this the draft set-back will be used to ensure the coast remains accessible to all. To achieve these broader imperatives, set-backs require supportive regulatory mechanisms which will in turn require an integrative and multidisciplinary approach. The use of supportive regulatory mechanisms is also a requirement of the ICMA which states that local municipalities must incorporate set-backs into municipal coastal planning schemes. In recognition of the value of set-backs from a spatial planning perspective the City's draft set-back has been used to define the City's Coastal Urban Edge.

3. METHOD: GENERAL PRINCIPLES FOR THE DELINEATION OF CAPE TOWN'S SET-BACK

3.1 Introduction: socio-Institutional and biophysical response towards managing coastal risk

Although coastal dynamics and climate change pose a significant threat to the City, it is not the change of environmental systems in itself that will increases the City's risk profile. Rather it is the interaction of dynamic coastal processes, climate change pressures, the location of infrastructure along the coast and most critically the planning decisions that influence the location and nature of this infrastructure that determines the City's risk profile (Figure 2). With an increasingly transformed coastline, the presence of infrastructure within this dynamic space and the predicted impacts of climate change, there is a real threat that the opportunities the coastal environment currently provides will not only decrease into the future, but through continued inappropriate decision making and management interventions, the coast in itself will become an economic burden to the City. As it is now well known that the coast is a dynamic and unpredictable space, and that risk associated with the coast is expected to increase as a consequence of climate change, the City is developing planning mechanisms to more effectively guide and shape decisions to avoid the growth of risk into the future. The set-back is one such mechanism.



Figure 2: Hout Bay, Cape Town

A sediment by-pass system trying to re-establish itself and connect to Sandy Bay. It is not the migration of the dune system that is the problem, but rather the inappropriate decisions taken to allow infrastructure to be built in a high risk space *(Image courtesy of the Aerial Perspective: www.aerialphoto.co.za).*

The predicted impacts of global warming and the associated intensification of risk requires that there is a fundamental shift in the manner in which decisions are made in relation to the coast. Decision making needs to adopt a more risk averse approach, where the complex relations between coastal processes, infrastructure and risk management are taken into account. If the status quo remains

where there is a lack of a strategic city-wide decision support framework, decisions relating to coastal infrastructure and development will remain limited to an *ad hoc* and reactive and basis and risk to the city from the coast will increase.

There are multiple approaches, both globally and in South Africa, that have been used to manage the coast as a dynamic and risk space. According to Cartwright (2009) these approaches can be divided into six broad approaches:

1. 'holding the line', where coastal retreat from erosion is prevented through the installation of hard engineering interventions such as sea walls;
2. a phased retreat approach, whereby coastal infrastructure is re-aligned as a consequence of advancing coastal erosion;
3. socio-institutional learning, such as the establishment of set-backs to regulate development and activities along the coast;
4. biological responses (ecosystems-based management);
5. on-going decision making and iterative progress, and
6. 'do nothing and wait and see' approach where no intervention is undertaken to alter the status quo.

The City has developed a mechanism that has merged socio-institutional and biological responses, thus combining the merits of both, into a single strategy. Whilst socio-institutional responses include a range of approaches[5], this report is primarily focussed on the development of a coastal set-back for the City. Key to the success of any set-back line is the understanding of the unique local context within which the coast exists and to which the set-back will be applied. As set-backs have significant socio-economic implications, set-back methodologies must draw in and reflect localised social, economic and environmental interests. The application of set-backs to manage risk is not only the most cost effective approach from a cost benefit perspective (Figure 3), but it acts on the most critical issue: socio-institutional transformation through more appropriate and risk averse decision making. This approach will guide and shape decisions that are made in the sensitive coastal space, and it will ensure that the range of benefits and opportunities the coast provides will be retained and enhanced into the future. Thus, this socio-institutional and biological approach will ensure that when decisions are made, these decisions will be made in the interest of the broader community.

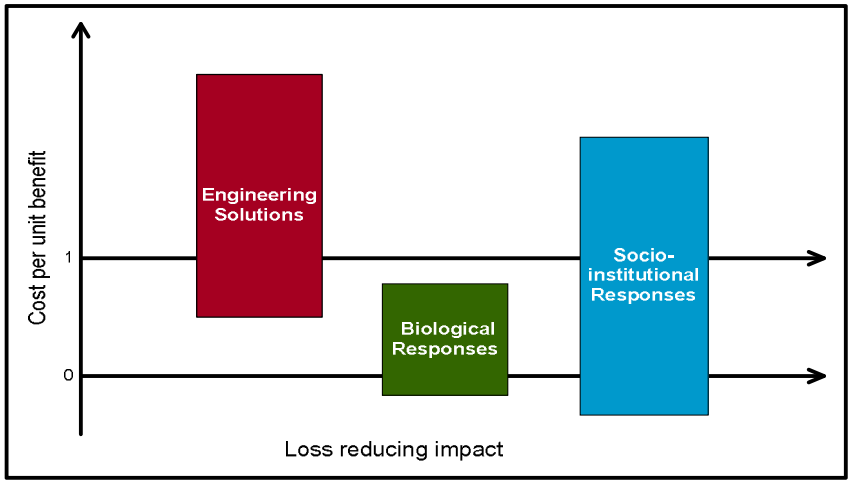


Figure 3: Cost benefit of a range of coastal protection interventions

A stylised representation of the range of cost benefit per unit for engineering, biological and socio-institutional responses (Source: Cartwright, 2009).

[5] Other socio-institutional responses include vulnerability mapping, application of coastal legislation, research and monitoring, early warning systems, disaster management systems etc. (Cartwright, 2008). Whilst the City has these in place, the intention of this report is to focus on the City's coastal set-back.

3.2 14 Key principles in developing a set-back

There are 12 key principles that are critical towards achieving an effective and pragmatic set-back. These 12 key principles are identified as (taken from Colenbrander *et al,* in press*)*:

1. The coast must be acknowledged as a complex and connected space, where social-ecological systems are inherently linked;
2. The social, economic and environmental implications of set-backs require that set-back methodologies shift away from a myopic focus on modelling biophysical risk to a more inclusive multi-disciplinarity that draws in socio-economic and broader environmental dimensions;
3. Risk from coastal modelling must be treated as indicative and not absolute;
4. Adopting a multi-disciplinary approach is key to aiding municipal planners to identify and navigate the tensions that arise out of the process of defining set-backs at a localised scale;
5. The inclusion of localised socio-economic and environmental dimensions is central to the effectiveness of set-backs, ICM and ultimately sustainable coastal development;
6. As local contexts require local solutions, set-back methodologies must be developed and grounded within local realities;
7. In the case where set-backs are defined internally within municipalities, municipal authorities must be capacitated. The capacitation of municipalities must be seen as the preferred alternative as with capacitation comes both institutional memory and local knowledge of the coast. It is this 'grounded' knowledge that is likely to yield set-backs that are connected to the social, economic and environmental nuances of the coast and which is critical in developing an effective and pragmatic set-back;
8. Set-backs must be developed in a way that promotes their integration into locally developed planning and building regulation schemes;
9. Practicality and simplicity: the coastal zone is a complex space. The effectiveness of a set-back is largely dependent upon its practical application;
10. Risk from coastal hazards is a shared problem. The development of set-backs to manage this risk must be founded on a collectively determined resolution between authorities and the public: the process must determine the outcome;
11. The determination of set-backs must be an iterative process informed by scientific, practitioner and community based knowledge;
12. The process of defining set-backs requires negotiation and dialogue over meaningful periods of time with I & APs;

These principles have been applied in the determination of the City's set-back. Based on these principles, the set-back forms the foundation from which to stimulate and promote the triple bottom line: economic development and access to the coast, the improvement of livelihoods of coastal communities through promoting economic and social opportunities whilst simultaneously reducing risk and finally the preservation of coastal ecosystems and associated goods and services.

The coast of South Africa is remarkably variable, in both socio-economic and biophysical attributes. Even within the city, there are vast differences in the socio-economic and biophysical attributes of the False Bay coastline compared to that of the West coast. These localised differences necessitate that local solutions are developed for local conditions. It is these unique conditions that must determine the informants used in developing the methodology for determining set-backs. In the case of Cape Town, it is the combination of a highly urbanised coastline interspersed by fragmented swathes of undeveloped land together with vastly differing socio-economic conditions along the coast that has largely influenced the City's set-back methodology.

3.3 A complex urban and peri-urban coastal environment: a practical approach

Cape Town is a metropolis. Much of the coastline has already been developed extensively, in many places up to the HWM. In some places, such as Sea Point and the Foreshore, reclamation has taken place. The coastline has therefore been completely altered in certain areas. However, interspersed between these developed segments of the coastline are stretches of undeveloped land retaining functional coastal ecosystems. It is these vastly differing segments of coastline and associated socio-economic attributes that has necessitated a practical approach towards defining a set-back that works for the City.

The placement of set-backs has real implications for property owners, especially where property may fall within (seaward of) set-backs. The implications are varied, but the most significant being the potential devaluation of the property as a consequence of set-backs defining risk zones. The recent experience in the Overberg District Municipality is a case in point where the process of defining the set-back line was met with much negativity and in some cases the position of the set-back was contested (DEA&DP, 2011). Considering that different models yield different results based on different input parameters and the subsequent uncertainty surrounding the prediction of risk from storm surges, coastal erosion and sea-level-rise, challenging the position of the set-back in relation to cadastral boundaries was fully justified.

Due to the presence of private properties with existing development rights in close proximity to the high-water mark, and the potential legal challenges that may arise through including properties within set-backs, the City has deliberately excluded properties with development rights from the City's draft set-back. This approach applies to properties with development rights that are potentially at risk from storm surges and coastal processes. Through adopting this approach, and as a general, rule of thumb, the City's draft set-back line follows the most seaward cadastral boundary of properties with development rights in developed areas. The opposite is true for less developed sections of the coast (land predominantly owned by the City) where coastal ecosystems are still intact and as such the City's set-back is extended further inland based on additional key informants. A detailed description of these informants is provided in Section 4: Key Informants in the Delineation of Cape Town's Set-back.

This approach has resulted in the following outcomes:

- A practical approach that seeks to achieve uncomplicated outcomes;
- This approach has enabled the City to focus on the priority areas of less developed coastal stretches;
- In these less developed areas the City is in the position to prevent inappropriate decision making (Figure 2, 5, 11 and 18 refers) in terms of coastal development recurring and increasing into the future;
- As a consequence the City's social risk profile is reduced;
- Reduce the unnecessary burden of environmental legislation on already developed footprints;
- Develop appropriate spatial planning mechanisms and equip the City to address and manage existing infrastructure at risk to coastal processes and storm surges, and These attributes have in turn resulted in majority (97%) public support and buy-in to the City's set-back.

This approach has been undertaken to get the 'basics' right first: prevention of further inappropriately located development along less developed stretches of the City's coast. As a consequence of this approach, and the deliberate exclusion of private property with existing rights from the draft set-back, there is a substantial amount of property and infrastructure that is located landward of the draft set-back, but is still at risk from storm surges and coastal erosion (Figure 4).



Figure 4: Private property in Bakoven at risk from storm surges

Properties such as these are on the landward side of the City's draft set-back but are still at risk from storm surges. Many of these properties can no longer claim insurance for damage caused by storm surges. Addressing this requires additional supportive regulatory frameworks (Section 8).

Addressing existing property at risk is a complex matter as it draws in legalities relating to property rights and impacts on property values. This cannot be adequately addressed through the application of another set-back. In addition to this set-backs are not designed nor equipped to address existing infrastructure at risk. Due to the ineffectiveness of set-backs in retrospectively responding to risk, the management of risk in these circumstances requires additional supportive regulatory mechanisms and is best dealt with through a policy approach. Although not directly linked to the City's method of defining a set-back, this report provides further detail on these regulatory mechanisms and the City's Integrated Coastal Management Policy (Annexure M) to give a broader context to the method and process in defining set-backs and how the City intends to manage existing infrastructure at risk into the future. This detail is covered in Section 8: Process Forward: Supportive Planning and Regulatory Mechanisms for the City's Set-back.

3.4 Table Mountain National Park

Cape Town's coastline is approximately 307km long. Of this, 67km (22%) of the length of this coastline falls within Table Mountain National Park. This land is administered by the South African

National Parks. In addition to national park land, there are other parcels of land that are located along the coast within the City's area of jurisdiction, but which is not administered by the City. Examples of these parcels of land include land surrounding the Koeberg Nuclear Station (Eskom), crown land and ports (National Ports Authority). As the City does not have any jurisdiction over this land, the City has not demarcated a set-back within these parcels of land. The City's existing draft set-back is therefore not contiguous for the entire length of coastline but is punctuated by gaps reflecting these various parcels of land.

4. METHOD: KEY INFORMANTS TO THE DELINEATION OF CAPE TOWN'S SET-BACK

The intention of a set-back line is to guide planning decisions to promote sustainable coastal development whilst simultaneously retaining and enhancing the ecosystems services provided by our coastal resources. To achieve this, it is important that the key coastal issues themselves are used to inform the process of defining a set-back. The effectiveness of a set-back is therefore largely dependent on our ability to grasp coastal issues at the local level and which span a variety of disciplines. Adopting a trans-disciplinary approach assists in the development of a more holistic understanding of the coast and the nature of connections between the various informants. This approach is paramount in efforts towards achieving the City's goals of retaining the coast as an asset and increasing the opportunities the coast provides into the future. Based on this trans-disciplinary approach, the following key socio-economic and environmental informants have been used in delineating the City's set-back line (Section 4.1. to 4.5 details how these informants were incorporated into the City's set-back):

- The socio-economic imperative of promoting access to the coast and redressing the inequalities of South Africa's past of exclusion;
- Risk from sea-level rise, storm surges and coastal erosion;
- Risk from coastal dynamic processes;
- The need to retain the sense of place, coastal aesthetics and heritage value of the coast;
- Protection of coastal systems and processes, and
- The importance of retaining biodiversity as a central pillar towards addressing these challenges.

Whilst these informants have been listed separately, there are strong connections between them. For example, by protecting coastal biodiversity corridors, not only are coastal aesthetics and sense of place retained, but the buffer potential that these systems provide to storm surges is retained. This in turn reduces the potential for transferring risk to coastal communities. The recreational and amenity value of the coast as an important social asset is also retained. The recognition of the coast as a coupled socio-economic and environmental system is critical not only in the process of defining a set-back but is central to the principals of ICM.

4.1 Set-back informant one: promoting access to the coast

The coast of Cape Town is an important socio-economic asset. Considering the vast inequalities of coastal communities along the City's coastline, and South Arica's apartheid past, it is imperative that previously disadvantaged communities are afforded the same opportunity to gain access to the coast to improve their livelihoods as did the ruling white minority in the past. The presence of communities

along the Cape Flats coastline is an example of 'Environmental Apartheid': different races were forced to live separately in terms of the Group Areas Act. In addition to this, certain races were forced to relocate to less desirable areas that are subject to harsh environmental conditions which include persistent and strong winds, wind-blown sand, salt spray etc. The Cape Flats is no exception. The desire to improve the livelihoods of previously disadvantaged communities through tapping into coastal resources of the Cape Flats coastline must therefore be balanced with avoiding risk arising from the harsh environmental and coastal conditions. Finding this balance between promoting access to the coast whilst remaining risk averse is critical and requires in-depth research. In the event of inappropriate coastal planning, the City unintentionally generates risk. Paradoxically, this risk is then transferred back to the local community to which such developments were intended to benefit.



Figure 5: Macassar Pavilion

Macassar Pavilion was developed to promote access to the coast through enhancing the recreational and amenity value of the coast. However, due to its location in a harsh environmental space exposed to strong south easters and wind-blown sand, the Pavilion is now derelict and subject to anti-social behaviour of prostitution, crime and drug abuse. The risk associated with these social ills has been transferred to the local communities to which this Pavilion was originally supposed to benefit.

Realising the impacts on spatial form of City development as a consequence of coastal set-backs, the process of designating coastal access was drawn into the principles contained within the set-back methodology. The City has identified two tiers of access according to the scale at which access is promoted along the coast. The first scale, or macro scale, is at the level of promoting broad scale socio-economic benefits through connecting communities to the coast by means of nodal growth. The second tier or micro scale is at the level of promoting safe and environmentally sensitive access to the beach via designated access paths, i.e. shoreline or coastal access. The City's set-back has been established with the intention to promote and enhance both tiers of access.

4.1.1 Macro scale access: nodal growth points

The intent to address the inequalities of the past through connecting communities to the coast via development, and ensuring that this development takes place in nodal rather than strip form is

reflected in the CT:SDF. The CT:SDF has identified a number of nodal growth points along the City's coastline. Current priorities are Silwerstroomstrand on the west coast as well as Strandfontein, Mnandi and Monwabisi in the Cape Flats region of the False Bay coastline. Along the False Bay coastline, where the need to promote access to the coast is more intense, nodal growth areas were identified in a study entitled *Rapid Planning Review of Potential Future Development Areas along False Bay Coastline* undertaken in 2009 (Annexure A). The study area focussed on the stretch of coast between Strandfontein and Monwabisi and investigated future urban development opportunities for the Cape Flats coastline. The study included the following:

- The development of a concise synthesis of strategy and policy imperatives that inform development along the coast;
- The identification of key development challenges and opportunities experienced within the study area;
- The identification of zones for development opportunity along the relevant section of the coastline;
- The identification of a set of guiding principles that should inform development proposals along this stretch of coastline, and
- A detailed analysis of the local biophysical informants that may restrict development at the identified zones of opportunity (CCT, 2009).

The outcomes of the study identified four key coastal nodal development opportunities at the sub-regional scale. These four nodal points were identified as Monwabisi, Mnandi, Blue Waters and the Strandfontein Pavilion (Figure 6).

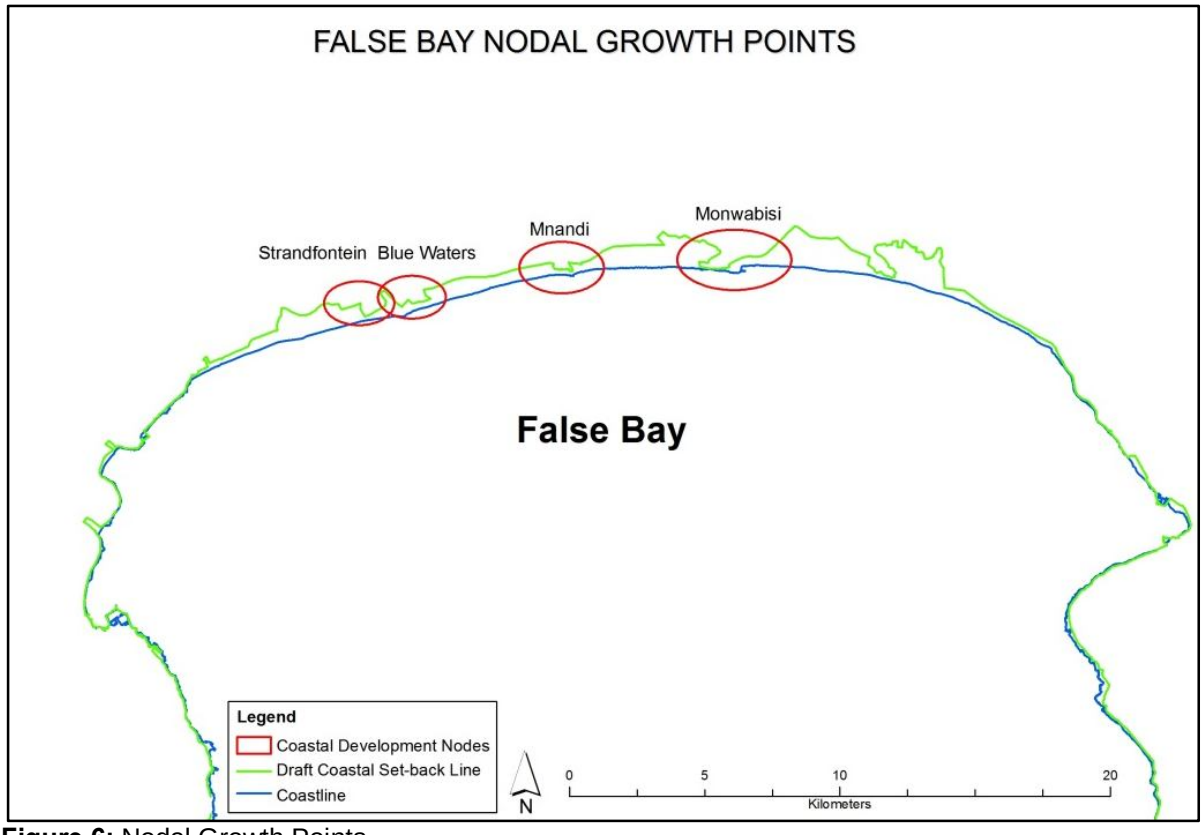


Figure 6: Nodal Growth Points

The four nodal growth points identified for the False Bay coastline

Provision was therefore made for these growth points in defining the City's coastal set-back. Although these nodal growth points have been defined in terms of the need to promote access to the coast, the specific footprint of these nodal growth points were further refined based on key informants of biodiversity corridors, dynamic coastal processes, risk from sea-level rise and storm surges etc (Figure 7). When funding is available and development does take place with these nodal growth points, more detailed studies as well as environmental authorisations will be required to limit the impact to the broader environment and to ensure that social risk to coastal hazards is reduced.

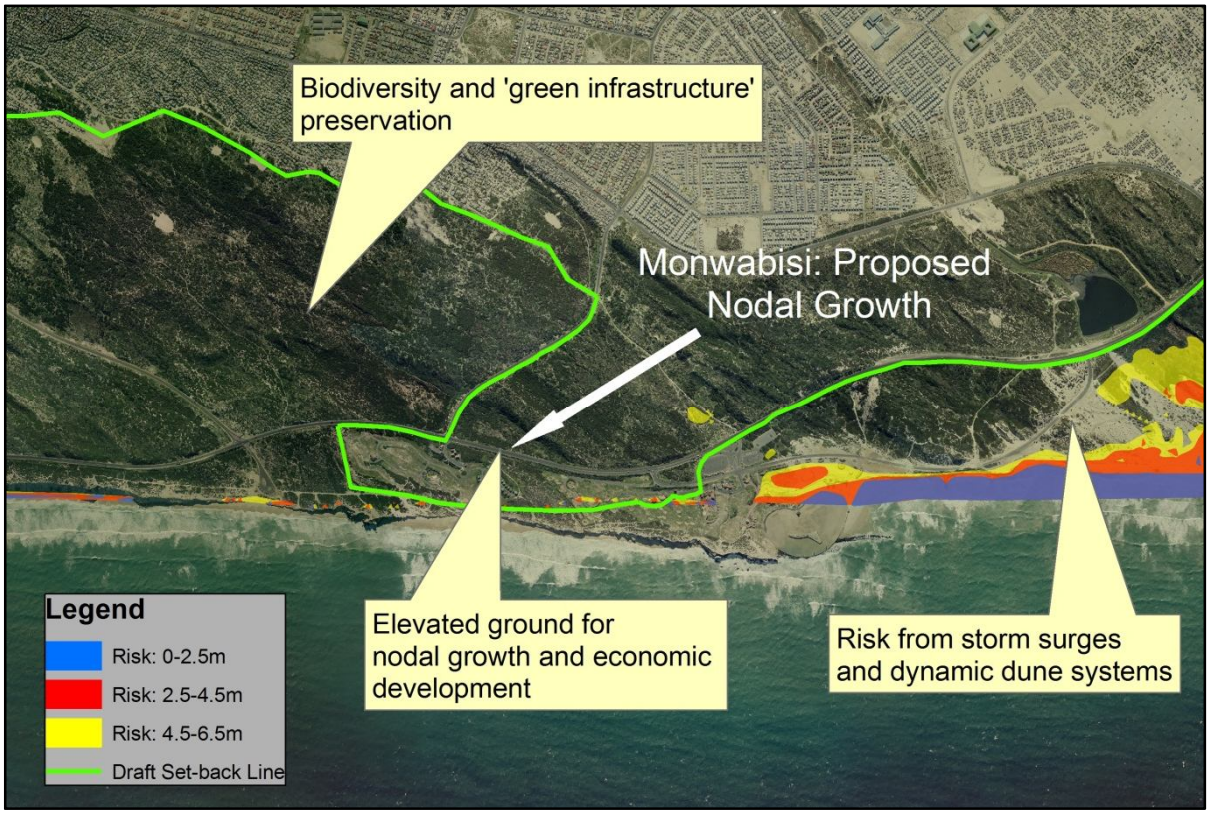


Figure 7: Monwabisi Coastal Resort

The City has defined a set-back that both promotes access to the coast through nodal growth whilst simultaneously ***retaining 'green infrastructure' and*** *demarcating areas to be avoided due to sea-level rise, storm surges and coastal dynamic processes.*

4.1.2 Micro scale access: access to the beach

As important as it is to unlock the economic potential of the coast through nodal growth points, it is similarly important to retain access to the coast on a smaller scale through designated coastal access paths. Access to the beach may become compromised due to a number of factors. The greatest threat to equitable access to the beach is strip development and subsequent privatisation of the coast (Figure 8).



Figure 8: Privatisation of the coast, Salt Rock, KZN

Access to the beach by the general public along this stretch of coast in KZN is severely compromised.

The only remaining access points along this stretch of coast in KZN are isolated servitudes, where there is little or no space allowed for supporting amenities such as car parks, showers, ablutions etc. (Figure 9). The City does not wish to repeat this.



Figure 9: Servitude at Salt Rock KZN

No space left for supporting amenities.

Through the promotion of nodal development along remaining less altered coastlines, coastal areas will remain accessible to all, and these access points will be supported by the necessary amenities.

4.2 Set-back informant two: sea-level rise, storm surges and coastal erosion

The City completed a Sea-Level Rise Risk Assessment (SLRRA) in 2009. The intention of the assessment was to:

- Spatially model the predicted sea-level changes in a range of scenarios (time series, incremental climate change, shear events, and storm frequency and intensity);
- Model the form that those changes will take;
- Understand the associated impacts on existing coastal systems, infrastructure and property;
- Provide guidance on and information about implications for future coastal development;
- Identify high risk areas that are prone to high impact, and
- Begin to understand and develop long-term adaptation and mitigation measures against these coastal hazards.

The outcomes of this research has enabled the City to make more informed decisions in terms of future planning, preparedness and the promotion of risk averse decision making along the City's coastline. The term 'risk' in itself is subjective and requires careful consideration. In understanding and managing risk, key questions need to be considered: What is risk? How do different sectors perceive risk? What are the drivers of risk? How is risk experienced and how does it manifest across different scales? In acknowledgement of the complexity of the term 'risk', the City's SLRRA was undertaken in five different phases. These phases included:

Phase 1: Sea-Level Rise Model (March 2008) (Annexure B)
Phase 2: Risk and Impact Identification (May 2008)
Phase 3: Quantifying the Risk (June 2008)
Phase 4: Sea-Level Rise Adaptation + Risk Mitigation Measures (July 2008)
Phase 5: Full investigation of alongshore features of vulnerability on the City of Cape Town coastline (December 2009) (Annexure C)

Whilst the SLRRA examined risk from both a physical and socio-economic perspective through these various phases, Phases 1 and 5 focussed primarily on physical risk and the most appropriate responses to manage this risk respectively. Phase 1 and Phase 5 were therefore key phases in the development of the City's set-back in terms of addressing risk from physical coastal processes. More emphasis has therefore been placed on Phase 1 and 5 in this report (full reports provided as Annexures B and C) whilst Phases 2 to 4 in this report are limited to brief descriptions.

4.2.1 Phase 1: spatially modelling sea-level rise and storm surge events through GIS

As a starting point to understand physical risk from sea-level rise and storm surges, a Geographic Information System (GIS) was used to develop the risk model. This model spatially demarcates areas that may be physically impacted upon by storm surges and sea-level rise. This model was developed based on the following scenarios:

- Scenario 1: Present Day Worst Case Scenario;
- Scenario 2: Sea-level Rise Scenarios Into the Near Future, and
- Scenario 3: Sea-level Rise Scenarios after the Collapse of the Polar Ice Sheets.

As there is much uncertainty regarding the timing, extent and acceleration rates of the polar ice sheet melt and the eventual contribution to sea-level rise and coastal erosion, Scenario 3 has not been used to inform the development of the City's draft set-back. The report will therefore focus on Scenarios 1 and 2.

Scenario 1: Present Day Very Worst Case Scenarios

This scenario presents the current worse case storm surge and is based on the simultaneous occurrence of an extreme tide[6] and an extreme storm, an event with a nominal return period of 500 years (Brundrit, 2008). Such an event has not occurred along the Cape coast in recent years but it did occur along the KZN coast on 19th and 20th of March 2007. Measurements[7] were taken from this extreme storm in KZN and were incorporated into the Present Day Very Worst Case Scenario, particularly in respect of exposed and very exposed portions of the coastline. Based on the degree of exposure, three inundation levels were determined and built into the model. These three inundation levels (Figure 10) include the following:

- Land Levelling Datum (LLD) +2m in sheltered environments;
- LLD+4.5m above mean sea-level in exposed environments, and
- LLD+6.5m above the mean sea-level in very exposed environments

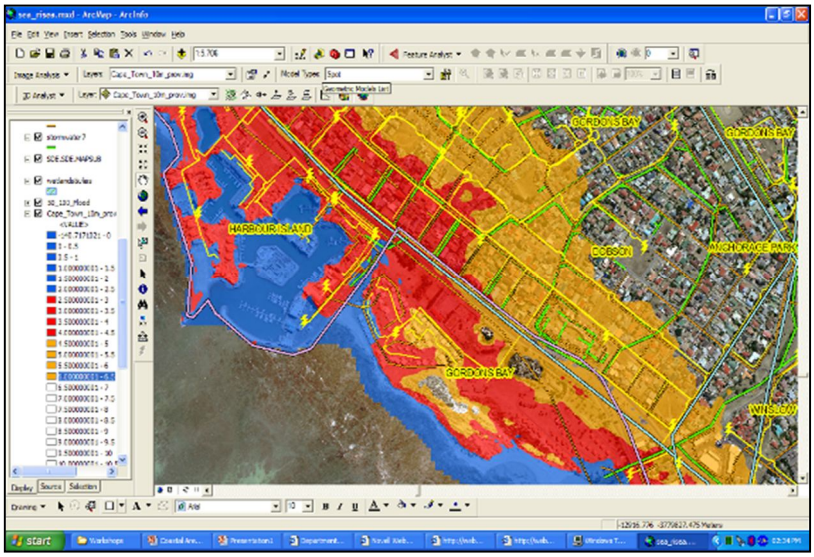


Figure 10: Flood risk scenarios for the City over the next 25 years

The inundation levels in the model are depicted in different colours for analytical purposes namely; blue, red and orange for LLD +2m, LLD+4.5m and LLD+6.5m respectively. With these scenarios, the inundation levels are not considered permanent, but rather as levels of temporary inundation typically experienced during a storm surge event[8].

Scenario 2: The Scenario at the End of the Next Decade

This scenario models the likely trends into the future based on increased storminess and sea-level rise. Global observations indicate a statistically significant rise in sea-level of approximately 50cm over the next decade (Brundrit, 2008).The levels used in Scenario 2 and the details of the inundation to be expected are the same as Scenario 1. However, with the incremental rise in sea-level and the

[6] Highest Astronomical Tide of the Year (HATOY)
[7] Key statistics include a return period of 30 years and an erosion line consistently located between the 4m and 5m contours.
[8] This model assumed the coast as a homogenous environment and applied a 'blanket' approach to the entire coastline as the initial investigation. The coastline does however vary and has localised biophysical factors that influence risk. In acknowledgement of this, the City undertook a final investigation in Phase 5 as a means to fine tune this model and disaggrate risk by incorporating the local biophysical factors. The outcomes of Phase 5 are covered in more detail in Section 4.2.5.

expected increase in storminess[9], it is the return period that is expected to change. Rather than being a Very Worst Case Scenario with a return period of 500 years, Scenario 2 is expected to occur whenever an extreme storm occurs at the same time as any (fortnightly) spring high tide in the spring or autumn (Brundrit, 2008). With the expectation of storms becoming more frequent, in conjunction with the incremental rise in sea-level, the scenario at the end of the next decade becomes realistic rather than an unusual event and hence is used to predict the expected trends for the Cape Town coastline (Brundrit, 2008).

4.2.2 Phase 2: risk and impact identification

The main objectives of Phase 2 of the SLRRA were to:

- Determine the manner in which risk manifests as a consequence of sea-level rise impacts (coastal erosion, direct and indirect inundation of infrastructure, disruption of services, loss of habitat, etc.) and how this will affect the City of Cape Town.

- To develop an understanding of potential sea-level rise impacts based on Scenarios 1 and 2 on the present infrastructure and amenities along the City's coastline. Information was gained through hosting workshops primarily at an operational level across multiple departments responsible for City infrastructure and services, natural resource management, commercial and residential property and policies for ensuring compliance. Information from the workshops provided detail on the linkages between the expected impacts, and consolidated priorities.

4.2.3 Phase 3: quantifying the risk

Phase 3 of this study described and quantified the risk of sea-level rise for the City. This study involved drawing on projections of sea-level rise for the Cape Town coastline based on the projections determined in Phases 1 and 2, and assessing the socio-economic risks that might be associated with this phenomenon; more specifically, quantifying and detailing the risks to the City of Cape Town and its citizens of sea-level rise over a time period of 5-100 years.

In determining the economic impact the study relied on a collection of three proxy values – measures as a means to quantify economic loss:

- The first proxy value applied is the loss of real estate as the coastline becomes increasingly exposed to storm surges and existing properties are damaged and vacant land becomes both uninsurable and undesirable for development;
- The second proxy variable applied in this analysis is foregone tourism revenue. The Cape's coastline and beaches contribute to the City's tourism appeal, and
- As a third proxy, the cost of replacing certain public infrastructure that could be damaged by sea-level rise was included.

This economic impact is therefore represented by the formula:

$R_e = f_e \sum$(loss of private property value + loss of tourism revenue + loss of public infrastructure)

Where f_e represents the probability of a sea-level rise event e, where "e" is a sea-level rise event as described in Scenarios 1-3 (Cartwright, 2008).

[9] Increase in storminess is not restricted to mid-latitude cyclones, but also increases in intensity and duration of south easterlies (and subsequent south easterly driven wave chop) arising from the south Atlantic high pressure system.

Table 1: Quantifying the risk based on the flood risk scenarios over the next 25 years

25 years	Inundation level 1	Inundation level 2	Inundation level 3
Seal-level	2.5m	4.5	6.5
Probability in next 25 yrs.	95%	85%	20%
Threatened value	R5.2 billion (US $500 million)	R23.8 billion (US $2.3 billion)	R54.8 billion (US $5.4 billion)
Value at risk	R4.9 billion (US $490 million)	R20.2 billion (US $2 billion)	R11.0 billion (US $1.1 billion)

It should be noted that the City is unlikely to be confronted by the full extent of these costs in a single storm surge event; that would require the simultaneous impact from a storm surge at all points around the coastline and we know that due to local biophysical conditions that vary greatly along the City's coastline, the run-up of such events will vary significantly according to the location of the coast. Rather, the figures represent the cumulative risk and costs over a 25 year period at all points along the coast (Cartwright, 2008). In addition to this, these values are based on the assumption that the loss of tourism revenue, property and infrastructure is absolute rather than partial.

4.2.4 Phase 4: sea-level rise adaptation and risk mitigation measures

Phase 4 of the report aimed to identify adaptation and management measures to lower the risk profile of the City. This was undertaken by assessing the broad costs and merits of different approaches used to counter the impacts of sea-level rise in conjunction with storm surge events. It was found that the risk of sea-level rise could be significantly reduced by proactive socio-institutional responses to the problem. The Phase 4 report has outlined a number of measures and their costs and benefits that could be considered to reduce sea-level rise and storm surge risk for the City of Cape Town under the categories of:

- First resort: No regrets options – a risk averse approach;
- Second resort: Additional socio-institutional measures – i.e. development of set-backs;
- Third resort: Additional biological measures – an ecosystems based management approach, and
- Last resort: Additional physical measures – the use of hard engineering structures.

Based on the identification of the various adaptive options, comprehensive feedback was provided to officials that participated in the workshops held for Phase 2. This provided an enabling platform for a participatory approach with multiple stakeholders to determine trade-offs that might arise from the implementation of climate change adaptation measures. Further to this, this phase substantiated the importance of proactive measures and the potential long term consequences of deteriorating economic conditions from runaway climate change (Cartwright, 2008).

4.2.5 Phase 5: investigation of longshore features and adaptation options

Phase 5 of the SLRRA consisted of two reports. The first report was used to further refine the model generated in Phase 1 through the consideration of local biophysical factors that influence risk from storm surge events. The report distinguished areas in terms of their exposure to risk based on alongshore features such as wave set-up and wave run-up, wave shoaling, off-shore bathymetry, swell diffraction into shadow zones, focussing effects, coastal geomorphology as well as the extent and nature of coastal development. Included within this report are how these local biophysical factors interact with each other and how these interactions affect degrees of risk.

Based on this report, a total of 19 locations (Tables 2, 3 and 4 and Figure 12) were identified as being vulnerable. The vulnerability was determined by a binary assessment of four biophysical factors, namely wave-setup, wave run-up, coastal geology and development risk. A score of 1 was allocated to those areas that are perceived to be exposed to storm surges, and a score of 0 was given if the location is not exposed to that component. The assessment was conducted using the expert opinion of a group consisting of local oceanographers, coastal management practitioners and engineers, all of whom were drawing on in-depth knowledge of the city's coastline. The assessment not only provided a reasonable measure of the total sea-level rise risk at a given location, but it also provided important insight into the specific nature of sea-level rise risk at different locations.

Table Bay

Table Bay is an area of gently sloping bottom contours and a sandy coast fringed by low dunes and occasional rocky outcrops. Part of the coast is sheltered by Robben Island. The coast is eroding in the south, and is particularly vulnerable where it is backed by the lagoon of Diep River.

Table 2: Components of sea-level rise vulnerability for Table Bay

Location	Wave set-up	Wave run-up	Coastal geology. Hard or soft surfaces.	Development risk	Comment
Melkbosstrand	1	0	0	1	Exposed to big swell, but with some shelter from offshore reefs and a shallow bathymetry. Beachfront development and dune removal is problematic.
Blouberg (Bay)	1	0	0	1	Sheltered behind Robben Island, the beach should be an area of sand accretion. However, extensive development has encroached too close to the waterline. Protection is needed.
Tableview beachfront	1	0	0	1	Exposed to big waves, where the Beach Road will become at risk. Protection is needed.
Milnerton beach	1	1	0	1	Exposed to big waves and, at high tide, surging breakers. This is an eroding beach with a diminishing steep dune cordon. Potential major issue if the protection

					to Otto du Plessis Drive is lost.
Milnerton to harbour	1	0	1	1	Shadow zone, no big waves. Harbour construction has led to gradual erosion and set-back, with on-going loss of coastal infrastructure. Sea wall needs constant maintenance. Oil pipeline is strategic.

Atlantic Coast

The Atlantic Coast is a rocky coast with cliffs, offshore reefs and extensive kelp beds. Deep water is found close to the shore, permitting big waves to crash onto the coast so that protection is needed for any infrastructure at sea-level.

Table 3: Components of sea-level rise vulnerability for the Atlantic coast

Location	Wave set-up	Wave run-up	Coastal geology. Hard or Soft Surfaces	Developmen t Risk	Comment
Green Point & Sea Point	1	0	1	1	Exposed to big waves, but some shelter from offshore reefs. The coast is on an exposed wave cut platform at some height above the sea, but needs the protection of a strong sea wall requiring continuous maintenance.
Glen Beach	1	0	0	1	A small pocket beach with some protection. High value beach houses are exposed.
Camps Bay	1	1	0	1	This beach is exposed to big waves. Wide beach, but high sea-levels can reach the Beach Road.
Bakoven cottages	1	1	1	1	Very exposed to big waves and wave run up, and constantly under threat, as the houses are low down and on a hard rocky surface.
Kommetjie	1	1	0	1	Very exposed as deep water close inshore. Development has taken place in the protective dune field, reducing its effectiveness.
Witsands	1	1	0	0	Very exposed single building in dynamic dune field.

False Bay Coast

The western side of False Bay is steep and well sheltered from waves approaching from the south west. Within False Bay, the bottom contours are gently shoaling to the sandy northern shores. The eastern side of False Bay is steep.

Table 4: Components of sea-level rise vulnerability for the False Bay coast

Location	Wave set-up	Wave run-up	Coastal Geology. Hard or Soft Surfaces	Development Risk	Comment
Glencairn	1	0	0	1	Railway line running along a low wave-cut platform. Sheltered in shadow zone, but perhaps the foundations of the railway line in the backing wetland need continual maintenance.
Fish Hoek dune section	1	0	0	0	In shadow zone, but backing wetland may lead to vulnerability.
Kalk Bay	0	1	1	1	In shadow zone from southwest, but exposed to focussing from the south-east, so that harbour provides some protection.
Muizenberg corner	1	0	0	1	In the edge of the shadow zone, but protected by a wide and very flat beach with spilling breakers.
Strandfontein – Baden Powell Drive / Treatment Works / Landfill	1	0	1	1	Not too exposed but the road and the infrastructure are too close to the water's edge.
Monwabisi and Macassar Pavilions	1	1	0	1	Exposed to surging breakers at high tide and during storm events, with erosion of dune field.
Strand (entire beach front)	1	0	1	1	Exposed beach with protection from offshore reefs, but infrastructure constructed close to water and poorly planned sea-walls.
Bikini beach	1	0	0	1	In swell shadow, but infrastructure too close to water and needs protection.

					Beach sand erodes.

The identification of the vulnerable areas based on the influence of local biophysical factors and the subsequent disaggregation of risk has been key to the process of understanding risk at a localised scale. A great deal of risk from sea-level rise and storm surges can be removed by timely interventions, but deciding exactly how to respond and who should take responsibility is difficult. The second report of Phase 5 therefore focussed on determining ways and means of ensuring a coherent and strategic approach towards prioritising actions and promoting consistent decision making with respect to managing this risk. The nature of risk from sea-level rise and storm surge events requires that set-backs are complimented by additional regulatory mechanisms. A holistic overview of coastal regulatory mechanisms and how they link together is provided in Section 8.

4.2.6 Comparative study: actual wave-run up vs. modelled predictions

This study was undertaken as an addendum to Phase 5 of the SLRRA. On the 31st August 2008 the city experienced an extreme storm surge event. A sub-tropical cyclone developed approximately 600km west of Cape Town and at the same time a secondary severe low pressure system also developed which resulted in a case of explosive cyclogenesis. The combination of these low pressure systems resulted in significant erosion and damage to infrastructure along the city's coastline (Figure 11).



Figure 11: Storm surge event on the 31st August 2008

Coastal erosion at the Milnerton Golf Clubhouse.

The purpose of this study was to draw a comparison between actual wave run-up[10] heights at vulnerable locations (Figure 12) experienced by the 2008 storm with the City's model as well as the model developed by Mather *et al* used to predict extreme wave run-up heights.

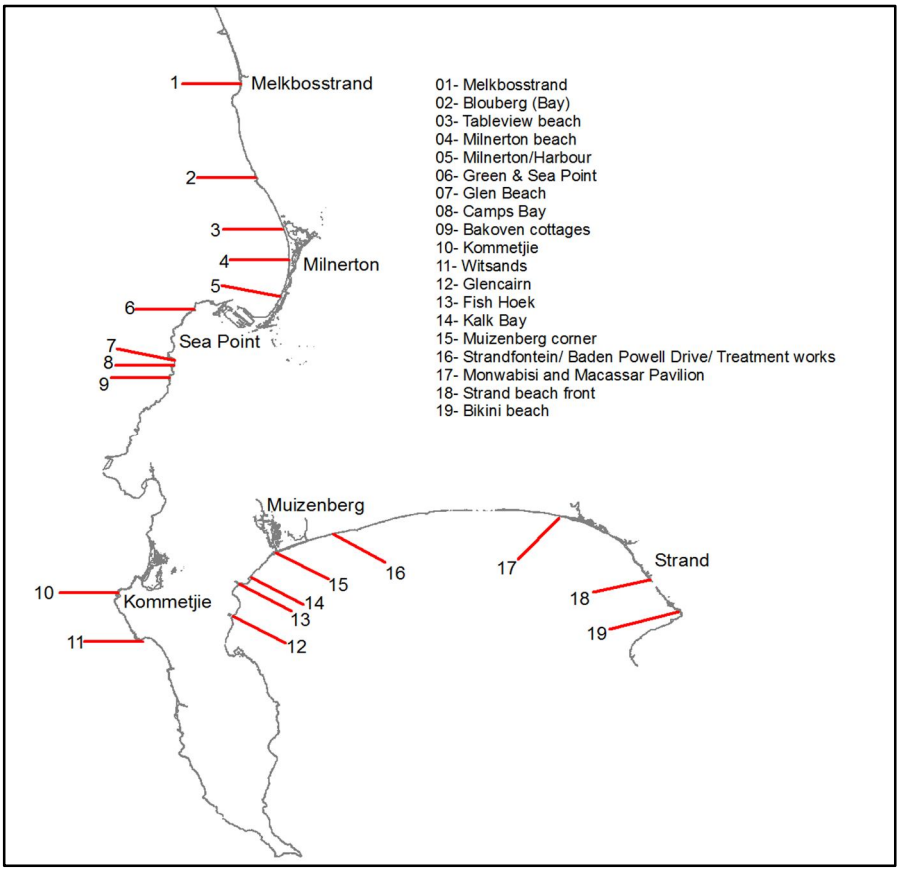


Figure 12: Vulnerable areas of the City's coastline

Being able to accurately predict wave run-up heights is an important component in the development and placement of set-backs. The Mather *et al* model is generally accepted as the most robust wave run-up model in South Africa and as such was used for one of the comparisons. The model uses distances offshore x_h to water depth *h* to estimate a near-shore profile slope as $S = h/x_h$ where the depth of closure is the suggested choice for *h*. Extreme run-up R_x is then expressed in terms of S as $R_x/H_0 = CS^{2/3}$ (Mather *et al,* 2011)(Figure 13).

[10] Extreme wave run-up may be defined as the maximum level, relative to the still water level reached by a wave or by a series of waves (Mather, *et al*, 2011).

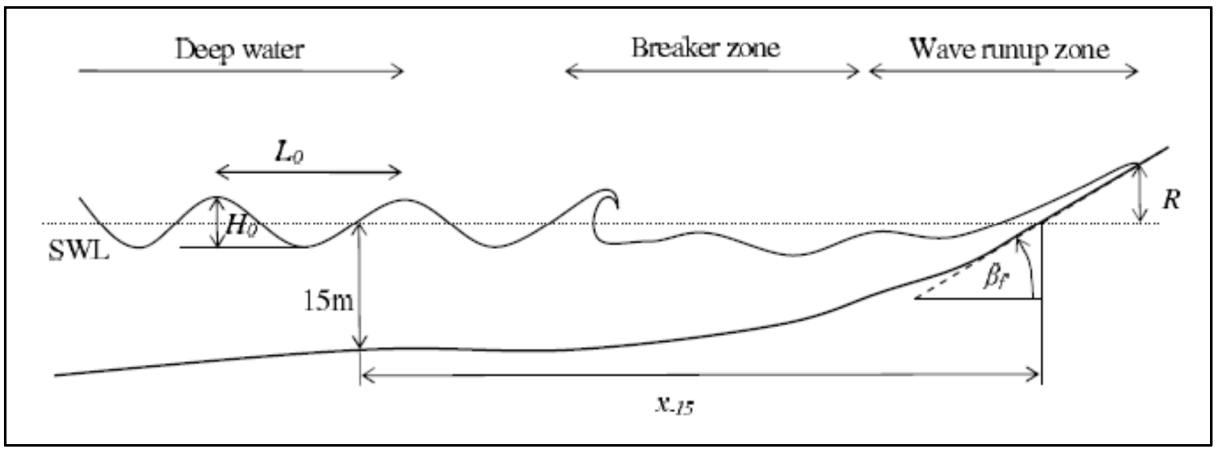


Figure 13: Parameters used in the Mather *et al* model

R is the run-up value, x_{15} is the chart distance from the shoreline to the 15m isobath, H_0 is deep water significant wave height (Source: Mather et al, 2011).

In the equation as $R_x/H_0 = CS^{2/3}$, C is a dimensionless coefficient that is used to predict wave run-up based on different coastline types. Figures for upper/lower bounds and median values are shown in Table 5.

Table 5: Coefficients for the various types of coastline used in the Mather *et al* model

Coastline Type	Upper Bound	Median	Lower Bound
Open coast	$C = 10$	$C = 7.5$	$C = 3.0$
Large embayment	$C = 10$	$C = 5.0$	$C = 3.0$
Small embayment	$C = 10$	$C = 4.0$	$C = 3.0$

(Source: Mather *et al,* 2011)

In the comparative study the coefficients used in the model were selected in accordance with the median values as suggested by Mather *et al*. The results indicate that there is some variation between the predicted wave run-up between both the City's as well as the Mather *et al* model and the actual wave run-up measurements taken from the August 2008 storm surge event (Annexure D). In some instances actual wave run-up exceeded the predictions from both models (Figure 14) and in other areas, the actual wave run-up was less than the height predicted.



Figure 14: Hout Bay - modelled risk compared with a real life event.

Actual wave run-up height measured with a differential GPS from the 31st August 2008 storm surge event overlaid with the City's SLRRA model.

The variation in results between an actual event and modelled predictions are to be expected. This is because there are a number of variables that may have non-linear relationships that interact over time and space. This complexity cannot be adequatly represented by an empirical model. Some of these anomolies include scalar influences in identifying the appropriate coefficicent value to represent coastline type, the influence of wave set-up and tidal levels during the event and local oceanographic and atmospheric influences, such as swell refraction, swell shadow, wind direction and wind strength during the event. Additional surf zone influenes include infra-gravity waves, swash action and incident wave energy that may influence wave run-up height (Mather, *et al* 2011). Lastly, and perhaps most critically, is the influence of erosion that may take place during a storm surge event. Erosion during an event alters the beach and dune profile which will influence wave run-up heights. In addition to this, overtopping rates, especially in cases where the topography may subside landward of the dune cordon, may increase during a storm surge event.

Based on the results from these comparisons , the following may be deduced:

- Risk based on modelled outcomes should be treated as indicative rather than definitive;
- Risk cannot be pinpointed absolutely: there are a number of influencing variables that may interact over temporal and spatial scales with non-linear relationships that cannot be measured absolutely, and
- The results highlight the importance of ground truthing and taking into consideration the influence of local biophysical factors as opposed to applying models across broad scales based on a desktop analysis.

4.3 Set-back informant three: coastal dynamic processes

There are a number of processes that make the city's coastline a highly dynamic space. At a broad scale, these processes are largely driven by the two major atmospheric conditions: namely the sub-tropical-driven cyclones in winter and the mid-Atlantic high pressure system driving south easterlies in summer. The following processes were identified to determine the dynamic coastal process zone along Cape Town's coast:

- Wind-blown sand and migrating dune systems;
- Migrating estuary mouths, and
- Coastal erosion.

Key to identifying and understanding the behaviour of these processes was the local knowledge of municipal authorities. This knowledge was gleaned from a core group of municipal coastal practitioners that have a combined experience of 60 years of managing the city's coastline. Understanding these processes through this detailed knowledge is fundamental in planning for coastal processes through the use of set-backs.

4.3.1 Wind-blown sand and migrating dune systems

Historically speaking, many of Cape Town's dune systems were highly mobile wind-driven systems which migrated inland beyond the existing urban coastal fringe. This extensive development has had two primary consequences. Firstly, many coastal processes, such as sediment by-pass systems, are no longer functioning which in turn is having an impact on sediment budgets along the city's coastline (Figure 15). In some regions this is resulting in beach regression and coastal erosion. The second impact of this extensive development is that the space in which these dynamic processes function, has been encroached upon. As the drivers of these migrating dune systems are by-enlarge still in place i.e. south easterly winds and sediment supply from the sea, these migrating systems are constantly in the process of reforming in the remaining littoral active zone in an attempt to follow their historic pathways. The end result is the encroachment of sand onto coastal infrastructure and property.

Given the context that Cape Town has developed into a metro, the City has applied a practical approach towards delineating coastal dynamic zones. Whilst these zones have the potential to re-establish themselves to their historical pathways, allowing them to do so would have major financial and service delivery implications to the city and its citizens.

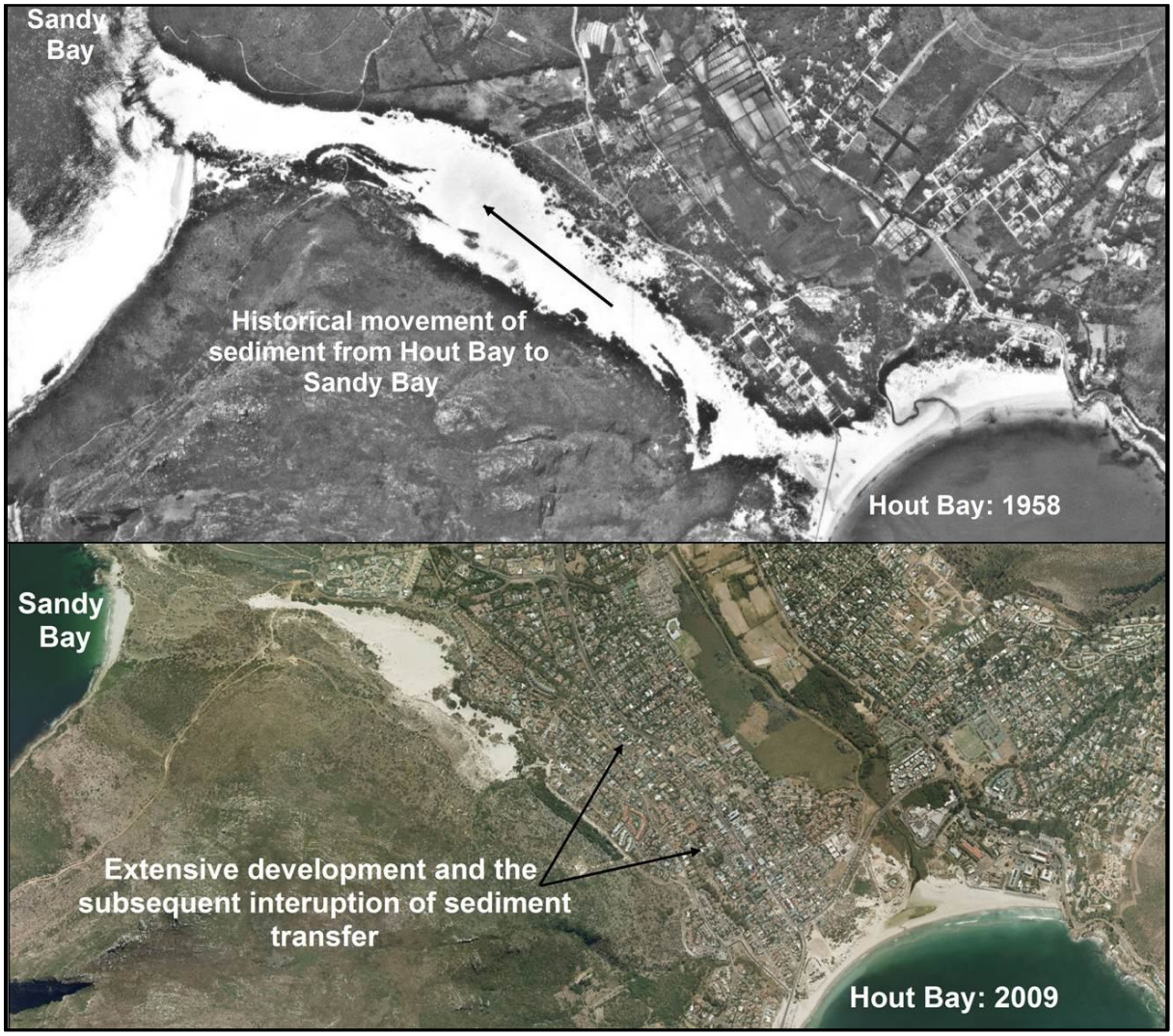


Figure 15: Historic sediment by-pass system in Hout Bay

Development has severely compromised this sediment by-pass system.

Due to the extent the City's coastline has been developed and considering the impracticality of relocating infrastructure from these dynamic spaces, the City cannot re-establish these historical pathways. Instead the City has used the draft set-back to demarcate remaining dynamic spaces and within these remaining spaces apply management interventions to mitigate the impacts of these dynamic processes on the built environment (Figure 16).

Figure 16: Position of the draft set-back in Hout Bay

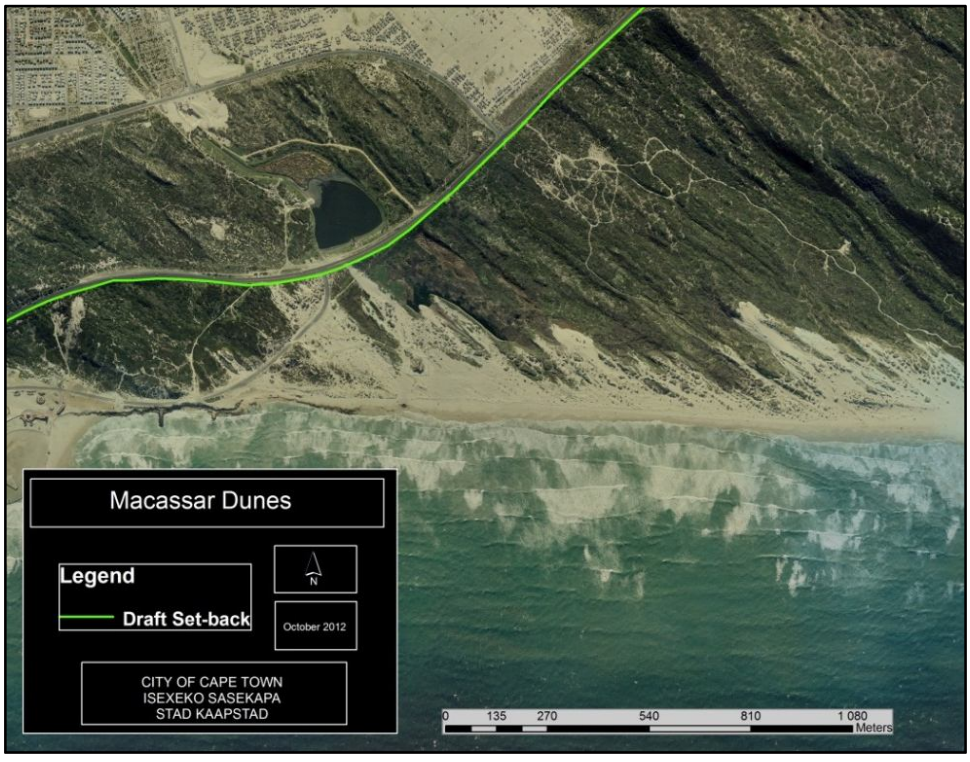
An example of demarcating remaining dynamic systems in Hout Bay. The set-back has been positioned along the urban fringe where such systems will be actively managed.



Conversely, in peri-urban and rural areas, where existing wind-driven dune systems are largely intact, the set-back has shifted further inland to demarcate these spaces (Figure 17) as a means to prevent the same mistake of inappropriate development (Figure 2, 5, 11 and 18 refers) in dynamic zones from recurring into the future.

Figure **17**: Position of the draft set-back in Macassar

It would be unwise to allow development seaward of the draft set-back due to the presence of a highly dynamic wind-driven sand environment and the social risks that would arise as a consequence.



4.3.2 Migrating estuary mouths

The direction, timing and rate of migrating estuary mouths are impossible to predict. The City of Cape Town has numerous estuaries that are subject to this unpredictable movement. In the past, such migration has resulted in coastal erosion which in turn has undermined and damaged critical infrastructure (Figure18).



Figure 18: Macassar Pavilion and the Eerste River

Damage to the Macassar Pavilion (foreground) and a sewer pump station (background) due to the westward migration of the Eerste River mouth.

As a consequence of the potential destruction that migrating mouths may cause together with their unpredictable nature, the City's set-back has been positioned with the intent to create space to allow estuaries to migrate as they would naturally do along less altered stretches of the City's coast. Whilst conservative estimates may be applied in defining areas in which estuaries are expected to migrate, the presence of private property in close proximity to some estuaries (typically in developed stretches of the coast – Figure 19 refers) necessitates that the same principle is applied whereby the set-back, as a means to avoid the legal implications that may arise as a consequence of the position of a set-back in relation to private properties with development rights, is defined on the estuary side of the cadastral boundary of those properties. Whilst this approach avoids the legal difficulties, properties located landward of the set-back adjacent to estuaries may still be at risk to estuarine related risk: i.e. erosion, storm surge induced flooding etc. Again set-backs in isolation are not equipped to respond to existing infrastructure at risk and requires the application of planning mechanisms to manage the

complex matter of existing property at risk to coastal hazards. In these cases overlay zones will be developed and applied. Overlay zones are discussed in more detail in Section 8.1.1.



Figure 19: Diep River Estuary

Estuary mouths in built up areas are no longer able to migrate as they would naturally do.

4.4 Set-back informant four: scenic drives, aesthetics and sense of place

The City is world renowned for its aesthetics and coastal beauty. Much of Cape Town's beauty is witnessed in transit along Cape Town's extensive road network. However, development that has no regard for or does not contribute to the value and experience of scenic routes tends to have a significant negative impact on Cape Town's scenic value. It is for this reason that the City has implemented a Scenic Drive Network Management Plan (SDNMP). This management plan identifies routes which traverse areas of outstanding scenic quality in Cape Town and attempts to establish a sustainable balance between the conservation of its associated natural and built amenities and the development of the tourism and recreational potential linked to these routes (CCT, 2003).

The SDNMP has identified a total of 57 scenic routes throughout the City, 17 of which fall within or border[11] the City's coastal draft set-back (Table 6).

[11] The management unit of a scenic drive consists of the Scenic Drive Envelope (SDE). The SDE consists of carriageway, the road reserve immediately adjacent public land and the first erven abutting any of these.

Table 6: Scenic Drive Routes falling wholly or partially within the City's draft set-back

Route	Route Name	Start Point	End Point
2	Main Road	Smithswinkel	Muizenberg
4	Witsand Main Road	Plateau Rd	Slangkop Rd
5	Soetwater Main Road	Witsand Rd	Slangkop Rd
6	Slangkop Road	Kommetjie	Witsand Main Road
7	Glencairn Expressway	Main Road	Kommetjie Main Road
11	Chapman's Peak Drive	C. Peak Hotel	Die Hoek Lookout
16b 17a	Princess Street Victoria Rd	Victoria Rd Victoria Rd	Hout Bay Main Rd Princess Street
17b	Victoria Road	Victoria Rd	Bakoven
17c	Victoria & Beach Roads	Bakoven	Portswood
18	Camps Bay Drive	Kloof Nek	Victoria Rd
25a	Atlantic & Roal Roads	Atlantic/Main Rd	Sunrise Circle
25b	Baden Powell Drive	Main Road	CCT boundary
35	Melkbosstrand Road	N7	West Coast Road R27
36a &b	Otto Du Plessis Drive	Melkbos urban area	Marine Drive
36c&d	Marine Drive R27	Ott Du Plessis	Racecourse Rd
38a	R44 / Beach Rd-North	Study area boundary	Lourens River Crossing
38b	R44 / Beach Rd-East	Lourens River	Beach/Faure Marine Dv

Whilst the priority of the set-back is to reduce risk to the City, the alignment of the set-back with scenic routes along sections of Cape Town's coastline will compliment and assist both the SDNMP and the ICMA (section 25(1)(a)(iii)).

4.5 Set-back informant five: biodiversity betwork

The City's Biodiversity Network (BioNet) has been approved nationally as a fine-scale plan for the City. The BioNet, in conjunction with the need to promote access to coastal resources, is the central pillar to the set-back in less altered stretches of the coastline. The BioNet has been used as the 'baseline' layer from which to achieve the broader objectives of the set-back. For this reason the City has ensured that the draft set-back, as far as possible, is aligned with the BioNet along the coastal fringe. This alignment is critical to ensure that the objectives of both the BioNet and the set-back are achieved under a single strategy.

The determination of the BioNet was based on the National Vegetation Type target percentages as determined for the 2004 National Spatial Biodiversity Assessment and was applied at the city level to recognise vegetation subtypes (CCT, 2009). The preservation of the BioNet is fundamental towards addressing the following socio-economic imperatives:

- Retaining aesthetics and sense of place (cultural benefit);
- Improving the buffer potential against storm surges, coastal erosion and wind-blown sand as a means to reduce the social risk and build resilience (regulatory benefit);
- Improve the recreational and amenity value of the coast (provisional benefit), and

- Promote equitable access to the coast through the retention of green corridors as opposed to strip development (cultural).

The BioNet was determined in 2009 through a systematic conservation planning approach as a means to prioritise remnant indigenous vegetation based on factors of connectivity, habitat condition, and location of rare and endangered flora (CCT, 2009)(Annexure E). A product of the systematic conservation planning approach was the BioNet GIS shapefile. The BioNet GIS shapefile was generated through a combination of software tools, namely C-Plan and Marxan. After extensive ground truthing of vegetation remnants from 2007 to 2008, C-plan was run using habitat condition as an additional informant. Following this analysis Marxan was applied. A key attribute to the Marxan software is its capability (through the Boundary Length Modifier Tool) of identifying additional remnants required to improve connectivity among selected remnants and thus determine feasible corridors in the BioNet[12] (CCT, 2009).

Biodiversity corridors are important in preserving ecological processes such as the dispersal and migration of plants and animals which in turn is necessary to conserve healthy populations in the long term (CCT, 2009). In acknowledgement of the importance of these corridors, the City's draft set-back was defined based on the presence of corridors in the coastal belt. Where the BioNet corridors abutted the coast, the set-back line was delineated on the landward side of these corridors (Figure 20). The BioNet is the nationally recognised fine scale conservation plan; as such it must be integrated with the set-back line.

[12] In addition to the identification of corridors, the conservation planning analysis through the application of C-Plan and Marxan also identified 59 different vegetation types in the city. These vegetation types were in turn categorised according to conservation status. A total of 10 categories were identified. Further detail on this is available in Annexure E.

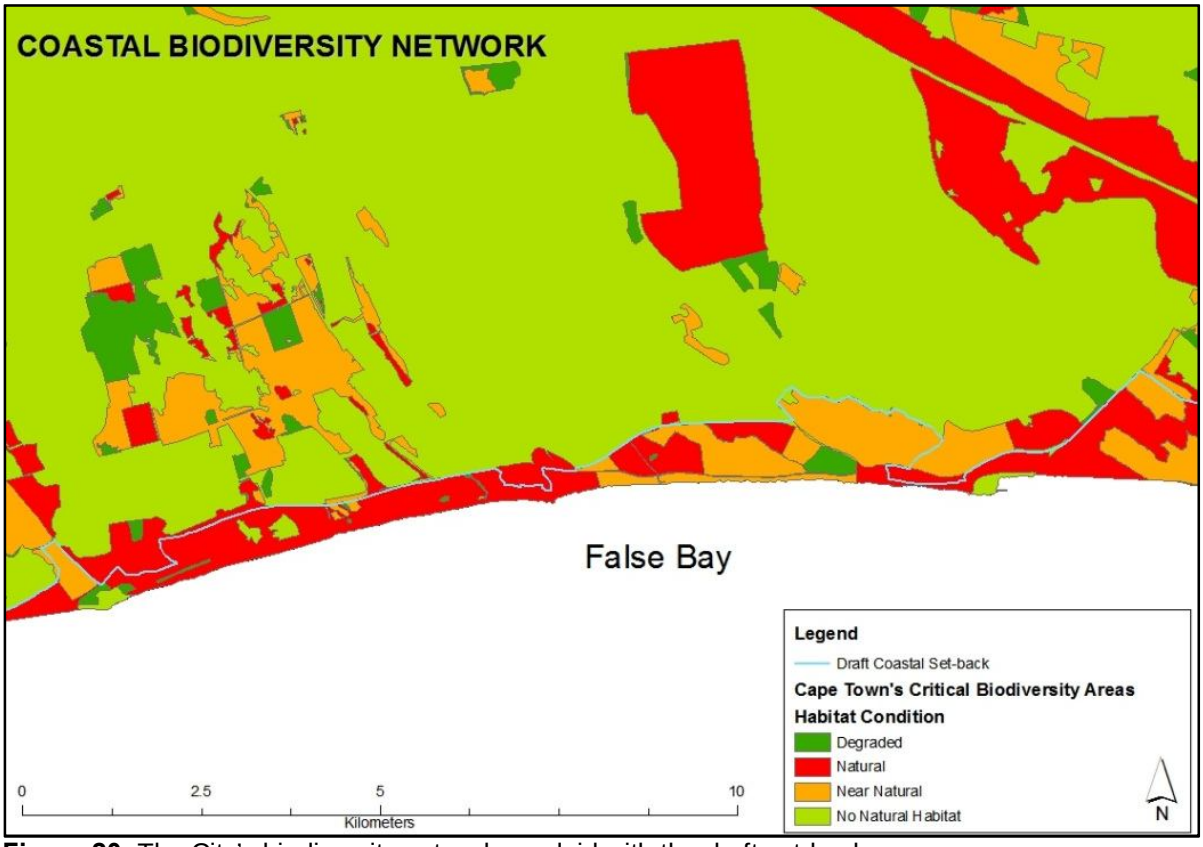


Figure 20: The City's biodiversity network overlaid with the draft set-back

The presence of biodiversity corridors in the coastal belt was a key informant to defining the City's set-back. In this case the set-back is positioned to include a critical corridor between Strandfontein and Macassar.

5. ESTUARIES

A total of 12 estuaries have been identified for inclusion within the City's set-back (Table 7).

Table 7: Estuaries identified within the City of Cape Town

	Name	**Location**	**Coordinates**
1	Sout River	Melkbosstrand	18˚26'40.464"E and 33˚42'47.927"S
2	Diep River (Rietvlei)	Milnerton	18˚29'4.598"E and 33˚53'22.89"S
3	Disa River	Hout Bay	18˚21'22.202"E and 34˚2'40.636"S
4	Bokramspruit	Kommetjie	18˚19'57.633"E and 34˚8'3.659"S
5	Else River	Glencairn	18˚25'53.349"E and 34˚9'37.508"S

6	Silvermine River	Fish Hoek	18˚26'40.464"E and 33˚42'47.927"S
7	Zandvlei	Muizenberg	18˚26'20.122"E and 34˚7'77.946"S
8	Zeekoe	East Beach	18˚30'17.762"E and 34˚5'54.308"S
9	Eerste River	Macassar	18˚45'13.402"E and 34˚4'43.777"S
10	Lourens River	Strand	18˚48'39.034"E and 34˚6'0.187"S
11	Sir Lowry's River	Gordon's Bay	18˚51'53.622"E and 34˚9'20.016"S
12	Steenbras River	Steenbras Nature Reserve	18˚49'9.883"E and 34˚11'41.348"S

The City's set-back has only been defined within City administered land. Thus estuaries falling within Table Mountain National Park (TMNP) (Table 8) were not included in the City's estuary delineation process.

Table 8: Estuaries falling within Table Mountain National Park

	Name	Location	Coordinates
1	Wildevoelvlei River	Kommetjie, TMNP	18˚20'35.833"E and 34˚7'38.679"S
2	Schuster River	Cape Point, TMNP	18˚22'15.265"E and 34˚12'7.361"S
3	Krom River	Cape Point, TMNP	18˚22'42.243"E and 34˚13'51.391"S
4	Buffels River	Cape Point, TMNP	18˚27'42.415"E and 34˚19'5.653"S

Besides those rivers located within TMNP, the only other river that has been excluded from the set-back delineation process is the Salt River in the Paarden Eiland industrial complex. The Salt River is canalised and is not considered a functional estuarine system. Whilst there is a risk element of flooding from the Salt River canal, this element is addressed through the City's Floodplain and River Corridor Management Policy and Storm Water By-law (Section 5.2, Annexure F and G respectively).

5.1 Method: delineating the City's estuaries

Water courses that are classified as being either permanently or temporally open to the sea are defined as estuaries. The spatial extent of estuaries, in terms of the requirements of the ICMA, may be defined based on a variety of parameters. These parameters may be split according to two broad categories: the inland reach of estuaries (vertical) and the width of estuaries (lateral). The vertical extent of estuaries is determined by:

- The inland point at which tidal influence is no longer measurable, or

- The inland point at which salinity is measurable higher as a consequence of the influence of the sea, or
- The landward most limit of either of the influences (whichever influence penetrates furthest inland).

The lateral extent of estuaries may be defined based on the following parameters:

- The location of the 50 year flood line in relation to the estuary up to the estuaries inland limit, or
- The location of the 5m contour in relation to the estuary up to the estuaries inland limit, or
- The spatial extent to which vegetation associated with estuarine environments is present.

A status quo analysis of data sources applicable to estuarine delineation was undertaken (Table 9). The following data sources were identified:

- Van Niekerk, L., & Turpie, J. K. (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 (Annexure H)
- Catchment Management Department, City of Cape Town: 50 and 100 year delineation of selected estuaries (Due to the sheer size of these reports, they have not been included as annexures. They are however available upon request).
- Geomatics Department, City of Cape Town: Digital Elevation Models extracted from LiDAR data (spatial data available upon request).

Table 9: Analysis of data sources available for estuary delineation

Data source	Description	Advantages	Drawbacks
Catchment Management Department, City of Cape Town: 1985-2003	50 and 100 year estuary floodlines were determined by external consultants commissioned by the City. These delineations were based on advanced modelling which considered a wide range of factors.	*Reliability*: In-depth detailed studies conducted by external consultants taking into account a wide range of factors (e.g. topographical surveys, backwater analyses, surface roughness coefficients and vegetation cover). *Transparency*: Detailed meta-data available in all cases but one (Disa River, Hout Bay)	*Reliability*: Studies sometimes conducted as long ago as 1985. Floodplain for the entire river, not only the estuary, needs to set a boundary inland. *Transparency*: Lack of meta-data in the case of the Disa River.
CSIR 2011	Delineations based on digitized Spot 5 imagery (dating back from 2008), the estuaries' lateral boundaries were delineated based on "associated wetlands, intertidal mud and sand flats, beaches and foreshore environments that are affected by riverine or tidal flood events" (Edgar 2000, cited in Van	*Validity:* Data up to date, as lines drawn in 2011, some floodplains were delineated based on on-site inspections.	*Reliability*: Study takes into account a smaller account of input factors, coarse delineations. 5-meter contours were used, but not as accurate as elevations generated by LiDAR

	Niekerk and Turpie 2011, p.31) as well as 5-meter contours from the Chief Directorate Surveys and Mapping, or digitized based on orthophotos when the Directorate data was lacking. "Where no orthophotos were available (13 systems[13]), floodplains were mapped from Spot 5 imagery using changes in topography and vegetation types as indicators. The estuary mouth was taken as the downstream boundary of an estuary or, where the mouth was closed, the middle of the sand berm between the open water and the sea. The upstream boundary was determined as the limits of tidal variation or salinity penetration, whichever penetrates furthest. Wherever possible the upstream boundary was derived from the literature, expert judgment or field observations". (Van Niekerk and Turpie 2011, p. 31-32).		data. *Transparency*: The CSIR has not detailed which methodology, or combinations of methods it has applied per estuary.
Geomatics Department, City of Cape Town: 2009	Digital Elevation Models in raster format (pixel size of 2*2) extracted from LiDAR remote sensing data, and useful for delineating extremely accurate contours.	*Accuracy*: LiDAR data- (XY +- 30cm, Heights +- 15cm), and 5m contours generally a good proxy for delimitating 50 year floodplains (Van Niekerk and Turpie 2011, p. 34-35).	*Validity*: coarse, only takes into account topography, not other factors such as soil porosity, vegetation cover, much space for interpretation (where to set the estuary mouth).

The City, through the application of GIS, overlaid the relevant spatial layers per estuary for the entire coastline of Cape Town. The individual analysis of each estuary in relation to the spatial data allowed the City to develop a holistic perspective of the spatial extents, both vertically and laterally, of the 12 estuaries. Based on this analysis, each estuary was delineated as part of the City's set-back.

5.1.1 Developed flatlands: flood lines and the 5m contour

[13] Within the City, this applied only to the Steenbras River.

Some of the City's estuaries are located in areas where the topography is flat. Notably this includes estuaries along the False Bay coastline, in particular the Zandvlei, Zeekoe, Eerste and Lourens estuaries. Applying the 5m meter contour to define estuaries in these instances becomes problematic as, due to the flat topography, the 5m contour includes extensive areas. The extent of these areas defined by the 5m contour is not representative of estuaries, estuarine vegetation nor does it provide a realistic representation of the area prone to flood risk. Though using the 50 year flood line refines the spatial extent, the 50 year flood line still includes significant areas that are developed adjacent to estuaries. These developed areas which are at risk to a 50 or a 100 year flood event, have not been included within the City's set-back. The same principle (as described in more detail in Section 3.3) applies whereby the City wishes to avoid impacting on development rights through inclusion of such areas within its set-back. A set-back is not equipped to solve and address the issue of existing development at risk and as such requires a more comprehensive planning mechanism in an overlay zone (discussed further in Section 8.1.) Such areas are also addressed through the Floodplain and River Corridor Management Policy (section 5.2 refers).

5.2 Beyond estuaries: the role of the City's Floodplain and River Corridor Management Policy and Storm Water By-law

Flood lines determined by the City's Catchment Management Department extend beyond estuaries and include water bodies within catchment headlands. These flood lines are supported by regulatory mechanisms developed by the City's Roads and Storm Water Department. A Floodplain and River Corridor Management Policy was approved by Council on the 27th of May 2009 and has been incorporated into the City's Integrated Development Plan. At a broad level, the policy, aims to:

- reduce the impact of flooding on community livelihoods and regional economies, and
- safeguard human health, protect natural aquatic environments, and improve and maintain recreational water quality

This policy in turn is regularised through the Storm Water Management By-law. Within the by-law, "Storm water system" is defined as:

"…both the constructed and natural facilities, including pipes, culverts, water courses and their associated floodplains, whether over or under public or privately owned land, used or required for the management, collection, conveyance, temporary storage, control, monitoring, treatment, use and disposal of storm water" (CCT, 2009).

The inclusion of "water courses and their associated floodplains" captures estuaries within the definition of a storm water system. Thus both the policy and the by-law become applicable to not only water bodies such as inland rivers, but estuaries too in a manner that:

- "limits or reduces exposure to flood risk by avoiding hazardous, uneconomic or unwise use of floodplains, thereby protecting life, property and community infrastructure;
- Protects and enhances the intrinsic value and the environmental goods and services provided by watercourses, wetlands and associated riparian areas and floodplains;
- Facilitates the beneficial integration of watercourses into urban landscapes by creating an aesthetically pleasing public resource which will ultimately allow for the social and economic upliftment of communities adjacent to watercourses and wetlands;
- Provide an effective decision making tool for officials, developers and consultants by introducing an element of predictability with regards to applications for development along watercourses/river corridors and adjacent to wetlands, and
- Promote sustainable development from engineering, environmental and socio-economic perspectives".

The objectives of the Floodplain and River Corridor Management Policy as well as Stormwater By-law is consistent with the requirement of the ICMA in terms of promoting risk averse decision making to water bodies from source to sea.

6. THE PUBLIC PARTICIPATION PROCESS

The establishment of set-backs have significant socio-economic implications, for both property owners as well as for communities. These may impact on property rights, value of property and real estate, opportunities to benefit from coastal resources through nodal coastal development, access to the coast, livelihoods etc. Consequentially engagement with stakeholders surrounding the position of set-backs is often emotionally charged and can be contentious. Considering this, and considering the complexity of coastal legislation, it is imperative that the stakeholder engagement process takes place over periods of time that allow and encourage dialogue and meaningful two-way communication between the implementing authority and Interested and Affected Parties (I&APs). This is key in allowing the process to determine the outcome.

Recognising the sensitivity required in this process of defining a set-back, the City purposefully engaged with I&APs on an informal basis over an extended period of time prior to undertaking the formal PPP. The intent of these engagements was essentially to co-produce knowledge between the public and City officials surrounding coastal issues and how the concept of set-backs can be used to address these issues.

6.1 Informal stakeholder engagement

The City's informal stakeholder engagement process was initiated in 2007 and continues today. It consists of the following:

- Informal engagements with rate payer associations across the City of Cape Town;
- Presentations to ratepayer and interest groups focussing on:
    - Identifying pressures along the City's coastline
    - Identifying the impacts of these pressures and understanding how these impacts are experienced
    - Legal mandate of the City to establish coastal regulatory mechanisms, especially set-backs
    - The City's proposed methodology for determining the draft coastal set-back
    - Obtaining feedback from the public as key to shaping the City's methodology
- Site inspections and 'demonstrations' with local ward councillors

This process culminated in the delineation of the draft set-back line which was in turn presented to the officials of each of the City's planning districts in 2010 for further input and consideration. Following from this process the City entered the formal PPP process.

6.2 Formal stakeholder engagement

Following from the informal stakeholder engagement process and consultation with the planning districts, the City further refined its set-back methodology and adjusted the position of the set-back accordingly. In addition to this the City developed a supportive draft by-law as a means to regulate activities in the space between the HWM and the draft set-back. Both the draft set-back and the draft by-law were taken through an extensive PPP process. Publicising of the draft by-law in conjunction

with the draft set-back enabled the public to not only determine the position of the draft set-back at an erf scale for the entire coastline, but it also enabled the public to gain an understanding of the regulatory context and 'meaning' of the draft set-back thus making the PPP transparent and effective.

6.2.1 The City of Cape Town's Spatial Development Framework public participation process

The City's draft set-back was incorporated into the CT:SDF, where it is termed the Coastal Urban Edge. The CT:SDF defines clear strategies and policy statements that will be used to guide the preparation of sector plans, lower-order spatial plans, detailed policies, guidelines and implementation plans and will also be used to assess development applications (CT:SDF, 2012).

The CT:SDF identifies the following key strategies applicable to the draft coastal set-back:

KEY STRATEGY 1:	Manage urban growth, and create a balance between urban development and environmental protection
Sub-strategy:	Encourage a more compact form of development
Policy Statement No. 23:	Contain the development footprint of the city, and protect natural, urban and heritage assets with development edges
Sub-strategy:	Appropriately manage urban development impacts on natural resources and critical biodiversity networks
Policy Statement No. 27:	Manage urban development along the coast in a sustainable and precautionary manner
KEY STRATEGY 3:	Build an inclusive, integrated and vibrant city
Sub-strategy:	Promote accessible, citywide destination places
Policy Statement No. 50:	Develop high quality, accessible destinations and public spaces in newly developed and neglected areas

These key strategies and policy statements are fundamental to the intents of the City's draft coastal set-back and were communicated extensively through the CT:SDF PPP (Annexure I)[14] from 2007 to 2010 (Figure 21).

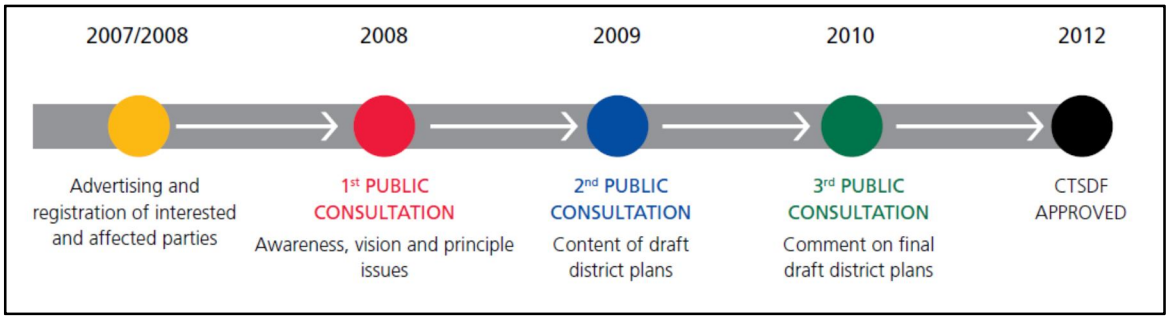


Figure 21: The City's Spatial Development Framework Public Participation Process timeline

6.2.2 Coastal by-law public participation process

[14] Sub-annexures to Annexure I are available upon request.

The City's draft coastal by-law was developed with the intent of regulating the space between the HWM and the draft set-back (further details on the City's by-law provided in Section 8.1.2). The PPP for the draft by-law was not only important for re-iterating the position of the proposed set-back, but critically it provided an opportunity for I&APs to gain an understanding of the context of the set-back and the potential implications the draft set-back would have for the public. The publicising of the draft by-law also enabled the public to make informed comments on the City's approach to developing coastal regulations. Whilst the by-law received 97% support (Annexure J: Comments Response Report), the draft by-law is currently being revised to ensure better alignment with the City's Planning Development and Building Management Department's regulations. When these revisions are complete, the draft by-law will once again be taken through the PPP.

7. COMPARISONS WITH THE OVERBERG DISTRICT SET-BACK DELINEATION METHOD

The City was represented on the Steering Committee: Development of a Methodology for Defining and Adopting Coastal Development Set-back Lines for the Western Cape Province. This process was completed in May 2010. The City played an active role in this steering committee and made recommendations based on the City's approach towards defining set-backs as well as sharing lessons learnt from the City's own stakeholder engagement process. It is noted that whilst this process was initiated by the Development Facilitation Unit of the of the DEA&DP with the intent to determine the official method for set-back delineation for the Western Cape Province, the subsequent set-back methodology applied in ODM deviated from the proposed Western Cape Provincial methodology. It is also noted that the method applied in the ODM was undertaken with a view to further refine the Western Cape methodology. The City has drawn a comparison between the method and process adopted in Cape Town with the method and process applied in the ODM.

7.1 Unique areas require unique solutions

Overberg District Municipality and the Cape Town metro are vastly different in many respects, not to mention the extent to which the City's coastline has been developed, altered and in some cases reclaimed. The highly altered and in many places 'fixed' coastline, as well as vastly differing socio-economic attributes brings unique challenges to the City. Naturally the City requires locally tailored responses to manage the city's unique coastal space. Even within the City's area of jurisdiction, the coastline varies significantly (i.e. from False Bay to the West Coast) not only in terms of physical attributes (including developed state) and oceanographic climate (such as bathymetry, swell shadow and wave set-up), but the socio-economic attributes along the city's coastline differ substantially as well.

Applying a standardised methodology across the Western Cape Province based on a set of generically determined and empirically orientated formulas does not empower municipalities to consider and factor in local nuances (both biophysical and socio-economic) that are critical in generating effective and pragmatic set-backs. For this reason, it is imperative that the determination of set-backs are rather guided by a set of regionally agreed upon principles which include that the set-back delineation process is undertaken at a local level by practitioners who have local knowledge and that in instances where the set-back is modelled, the position of the modelled portion of the set-back is ground-truthed. The ground-truthing of remotely modelled set-backs is critical to ensure that the line

on the map is in fact 'connected' to reality on the ground. These are key principles that the City has applied in the process of delineating its draft set-back and which differ to the method applied in ODM.

7.2 Timescales and public engagement

The Public Participation Process (PPP) for the delineation of the set-back in the ODM took place over a period of 6 months between 17th January 2011 and 22nd August 2011 (SSI, 2011). This consisted of two rounds of public engagement. Each round consisted of a total of 5 focus group meetings (in centrally located venues) as well as ad hoc telephonic, e-mail and face to face communication between Interested and Affected Parties (I&APs) during this period (SSI, 2011). The final round of public engagement followed a six week comment period (SSI, 2011).

The process of defining a coastal set-back for ODM was largely viewed in a negative light by the I&APs which may have been partly attributed to the misinterpretation of information provided (SSI, 2011). According to R. Cox (pers. comm., 28 February 212) the perception by I&APs was that such an exercise was "out of the blue" and that this sudden enforcement was reflective of an authoritarian style of governance which in turn led to this negativity and in some respects hostility. Perception, whether informed or not, has the potential to derail delicate discussions surrounding the establishment of set-backs. This is especially true where perception may be shared collectively amongst the public. In acknowledgement of the "power of perception" and the need to engage with I&APs over meaningful periods of time, the City proactively initiated engagement on both an informal and formal level. This process commenced in 2007 and culminated in the successful adoption of the CT:SDF and overwhelming support of the by-law (Annexure J).

7.3 Modelling, local biophysical factors and ground truthing

The method employed in the OMD is largely dependent upon empirical modelling which has been applied at a broad scale from remote desktop analysis. The application of these models over broad spatial areas is primarily a consequence of economies of scale: due to budget and time restrictions imposed on this project[15], the broad-scale application of models to determine physical risk is used as the most feasible means towards meeting budget and deadline requirements. Although such an approach reduces resources required, thereby enabling project consultants to meet deadlines and budget limitations, the budget and temporal limitations imposed also result in the exclusion of local biophysical factors in the determination of hazard areas. Local biophysical factors, such as bathymetry, swell shadow, wave refraction, beach profile and sub-straight have a significant influence on coastal erosion and wave run-up. It is therefore critical that these local elements are incorporated into the process of modelling and determining hazard areas.

The City, in its 5th and final phase of the SLRRA, fined tuned the original model developed in Phase 1 by collating data on local bio-physical attributes and factoring this data into the model (Section 4.2.5 and Annexure B). This enabled the City to identify a total of 19 vulnerable locations as identified in Tables 2, 3 and 4 and Figure 11). Further to this, the finer resolution study has enabled the City to disaggregate risk per location and thus more accurately determine the landward extent of hazard areas. Within an urbanised environment this is critical in the development of coastal planning and building development regulations.

[15] This is by no means deliberate, but merely a product of the fiscal structures of governning bodies which are largely infleunced by budgetary expenditure being restricted to annual cycles.

7.4 Socio-economic dimensions, spatial planning and urban design

The ODM methodology makes recommendations as to the importance of aligning and integrating the set-back with local spatial planning schemes, as the two should not be treated as mutually exclusive, but rather mutually dependant. Whilst the coastal set-back should be used as the primary informant to shape spatial planning schemes along the coastal fringe to promote risk averse coastal development, spatial planning schemes are also largely shaped by socio-economic priorities and at times may be in conflict to the objectives and 'position' of a coastal set-back. This is especially so considering the perception that coastal frontage property equates to economic wealth and gain as well as the potential the coast offers in addressing the legacy of the apartheid era through redistribution of resources. Whilst it is clear that the two mechanisms need to be aligned, the method in the ODM is largely silent on how this can be practically and measurably achieved. Again this may be attributed to the limitations under which the relevant consultants had to work.

Whilst the City has relied on the use of a model to determine hazard areas, the identification of hazard zones forms only one component of the broader process of defining the City's set-back. The consideration of socio-economic and politicised factors requires stakeholder engagement over meaningful periods of time at a site specific scale. This is not only critical to ensure that the set-back is workable, effective and practical, but that the set-back is aligned to, and meets the needs of the local spatial planning schemes. Due to the socio-economic disparities and resulting priorities along the city's coastline, the City initiated the process of engaging with coastal communities and ward councillors at the outset of determining its draft coastal set-back in 2007. This local level engagement process was used to gain a sensitive understanding into the various socio-economic pressures and imperatives present along the coast. A key outcome of this process was the stark realisation of the lack of access to the coast (and associated opportunity) for previously disadvantaged communities. This led to the identification of key coastal nodal growth areas (Figure 6 and Annexure A refers) as a way to address this priority.

7.5 A management set-back line and a limited development set-back line

The method in ODM proposes the refinement of the two lines identified in the Western Cape Methodology. These two lines are represented as a management set-back and a limited or controlled development set-back. The City has identified a single line, where this line is supported by additional coastal regulatory mechanisms. The following sections underline the difference between the City's approach and the recommended set-back lines in the ODM method.

7.5.1 Management set-back Line

The ODM method proposes that the management set-back line "Demarcates the area seaward of current developments, and includes the area below the projected hazard zone where no development has taken place, and currently/immediately threatened properties in areas where development is already present in the risk zone. The zone is demarcated manually based on local knowledge of the development line and local planning intricacies" (SSI, 2011: 15).

The management set-back proposed in the ODM is essentially equivalent to the City's set-back, the only difference being that in urban areas the position of the line still excludes (properties fall on the

landward side of the draft set-back) current/immediately threatened properties. As indicated in Section 3.3, this approach has been applied to facilitate efficiency and practicality through avoiding legal challenges of incorporating properties with development rights seaward of set-backs. The City's draft set-back, as a general rule of thumb, skirts closer to the HWM in urban areas whilst in less developed rural areas, the City's draft set-back moves further inland. It is the remaining un-developed spaces that require immediate and effective governance to prevent the existing coastal issues (property at risk from coastal erosion and storm surges) from recurring and increasing into the future.

7.5.2 Limited or controlled development set-back Line

The limited or controlled development set-back: "This area is equated to the Coastal Protection Zone within which coastal sensitivities need to be taken into account in all development decisions. This zone is determined based on local sensitivities such as long-term coastal processes risks, coastal vegetation, wetlands, estuaries and socio-cultural features. It includes developed areas where the projected erosion risk extends over existing developed areas but where realistic planning horizons mean that development approvals are unlikely to be refused" (SSI, 2011:15).

Much of Cape Town's coastline is in a highly developed state, a significant proportion of which is in close proximity to the HWM and in some cases on reclaimed land. The deliberate exclusion of property with development rights from the draft set-back in developed areas means that that there are numerous properties along the City's coastline that fall on the landward side of the set-back, but which are still at risk from coastal erosion, storm surge events and general coastal processes. Governing property that is currently at risk is a complex process and requires more substantive regulatory responses than a second set-back line. In light of this, the City is in the process of developing a Coastal Overlay Zone as a land use mechanism that will become applicable to coastal hazard areas, both seaward and landward of the draft set-back. Further detail on the mechanics of the Coastal Overlay Zone regulatory mechanism is provided in Section 8.1.1. The City is also mindful of not over-complicating the coastal space by creating multiple lines based on empirical modelling which are in effect theoretical lines.

8. PROCESS FORWARD: SUPPORTIVE PLANNING AND REGULATORY MECHANISMS FOR THE CITY'S SET-BACK

The City's draft set-back requires supportive regulatory mechanisms to ensure the objectives of the set-back are achieved. The City has delineated its draft set-back and by-law as a priority to manage activities within remaining critical open spaces between the draft set-back and HWM along the length of the city's coastline. In addition to this, the City requires more substantive land use regulatory mechanisms to effectively address the complex issue of existing property and infrastructure at risk to coastal hazards. The following sections provide an outline and intent of the key regulatory mechanisms the City is developing as a means to retain the value of the coast and reduce the City's risk profile. A report requesting support for the development of various policy and regulatory mechanisms was submitted to the City's Economic, Environment and Spatial Planning Directorate in 2011 (Annexure K). The report and the proposed regulatory mechanisms were supported (Annexure L).

8.1 Integrated Coastal Management Policy

The City has developed a draft Integrated Coastal Management Policy (Annexure M). This policy provides a strategic and overarching guideline that defines the rationale for the development of the City's coastal regulatory mechanisms. The policy also determines the vision, objectives and principles which will be used as a platform to promote consistent decision making across the City and to meet the principles of the ICMA. The policy will be supported by the City's Municipal Coastal Management Programme (MCMP) and which this MCMP will be operationalized through the Coastal Overlay Zone, Coastal By-law, the Coastal Economic and Spatial Development Plan and a range of Coastal Operational Management Protocols.

8.1.1 Coastal overlay zone: managing risk through existing land use management regulatory systems

The City's proposed by-law will focus on the regulation of activities between the HWM and the City's draft set-back. Considering the extent to which the City's coastline has been developed, and the close proximity of this development to the HWM, there is a significant amount of development that is at risk from coastal hazards, namely from storm surge, wind-blown sand, migrating river mouth induced coastal erosion and coastal flooding from estuaries. Managing existing properties and infrastructure currently at risk (especially where this risk is expected to increase into the future due to sea-level rise) through regulatory mechanisms requires sensitive negotiation with property owners due to existing land use rights. The City's ability to retrospectively address existing property that may be at risk through land use planning mechanisms will ultimately determine the City's effectiveness at managing risk posed by coastal hazards.

The City, in 2013, introduced a single unified zoning scheme (to replace its current fragmented zoning schemes) for its entire area of jurisdiction. Amongst others, the new scheme includes a mechanism to introduce overlay zones for specific purposes. Providing the opportunity to impose additional regulations in respect of specifically demarcated areas, or in respect of specific management issues across the city as a whole, this mechanism will provide the necessary flexibility to deal with diversity and uniqueness across the city and accommodate different objectives (such as those already spelled out in the CT:SDF). As such, developing a Coastal Overlay Zone is considered the most appropriate mechanism to manage and regulate land use and building development both seaward and landward of the City's draft coastal set-back, as it will be institutionalised as part of, and in a way that makes use of the City's already existing statutory development management systems and processes. Taking this approach will ensure alignment with and benefit from existing regulatory regimes and institutional systems and processes.

Forming part of the zoning scheme regulations (development management), an overlay zone is therefore a more detailed zoning mechanism that is applied in addition to the base zone of a property. The introduction of overlay zones is not an inevitable consequence of local area planning initiatives as identified through District SDPs, but rather a consequence of the critical need identified in the CT:SDF for targeted and specific development rules in addition to the underlying general base zone of land in the coastal area (CT:SDF, 2012). In the case of property or infrastructure at risk from coastal hazards, additional development rules in the overlay zone will be applied. Thus, overlay zones will be used as critical tool for strategic land use and building development not only to achieve a shared vision for Cape Town in terms of the CT:SDF, but also as a means to reduce the City's risk profile.

8.1.2 Draft Integrated Coastal Management By-law: regulating activities

The City has drafted a coastal by-law in terms of the provisions made in the Constitution of South Africa (Act 108 of 1996). Section 156(2) of the Constitution provides that a municipality may make and administer by-laws for the effective administration of the matters which it has the right to administer, and to exercise any power concerning a matter reasonably necessary for, or incidental to, the effective performance of its functions. The draft by-law will be applicable to the space between the City's draft coastal set-back and the HWM.

The City's draft coastal by-law is being developed with the intention to regulate a range of activities along the city's coastline. These activities stand to have significant negative coastal socio-economic and environmental impacts if they are not addressed. Key activities that the by-law focusses on include the following:

- Encroachment into coastal Public Open Space (to be addressed jointly by the overlay zone);
- Illegal structures (to be addressed jointly with the overlay zone);
- Harvesting of natural resources;
- Recreational activities: i.e. fireworks, use of jet skis etc.;
- Interference with coastal processes or the littoral active zone;
- Activities that impact on coastal biodiversity;
- Overnighting on beaches;
- The use of fires;
- Activities that may impact on public access to the coast;
- Pollution and littering;
- Commercial activities and trading, and
- Private functions.

The City views the development and implementation of the Coastal By-law as a critical local regulatory mechanism for a variety of reasons. In terms of promoting ICM, these include the following:

- To promote improved integration between the various City departments with respect to management of activities that have an impact on the coast;
- To equip the City to more effectively deal with illegal activities taking place along the City's coastline;
- To ease the administrative burden on both DEA and DEA&DP with respect to ensuring environmental compliance;
- To cover the gaps in existing coastal and environmental legislation in terms of coastal activities;
- Promote efficiency of legal proceedings;
- Promote consistency in decision making with respect to regulating coastal activities, and
- Achieve the objectives as set out in the ICMA.

8.1.3 Aligning the City's Draft Coastal By-law with ICMA

While the City's draft coastal by-law has been established in terms of the provisions made by the Constitution, the intention and objectives of the proposed coastal by-law are closely linked to the principles of ICMA and would be one of the City's most useful tools towards achieving the intent of

the City's MCMP. As such, it is the City's intention to align the draft coastal by-law in accordance with the requirements of the ICMA and ultimately use the by-law to implement the MCMP.

The ICMA empowers municipalities to make by-laws for the effective administration of coastal access land (section 20(2)); empowers metropolitan municipalities to establish a coastal committee (section 42); to establish and implement a municipal coastal management programme (section 48); to make by-laws to implement, administer and enforce municipal coastal management programmes (section 50); and for municipalities to develop coastal planning schemes (section 56(3)(d)).

The City will continue with the development and implementation of its by-law in terms of the Constitution as an interim measure until such time that the City's MCMP is formalised. Upon formalisation of the City's MCMP, the by-law will be adjusted to meet the requirements of the ICMA.

8.2 Coastal Protection Zone and the Municipal Coastal Management Programme

Section 28 of the ICMA requires that the MEC determines a Coastal Protection Zone where the intent of the CPZ is to:

- "protect the ecological integrity, natural character and the economic, social and aesthetic value of coastal public property;
- Avoid increasing the effect or severity of natural hazards in the coastal zone;
- Protect people, property and economic activities from risk arising from dynamic coastal processes, including the risk of sea-level rise;
- maintain the natural functioning of the littoral active zone;
- maintain the productive capacity of the coastal zone by protecting the ecological integrity of the coastal environment; and
- make land near the sea shore available to organs of state and other authorised persons for –
    - Performing rescue operations; or
    - Temporarily depositing objects and materials washed up by the sea or tidal waters" (ICMA, 2008:36).

The Coastal Protection Zone defines the area to which the City's MCMP will be applied. The CPZ will be defined based on the landward most limit of the overlay zones (Figure 22).



Figure 22: An example of the spatial configuration of coastal planning mechanisms.

9. A CITY WITHOUT A SET-BACK?

Without a coastal set-back line the status quo of ad hoc, ill informed, piece-meal and reactive decision making within the City will continue. This in turn will increase the City's risk profile. The City stresses the fact that this risk is not limited to physical damage that may arise from coastal dynamic processes or storm surges, but that risk created from inappropriate decision making will manifest in a variety of broader environmental and socio-economic forms.

In the absence of a formal set-back, applications for *ad hoc* set-back lines by the public will continue to increase. These *ad hoc* set-backs are problematic for a number of reasons, namely:

- Applications for *ad hoc* set-backs at an erf scale are inappropriate and disruptive towards the City's efforts in achieving consistency in determining its own set-back;
- Acceptance of *ad hoc* set-backs interrupts and reduces the potential for linear integration of the more desired application of continuous set-backs at broader scales;
- There are legal uncertainties surrounding these *ad hoc* set-backs especially in terms of land use rights that may be affected in the future;
- *Ad hoc* set-backs are issued by the competent authority without undertaking site inspections or ground truthing, and
- *Ad hoc* set-backs are issued by the competent authority without conducting the necessary and relevant research.

Collectively these issues that arise as a consequence of not having a formal set-back in place restricts the City's ability to achieve the objectives of the ICMA. In addition the absence of a formal

set-back increases the City's legislative burden which has cost implications from a staffing perspective, time delays and ultimately service delivery delays. At a grassroots level this translates into the gradual deterioration of the coast and with it the socio-economic opportunities the coast provides. The end result is that the coast is gradually being converted from an asset to a burden.

10. CONCLUSION

The City has undertaken a thorough process in delineating its draft coastal set-back. The process is being led by the City's Environmental Resource Management Department (ERMD) that has a combined experience of over 60 years in the field on Integrated Coastal Management. More importantly, officials within the ERMD have an intricate knowledge of the city's coastline which is critical in developing a grounded, effective and pragmatic coastal set-back.

The City's draft set-back is embedded within the CT:SDF. This was undertaken with the knowledge that the effectiveness of a coastal set-back is largely dependent on how closely local planning schemes are aligned with the set-back. Whilst on a map this alignment is represented by the City's urban edge in terms of the CT:SDF and the draft set-back in terms of ICMA as a single line, from a City governance perspective this single line represents the synthesis of planning for socio-economic priorities into the future whilst simultaneously promoting a risk averse approach to coastal development. The investigation into the influence of local biophysical factors and the subsequent disaggregation of risk per location was critical to the process of defining risk areas and integrating these risk areas within the CT:SDF.

The alignment of the CT:SDF and the draft set-back has not only reduced the scope for confusion within an already complex and dynamic space, but such an approach has achieved a measure of practicality. The fusion of the CT:SDF with the draft set-back as one line has created clarity, not only for City officials in terms of guiding coastal planning and promoting risk averse and appropriate decisions, but it has also provided an appropriate platform of clarity for potential developers and investors. The formalisation of the City's draft set-back will also streamline the Environmental Authorisation process. These key traits have resulted in overwhelming public support for the City's draft coastal set-back and supporting regulatory mechanisms.

11. REFERENCES

Brundrit, G. (2008), *Global Climate Change and Adaptation – a sea-level rise risk assessment, Phase 1.*City of Cape Town.

Cartwright, A. (2008), *Global Climate Change and Adaptation – a sea-level rise risk assessment, Phase 3.*City of Cape Town.

Cartwright, A. (2009), *Global Climate Change and Adaptation – a sea-level rise risk assessment, Phase 5.* City of Cape Town.

City of Cape Town (2003) *Scenic Drive Network Management Plan, Volume 3: Assessment and Evaluation of S1 and S2 routes identification of projects, programmes and management policies.*

City of Cape Town (2009) *Cape Town Spatial Development Framework, Technical Report*, Cape Town, South Africa.

City of Cape Town (2009) *Rapid planning review of potential future development area along False Bay Coastline (Cape flats and Khayelitsha/Mitchells Plain Districts.* Report submitted to the Planning and Environment Portfolio Committee, 2009.

City of Cape Town (2012) *Cape Town Spatial Development Framework, Statutory Report,* Cape Town, South Africa.

Colenbrander, D., Sutherland C., Oelofse, G. Gold, H. and Tsotsobe, S. (2012) Reducing the pathology of risk: developing an integrated Municipal Coastal Protection Zone for the City of Cape Town in Cartwright, A., Oelofse, G., Parnell, S. and Ward, S. (eds) *Climate Change at the City Scale*, Routledge.

Colenbrander, D., Sowman, M. and Oelofse, G. (in press) *Delineating set-backs: navigating the realities of developing city-scale contexts.*

Cox, R (2012) Personal communication. Coastal Engineering within Climate Change, Stellenbosch, South Africa.

DEAT (Department of Environmental Affairs and Tourism) (2000) *White Paper*: *Sustainable Coastal Development in South Africa*, Government Press.

DEAT (2006) The Integrated Coastal Management Bill, *A brief guide to assist the public participation process*, Government Press, Roggebaai.

DEAT (2008) *The Integrated Coastal Management Act*, Government Press, Roggebaai

SSI (2011) *The establishment of a set-back line for the Overberg district.* Report commissioned by the Western Cape Department of Environmental Affairs and Development Planning, Cape Town.

De Wit, M., van Zyl, H., Crookes, D., Blignaut,J., Jayiya, T., Goiset, V. and Mahumani, B. (2009) Investing in Natural Assets: A business case for the environment in the City of Cape Town.

Mather, A. Stretch, D. and Garland, G. (2011) *Predicting extreme wave run-up on natural beaches for coastal planning and management, Coastal Engineering Journal 53 (2): 87-109*.

South African Info (2008) *Spatial Development Initiatives.*
http://www.southafrica.info/doing_business/economy/development/sdi.htm
(03/07/2012)

Tadross, M. Taylor, A. and Johnston, P. (2012) Understanding Cape Town's climate in Cartwright, A., Oelofse, G., Parnell, S. and Ward, S. (eds) *Climate Change at the City Scale*, Routledge - Earthscan.

13. ANNEXURES

REPORT TO PLANNING AND ENVIRONMENT PORTFOLIO COMMITTEE

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

1. **ITEM NUMBER : PLAN 15/08/09**

2. **SUBJECT:**
RAPID PLANNING REVIEW OF POTENTIAL FUTURE DEVELOPMENT AREAS ALONG FALSE BAY COASTLINE (CAPE FLATS AND KHAYELITSHA/MITCHELLS PLAIN DISTRICTS)

ONDERWERP:
SNELBEPLANNINGSOORSIG VAN MOONTLIKE TOEKOMSTIGE ONTWIKKELINGSGEBIEDE AAN DIE VALSBAAIKUS (KAAPSE VLAKTE- EN KHAYELITSHA/MITCHELLS PLAIN-DISTRIK)

ISIHLOKO:
UHLAZIYO OLUKHAWULEZAYO LOCWANGCISO LOPHUHLISO OLUNOKUQHUBEKA KWIXESHA ELIZAYO KWIINDAWO EZINGAKUNXWEME LWASE-FALSE BAY (KWIZITHILI ZE-CAPE FLATS NASEKHAYELITSHA/MITCHELLS PLAIN)

3. **PURPOSE**

This report seeks endorsement from the Planning and Environment Portfolio Committee (PEPCO) for a set of sub-regional guiding principles for development relating to a stretch of the False Bay coastline (from Strandfontein Pavilion to Monwabisi) based on a rapid planning investigation into future urban development opportunities in the area.

4. **STRATEGIC INTENT**

Spatial and land use planning should aim to promote:

- *Shared Economic Growth and Development*
- *Sustainable Urban Infrastructure and Services*
- *Energy Efficiency for a Sustainable Future*
- *Public Transport Systems*
- *Integrated Human Settlements*
- *Safety and Security*
- *Health, Social and Human Capital Development*
- *Good Governance and Regulatory Reform*

City leadership in clarifying the City's expectations of development and providing development guidelines in appropriate locations along the coast upfront creates a predictable decision-making culture for development, which is in the interests of good governance and regulatory reform.

5. FOR DECISION BY

Delegated: for decision by PEPCO
The terms of reference of this committee is policy formulation and implementation monitoring within *inter alia* the following functional areas:

The Planning function which includes:
Citywide Planning & Urban Design services
(1) To develop policy relating to the functions described in terms of reference of this committee (excluding the functions listed on 37(7)) and to recommend same to the Executive Mayor.
(6) To ensure public participation in the development of policy, legislation, IDP's and budget.

(System of Delegations, City of Cape Town, June 2009)

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6. EXECUTIVE SUMMARY

Cape Town's coastline is seen as one of its greatest natural and economic assets. Relatively little urban development has occurred along False Bay, particularly the stretch of coastline between Strandfontein and Macassar. To date, apartheid policies of contained township development, as well as environmental constraints and unique climatic conditions have historically limited development along False Bay.

Recent city policy has acknowledged this historic deficiency and recommended that development appropriate to the specific context, and mindful of environmental constraints and imperatives, should be encouraged to facilitate urban development that is people-centered, is spatially and socially integrated, and which maximizes the coastline's amenity opportunities.

As a means to reflect on the possibilities for coastal development along this stretch of coastline, a rapid planning review was undertaken, focusing on a 15km stretch of the False Bay coastline between Strandfontein Pavilion and Monwabisi Coastal Resort (see Annexure A.1). This was presented to sub councils 10 and 12 in April and May of 2009 for comment and support before submission of the rapid planning review to PEPCO for endorsement (see Annexure A.7).

The outcomes of the study reflect four key, but varied, coastal nodal development opportunities at the sub-regional scale including Monwabisi, Mnandi, Bluewaters and Strandfontein Pavillion nodes. It is proposed that development of these nodes should be informed by the set of guiding principles as identified in the Chapter 8 (Discussion/Contents) of this report and that site planning within the coastal nodes take informants identified in Annexure A.5 and A.6 into consideration when developing proposals. Furthermore, it is proposed that planning resources be prioritized around the Monwabisi and Mnandi coastal nodes due to existing planning initiatives and funding allocation by the Neighbourhood Development Partnership Grant Programme and Presidential Urban Renewal Programme respectively.

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7. RECOMMENDATIONS

Delegated: for decision by PEPCO

It is recommended that:

(a) PEPCO endorse the set of sub-regional guiding principles for development relating to the stretch of the False Bay coastline (from Strandfontein Pavilion to Monwabisi) based on a rapid planning investigation into future urban development opportunities in the area;

(b) The Rapid Planning Review of potential future development areas along the False Bay coastline serve as an input to the District Planning process and local planning initiatives.

(c) That the main nodal opportunities (Monwabisi and Mnandi / Kapteinsklip) be prioritized for planning intervention due to existing initiatives and funding allocation (through the Urban Renewal and Neighbourhood Development Partnership Grant programmes respectively) for these projects.

AANBEVELING

Gedelegeer vir besluitneming deur die portefeuljekomitee oor beplanning en omgewingsake (PEPCO):

Daar word soos volg aanbeveel:

(a) Dat PEPCO die stel subgebiedsrigsnoere vir die ontwikkeling van die stuk Valsbaaikus (van die Strandfontein-paviljoen tot by Monwabisi) op grond van 'n snelbeplanningsondersoek na toekomstige stedelikeontwikkelingsgeleenthede in die gebied onderskryf.

(b) Dat die snelbeplanningsoorsig van moontlike toekomstige ontwikkelingsgebiede aan die Valsbaaikus by die distriksbeplanningsproses en plaaslikeregeringsprojekte ingevoer word.

(c) Dat die hoof- nodale geleenthede (Monwabisi en Mnandi/Kapteinsklip) die voorrang geniet vir beplanningsintervensie, aangesien dit reeds (deur die program vir stadsvernuwing, en die vennootskapsprogram vir buurtontwikkeling onderskeidelik) deur veldtogte en finansiering gerugsteun word.

IZINDULULO

Zithunyelwe kwi-PEPCO ukuba ithathe isiqqibo

Kundululwa ukuba :

(a) I-PEPCO iqinisele imithetho-siseko esisikhokelo sengingqana sophuhliso oluphathelele kwindawo engakunxweme lwe-False Bay (ukusuka eStrandfontein Pavilion ukuya eMonwabisi) esekelwe kuphando locwangciso olukhawulezayo lwamathuba ophuhliso lwedolophu kule ndawo;

(b) UHlaziyo loCwangciso oluKhawulezayo lophuhliso olunokuqhubeka kwixesha elizayo kwindawo engakunxweme lwe-False Bay liza kuba ligalelo kwinkqubo yoCwangciso lweSithili kunye naminye imisebenzi yocwangciso yale ngingqi.

(c) Amathuba apho zidibana khona ezi ndawo (Monwabisi and Mnandi / Kapteinsklip) abonwe nje ngawona aphambili kwimisebenzi yocwangciso ngenxa yokuqhubekayo kwezi ndawo ngoku kwakunye nemali ebekelwe bucala (essiibonelelo seenkqubo ze-Urban Renewal and Neighbourhood Development Partnership ngokulandelelanayo) ukulungiselela ezi projekthi.

8. DISCUSSION/CONTENTS

Cape Town's coastline is seen as one of its greatest natural and economic assets. To date, extensive development has occurred along many coastal areas in Cape Town, including: Camps Bay, Clifton, Sea Point, Hout Bay, Table View, Simonstown, Fish Hoek, Muizenberg, Strand, and Gordon's Bay. Areas that have to date not been developed face increasing development pressure.

Relatively little urban development has occurred along False Bay, particularly the stretch of coastline between Strandfontein and Macassar. This is attributable to two main reasons. Firstly, Apartheid policies of contained township development for coloured and black groups and planning approaches of the time resulted in townships along the coastline having little or no spatial relationship with the coast. Development along the False Bay coastline (FBC) over the last number of decades was limited to a number of coastal resorts that were designated for use by so-called 'non-white' residents of Cape Town. These coastal resorts include Strandfontein, Bluewaters, Mnandi, and Monwabisi.

Secondly, environmental constraints and unique climatic conditions have historically limited development along False Bay. Recent recognition of biodiversity value and maintaining connectivity of green spaces within the City has prompted the conservation of biodiversity corridors, such as the biodiversity corridor along False Bay coastline. Part of which is conserved by the Wolfgat Nature Reserve. Sea level rise is also an imminent threat to development at the coast, the impacts of which will have significant effects on existing coastal systems, built infrastructure, and property. Therefore, coastal inundation is considered as a key informant to development along the False Bay coast. Fortunately, because the primary dune system along this stretch of coastline is in a relatively good state, the impact of coastal inundation during storm surges and incremental climate change is minimal. Provided that the integrity of the coastal dune systems along the False Bay coast are maintained, development would be possible with little or no impact from coastal inundation.

To date, residents living in close proximity of the False Bay coastline remain disconnected from it. This is due in part to the limitations and decline of coastal resorts within the study area. Recent city policy has acknowledged this historic deficiency and recommended that development appropriate to the specific context, and mindful of environmental constraints and imperatives, should be encouraged to facilitate urban development that is people-centered, is spatially and socially integrated, which maximizes its amenity opportunities, and which better connects settlements such as Khayelitsha and Mitchells Plain with the coast.

As a means to confirm the possibilities for coastal development along this stretch of coastline, a rapid planning investigation was undertaken focusing on a 15km stretch of the FBC, between Strandfontein Pavilion and Monwabisi Coastal Resort (see Annexure A.1).

The focus of the rapid planning investigation is the following:

- To develop a concise synthesis of current strategy and policy imperatives, which inform development along the coast. (see Annexure A.2)
- To identify key development challenges and opportunities experienced within the study area. (see Annexure A.3).
- To define zones of development opportunity along the relevant section of the False Bay coastline. (see Annexure A.4).
- To identify a set of guiding principles that should inform any development proposals along this stretch of coastline.
- A detailed analysis of the local physical informants to development at identified zones of opportunity. (see Annexure A.6).

- To identify a set of local development guidelines, to be considered when planning development within the proposed coastal development nodes (see Annexure A.7).

The outcomes of the study reflect four key, but varied, coastal nodal development opportunities at the sub-regional scale including Monwabisi, Mnandi, Bluewaters and Strandfontein Pavillion nodes. It is proposed that Monwabisi and Mnandi be prioritized due to existing planning initiatives and funding allocation to these nodes. Monwabisi Coastal Node is a Neighbourhood Development Partnership Grant Project (NDPG) with funding allocated to the City of Cape Town by National Treasury. In this regard, the Spatial Planning and Urban Design Department is currently conducting an investigation into the feasibility of developing the broader coastal node. The Department of Sports, Recreation and Amenities is running a project (with NDPG support) focussed on upgrading amenities at the resort. Furthermore the Spatial Planning and Urban Design Department, in conjunction with the Presidential Urban Renewal Programme, is in the process of establishing a planning and urban design framework for the development of the Kapteinsklip precinct, including the Mnandi Resort area. The objective is to enhance the precinct as a destination place and new coastal development node. The process is currently at the prefeasibility stage, and upon completion will inform an implementation process.

It is proposed that the following guiding principles for development at the sub-regional and local scale, inform development proposals along the False Bay Coastline and within coastal development nodes respectively. These are informed by an understanding of context and planning imperatives.

- **Guiding Principle 1: Promote nodal development in identified zones of opportunity:** All development should be nodal rather than strip development and should be situated in the zones of highest opportunity as identified in the preceding analysis. These nodes include Strandfontein Pavilion, Mnandi, Monwabisi and Blue Waters coastal resorts.

- **Guiding Principle 2: Maintain a continuous east west ecological corridor:** East-west biodiversity connectivity (especially for faunal movement) must be maintained. Strandveld corridors connecting larger remnants should be a minimum of 200m wide to sustain ecological functioning. Faunal corridors of Strandveld vegetation should be a minimum of 20m wide with a buffer of 25m on either side. This amounts to a minimum combined corridor width of 70m to ensure connectivity for faunal species.

- **Guiding Principle 3: Ensure public access to and along the coast is maintained:** Public access to the coast should be a foremost consideration in any development proposal for coastal nodes. Infrastructure that facilitates public access and experience of the coastline such as boardwalks, hiking trails and viewing platforms are critical. No privatisation of the coastline to the detriment of public access to and along it should be considered.

- **Guiding Principle 4: Address inequities through promoting active, diverse and safe coastal nodes which become destination places:** The coastal nodes should become vibrant people places. The coastal nodes should be considered as distinct from each other and could reflect varying roles which should be a response to local contextual conditions and need.

  Public recreational and tourism opportunities should be the key component of the coastal nodes. Activities that maximise people's experience of the coastline are envisaged. These should aim to provide recreational, social and local economic opportunity in areas where they are greatly needed.

Residential development and intensification of underdeveloped areas should be pursued as a means to create the necessary thresholds to support such destination places.

Safety and security in respect of any development along the FBC should receive priority. High intensity mixed-use development within appropriate areas of coastal nodes should be promoted to facilitate/maximise surveillance.

- **Guiding Principle 5: Design with due regard for coastal processes:** At nodal development areas environmental constraints (wind, sand, storm surges, coastal inundation/sea level rise, etc.) and coastal processes must be key informants to development guidelines and local design considerations. In particular, shelter from the elements and maintenance of infrastructure should be afforded careful consideration to ensure sustainability from a maintenance perspective.

  Roads in an east west direction in close proximity to the frontal dune system should be avoided along this coastline as they cannot be sustainably managed, given the mobility of sand in particular. North south access roads should be promoted to provide access to coastal nodes.

  A minimum buffer of 50m from primary dune areas should be respected to ensure that development impact on coastal processes is mitigated as far as possible.

- **Guiding Principle 6: Maintain visual quality along the False Bay coast:** The scenic beauty of the FBC is a significant asset, which needs to be managed effectively. Mitigating visual impact should be given attention in visually sensitive areas.

  The scenic drive status of Baden Powell Drive should be a consideration in any development proposal and the visual impact of development along this route should be carefully considered. Furthermore, areas with the potential to enable the visual experience of the FBC by the public should be enhanced, and made secure for public enjoyment.

The rapid planning investigation also identifies informants, at the site level, which should be considered in the development of nodal development proposals. (see Annexure A.6 and A.7).

8.1. Constitutional and Policy Implications

All relevant constitutional and council policy informants have been considered in undertaking this investigation.

8.2. Environmental implications

Does your report result in any of the following:

No ☐

Yes (if yes, please complete the section below by clicking on the relevant tick boxes)

Loss of or negative impact on natural space and/or natural vegetation, rivers, vleis or wetlands?	☐	Loss of or negative impact on the city's heritage, cultural and scenic resources?	☐
An increase in waste production or concentration, pollution or water usage?	☐	Development or any construction within 500m of the coastline?	☒

Does your activity comply with the National Environmental Management Act (NEMA)?
(mark by clicking on the tick box)

Yes ☒ No ☐

Does your report complement and support the City's approved IMEP strategies?
(if yes, please select from list below by clicking on the relevant tick box)

Biodiversity Strategy and Biodiversity Network	☒	Coastal Zone Management Strategy	☒	Energy and Climate Change Strategy	☒
Environmental Education and Training Strategy	☐	Heritage Management Strategy	☐	Air Quality Management Plan	☐
Integrated Waste Management Strategy	☐	Invasive Species Strategy	☐		

Do the activities/actions arising from your report:
(if yes, please select from list below by clicking on the relevant tick box)

Enhance Cape Town's unique environmental assets?	☒	Negatively impact on Cape Town's unique environmental assets?	☐

8.3. Legal Implications

This report is an investigation into the potential for development along the False Bay Coastline. Guidelines are proposed and no steps are required to comply with any legal requirements. Legal informants, insofar as they are relevant to this environment, were taken into account as part of the preparation of the report.

8.4. Staff Implications

Does your report impact on staff resources or result in any additional staffing resources being required?

No ☒

Yes ☐

8.5. Risk Implications

Does this report and/or its recommendations expose the City to any risk?
(i.e. does it have any adverse influence on service delivery?)
No ☒
Yes ☐

8.6. Other Services Consulted

Department of Environmental Resource Management: Biodiversity Management Branch (Dr. Patricia Holmes – tel: 021 514 4170)

Department of Environmental Resource Management (Ms. Janet Bodenstein – tel: 021 487 2133

Spatial Planning and Urban Design Department: Metropolitan Spatial Planning Branch (Mrs. Anele Horn – tel: 021 400 2161)

Department of Sports, Recreation and Amenities (Mr. Joe Olivier - tel: 021 400 4181).

These departments have supported the proposed development guidelines and provided input and comment regarding this rapid planning review.

ANNEXURES

Annexure A1:	The study area (Map)
Annexure A2:	Strategy and policy imperatives
Annexure A3:	Summary of the key development challenges and opportunities
Annexure A4:	Zones of opportunity
Annexure A5:	Local informants: Coastal Nodes
Annexure A6:	Local guidelines: Coastal Nodes
Annexure A7:	Subcouncil meeting minutes

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DIRECTORATE	*Strategy and Planning*
FILE REF NO	
SIGNATURE : DIRECTOR	

☑ REPORT COMPLIANT WITH THE PROVISIONS OF COUNCIL'S DELEGATIONS, POLICIES, BY-LAWS AND ALL LEGISLATION RELATING TO THE MATTER UNDER CONSIDERATION.

☐ NON-COMPLIANT

LEGAL COMPLIANCE

DATE 21 July 2009

COMMENT :

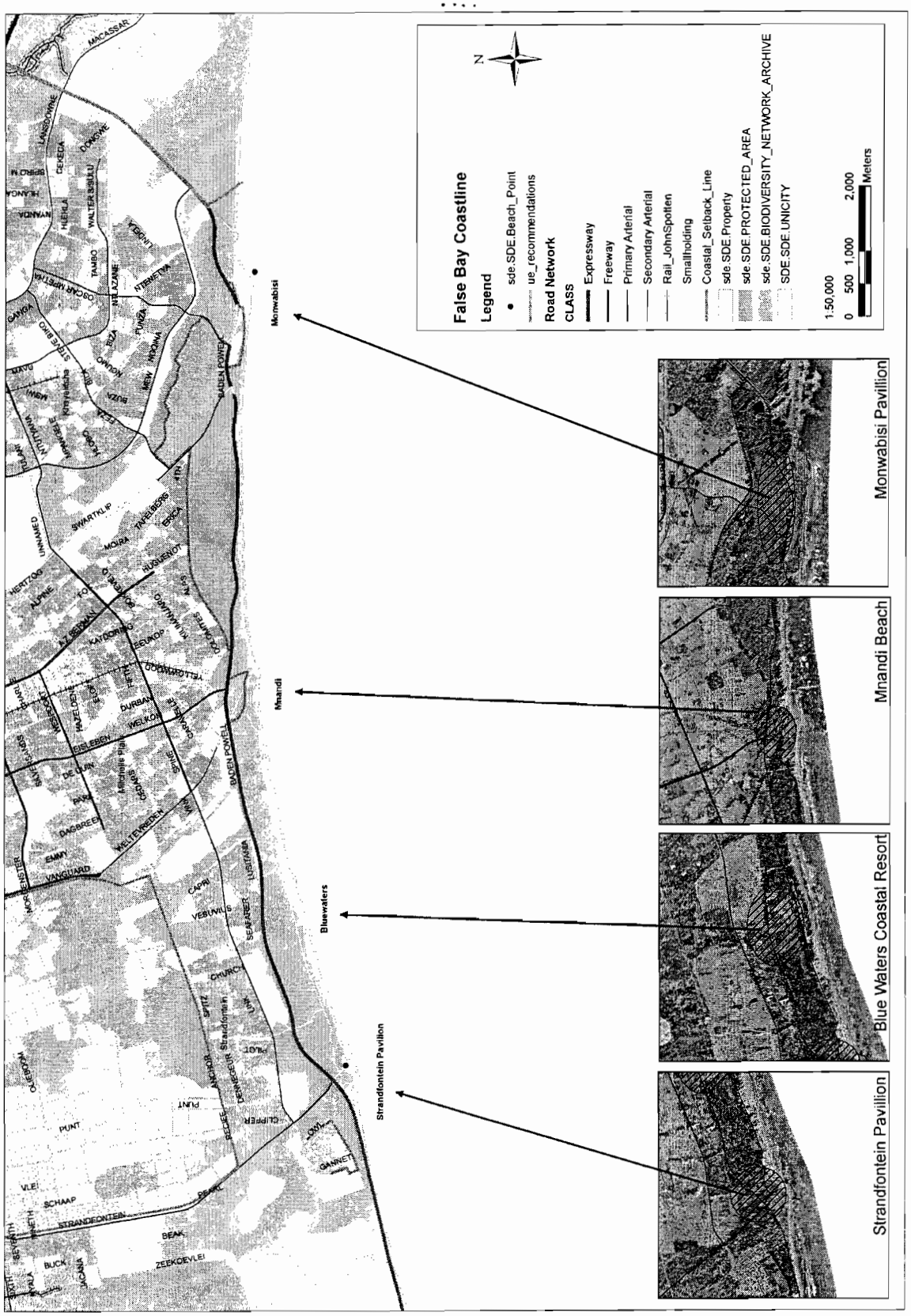
EXECUTIVE DIRECTOR
PIET VAN ZYL

DATE 23.07.2009

Comment:

For review and approval by PEPCO.

ANNEXURE A.1 – The study area



City-wide policy and planning frameworks that inform the development of the False Bay Coast include:

- Future Cape Town: An argument for the long-term spatial development of Cape Town (2006);
- City of Cape Town: Coastal Zone Management Strategy (2003);
- The Biodiversity Strategy (2003);
- Draft City of Cape Town - Coastal Development Guidelines report (2007);
- Draft City Development Edges Policy: Urban and Coastal Edge (April, 2009) and
- Draft Cape Town Spatial Development Framework and Draft District SDP/EMF Documents (Districts F and G)

All of the abovementioned documents subscribe to the vision of managing this coastline in an innovative and integrated manner that will ensure the environmentally sustainable functioning of its natural systems while optimizing its economic and social benefits (CoCT (b), 2005/06). There is also general alignment with reference to the principles relating to the "meeting of the coast."

Two key high level spatial directives emanating from the abovementioned policy and planning frameworks reviewed are clear:

- Firstly, meeting the coast should involve the creation of special people places. Celebrating the coast as a city destination place supports citywide policy imperatives of creating more great people places. Appropriate development at the coast contributes to the unique sense of place of Cape Town by creating new special places.
- Secondly, the creation of special people places should carried out while creating and maintaining a "functional coastal biodiversity corridor". We need to be mindful of the biodiversity imperatives of this significant coastal asset so that this great opportunity can be enjoyed by present and future generations.

ANNEXURE A.3 - Summary of the key development challenges and opportunities

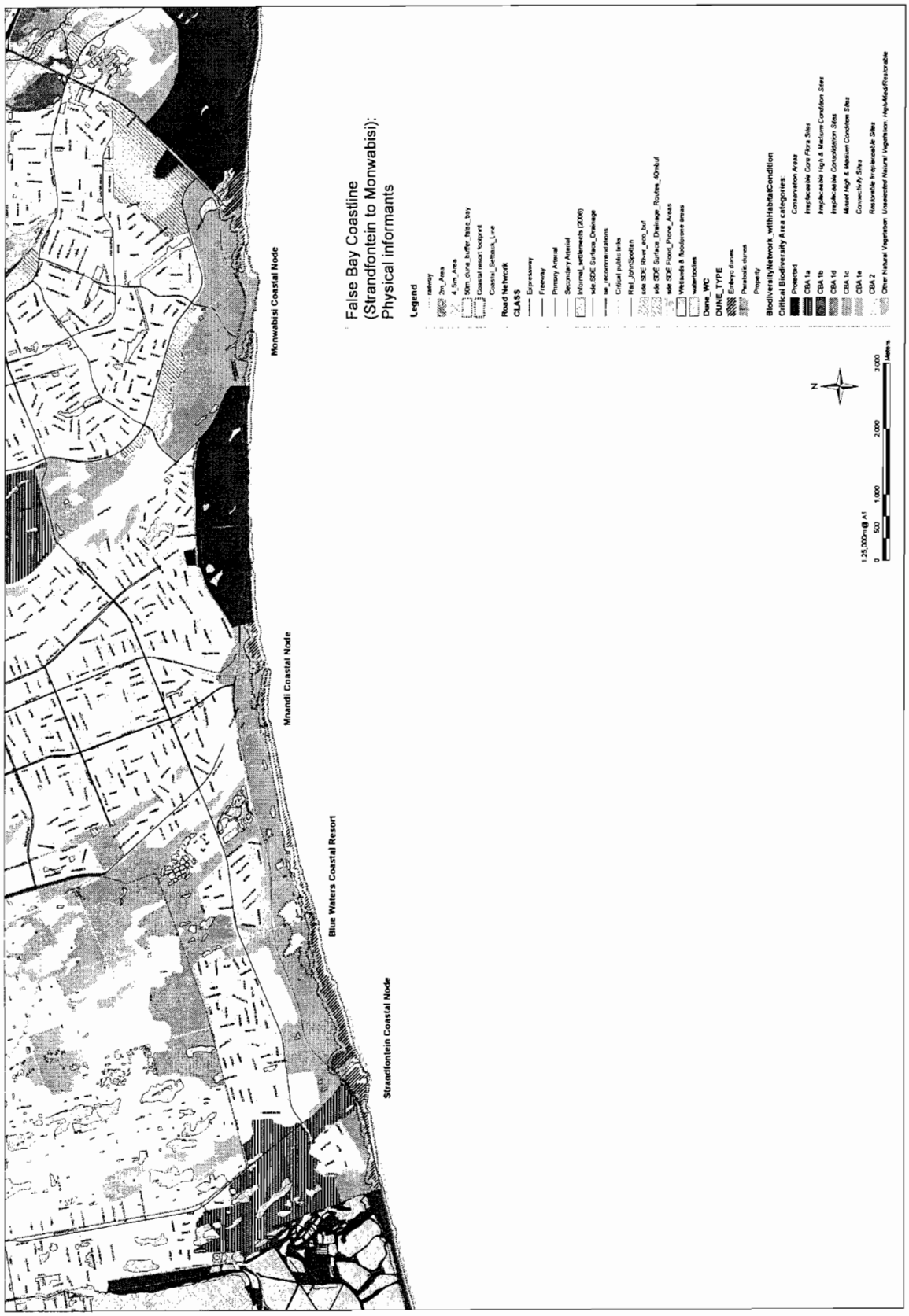
The following key development challenges and opportunities have been identified in respect of analysis of the sub-regional physical informants to development within the study area. Physical informants analyzed include coastal primary dune areas and associated buffers, coastal inundation and storm surge areas, topography, critical biodiversity areas, access and movement desire lines, settlement patterns, and existing infrastructure and coastal resort footprints (see figure below – False Bay physical informants: Strandfontein to Monwabisi).

(i) Challenges

- Achieving balance between the need for development and the maintenance of the integrity of a biodiversity corridor and other biophysical systems is a key challenge. Maintaining and enhancing a green corridor along the False Bay coast is seen as critical given the City wide importance of the False Bay coastline as one of the last remaining major ecological corridors.
- Limited physical linkage between communities and existing underdeveloped coastal recreation areas needs to be addressed. Development aimed at creating better access to the coast should actively seek means to create more accessible, safer and mixed use destination places that are sustainable and that enhance communities" (particularly poor communities) experience of the coastline.
- The inherent tension between the need to protect nature areas and the imperative to meet the coast to create 'great people places' requires careful consideration in determining guidelines for development in coastal nodes.
- Lack of safety and security along the FBC and particularly at existing coastal recreation nodes is a significant constraint. Mono-functionality of the existing resorts results in limited thresholds in terms of the users of these areas throughout the year.
- Land invasion, especially between Monwabisi and Khayelitsha remains a risk given the uncertainty over the future of this area. Ever-increasing levels of urbanisation and an escalating housing backlog means that land invasion will increase over time.

(ii) Opportunities

- Maintaining the integrity of the False Bay coastal biodiversity corridor between coastal development areas presents key recreational opportunities such as recreational walks on hiking trails and boardwalks, environmental education, lookout points and scenic views etc. The minimum corridor width for Dune Strandveld vegetation connecting larger remnants is 200m, with an accepted width of 70m to maintain connectivity for faunal movement where the east-west corridor intersects with coastal development nodes.
- Higher intensity activities of a mixed-use nature at coastal nodes could create the necessary preconditions to promote thresholds to support well functioning destination places. This will have a positive impact on the current safety and security challenge. Disturbed areas and existing infrastructure at coastal resorts present opportunities for higher intensity mixed land uses.
- Baden Powell Drive is identified as a scenic drive. Appropriate development at certain coastal nodes along its length could create destination points along its course, thereby further enhancing the functionality of the route as a scenic route. The City of Cape Town: Scenic policy guidelines should be considered when compiling detailed planning frameworks for identified zones of opportunity.
- Sea-level rise is a real threat to all coastal areas, both natural and developed. However, the advantage of the False Bay Coastline lies in the primary dune systems, which provides protection to areas landward of the dunes. Design and development with due regard for coastal processes will enable sustainable development along the False Bay Coast.


False Bay Coastline
(Strandfontein to Monwabisi):
Physical informants
Legend
railway
2m_Area
4.5m_Area
50m_dune_buffer_false_bay
Coastal resort footprint
Coastal_Setback_Line
Road Network
CLASS
Expressway
Freeway
Primary Arterial
Secondary Arterial
Informal_settlements (2006)
sde.SDE.Surface_Drainage
sde_recommendations
Critical public links
Rail_JohnSpoken
sde.SDE.River_and_buf
sde.SDE.Surface_Drainage_Routes_40mbuf
sde.SDE.Flood_Prone_Areas
Wetlands & floodprone areas
waterbodies
Dune_WC
DUNE_TYPE
Embryo dunes
Parabolic dunes
Property
BiodiversityNetwork_withHabitatCondition
Critical Biodiversity Area categories:
Protected
Conservation Areas
CBA 1a
Irreplaceable Core Flora Sites
CBA 1b
Irreplaceable High & Medium Condition Sites
CBA 1d
Irreplaceable Consolidation Sites
CBA 1c
Mixed High & Medium Condition Sites
CBA 1e
Connectivity Sites
CBA 2
Restorable Irreplaceable Sites
Other Natural Vegetation
Unrestricted Natural Vegetation: High/Med/Restorable
Monwabisi Coastal Node
Mnandi Coastal Node
Blue Waters Coastal Resort
Strandfontein Coastal Node
N
1:25,000 @ A1
0
500
1,000
2,000
3,000
Meters

ANNEXURE A.4 – Zones of opportunity

Taking into consideration the key challenges and opportunities, as well as the key policy and planning imperatives, it is apparent that specific zones of opportunity can be identified. Each of the zones shares a number of common characteristics in that they are areas in which the key opportunities identified are present. They present opportunities to optimise meeting the coast in a manner that respects existing natural systems and maximises linkages with adjacent communities.

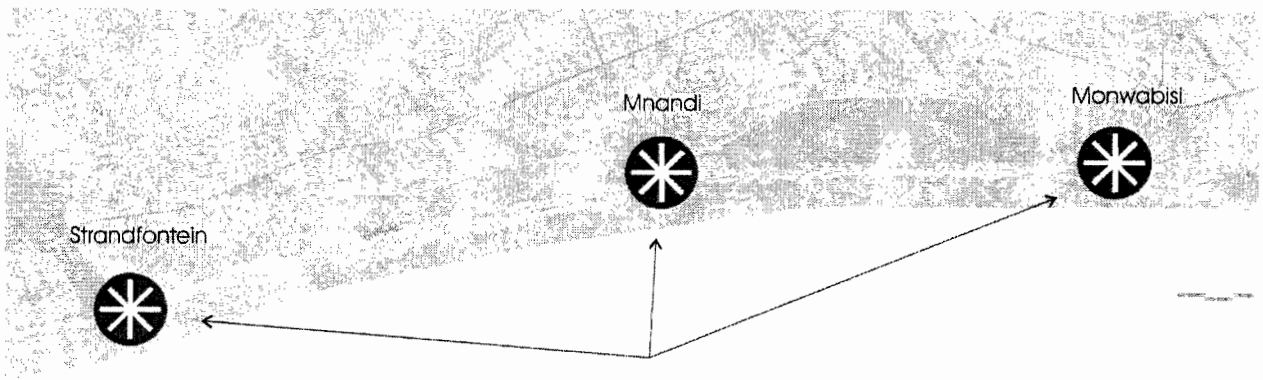
The rationale for identifying these coastal development zones includes:

- Areas that will facilitate nodal development at the coast as opposed to strip development
- Focussing on existing areas of environmental disturbance and existing infrastructure.
- Minimising potential impacts on dynamic coastal processes and critical biodiversity remnants.
- Capitalising on areas with high levels of accessibility within the study area (transport routes of sub-metropolitan and metropolitan significance)

The zones of higher intensity coastal development opportunity include (see figure below – coastal development zones of opportunity):

- Strandfontein Pavilion
- Mnandi Beach Resort,
- Monwabisi Coastal Resort.

It is envisaged that these locations accommodate high intensity mixed use activities that promote the creation of higher intensity destination places in meeting the False Bay coast. Blue Waters Resort and Promenade represents a lower intensity coastal development zone of opportunity due to its suitability (less accessible, more exposed to environmental processes etc) as a predominantly recreation and tourism node.



Coastal Development Zones
of Opportunity

ANNEXURE A.5 – Local Informants: Coastal Nodes

The following section is an extract from the False Bay Coastal Investigation technical report, which identifies the local physical informants in relation to identified zones of opportunity. These informants form the basis for determining development guidelines for each of the coastal nodes.

A.5.1 Monwabisi Coastal Node

At the local scale the following informants are applicable (refer to figure A.5.1):

- Relief (steep hill slopes; gentle slopes)

Most of the landscape in this zone consists of undulating plains. A larger dune ridge is situated to the immediate south of Mew Way, extending southwards from Monwabisi Park informal settlement to the primary dune system to the east of Monwabisi Resort. The area to the north of Mowabisi Resort on the landward side of Baden Powell Drive is of a gentler gradient, and may be better suited to development.

- Primary dunes

The extent of primary/embryonic dunes is limited within the Monwabisi Coastal Node area as this part of the coastline is made predominantly of rocky outcrops. There has been limited development in proximity to these dunes, thus they are in a relatively good condition. Future development should continue to respect a 50m buffer from primary dune areas.

- Flood prone areas

Due to the levels of protection provided by the primary dune system and the rocky coastline at Monwabisi Coastal Node, the area is at low risk from inundation and storm surge flooding. A stormwater detention pond exists south of Enkanini Informal Settlement, between Mew Way and Baden Powell Drive. The seepage from the detention pond flows southwards towards the ocean to the east of Monwabisi Resort.

- Green links

'High & medium condition' biodiversity sites are located within the Monwabisi Coastal Node. Ecological corridor linkages are required in this area to maintain biodiversity connectivity

- Movement desire lines

A strong desire line of movement exists between Monwabisi Park informal settlement and Monwabisi Resort. This desire line extends through harsh natural terrain and presents the opportunity to provide direct access with active land use interfaces fronting onto it.

- Informal settlements

The expansion of Monwabisi Park informal settlement south of Khayelitsha, on the seaward side of Mew Way, has resulted in increased development pressure on the biodiversity corridor at Monwabisi Coastal Node. Since Baden Powell runs relatively close to the coast at Monwabisi Coastal Node, it has been easier for informal settlements to expand southwards towards the coast.

- Existing areas of disturbance

Facilities existing at the resort include the beach and tidal pool area, an administration office, braai facilities, and a caravan park and overnight chalets. The footprint of Monwabisi Coastal Node is quite extensive due to the overnight camping facilities and chalets and other day recreation facilities.

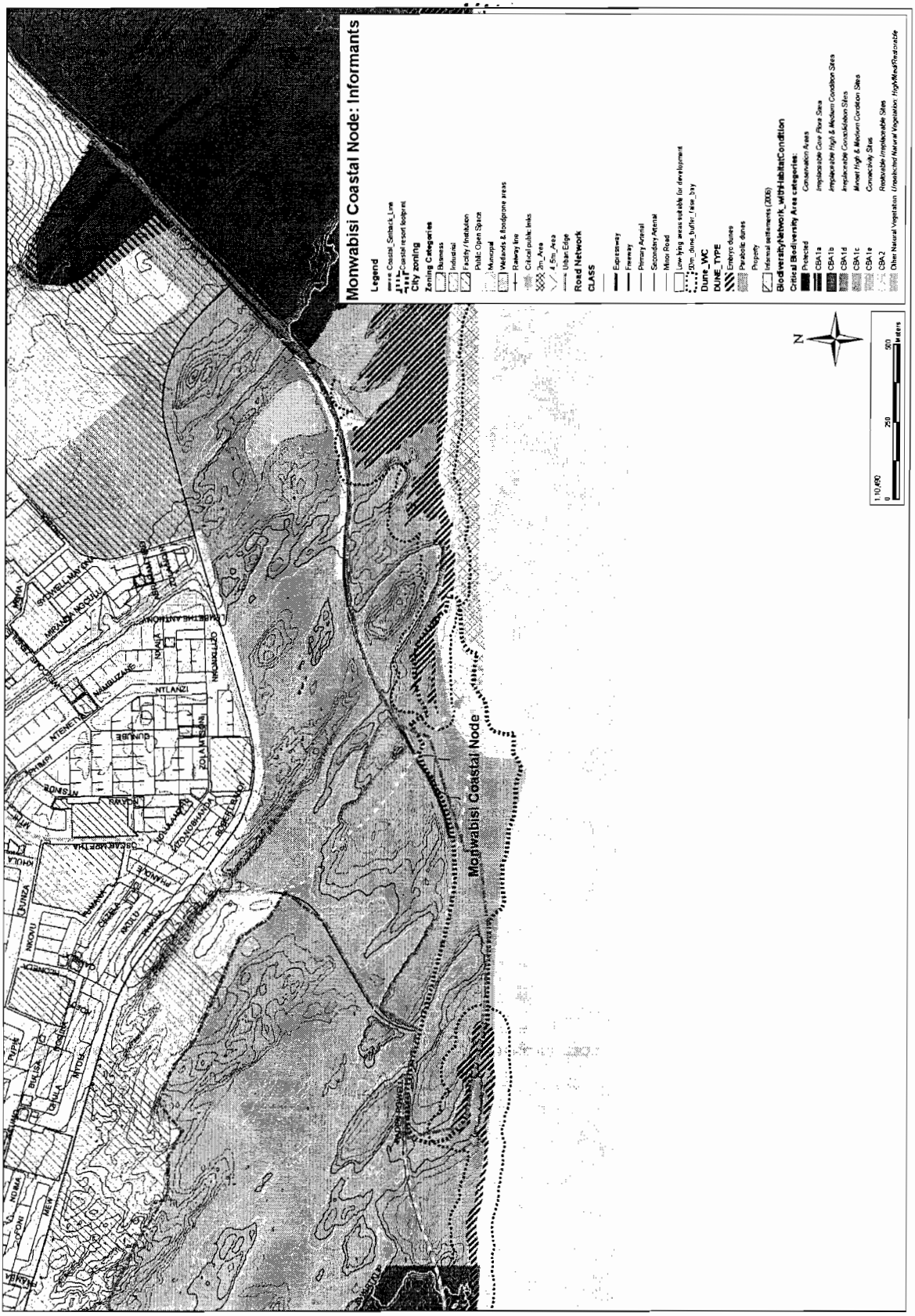


Figure A.5.1: Monwabisi Coastal Node - Informants

A.5.2 Mnandi Coastal Node

At the local scale the following informants are applicable (refer to figure A.5.2):

- Relief (steep hill slopes; gentle slopes)

Steep dune slopes exist within the Mnandi precinct, separating Mnandi coastal node from Kapteinsklip. The existence of these steep dune slopes reinforces the scenic quality of Baden Powell Drive.

- Primary dunes

Primary/embryonic dunes are not prevalent within the Mnandi Coastal Node area as this part of the coastline comprises predominantly rocky outcrops. Impact levels on existing primary dunes are low to moderate due to limited development impact.

- Flood prone areas

Due to the levels of protection provided by the primary dune system and the rocky coastline at Mnandi Coastal Node, the area is at low risk from inundation and storm surge flooding.

- Green links

The Mnandi Coastal Node is located within a 'high & medium condition' biodiversity site. An east-west ecological corridor linkage needs to be determined in this area to maintain biodiversity connectivity. A corridor link may be most appropriate along the southern boundary of Baden Powell Drive since this area is mostly covered by steep hill slopes.

- Movement desire lines

A strong desire line exists between Kapteinsklip Station and Mnandi Coastal Node. This desire line is enhanced by the pedestrian bridge linking these precincts across Baden Powell Drive. However, since there is no form of activity along this desire line, pedestrian movement during times of low activity is unsafe.

- Informal settlements

A small informal settlement exists on City-owned land north of Baden Powell Drive in close proximity of Kapteinsklip Station. Since there is no immediate planning for the area, the potential expansion of this informal settlement is a quite tangible threat to future development within the node.

- Existing areas of disturbance

Existing facilities available at the resort include the Mnandi Blue Flag Beach area, day recreation facilities, and extensive parking facilities. Facilities are scattered throughout the Mnandi Coastal Node are in relatively good condition and are in keeping with the standard of Mnandi Blue Flag Beach.

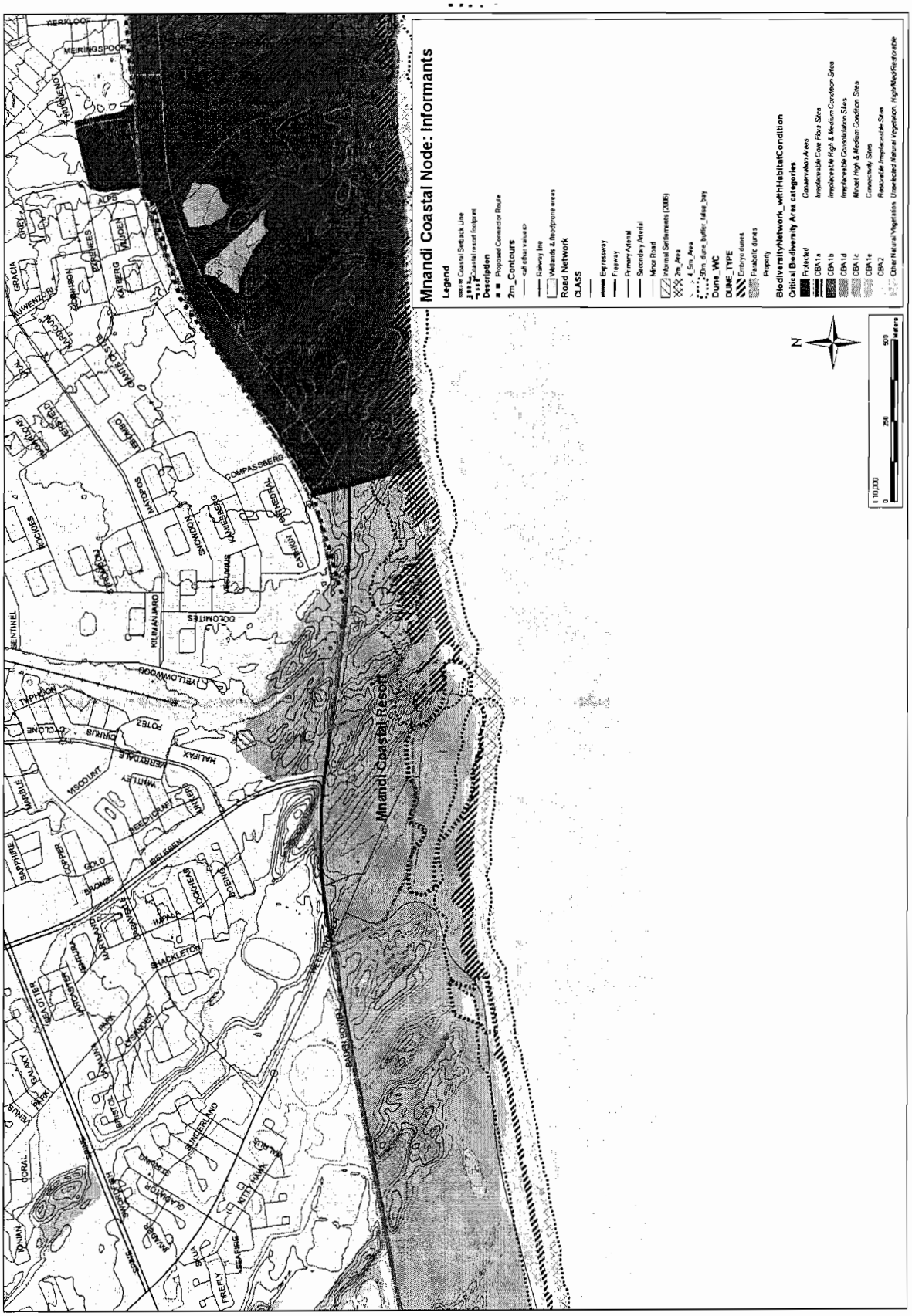


Figure A.5.2: Mnandi Coastal Node - Informants

A.5.3 Strandfontein Pavilion Coastal Node

At the local scale the following informants are applicable (refer to figure A.5.3):

- Relief (steep hill slopes; gentle slopes)

Relief is a significant informant to areas suitable for development. 2m contours, used to analyze the relief for the area indicate that steep slopes exist along the eastern side of Strandfontein Road (between Spine Road and Baden Powell Drive), with the primary ridge lines extending northwards into the False Bay Ecology Park and into Philippi.

Other slopes exist to the east of Strandfontein Sports Complex. These are major informants to the determination of functional ecological corridor links. Areas of gentler gradient should be considered more for development.

- Primary dunes

Primary/embryonic dunes are prevalent within the Strandfontein Resort area. These areas are partially vegetated and dissected by roads. Primary dunes have been moderately impacted on by urban development within the coastal node.

- Flood prone areas

Low-lying areas prone to flooding exist south of the Strandfontein Sports Complex. However, these are isolated depressions which do not form part of any larger watercourses or wetland systems.

Certain areas within the existing Strandfontein Resort footprint are prone to inundation during storm surges. However, the impacts of storm surges on the coastal node are moderate due to the integrity of the primary dune system.

- Green links

Parts of the Strandfontein Coastal Node are identified as 'high & medium condition' sites (refer to figure 6). These sites are selected areas in terms of national biodiversity targets. They require further articulation in terms of functional ecological connectivity in terms of physical analysis of the area.

- Movement desire lines

Currently, the coastal node is dislocated from the Strandfontein Community. Pedestrian and NMT links are virtually non-existent. However, footpaths are visible between the pavilion area and Strandfontein Sports Complex.

In addition, Camp Street is a tarred road, which provides vehicular access to Strandfontein coastal node. Camp Street does not provide vehicular access onto Baden Powell Drive as it passes underneath it. Other desire lines to the coast are visible from Pelikan Heights. It is most likely that these are unsafe passages for pedestrians.

- Informal settlements

A small informal settlement exists on City-owned land north of Baden Powell Drive and west of Camp Street. Since there is no immediate planning for the area, the potential expansion of this informal settlement presents a tangible threat to land suitable for development as well as the existing biodiversity corridor.

- Existing areas of disturbance

The existing Strandfontein coastal resort footprint constitutes an area of existing disturbance and could present opportunities for development. Existing facilities available at the resort include a tidal pool, a concrete berm/windbreak, a beach office, ablution facilities, and substantial parking

facilities. Structures are scattered throughout the resort area with extensive grass embankments in between.



Figure A.5.3: Strandfontein Coastal Node - Informants

A.5.4 Blue Waters Coastal Resort

At the local scale the following informants are applicable (refer to figure A.5.4):

- Relief (steep hill slopes; gentle slopes)

This section of the FBC is a relatively flat plain. Blue Waters Coastal Resort is partially protected by the parabolic dunes in the coastal zone, which provide sheltered from cold on-shore winds at night. Most of the Blue Waters overnight accommodation (chalets and camping areas) are found within this protected zone.

- Primary dunes

Extensive embryonic dune systems defend this stretch of the coast. However, these are significantly impacted on by built infrastructure. The Middelbank Promenade area is situated directly within the primary dune system up to the high water mark. In addition, Lukannon Drive, linking Strandfontein and Mnandi Coastal Nodes, and providing access to Blue waters Resort, dissects the Primary dune system and is often covered by windblown sand.

- Flood prone areas

The coastal zone at Blue Waters is fairly well protected from inundation by the primary dune system. There are a few isolated depressions on the landward side of the dunes which are prone to flooding.

- Green links

With the exception of the Blue Waters Resort area, this stretch of the coastal zone is identified as a 'high & medium condition' site. These sites are selected areas in terms of national biodiversity targets. They require further articulation in terms of functional ecological connectivity in terms of physical analysis of the area.

It is proposed that the existing resort footprint be rationalised to a more contained and manageable size. This will free up more land for rehabilitation of natural vegetation.

- Movement desire lines

Like Camp Street to the west of Blue Waters, Nautilus Road is an underpass with no road access being provided onto Baden Powell Drive. Nautilus Road to the east of Blue Waters provides direct access from Strandfontein to the coast.

At present, road access to Blue Waters Resort can only be obtained via Lukannon Drive between Strandfontein and Mnandi Coastal Nodes. This is problematic as Lukannon Drive is plagued by windblown sand, which has to be cleared regularly to keep the road open. This road is also unsafe, especially at night, as there is no lighting and there is very little activity apart from fishermen.

Salerno Way, which extends from Spine Road to Baden Powell Drive, is viewed as a critical movement desire line. The possible extension of Salerno Way to meet the road infrastructure at Blue Waters Resport would provide the opportunity for access to the Resort to be obtained from Baden Powell Drive.

- Existing areas of disturbance

Blue Waters is a predominantly recreational node. Infrastructure at Blue Waters Resort is currently scattered over a large footprint. The level of disturbance is moderate. Existing facilities and activities include a caravan park and chalets, staff housing, Department of Sports, Recreation and Amenities district offices, Blue Waters Life Saving Club (Beach area), braai areas on the seaward side of Lukannon Drive (Beach area).

The Blue Waters Resort was developed under the Apartheid Separate Amenities Act, No. 49 of 1953, which forced 'non-white' persons to use the resort, with the result of a false market being created for it. These days the resort is not seen as an attraction for most middle income holiday-makers. However, there is still some level of usage by the lower income segment of the market. More recently, a temporary refugee camp has been established to accommodate the overflow of foreign migrants to the city.

Structures are scattered over a large footprint, making inefficient use of available land. Extensive grassed areas exist on the periphery used for camping and daily recreation activities such as braaing and picnicking. Only certain portions of these areas are being maintained, while others have been overgrown with natural vegetation.

Infrastructure at Blue Waters Promenade area is a significant disturbance to coastal processes, especially embryonic dune movement. The promenade is highly visible and the towers are used as lookout points. This area is especially prone to vandalism (graffiti, theft, etc.) and vagrancy due to the general lack of activity limited to fishermen. There are a number of under-utilised parking areas along Lukannon Drive.

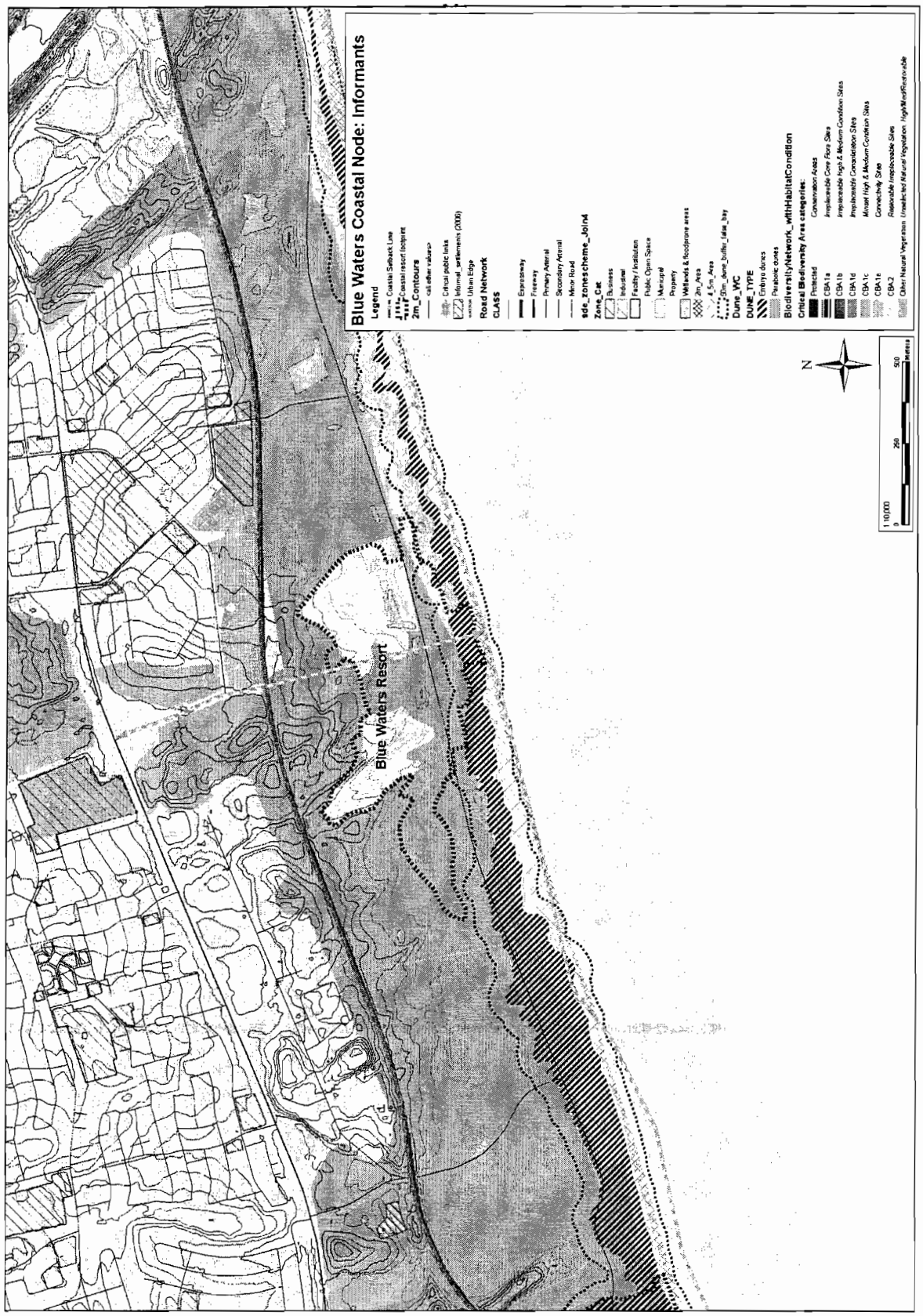


Figure A.5.4: Blue Waters Coastal Node - Informants

The purpose of this section is to provide localised development guidelines that reflect an understanding of the local context of the proposed coastal development nodes.

A.6.1 Monwabisi Resort

Local guidelines are developed in terms of generalised sub-regional guidelines for development (refer to figure A.6.1):

(1) Maintain a continuous east-west biodiversity corridor

a. Any development proposals in relation to the node should maintain and enhance a functional green link connecting Wolfgat Nature Reserve and Macassar Dunes Nature Reserve, running along the southern edge of Monwabisi Park Informal Settlement.
b. The biodiversity corridor should extend along the major dune ridge in a south-easterly direction towards the eastern edge of the Monwabisi Coastal Node.

(2) Ensure public access to and along the coast is maintained

a. A new access to the resort area off Oscar Mpetha Road, should be considered to provide direction public access to the focal point of the resort area tidal pool).
b. Safe north-south pedestrian movement should be prioritized between Khayelitsha and the resort area as part of any development proposals.
c. Any development proposal should enhance opportunity for public access along the coastline. This should be focussed on clearly demarcated footpaths designed so as to reduce impact on sensitive environments.

(3) Promote active, diverse and safe coastal nodes which become destination places

a. Promote active multi-functional places supporting higher thresholds for public services and public facilities:

- The broader nodal area should be developed as a high density mixed use coastal node linked to Khayelitsha via a development corridor. This type of development should occur in identified areas to the north of Baden Powell Drive.

b. Safe public destination places which promote tourism development

- Development within the existing resort footprint of Monwabisi should the focus on public facilities, tourism infrastructure which could include low impact or sensitively designed overnight accommodation. This development should contribute to the destination role of the resort.
- Existing resort buildings should be upgraded or reused where appropriate.

(4) Design with due regard for coastal processes

a. The beach area around the tidal pool as well as grass areas within the primary dune system should be rehabilitated. Protected natural dune corridors should serve as connectors of protected areas.
b. Active open space activities should be used as transitional areas between natural areas and urban development.
c. New development should avoid sensitive areas around the coastal cliffs to the west of the resort area.

(5) Maintain visual quality along the False Bay coast

a. The visual sensitivity of the Baden Powell scenic drive should be responded to when developing in proximity of this alignment.

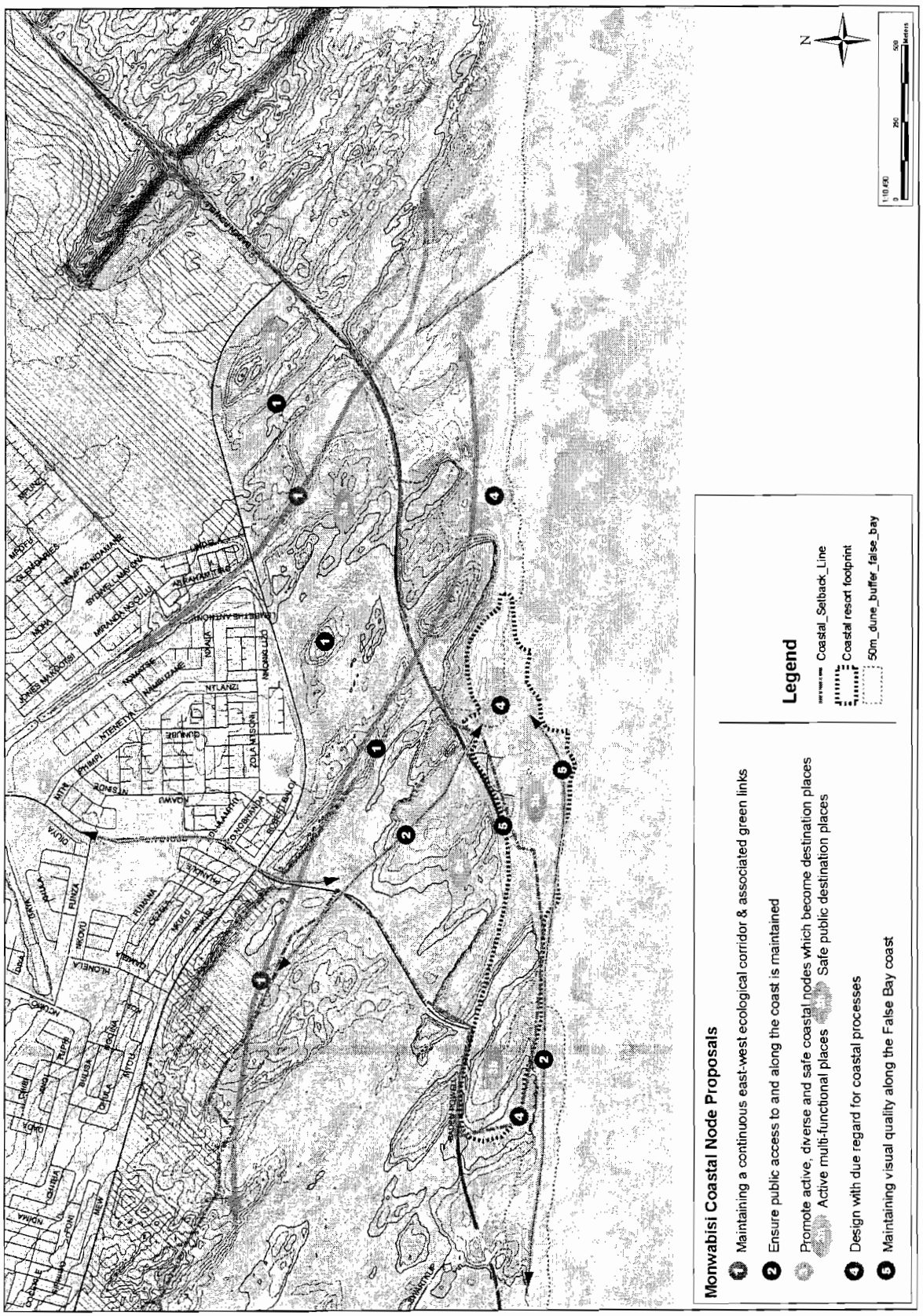


Figure A.6.1: Monwabisi Coastal Node - Proposals

A.6.2 Mnandi

Local guidelines are developed in terms of generalised sub-regional guidelines for development (refer to figure A.6.2):

(1) Maintain a continuous east-west biodiversity corridor

a. An east-west biodiversity link along the southern edge of Baden Powell Drive should be maintained. This alignment coincides with the major dune ridge running through Mnandi Coastal Node.
b. Biodiversity outside the coastal node between Baden Powell Drive and the high water mark should be protected. This includes embryonic dunes within this area.

(2) Ensure public access to and along the coast is maintained

a. NMT access from Kapteinsklip Station to Mnandi Coastal Node should be enabled and strengthened by new development within the precinct.
b. Public access along the coastline should be retained as an integral element of the any development proposal.

(3) Promote active, diverse and safe coastal nodes which become destination places

3a Active multi-functional places supporting higher thresholds for public services and public facilities:

- Land north of Baden Powell Drive (Kapteinsklip Station Precinct) should be developed in accordance with transit-oriented development principles to encourage a vibrant mixed use station precinct.
- Development relating to the resort area should include higher intensity mixed use activity promoting increased activity within the coastal node. Positive relationships should be ensured between development and upgraded public areas (resort and beachfront areas).

3b Safe public destination places which promote tourism development

- The existing resort footprint of Mnandi should be upgraded and public spaces and facilities enhanced with low intensity recreational and tourism infrastructure. This will reinforce the status of Mnandi Beach as a 'blue flag' beach and increase the tourism potential of the area.

(4) Design with due regard for coastal processes

a. The major dune ridge running in a south-easterly direction from the eastern section of Mnandi Coastal Node to the Baden Powell/Eisleben t-junction should be protected.
b. Embryonic dunes as well as the identified 50m dune buffer should be protected from any urban development. Therefore, development along the southern edge of the resort area should be managed to facilitate an appropriate transition between urban development and the coast.
c. The possible partial closure of Lukannon Drive should be investigated to encourage the rehabilitation of the embryonic dune system along this stretch of the coast and reinforce north-south links as the access to the coast.

(5) Maintain visual quality along the False Bay coast

a. The visual sensitivity of Baden Powell Drive should be adhered to by wrapping development around the existing Mnandi Resort footprint.

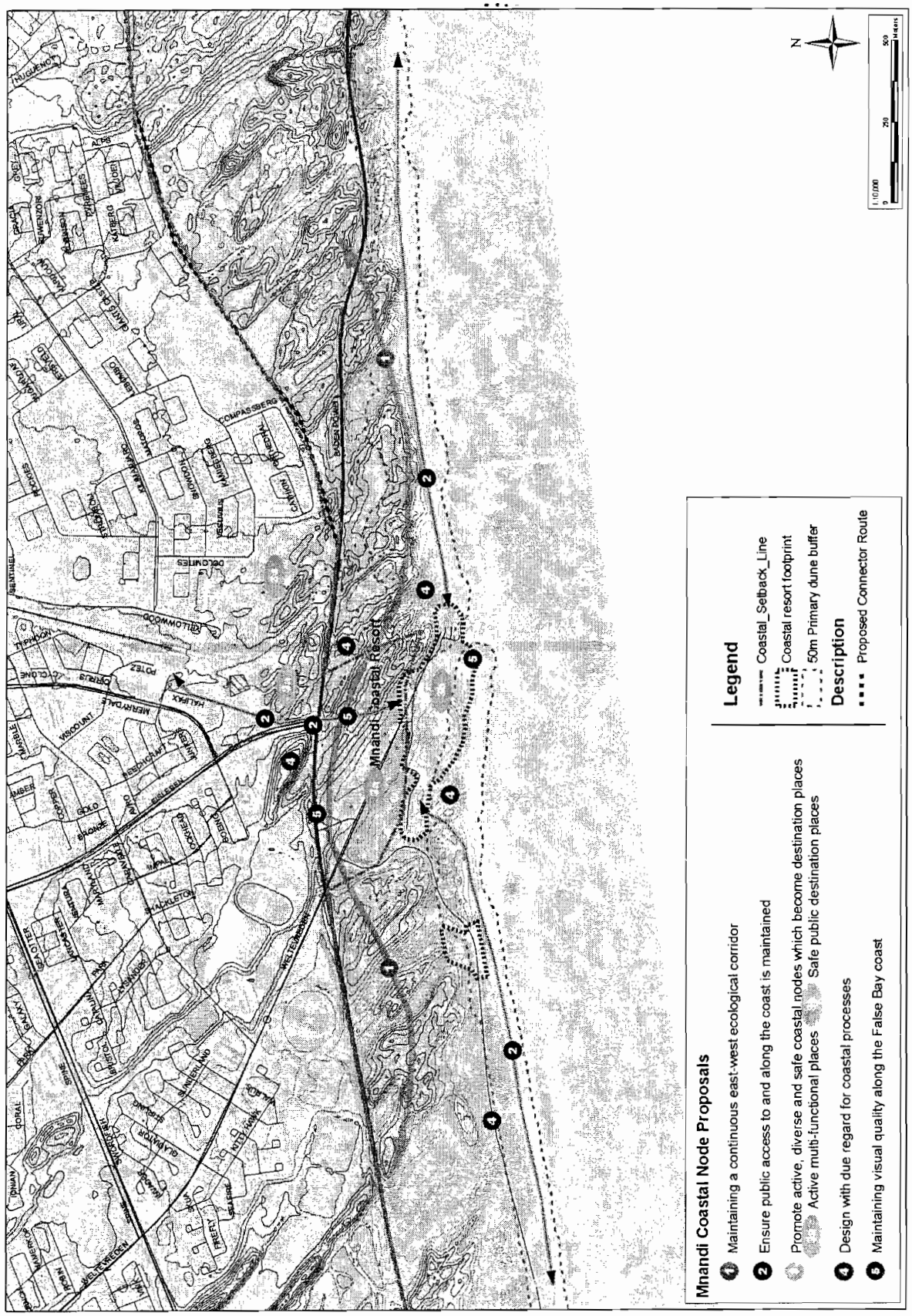


Figure A.6.2: Mnandi Coastal Node - Proposals

A.6.3 Strandfontein

Local guidelines are developed in terms of generalised sub-regional guidelines for development (refer to figure A.6.3):

(1) Maintain a continuous east-west biodiversity corridor

a. An east west biodiversity corridor should be maintained in the area between the eastern edges of Pelican Heights and the Strandfontein Sports Complex, and the southern edge of Pelikan Heights and the high water mark up to Strandfontein Coastal Node. The corridor should also include the dune ridge running between Strandfontein Road and the western boundary of the Strandfontein Sports Complex. The alignment of the biodiversity corridor should run along the seaward side of Baden Powell Drive where it intersects with Strandfontein Coastal Node, and continue along the landward side of the primary dune to the east of the coastal node.

(2) Ensure public access to and along the coast is maintained

a. NMT access between Strandfontein Sports Complex and Strandfontein Coastal Node should be enabled by new development in and around the resort area.
b. Public access along the coastline should be retained as an integral element of the development proposal

(3) Promote active, diverse and safe coastal nodes which become destination places

3a Active multi-functional places supporting higher thresholds for public services and public facilities:

- South of Spine Road, North of Baden Powell Drive, west of Camp Road and east of the dune, and adjacent to the eastern edge of the Strandfontein Sports Complex.
- East of the ridge, which is adjacent to the eastern edge of Strandfontein Road, south of the southern boundary of the Strandfontein Sports complex, north of Baden Powell Drive and west of the dune ridge identified east of the Strandfontein Sports complex.
- West of Camp Road, south of Baden Powell Road and north of the proposed east west green link (which is proposed approximately 50m north of Lukannon Drive), east of the existing eastern edge of the coastal resort and
- The area east of Camp Road, south of Spine Road and north of Baden Powell Drive comprises underdeveloped land which is home to various public institutions. The land is owned by the City of Cape Town and is leased to these institutions. The ad hoc and disjointed nature of the development has resulted in sub-optimal use of the land and thus it is proposed that the land is redeveloped and land uses intensified. This should be a mixed use precinct.

3b Safe public destination places which promote tourism development

- Urban development should seek to create a positive interface and well defined edge to the Strandfontein sports complex.
- Low intensity recreational and tourism infrastructure should focus within the disturbed area within the resort footprint.

(4) Design with due regard for coastal processes

a. Major dune ridges running along the eastern edge of Strandfontein Road between Strandfontein Road and the western edge of the Strandfontein Sports Complex and and to the western edge of the Strandfontein Sports Complex south of Spine Road and north of Baden Powell Drive should not be developed.
b. The embryonic dune, as well as a 50m buffer adjacent to the dune which has been identified along the entire length of the stretch of coastline in proximity to the Strandfontein node should be protected from any urban development.

c. The dune system and its restoration should be an integral part of the proposed recreational and tourism infrastructure proposed at the existing coastal resort.
d. The partial closure of Lukannon drive and facilitating access to the existing resort via a north south link should be considered.

(5) Maintain visual quality along the False Bay coast

a. The development of Strandfontein resort should celebrate its role as a gateway to the coast. Design should be sensitive to the role of Baden Powell Drive as a scenic drive.

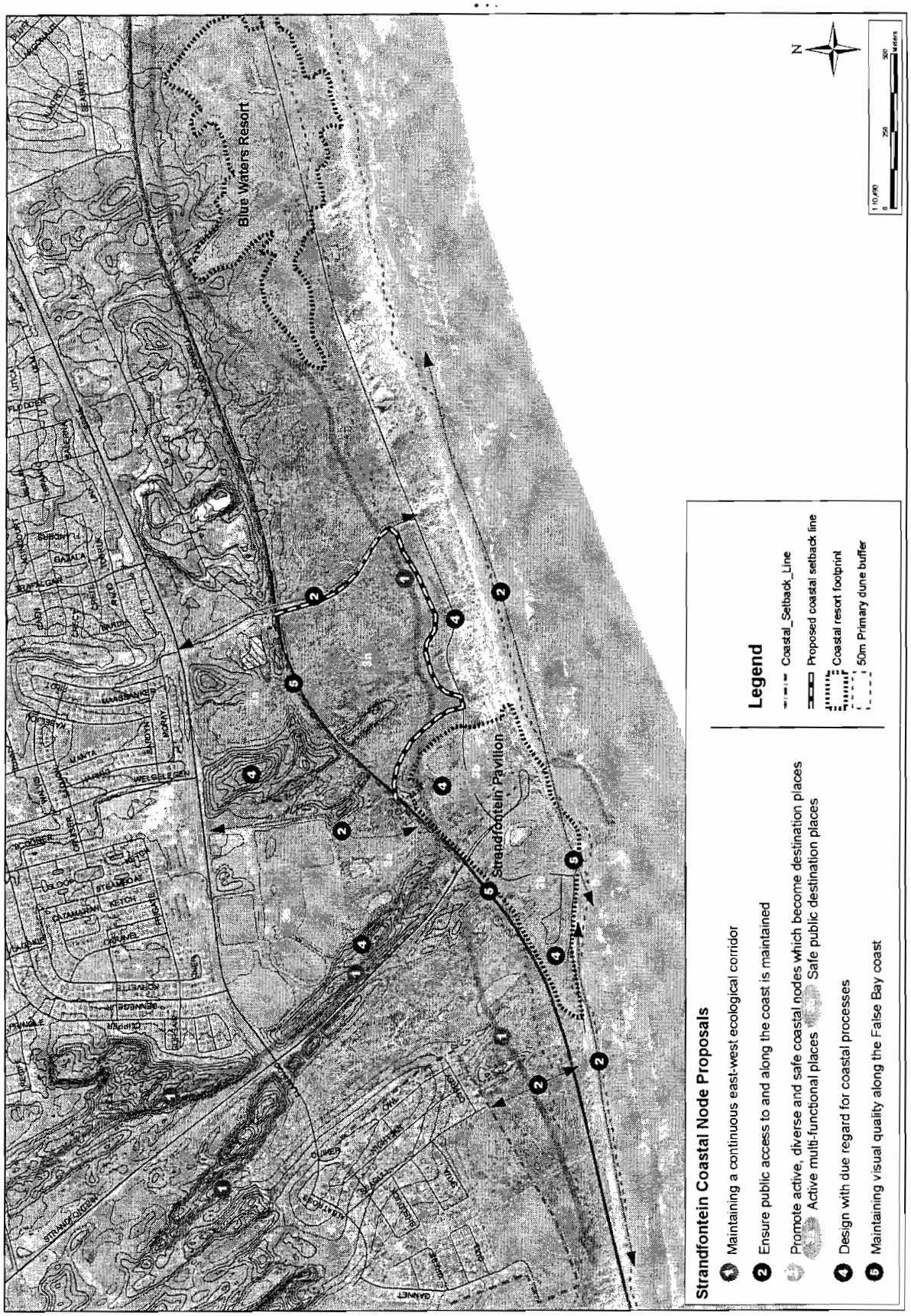


Figure A.6.3: Strandfontein Coastal Node - Proposals

A.6.4 Blue Waters Resort

The characteristics of the Blue Waters resort are distinctly different from the other three coastal development zones discussed. It is recommended that the Blue Waters Resort should remain a community resort which is easily accessible, particularly to local residents of the adjacent residential areas. Improvements should be made to existing resort infrastructure and beach facilities (refer to figure A.6.4).

(1) Maintain a continuous east-west biodiversity corridor

a. Essentially, the entire strip of the coastal zone on the seaward side of Baden Powell Drive between Strandfontein and Mnandi Coastal Nodes should be identified as a green corridor link, with Blue Waters Resort continuing to function within this link.

(2) Ensure public access to and along the coast is maintained

a. Consideration should be given to extending Salerno Way from Baden Powell Drive to meet the coast, in order to increase local access to the resort.
b. Consideration should be given to linking Salerno Street link with existing road infrastructure at the Department of Sports, Recreation and Amenities district offices, and provide north-south access to the coast at Blue Waters Promenade in order to provide direct and safer access to the resort and beach areas off Baden Powell Drive.
c. Camp and Nautilus Streets are existing north-south road links providing direct access to the coast for the residents of Strandfontein. Parking areas with ablution facilities should be provided on the landward side of the primary dune area, with boardwalks linking parking areas with the beach.
d. Any development proposals should maintain public access along the coast (e.g. through the provision of a structured east-west coastal pedestrian walkway).

(3) Promote active, diverse and safe coastal nodes which become destination places

3a Active multi-functional places supporting higher thresholds for public services and public facilities:

- Due to the role of Blue Waters Resort as a low intensity recreational node, no high intensity development is proposed.

3b Safe public destination places which promote tourism development

- Development should focus on upgrading and consolidation of existing infrastructure within the report footprint with a focus on tourism and recreation infrastructure.
- Consolidation of infrastructure should enable the shrinking of the grassed resort area and the re-establishment of natural vegetation (within areas such as the camp site).
- Consideration should be given to upgrading the chalet area and potential increased development of tourism accommodation in a low impact manner..
- The current main entrance to Blue Waters along Lukannon Drive is seen as a gateway precinct to the entire node. Consideration should be given to appropriately enhancing this precinct by means of landscaping (parking areas and visible signage) and high quality public recreation areas to maximise the public experience and promote tourism.

(4) Design with due regard for coastal processes

a. The existing resort footprint should be consolidated in order to restore under-utilised areas to their natural state, ensure more efficient use of land to facilitate the development of a higher quality multi-functional public destination place.
b. Consideration should be given to the closure of Lukannon Drive between Strandfontein and Mnandi Coastal Nodes, and the rationalisation of parking and ablution facilities along its

length to north-south road links to reduce the development impact of infrastructure on the primary dune system and also to minimise the maintenance costs.

(5) Maintain visual quality along the False Bay coast

a. The visual quality of the area should be maintained and enhanced where possible. To this extent, consideration should be given to investigation the potential of the little 'koppie' to the south-west of the district offices, as well as the towers at Blue Waters Promenade as public lookout points.

b. The visual sensitivity of the Baden Powell scenic drive should be responded to when developing in proximity of this alignment.

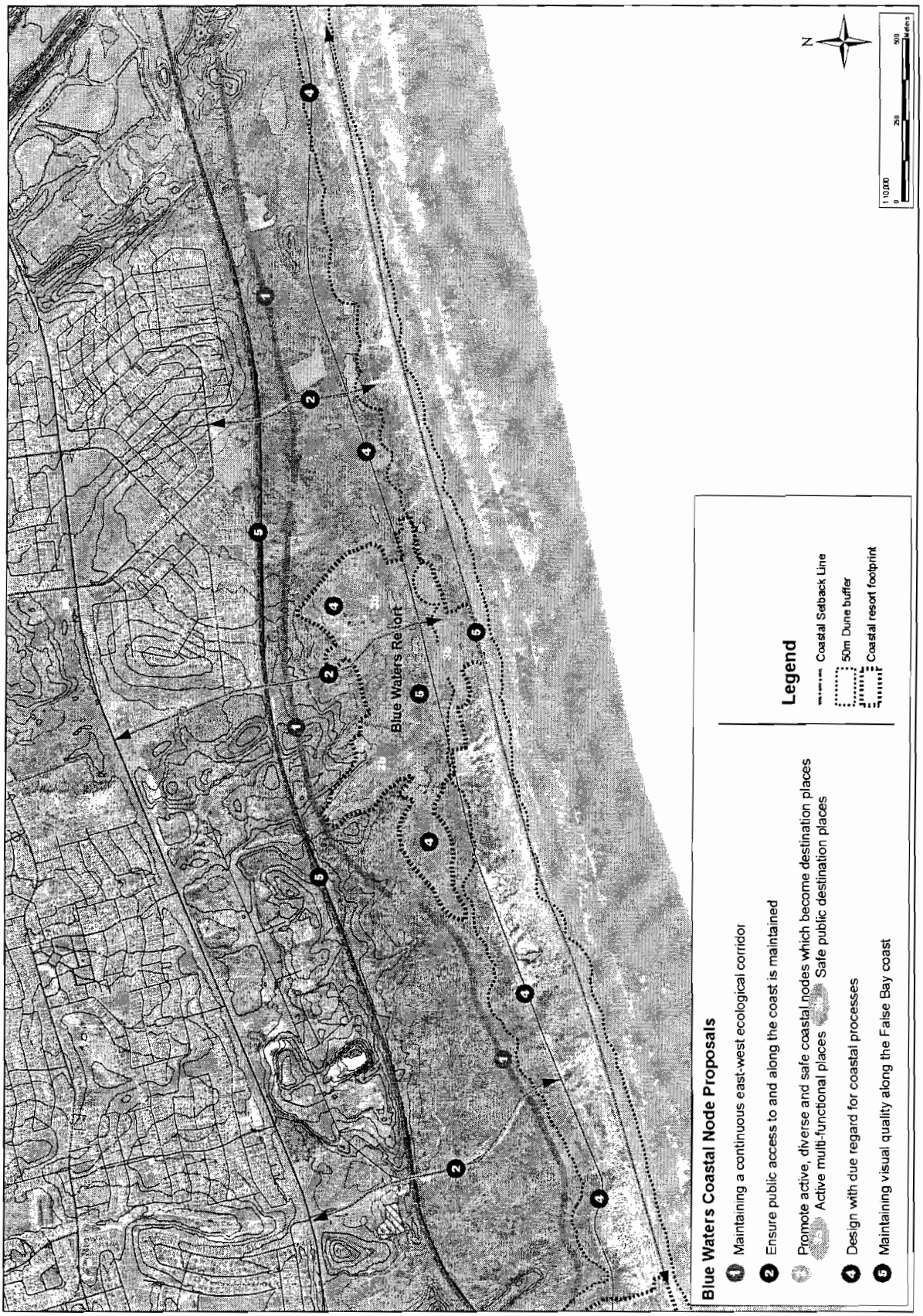


Figure A.6.4: Blue Waters Coastal Node – Proposals

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Agenda Item No	10SUB10/05/09
Subject	RAPID PLANNING REVIEW OF POTENTIAL FUTURE DEVELOPMENT AREAS ALONG FALSE BAY COASTLINE (DISTRICTS G 7 F)
SubCouncil	Charlotte Maxeke SubCouncil
Meeting Date	Monday, May 18, 2009
Resolution	;#Noted;#
Date Closed	Saturday, May 30, 2009

Resolution Detail

Mr Siwisa mentioned that he attended Sub-council 12 meeting and Mitchell's Plain people have been very vocal about development of False Bay coast line and it will also benefit the community of Khayelitsha since the document is submitted to this Sub-council for comments before it can be submitted to PEPCO for endorsement as per recommendations.

Resolved that

The report be noted by Sub-council 10.

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Agenda Item No	12SUB12/04/09
Subject	RAPID PLANNING REVIEW OF POTENTIAL FUTURE DEVELOOPMENT AREAS ALONG FALSE BAY COASTLINE (DISTRICTS G & F)
SubCouncil	Mitchells Plain SubCouncil
Meeting Date	Thursday, April 30, 2009
Resolution	;#Noted;#
Date Closed	Thursday, April 30, 2009

Resolution Detail

This item was dealt with item 12SUB08/04/09

Action: Refer to L Boyd (author)

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Global Climate Change and Adaptation – A Sea-Level Rise Risk Assessment.

PROPOSAL NUMBER: R030800032
REFERENCE NUMBER: GLOBAL CLIMATE CHANGE

Prepared For:
The City of Cape Town
Delivery Address:
Environmental Resource Management Department
City of Cape Town

Phase one:
Sea Level Rise Model
Report prepared by Prof. Geoff Brundrit
March 2008

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The scientific evidence is now overwhelming: climate change presents very serious risks, and it demands an urgent global response. *Stern Review 2007*

A storm swell, coinciding with a Saros spring high tide, struck the Kwa Zulu Natal coast on 19/20 March 2007. At its peak, the storm produced swells of ~8.5m, caused significant coastal erosion and unprecedented damage to coastal property, estimated at more than one billion rand. *Smith et al 2007*

Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea level rise. The effect will be exacerbated by increasing human pressure on coastal areas. *IPCC Fourth Assessment Report Feb 2007*

Sea level will rise between 18 and 59cm by 2100. *IPCC AR4 Feb 2007*

I find it almost inconceivable that "business-as-usual" climate change will not result in a rise in sea level measured in metres within a century. *James Hansen NASA July 2007*

It became apparent that, concerning the melting of the Greenland and Antarctic ice sheets, we really don't know enough. *Rajendra Pachauri, IPCC Chair Nov 2007*

The 2007 melting season set a new record for snowmelt over the Greenland ice sheet.

EOS 25 Sep 2007

Arctic sea ice declined rapidly to unprecedented low extents in the summer of 2007.

EOS 8 Jan 2008

Current models suggest virtually complete elimination of the Greenland ice sheet and a resulting contribution to sea level of about 7m if global average warming were sustained for millennia in excess of 1.9 to 4.6 degrees Celsius relative to pre-industrial values.

IPCC Synthesis Report Nov 2007

The benefits of strong early action on climate change outweigh the costs.

Stern Review 2007

INTRODUCTION

The City of Cape Town have awarded LaquaR Consultants CC the contract for their Proposal Number: R03-404/06-07

Reference: Global Climate Change

Date: January – July 2008.

An extract from the Terms of Reference of the contract, relevant to this first Phase One, now follows.

TERMS OF REFERENCE

Global Climate Change: Coastal Climate Change and Adaptation - A Sea-Level Rise Risk Assessment for the City of Cape Town

1. Background and Introduction:

The City of Cape Town administers approximately 307 km of coastline, arguably its single greatest economic and social asset. In October 2003 the City formally adopted a Coastal Zone Management Strategy with the intention of managing and safeguarding the coastal asset for current and future generations.

The City's coast provides a range of social and economic opportunities including recreational and amenity areas, sought after housing and development opportunities as well as core economic attributes. In addition, the City's coast is a dynamic ecological system that supports a wide range of species, ecological systems and ecological services.

Global climate change predictions suggest that amongst others, sea level rise and an increase in the intensity and frequency of storm events may have significant impact on

coastlines across the globe. Cape Town with its extensive coastline may be particularly vulnerable to these predicted changes.

2. Motivation and Aim of Project

The aim of the Sea-Level Rise Risk Assessment Project is to:

- Model the predicted sea-level changes in a range of scenario's (time series, incremental climate change, shear events, and storm frequency and intensity).
- Model the form that those changes will take.
- Understand the associated impacts on existing coastal systems, infrastructure and property
- Provide guidance and implications to future coastal development (to be included in the City's Coastal Development Guidelines)
- Identify high risk areas that are prone to high impact
- Begin to understand and develop long-term mitigation measures.

The primary objective of this study is therefore:

To model and understand the ramifications of predicted sea-level rise and increased storm events for the City of Caped Town, thereby providing information that may be used for future planning, preparedness and risk mitigation.

3. Project Phases

The project will be undertaken in four distinct phases. Each phase of the project will provide specific outcomes and deliverables.

Phase One: Climate Change Sea-Level Rise Model

Phase one of the project will model the predicted sea-level changes in a range of scenarios. A computer based GIS model will be developed that will demonstrate the coastal changes resulting from sea-level rise. The model must be developed in such a way that variables within the model may be changes to accommodate variations within predictions as well as illustrate the impacts of catastrophic and combined events. The GIS model must make use of existing climate and climate change models, the City's aerial photography and survey data, contour maps and infrastructure information (hard and soft coastal edges).

The model must be designed to incorporate and demonstrate, at a minimum, the following information:

- Time series: Show changes over time within a 5-100 year horizon based on best available climate change predictions.
- Demonstrate the impacts of sea-level rise based on incremental change in climate patterns
- Demonstrate the impacts of sea-level rise based on shear events, i.e. dramatic and immediate change in sea-levels.
- Demonstrate the impacts of combination events (i.e. sea-level rise combined with spring high tide, a storm event coupled with a high rainfall event).

- Model and demonstrate the form that these changes will take, taking into account the different coastal edges (hard man-made surfaces such as the Sea Point Promenade, rocky shores, sandy beaches and coastal estuaries).

In order to achieve the **Phase One: Climate Change Sea Level Rise Model** requirements, the following approach is taken.

- Review the nature of extreme sea level events along the coastline of the City of Cape Town, so as to establish the various contributions/components/constituents that might evolve under the effects of climate change. This will be achieved through a re-interpretation of sea level records from the SA Navy Tidal Network stations at Simon's Town and Cape Town. This forms the **First Study**, which provides a **Present Day Very Worst Case Scenario** of extreme sea levels for use in the GIS Inundation Model for the coastline of the City of Cape Town.

- Review global projections of the influence of climate change on sea level, as given in studies such as the recent Assessment Reports of the Inter-Governmental Panel on Climate Change. This will provide estimates of the influence of climate change on local constituents of sea level in the vertical, as a series of projections on decadal and centennial scales, together with their range of uncertainties. The **Second Study** gives estimates of sea level rise for the coastline of the City of Cape Town in the near future, and provides the **Scenario at the End of the Next Decade** for the GIS model. The **Third Study** focuses on the much more uncertain longer term situation when wholesale ice melting is expected to lead to greatly enhanced sea level rise, and provides the **Polar Ice Sheet Melt Scenario** and its effects on the coastline of the City of Cape Town on century time scales.

- Build these projections of sea level rise into the Geographic Information System (GIS) terrain model of the metropolitan area, maintained by the Geomatics Department of the City of Cape Town. This will generate illustrative scenarios of future inundation of coastal land, and the identification of vulnerable locations. Overlays of the infrastructure and services within the GIS model will then begin

to highlight the potential negative consequences of climate change from inundation in these vulnerable locations.

THE FIRST STUDY

EXTREME SEA LEVELS ALONG THE COASTLINE OF THE CITY OF CAPE TOWN

There is concern about the impact of extreme sea levels on infrastructure and services along the coastline of the City of Cape Town, especially with the threats of sea level rise and increased storminess associated with global warming. The purpose of this first study is to summarise what is known about present day sea levels, with an emphasis on extreme events and on particularly vulnerable sections of the coastline. Once this study is complete, it will be possible to shift the focus onto the implications of the future addition of sea level rise to the situation.

There are essentially three factors that contribute to present day sea level: tides, weather effects and wave set-up, though the last mentioned only affects surf zones. They have different characteristics, so the three factors need to be carefully combined to assess their total contribution and potential impact. The material relevant to the coastline of the City of Cape Town is extracted and embellished in this study.

The Tides

The tides are completely predictable and affect the entire coastline in a uniform way. However, tidal heights vary on a daily, fortnightly, seasonal and on a year to year basis. The detail is provided in the Tide Tables published on an annual basis by the

Hydrographic Office of the South African Navy, and the information for Granger Bay (Table Bay) and Simon's Bay (False Bay) is particularly relevant to this study.

In this study, the Land Levelling Datum (LLD), rather than Chart Datum (CD), is used as a baseline for all heights and levels, so that they are immediately recognizable by the Geographic Information System Inundation Model being developed by the City of Cape Town. The relationship between LLD and CD over the years is tabulated in the Tide Tables.

Tidal Characteristics	Simon's Bay	Granger Bay
Mean Tide Level (MTL)	LLD+16cm	LLD+15cm
Mean High Water Neaps (MHWN)	LLD+44cm	LLD+43cm
Mean High Water Springs (MHWS)	LLD+90cm	LLD+86cm
Highest Astronomical Tide (HAT)	LLD+124cm	LLD+120cm

In summary the tides for these two ports are very similar, so that it is possible to use the longer and more reliable information from Simon's Bay as being representative of the entire coast of the City of Cape Town.

Within each fortnight between full moon and new moon, high tide over the days of neap tide typically only reaches levels of 44cm above LLD whilst, over the days of spring tides, the high tide reaches 90cm above LLD. The overall maximum spring high tide is much higher, being the Highest Astronomical Tide at LLD+124cm. The tide does not reach HAT every year. HAT is the maximum tidal height reached in the 18.6 year cycle of the precession of the Moon's ascending node (also known as the Saros cycle). The mean for the other tidal measures is also taken over this long 18.6 year cycle time.

When it comes to extreme tides, only high water at spring tides occurring around the time of full and new moon, rather than at neap tides, need to be taken into account. These spring high tides exhibit great variability in height, but have a regular pattern (the equinoctial, lunar perigee and Saros cycles) over the long term. In any given year, the spring high tides peak in the seasons of spring and autumn as part of the equinoctial cycle, so that the Highest Astronomical Tide of the Year (HATOY) will occur in one of the months within spring or autumn. HATOY will also be higher in those years when the Moon's perigee occurs in spring or autumn, which happens every 4.4 years. Finally HATOY will reach HAT in the peak year of the Saros cycle.

The values and times of HATOY at Simon's Bay in recent years are tabulated to illustrate this.

Year	HATOY	Time and Date
2003	HAT-6cm	O4h29 Mar 20
2004	HAT-11cm	03h39 Apr 6
2005	HAT-8cm	04h16 Feb 10
2006	HAT-1cm	04h10 Mar 1
2007	HAT-2cm	03h57 Mar 20
2008	HAT-10cm	03h50 Apr 7

The highest tides are restricted to a few hours on particular days in particular months in particular years and are completely predictable. If the tides are the determining factor in extreme sea level (*Searson and Brundrit 1995*), it will be important to note these times of particular vulnerability. The dates and times and heights can be extracted from the Tide Tables, which are published each year by the Hydrographer of the South African Navy.

The Weather Effect

The effect of passing synoptic weather systems means that observed sea level can be higher than the predicted tide when the air pressure is low and when the wind piles the water up against the coast (passing mid-latitude depressions; low pressure systems; cold fronts). As with the tides, the entire coastline is affected. Synoptic weather effects last for two or three days, but their predictability is limited to little more than one week. Forecasts of severe weather are issued by the South African Weather Service.

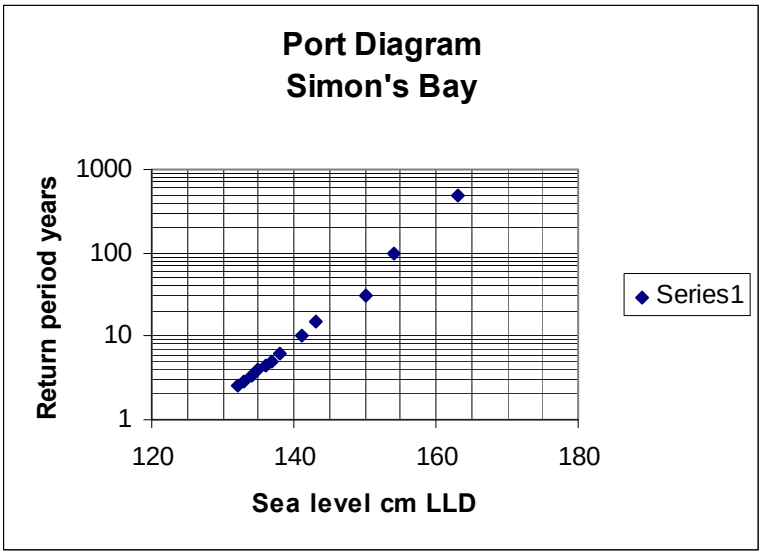
While individual depressions do vary in their intensity and duration, their statistical characteristics vary little from season to season or from year to year. An overall description can be obtained from a 30 year record of hourly observations of sea level from Simon's Bay between 1960 and 1990 (*Searson and Brundrit 1995*). The almost 250 000 hourly deviations of sea level from the predicted tide, due to the synoptic weather effect, form an essentially normal distribution with a standard deviation of 8.2cm.

For further study of the extreme values, the deviations can be grouped into monthly maxima for each month of the 30 year period. The overall monthly maximum deviation in the 30 year record was + 39cm, whilst in 15 of the 360 monthly maxima, the deviation exceeded +25cm. The spread of these extreme monthly maximum deviations was not uniform over the three decades. Three occurred in the 1960s, two in the 1970s and the remaining ten were in the 1980s. Whilst this might suggest that there is a tendency towards increasing storminess, it should be noted that the overall maximum deviation of +39cm occurred in August 1963.

Sea Level

The 30 year record of observations of sea level can be analysed for extremes of the joint effect of tides and weather on sea level around the coast of the City of Cape Town. Such an analysis gives the mean sea level as LLD+17cm, with a 30 year maximum sea level of LLD+150cm. The 30 year observed maximum sea level at Simon's Bay occurred on 25 September 1981, on a peak spring high tide with a height of LLD+119cm and an extreme storm with a deviation of +31cm. Indeed the seven highest observed sea levels at Simon's Bay in this thirty year period all coincided with near equinoctial spring high tides, emphasizing the enhanced vulnerability from such events. Although this 30 year maximum sea level exceeds HAT, it does not approach the level of (LLD+124) + 39cm, or LLD+163cm, which would be achieved on the simultaneous occurrence of HAT (an 18.6 year tide event) and a 30 year storm event. Such a joint extreme event has a return period of some 500 years. A Port Diagram showing the detailed return periods for

extreme sea levels at Simon's Bay is shown in *Searson and Brundrit 1995*, whilst a simplified Port Diagram, based on annual maxima, follows.



The observed annual maximum sea levels are used in the Simon's Bay Port Diagram for return periods up to 30 years, whilst the sea levels of LLD+154cm at a return period of 100 years and LLD+163cm for a return period of 500 years are extrapolations for illustration.

KZN Storm of March 2007

The simultaneous occurrence of a tidal height close to HAT and an estimated 30 year storm occurred along the coast of Kwa Zulu Natal in the early hours of 19 March 2007 (*Smith, Guastella, Bundy and Mather 2007*). The measurements taken at that time provide a valuable resource for confirming the approach taken for the coast of the City of Cape Town, and for suggesting values that should be used on exposed coasts.

The Highest Astronomical Tide for Durban is LLD+139cm. A ten year record of sea level observations from Durban from 1980-1990 again shows the deviation of observed sea level from the predicted tide to be normally distributed, with a standard deviation of 10.3cm (*Searson and Brundrit 1995*). The maximum deviation over the ten years gives an extra height of +37cm. The simultaneous occurrence of HAT and a ten year storm leads to a sea level of LLD+176cm with a return period of some 180 years. By contrast, the earlier ten year record of sea level observations gives a maximum sea level of LLD+159cm.

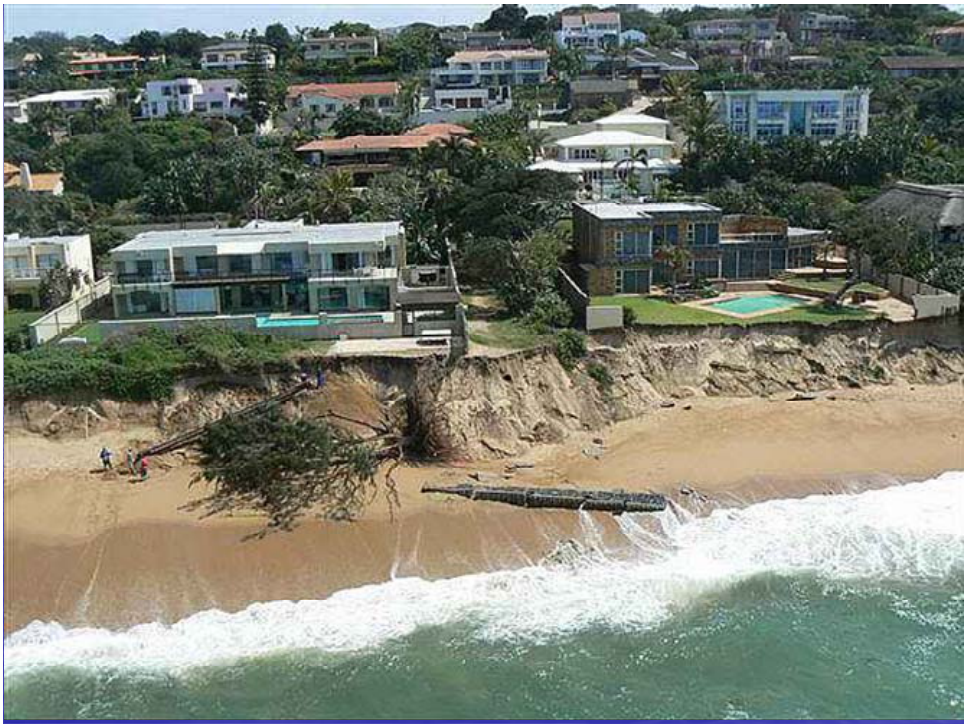
Turning to the situation on the KZN coast early on the morning of 19 March 2007, the observed sea level was LLD+188cm. The predicted early morning high tide for 19 March was only LLD+133cm, giving a contribution from the storm of +55cm. Such an extreme storm probably has a return period approaching 100 years. It should be noted that the predicted tide for the next day, early morning on 20 March 2007 was the HATOY for

2007 at LLD+137cm. If the storm had persisted or occurred at that time, the observed sea level would have been LLD+192cm and even greater damage would have been caused.

Wave Set-up and Storm Impact

The effect of wave set-up can now be summarized. This occurs due to interactions in the surf zone, where there is an increase in the water level leading to more vigorous run-up in the swash and intensified erosion of dune faces and other soft material. Measurements were made during the storm on the KZN coast in the early morning of 19 March 2007, and are reported in *Smith, Guastella, Bundy and Mather (2007)*. Referring these measurements to Land Levelling Datum rather than Chart Datum, the landward edge of the swash zone was surveyed at LLD+700cm in the Durban area, whilst at Ballito and Salt Rock the same swash levels were recorded at locations with a southerly aspect, adjacent to headlands. The erosion line for this storm was consistently located between the 4 and 5m contours above mean sea level, with the high water mark retreating by between 10-30m in a few hours as the nearshore sand was rapidly washed away. These extraordinary levels are consistent with the extreme intensity of the storm and the dramatic damage along the coast. “Roads were damaged at Margate, Uvongo, St Michael’s-on-Sea, Port Shepstone, Umkomaas, Durban, Umdloti, Ballito and Zinkwazi. The South Coast railway-line experienced severe damage at Mtwalume and Sezela. Private property along the coast was also damaged. The provisional repair bill exceeds one billion rand. (*Smith, Guastella, Bundy and Mather 2007*)”.





Potential Damage from Coastal Erosion

Coastal type and exposure influenced the severity of damage along the KZN coast. Sandy and rocky coastal sections generally withstood the storm's onslaught, but mixed coastlines of rock and sand, especially pocket beaches, were severely impacted. Many built structures that failed were located adjacent to, or upon rocky, headlands and within bays encompassed by rock shelves. Wave energy was focused in these areas, especially where over wash was not allowed to dissipate naturally.

There are lessons for the identification of areas along the coastline of the City of Cape Town which are vulnerable to the impacts from severe storms. Dunes must be high enough (at least 5m for the erosion line) and wide enough (room for a high water retreat of 30m) to afford protection from the sea. Once breached, infrastructure and services on land beyond the dunes is exposed to the risk of direct attack from the sea. A careful investigation of the land behind the sandy beaches of Table Bay and False Bay is indicated. Deep water channels leading into pocket beaches can be a focusing conduit for wave energy from destructive storms. An important lesson from the KZN storm is that buildings too close to the sea at the head of pocket beaches are at particular risk of severe damage. There are many exposed pocket beaches along the Atlantic coast of the Cape Peninsula. It should not be forgotten that the KZN storm was a cut-off low, leading to long wave surge from the east, a synoptic situation which also on occasion affects the western coastline of False Bay.

Scenario One

This is the **Present Day Very Worst Case Scenario** for the 300km coastline under the jurisdiction of the City of Cape Town. It results from the simultaneous occurrence of an extreme tide and an extreme storm, an event with a nominal return period of 500 years. Such an event has not occurred along the Cape coast in recent years but it did occur along the KZN coast on 19/20 March 2007. Measurements taken from the KZN extreme event have been incorporated into this Present Day Very Worst Case Scenario, particularly in respect of exposed and very exposed portions of the coastline. The erosion damage in KZN was spectacular, and similar damage should be anticipated along vulnerable sections of the Cape Town coast in such circumstances. The identification of these vulnerable sections of the Cape Town coast is an important output from this scenario.

The permissible resolution for sea levels in the GIS Inundation Model is 0.5m, and expected levels for scenarios should be rounded up from the levels reported earlier in the historic analysis. The maximum levels that should, therefore, be expected to be reached by the sea in this Present Day Very Worst Case Scenario are:

- LLD+2m in sheltered environments,
- LLD+4.5m in exposed environments, and
- LLD+6.5m in very exposed environments.

The levels reached in the exposed and very exposed environments along flat sandy beaches and into pocket beaches, are due to extreme swash heights associated with wave set up and run up in the surf zones from ~8m waves at the breakpoint. Even higher levels were measured at the limit of the swash zones in places where the greatest damage was caused along the KZN coast.

The inundation to be shown in the GIS reconstruction should identify those sections of the Cape Town coast that are most at risk in this Present Day Very Worst Case Scenario. Vulnerable infrastructure and services should be highlighted. Of particular interest will be where existing (dune) protection is eroded away in the storm and seawater is able to reach into unexpected areas of low-lying land. Because this scenario is possible (though unlikely) in the present day situation, it deserves to be carefully studied so that the extent of potential economic loss can be assessed.

SECOND STUDY

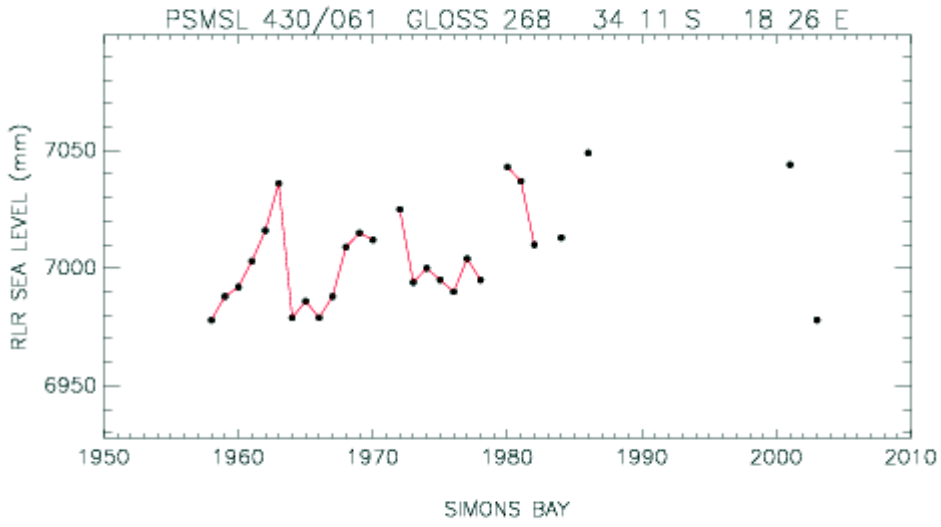
SEA LEVEL RISE PROJECTIONS IN THE NEAR FUTURE

ALONG THE COASTLINE OF THE CITY OF CAPE TOWN

Observations of sea level globally show a statistically significant sea level rise as part of human-induced climate change. At present, the rate of sea level rise is slow, but it does appear to be accelerating. This second study is intended to describe the situation along the coastline of the City of Cape Town, and to extrapolate from this situation so as to provide an estimate of the likely trends in the near future. The potential massive contribution to sea level rise from new climate change processes such as the melting of the polar ice sheets is the subject of the third study.

The primary effects of climate change in the coastal zone are the potential modifications due to sea level rise and storminess. The latest sea level rise predictions and their applicability to southern Africa are reviewed in *Theron 2007*, providing a useful context within which to place this study of sea level rise along the coastline of the City of Cape Town. Any analysis of sea level rise requires careful and consistent observations of sea level over several decades. These are not really available in South Africa (*Brundrit 1995*), nor in Africa as a whole (*Woodworth, Aman and Aarup 2007*).

A relatively long record of annual mean sea level is available for Simon's Bay from the Permanent Service for Mean Sea Level, which applies rigorous quality checks on such data. The PSMSL uses RSR sea level rather than LLD as its datum. At Simon's Bay, RSR is 6.846m below LLD, so that 7.000m RSR is 15.4cm above LLD.



It can be seen that there is reliable data only over a thirty year period from 1958 to 1986, but nothing in more recent years. Some important conclusions can be drawn from the reliable data. Annual mean sea level appears to shift between two distinct warmer and cooler climate states. Similar warmer and cooler states are found in annual sea surface temperature observations for the South Atlantic. Both climate states exhibit an upward trend in sea level of approximately 2mm per year, which is consistent with the accepted global rate of sea level rise over the same period. This means that more recent estimates of global sea level rise can be used as proxies for extending the rate of sea level rise into the period of unreliable data for Simon's Bay.

The Intergovernmental Panel on Climate Change in its Fourth Assessment Report has provided a Summary for Policy Makers of its 2007 Climate Change Synthesis Report. In discussing observed changes in climate and their effects, the IPCC reports as follows. "Rising sea level is consistent with warming. Global average sea level has risen since 1961 at an average rate of 1.8 [1.3 to 2.3] mm per year and since 1993 at 3.1 [2.4 to 3.8]

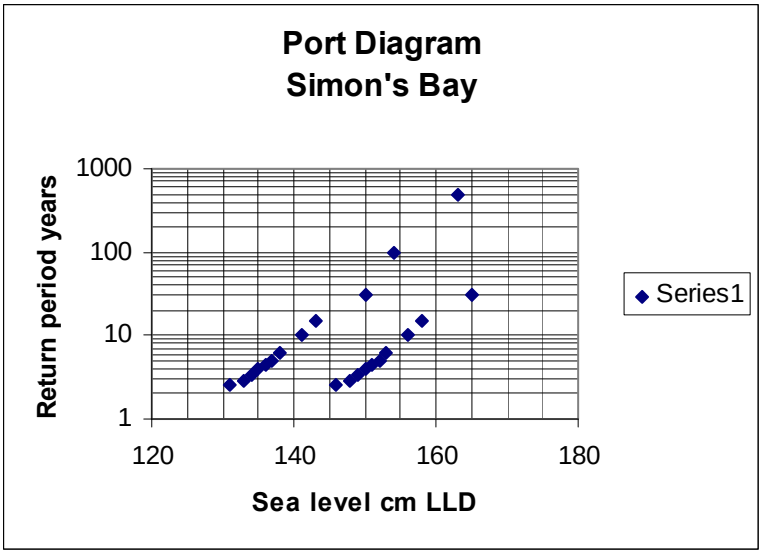
mm per year", and "Whether the faster rate for 1993 to 2003 reflects decadal variation or an increase in the longer term trend is uncertain".

In its projections of future changes in climate over the 21st century, the IPCC draws on a set of models of sea level rise at 2090-2100 relative to 1980-1999, which exclude rapid dynamical changes in ice flow. This is an important reservation. The recently documented ice melting, both at sea and on the polar ice-caps, has led the IPCC to abandon its earlier projections. Now in its Synthesis Report of November 2007, it states that "because understanding of some important effects driving sea level rise is too limited, this report does not assess the likelihood, nor provide a best estimate or upper bound for (future) sea level rise".

It would therefore appear to be prudent to restrict projections of sea level rise based on extrapolations of current trends to the next decade alone. Even there, the extrapolations would cover a wide range, depending on whether sea level rise reverts to its earlier rate, maintains its new rate, or continues to accelerate at a constant rate.

Decade	revert	steady	accelerate
1980-1989	1.8cm	1.8cm	1.8cm
1990-1999	3.1cm	3.1cm	3.1cm
2000-2009	1.8cm	3.1cm	4.4cm
2010-2019	1.8cm	3.1cm	5.7cm
accumulated	8.5cm	11.1cm	15.0cm

At the end of the next decade, the sea level to be expected is not a great change from present day circumstances. Thus there is little threat of additional inundation. What is different is how often any particular sea level can be expected. This can be seen by plotting additional points on the earlier Port Diagram for Simon's Bay. As well as the return periods based on the original observed annual maximum sea levels from 1960-1990, and the extrapolations for return periods of 100 and 500years, the new points increase each observed sea level by 15cm, whilst retaining their return period. This is the Port Diagram relevant to the present day and to the end of the next decade.



The present day extreme sea level of LLD+163cm with an expected return period of 500 years should be compared with the sea level of LLD+165cm expected to occur with a return period of only thirty years at the end of the next decade. While the observed maximum sea level of LLD+150cm from 1960-1990 is expected to occur with a return period of just four years at the end of the next decade. In the future, storms will cause more damage because they are built upon higher sea levels. Given that climate change is expected to increase the frequency of extreme storms, the situation could well become even more serious.

Scenario Two

This is the **Scenario at the End of the Next Decade** after the acceleration in sea level rise which is expected to add 15cm to base levels. Given the resolution of 0.5m in the GIS Inundation Model, the levels to be used in this Scenario Two and the details of the inundation to be expected are the same as in Scenario One!

- LLD+2m in sheltered environments,
- LLD+4.5m in exposed environments, and
- LLD+6.5m in very exposed environments.

Thus, every conclusion to be drawn from the impact of Scenario One on the infrastructure and services provided by the City of Cape Town is immediately relevant to this Scenario at the End of the Next Decade.

It is the circumstances of how often this Scenario Two is expected that are different. Rather than being a Very Worst Case Scenario with a return period of 500 years, Scenario Two is to be expected whenever an extreme storm occurs at the same time as any (fortnightly) spring high tide in the spring or autumn. With the further expectation that extreme storms will become more frequent under climate change, this Scenario at the End of the Next Decade is a realistic expectation rather than an unusual event for the end of the next decade.

All the effort made in understanding the impacts and vulnerabilities of present day Scenario One can then be used to illustrate what might be expected as the norm for Scenario Two at the end of the next decade, when extreme spring and autumn storms coincide with spring tides.

THIRD STUDY

SEA LEVEL RISE SCENARIOS ALONG THE COASTLINE OF THE CITY OF CAPE TOWN AFTER COLLAPSE OF THE POLAR ICE SHEETS

The timing of future sea level rise in the longer term is problematic. The Intergovernmental Panel for Climate Change has withdrawn any upper bound estimate to its forecasts of sea level rise over the 21st century. An alternative and preferable approach for the longer term future is to link sea level rise to the possible stabilization levels of greenhouse gases in the atmosphere and the accompanying global warming and polar ice melt. This is the approach which is recommended in the *Stern Review (2007)*, and then followed in the *IPCC Synthesis Report (Nov 2007)*.

The following linkages of climate change are expected from the sets of climate models which are used in the *Stern Review (2007).* It should be noted that the present level of carbon dioxide equivalent is at 380ppm, and rising. Any stabilization level will require urgent global action on constraining the input of greenhouse gases into the atmosphere.

Scenario A.

450ppm carbon dioxide equivalent stabilization level

2 degree Celsius temperature rise

1m sea level rise from thermal expansion only

Rising intensity and frequency of storms

Onset of irreversible melting of the Greenland Ice Sheet

Initiation of further sea level rise as the melting progresses

Scenario B.

550ppm carbon dioxide equivalent stabilization level

3 degree Celsius temperature rise

1.5m sea level rise from thermal expansion only

Significant contribution to sea level rise from the Greenland Ice Sheet

Increasing risk of collapse of the West Antarctic Ice Sheet

Sea level rise of a few metres

Scenario C.

750ppm carbon dioxide equivalent stabilization level

4 degree Celsius temperature rise

2m sea level rise from thermal expansion only

Yet more storminess

Onset of collapse of the West Antarctic Ice Sheet

Eventual sea level rise of over ten metres

These linkages are illustrated with median levels of each quantity; there are considerable spreads about these median levels. Lower stabilization levels are unlikely. It is important to recognize that no time scales are provided for these scenarios. However, the gradual progression of climate change through the stabilization levels, global warming and polar ice melt will provide better estimates of the timing and extent of global sea level rise.

The *IPPC Synthesis Report (2007)* follows the *Stern Review(2007)* and considers projections of future climate change over and beyond the 21st century. Rapid sea level rise on century time scales cannot be excluded. Net ice loss will set in with a global

average warming in excess of 2 degrees Celsius, marking the onset of an accelerating ice melt contribution to sea level rise. The complete elimination of the Greenland Ice Sheet will eventually lead to a contribution to sea level rise of 7m. These temperatures correspond to those of the last inter-glacial of 125000 years ago, when sea level was 4 to 6 m higher than present levels. Around the Cape Peninsula the sea level at this time is reasonably well marked as the 18 foot wave cut platform. It should be noted that this feature has been utilized for road and rail communication, eg the railway line from Muizenberg to Simon's Town!

The prime effect of the rapid sea level rise over the longer term future is the permanent inundation of low lying coastal areas, rather than the intermittent effect of storm damage. As sea level rise continues, it will lead to the wholesale disruption of services along the coast. In the GIS model, these scenarios extracted from the *Stern Review (2007)* can be illustrated with a mean sea level rising from LLD in steps of 1m up to LLD+12m.

Scenario Three

When wholesale melting of the Greenland and West Antarctica Ice Sheets begins to contribute to sea level rise, the anticipated levels will be greatly in excess of earlier levels. This leads to the **Polar Ice Sheet Melt Scenario.** There is much uncertainty about the extent and the timing of the melting of the polar ice sheets and their eventual contribution to sea level rise and coastal inundation. Consequently, this Scenario Three is fundamentally different from the earlier scenarios. The focus should be on Mean Sea Level and the changes to be expected from the ice melt alone, so as to provide an every day scenario for these circumstances. It will map the location of the new coastline. Tides and storms can be added later, if need be, to illustrate the variability to be expected on a day by day basis.

Because storms are excluded, there is now no difference between sheltered and exposed sections of coast; all experience the same sea level. In the GIS model, only one colour will be needed to illustrate the inundation from sea level rise affecting the entire coast. I suggest that this be shown as LLD, LLD+2m, LLD+4m, LLD+6m etc moving steadily upwards in steps of 2m to (say) LLD+12m. (Perhaps the levels should be taken up to when the Cape Peninsula becomes an island!)

In this Polar Ice Sheet Melt Scenario, the important information that will come from the GIS inundation model will be the **order** in which different land areas are overwhelmed in the inexorable rise in sea level. Emphasis can then be placed on separate categories of infrastructure and services, such as loss of industrial areas, residential areas and disruption of the transport networks. The information on the order in which disruption will occur will aid in preparation for adaptive planning for the very worst consequences of sea level rise on the City of Cape Town. Remember that there is great uncertainty on the timing of such a long lead time scenario; this is a scenario not a prediction.

REFERENCES

Monographs

South African Tide Tables (Annual publication). Hydrographer, South African Navy.

The Stern Review: The Economics of Climate Change (2007), United Kingdom Government.

IPCC AR4 Synthesis Report: Summary for Policy Makers (Nov 2007). Intergovernmental Panel on Climate Change, Fourth Assessment Report.

www.ipcc.ch/ipccreports/ar4-syr

Sea level observations

Historic archive of sea levels at the Permanent Service for Mean Sea Level www.pol.ac.uk/psmsl/

Real time sea levels from the Tsunami Sea Level Station Monitoring Facility www.sealevelstation.net

Journal articles

GB Brundrit (1995). Trends of southern African sea level: statistical analysis and interpretation. South African Journal of Marine Science **16**: 9-17.

S Searson and GB Brundrit (1995). Extreme high sea levels around the coast of southern Africa. South African Journal of Science, **91**, 579-588.

A.M. Smith, L.A. Guastella, S.C. Bundy and AA Mather (2007). Combined marine storm and Saros spring high tide erosion events along the KwaZulu-Natal coast in March 2007. South African Journal of Science **103**, 274-276.

AK Theron (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. p 269-284

PL Woodworth, A Aman and T Aarup (2007). Sea level monitoring in Africa. African Journal of Marine Science **29(3)** 321-330.

THE THREE SCENARIOS

AS INPUT TO THE GIS INUNDATION MODEL

Three Scenarios are presented, one from each of the three studies.

Scenario One.

This is the **Present Day Very Worst Case Scenario** for the 300km coastline under the jurisdiction of the City of Cape Town. It results from the simultaneous occurrence of an extreme tide and an extreme storm, an event with a nominal return period of 500 years. Such an event has not occurred along the Cape coast in recent years but it did occur along the KZN coast on 19/20 March 2007. Measurements taken from the KZN extreme event have been incorporated into this Present Day Very Worst Case Scenario, particularly in respect of exposed and very exposed portions of the coastline. The erosion damage in KZN was spectacular, and similar damage should be anticipated along vulnerable sections of the Cape Town coast in such circumstances. The identification of these vulnerable sections of the Cape Town coast is an important output from this scenario.

The scenario should use three colours to identify inundation of three sections of the coastline:

1. Sheltered and hard (rocky or armoured) sections of the coast.

2. Exposed sandy beach (and low-lying) sections of the coast, subject to erosion from the storm.

3. Very exposed sandy beach (and low-lying) sections of the coast, subject to extreme erosion.

The maximum levels that should be expected to be reached by the sea in this Present Day Very Worst Case Scenario in the environments as above are:

LLD+2m in sheltered environments,

LLD+4.5m in exposed environments, and

LLD+6.5m in very exposed environments.

The levels reached in the exposed and very exposed environments along flat sandy beaches are due to extreme swash heights associated with wave set up and run up in the surf zones from ~8m waves at the breakpoint. Even higher levels were measured at the limit of the swash zones in places where the greatest damage was caused along the KZN coast.

The inundation shown in the GIS reconstruction should identify those sections of the Cape Town coast that are most at risk in this Present Day Very Worst Case Scenario. Vulnerable infrastructure and services should be highlighted. Of particular interest will be where existing (dune) protection is eroded away in the storm and seawater is able to reach into unexpected areas of low-lying land. Because this scenario is possible (though unlikely) in the present day situation, it deserves to be carefully studied so that the extent of potential economic loss can be assessed.

Scenario Two

This is the **Scenario at the End of the Next Decade** after the acceleration in sea level rise which is expected to add 50cm to base levels. The levels to be used in this Scenario Two and the details of the inundation to be expected are the same as in Scenario

One! Thus, every conclusion to be drawn from the impact of Scenario One on the infrastructure and services provided by the City of Cape Town is immediately relevant to this Scenario at the End of the Next Decade.

It is the circumstances of how often this Scenario Two is expected that are different. Rather than being a Very Worst Case Scenario with a return period of 500 years, Scenario Two is to be expected whenever an extreme storm occurs at the same time as any (fortnightly) spring high tide in the spring or autumn. With the expectation that extreme storms will become more frequent, this Scenario at the End of the Next Decade is a realistic rather than an unusual event for the end of the next decade.

All the effort made in understanding the impacts and vulnerabilities of Scenario One can then be used to illustrate what might be expected as the norm for big spring and autumn storms at the end of the next decade in Scenario Two.

Scenario Three

When wholesale melting of the Greenland and West Antarctica Ice Sheets begins to contribute to sea level rise, the anticipated levels will be greatly in excess of earlier levels. This leads to the **Polar Ice Sheet Melt Scenario.** There is much uncertainty about the extent and the timing of the melting of the polar ice sheets and their eventual contribution to sea level rise and coastal inundation. Consequently, this Scenario Three is fundamentally different from the earlier scenarios. The focus should be on Mean Sea Level and the changes to be expected from the ice melt alone, so as to provide an every day scenario for these circumstances. It will map the location of the new coastline. Tides and storms can be added later, if need be, to illustrate the variability to be expected on a day by day basis.

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In this Polar Ice Sheet Melt Scenario, the important information that will come from the GIS inundation model will be the **order** in which different land areas are overwhelmed in the inexorable rise in sea level. Emphasis can then be placed on separate categories of infrastructure and services, such as loss of industrial areas, residential areas and disruption of the transport networks. The information on the order in which disruption will occur will aid in preparation for adaptive planning for the very worst consequences of sea level rise on the City of Cape Town. Remember that there is great uncertainty on the timing of such a long lead time scenario; this is a scenario not a prediction.

Global Climate Change and Adaptation: City of Cape Town sea-level rise risk assessment

Phase 5: Full investigation of alongshore features of vulnerability on the City of Cape Town coastline, and their incorporation into the City of Cape Town Geographic Information System (GIS).

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December 2009

econologic
economics for people & planet

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Glossary of terms as applied in this document

Mean sea-level: Mean sea level (MSL) is a measure of the average height of the ocean's surface (such as the halfway point between the mean high tide and the mean low tide); used as a standard in calculating land elevation.[1] Can be influenced by prevailing winds, but not tides, storms or changes in air pressure.

Still water: A measure of sea-level as it is affected by changes in mean sea level, tides and atmospheric pressure, but not by wind or waves. Equivalent to the sea-level if it were recorded within a glass cylinder, that was only open top and bottom.

Wave run-up: A function of sea depth. Occurs where there is appreciable wave height at the beach. Wave run-up affects the "water's edge".

Wave set-up: Is a function of swell height, which in turn is a function of the direction of the swell, the ocean from which the swell approaches and the orientation of the coastline relative to the approaching swell. Wave set-up determines the size of the swell at the break, which in turn affects the size (and energy) of the waves at the beach. Wave height at the break is typically three times the wave size at the beach.

Sheltered coastline: Exposed to changes in mean sea-level, but not exposed to wave set-up or wave run-up.

Exposed coastline: Coastline that is vulnerable to changes in mean sea-level and wave set-up.

Very exposed coastline: A section of coastline that is exposed to changes in mean sea-level, and because of its bathymetry, orientation and shape is also exposed to wave set-up and wave run-up.

Low risk coastline: Coastline that is sheltered, contains a geology that either absorbs or withstands wave energy without changing and does not contain valuable or strategic infrastructure or sensitive ecological habitats.

Medium risk coastline: "Exposed" coastline that contains some valuable infrastructure.

High risk coastline: "Very exposed" coastline that contains valuable infrastructure or sensitive ecological habitats.

Very big wave events: Storms with waves that exceed 10 metres in peak-to-trough amplitude.

[1] Proudman Oceanographic Laboratory

1. Introduction

The terms of reference require that this Phase 5 "improve(s) understanding of the extent and manner in which City of Cape Town's coastline is likely to be impacted by sea level rise. It is propose to achieve this by adding the influence of local factors such as offshore bathymetry, storm direction and coastal geography to the sea level rise model developed in Phases 1-4, and by including an understanding of how the various influences on sea-level rise interact with each other at a specific locations and over time."

The study is written up in two self contained reports. This, the first of the reports, incorporates ocean and coastal dynamics into the GIS model developed in Phases 1-4. The initial model relied heavily on altitude (height above sea-level) to identify the location of sea-level rise risks. This phase develops that model by adding the influence of coastal topography and geology, as well as the swell direction and the extent and nature of coastal development.

The second report integrates the findings of the first report into a coastal vulnerability assessment and proposes means of taking sea-level rise adaptation decisions so as to ensure coherence and effective prioritisation.

2. Summary of the Capabilities of the Existing GIS

The primary objective of the early phases (1-4) of this study was to model and understand the ramifications of predicted sea-level rise and increased storm events for the City of Cape Town, thereby providing information that may be used for future planning, preparedness and risk mitigation. This was achieved through a computer-based Geographic Information System (GIS), housed in the City of Cape Town Geomatics Division.

The GIS model demonstrates the potential changes to the coast resulting from sea-level rise. Variables within the model are able to be changed to accommodate variations in predictions as well as illustrating the impacts of catastrophic and combined events. The model incorporates the City's aerial photography, survey data, contour maps and overlays of the infrastructure and services. Examples of the output of the GIS inundation model for the entire City of Cape Town and for the Strand area are shown in Figures 1 and 2 below.

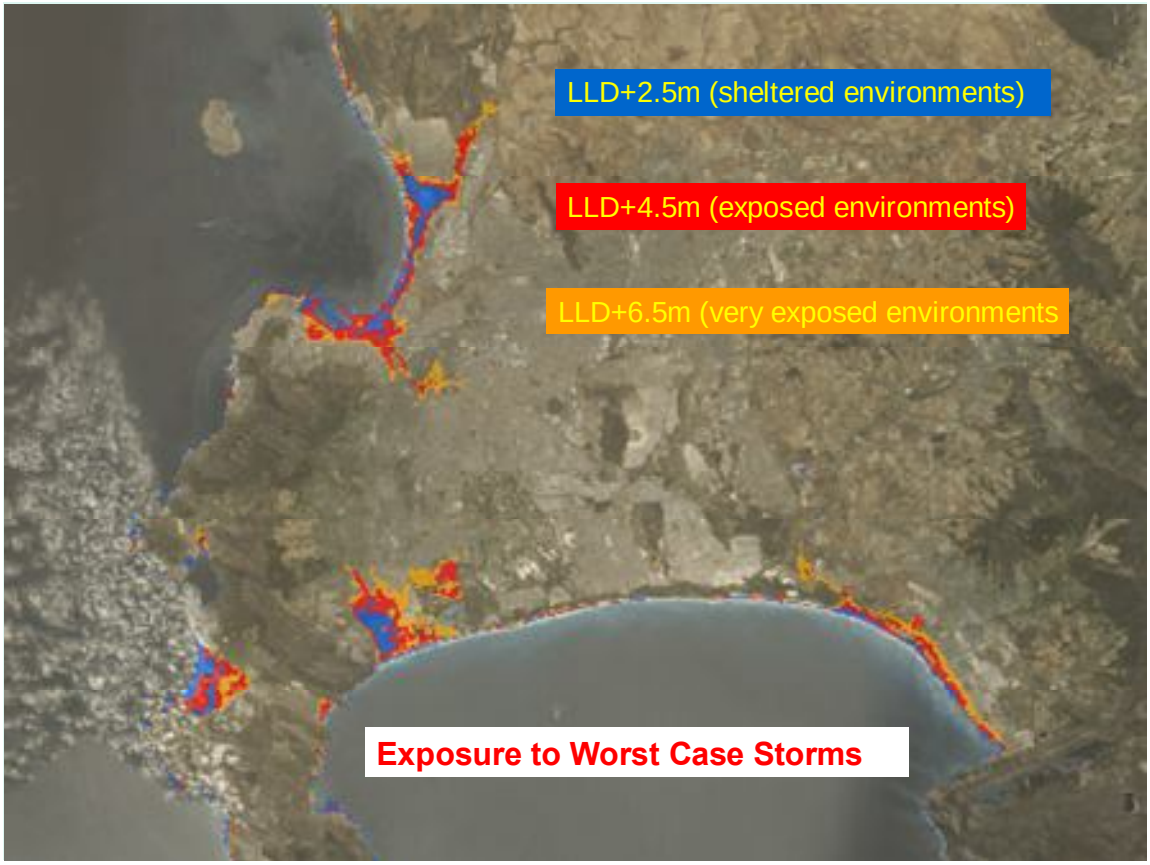


Figure 1: The exposure of the City of Cape Town to the worst case storms to be expected.

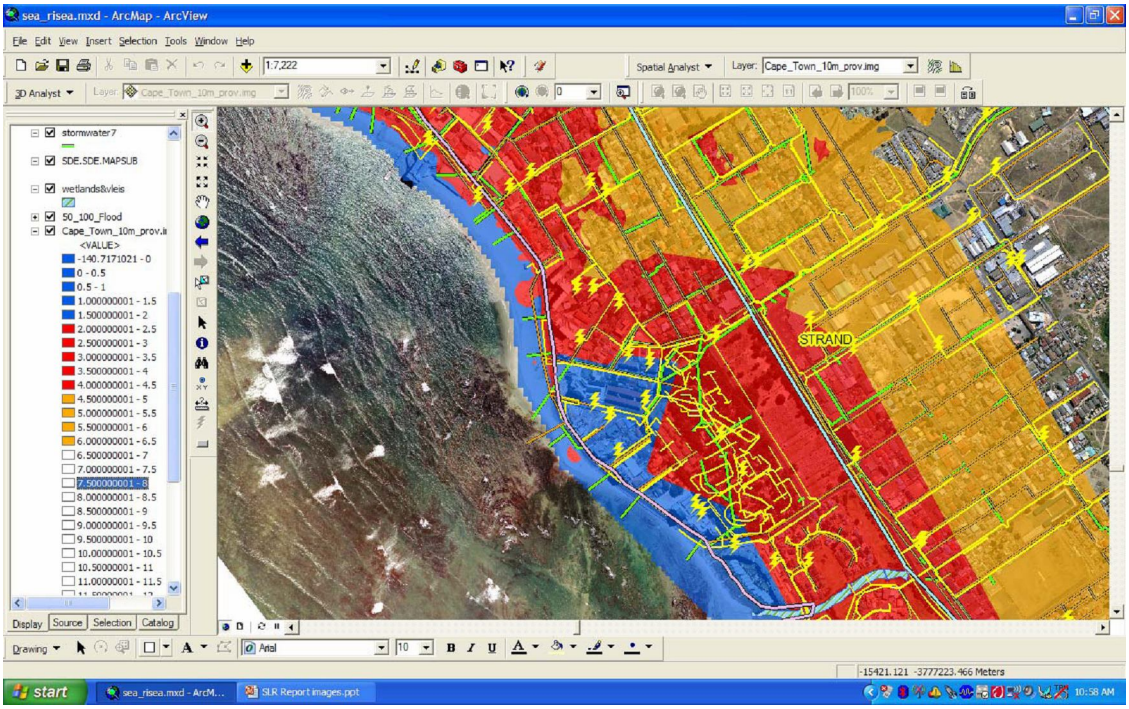


Figure 2: A snap shot image (1:7,222) of the Strand area (a low-lying area without much protection), depicting the three inundation areas used in the GIS inundation model

The nature of extreme sea level events along the coastline of the City of Cape Town was investigated through a re-interpretation of sea level records from the SA Navy Tidal Network stations at Simon's Town and Cape Town, to give extreme sea levels relevant to sheltered coasts. Where the coast is not protected, particularly on sandy beaches, the extreme waves associated with severe storms can lead to wave set-up, which needs to be added to the sea levels on such exposed coasts. When deep water is found close to the coast, the coast becomes very exposed, and both wave run-up and wave set-up need to be added to the sea level. These additional amounts can be estimated from the wave climatology derived from the wave recorder off the coast at Slangkop, and from observations of extreme storm events at the coast.

The interpretation of the extreme sea levels, and the corresponding inundation areas at risk, depends critically on the degree of exposure along each stretch of coast. All sea levels are referenced with respect to Land Levelling Datum, which is close to Mean Sea Level.

- The blue inundation area, up to LLD+2m, is relevant to **sheltered environments** along the coast.
- The red inundation area, between LLD+2m and LLD+4.5m, is the extra area relevant to **exposed coastal environments**, and

- The orange inundation area, between LLD+4.5m and LLD+6.5m, is the extra area relevant to **very exposed coastal environments.**

Figure 1 shows the extent of the three areas at risk around the entire coast of the City of Cape Town. There is a contrast between the extent of the areas at risk on the steep cliffs of the Peninsula and the lower coastline of Table Bay and northern False Bay. The vulnerability of low-lying lagoons, both existing and reclaimed is also apparent. A snapshot of a vulnerable area at the Strand, Figure 2, shows the capability of the original GIS model to illustrate the three inundation areas, and identify some of the municipal infrastructure (roads, electricity etc) that is at risk.

The actual degree of exposure relevant to each section of coast has not been incorporated into the existing GIS. Rather, all three categories of exposure are given at every section. This constitutes a limitation to the use of the GIS, and its value as an interpretative tool. The determination of the degree of exposure relevant to each stretch of coast, its incorporation into the GIS, and its risk interpretation are the principal objectives of Phase 5 of this project.

3. Influence of Sea Level Rise on the Vulnerability from Extreme Storms

Figure 1 can be used immediately to illustrate the consequences of the very worst sea level situation that can be expected at the present time. Such a situation would arise only if an extreme weather event along the coast coincided with an extreme spring high tide, a situation with a nominal return period of 500 years. Then, the blue inundation area would be appropriate for a sheltered coast, the red inundation area for an exposed coast and the orange inundation area for a very exposed coast.

Global projections of the influence of climate change on sea level, as given in studies such as the recent Assessment Reports of the Inter-Governmental Panel on Climate Change (IPCC), suggest that sea level rise over the next decade will be restricted to some 20cm. The principal influence of this projected sea level rise will be that storms will be built on a higher foundation. There will be little difference to the sea levels reached in these storms over the next decade. Thus the blue, red and orange inundation areas will remain valid. What will be different is the frequency with which the sea level of LLD+2m, relevant to sheltered areas, will be achieved at the end of the next decade, compared to present. Rather than being associated with a return period of 500 years, the return period will shorten to some 30 years. In this way the return period of high sea-level rise events is a log function of land levelling datum, and relatively small increases in sea-level (such as have already been observed) have a disproportionate effect on the frequency of extreme sea-levels.

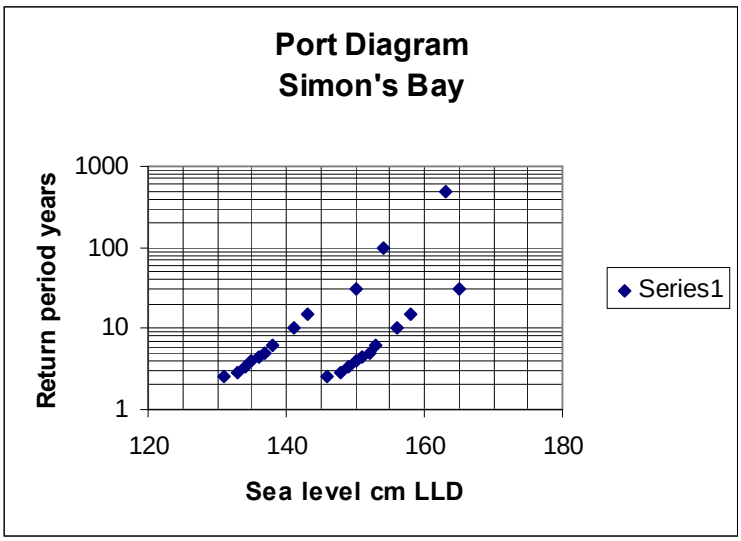


Figure 3: Extreme sea levels expected in sheltered areas at the present time, and after sea level rise of 20cm.

The blue areas all around the coast will be inundated at increasingly shorter intervals, and the risk of damage to the first line of defense will grow. The blue areas will be a valuable guide in setting out the new Coastal Protection Zone for the City of Cape Town.

An assessment of the adequacy of the present protection to the blue inundation areas all around the coast of the City of Cape Town is urgently needed. This is the first recommendation of this Part 1 of Phase 5 of the Study.

When it comes to the red and orange inundation areas marked in Figure 1, these are only relevant at those parts of the coast that are exposed or very exposed. The degree of exposure will be limited to those parts of the coast where the big storm waves are able to penetrate right up to the coast, without any appreciable dissipation. Exposure to big storms is addressed in Section 4 (below).

4. Key Directions for Extreme Storm Waves and their Characteristics in the Open Ocean.

4.1 Wave Climatology

A wave climatology for the South African coastline has been assembled from observations made by the CSIR Wave Research Group, and reported by Rossouw (1989). The wave recording site of principal interest to the City of Cape Town is referred to as Slangkop. This deep water recording site was situated 14km offshore of Slangkop lighthouse in 170m of water. A total of 11424 records of wave height at 6 hourly

intervals, provided 63% coverage over the 12 years prior to 1988. These records provide the significant wave height, H_S defined as the average of the highest one-third of all wave heights in the recording interval. A statistical analysis of the significant wave heights permits estimates of the median H_S, and the expected return periods of its extreme values.

Table 1: Significant Wave Height Statistics from Slangkop 1976-1988

Significant wave height H_S	
Median value	2.54m
Value at a return period of 1 year	7.61m
Value at a return period of 10 year	9.37m
Value at a return period of 100 year	11.11m

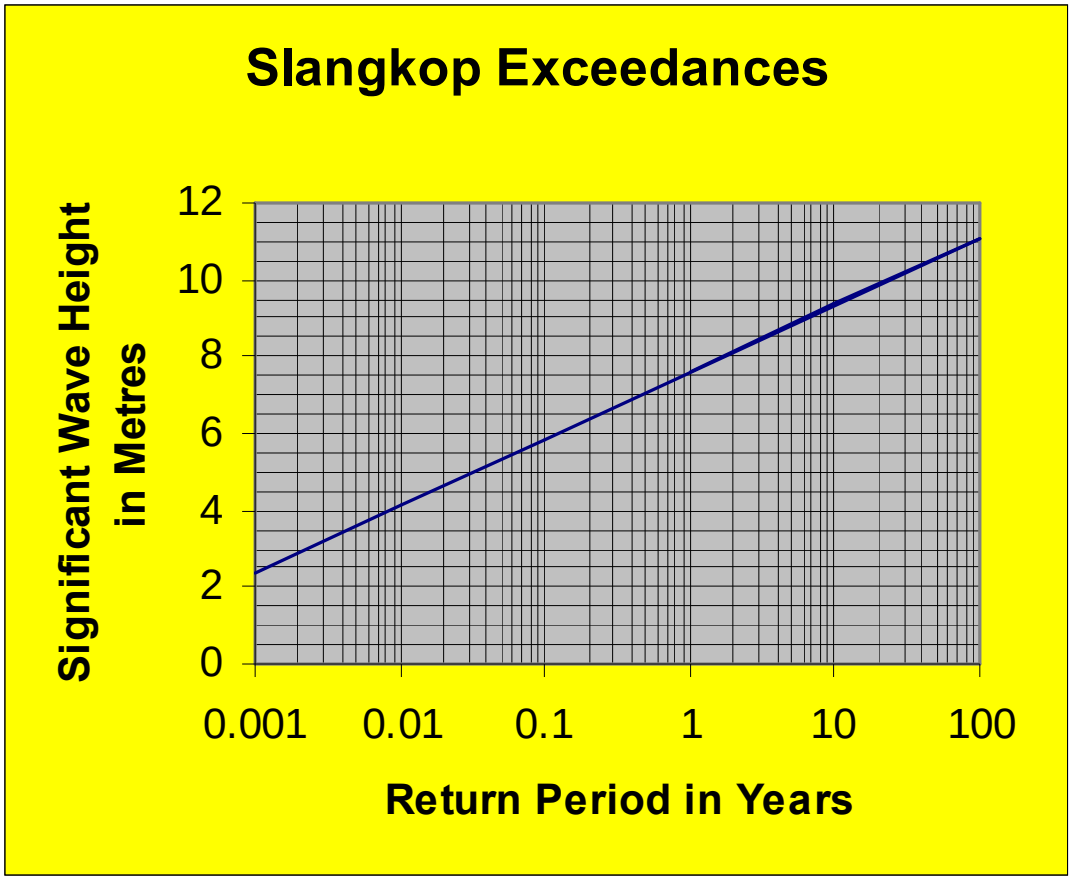


Figure 4: Significant wave height exceedances at Slangkop

The median peak period of the waves measured at Slangkop was 12.4 seconds, whilst the peak period exceeded 15.5 seconds for 10% of the time.

The wave recorder in use at that time did not record wave direction. In order to obtain directional data, the records from Voluntary Observing Ships were used. This data was obtained intermittently, with the most useful data coming from the shipping lanes to the northwest of Cape Town and to the east of Cape Point. In the area to the northwest, waves are from between the south and west (140 to 280 degrees) for 90% of the time while, in the area to the east, there is a broader spread, with waves from the east occurring just 8% of the time.

In more recent years, the site of the Slangkop wave recorder has been moved closer inshore, to a water depth of 70m, in order to avoid downtime from damage by passing ships. It is now possible to monitor wave conditions at Slangkop in real time at http://www.wavenet.csir.co.za The instrumentation has also improved, with the significant wave height being calculated for an interval of 4 hours and wave direction being included since 2000. The results from recent years have confirmed the detail of the earlier wave climatology.

4.2 Big Wave Events from the South-West

The archived wave observations from Slangkop and other wave recorders along the coast of South Africa make it possible to investigate the character of big wave events. Following Van der Borch (2004), a big wave event is defined as one which has a significant wave height exceeding 6.5m for at least 6 hours. This is done to exclude isolated short-term exceedances. Between 1983 and 2003, the records from Slangkop identified 32 such big wave events over the 21 year period, with the actual dates given in Appendix 1.

These 32 big wave events are not distributed uniformly over the 21 year period. They all occur during the winter months of each year, but are clustered together in particular groups of years.

Table 2: Years in which more than one big storm event occurred

1983		**1989**	**1990**	**1991**		**1995**	**1996**	**1997**		**2000**	**2001**	**2002**
3		3	3	2		2	2	2		2	2	4

Table 2 shows that 25 big wave events occurred in 10 particular years, with the other 7 events spread over the remaining 11 years. There appears to be a link between these years with several big wave events, and the years of persistent occurrence of warmer than usual sea surface temperatures in the coastal ocean off south western Africa.

As the second recommendation in this report, an investigation of this possible correlation is suggested as this may provide early warning of likely big storm events in the next winter.

The average significant wave height within these 32 big wave events is 7.72m, with standard deviation 1.01m, which can be compared with the value of the significant wave height at a return period of one year of 7.61m, as given in Table 3.1. The average of the maximum individual wave heights within each big wave event is 12.66m, with a standard deviation of 1.80m, so that the events can certainly be classed as big wave events. The overall maximum individual wave within these 32 big wave events reached 17.09m.

Measured wave direction is available for the nine big wave events from 2000 to 2003. Compared to the directions from the overall wave climatology of Rossouw (1989), there is a more restricted directional spread, with 95% of the records taken within the big wave events being from the south-west between 200 and 260 degrees.

Table 3: Directional wave distribution in percentages for Big Wave Events at Slangkop

		Wave	**Direction in**	**Degrees**		
	200-210	210-220	220-230	230-240	240-250	250-260
Percentage	4%	9%	23%	35%	20%	4%

The period of the swell for these big wave events ranged from 10 seconds to 16 seconds, with a lengthening during the peak of the event.

The daily weather bulletins issued by the South African Weather Service were analysed to identify the nature of the synoptic weather conditions forcing each of the 32 big wave events. The vast majority were associated with the passage of cold fronts (19), cyclo-genesis (7) and even explosive cyclo-genesis (5). The one exception was due to a cut-off low to the south of Cape Town in early September 2001, the event with the individual maximum wave height of 17.09m. Details of the synoptic weather conditions are also to be found in Appendix 1.

4.3 Very Big Wave Events from the South-West

Three of the Big Wave Events investigated in the previous section had significant wave heights which exceeded ten metres, and can be referred to as Very Big Wave Events. Since 2003, there has been yet another Very Big Wave Event, which should be added to the list of four Very Big Wave Events in recent years, deserving of special attention.

The dates of these Very Big Wave Events were as follows:

- **16 May 1984**: Explosive cyclo-genesis of a very deep depression to the south west of Cape Town led to an extreme storm with hurricane force winds and a significant wave height reaching 11 metres. The significant wave height in this storm was sustained at over 8m for over eighteen hours. Considerable damage was incurred by the coastal infrastructure of the south western Cape (Jury et al 1986).

- **5 September 2001**: A cut off low, south west of Cape Town gave rise to strong winds and a significant wave height of over 10 metres. This storm gave rise to the highest individual wave height ever recorded at the Slangkop wave recorder, reaching a massive 17.09 metres. This storm played havoc with shipping, and the bulk carrier Ikan Tanda was grounded on the beach at Scarborough.

- **25 May 2002**: A deepening depression, travelling rapidly to the south of Cape Town was associated with significant wave heights reaching 10 metres.

- **31 August 2008**: A severe storm passing to the south of Cape Town with waves with significant wave heights exceeding 10 metres, at Slangkop, gave rise to very high sea levels along the Atlantic seaboard of the Cape Peninsula. The next day, these high waves entered False Bay and reached relatively unprotected areas of the western shore, where they caused considerable damage to coastal infrastructure. The railway line to Simon's Town was closed for several days, and Jager Walk at Fish Hoek sustained damage of over R1m).

"Very Big Wave Events" with significant wave heights exceeding ten metres should, according to the exceedance diagram in Figure 4, be associated with a return period of 11 years. The occurrence of four Very Big Wave Events over the past 26 years, particularly the occurrence of three such events on the past eight years, suggests that either the frequency or the intensity of Very Big Wave Events is increasing. However, the short record and the tendency of storm events to clump together in the record means that such a conclusion is difficult to confirm.

4.4 Big Wave Events from the South-East

Big wave events from the east will not register at Slangkop, due to the sheltering effect of the Cape Peninsula. Wave recordings are next made at the offshore FA Platform 100km south of Mossel Bay, and wave directions are only available even further east at East London. This means that accurate information on waves entering False Bay from

the south east, and usually associated with so-called Black South-Easter meteorological conditions, are hard to find. Recourse has to be made to anecdotal information.

Five big wave events (significant wave height exceeding 6.5 metres and sustained for at least 6 hours) were measured in 2001 and 2002 at East London, and provided directional information. Two of these events were also noted at the FA Platform, but none were noted at Slangkop. Only the first event was associated with waves from the south east, with its peak on 16/17 August 2002, and significant wave heights of 8m. At the FA Platform individual waves were exceeding 14m and this big wave event would have entered False Bay. The records kept at Kalk Bay harbour confirm that rough seas were experienced there on 17 August 2002. Other events of importance at Kalk Bay include 21 April 1996 when two people were swept off the harbour wall and drowned, as well as the storm on 1 September 2008 when considerable damage was caused all along the coast

The records maintained at Kalk Bay Harbour by Marianne Jordaan provide useful anecdotal evidence of the frequency of wave events associated with rough sea conditions and damage at the harbour. Over the past thirty months, the harbour records reveal the following nine instances.

- 13 Feb 2007 Woman knocked into the water.
- 26 June 2007 Wave damage within the harbor.
- 1 Oct 2007 Moorings break.
- 29 April 2008 Rough seas.
- 17 June 2008 Rough seas with more damage.
- 31 August 2008 and 1 Sept 2008. High winds and heavy swell from SW, reaching round to Kalk Bay.
- 11 Nov 2008 Water over harbour wall from heavy SE swell associated with cut-off low.
- 15 to 20 May 2009 bad weather.
- 24 June 2009 SW swell wrapping round. Moorings broken on boats.

It is important to note that these events are spread throughout the year, although there is some influence of winter storms. There are no measurements of actual wave heights at Kalk Bay harbour, though waves reflected off the harbour wall will tend to create standing wave patterns, which will be almost double the height of the incoming waves. These storm waves are responsible for the damage to property in the harbour.

5. Shoaling Effects on Waves, from the Open Ocean to the Surf Break

5.1 Refraction due to Offshore Bathymetry

Refraction effects will reduce the significant wave heights in a straightforward way. The detail requires a comparison between the direction of propagation of the big wave events and the direction of shoaling of the bottom contours as the waves approach the coast. Refraction of an incoming big wave, centred in direction 56.75 degrees at water depth of 70 metres (at the Slangkop buoy), will occur as the wave enters shallow water. If the shoaling direction at the inshore contour is oriented at a greater angle than 56.75 degrees, the incoming wave will gradually bend to the right as it moves into the shallower water. In contrast, if the shoaling direction is oriented at a lesser angle than 56.75 degrees the incoming wave will gradually bend to the left. The extent of the refraction will depend on the amount of shoaling from the deeper water, with more refraction for shallower water, and an eventual alignment of the wave direction with the shoaling direction in the surf zone.

Snell's Law can be used to set up an appropriate Refraction Table at various depths of shallow water and shoaling directions for incident wave direction of 56.25 degrees. At the same time, the proportionate decrease in the incident significant wave height due to the spread of the refracted wave can be noted.

Table 4: Refraction Table for Incident Wave Direction of 56.25 Degrees

Shoaling	-22.5	0	22.5	45	**56.25**	67.5	90	112.5	135
Direction	NNW	N	NNE	NE		ENE	E	ESE	SE
Depth	40m								
Refraction	23.4	39.0	**47.3**	**53.5**	**56.25**	**59.0**	**65.2**	73.6	87.1
Ht Ratio	0.54	0.85	**0.96**	**1**	**1**	**1**	**0.96**	0.85	0.54
Depth	20m								
Refraction	9.1	26.4	**39.8**	**51.0**	**56.25**	**61.5**	**72.7**	86.1	103.4
Ht Ratio	0.48	0.79	**0.93**	**0.99**	**1**	**0.99**	**0.93**	0.79	0.48
Depth	10m								
Refraction	-0.7	18.3	**34.6**	**49.2**	**56.25**	**63.3**	**77.9**	94.2	113.2
Ht Ratio	0.46	0.76	**0.92**	**0.99**	**1**	**0.99**	**0.92**	0.76	0.46

The proportionate decrease in the incident significant wave height in the 40m, 20m and 10m shallow water remains above 0.90 for shoaling directions between NNE (22.5

degrees) and E (90 degrees) where the refraction from the incident direction of 56.25 degrees remains between 34.6 and 77.9 degrees. The correspondence with the spread of the incident wave from 33.75 to 78.75 degrees should be particularly noted. This means that contours with shoaling directions between NNE and E can be considered to be potentially exposed to big storm waves, as there is little reduction in the significant wave height despite the effect of refraction.

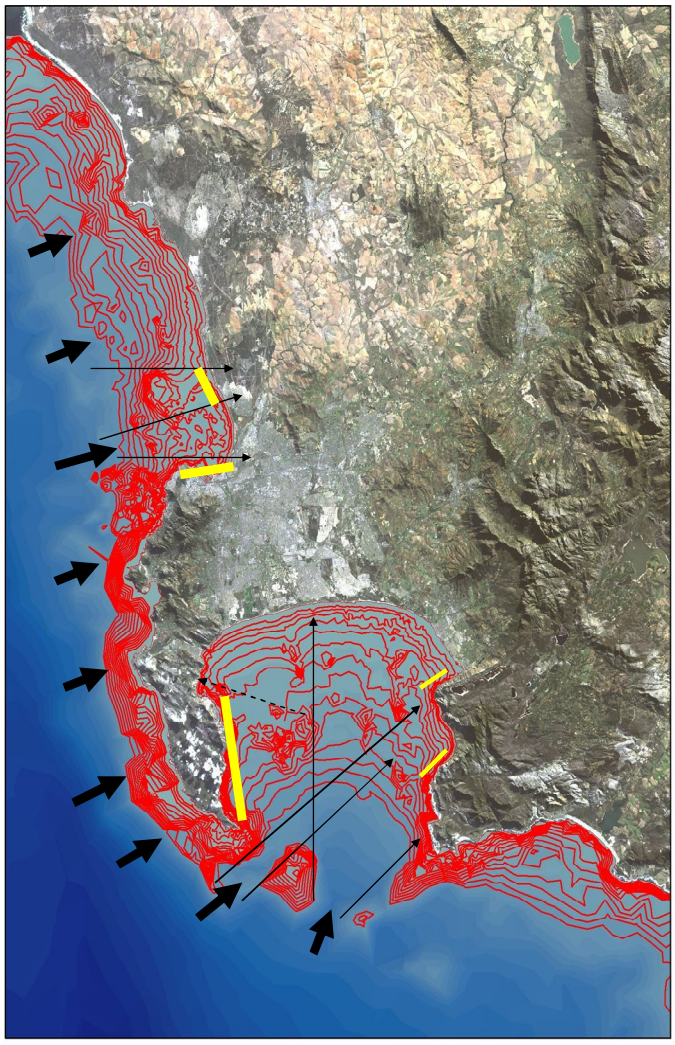


Figure 5. Bathymetry around the Cape Peninsula down to a depth of 70m at 5m intervals.

Much of the Atlantic coast has a shoaling direction between NNE and E, and can be marked as areas potentially exposed to big wave events. The two major exceptions are the coast behind Robben Island, and the sheltered southern end of Table Bay, east of Green Point. There is also a contrast between the gradually sloping bottom contours of

Table Bay, with its sandy beaches, and the steeply sloping contours of the Atlantic coast of the Peninsula, with its cliffs interspersed with mainly pocket beaches. False Bay has gently sloping bottom contours to its northern sandy beaches, but the sides have steeply sloping contours to cliffs and pocket beaches. The entire western shore of False Bay north of Cape Point is potentially sheltered to waves from the south west, whilst everywhere else except for Gordons Bay is potentially exposed.

These coastlines are only potentially exposed because offshore reefs, where they occur, may provide some real protection. By contrast, deep water close inshore can result in a very exposed coast. In the wave shadow, the coastline is only potentially sheltered, because diffraction can transfer significant amounts of wave energy into the shadow zone, particularly if only a small diffraction angle is required. These various possibilities are now explored.

5.2 Bottom Dissipation from Offshore Reefs

Rough bottom topography such as off shore reefs should cause a loss of wave height as wave energy is dissipated through bottom friction. In the north-east corner of False Bay, there is an opportunity to compare observations of break-point significant wave height at a return period of one year, as measured in studies of bathing beaches, with the same significant wave height measured at the Slangkop wave recorder.

Table 5: Significant wave heights with 1 year return periods, at beach break-points on the north-east corner of False Bay and at the Slangkop wave buoy.

	Gordon's Bay	Strand	Macassar	Slangkop
Sign. wave height	1.7m	3.3m	4.9m	7.6m
Ratio to Slangkop	22%	43%	64%	

There is a gradual decrease in significant wave height along the coast from Macassar to Gordon's Bay, due to the effect of refraction and the passage of the waves entering False Bay moving over increasingly greater areas of offshore reef before reaching the coast. The route from the mouth of False Bay to Macassar avoids much of the offshore reef areas, and follows the long gradually shoaling sandy bottom. Even this route sees a reduction to a significant wave height at Macassar of 4.9m over the 7.6m experienced at the Slangkop buoy, for a one year return period. It is worth noting that when high waves coincide with a high tide at Macassar, the beach becomes dangerous for swimming, and erosion of the shore-side dune field is experienced.

5.3 Focusing Effects in False Bay

As waves pass over isolated shallow areas, refraction around the shallow feature can lead to focusing of wave energy and higher waves on the coast. This is a localised effect, which has not been well studied. An exception is the focusing of south-west swell entering False Bay and being focused as the waves pass over the shallow Rocky Bank. Wave energy is then concentrated into the direction that cuts the eastern coast of False Bay at Kogelbaai, a locality associated with fishermen being washed off rocks. It is also possible that the lack of an extensive offshore reef may contribute to the heightened energy on this stretch of coast. A study from Ian Hunter of the South African Weather Service is included as Appendix 3.

5.4 Diffraction into Shadow Zones

The western shore of False Bay from Muizenberg southwards lies in the shadow zone of big wave events travelling through the entrance to False Bay. The waves can be diffracted into the shadow zone and, after refraction by the bathymetry, can reach the coast. The general rule for diffraction is that the greater the angle through which the waves are bent by diffraction, the greater will be the reduction in wave height and wave energy. Thus the big wave events from the south west will have decreasing impact as one moves southward down the coast from Muizenberg/Kalk Bay to Fish Hoek/Simon's Town. Nevertheless the biggest events will still be associated with considerable damage between Muizenberg and Kalk Bay and, even on occasions such as 1 September 2008, at Fish Hoek.

In the same way, there will be considerable interaction between the waves and the bathymetry, as the big storm waves enter Table Bay. Green Point will shelter much of the north facing coast close to the Port of Cape Town, while the breakwaters will protect the Port itself.

6. Coastal vulnerability

So far this study has dealt with wave set-up. That is the waves from the big wave events reaching the outer edge of the surf zone from the open sea. Now attention turns to wave run-up as determined by conditions in the surf zone and on the coast itself. Roughly speaking waves will break when they are close enough to the coast for the water depth to be less than 80% of the wave height. Thus the edge of the surf zone where the waves are 10m in height will be in a water depth of roughly 8m. The resulting width of the surf zone will depend upon the beach slope under the waves from the surf break-point to the shore, on whether the beach is flat or steep. Given that individual waves vary

considerably in height, the position of the break-point and the width of the surf zone will also vary considerably. It is the biggest waves that count so that the significant wave height is usually taken as determining the surf break-point and the width of the surf zone. It should also be clear that a tidal range, which approaches 2m at springs, will also have an influence on the character of the surf zone, with possible differences between high tide and low tide.

There will also be differences in the character of the breakers within the surf zone. Details of breaker types and surf zone characteristics can be found in Appendix 4. On relatively flat beaches, plunging breakers can dump much of their energy at the outer break-point itself while, on steep beaches with deep water close to the shore, surging breakers can bring substantial wave energy close to the shore and cause much damage. The very flattest beaches can be associated with spilling breakers that spread their loss of wave energy evenly through the surf zone. Again, the character of the surf zone at each location is not fixed, as there may be differences in breaker types at different states of the tide.

The critical situation is when deep water close inshore allows the wave energy to approach the shore. This may be on a hard coast where cliffs drop deeply into the sea, or where a steep beach is really a dune face, with surging breakers rapidly eroding that dune face. Pocket beaches, a combination of both hard and soft coasts with deep water close to the shore, may be particularly vulnerable.

The experience of the City of Cape Town in repeated maintenance of its protection measures around the coast can be compared with the degree of exposure as revealed in this study.

Exposure, and the associated risk of sea-level rise, is location specific. In this study exposure is disaggregated according to specific location's exposure to wave set-up, wave run-up, the natural predisposition of a location as a function of the coastal geology (hardness and softness of the coastline, where soft coastline is typically less exposed than hard coastline, but particular combinations of hard and soft can lead to heightened risks), and the value or strategic nature of the development in that area.

The table below scores 20 locations that are known to be on the City of Cape Town's list of potentially exposed locations in terms of these four criteria. Applying a binary system, a score of 1 is allocated to those areas that are perceived to be exposed to the specific component of sea-level rise risk, and a score of 0 is given if the location is not exposed to that component. The assessment was conducted using the expert opinion of a group consisting of local oceanographers, coastal conservationists and engineers, all of whom were drawing on a history of experience with the City of Cape town coastline. The assessment not only provides a reasonable measure of the total sea-level rise risk at

a given location – and disaggregating risk per location is important – but it also provides important insight into the specific nature of sea-level rise risk at different locations.

Table 6: Components of sea-level rise vulnerability for different locations around the City of Cape Town coastline

	Wave set-up	Wave run-up	Coastal geology. Hard or soft surfaces.	Development risk	Comment
Table Bay: This is an area of gently sloping bottom contours and a sandy coast fringed by low dunes and occasional rocky outcrops. Part of the coast is sheltered by Robben Island. The coast is eroding in the south, and is particularly vulnerable where it is backed by the lagoon of the Diep River.					
Melkbosstrand	1	0	0	1	Exposed to big well, but with some shelter from offshore reefs. Beachfront development and dune removal is problematic.
Blouberg (Bay)	1	0	0	1	Sheltered behind Robben Island, the beach should be an area of sand accretion. However, extensive development has encroached too close to the waterline. Protection is needed.
Tableview beachfront	1	0	0	1	Exposed to big waves, where the Beach Road will become at risk. Protection is needed.
Milnerton beach	1	1	0	1	Exposed to big waves and, at high tide, surging breakers. This is an eroding beach with a diminishing steep dune cordon. Potential major issue if the protection to Otto du Plessis Drive is lost.
Milnerton to harbour	1	0	1	1	Shadow zone, no big waves. Harbour construction has led to gradual erosion and set-back, with ongoing loss of coastal infrastructure. Sea wall needs constant maintenance. Oil pipeline is strategic.

Atlantic Coast: This is a rocky coast with cliffs, offshore reefs and extensive kelp beds. Deep water is found close to the shore, permitting big waves to crash onto the coast so that protection is needed for any infrastructure at sea level.					
Green Point & Sea Point	1	0	1	1	Exposed to big waves, but some shelter from offshore reefs. The coast is on an exposed wave cut platform at some height above the sea, but needs the protection of a strong sea wall requiring continuous maintenance.
Glen Beach	1	0	0	1	A small pocket beach with some protection. High value beach houses are exposed.
Camps Bay	1	1	0	1	This beach is exposed to big waves. Wide beach, but high sea levels can reach the Beach Road.
Bakoven cottages	1	1	1	1	Very exposed to big waves and wave run up, and constantly under threat, as the houses are low down and on a hard rocky surface.
Kommetjie	1	1	0	1	Very exposed as deep water close inshore. Development has taken place in the protective dunefield, reducing its effectiveness.
Witsands	1	1	0	0	Very exposed single building in dynamic dunefield.
False Bay Coast: Western coast is steep but well sheltered from big waves from the southwest. Within False Bay, the bottom contours are gently shoaling to the sandy northern shore. The eastern coast is steep.					
Glencairn	1	0	0	1	Railway line running along a low wave-cut platform. Sheltered in shadow zone, but perhaps the foundations of the railway line in the backing wetland need continual

					maintenance.
Fish Hoek dune section	1	0	0	0	In shadow zone, but backing wetland may lead to vulnerability.
Kalk Bay	0	1	1	1	In shadow zone from southwest, but exposed to focussing from the south-east, so that harbour provides.
Muizenberg corner	1	0	0	1	In the edge of the shadow zone, but protected by a wide and very flat beach with spilling breakers.
Strandfonetin – Baden Powell Drive / Treatment Works / Landfill	1	0	1	1	Not too exposed but the road and the infrastructure are too close to the water's edge.
Monwabisi and Macassar Pavilions	1	1	0	1	Exposed to surging breakers at high tide and during storm events, with erosion of dune field
Strand (entire beach front)	1	0	1	1	Exposed beach with protection from offshore reefs, but infrastructure constructed close to water and poorly planned sea-walls.
Bikini beach	1	0	0	1	In swell shadow, but infrastructure too close to water and needs protection. Beach sand erodes.

In many of these key locations, further study is needed. The character of the surf zone under different conditions of tide and storm will identify the requirements for protection. The occurrence of surging breakers and the erosion of natural dune protection is particularly important. Such local assessments can be made through video monitoring.

7. Incorporation into the GIS

The coastal bathymetry, as illustrated in Figure 5 with contours at 5m intervals down to 70m, has been incorporated into the GIS maintained by the Geomatics Division of the City of Cape Town. This resolution is sufficient for estimates of the effect on significant wave height from refraction, offshore reefs, focusing, and diffraction as the waves move from the open ocean to the surf break. These studies can be summarized as follows.

- The refraction study shows that those parts of the coast with an offshore shoaling direction between NNE and E will be potentially exposed to the big storm waves from the south west. The red areas of the GIS, corresponding to extreme sea levels on the coast of up to LLD+4.5m, will then be potentially appropriate but could be reduced due to other effects.
- The Atlantic coast of the Peninsula itself, because deep water can come close to the coast, will be potentially very exposed to big storm waves from the south west. The orange areas of the GIS, corresponding to extreme sea levels on the coast of up to LLD+6.5m will then be potentially appropriate, but could be reduced due to other effects. Table Bay and the northern and eastern coasts of False Bay would remain as potentially exposed coasts.
- Finally those parts of the coast in the shadow of big storm waves from the south west, such as the lee of Robben Island, the southern coast of Table Bay and the western coast of False Bay, will be potentially sheltered. The blue areas of the GIS, corresponding to extreme sea levels on the coast of only up to LLD+2m, will then be potentially appropriate, but could be increased due to other effects.
- The effect of bottom dissipation as waves travel over shallow water can reduce the significant wave height between the open ocean and the surf break. The study into the north-east corner of False Bay shows that the reduction in significant wave height can exceed 40%, which means that the contribution of wave set-up on exposed coasts can be reduced by a similar amount. This reduction can be used as a first estimate of the bottom dissipation effect on exposed coasts in Table Bay and False Bay. There the extreme sea levels in the red areas should be reduced by 1m to LLD+3.5m.
- Offshore reefs can have an even greater effect, particularly if combined with kelp beds. Areas of coast which are potentially very exposed can actually be sheltered, though this will be a very localized effect.

- Focusing can have the effect of increasing the significant wave energy at points along the coast. The prime example is in False Bay where storm waves from the south west are focused onto the coast at Kogelbaai, countering the dissipation effect in the bay and returning that part of the coast to exposed or even very exposed status. A similar focusing may affect Kalk Bay with big storm waves from the south east.
- Diffraction of wave energy into a wave shadow can mean that a previously sheltered coastline becomes exposed. The amount of exposure to wave set-up can be estimated as thirty percent of the significant wave height at the surf break. It is this additional factor that is responsible for damage to the north western corner of False Bay from big storms from the south west, and for the massive breakwaters protecting Table Bay harbour.

- Finally, if the energy in the big storm waves is undiminished in reaching the coastline at the water's edge, then the potential of an exposed or very exposed coastline can be fully realised. On a hard coast, reflection of the waves off the coast can lead to a doubling of wave height in a greatly enhanced standing wave. On a steep sandy beach, a surging breaker can erode a dune face at an astonishing speed.

Particular areas can be highlighted for special study. The techniques for assessing exposure and protection as the waves move from the open sea to the surf break, as summarized above, can be used in these special studies. If the result is not sufficiently detailed, a period of wave observations at the particular location may be needed to provide the missing detail.

In order to establish the characteristics of the surf zone in the locality of interest, monitoring over various extreme sea levels due to tides and storms through video techniques can provide relevant assessments. The various infrastructure overlays can then be used to investigate the risks of damage.

8. References

Cartwright, A (2008) Global climate change and adaptation – a sea-level rise risk assessment. Phase 3: Sea-level rise risks for the City of Cape Town. Environmental Resource Management Department. LaquaR Consultants.

Jury M.R. *et al* (1986). Meteorological and oceanographic aspects of a winter storm over the south-western Cape Province, South Africa. South African Journal of Science, vol 82, pp. 315-319.

Rossouw, J (1989). Design Waves for the South African Coastline. PhD Thesis, University of Stellenbosch, 140pp.

Van der Borch, E & Van Verwolde (2004). Characteristics of extreme wave events along the South African coast. Applied Marine Science taught Masters Dissertation. University of Cape Town, 124pp.

9. Appendices

Appendix 1: Big Storm Dates and Corresponding Synoptic Situation

Table A1: Big Storm Dates and Corresponding Synoptic Situation

Slangkop		
12-16 May 83		Cold front
18-22 May 83		Cyclogenesis
20-26 Jun 83		Cold front
13-19 May84		Explosive cyclogenesis
28-31 Mar 86		Cold front
27-30 Oct 88		Cold front
28 Mar-3 Apr 89		Cold front
13-16 Jul 89		Cold front
23-27 Aug 89		Cold front
18-22 May 90		Explosive cyclogenesis
10-14 July 90		Cold front
8-12 Aug 90		Cold front
23-27 Jul 91		Cyclogenesis
29 Jul-2 Aug 91		Cold front
20-26 Jun 92		Cold front
18-22 Jun 94		Cold front
5-9 Jul 95		Explosive cyclogenesis
15-19 Jul 95		Cyclogenesis
13-18 Jun 96		Cold front
23-27 Sep 96		Cold front
20-24 Jun 97		Explosive cyclogenesis
25-29 June 97		Explosive cyclogenesis
1-4 Aug 99		Cyclogenesis
13-16 Jul 00	Direction SW	Cold front
16-21 Jul 00	Direction SW	Cyclogenesis
18-21 Aug 01	Direction SW	Cold front
3-7 Sep 01	Direction SW	Cut off low
21-26 May 02	Direction SW	Cyclogenesis
16-20 Jun 02	Direction SW	Cold front
25-30 Jul 02	Direction SW	Cyclogenesis
31 Jul-4 Aug 02	Direction SW	Cold front
17-21 Aug 03	Direction SW	Cold front

Appendix 2: Refraction due to offshore bathymetry

Refraction effects will reduce the significant wave heights in a straightforward way. The detail requires a comparison between the direction of propagation of the big wave events and the direction of shoaling of the bottom contours as the waves approach the coast. These directions will first be converted to the sectors defined by the compass directions.

Table A2: Wave directions during big wave events from 2000-2004 at Slangkop

200-210	210-220	220-230	230-240	240-250	250-260
4	9	23	35	20	4

Compass directions SW and WSW cover angles between 213.75 and 258.75 degrees (45 degree spread with midpoint at 236.25 degrees), which include around 90% of observations of the big wave events. This is chosen as the composite direction from which the big waves come. It will be necessary to turn this around and note that 236.25-180=56.25 degrees is the principal direction in which the big wave events are travelling, with a spread of 33.75 to 78.75 degrees. Thus the big wave events are travelling in compass directions NE and ENE.

A first step is to represent the shelf bathymetry with contour segments, selected from the limited compass direction set, so that the directions may be easily compared with the direction of travel of the big waves. For example the contours off Camps Bay may be N-S, whilst those off the north shore of False Bay may be E-W. The segmented contours are associated with a single shoaling direction. Off Camps Bay, this single shoaling direction is likely to be E, and off the north shore of False Bay, the single shoaling direction is likely to be N.

For refraction of the incoming storm waves, the set of shoaling directions must make an acute angle with the incoming wave. Other shoaling directions are completely sheltered from refraction, though diffraction may bring waves into the sheltered coast, (Eg. the coast of False Bay, south of Muizenberg). With the incoming wave moving in a direction centred at 56.25 degrees, the relevant shoaling directions must lie between -33.75 degrees (or 326.25 degrees) and 146.25 degrees, as given in the following table.

Table A3: Relevant Shoaling Directions as Angles Clockwise from North

Direction	NNW	N	NNE	NE	ENE	E	ESE	SE
Angle	-22.5	0	22.5	45	67.5	90	112.5	135

Refraction of the incoming wave in direction 56.75 degrees at water depth of 70 metres (at the Slangkop buoy) will occur as the wave enters shallow water. If the shoaling direction at the inshore segmented contour is oriented at a greater angle than 56.75

degrees, the incoming wave will gradually bend to the right as it moves into the shallower water. Whilst, if the shoaling direction is oriented at a lesser angle than 56.75 degrees, the incoming wave will gradually bend to the left. The extent of the refraction will depend on the amount of shoaling from the deeper water, with more refraction for shallower water.

Snell's Law can be used to set up Table A.4 as an appropriate Refraction Table at various depths of shallow water and shoaling directions for incident wave direction of 56.25 degrees. At the same time, the proportionate decrease in the incident significant wave height due to the spread of the refracted wave can be noted.

Table A4: Refraction Table for Incident Wave Direction of 56.25 Degrees

Shoaling	-22.5	0	22.5	45	**56.25**	67.5	90	112.5	135
Direction	NNW	N	NNE	NE		ENE	E	ESE	SE
Depth	40m								
Refraction	23.4	39.0	**47.3**	**53.5**	**56.25**	**59.0**	**65.2**	73.6	87.1
Ht Ratio	0.54	0.85	**0.96**	**1**	**1**	**1**	**0.96**	0.85	0.54
Depth	20m								
Refraction	9.1	26.4	**39.8**	**51.0**	**56.25**	**61.5**	**72.7**	86.1	103.4
Ht Ratio	0.48	0.79	**0.93**	**0.99**	**1**	**0.99**	**0.93**	0.79	0.48
Depth	10m								
Refraction	-0.7	18.3	**34.6**	**49.2**	**56.25**	**63.3**	**77.9**	94.2	113.2
Ht Ratio	0.46	0.76	**0.92**	**0.99**	**1**	**0.99**	**0.92**	0.76	0.46

The proportionate decrease in the incident significant wave height in the 40m, 20m and 10m shallow water remains above 0.90 for shoaling directions between NNE (22.5 degrees) and E (90 degrees) where the refraction from the incident direction of 56.25 degrees remains between 34.6 and 77.9 degrees. The correspondence with the spread of the incident wave from 33.75 to 78.75 degrees should be particularly noted. This means that segmented contours corresponding to shoaling directions between NNE and E can be considered to be potentially exposed to big storm waves, as there is little reduction in the significant wave height despite the effect of refraction.

Appendix 3: Weather Systems and Enhanced Wave Conditions in False Bay – 12 November 2008

Last Wednesday 12 November 2008 heavy seas once again crashed over the breakwater into the Kalk Bay fishing harbour threatening the adjacent restaurants. Fortunately the wave conditions did not reach the extremes of 1 September when considerable damage was incurred – not just in Kalk Bay but all along the coast from Table Bay to East London.

Earlier this year on 17 June heavy seas resulted in some of the concrete fish-cleaning tables inside the harbour being smashed. Thus enhanced wave conditions in this area are by no means rare. They also occur along other sections of the False Bay coastline - between Steenbras River Mouth and Cape Hangklip numerous crosses mark the spots where rock anglers have been caught unawares.

Divers and small boats have similarly fallen foul of these sudden, short-lived events.



Figure A1: A cross located just to the west of Steenbras River Mouth marks one of many spots where rogue waves have washed fisherman into the sea. The swell direction at the time of these tragedies is invariably SW'ly – with wave focussing taking place as a result of bathymetrical features

Heavy SE'ly swell entering False Bay – cut-off low/ blocking high combination
In 1965 a naval cutter (ship's boat with sailing gear) was becalmed off Kalk Bay when a sudden, quick succession of steep high waves capsized the vessel, resulting in the loss of 7 of the 11 crew members. In this case the swell direction was SE'ly. This latest event (12 November 2008) was also a case of a heavy SE'ly swell entering the Bay – and being focussed onto the Kalk Bay area. These events are almost always associated with a cut-off low event (COL). See Figure A2, the sea level pressure analysis on the morning of 12 November.

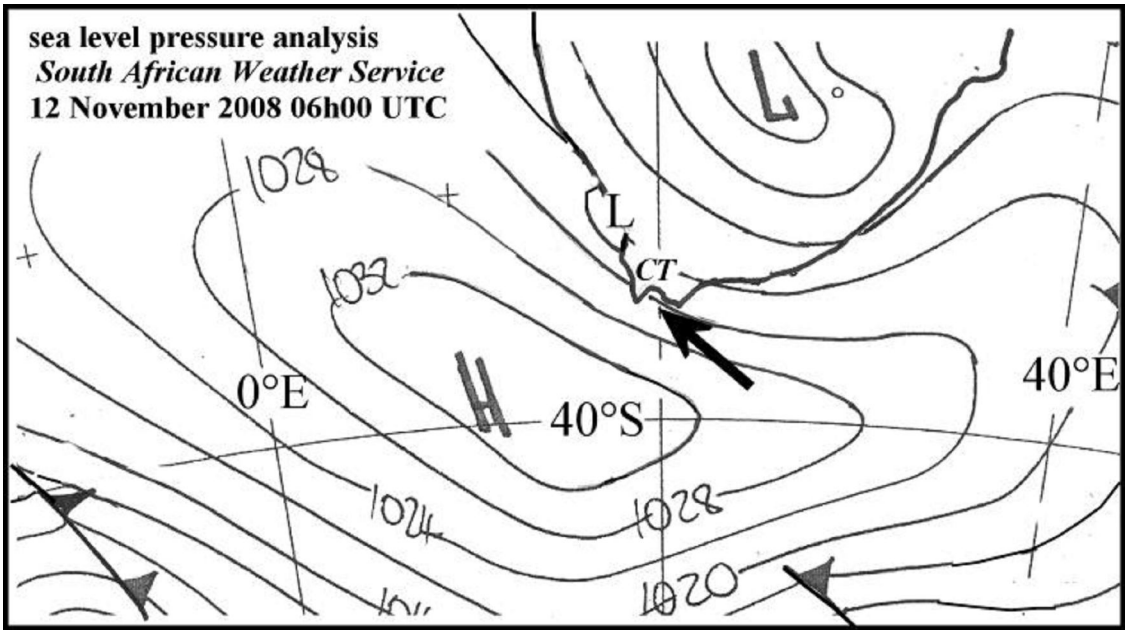


Figure A1: SAWS sea level pressure analysis for 06h00 on 12 November 2008. Note that the wind is angled across the isobars due to friction and pressure gradients increasing rapidly with time

The term 'cut-off' actually refers to the upper air circulation but this sea level analysis shows the typical pattern - a tight SE'ly fetch zone (arrowed) squeezed in between a COL / Blocking High combination. Compared with the normal Cape SE'er the high is generally further south, the low is deep (not your normal shallow, coastal low) – and sometimes located offshore. Both systems are *semi-stationary*, thus increasing the wave generation 'duration' factor.

There is a longer-than-normal fetch zone and all of this combines to build up an unusually heavy SE'ly swell. The swell period is relatively short, but Whittle Rock is shallow – refraction and focussing still come into play. The blue arrows in Figure 4 apply, with thickness representing wave energy.

Note that the sea state on the Western Cape's *west* coast remains relatively calm in these (deep) SE'ly conditions – the wind being offshore and there thus being a very limited fetch.

Heavy SW'ly swell – intense mid-latitude trough

The extreme wave conditions of 31 August and 1 September were associated with a deep mid-latitude trough moving fairly rapidly eastwards (cf stationarity of COL / Blocking High combination).

Rocky Bank (which rises to 22m, 5nm southeast of Cape Point) has been identified by means of wave refraction diagrams as the bathymetric feature responsible for focusing a heavy SW'ly swell onto the coast between Steenbras River Mouth and Rooiels. However, in the case of a particularly long period SW'ly swell the effect of the Bank is to refract the wave energy even more – and focus it onto the Kalk Bay area Thus abnormal wave conditions in Kalk Bay can be associated with both heavy SW'ly and heavy SE'ly swell conditions.

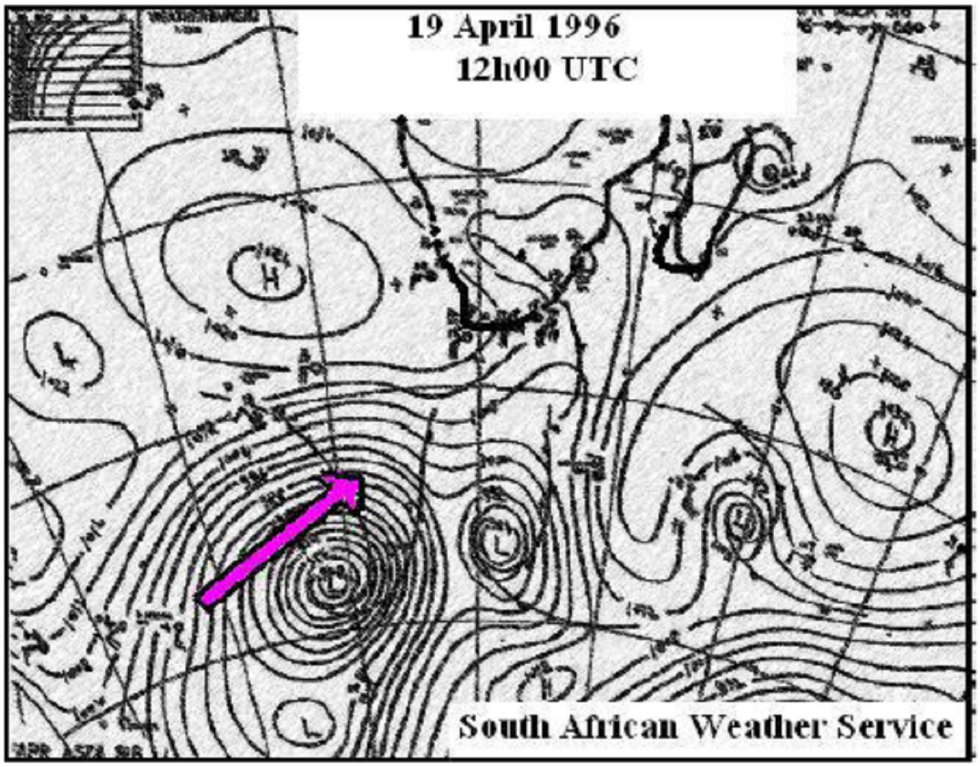


Figure A2: Sea level pressure analysis for 12h00 UTC on 19 April 1996. The arrow indicates the tight SW'ly fetch zone in which winds upwards of 60 kts were probably present. In the associated vortex central pressure dropped below 950 hPa.

Figure A2 shows the sea level pressure analysis associated with a long-period ***SW'ly swell*** that resulted in the deaths of 2 people, swept off the Kalk Bay breakwater on 21 April 1996 (cf red arrows in fig A3). Note that the date of the analysis is 19 April – 2 days before the swell arrived in False Bay. As the SW'ly swell travelled the ~ 2000 km wave energy would have been shifting into the longer periods (i.e. longer wavelengths). Even at 22m depth Rocky Bank had a marked effect, turning and focussing the swell into the northwestern corner of False Bay.

During the period 30 August to 2 September 2008, when many millions of rands damage was done to coastal infrastructure, the dominant wave-generating synoptic scale weather system was again a relatively fast-moving, intense mid-latitude trough. The near-record (deep sea) wave heights may well have been related to the propagation speed of the front and the extensive SW'ly fetch zone it dragged behind it.

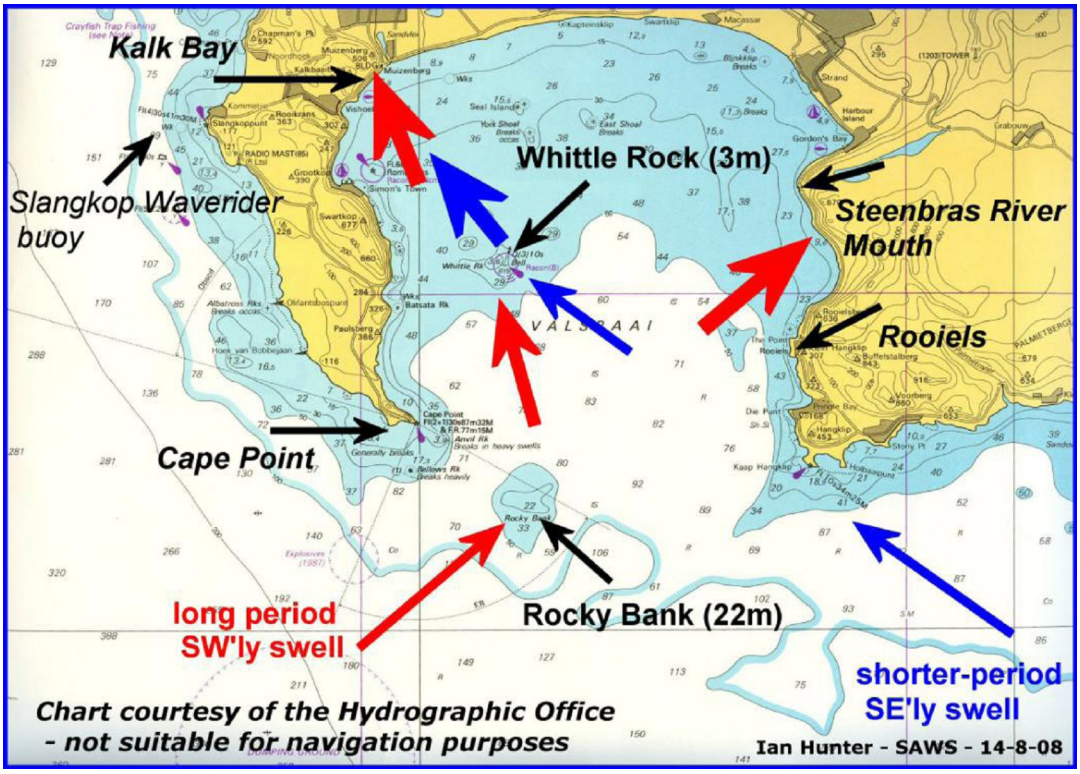


Figure A3: Refraction and focusing in False Bay – SW'ly (red) vs SE'ly (blue) swell conditions

Figure A3 has been annotated so as to indicate the relevant swell directions and some of the wave focusing areas associated with them. In the open ocean south of Cape Town a heavy SW'LY swell is far more common than one from the southeast, but in years when numerous cut-off lows are experienced over the Western Cape (e.g. 2008), Kalk Bay may suffer almost equally under both conditions.

Appendix 4: Wave type and energy

Characterisation of breaker types can be established through the surf scaling parameter E

$E = (2*PI^2*H_b) / (g*T^2*\tan^2(beta))$ H_b is breakpoint wave height
T is wave period
Beta is surf zone bottom slope

E is also related to the Iribarren Number given by the square of the bottom slope divided by the wave steepness.

Spilling breakers	20<E	dissipates energy evenly through entire surf zone.
Plunging breakers	2.5<E<20	dumps energy at the break point.
Surging breakers	E<2.5	carries energy to beach to be reflected.

Flat beaches, such as Muizenberg, are associated with spilling breakers and are referred to as dissipative beaches. Steep beaches, where deep water comes close to the coast, are associated with surging breakers and are referred to as reflective beaches. Estimates of inshore bottom slope are needed for the calculation of surf scaling parameter, particularly on exposed beaches. The bathymetric charts may not give enough information close to shore, but video studies can help.

Estimates of wave period can be obtained from the observations of the big storm waves at the Slangkop buoy. An estimate of the break point wave height can be obtained from the deep(er) water wave height at the Slangkop buoy by using Komar's approximation.
$H_b = 0.39\, g^{0.2} (T\, H_0^2)^{0.4}$ T period, H_b break point height, H_0 buoy height.

Appendix 5: Terms of Reference for Phase 5 study

The primary objective of this study is to improve understanding of the extent and manner in which City of Cape Town's coastline is likely to be impacted by sea level rise. It is propose to achieve this by adding the influence of local factors such as offshore bathymetry, storm direction and coastal geography to the sea level rise model developed in Phases 1-4, and by including an understanding of how the various influences on sea-level rise interact with each other at a specific locations and over time.
Realising this primary objective rests on the incorporation of data pertaining to:

- Knowledge of the offshore wave climatology.

- The detail of the coastal bathymetry and its influence on wave run up.

Both these data are limited by the resolution of available observations. This appears to be recognised in the Terms of Reference by the restriction of the wave directions to the coarse compass directions NW, W, SW, S and SE. The course resolution will place constraints on the type of model and the accuracy of the results that can be expected from such models. Nevertheless, it should be possible in this Phase 5 to achieve the outcomes asked for in the Terms of Reference, namely:

- Develop a finer scaled and more accurate approach to the existing GIS model by identifying areas at risk due to a uniquely varying shoreline, bathymetry and coastal geography;
- Apply five storm direction scenario's to the City's coastline (NW, W, SW, S and SE);
- Identify key risk areas for each storm direction scenario based on swell direction, bathymetry, shoreline, swell shadows and coastal geography, and
- Improve the level of accuracy in the predictions for sea level rise events

Once these key risk areas have been identified, further observation programmes at a greater resolution can be contemplated, with a view to obtaining more predictive capability from the use of sophisticated inshore wave models.

The approach proposed for this study is to add to the factors in the existing GIS to enable impact variability along the coast to be assessed and predictability improved. The following aspects will be investigated:

- Swell dynamics i.e. characteristics of swell direction;
- Correlations that may exist between the various swell characteristics i.e. average wave height and wave length may be associated to a particular swell direction, time of year, wind direction, weather pattern etc;
- Coastal areas that will receive specific swell head-on, and those that will be sheltered from swell based on the five different storm direction scenarios;
- Critical coastal bathymetry. Shallow offshore banks will play a significant role in reducing swell energy reaching the coast whereas deeper near-shore bathymetry will result in increased wave energy reaching the coast;
- The effect of coastal geology and topography on hinterland vulnerability (sandy shore vs rocky shore)
- The direction and dynamics of longshore drift;
- The presence, state and influence of other natural barriers i.e. kelp forests in terms of reducing the impacts of storm swell and in which areas;
- The physical composition of the beach: A combination of rocks and sand tends to be more susceptible to erosion, and
- Vulnerable areas as a result of human development and activity.

Appendices References

Aarninkhof, S.G.J. (2003). *Nearshore bathymetry derived from video imagery*. PhD. Thesis, Delft University of Technology, 175 pp.

Holland, K.T. and Holman, R.A. (1993). The statistical distribution of swash maxima on natural beaches. *Journal of Geophysical Research*, 98, pp. 10271-10278.

Plant, N.G. and R.A. Holman. (1997) Intertidal beach profile estimation using video images. Marine Geology 140(1-2): 1-24.

Global Climate Change and Adaptation: City of Cape Town sea-level rise risk assessment.

Phase 5: Sea-level rise vulnerability assessment and adaptation options

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1. Introduction

People have been adapting to variability in the City of Cape Town's coastal zone for as long as they have lived there, but anthropogenic climate change presents novel challenges and is exposing the imprudence of some of the coastal development that has taken place.

Phase 3 of this study (Brundrit et al., 2008) estimated that 25 km^2 of land interior to the City of Cape Town's 307 kilometre coastline is currently exposed to high sea-events 2.5 metres above land levelling datum (LLD), caused by a coinciding extreme high tide and storm surge. There is R5 billion worth of infrastructure and property within Cape Town's 2.5 metre contour, and although no single event would affect all of this at the same time, it is clear that the City is exposed to sea-level rise risks. Seas 2.5 metres above LLD are not common, but as storms become more frequent and the mean sea-level platform on which these storms and tides manifest is raised, this could change.

In the initial component of this Phase 5, Brundrit advanced the work undertaken in Phases 1-4 by identifying those areas of the City of Cape Town's coastline that are particularly vulnerable to this "current worst case" scenario. In mapping this vulnerability, Brundrit applied four physical attributes – (1) wave set-up as influenced by bathymetry, swell direction, swell conversion and shoaling (2) wave run-up as influenced by the topography of the coast and bathymetry (3) geological predisposition of the coastline as influenced by the hardness or softness of the coastline and (4) the extent and nature of coastal development – to the altitude parameter that was used exclusively in Phases 1-4:

i. **Wave set-up** is a function of wind, swell direction and the extent to which waves are refracted by the coastal topography; refraction reduces wave energy. Brundrit shows that most significant sea-surges off the Cape Town coast approach from the south-west (200 - 260°). Coastlines that front directly to these seas are the most vulnerable. Offshore reefs, islands and wave refraction typically reduce exposure to wave set-up. Thirty two "wave set-up events" – waves off the coast of over 6.5 metres lasting longer than 6 hours – were recorded off the City of Cape Town's Atlantic coastline between 1981 and 2003. Brundrit notes a correlation between these events and warmer sea surface water south west of Cape Town, and suggests a better understanding of the relationship between atmospheric temperature, sea temperatures in this region and large waves is important.

ii. **Wave run-up** is defined by the extent to which waves advance inland once they have broken, and the energy with which they advance. Wave run-up is reduced by bottom friction and accordingly coastlines with gradual gradients, coarse shallow sea-surface bottoms (such as those with reefs) and beaches protected by kelp tend to be less prone to wave run-up. Conversely where deep water is found close to the coastline, wave run-up can cause aggressive coastal erosion and damage. Wave run-up can be influenced by "wave focusing" – the convergence of waves from different angles, as is the case at Kogelbaai in False Bay.

iii. **Coastal geology** determines the hardness or softness of the coastline. The hardness (rockiness or sea-wall) or softness (sand or vegetation) of a coastline in turn determines its "natural" ability to withstand or recover from sea-level rise risks and its predisposition to storm damage. As a rule of thumb soft coastlines are more able to absorb wave energy and withstand sea-level rise impacts than hard coastlines. Well engineered coastlines can, of course, reduce sea-level rise risk but the danger is that poorly engineered coastlines either transfer or concentrate wave energy onto a single point or are over-topped by high seas. The engineering of coastlines usually takes place at the expense of natural buffers, and where (hard) engineered defences are breached the coast is particularly vulnerable. In this way some of the most vulnerable coastlines are those that involve a combination of hard and soft surfaces. Roads built on beaches and sea-walls in conjunction with sand dunes, are particularly vulnerable.

iv. **Value and strategic nature of the development.** From the City of Cape Town's perspective, coastal vulnerability is a function of the assets (natural or constructed) that the coastline contains. This is true in two ways. Firstly the assets, whether houses, roads or wetlands, are a part of the coastline's composition and determine the damage that a given storm event can cause. Secondly, the value (both economic and strategic) that the coastline contains determines the extent of what is at risk from sea-level rise. If a section of coastline containing a major access road to the City is at risk from sea-level rise, this is probably a greater priority than a remote section of coastline at which only sand and rocks are exposed. Similarly, if a wetland that prevents flooding and provides a habitat for rare species is at risk, this is arguably a greater priority than a section of coastline containing only common vegetation and no specific habitats. The nature and extent of development provides further important insight into who is liable for sea-level rise damage and the cost of adaptation measures. Private infrastructure - houses for example - that have been constructed naively close to the sea may present the potential for significant loss of value (especially where the houses are high value), but may not be considered the City's responsibility. Public infrastructure or infrastructure that if damaged will have a significant impact on the public may in contrast be considered a high priority for the City.

By screening for exposure to wave set-up and wave run-up Brundrit was able to identify those areas that were respectively:

- "Sheltered": Currently exposed to events 2 metres above land levelling datum, and most sensitive to changes in mean sea-level.

- "Exposed": Currently vulnerable to some wave run-up and set-up capable of causing events 4.5 metres above land levelling datum. These areas are exposed to changes in both mean sea-level and the changing nature of storms and sea-surges.

- "Highly exposed": Currently prone to events of 6.5 metres and vulnerable to both wave set-up and run-up. For these areas the changing nature and frequency of storms is critical, and the rising mean sea-level is important.

Figure 1 shows (in yellow) "sheltered" coastlines as well as the extent of the exposure of Cape Town's Atlantic coast to storm action. Local experts drew on their knowledge of past events to "ground truth" this work and a collective effort identified "hot spots" around the City of Cape Town's coastline. Hot spot locations are particularly vulnerable to coastal damage. In taking this step it was necessary to add the distribution of valuable infrastructure and human settlement to Brundrit's physical and climate oriented map.

A key realisation to come from Brundrit's work is that different coastal settlements are vulnerable to different combinations of change in mean sea-level, swell direction and size and wave run-up.

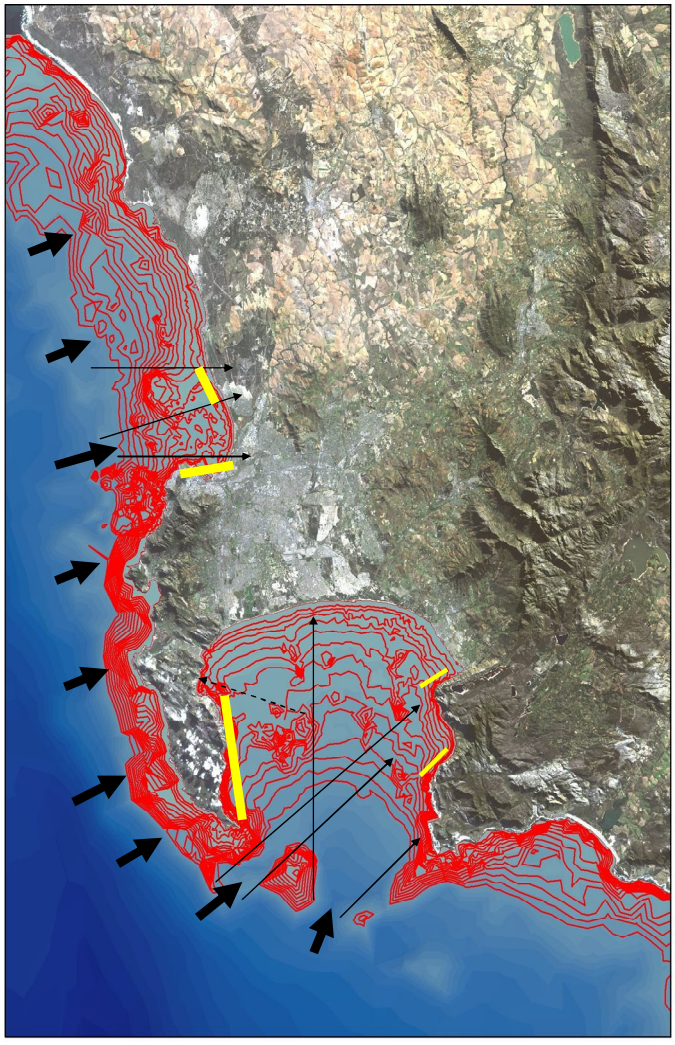


Figure 1: Sheltered and vulnerable regions based on wave set-up and wave run-up. (Source: Brundrit, 2009).

The hotspots were then subjected to an additional screen that involved including hardness and softness of the coastline and the extent and nature of coastal development to the parameter of wave set-up and run-up. The four parameters were used to provide a screen that differentiated the extent and reason for vulnerability at the respective "hot-spot" locations (see Section 3).

2. New risks to Cape Town's coastal zone

In most instances the list of vulnerable "hot spot" locations confirms what people in the City of Cape Town already know. In some instances efforts are already underway to protect these areas. This might suggest that approaches used to cope with sea-level rise events in the past, provided they are maintained, will serve Cape Town's residents well in the future. After all many of the topographical and geological parameters applied in identifying exposure to wave run-up and wave set-up are not changing over time frames that are significant to planners.

New concerns over coastal vulnerability in Cape Town are based both on (1) the increasing value of infrastructure, property and human life found proximal to the coastline and (2) changes in mean sea-level (land levelling datum) and the frequency and intensity of storms. There is further concern over the lack of a coherent approach in dealing with arising threats, and the reliance on ad-hoc and reactive responses. The basis for these concerns is expounded below:

2.1 Mean sea-level:

Measures of mean sea-level are complicated because the sea is neither level nor rising at a uniform rate around the world. The Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (2007) cited an average change in sea-levels of 0.17 (0.12-1.22) metres over the 20th Century and projected an upper-limit increase of 0.59 (0.18-0.59) metres by 2100. For all but the world's low lying islands these changes are within the bounds of previous high tides and severe storm surges. However Krabill et al. (2004), Velicogna and Wahr (2006), Rignot and Kanagaratnam (2006), Hansen[1] (2007) and Tol et al. (2008) have questioned the IPCC projections. Much of their work is focussed on the potential for non-linear, rapid melting of the Greenland and West Antarctic Ice Sheets. Such events would result in sea-level rise an order of magnitude greater than those projected by the IPCC. The likelihood of larger and more rapid sea-level increases appears to be supported by a range of anecdotal observations recorded in UNEP's 2008/9 Year Book[2]. Collectively this evidence suggests that atmospheric temperature increases are merely the catalyst for complex ice sheet collapse processes that, once underway, become driven by more than temperature. UNEP (2009) notes:

[1]Jim Hansen is head of NASA's Goddard Institute for Space Studies.

[2] The Year Book was released on 10 March 2009 in Nairobi.

- In 2008, for the second year in a row, there was an ice-free channel in the Northwest Passage through the islands of northern Canada. 2008 also witnessed the opening of the Northern Sea Route along the Arctic Siberian coast. The two passages have probably not been open simultaneously since before the last ice age some 100,000 years ago.

- The Greenland Ice Sheet, which could raise sea levels by six metres if it melted away, is currently losing more than 100 cubic kilometres a year. This is faster than can be explained by natural melting.

- Losses from the West Antarctic Ice Sheet increased by 60 per cent between 1996 and 2006, while losses from the Antarctic Peninsula increased by 140 per cent over the same period.

There is, then, some uncertainty over the extent and rate of climate change induced sea-level rise. What is clear is that globally sea-levels are rising, the rate of rise is increasing and relatively small increases in mean sea-level have disproportionately large impacts on the damage that storms cause to the coastal zone.

Measurements taken at Port Nolloth between 1962 and 1987 (Brundrit, 1995) and Durban between 1970 and 2003 (Mather 2007) show average rises of 1.2±0.4 mm per annum and a 2.7±0.05 mm rise per annum, respectively. Based on this Brundrit concludes that mean sea-level in Cape Town is probably rising in line with the global mean, and is currently 0.2 metres above the average for the past 100,000 years. In the context of a tidal flux for the same region of 2 metres and storms that produce 2 metre waves, this may not sound particularly significant, but (as shown in Figure 2) a small increase in mean sea-level reduces the frequency with which a 1.7 metre sea-level rise event occurs from one in 700 years to one in 40 years. Sea-level rises lag atmospheric warming due to the processes that govern thermal expansion of the oceans. The mean sea-level rises that are already inevitable, based on existing atmospheric warming, will see dramatic coastal events becoming more common along the Cape Town coastline. Not only would this reduce the recovery time between events, but it would also allow the sea to impact upon sections of the coastline that have little resilience to such impacts.

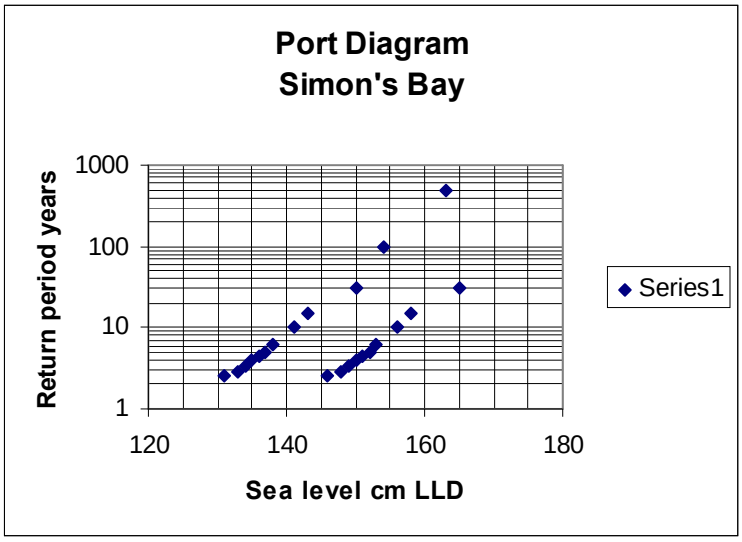


Figure 2: Return period of extreme sea levels expected in sheltered areas at the present time, and after sea-level rise of 20cm. The figure shows that return times of extreme sea-level events are a log function of land levelling datum; small changes in land levelling datum have a disproportionate impact on the frequency of extreme events.

2.2 Coastal storms:

The risks caused by changes in mean sea-level are compounded by the anticipated impacts of climate change on the intensity and frequency of storms. SwissRe (2009) projects a small decrease in the number of extra-tropical cyclones, but a 15-20 per cent increase in the occurrence of severe extra-tropical cyclones, particularly in the southern hemisphere. SwissRe's conclusion is supported by Lambert and Fyfe (2006) and broadly consistent with the findings of Bengtsson et al. (2006), who cite a "poleward shift" of mid-latitude storm tracks.

Definitive local studies of the relationship between atmospheric temperature and storms are still emerging, but the available downscaled evidence is consistent with the international trend (Tadross[3] pers. comm.). A more specific hypothesis (Brundrit, 2008) proposes that the Atlantic coastline is being exposed to increasing frequency and intensity of south-west storms – the storms that have accounted for all of the major sea-level rise events in the past three decades (Schumann and Brink, 1990) - but definitive support for this is not yet available. MacDeevit and Hewitson (2007) projected a doubling of the incidents of extreme winds (7.6 m/s) in the Western Cape by 2081-2100, and it is known that increases in wind speed cause a disproportionate increase in wave height. Brundrit (2009) shows that "very big wave events" have occurred every 11 years on average over the past two hundred years, but notes four such events in Cape Town in the past twenty six years.

[3] Mark Tadross is a climatologist at the University of Cape Town's Climate Systems Analysis Group.

In short there is the distinct possibility that either or both the frequency and intensity of the south west storms that cause most of the coastal damage in the City of Cape Town, could be exacerbated by climate change and monitoring this change will be particularly crucial for those locations exposed to south west wave set-up and wave run-up.

2.3 Socio-economic development:

Cape Town's physical and climatological predisposition to coastal vulnerability is aggravated by institutional and socio-economic developments. Much of the peninsula's transport infrastructure (most notably the False Bay Railway line) is built on a wave-cut platform created 125,000 years ago by sea-levels 4-6 metres higher than present. At the same time coastal property has become increasingly sought-after and the value of coastal development has escalated. The country's White Paper on Sustainable Coastal Management (2000) describes the coast as a "national asset" and encourages "sustainable economic use" of this asset without compromising its "ecological integrity". In the past, however, land reclamation, the removal of coastal dunes, the stabilisation of sand that has historically replenished beaches, the development of estuaries (Turpie, 2004) and sand mining have collectively reduced many of the coast's natural buffers, exposing sections of the coastline to damage from increasingly variable and rising seas.

Cape Town's coastal development has altered the "hardness" and "softness" of coastline, which in turn influences the impacts that given waves, tides and changes to mean sea-level have on the coastline. As a rough rule softer coastlines – that is coastlines with a combination of vegetation, kelp, reefs, sand and natural contours – absorb wave energy better than hard coastlines containing rocks or walls. Soft coastlines can, however, be more damaged by storms and where the natural forms of replenishment and rehabilitation have been curtailed, can be easily perturbed and permanently damaged.

2.4 Coastal governance:

Institutionally the governance of coastal zones in Cape Town is patchy. Most beaches are officially "crown land" and under the jurisdiction of national government, but the land immediately adjacent to beaches belongs to an array of national government departments, agencies and local authorities. The public company Portnet is responsible for the Cape Town harbour, but The City of Cape Town is obliged to extend and maintain services to individuals and companies that own coastal land and have received planning permission. Unfortunately the authorities granting planning permission are not always the same authorities that are cognisant of sea-level rise risks.

The situation is compounded by the historical exclusion of much of Cape Town's population from coastal amenities and coastal properties. Under apartheid, black and coloured people were not able to share in the development of coastal property that proved lucrative for white Capetonians, and were not permitted to share public amenities such as beaches and swimming

pools. Politically motivated restrictions to coastal access in the past make current attempts to prevent coastal development sensitive.

3. Assessing sea-level rise risk at Cape Town's coastal locations

Table 1: Components of sea-level rise vulnerability for different exposed locations around the City of Cape Town coastline

	Wave set-up	Wave run-up	Coastal geology. Hard or soft surfaces.	Risk to infra-structure and ecological assets	Comment
Table Bay: This is an area of gently sloping bottom contours and a sandy coast fringed by low dunes and occasional rocky outcrops. Part of the coast is sheltered by Robben Island. The coast is eroding in the south, and is particularly vulnerable where it is backed by the lagoon of the Diep River.					
Melkbosstrand	1	0	0	1	Exposed to big well, but with some shelter from offshore reefs. Beachfront development and dune removal is problematic.
Blouberg (Bay)	1	0	0	1	Sheltered behind Robben Island, the beach should be an area of sand accretion. However, extensive development has encroached too close to the waterline. Protection is needed.
Tableview beachfront	1	0	0	1	Exposed to big waves, where the Beach Road will become at risk. Protection is needed.
Milnerton beach	1	1	0	1	Exposed to big waves and, at high tide, surging breakers. This is an eroding beach

					with a diminishing steep dune cordon. Potential major issue if the protection to Otto du Plessis Drive is lost.
Milnerton to harbour	1	0	1	1	Shadow zone, no big waves. Harbour construction has led to gradual erosion and set-back, with ongoing loss of coastal infrastructure. Sea wall needs constant maintenance. Oil pipeline is strategic.
Atlantic Coast: This is a rocky coast with cliffs, offshore reefs and extensive kelp beds. Deep water is found close to the shore, permitting big waves to crash onto the coast so that protection is needed for any infrastructure at sea level.					
Green Point & Sea Point	1	0	1	1	Exposed to big waves, but some shelter from offshore reefs. The coast is on an exposed wave cut platform at some height above the sea, but needs the protection of a strong sea wall requiring continuous maintenance.
Glen Beach	1	0	0	1	A small pocket beach with some protection. High value beach houses are exposed.
Camps Bay	1	1	0	1	This beach is exposed to big waves. Wide beach, but high sea levels can reach the Beach Road.
Bakoven cottages	1	1	1	1	Very exposed to big waves and wave run up, and constantly under threat, as the houses are low down and on a hard rocky surface.
Kommetjie	1	1	0	1	Very exposed as deep water close inshore.

					Development has taken place in the protective dunefield, reducing its effectiveness.
Witsands	1	1	0	0	Very exposed single building in dynamic dunefield.
False Bay Coast: Western coast is steep but well sheltered from big waves from the southwest. Within False Bay, the bottom contours are gently shoaling to the sandy northern shore. The eastern coast is steep.					
Glencairn	1	0	0	1	Railway line running along a low wave-cut platform. Sheltered in shadow zone, but perhaps the foundations of the railway line in the backing wetland need continual maintenance.
Fish Hoek dune section	1	0	0	0	In shadow zone, but backing wetland may lead to vulnerability.
Kalk Bay	0	1	1	1	In shadow zone from southwest, but exposed to focussing from the south-east, so that harbour provides.
Muizenberg corner	1	0	0	1	In the edge of the shadow zone, but protected by a wide and very flat beach with spilling breakers.
Strandfonetin – Baden Powell Drive / Treatment Works /	1	0	1	1	Not too exposed but the road and the infrastructure are too close to the water's edge.

Landfill.					
Monwabisi and Macassar Pavilions.	1	1	0	1	Exposed to surging breakers at high tide and during storm events, with erosion of dune field.
Strand (entire beach front).	1	0	1	1	Exposed beach with protection from offshore reefs, but infrastructure constructed close to water and poorly planned sea-walls.
Bikini beach	1	0	0	1	In swell shadow, but infrastructure too close to water and needs protection. Beach sand erodes.

The risk analysis in Table 1 provides a number of important insights. Most obvious is that sea-level rise risk – a term that is applied at various scales and in an increasing number of contexts - is location specific and the result of different causes. The same sea-level rise event can affect places located quite close together, in very different ways due to the topography of the location, the orientation of the coastline relative to swell direction, the hardness or softness of the coast and the extent and type of coastal development. Understanding the particular combination of wave run-up, wave set-up, coastal erosion, change in still water level and imprudently located construction that affects a given location, is essential in correctly monitoring the changing nature of this risk under climate change and in the formulation of effective adaptation measures.

Secondly unless the respective components of sea-level rise are understood, it is very difficult to manage the trade-offs between development and coastal protection in a coherent manner. The most appropriate responses to wave-set up risks and wave run-up risks will, for example, differ. Equally the construction of hard infrastructure at a location that is naturally “soft”, but prone to wave set-up (such as Llandudno beach), is unlikely to be effective and likely to cause unforeseen consequences. Similarly the use of soft measures – such as sand replenishment – at hard locations that experience exposure to wave set-up (such as Bakoven) is unlikely to prove effective.

A further insight to emerge clearly from the analysis is that most sea-level rise risks have their origins in ill-advised coastal development. Climate change induced sea-level rise is exposing poor coastal management. At all but two of the vulnerable locations, it is housing and infrastructure that is central to the sea-level rise risk, and whilst some of this is only at risk due to sea-level rise, most of it would be vulnerable even if the ocean was not rising. This is not to say that infrastructure and housing is the problem (this is clearly not the case), but to highlight the importance of applying diligence and caution in locating development. The City of Cape Town's coastal zone is dynamic and subject to climate change influences. Development that impedes the coastal equilibrium, and the shift in this equilibrium, invites economic and social risk. The OECD (2009) encourages "Climate conscious development"; the basis of this approach is based on an understanding that in an urban context the built environment defines the relationship between people and the natural environment. In the context of integrated coastal zone management and sea-level rise, the built environment should reduce and not amplify sea-level rise risks or transfer them to another location.

An interesting distinction arises when the type of coastal development is examined. The houses at Bakoven are vulnerable to wave run-up, wave set-up, due the hard nature of the coast and because houses have been built perilously close to the sea. The housing investment is, however, largely private and accordingly the City of Cape Town may not feel under any obligation to protect these houses but should ensure that any private measures undertaken to protect the houses is compliant with legislation. In contrast the infrastructure between Milnerton and the harbour is of public significance and includes an oil pipeline and a major feeder road for the City. In addition some of the coastal erosion in this region has been caused by the construction of the Cape Town port. Clearly both the infrastructure itself, the implication of the infrastructure being damaged and the potential liability is a public issue at this location and, unlike at Bakoven, should be prioritised for public attention.

Table 2: Combined risk caused by wave run-up, wave set-up, nature of coastline and extent of development at exposed locations around the City of Cape Town's coastline.

	Aggregate risk
Melkbosstrand	2
Blouberg (Bay)	2
Tableview beachfront	2
Milnerton beach	3
Milnerton to harbour	3
Green Point & Sea Point	3

Glen Beach	2
Camps Bay	3
Bakoven cottages	4
Kommetjie	3
Witsands	2
Glencairn	2
Fish Hoek dune section	1
Kalk Bay	3
Muizenberg corner	2
Strandfonetin – Baden Powell Drive / Treatment Works / Landfill.	3
Monwabisi and Macassar Pavilions.	3
Strand (entire beach front).	3
Bikini beach	2

Table 2 aggregates the different components of sea-level rise risks at different locations. The aggregation conceals important information, including information on that can be used to lower risk, but the aggregation does provide a sense of which locations are most exposed and most likely to require attention in the short term.

4. Adapting to sea-level rise

In the face of rising sea-levels, increasing frequency and intensity and of storm surges and pressure for coastal development, the challenge for the City of Cape Town is how to respond. Timely responses can reduce the cost of sea-level rise impacts, but responses themselves impose costs (Stern et al., 2006; Tol, 2006).

Responses to sea-level rise fall under the broad rubric of climate change adaptation. When climate adaptation concerns coastal zones the general consensus is that is that the best responses are location specific and take place under the remit of "integrated coastal zone

management" (ICZM).[4] The conceptual merits of ICZM are seldom disputed, but for local decision makers the challenge remains how to apply this theory in the face of intractable trade-offs and difficult to quantify risks. Specific to this challenge are the uncertainties surrounding, the extent of expected sea-level rise events, the timing of sea-level rise events, and establishing acceptable levels of public risk ("how safe is safe enough?"). Inherent uncertainties regarding future concentrations of greenhouse gases (IPCC, 2007) let alone how these concentrations will translate into changes in atmospheric temperature and ocean dynamics, make these questions impossible to answer precisely. What is clear is that the level of certainty that has, in the past, been assumed with regards to sea-levels along the Cape Town coast, no longer applies. This necessarily has implications for development planning, insurance, investment and emergency relief.

3.1 Adaptation as a set of decisions

In a stylised sense the options available to the City of Cape Town can be illustrated as in Figure 3.

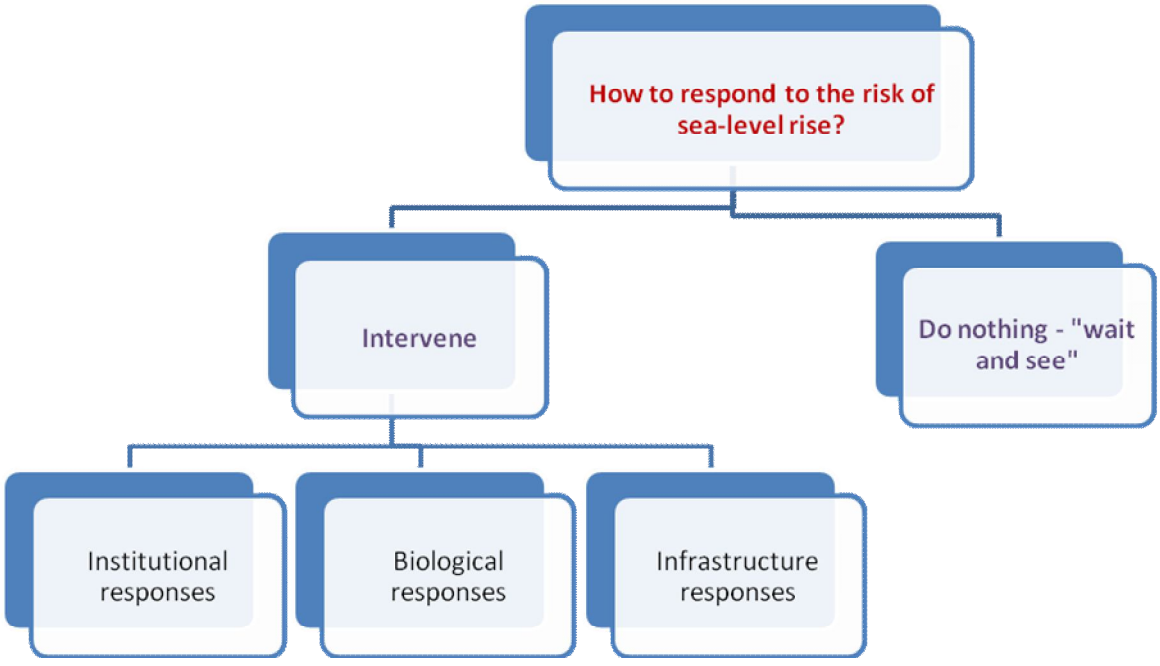


Figure 3: Options available in responding to sea-level rise risks.

The defining decision confronting the City of Cape Town is whether or not to do anything about sea-level rise at all. Adopting a "wait and see" approach is not as insouciant as it may

[4] ICZM aims to "Consider over the long term to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics" (Commission of European Communities, 2000)

sound. Past interventions have not been particularly effective, a delay permits additional information to emerge on the nature of the threat - information that can be applied in crafting a more appropriate response. The City of Cape Town needs to avoid setting a precedent that will see it called upon to safeguard its coastline in an untenable number of cases. By intervening to ensure people's safety in the face of a sovereign threat, it is possible to promote moral hazard in the form of civil apathy or worse, a continuation of hazardous coastal development. The final, and often most relevant appeal of the "wait and see" approach lies in its avoidance of the costs that are often incurred in adaptation efforts. This cost avoidance, however, can represent a false economy. Stern et al. (2006) and SwissRe (2009b) emphasise that money spent avoiding climate change impacts in the immediate term, save much larger amounts of money required to deal with the consequences of these impacts. The merits of early action are both moral and financial, but where this ignored in favour of a "wait and see" approach there should at least be an increased investment in disaster relief capacity.

Assuming that something must be, the next decision involves selecting "what". Phase 4 of this study identified a range of options. The most attractive of these were considered "no regrets" in their nature; the sort of options that the City of Cape Town should be doing even if sea-level rise were not a threat, but which will reduce the risk of sea-level rise if implemented. These include not reclaiming additional land, protecting wetlands, estuaries and dune cordons from further degradation, maintaining drains and stormwater systems so as that they operate to their specifications and alleviating poverty so as to reduce exposure to a wide range of risks, including the risks imposed by sea-level rise.

The more difficult decisions lie in selecting options specifically aimed at countering the sea-level rise risk. Phase 4 classified options into:

- Infrastructure interventions – sea-walls, groynes, barrages and barriers, raising infrastructure, revetments, rock armour, dolosse and gabions, off shore reefs, beach nourishment, water pumps, beach drainage.
- Biological interventions – dune cordons with vegetation, estuary and wetland rehabilitation, kelp beds.
- Socio-institutional interventions – vulnerability mapping, risk communication, apply legislation (Coastal Development Guidelines, Integrated Coastal Management Bill, White Paper on Sustainable Coastal Management), apply a coastal buffer zone, prevent sand mining, research and monitoring, early warning system, heightened disaster management system and insurance market correction.

Different approaches to deciding on options are illustrated (below) by their application to the sea-level rise adaptation options identified in Phase 4 in the context of a known City of Cape Town "hot spot", the Milnerton Golf Club. The club is constructed on a sandspit between the Milnerton Lagoon and the sea. The affronting beach is protected from large wave erosion by Robben Island, but the construction of the Cape Town harbour and foreshore land reclamation

have altered the near-shore currents so as to accelerate beach erosion at Milnerton. It is the coastal erosion caused by redirected long-shore currents and higher mean sea-levels to which the golf club is most exposed, although the lagoon on the landward side of the golf club exposes the building to the possibility of erosion from both sides. The local golf club is in currently in danger of being undercut and collapsing. The club's private efforts to protect its building have included sand bags and some beach replenishment, but these have not proven effective to date.

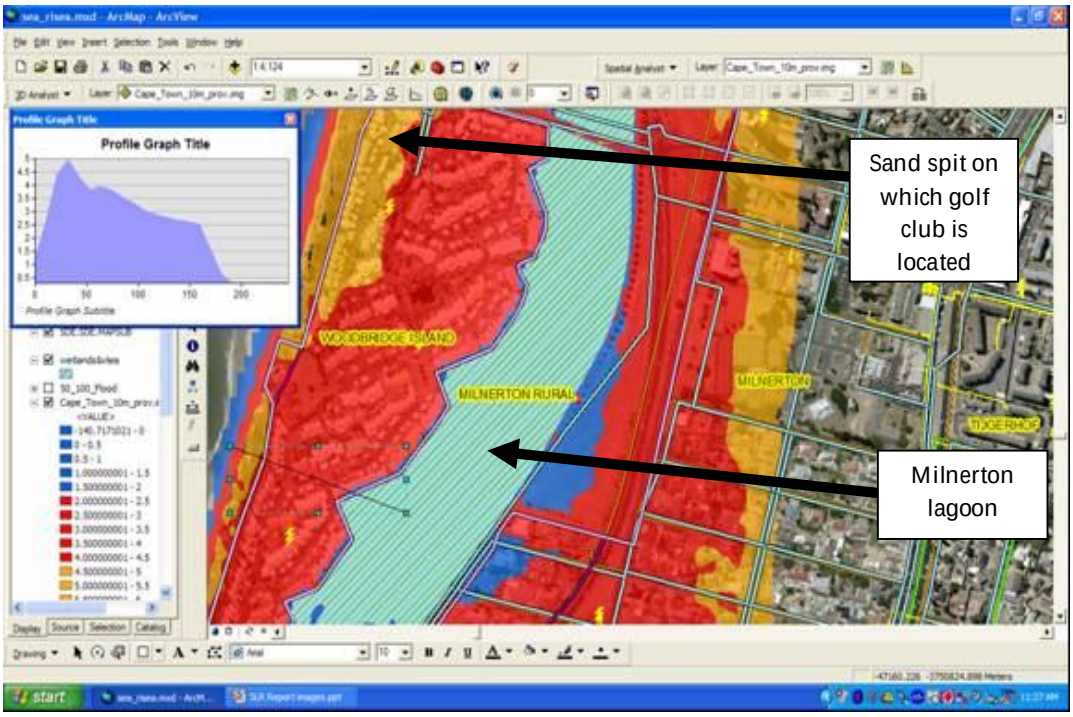


Figure 4: The Milnerton lagoon area close to where the Milnerton Golf Course is located showing the impact of a 2.5 metre (blue), 4.5 metre (red) and 6.5 metre (orange) sea-level rise increase, and the general exposure of the region to coastal erosion. (Source: Phase 2 of this Study).

3.2 Cost benefit analysis (CBA)

The conventional way of selecting adaptation options has involved cost benefit analysis (CBA) (Stern et al., 2006; Von Ierland et al., 2007; Hallegatte, 2008; SwissRe, 2009b); the options that save the greatest cost for the least expense are considered most desirable. Adopting this approach can be useful in securing financial and political support and CBA can be used - as demonstrated by SwissRe (2009b) - to distinguish between measures that:

- Are cost negative and therefore create savings, many of which are "no regret" options.

- Present economic benefits that outweigh the cost of implementation, and should be considered a prudent investment.
- Cost more than they save but which may be deemed necessary to protect human life, heritage or biodiversity.

A more interesting application for CBA involves its application in establishing long-term differences between biological, infrastructural and socio-economic options. Data and appropriate valuations remains a problem but when applied across a wide number adaptation options under different circumstances at different locations it becomes clear that generally (this is not always the case), socio-institutional options offer better returns than biological options, which offer better returns than infrastructural options (Figure 5 and 6).

There are, however, limitations to CBA. Typically the data required for such analyses are not available. It can be difficult to accurately assess both cost and benefits when the exact nature and timing of the threat is unknown, this type of analysis tends to treat options as discrete while in practice it is combinations of options that are likely to be most effective and there is subjectivity involved in valuing environmental goods and services and heritage products that are not traded in markets but recognised as being valuable in preventing sea-level rise impacts. Perhaps most critically CBA tends to suggest levels of precision and certainty in decision making that are not warranted, and even disingenuous, in the context of climate change impacts.

CBA can be useful as a decision support tool, but to apply it exclusively so as to attain some form of "financially optimal" solution to sea-level rise verges on hubris.

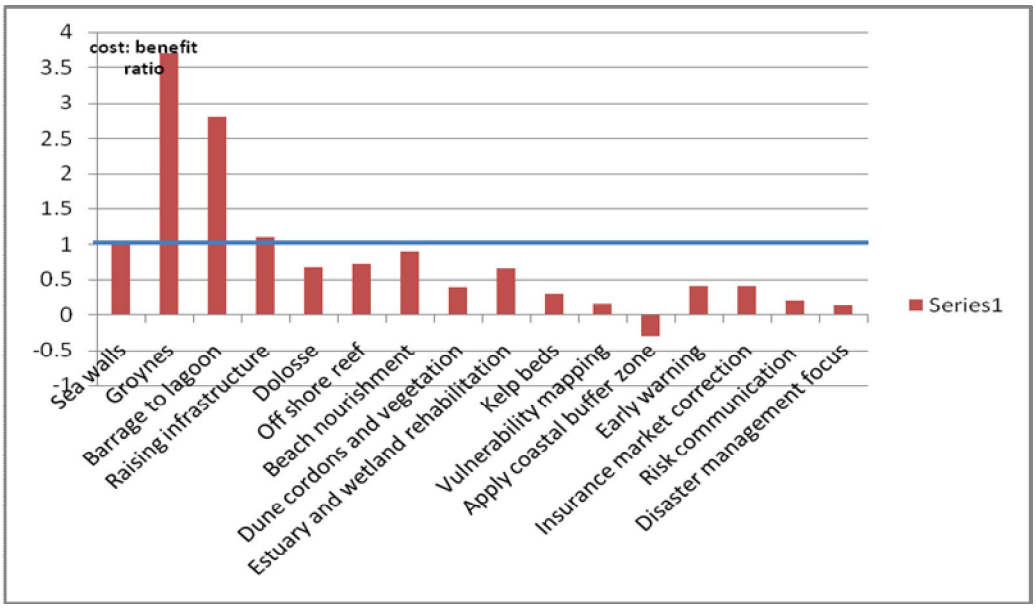


Figure 5: Hypothetical cost: benefit ratio for the adaptation options available to the Milnerton Golf Club (based on SwissRe (2009b)) estimates for sea-level rise damage in Florida. In practice it is difficult data to make these calculations and such efforts struggle to apply appropriate timeframes and values to costs and impacts. The analysis can be useful in showing that some options (those below the horizontal "zero" line) save money, some options (those below the blue line at 1) save more money than they cost, and some options (those above the blue horizontal line at 1) simply cost money.

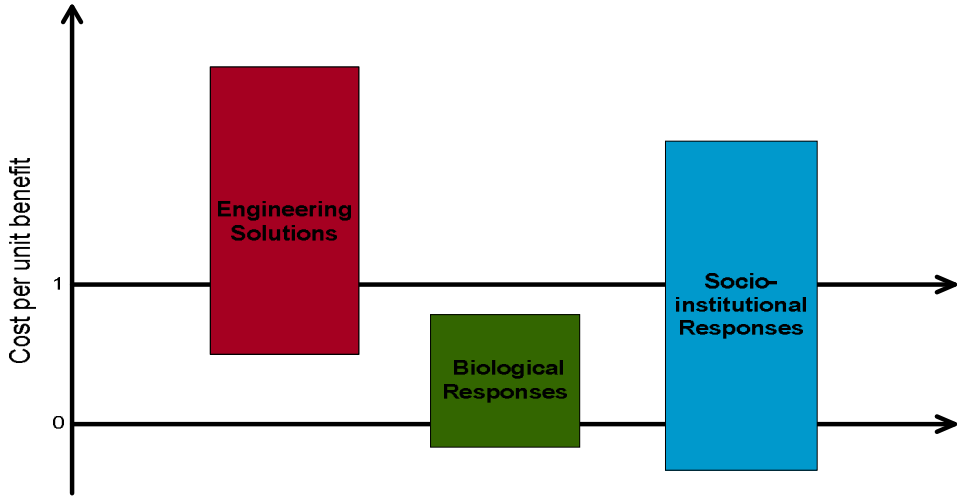


Figure 6: A stylised representation of the range of cost per unit benefit of general infrastructure (engineering), biological and socio-institutional adaptation options. (Source: Cartwright and Constable, 2009).

3.3 Multi-criteria assessment (MCA)

A more robust means of taking sea-level rise adaptation decisions involves subjecting options to a multi-criteria assessment (MCA). Under this approach options are interrogated in terms of an agreed upon set of assessment criteria, with the intention being to create multi-disciplinary consensus on the most appropriate course of action. Crucially MCA is well suited to create the type of institutional capacity that is required for effective climate change adaptation. Climate change adaptation theory emphasises the importance of "socio-institutional learning" (Downing et al. 2007), monitoring, reflexive institutions, ongoing decision making and iterative progress, all of which is more likely under MCA than CBA.

MCAs have been criticised for their subjectivity. The questions, "Who gets to select the criteria?" and "Who gets to perform the assessment?" are legitimate, but crucially MCAs of sea-level rise risks are capable of bringing together South Africa's particularly divergent development needs and integrating the needs of private land owners, local governments, provincial governments, various departments within national government and conservation authorities all of which have responsibilities towards Cape Town's coastline.

For the City of Cape Town the type of criteria that are relevant include:

- Risk reduction: The extent to which the options reduces risk of sea-level rise.
- Ease of implementation: Not all desirable responses are possible, either due to the institutional complexity involved in implementing them or their cost. In the case of the City of Cape Town, it is particularly important to identify who is responsible for the intervention and who will pay for the intervention. Options should be selected commensurate with capacity to deliver them effectively.
- Positive externalities: The extent of positive externalities associated with the option. Does the implementation yield, or make more likely, benefits that are not related to sea-level rise.
- Scope for mal-adaptation: Some options, and particularly infrastructural options, are more difficult to do well. Options should be selected cognisant of the need to avoid unintended negative consequences. This should include mal-adaptation arising uncoordinated private efforts.
- Cost: Budget constraints inform decisions and the extent of reduced impact per unit investment over the long term remains crucial.
- Greenhouse gas emissions: Options that involve large volumes of additional greenhouse gas emissions (beach pumping, cement structures) should be considered less suitable that those that do not.

- Reversibility and flexibility: Given that the precise extent and nature of sea-level rise impacts is not known, those options that can be reversed or altered as more information becomes available should be considered preferable.

- Retention of complementary options: Combinations of options tend to be more effective than single approaches but not all options permit complementary solutions. Those options that permit complementarily are favourable.

- Equality implications: Poor people tend to be more risk averse than affluent people. Cape Town remains a highly unequal society. The default when climate change interventions are not planned is for risk to be transferred to poor people who are least able to afford it or insure themselves against it. This will exacerbate Cape Town's inequality and underdevelopment. Effective adaptation options should be socio-economically progressive and where necessary transfer risk away from poor people.

MCAs are necessarily participatory activities, but by way of example a hypothetical application on the Milnerton Golf Course decision is conducted below.

Table 3: Multi-criteria assessment of sea-level rise options to support the Milnerton Golf Club.

	Risk reduction	Positive externalities	Institutional complexity	Scope for maladaptation	Cost	Contribution to GHG mitigation	Reversibility and flexibility	Retention of complementary options	Equality implications	SUM
Sea walls	2	1	1	1	1	1	1	1	1	10
Groynes	1	2	1	1	2	2	1	2	2	14
Barrage to lagoon	2	1	1	1	1	1	1	1	1	10
Raising infrastructure	1	1	2	1	2	1	1	1	1	11
Dolosse	3	1	2	2	2	1	1	1	2	15
Off shore reef	3	2	1	1	2	2	1	2	2	16
Beach nourishment	2	2	2	2	2	3	2	3	2	20
Dune cordons and vegetation	2	3	2	3	2	3	3	3	3	24
Estuary and wetland rehabilitation	1	3	2	3	2	2	3	3	3	22
Kelp beds	2	2	2	1	2	3	2	3	2	19
Vulnerability mapping	1	3	2	2	2	3	3	3	3	22
Apply coastal	3	3	1	3	1	2	3	1	3	20

buffer zone										
Early warning	2	3	3	2	3	2	3	3	3	24
Insurance market correction	2	2	2	2		2	3	3	2	18
Risk communication	1	3	3	2	3	2	2	3	3	22
Disaster management focus	2	1	3	3	2	2	2	3	3	21
Managed retreat	3	3	1	3	1	2	1	3	3	20

1= poor, 2= neutral / moderate, 3= excellent

MCAs are capable of producing more balanced and considered decisions than CBA, but like CBA they represent a decision support tool and should not be applied expediently. Certainly multi-criteria assessments do not provide a surrogate for good decision making. By applying quantitative scores to the options it is possible to get a sense of the relative merits of different options. The quantification should not, however, be exploited for inference purposes. In drawing inference, however, the distinction between a cumulative score of 18 and 19 should not be seen as the basis for decision making. MCAs are useful in identifying generally better options, and screening the options confronting decision makers. It is possible to refine the screen, scrutinise options under new criteria and even re-weight specific criteria that are deemed more important than others.

In the Milnerton example it becomes clear that infrastructural responses present problems on certain accounts: they tend to promote lock-in and hinder reversibility and flexibility, they present scope for mal-adaptation, they do not promote the use of complementary options, they protect only those that can afford to pay for the considerable cost and where infrastructure involves cement, it releases greenhouse gases. This finding concurs with the literature (Van Ierland et al., 2007; Hallegatte, 2008; SwissRe 2009b). There are specific instances – immovable assets such as harbours, or strategic infrastructure such as electricity substations - in which the use of infrastructure is essential and does represent the best option, but this tends to represent the last resort once other options have been exhausted. The MCA suggests that where infrastructure or engineering solutions are deemed necessary at Milnerton, beach nourishment, off shore reefs and possibly dolosse appear to be the most favourable options. Dune cordons with vegetation (if these can be adequately re-established and stabilised at this site) and an early warning system that triggers the placing of sandbags or simple evacuation and removal of valuable property are identifies as being suitable against a wide range of criteria. Where these options are shown to provide inadequate cover they can be easily complemented or enhanced. The same is not typically true of infrastructure approaches.

5. Conclusion

The City of Cape Town is at the forefront of developing country responses to climate change. Collectively, these responses involve an experiment as countries and cities grapple to establish workable solutions and guiding principles. In spite of the innovative nature of Cape Town's work, it is not the only country or institution to research or respond to sea-level rise risks: NASA's Goddard Institute[5], The United Nation's Environment Programme (UNEP), Climate Action Network International (CANI), Stockholm Environment Institute (SEI), the WeAdapt Partnership and eThekwini Municipality are among the other leaders in this field and there is some merit in exploring solution collectively.

This Phase 5 of the City of Cape Town's Sea-level Rise Risk Assessment study advanced the work undertaken in Phases 1-4 by exploring the detailed nature sea-level rise risks along the City's 307 kilometre coastline (including conservation areas).

The study highlights the location specific nature of sea-level rise events and distinguishes areas in terms of their exposure to mean sea-level, wave set-up and wave run-up, respectively whilst also including the "hardness" and "softness" of the coastline and the extent and nature of coastal development . Given that the phrase "sea-level rise" is used to describe an increasing variety of events, this distinction is central to gaining a better understanding of the nature of sea-level rise threats and allows monitoring and early warning systems to be tailored for specific locations.

The study supports the notion that the level of certainty that has been applied in the past with regards to sea-levels, no longer applies. Whilst sea-levels at Cape Town appear to be rising in line with the global mean, and the IPCC expects this mean to have increased by 0.18 – 0.59 metres by the end of the 21st Century, inherent uncertainty still defines projections and the evidence in support of far greater and more rapid increases appears to be mounting. Even small increases will cause disproportionately large impacts, especially where they are compounded by more intense (and possibly more frequent) storm events, as is expected.

A great deal of sea-level rise risk can be removed by timely interventions, but deciding exactly how to respond and who should take responsibility and pay for responses is complex. The nature of sea-level rise risks is subjective. The same risks affect different people in different ways and there is no single "socially acceptable" level of risk or loss, particularly where loss of life and private property is involved. The complex nature of sea-level rise risks make it inappropriate to leave the defining pronouncements and selection of adaptation measures on this matter, to either economists using CBA or actuaries applying risk calculation instruments. The need is for what SwissRe (2009b) term a "risk consensus"; a general agreement on the

[5] National Aeronautical Space Administration.

nature of sea-level rise risks and how this risk should be most appropriately shared in the context of other development goals.

This study applied a illustrative CBA and MCA to the adaptation options available to protect a known City of Cape Town sea-level rise hotspot, the Milnerton Golf Course. It is proposed that a multi-criteria assessment, provided the selection of criteria and assessment can be performed in a participatory manner, represents a more appropriate means of ensuring consistent and effective sea-level rise adaptation decisions in the long term.

Reference list

Bengsston, L, Hodges, K and Roecknet, E (2006) Storm Tracks and Climate Change. Journal of Climate 19, pp. 3518-3543.

Bindschadler, R (2006) Hitting the Ice Sheets Where it Hurts, Science 24 March, Vol. 311. no. 5768, pp. 1720 – 1721, DOI: 10.1126/science.1125226.

Brundrit, G (1995) Trends in Southern African sea level: statistical analysis and interpretation, South African Journal of Marine Science, vol. 16, pps 9-17.

Brundrit, G (2008) Global Climate Change and Adaptation – a sea-level rise risk assessment. Phase 1: Assessments of sea-level rise for the City of Cape Town.

Brundrit, G, Cartwright, A and Fairhurst, L (2008) Global Climate Change and Adaptation – a sea-level rise risk assessment. Phase 1: Assessments of sea-level rise for the City of Cape Town. Executive Summary Phases 1-4.

Brundrit, G (2009) Global Climate Change and Adaptation – a sea-level rise risk assessment. Phase 5: Full investigation of alongshore features of vulnerability on the City of Cape Town coastline, and their incorporation into the City of Cape Town Geographic Information System (GIS).

Cartwright, A (2008) Global Climate Change and Adaptation – a sea-level rise risk assessment. Phase 4: Sea-level rise adaptation and risk mitigation measures for the City of Cape Town.

Cartwright,A; Constable, L (2009) eThekwini Municipal Adaptation Plan; health and water. Municipal Climate Protection Programme: eThekwini Municipality.

Commission of the European Communities (2000), Communication from the Commission to the Council and the European Parliament on Integrated Coastal Zone Management: a Strategy for Europe (COM/2000/547/Brussels)

Downing, T. E., Cartwright, A and Smith, B (2007) Defining the Food and Agriculture's Role in Climate Change Adaptation. Report in partial completion of the compilation of FAO's Climate Change Adaptation Strategy. Available at: http://www.fao.org/climatechange/home/en/

Hansen, J (2007) Scientific reticence and sea-level rise. IOP Environmental Research Letters. Available at http://www.iop.org/EJ/article (Published 24 May 2007).

Hallegatte, S (2008) Strategies to Adapt to an Uncertain Climate Change. Global Environmental Change, 684, pp. 8.

IPCC (Intergovernmental Panel on Climate Change) (2007) Fourth Assessment Report (AR4), Synthesis Report, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 20 pp. Available at www.ipcc.ch

Kana, T; Michel, J; Hayes, M and Jensen, R (2005) The Physical Impact of Sea-level Rise in the Area of Charleston, South Carolina. Climate Change 52(1–2):65–91.

Krabill, W, Hanna, E, Huybrechts, P, Abdalati, W, Cappelen, J, Csatho, B, Frederick, E, Manizade, S, Martin, C, Sonntag, J, Swift, R, Thomas, R and Yunge, J (2004) Greenland Ice Sheet: increased coastal thinning. Geophysical Research Letters, 31: L24402, doi:10.1029/2004GL021533.

OECD (2009) Kamal-Chaoui, Lamia and Alexis Robert (eds.) (2009), "Competitive Cities and Climate Change", OECD. Regional Development Working Papers N° 2, 2009, OECD publishing.

Lambert and Fyfe (2006) Changes in Winter Cyclone Frequencies and Strengths Simulated in Enhanced Greenhouse warming Experiments: results from the models participating in the IPCC diagnostic exercise. Climate Dynamics 26, pp. 713-728.

MacDeevit, C and Hewitson, B (2007) Sea-level Rise on the Cape Coast. Atmospheric Science Working Paper produced after Honours Thesis 2007. Climate Systems Analysis Group, University of Cape Town.

Mather, A (2007) Coastal Erosion and Sea-level Rise: are municipalities ready for this? Internal Document, eThekwini Municipality, KZN, South Africa.

Nicholls, R., and Tol, R. (2006) Impacts and responses to sea-level rise: a global analysis of the SRES scenarios over the twenty-first century. Philosophical Transactions of the Royal Society, A, 364 (1841): 1073-1095.

Nicholls R, Tol R, Vafeidis, A (2008) Global estimates of the impact of a collapse of the West Antarctic Ice Sheet. Climate Change (special issue).

Revkin (2009) Northern Sea Route Through the Arctic Becomes a Reality. New York Times, 28 July, 2009.

Rignot, E. and Kanagaratnam, P. (2006) Changes in the velocity structure of the Greenland Ice Sheet. Science, 311: 986-990.

Schumann, E and Brink, K (1990) Coastal-trapped waves off the coast of South Africa: Generation, propagation and current structures. Journal of Physical Oceanography 20:1206–1218.

Siddall, M; Stocker, T and Clark, P (2009). Constraints on future sea-level rise from past sea-level reconstructions. Nature Geoscience, DOI: 10.1038/NGEO587.

Smith, A; Guastella, L; Bundy, S and Mather, A (2007) Combined marine storm and Saros spring high tide erosion events along the KwaZulu-Natal coast in March 2007. South African Journal of Science, 103: 274.

Stern, N., S. Peters, V. Bakhshi, A. Bowen, C. Cameron, S. Catovsky, D. Crane, S. Cruickshank, S. Dietz, N. Edmonson, S.-L. Garbett, L. Hamid, G. Hoffman, D. Ingram, B. Jones, N. Patmore, H. Radcliffe, R. Sathiyarajah, M. Stock, C. Taylor, T. Vernon, H. Wanjie, and D. Zenghelis (2006), Stern Review: The Economics of Climate Change, HM Treasury, London.

Swiss Re (2009) Influence of Global Warming on Extra-Tropical Storms. Climate Change Facts Compiled by ProClim. Available online at: http://www.swissre.com/resources/

SwissRe (2009b) Shaping Climate Resilient Development; a framework for decision making. Report of the Economics of Climate Adaptation Working Group.

Tol, R (2006) The Stern Review of the Economics of Climate Change: a comment, November 2, 2006. Available at: http://www-iam.nies.go.jp/aim/stern/Tol_sternreview.pdf

Tol, R; Klein, R & Nicholls, J (2008) Towards Successful Adaptation to Sea-level Rise Along Europe's Coast. Journal of Coastal Research, 24(2), pp. 432-442.

Turpie (2004) South African National Spatial Biodiversity Assessment 2004: Technical Report. Estuarine Component. Pretoria. South African National Biodiversity Institute.

United Nations Environment Programme (UNEP) (2009) Year Book 2008/9. Available at: http://www.unep.org/geo/yearbook/yb2009/

Van Ierland, E, de Bruin, K; Dellink, R and A. Ruijs (2007) A Qualitative Assessment of Climate Adaptation Options and Some Estimates of Adaptation Costs. Study performed within the framework of the Netherlands Policy Programme. ARK as Routeplanner projects 3, 4 & 5, Wageningen University.

Velicogna, I. and Wahr, J (2006). "Measurements of Time-Variable Gravity Show Mass Loss in Antarctica". Science 311 (5768): 1754-1756. vol 5, pp 107–140.

Appendix A: Terms of Reference for Phase 5 study

The primary objective of this study is to improve understanding of the extent and manner in which City of Cape Town's coastline is likely to be impacted by sea level rise.

It is propose to achieve this by adding the influence of local factors such as offshore bathymetry, storm direction and coastal geography to the sea level rise model developed in Phases 1-4, and by including an understanding of how the various influences on sa-level rise interact with each other at a specific locations and over time.

Realising this primary objective rests on the incorporation of data pertaining to:

- Knowledge of the offshore wave climatology.
- The detail of the coastal bathymetry and its influence on wave run up.

Both these data are limited by the resolution of available observations. This appears to be recognised in the Terms of Reference by the restriction of the wave directions to the coarse compass directions NW, W, SW, S and SE. The course resolution will place constraints on the type of model and the accuracy of the results that can be expected from such models. Nevertheless, it should be possible in this Phase 5 to achieve the outcomes asked for in the Terms of Reference, namely:

- Develop a finer scaled and more accurate approach to the existing GIS model by identifying areas at risk due to a uniquely varying shoreline, bathymetry and coastal geography;
- Apply five storm direction scenario's to the City's coastline (NW, W, SW, S and SE);
- Identify key risk areas for each storm direction scenario based on swell direction, bathymetry, shoreline, swell shadows and coastal geography, and
- Improve the level of accuracy in the predictions for sea level rise events

Once these key risk areas have been identified, further observation programmes at a greater resolution can be contemplated, with a view to obtaining more predictive capability from the use of sophisticated inshore wave models.

The approach proposed for this study is to add to the factors in the existing GIS to enable impact variability along the coast to be assessed and predictability improved. The following aspects will be investigated:

- Swell dynamics i.e. characteristics of swell direction;

- Correlations that may exist between the various swell characteristics i.e. average wave height and wave length may be associated to a particular swell direction, time of year, wind direction, weather pattern etc;
- Coastal areas that will receive specific swell head-on, and those that will be sheltered from swell based on the five different storm direction scenarios;
- Critical coastal bathymetry. Shallow offshore banks will play a significant role in reducing swell energy reaching the coast whereas deeper near-shore bathymetry will result in increased wave energy reaching the coast;
- The effect of coastal geology and topography on hinterland vulnerability (sandy shore vs rocky shore)
- The direction and dynamics of longshore drift;
- The presence, state and influence of other natural barriers i.e. kelp forests in terms of reducing the impacts of storm swell and in which areas;
- The physical composition of the beach: A combination of rocks and sand tends to be more susceptible to erosion, and
- Vulnerable areas as a result of human development and activity.

Global Climate Change and Adaptation:

City of Cape Town

Sea-level Rise Risk Assessment

Phase 5: Addendum

Wave run-up estimations from the application of Mather's extreme wave run-up model to 19 sites on the coast of the City of Cape Town, identified as vulnerable to sea level rise and storm surge, and a comparison with the actual wave run-up levels experienced in the 2008 storm.

Erich Koch

City of Cape Town

December 2010

The contributions of Andrew Mather and Geoff Brundrit to this Addendum are acknowledged with thanks.

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1. INTRODUCTION

The City of Cape Town (CoCT) is currently busy developing proactive management strategies to account for the increased environmental risks associated with increases in current mean sea levels due to climate change. Research has been undertaken to complete a full assessment on the risks of Sea Level Rise (SLR) around CoCT. Various vulnerable sites around CoCT's coastline have been identified (Figure 1), mitigation costs and possible management strategies have been proposed and a detailed GIS model has already been developed (Brundrit 2009).

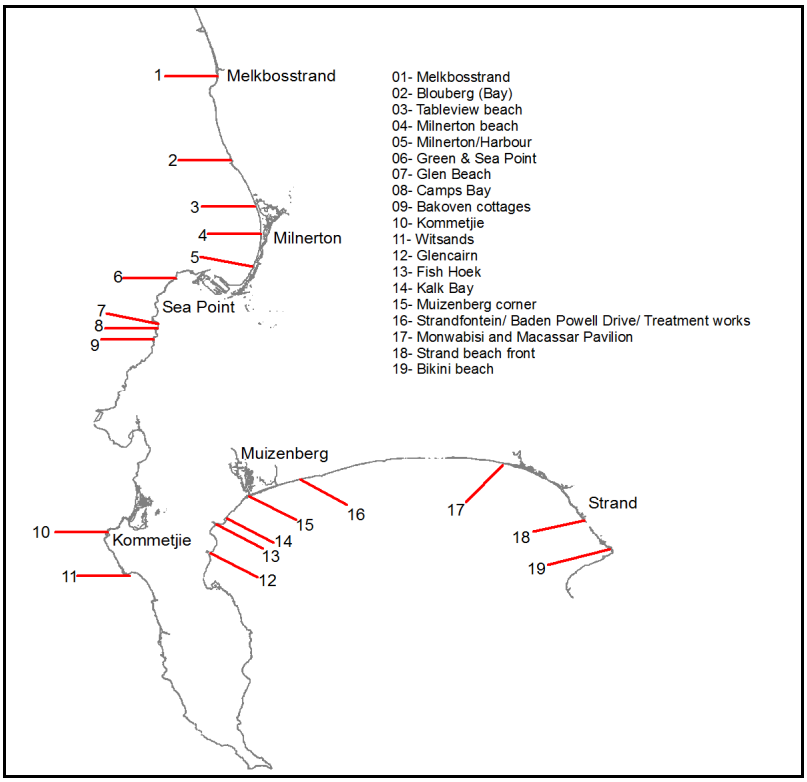


Figure1. The position of each of the 19 vulnerable sites identified in the fifth phase of the Global Climate Change and Adaptation – A sea level rise risk Assessment (ANON – City of Cape Town)

The SLR risk assessment study has identified three main factors which impact the coastline from the ocean: 1) mean sea level rise; 2) wave set-up and 3) wave run-up. Mean sea level is expected to influence every coastal site independently of exposure. Wave set-up is mainly a factor affecting beaches and wave-run is an additional factor which is only expected to bring increased flooding into very exposed sites as described in the Phase 5 of the SLR assessment (ANON – City of Cape Town).

This SLR assessment has completed required research to better understand expected effects of mean SLR and wave set up at each of the identified vulnerable sites around the CoCT. This study is aimed at getting a better understanding on wave run-up values expected at these sites.

Extreme wave run-up levels are important in many coastal planning processes but especially for providing a basis in which to identify the positions of appropriate coastal development set back lines. According to Mather *et al.* (*in press*), extreme wave run-up is defined as the maximum level, relative to the still water level reached by a wave (or group of waves) as they break and run up a beach profile. Accurately predicting expected wave run-ups on permeable beaches is essential if coastal development is to be planned sensibly and with due consideration of the risks associated with wave damage. The latest model described in Mather et al. (*in press*) has been shown in various independent tests to be the most robust wave run-up model available to coastal engineers for natural sandy beaches (Roberts et al. 2010).

Statistical measurements are used to characterize extreme wave events, using significant wave height return periods to calculate the probability and height of such extreme run-up events. Most of the numerous extreme wave run-up models developed over the years require input parameters which are often difficult and expensive to obtain (Roberts et al. 2010 and Mather et al. *in press*). For a more detailed description regarding various models, the components of wave run up and its respective interactions and the model used in this paper please refer Stockdon et al. (2006), Roberts et al. (2010) and Mather et al. (*in press*).

The purpose of this Addendum is too establish run-up estimates for each of the 19 vulnerable locations, which could possibly result in hazardous conditions for infrastructure and people or risks to economic stability in the vulnerable locations identified. This is aimed to provide additional information to risk rating for the 19 vulnerable locations identified by the previous SLR studies (ANON - City of Cape Town). City of Cape Town has tentatively identified a 6.5 m wave run-up level

above MSL for all the vulnerable location; this study will provide insight to identify which locations are at highest risk to wave run-up events, and to which extent wave run up events may impact the vulnerable locations.

2. METHOD

2.1 Mather et al. model

The model described by Mather et al. (*in press*) has been developed and been verified using the South African coastline, and has been developed to be affordable and easily applied to natural sandy beaches. The model departs from more traditional approaches that use the slope of the beach face, or the surf similarity parameter (also known as the *Iribarren* number) to predict run up, and instead uses the distances offshore to the -15m isobath as a proxy for the near-shore profile (figure 2). The model proposes a relatively simple formula to predict wave run-up:

$$R_x = C \times S^{2/3} \times H_0 \qquad (1)$$

where R_x is the predicted wave run-up above Still Water Level (SWL), C is the selected Coastline coefficient (table 1) and S represents the Shoaling effect of the slope to the profile [S = water depth (h) / distance offshore (x)]. (using a water depth h = 15m below mean sea level). H_0 is the deep water significant wave height. The sensitivity of selecting values for each parameter for the resulting wave run-up is shown in table 6 (Appendix 1).

It should be noted that the actual (land survey) level, reached by the sea, will also depend upon the state of the tide. A correction for the height of the Still Water Level above Mean Sea Level (Land Levelling Datum) needs to be applied. The calculation of this correction can be made with the use of the Tide Tables produced by the South African Naval Hydrographic Office.

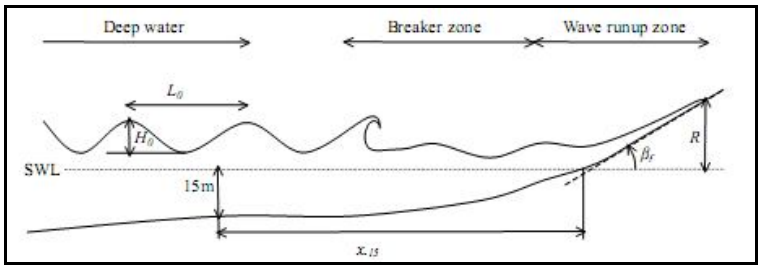


Figure 2. Showing parameters used in the model. R is the run-up value, x_{15} is the chart distance from the shoreline to the 15m isobath, H_0 is deep water significant wave height (taken from Mather et al. *in press*).

Table 1. Coastline Coefficients C for various types of coastline (taken from Mather et al. *in press)*.

Type of Coastline	Coefficient C		
	Upper bound of wave run up	Median of wave run up	Lower bound of wave run up
Open	C=10	C=7.5	C=3
Large embayment (~40 kms between headlands)	C=10	C=5	C=3
Small embayment (~3 kms between headlands)	C=10	C=4	C=3

2.2 Bathymetry

The distance between the 15m isobath and the mean sea level (MSL) on shore at each vulnerable site was calculated using bathymetrical contours obtained from the South African Naval Hydrographic Office. Using the City of Cape Town Geographic Information System database, the minimum distance from several transects at each identified vulnerable site (Table 2) was used to calculate the Shoaling Slope S at each vulnerable site.

Table 2. Nearest distance (m) from each vulnerable location to the 15m isobath as estimated from the CoCT GIS database.

Location	Nearest distance to 15m isobath (m)
Melkbosstrand	1850
Blouberg	1100
Tableview	1300
Milnerton	1100
Milnerton- Harbour	3700
Green & Sea Point	380
Glen Beach	940
Camps Bay	750
Bakoven	440
Kommetjie	1350
Witsand	700
Glencairn	480
Fish Hoek	990
Kalk Bay	660
Muizenberg	1820
Strandfontien	2270
Maccassar	1750
Strand	2470
Bikini Beach	2530

2.3 Coefficient selection

The coefficients used in the model were selected in accordance to the median values suggested by Mather et al. (*in press*) for each site listed as a vulnerable location. When the model is used for planning purposes rather than validation with observations, it may be better to use the maximum value rather than the median value of C.

Table 3: Co-efficient used in run-up calculations for each of the vulnerable sites, taken from Mather et al. *(in press)*

Area	Co-efficient
Melkbosstrand	7.5
Blouberg	7.5
Tableview	7.5
Milnerton	7.5
Milnerton- Harbour	7.5
Green & Sea Point	7.5
Glen Beach	7.5
Camps Bay	7.5
Bakoven	7.5
Kommetjie	7.5
Witsand	7.5
Glencairn	5
Fish Hoek	5
Kalk Bay	5
Muizenberg	5
Strandfontien	5
Maccassar	5
Strand	5
Bikini Beach	5

2.4 Significant wave heights

The extreme significant wave heights used in this study were collected from a number of various sources and are shown in Table 4. Significant wave height data around the CoCT coastline was difficult to obtain, mainly because of a lack of research undertaken on the topic.

Significant wave height data along much of the Atlantic coast were calculated from South Africa's longest-existing wave-height buoy record off Slangkop (figure 2), which has been collecting wave height data since 1976 (Rossouw et al. *in press*). The wave height data collected at the Slangkop data buoy is directly used as the deep water wave height for all the sites between Sea Point and Witsand.



Figure 2. Position of Slangkop Buoy, the longest wave record South Africa has along the coast, was used to calculate the significant wave heights for the various return periods used in this study (data supplied from CSIR, M. Rossouw).

The vector data collected off the Slangkop buoy is used as an input parameter to a wave height and refraction prediction model (figure 3), the online Virtual Buoy system. It was developed and is maintained by the CSIR for the Cape Town harbour (Rossouw et al. *in press*). The return periods and significant wave height data calculated at a Virtual Buoy point (Anchor 4) (figure 4) in Table Bay was used for the sites from the harbour to Blouberg. The data from the Slangkop wave buoy and the Table Bay Virtual Buoy was made available by M. Rossouw from CSIR Stellenbosch (all data is based on 3hourly readings, and was made available as first estimate data).

The return periods and heights calculated at more exposed site at Melkbos were obtained from short term (< 4 year) wave studies conducted in the 1980s around the Koeberg area (Rossouw 1989).

Since there was no significant wave height data or estimates available within the False Bay area, deepwater values obtained from Slangkop wave buoy were used for the analysis within False Bay.

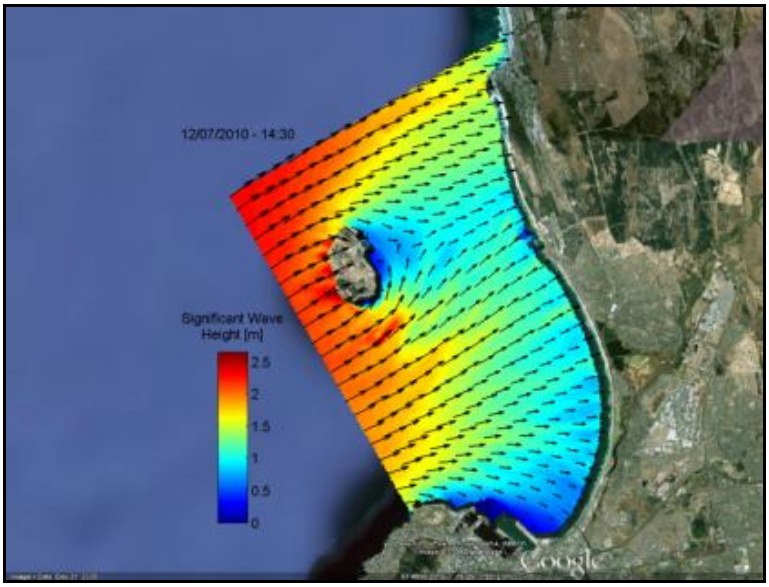


Figure 3. Resulting wave height and refraction predictions in Table Bay using real time data from the deep water Slangkop buoy off Cape Point. Taken from the wave net website with permission from CSIR (http://wavenet.csir.co.za/OnlineData/TableBay/TableBaywaveD.htm on the 12/07/2010). At the time of this image, the significant wave height at Slangkop ranged between 3-4m.

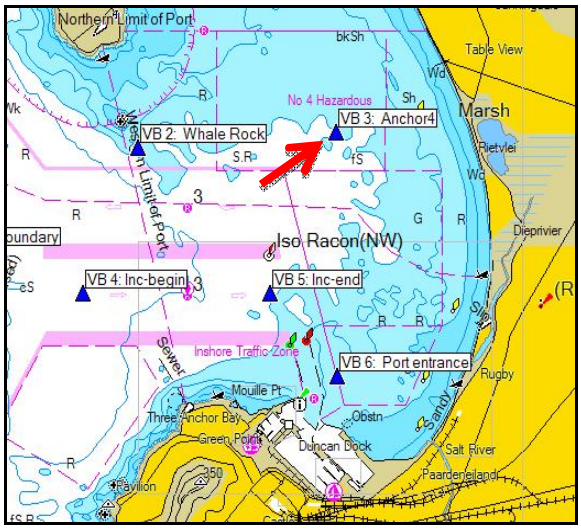


Figure 4. Position of the Virtual Buoy 3, Anchor 4 was used to calculate the return periods for the significant wave heights used in the study for the locations in the Table Bay area (image from M. Rossouw, CSIR Stellenbosch).

Table 4: Significant wave-heights used in wave run-up calculations for each of the vulnerable sites.

Area	**H_1**	**H_{10}**	**H_{50}**	**H_{100}**	**Data Source**
Melkbosstrand	7.5	8.4	9	10.3	Rossouw (1989)
Blouberg	4.1	5.1	5.7	6	VB CSIR (2010)
Tableview	4.1	5.1	5.7	6	VB CSIR (2010)
Milnerton	4.1	5.1	5.7	6	VB CSIR (2010)
Milnerton- Harbour	4.1	5.1	5.7	6	VB CSIR (2010)
Green & Sea Point	8.3	10.2	11.6	12.2	CSIR (2010)
Glen Beach	8.3	10.2	11.6	12.2	CSIR (2010)
Camps Bay	8.3	10.2	11.6	12.2	CSIR (2010)
Bakoven	8.3	10.2	11.6	12.2	CSIR (2010)
Kommetjie	8.3	10.2	11.6	12.2	CSIR (2010)
Witsand	8.3	10.2	11.6	12.2	CSIR (2010)
Glencairn	8.3	10.2	11.6	12.2	CSIR (2010)
Fish Hoek	8.3	10.2	11.6	12.2	CSIR (2010)
Kalk Bay	8.3	10.2	11.6	12.2	CSIR (2010)
Muizenberg	8.3	10.2	11.6	12.2	CSIR (2010)
Strandfontien	8.3	10.2	11.6	12.2	CSIR (2010)
Maccassar	8.3	10.2	11.6	12.2	CSIR (2010)
Strand	8.3	10.2	11.6	12.2	CSIR (2010)
Bikini Beach	8.3	10.2	11.6	12.2	CSIR (2010)

2.5 Actual extreme event comparison

An extreme storm event occurred around the coast of the CoCT during the period following 31st August 2008, which then affected most of the southern coastal area of the Western Cape Province. A frontal weather system developed approximately 600km south west of Cape Town as a secondary severe low pressure zone also developed, a case of explosive cyclogenesis. The combined effect of both extreme low pressure systems brought significant damage to harbours and coastal infrastructure (Mather et al. *in press*). The swell direction of this low pressure event resulted in southerly swell running parallel to the Atlantic sea board, and greater damage could have been expected if the swell direction had come from the West.

Mather et al. *(in press*) describe how storm surveyors recorded wave run-up heights above Still Water Level at beaches around CoCT. The values in Table 2 of Mather et al (*in press)* are compared to the results obtained by using the Mather model to calculate extreme run-ups

Table 5. Highest expected wave run-ups above Still Water Level for each of the vulnerable sites identified in the previous SLR studies around Cape Town (ANON – City of Cape Town), using the Mather *et al. (in press)* model.

	Highest expected run-up (m) in :			
Location	**1 year**	**10 years**	**50 years**	**100 years**
Melkbosstrand	2.1	2.6	2.8	3.2
Blouberg	1.8	2.2	2.5	2.6
Tableview	1.6	2.0	2.2	2.4
Milnerton	1.8	2.2	2.5	2.6
Milnerton- Harbour	0.8	1.0	1.1	1.2
Green & Sea Point	7.4	9.1	10.3	10.8
Glen Beach	4.1	5.0	5.7	6.0
Camps Bay	4.7	5.8	6.6	6.9
Bakoven	6.7	8.2	9.4	9.8
Kommetjie	3.2	3.9	4.5	4.7
Witsand	4.9	6.1	6.9	7.2
Glencairn	4.2	5.2	5.9	6.2
Fish Hoek	2.6	3.2	3.7	3.8
Kalk Bay	3.4	4.2	4.8	5.0
Muizenberg	1.7	2.1	2.4	2.6
Strandfontien	1.5	1.9	2.1	2.2
Maccassar	1.8	2.2	2.5	2.6
Strand	1.4	1.8	2.0	2.1
Bikini Beach	1.4	1.7	2.0	2.1

3. RESULTS

3.1 Table Bay

3.1.1 Melkbosstrand

Melkbosstrand is known for a beach which has relatively tame waves, but the open coastline can at times be exposed to big swell, and much larger significant wave heights are expected in Melkbos than in the area between Blouberg and the harbour (figure 3). Melkbos is just outside of the wave shadow zone created behind Robben Island and Sea Point. There is some shelter due to offshore reefs, and even though a significant wave height of ~10m is expected with a 100 year return period, the very shallow slope off Melkbos reduces the wave run up calculated by Mather's model to a maximum of ~3.2 m.

This expected run up value predicted by the model is very similar to the 2008 storm, where values along Melkbos ranged between 2.1 and 3.5m.



Figure 5. The location of transects along Melkbosstrand used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 2.2km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.1.2 Blouberg

Blouberg is well sheltered behind Robben Island, and the -15m isobath is located offshore of Robben Island, with it being further than 1100m from the shore (figure 6). Due to the shallow slope of the ocean floor in the Table Bay area and the smaller significant wave height of ~6m with a 100 year return period, results in a wave run-up estimate of <2.6m for all sites between Blouberg and Milnerton, and is expected to be <1.7m directly behind the Robben Island wave shadow zone.

The area around Blouberg experienced a wave run-up of between 2 and 2.8m in the 2008 storm, thereby confirming predictions made the model in that extreme event.



Figure 6. The location of transects along Blouberg used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 1.5km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.1.3 Tableview and Milnerton

Tableview and Milnerton are sites of open coastline, and are often exposed to large waves. For Tableview, due to the gentle beach slope, Mather's model predicts run-up values of 2.4 m with a 100 year return period (figure 7). The dumping waves experienced along this section of coast makes it very unpopular for swimming, and certain areas can be exposed to surging breakers during high

tide, resulting in a very high risk of eroding the base of Beach Road and the dune protection system that buffers Otto du Plessis Drive.



Figure 7. The locations of transects along Tableview used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 1.5km (Table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

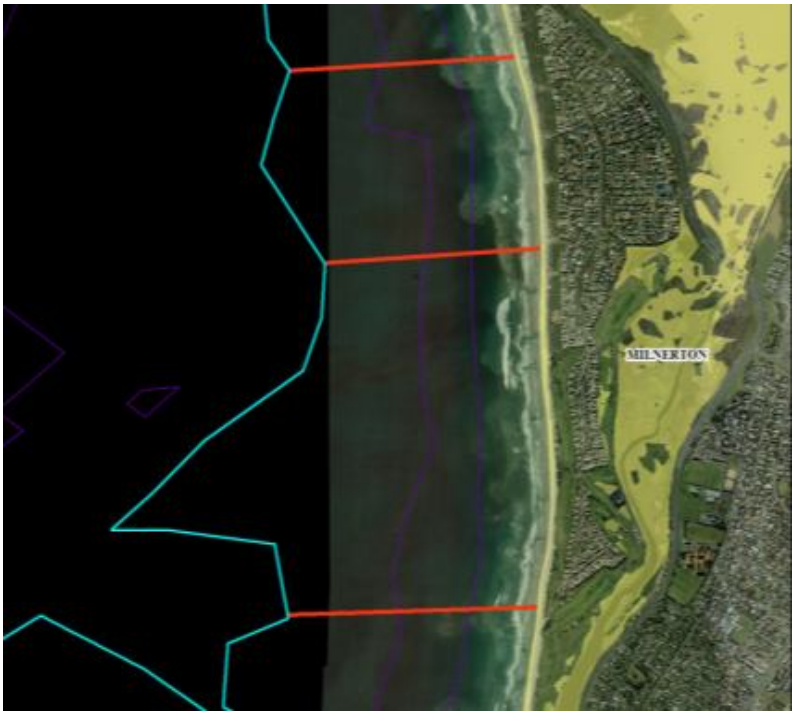


Figure 8. The location of transects along Milnerton used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 1.1km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

The recorded run-up experienced in these areas following the 2008 storm exceeded wave run-up values predicted by the model by 1.5m. Assuming that the compensation for the state of the tide has been correctly carried out, this discrepancy is possibly due to offshore and refraction dynamics occurring within the Table Bay area. The highest run-up experienced in the 2008 storm along this more exposed section of coast was at 4.8m just south of Milnerton, whereas the model predicted a 2.6m run up with a 100 year return period.

3.1.4 Milnerton to Harbour

The shoreline between Milnerton and the harbour is directly in the shadow zone created by Sea Point with very small waves in this area, even at times of strong winds. The nearest -15m isobath is more than 3500m away from this shoreline (figure 9). Even if a large westerly wave field were to enter into Table Bay, creating an unlikely wave height of ~6m (100 year return period) , the Mather model, wave run up is expected to be 1.2m

There were no records available to indicate the run-up values experienced by the 2008 storm for this area.



Figure 9. The location of transects along Milnerton to the Harbour used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 3.5km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.2 Atlantic Coast

3.2.1 Green Point

Green Point and Sea Point are often exposed to very large waves, with the -15m isobath being closest to the shoreline when compared to all the other vulnerable sites around CoCT (figure 10). The steep slope and large significant wave results in wave run up expected to be ~7.4 m at least once a year, and 10.8 m run-up with a 100 year return period. Green Point and Sea Point are both sites on a wave cut platform, with rocky shores and small isolated pocket beaches with offshore rocky reefs. The Mather model was not developed for such a beach type, but can be used as a crude estimate for the potential wave energy for the shoreline and sea wall protecting the infrastructure around this location (Brundrit *pers comm*). The estimated run-up in the current CoCT vulnerability GIS model can likely be increased to more than the current ~6.5m estimate. Due to the height of the Sea Point sea wall, Sea Point is well protected The area of high risk would be towards Mouille point at time of perpendicular swell, and it can be expected that the wave set-up and run-up to come past the Mouille Point Beach Road and cover the Metropolitan Golf club (figure 11).

The available records for the 2008 were only available towards the back end of Mouille point towards the V&A Waterfront development in the wave shadow zone, where wave run up exceeded 3m, but it is likely that greater values than that could be expected over Mouille point. Following large storm events, the Sea Point main road has often been flooded even with the protection offered from the high sea wall.



Figure 10. The location of transects along Sea Point and Green Point used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 390m (Table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.



Figure 11: Sea Point and Green Point showing expected flood levels to due to run-up in extreme wave events. Main areas of risk are the Beach Road and infrastructure off Mouille Point.

3.2.2 Glen Beach

Glen Beach is a small pocket beach with most houses built high on the rocks in the northern corner of Camps Bay beach (figure 12). The expected wave run up for both Camps Bay and Glen Beach are similar at ~6 m.

3.2.3 Camps Bay

Camps Bay is about 700m long and very exposed to the open ocean (figure 12). The beach is exposed to large waves and it is quite common that with high sea levels the waves reach the road, with a predicted 6,9m wave run up expected with a 100 year return period.

The 2008 storm seems to have focussed a lot of energy in this location, with run-up values being the highest in this region when compared to the rest of Cape Town, with run-up exceeding 7.5m. This is an area where Mather's model slightly underpredicts recorded storm values.

3.2.4 Bakoven

The rocky shores of Bakoven cottages are not intended to be studied using the sandy beach model of Mather et al. (*in press*), but once again the predicted wave run ups can be used as crude estimates of the risk of run up in such an area. The steep rock face on which most of the infrastructure is built lowers the risk of sea Level rise, but Bakoven's proximity to the -15m isobath (only about 500m) makes it a high risk location due to set-up and run-up (figure 12). According to the Mather model, if Bakoven were a natural sandy beach, wave run up could exceed ~6m about once a year and between 9-10m every 50years (Table 2).

This makes Bakoven and Sea Point the two sites at which potential run-up could have the most significant effects if the the tide is such that the Still Water Level is high enough to allow for overtopping to occur over the natural rocky barrier (or sea wall in the Sea Point).



Figure 12. The location of transects along the Camps Bay area. The top two transects are for Glen Beach, the following two for Camps Bay, and the bottom three transects for Bakoven which were used to calculate the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance to the -15m isobath from Camps Bay and Glen Beach is approximately 850m and Bakoven is approximately 500m (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.2.5 Kommetjie

Kommetjie is known for its large waves and its full exposure to the South Westerly waves. Its shoreline (Figure 13) is situated >1400m from the -15m isobath (Figure 13). The gentle slope of the ocean floor results in wave run-ups expected to be around 4.5 m for the 100 year return period.

These values are slightly higher than the effects of the 2008 storm, where wave run up levels were just below the 3.5m mark.

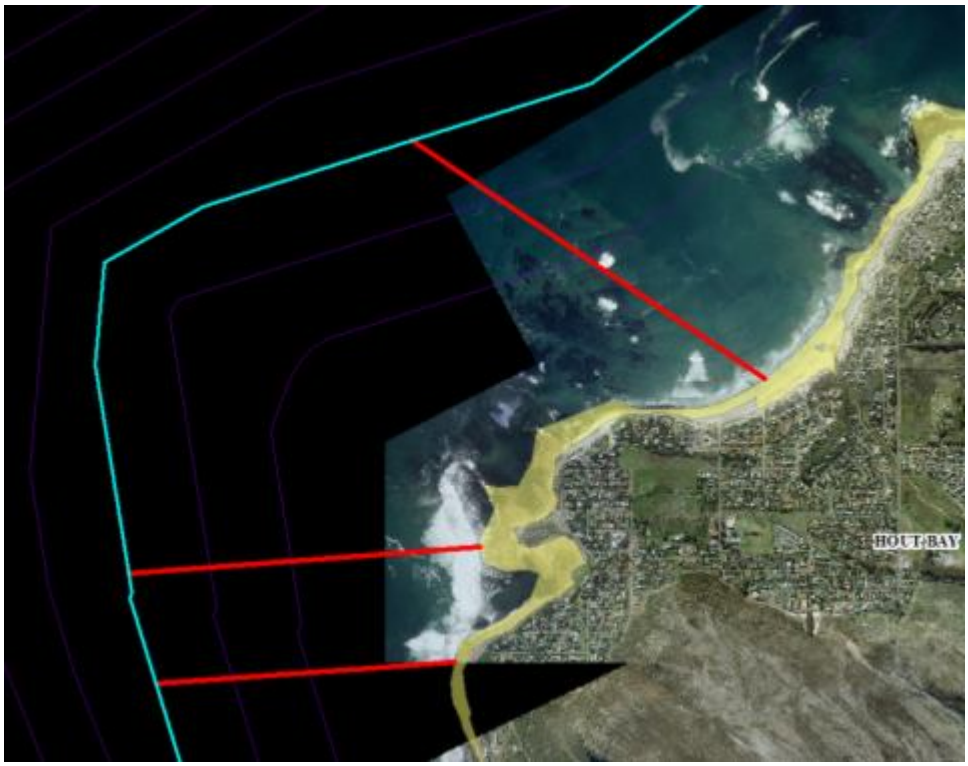


Figure 13. The location of transects along Kommetjie used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up model. The average distance is approximately 1.5km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.2.6 Witsands

The beaches in this area are known for strong rips and powerful waves. Witsands is within 750m of the -15m isobath (figure 14), and resulted in a maximum run-up value of 7.2 m for a 100 year return period, with values between 4.5-5 m expected every year.

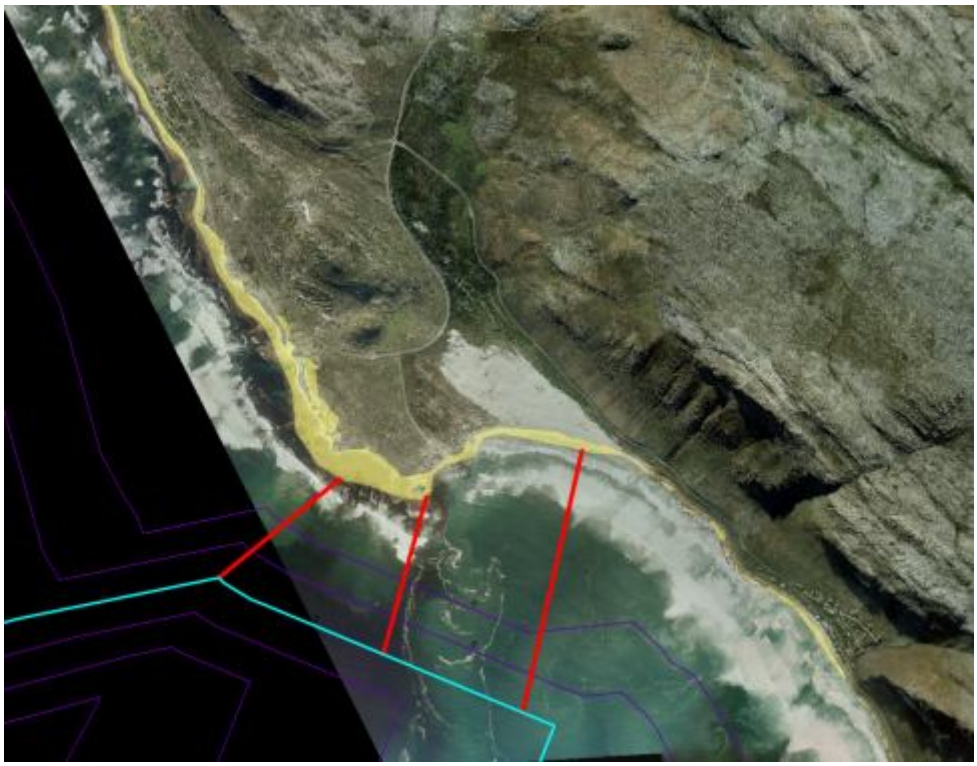


Figure 13. The location of transects along Witsands used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 1km (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3 False Bay

Significant wave height data for the following few sites were unavailable for the study. Wave heights were based on deepwater values obtained from Slangkop and it is acknowledged that these are not appropriate for such an empirical study, but are currently the only available estimates. False Bay lacks wave height studies, and it is suggested that projects in the future will need to be undertaken to verify the estimates used in this model. It is known that during times of strong winds known as the "Black Southeaster" wave heights can get very large in this region, and very large "death waves" refracted in from rocky bank are also known to occur in the Kalk Bay area, but no significant wave height measurements have been recorded to accurately describe these events.

3.3.1 Glencairn

Glencairn is sheltered in the wave refraction zone, but is potentially the site at highest risk to wave run-up in False Bay due to its close proximity to the -15m isobath, approximately 700m offshore

(Figure 14). Using the Mather model, with a significant offshore wave height from Slangkop, run up values are expected to reach 6 m every 100 years.



Figure14. The location of transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for Glencairn. Distances used are recorded in table 2. The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.2 Fish Hoek

Fish Hoek and Kalk Bay also lie in the wave shadow zone from the southwest, but are exposed to the focussing of the waves from the south east and can experience very large waves at times between Fish Hoek and especially at Kalk Bay. Both sites have gentle sloping beaches, with the -15m isobath about 1km away from shore (Figure 15). The Mather model predictions for Fish Hoek give a 100 year return period for wave run up of 3.9 m.

3.3.3 Kalk Bay

Kalk Bay is known as a place where freak large waves occur, and with the -15m isobath only about 600m from the harbour, results in a high predicted wave run up in the harbour area of approximately 5m in a 1:100 year event. Further east of the harbour the -15m isobath moves further offshore to

about 1km and around this area near the railway line (Figure 15), where an expected wave run up of approximately 4.3 m is estimated every 100 years.

The area between Glencairn and Kalk Bay would have originally been situated in the shadow zone of the South-western low pressure system during the 2008 storm, but the low pressure cell moved eastwards, causing damage to Port Elizabeth later, resulting in swell and wave energy to be directed into the North-western corner of False Bay during its movement. This resulted in a wave run up of approximately 2m.



Figure 15. The location of transects along between Fish Hoek and the Kalk Bay used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode. The average distance is approximately 1km, with it closest nearest at the harbour at about 660m (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.4 Muizenberg

From Muizenberg moving towards Gordons Bay, the bottom contours remain relatively consistent, with the -15m isobath approximately 2km offshore, and increasing close to 3km offshore at the Strand. Even though large waves can be expected in these locations, run-up values exceeding 2.6 m

are not expected even in a 100 year return period when using the significant wave heights for Slangkop. Even though there is also unfortunately no information of the significant wave heights in False Bay, it was found that in the time of the 2008 storm that wave run-up ranged between ~2.3-3.5m between Muizenberg and the Strandfontein treatment works (Figure 16).



Figure16. The location of the transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for Muizenberg (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.5 Strandfontein

Significant wave heights off Macassar are also applied to Strandfontein (table 3), and using the distance to the -15m isobath from the shore (~2.3km) Mather's model predicts run up values of about 2.2m for Strandfontein even in a 100 year return period event. Larger run-ups of about 2.4-3m were experienced during the 2008 storm between Strandfontein and Macassar (Figures 17 and 18).

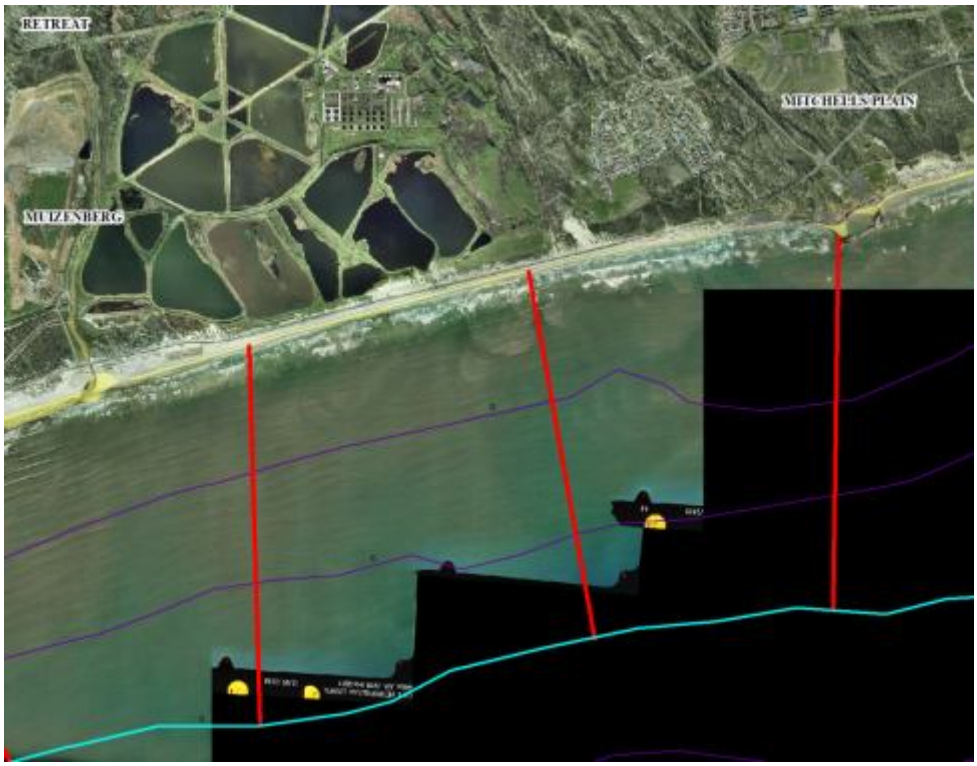


Figure 17. The location of the transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for Strandfontein (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.6 Macassar

The average distance between the -15m and the shorelines is at approximately 2km (figure 18), but it is still exposed to large surging breakers at high tide and during storm events which moves inshore far enough to erode the dune fields. According to the Mather model, the extreme wave run up for this area with a 50year return period is at ~2.5m and 2.6 m every 100years, but during the 2008 storm run-ups of about 3.4m were experienced between Strandfontein and Macassar.

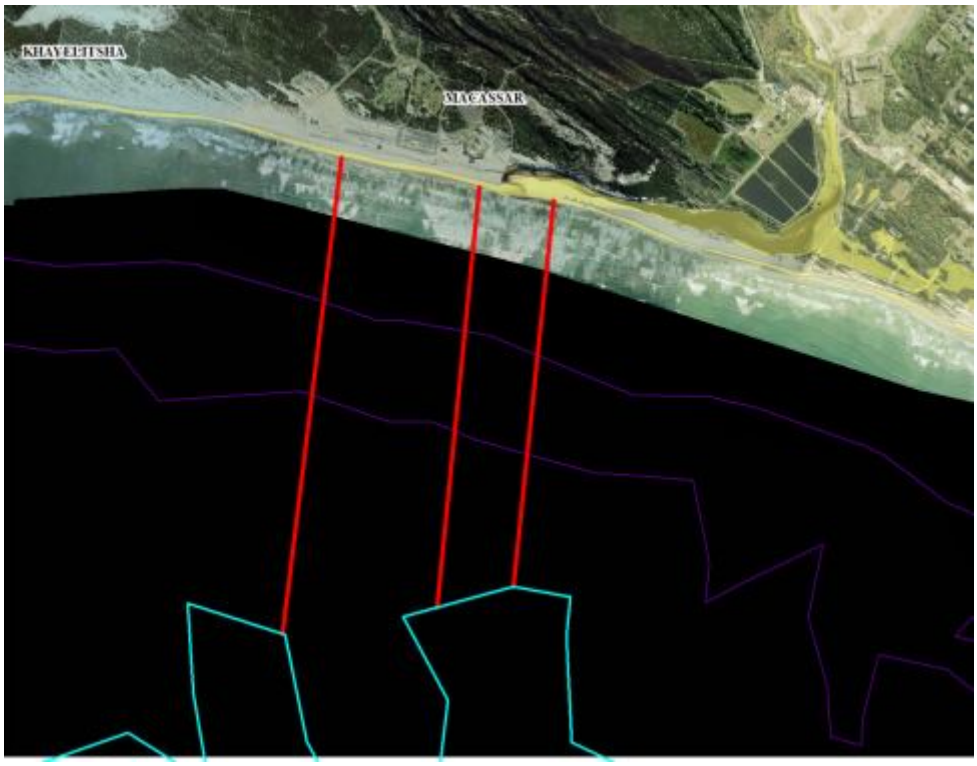


Figure 18. The locations of the transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for the Macassar area and pavilion (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.7 Strand

Strand and Bikini beach have very gently sloping beaches, with the -15m isobath ~3km offshore (figure 19), this results in a very low empirical estimate by the Mather *et al* (*in press*) model of ~2.1m in a 100 year event. The actual wave run-ups experienced along the section of coastline near the Strand coast in the 2008 storm reached 1.3-2.3m.

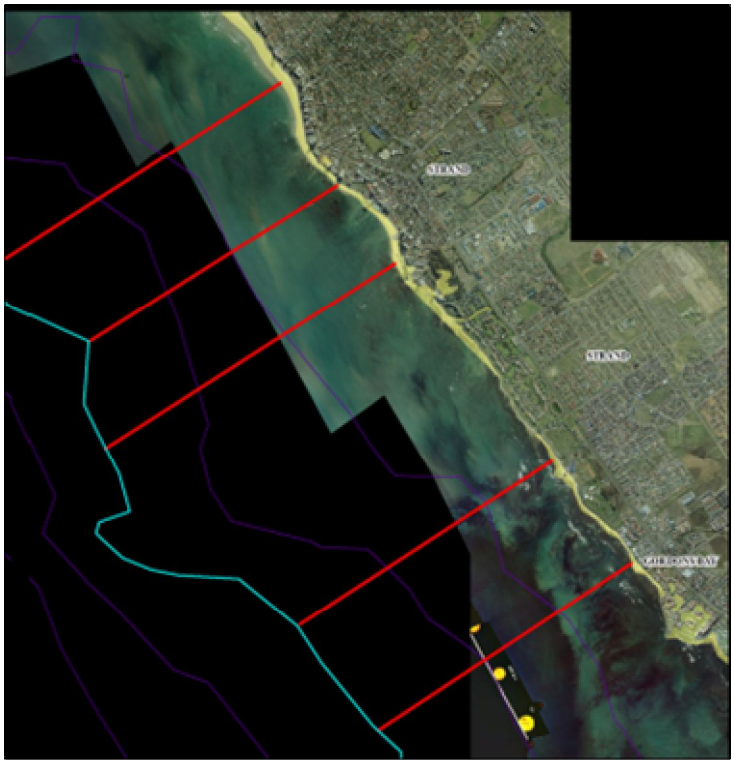


Figure 19. The location of the transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for the Strand (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

3.3.8 Bikini Beach

This small beach is approximately 2.5km from the -15m isobath, with a maximum of ~2.1 m wave run-up expected at this location using the Mather model (Figure 20) for the 1:100 year event. No 2008 wave run-up data was available at the time of this study.

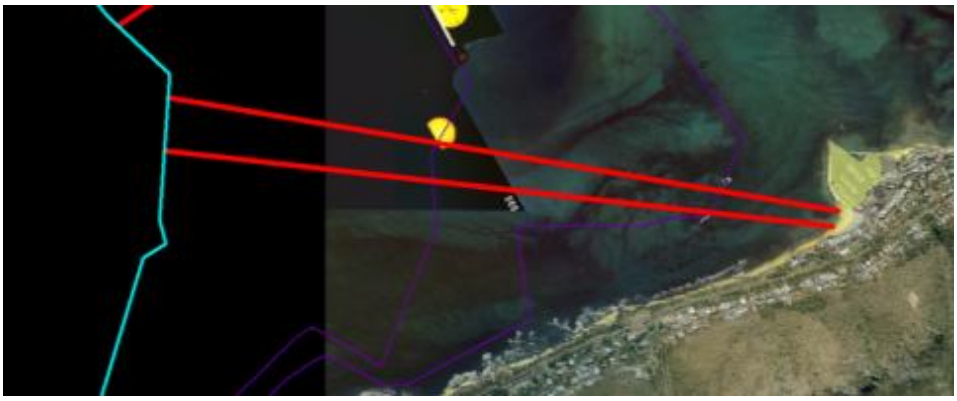


Figure 20. The location of the transects used in calculating the distances between MSL and the -15m isobath to be used in the Mather run up mode for the Bikini Beach (table 2). The superimposed light yellow marking represent new MSL following a 2m increase in sea level.

4. DISCUSSION

The purpose of this study was to calculate extreme wave-run ups above still water level at the vulnerable locations identified in the Phase 5 SLR study (ANON – City of Cape Town) using the model described by Mather et al. (*in press)* and to give comparisons to 2008 records of wave run-up above still water level.

It is important to understand that the model is based solely on empirical information, and was originally designed for natural sandy beaches without offshore sand bars, reefs or the ability to account for wave focusing effects according to various bathymetrical features. The model has been shown to currently be the most robust wave run up model available, and was designed using the South African coastline for base data in the model construction.

Some differences have been found between the results of the model and recorded wave run-up events of the 2008 storm. The 2008 storm was a very large storm. The differences may be due to various oceanographic features unique to each listed site. A few of these features are mentioned above, but a full description lies outside of the scope of this Addendum. Clearly these features will contribute to a full assessment of sea-level rise risk at a specific location. It is important to note that variations in storm surge, tidal fluctuation and wave set up play a role in the determination of overall wave run-up experienced in the 2008 storm, and may result in discrepancies from the values predicted by the Mather model.

The values estimated by the Mather model have not been corrected to account for eroding beaches during the extreme events, but only give expected wave run-up heights. On the other hand, the 2008 wave run up values result from observations of beaches which were actively eroding during the storm.

Finally, the choice of the coastal coefficient in the model can influence the predicted value of the wave run up. Values near to the reported median (Table 3) for each type of coast were used in the study. However, it may be more appropriate to use the maximum value of the coastal coefficient as recommended by Mather et al (*in press*), when the model is being used for planning coastal defences.

5. REFERENCES

Bartels, A and Schoones, J. S. 1987 – Ondersoek na die omgewingsfaktore den daarmee gepaardgaande baaigeskiktheid van die strande aan die noordoos-valsbaaise kus. CSIR Rep C/SEA 8718/1

Brundrit, G 2009 – Global Climate Change and Adaptation – a sea-level rise risk assessment. Phase 5: Full investigation of alongshore features of vulnerability of the City of Cape Town coastline, and their incorporation into the City of Cape Town Geographic Information System.

Mather, A. A., Stretch, D.D and G. G. Garland (in press) – A simple empirical model for extreme wave run-up on natural beaches. *Journal of Geophysical Research*.

Roberts, T. M., Wang, P. and N. C. Kraus 2010 - Limits of wave run-up and corresponding beach profile change from large scale laboratory data, *Journal of Coastal Research*, **26**(1), 184-198.

Rossouw, J. 1989 – Design waves for the South African coastline. PhD Thesis University of Stellenbosch. 140pp.

Rossouw, M., Luger, S., Kuipers. J., and S. Patel (in press) – Development of a virtual wave buoy system for the port of Cape Town, South Africa. CSIR in house document 10pp.

Roussouw, J. 1984 – Review of existing wave data, wave climate and design waves for South African and South West African (Namibian) coastal waters. CSIR Rep T/SEA 8401.

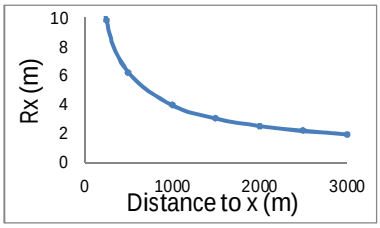
6. APPENDIX 1

Sensitivity analysis

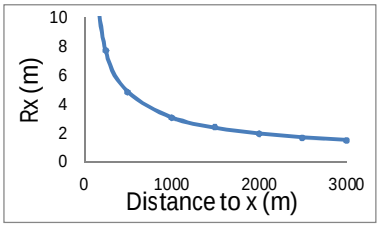
Table 6. Showing the effect changes in Coefficient (C), distance x (m) from the shore to the -15m isobath has on wave-run up (m) predictions and significant wave run-ups of Mathers model. The figures represent wave run-ups at various C values and x values at a H_0 of 7m

$$Rx = H_0 \times \left(\frac{h}{x}\right)^{2/3} \times C$$

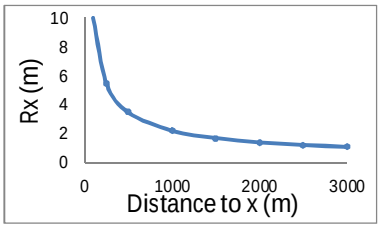
h=	15		H0 (m)		
x (m)	C	1	3	5	7
3000	9	0.3	0.8	1.4	1.9
2500	9	0.3	0.9	1.5	2.2
2000	9	0.4	1.1	1.8	2.5
1500	9	0.4	1.3	2.2	3.0
1000	9	0.6	1.7	2.8	**3.9**
500	9	0.9	2.7	4.4	6.2
250	9	1.4	4.2	7.0	9.8
100	9	2.6	7.7	12.9	18.0



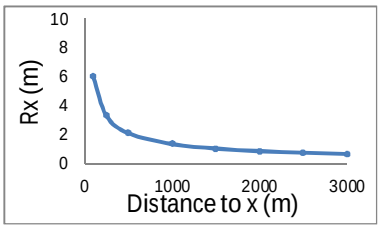
3000	7	0.2	0.6	1.1	1.5
2500	7	0.2	0.7	1.2	1.7
2000	7	0.3	0.8	1.4	1.9
1500	7	0.3	1.0	1.7	2.3
1000	7	0.4	1.3	2.2	**3.1**
500	7	0.7	2.1	3.5	4.8
250	7	1.1	3.3	5.5	7.7
100	7	2.0	6.0	10.0	14.0



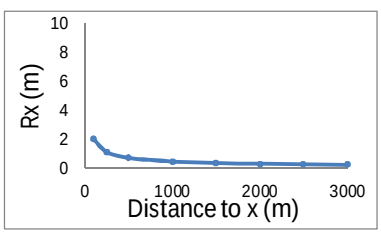
3000	5	0.2	0.5	0.8	1.1
2500	5	0.2	0.5	0.9	1.2
2000	5	0.2	0.6	1.0	1.4
1500	5	0.2	0.7	1.2	1.7
1000	5	0.3	0.9	1.6	**2.2**
500	5	0.5	1.5	2.5	3.5
250	5	0.8	2.3	3.9	5.5
100	5	1.4	4.3	7.1	10.0



3000	3	0.1	0.3	0.5	0.6
2500	3	0.1	0.3	0.5	0.7
2000	3	0.1	0.4	0.6	0.8
1500	3	0.1	0.4	0.7	1.0
1000	3	0.2	0.6	0.9	**1.3**
500	3	0.3	0.9	1.5	2.1
250	3	0.5	1.4	2.3	3.3
100	3	0.9	2.6	4.3	6.0



3000	1	0.0	0.1	0.2	0.2
2500	1	0.0	0.1	0.2	0.2
2000	1	0.0	0.1	0.2	0.3
1500	1	0.0	0.1	0.2	0.3
1000	1	0.1	0.2	0.3	**0.4**
500	1	0.1	0.3	0.5	0.7
250	1	0.2	0.5	0.8	1.1
100	1	0.3	0.9	1.4	2.0



7. HANDOVER NOTES

This is a short summary of important contacts and information to be aware of as this paper is further developed.

Individual contributions to the project from people such as Professor Geoff Brundrit (oceangeoff@iafrica.com) are invaluable to projects such as these, and have the ability to motivate and put projects into motions which relates to gathering specifically desired oceanographic data. Currently there is an urgent need for wave data and research to be conducted within False Bay on the return period of large wave and storm events.

M. Rossouw (mrossouw@csir.co.za) from the CSIR Stellenbosch was head of the project which developed the Virtual Buoy system used in Table Bay and various ports for wave predictions within the boating lanes used by port authorities around South Africa (Rossouw et al. *in press*). He has been collecting and updating the data recorded from the Slangkop wave buoy and is the key person to contact in regards to obtaining statistics on significant offshore wave height data for most areas around CoCT. He is also currently working on a project to extend the predictive ability of the SWAN model, which is used to generate the Virtual Buoy information in Table Bay, into the False Bay area. Please see http://wavenet.csir.co.za for more information.

A. Mather (mathera@durban.gov.za) from the Durban municipality was the engineer who developed the wave run-up model and A. Theron (atheron@csir.co.za) from the CSIR, Stellenbosch, are currently working specifically on wave run-up around the coast of South Africa, and could be consulted as the current local experts on the topic.

There are also various students in the UCT Oceanography department who are currently also working on modelling wave and currents within False Bay by extending the SWAN model into False Bay. A few

students are looking at the effect refraction due to bathymetry and funnelling effects has on the waves within False Bay and on its coast. The information from such research projects may prove invaluable to understand variations experienced between historical events and predicted events of the Mather run-up model. Such work extending the SWAN model from Table Bay into False Bay requires wave recorders around the False Bay coast to verify predictions.

The significant wave height data used for Melkbosstrand (Koeberg) and the north-eastern corner of False Bay is approximately 20-25years old, and only a short observational period of about 4years for Koeberg, and only about 1year for False was used to calculate expected wave heights for 10, 50 and 100 year return periods by extrapolation. This makes the estimates used in this study less credible and it is suggested that verification studies should be conducted in these areas.

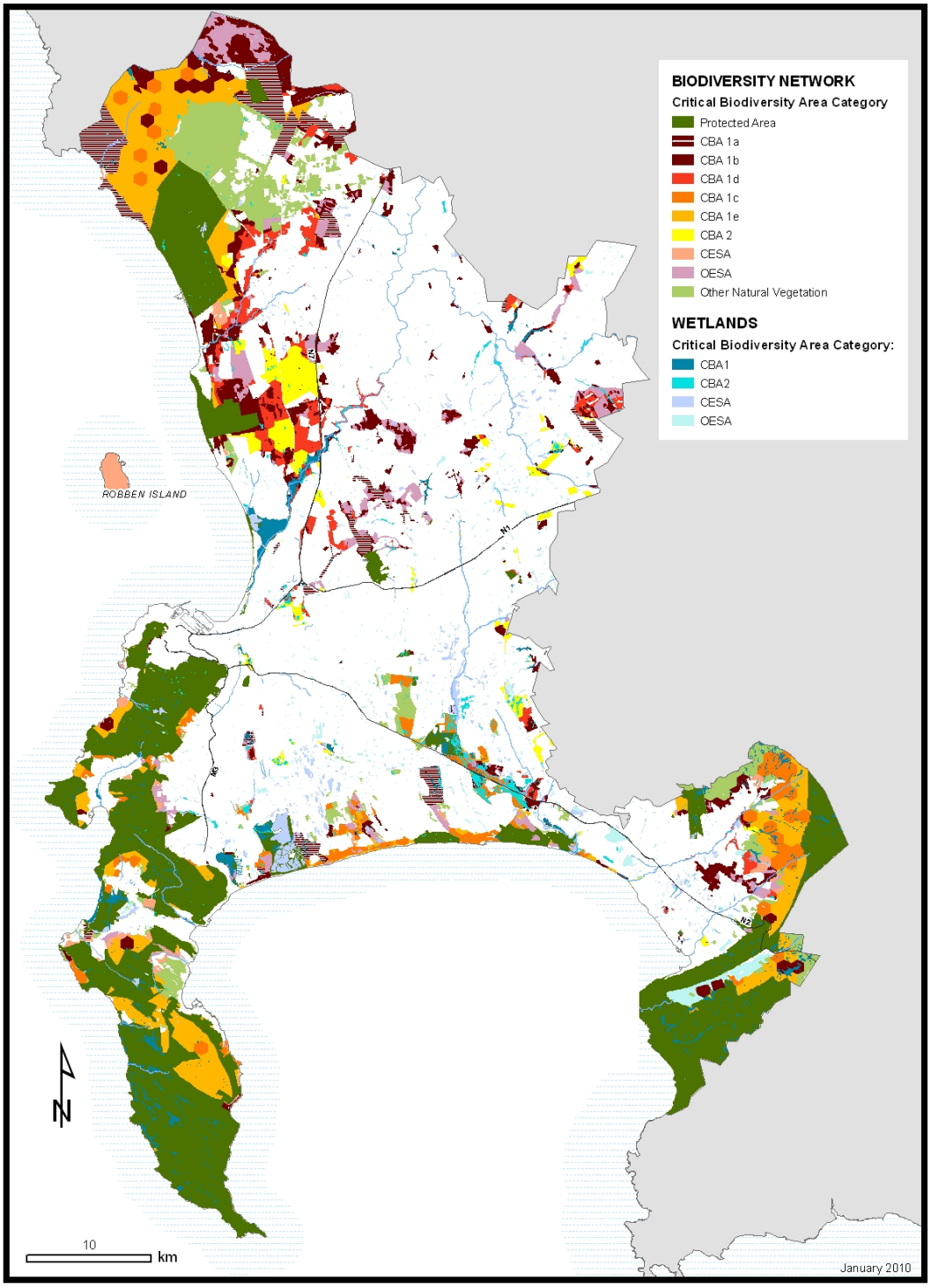
There are a few more documents which might also prove helpful in understanding wave dynamics within False Bay. The C/SEA 8046/1 and 8046/2 reports which are held at the CSIR offices in Stellenbosch are available to the CoCT, but written authorization from the contract holder is firstly required to obtain these documents. For further details please contact Annette Joubert (ajouber1@csir.co.za).

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City of Cape Town's Biodiversity Network

C-PLAN & MARXAN ANALYSIS: 2009 METHODS & RESULTS



Amalia Stipinovich & Patricia Holmes, Environmental Resource Management Department (ERMD), City of Cape Town, December 2009

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Acronyms

BioNet	Biodiversity Network
BLM	Boundary Length Modifier
CBA	Critical Biodiversity Area
CCT	City of Cape Town
CLUZ	Conservation Land Use Zoning
CR	Critically Endangered (IUCN Red List)
CREW	Custodians of Rare & Endangered Wildlife
EN	Endangered (IUCN Red List)
ERMD	Environmental Resource Management Department
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System/s
LT	Least Threatened (IUCN Red List)
NSBA	National Spatial Biodiversity Assessment
Red Data	Plant taxa that have been assessed according to their risk of extinction in the near future (See www.redlist.org)
SANBI	South African National Biodiversity Institute
SPF	Species Penalty Factor
VU	Vulnerable (IUCN Red List)

Acknowledgement

The 2008 unpublished report by Grant Benn of GeoCline Consulting CC entitled “City of Cape Town’s BioNet: Terrestrial Systematic Conservation Plan Re-Analysis: Methods and Results” formed the basis for this 2009 report (www.capetown.gov.za – follow links to ERMD, reports).

INTRODUCTION

The City of Cape Town (CCT) has used a systematic conservation planning approach to prioritise its remnant indigenous vegetation based on factors such as connectivity, habitat condition and location of rare and endangered flora. Systematic conservation planning generally involves the following steps:

- Subdividing a region into a series of planning units
- Gathering data describing the distribution of biodiversity features within this region
- Calculating the amount of each biodiversity feature found in each planning unit
- Setting targets for each biodiversity feature in order to ensure their adequate conservation
- Using software to select a set of planning units which meets these targets in an efficient manner

The primary product of this approach is the CCT's Biodiversity Network (BioNet), which exists in the form of a GIS shapefile, with associated tabular information. The shapefile can be mapped and analysed and statistics can be derived, giving users a picture of not only the situation on the ground but most importantly, where to focus their conservation efforts in light of limitations in staff, budget and available open space. This report gives an overview of the methodology used but the technical process using GIS technology and the conservation planning software packages of C-Plan and MARXAN/CLUZ is described in a separate manual for internal use only.

History of Systematic Conservation Planning In the City

In 2002, the first systematic conservation planning study to identify the minimum set of conservation areas required in the CCT was initiated using the conservation planning software "C-plan". This study pre-dated the National Environmental Management: Biodiversity Act (2004), the new National Vegetation Map (SANBI 2005) and the National Spatial Biodiversity Assessment (2004). The study built on earlier work done in partnership with the Botanical Society which resulted in a report entitled: "Core Flora Conservation Areas on the Cape Flats" report (Maze & Rebelo 1999[1]). In the

[1] *Maze K E & Rebelo A G 1999. Core flora conservation areas on the Cape Flats. FCC Report 99/1. Botanical Society of South Africa.*

latter report 38 sites were identified as critically important contributors to Cape Town's biodiversity and have since been known as the "Core Flora Sites". Data informants for the 2002 study included a remnant layer based on 1998 aerial photography, available plant species information and a local vegetation map drawn up by botanical consultant B. Low. The study culminated in the Biodiversity Network Prioritization Report (2004[2]).

In 2005 a revised desktop systematic conservation planning study was initiated to update the Biodiversity Network using the latest: 1) remnant layer from 2005 aerial photography, 2) species information and 2) vegetation map

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[2] Note: all City biodiversity reports are available on the ERMD website: http://www.capetown.gov.za/en/environmentalresourcemanagement/Pages/default.aspx; "publications > reports"

City of Cape Town. 2004. Biodiversity Network Prioritisation Project, Final Draft Report prepared by MLA-Sustainability Matters, in association with GISCOE, Biodiversity & Conservation Biology Department UWC, Settlement Planning Services & Freshwater Consulting Group.

aligned to the new national vegetation map (Mucina et al. 2005[3]). Results from this re-analysis may be found in the 2007 report[4]. This version of the Biodiversity Network was approved by council (PEPCO, November 2006) subject to continuing collaborations with Spatial Planning and Urban Development.

In 2008, after extensive ground-truthing of vegetation remnants during 2007-8, the remnant layer was again updated and C-plan was re-run using habitat condition as an additional informant. The programme "Marxan" was next applied, using a "Boundary Length Modifier" tool, to select additional remnants needed to improve connectivity among selected remnants. This, together with expert corridor sites, replaced the friction analysis used in the first analysis to identify corridors on the Biodiversity Network. Corridors help to conserve ecological processes, which include the dispersal and migration of plants and animals, necessary to conserve healthy populations in the long-term. All wetlands and rivers in this and earlier versions are considered part of the Biodiversity Network. In this analysis, the national ecosystem targets were used for the first time in setting the targets for conservation. Methods and results of this third run of the Biodiversity Network are reported in Benn (2008[5]).

DATA PREPARATION

Software

The data was prepared using ESRI's GIS software versions ArcGIS 9.3 and ArcView 3.3 and Microsoft's Excel and Access.

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[3] *Mucina L, Rutherford M L & Powrie L W (editors) 2005. Vegetation Map of South Africa, Lesotho and Swaziland. SANBI, Pretoria.*

[4] *City of Cape Town. 2007. The Identification and Prioritisation of a Biodiversity Network for the City of Cape Town, Final Report prepared by MLA-Sustainability Matters, in association with GISCOE (Pty) Ltd.*

[5] *Benn G. 2008. City of Cape Town BioNet: Terrestrial Systematic Conservation Plan Re-Analysis: Methods & Results.* (Available for download from ERMD website)

Analysis Data Inputs

See Table 1: Analysis Data Inputs

Formation of the Planning Units

The planning domain was the area enclosed by the administrative boundary of the CCT. The basis for the formation of the planning units within the planning domain was the CCT indigenous vegetation remnants coverage. The remnants had been ground-truthed in 2008 for the third C-plan analysis and creation of the BioNet of 2008. Each remnant's habitat condition was evaluated as being high, medium or low. Over the subsequent months, the status of some of these remnants was updated by the Environmental Resource Management Department (ERMD) so the information was as current as possible, habitat condition being a key factor in the analysis.

Each high, medium or low fragment of a remnant formed a planning unit. Any remnants over 100 hectares in size that were not classified as Protected Areas were further subdivided into hexagon grid cells of 100 hectares in area. Existing protected area boundaries were integrated into the remnant layer before this process was carried out. "Protected Areas" included those that were not yet proclaimed but that were managed by City of Cape Town.

Only features that were located on the existing BioNet, the current mapped extent of indigenous vegetation, within this planning domain were considered.

Table 1: Analysis Data Inputs

DATA	CONTENT	SOURCE	VERSION	FORMAT
Biodiversity Network (used to create Planning Units and to bring in habitat condition information)	Remnants of indigenous vegetation remnants classified as being of high, medium or low condition	City of Cape Town	August 2008	Polygon shapefile mapped at varying scales but constantly being refined to a scale of 1:2000; ground-truthed in 2008
Indigenous vegetation	Historic Indigenous vegetation cover of City of Cape Town	City of Cape Town (based on national SANBI version of 2005)	July 2009	Polygon shapefile originally mapped at National scale 1:50 000 but refined at a scale of 1:2000 in areas by City of Cape Town
CREW Red Data species	Indigenous floral species locations	CREW, SANBI	July 2009	Point shapefile (accurate to within 10m)
Protea Atlas Project Red Data species	Indigenous floral species locations	Protea Atlas Project	July 2009	Centroid coordinates (point taken to be accurate within a radius of 250m)
SaSflora Red Data species	Indigenous floral species locations	Barrie Low - Coastec	July 2009	Centroid coordinates (point taken to be accurate within a radius of 250m)
CCT Red Data species (added to the CREW data during the analysis)	Indigenous floral species locations	CCT staff & BioNet groundtruthing team. Also Nick Helme (consultant)	July 2009	Point shapefile (accurate to within 10m)
Wetlands (used for comparison purposes only)	Natural and artificial wetlands	City of Cape Town	July 2009	Polygon shapefile digitized at 1:10 000 from orthophotos and sample groundtruthed
Threats to Biodiversity Network	Agricultural, urban, mining and development threats	City of Cape Town	July 2009	Polygon shapefile created from best available CCT shapefile inputs

Threats to the Biodiversity Network

The threat level of each planning unit was used in the analysis of the BioNet as a cost surface, which influenced the potential selection of sites. Dr Tony Rebelo of SANBI had generated a combined threat layer for the 2008 analysis, which included the following threats:

- Human settlement
- Potential agriculture
- Potential mining areas

These were updated to reflect the situation in August 2009 and the cost surface revised to include:

- New Development Areas

The factors were then assessed as being of either high, medium or low threat. The relative area of each threat level per planning unit was calculated.

Biodiversity Features Incorporated

The indigenous flora of a planning unit was used to indicate biodiversity as the coverage of the available GIS data was far greater than that available for indigenous fauna. Existence of the flora is also a reliable indicator of existence of the fauna which depend on it. "Flora" includes the various national vegetation types and subtypes as well as the individual Red List threatened species: the variety, numbers or area, and rarity of each are considered by the conservation planning software. The biodiversity features brought into the analysis as factors were as follows:

- Current indigenous vegetation extent with remnants classified as being of high, medium or low condition
- Revised CCT indigenous vegetation: This uses SANBI's National Vegetation types but classes them at a finer scale per local subtype
- CREW's indigenous flora species data
- CCT's indigenous flora species data
- Protea Atlas Project's indigenous flora species data
- SaSflora's indigenous flora species data
- CCT wetlands (for post-analysis incorporation only: wetland prioritization was analyzed separately and then priority wetlands occurring on natural remnants were included in the BioNet).

Excluded Biodiversity Features

- The dunes at Atlantis were extracted from the vegetation coverage as they extend over an area of 270 hectares. Areas identified as "Beach" or "Reclaimed" areas in the Vegetation coverage were also excluded. The bare sand would have affected the vegetation target statistics if included.
- Subtypes of Southern Afrotemperate Forest vegetation were combined and brought in as one "Southern Afrotemperate Forest" unit as this

type covers a very small area and is formally conserved in the Table Mountain National Park.
- Any exotic flora species found in the CREW, CCT, SaSflora or Protea Atlas Project data were excluded.
- Large artificial water bodies and waste water treatment works (e.g. dams such as Steenbras and Kleinplasie) were extracted from the vegetation coverage so as not to bias vegetation statistics. The large natural and semi-natural water bodies (e.g. Rondevlei) fall into the Cape Lowland Freshwater Wetland vegetation type.

Allowing for Biodiversity Processes: Connectivity

Potential corridors to ensure connectivity through the fragmented landscapes of the City of Cape Town were mapped by Biodiversity Management Branch's experienced staff in 2008 and included in the analysis as a factor:
- Blaauwberg Conservation Area to Koeberg
- Diep River Fynbos Corridor (Rietvlei to Blaauwberg Conservation Area)
- Kuils River Corridor (Driftsands to Coast)
- False Bay Coastline

Assessment of Vegetation Type, Ecosystem & Conservation Status

Ecosystem status and conservation status were calculated using the status categories developed by SANBI. The assessment of the status can be done at either the National vegetation type or the CCT vegetation subtype level. This analysis operated at the subtype level. The SANBI categories are as follows:

SANBI ecosystem status categories and thresholds
- Critically endangered (CR): current area less than target area
- Endangered (EN): current area less than target + 15% of historical distribution
- Vulnerable (VU): current area < 60% of historic distribution
- Least threatened (LT): current area > 60% of historic distribution

SANBI conservation status categories
- Not protected: 0% of target conserved
- Hardly protected: 0 - <=5% of target conserved
- Poorly protected: 5> - <=50% of target conserved
- Moderately protected:>50 - <100% of target conserved
- Well protected: 100% of target conserved

Please see Table 2: Vegetation Statistics for the results of these calculations.

Calculation of Biodiversity Feature per Planning Unit

The planning unit and biodiversity feature datasets were then brought together in GIS to summarise the features per planning unit. The inputs required for the C-plan and Marxan software were tables. Population figures for each recorded location of a species were rare. The species input tables were instead records of the number of times a data point indicating the location of a particular species intersected with a planning unit. Available information on the IUCN Red Data status of each species e.g. CR, EN, was included.

The same was done for the planning units and vegetation datasets and the planning units and threats datasets. However, these recorded the areas in hectares of each vegetation type and each level of threat as opposed to number of locations. If wetlands had been incorporated into the C-plan/ Marxan analysis, the same would have been done for them too.

Setting Conservation Targets

Indigenous Vegetation

Targets were based on National Vegetation Type target percentages as determined for the 2004 National Spatial Biodiversity Assessment (NSBA) but were applied at the level of the City vegetation subtypes. Actual target values were calculated from the historic area for each type (Please refer to Table 2: General Vegetation Statistics).

Indigenous Flora Species Locations

For CREW, Protea Atlas Project, SaSflora and CCT's recorded floral species, targets were based on the number of known species locations. For species described in the datasets, a simple sliding scale target was used for each species on the basis of the number of locations.

- 100% of all locations for Critically Endangered (CR) species
- >=10 locations for Endangered (EN) species
- >=5 locations for any other Red Data species (including those with no status listed)

In other words, every known location of a CR species is targeted and rarer species are assigned relatively higher targets than more common species.

Wetlands

Targets for the City wetland types were based on the percentage target applied to all wetland types by the NSBA. A standard target of 24% was used by the NSBA, with actual target values based on the percentage of mapped wetland area for each type. However, wetlands data were not brought into

this C-plan/Marxan run directly. Wetland prioritization was analyzed separately by expert consultants (Snaddon et al. 2009; www.capetown.gov.za – follow links to ERMD/ Publications/ Reports).

Priority wetlands occurring on natural remnants were included post-hoc into the BioNet. Wetland ground-truthing indicated that priority wetlands located in transformed land were degraded and in practice would be difficult to restore and conserve. Such wetlands were only prioritized in the wetlands study owing to a lack of alternative natural sites supporting these wetland types.

ANALYSIS

Software

The ArcView 3.3 extension C-Plan was used to calculate the irreplaceability of a planning unit and to select an optimal and efficient set of remnants to meet the conservation targets. C-Plan is a conservation-planning tool that provides the tools for the application of a logical and sequential planning process. To assist in ensuring connectivity within the conservation network, MARXAN[6] was used to select additional planning units aimed at ensuring connectivity across the BioNet. MARXAN has the ability to consider spatial pattern in selecting reserve networks through the use of its Boundary Length Modifier (BLM). The BLM allows the selection process to consider landscape connectivity in the selection process. CLUZ[7] is an extension to ArcView3.3 and was used to provide a user-friendly interface to MARXAN.

C-Plan Analysis

Selection from High & Medium Habitat Condition Sites

To ensure that high and medium condition planning units were selected preferentially over low condition planning units, the latter were initially excluded from the analysis. Irreplaceability was then calculated, and those planning units with 100% irreplaceability scores selected. Irreplaceable planning units are those for which no alternatives exist if targets are to be met.

The Minset Algorithm

Outstanding target values were then met by running C-Plan's Minset algorithm that uses a series of rules. Successive rules in the Minset algorithm are only used when a tie occurs. The expert mapped corridors were used in the Minset to ensure that where possible, and if the preceding rules are tied,

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[6] Possingham et al. 2000, Ball and Possingham, 2000, http://www.ecology.uq.edu.au/index.html

[7] Smith 2004, http://www.mosaic-conservation.org/cluz

planning units within these corridors were preferentially selected. The Minset algorithm rules are as follows:

1. Highest Irreplaceability score
2. Habitat condition = High
3. High or medium threat lowest
3. Location of planning unit in one of the expert mapped corridors
4. Highest percentage contribution to meeting targets
5. Feature rarity
6. Summed rarity
7. Richness
8. Site Area Highest
9. Select first site in list

Selection from Low Habitat Condition Sites

The low condition planning units were then brought into the analysis and irreplaceability recalculated to try to meet any targets that had not yet been met when only high and medium condition planning units were considered. Any low condition planning units given a status of 100% irreplaceability were included in the set of selected planning units. At this point, all achievable targets were attained.

Checking of SaSflora Data Influences

Each change in status of a planning unit due to the addition of the SaSflora species and subspecies data into the C-plan analysis of 2009 was manually checked by Dr Patricia Holmes against a C-plan 2009 run that excluded this data. This was to ascertain the extent to which the SaSflora data influenced the results as this data had not been included in recent BioNet runs. All sites that were only included due to their containment of SaSflora species were found to have species required to meet minimum targets. The C-plan output with SaSflora data included was therefore considered to be the best result and was used as the input into Marxan.

MARXAN Analysis

The SaSflora biodiversity features were not included in the MARXAN analysis as they caused the software to freeze. This was not considered to be of concern as the required SaSflora sites had already been selected by C-Plan.

Boundary Length Modifier

The protected areas and the high and medium condition sites selected during the C-Plan analysis were set aside as having already been identified as essential to conserve. MARXAN was then run to select further sites that would allow for connectivity between these conserved areas. The sites would therefore be selected by Marxan even if they were not required to directly meet conservation targets. Considering the fragmented nature of the natural habitats of the CCT, it is important for connectivity to be considered in identifying critical areas for conservation.

A BLM of 0.5 was used, based on the findings of Grant Benn[8] in the 2008 BioNet run: the value 0.5 proved to be the least land-hungry, important in the case of the CCT where open land is at a premium. The higher you make the BLM, the more land hungry a run will be with the selection being more biased towards reducing boundary length and less towards meeting feature targets.

External edges were included in the determination of boundary length, although certain edges could be excluded in future where they make up a natural boundary, such as a coastline.

Species Penalty Factor

The Species Penalty Factor (SPF) is the cost associated with not meeting the target for a specific biodiversity feature. Setting a high cost value for a particular feature will increase the likelihood of that feature's target being met, as MARXAN acts to minimise the cost of the final portfolio that it identifies. 100 000, a very high value, was set for all features in the MARXAN analysis to ensure that all targets were met.
The number of iterations was set at 1,000,000 and the number of runs at 10. Increasing the number of iterations and runs would generally improve the efficiency of the portfolio that MARXAN identifies but also increase the processing time. [1]

CLASSIFICATION OF CRITICAL BIODIVERSITY AREAS

[8] Benn, Grant. 2008. City of Cape Town's BioNet: Terrestrial Systematic Conservation Plan Re-Analysis: Methods and Results. GeoCline Consulting CC (www.capetown.gov.za – follow links to ERMD/ Reports).

The selected planning units were given attributes by both the C-Plan and the MARXAN software. These attributes were combined and used to identify a range of different Critical Biodiversity Area (CBA) categories is presented in Table 3.

CBA 2 areas that had additional importance in that they served to consolidate CBA 1b remnants were manually upgraded to CBA 1d status. In most cases, remnants that were selected as CBA 2 in 2009 but were CBA 1d in 2008 could have this status transferred across but this was checked and corrected where necessary and where the remnant no longer demonstrated this additional value to the network it remained CBA 2.

IN FUTURE ANALYSES

- Prior to the next run, the SaSflora database should be checked and decisions made as to how to deal with the different species and subspecies and varieties and as to whether to treat them all as different taxa.
- The available fauna data needs to be assessed to see whether it could be incorporated in the future
- A check needs to be made of the appropriate categories for sites selected for species. Species targets have been set, and sites selected for a species should either qualify as MinSet or Irreplaceable categorization. Consideration should be given as to whether sites required to protect Red List threatened and least threatened species, respectively, require different categories, or whether Critical Biodiversity Area is appropriate to both.

Table 2: Results: General Vegetation Statistics

Units are in hectares unless otherwise specified.

National Vegetation Type	Historic extent *	Current extent	% Remaining from historic extent	National Ecosystem Target %	Target	Selected in BioNet	% Selected in Bionet from current extent	Target met in selected BioNet	Extent in proclaimed Protected Areas	% Target met in proclaimed Protected Areas	Ecosystem Status (calculated*)	SANBI conservation statistic for "protected"
Atlantis Sand Fynbos	25235	15712	62	30	7570	12696	81	Yes	0	0	LT	Not
Boland Granite Fynbos	9575	6064	63	30	2873	4807	79	Yes	355	12	LT	Poorly
Cape Estuarine Salt Marshes	40	26	65	24	10	26	99	Yes	26	268	LT	Well
Cape Flats Dune Strandveld: False Bay	27260	8468	31	24	6542	7273	86	Yes	1856	28	EN	Poorly
Cape Flats Dune Strandveld: West Coast	12700	10604	83	24	3048	6893	65	Yes	965	32	LT	Poorly
Cape Flats Sand Fynbos	54410	8467	16	30	16323	8465	100	No	464	3	CR	Hardly
Cape Lowland Freshwater Wetlands	1464	1095	75	24	351	1069	98	Yes	787	224	LT	Well
Cape Winelands Shale Fynbos	2667	1706	64	30	800	1389	81	Yes	218	27	LT	Poorly

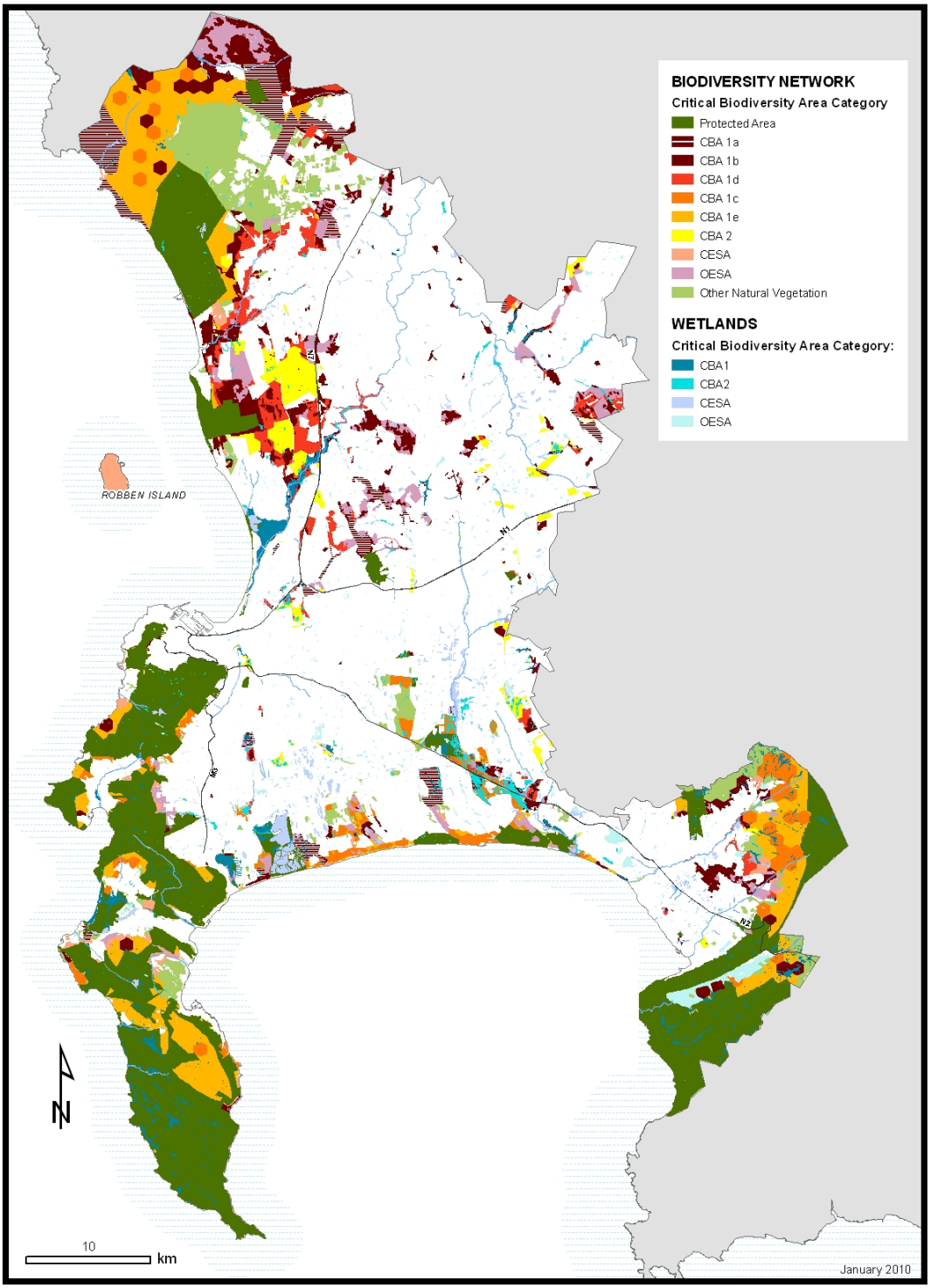
Elgin Shale Fynbos	841	321	38	30	252	283	88	Yes	5	2	EN	Hardly
Hangklip Sand Fynbos	3302	1910	58	30	990	1490	78	Yes	1364	138	VU	Well
Kogelberg Sandstone Fynbos	9500	9261	97	30	2850	8814	95	Yes	1944	68	LT	Moderately
Lourensford Alluvium Fynbos	4819	410	9	30	1446	410	100	No	190	13	CR	Poorly
Peninsula Granite Fynbos: North	1997	1439	72	30	599	1344	93	Yes	986	165	LT	Well
Peninsula Granite Fynbos: South	7149	2482	35	30	2145	2291	92	Yes	1770	83	EN	Moderately
Peninsula Sandstone Fynbos	21896	21349	98	30	6569	20762	97	Yes	17307	263	LT	Well
Peninsula Shale Fynbos	1263	690	55	30	379	689	100	Yes	687	181	VU	Well
Peninsula Shale Renosterveld	2375	317	13	26	617	317	100	No	262	42	CR	Poorly
Southern Afrotemperate Forest	348	347	100	34	118	347	100	Yes	277	234	LT	Well
Swartland Alluvium Fynbos	1742	76	4	30	523	76	100	No	0	0	CR	Not

Swartland Granite Renosterveld	8059	1952	24	26	2095	1952	100	No	36	2	CR	Hardly
Swartland Shale Renosterveld	46712	4019	9	26	12145	4019	100	No	408	3	CR	Hardly
Swartland Silcrete Renosterveld	1067	188	18	26	277	188	100	No	0	0	CR	Not
Western Shaleband Vegetation	329	329	100	30	99	329	100	Yes	31	32	LT	Poorly

* for City portion of vegetation type only

RESULTS

Figure 1: October 2009 Biodiversity Network of the City of Cape Town



National Vegetation Types

The results for 18 national terrestrial and two national wetland vegetation types are presented in Table 2. Three of the national types have been divided into two subtypes of regional importance, namely: Cape Flats Dune Strandveld into False Bay and West Coast subtypes, and Peninsula Granite Fynbos into North and South subtypes, the latter usually being located on wetter aspects and slopes. In addition, Peninsula Shale Fynbos may be considered a subtype of Cape Winelands Shale Fynbos.

Six national vegetation types are endemic (i.e. largely confined to the City). These are: Cape Flats Dune Strandveld, Cape Flats Sand Fynbos, Lourensford Alluvium Fynbos, Peninsula Granite Fynbos, Peninsula Sandstone Fynbos and Peninsula Shale Renosterveld.

The national targets were calculated from species-area curves as the minimum area required to conserve 70% of the plant species in a vegetation type. Note that this is the minimum requirement and that additional areas are needed for maintaining ecosystem processes and to provide habitat for certain threatened plant and animal species and migration corridors for conserving animal species. The areas required to meet vegetation and species targets are indicated on the map (Figure 1) as CBA1a-d and CBA2; and those areas required for connectivity as CBA1e. The ecological support areas required for ecosystem processes are indicated on the map as CESA.

In 2009, seven of the national vegetation types in the City have insufficient habitat remaining to conserve the minimum target. These are Cape Flats Sand Fynbos, Lourensford Alluvium Fynbos, Peninsula Shale Renosterveld, Swartland Alluvium Fynbos, and Swartland Granite, Shale and Silcrete Renosterveld vegetation types. Three of these are endemic to the City and thus cannot be conserved elsewhere: Cape Flats Sand Fynbos with 16% habitat remaining, Lourensford Alluvium Fynbos with 9% and Peninsula Shale Renosterveld with 13% remaining. The latter already is mainly conserved in the Table Mountain National Park, but the other two are an urgent priority for conserving remaining habitat. The four non-endemic types have traditionally been exploited for commercial agriculture (cereal & fruit crops) and little natural habitat remains either inside or outside the City.

Although sufficient remnant habitat remains to meet targets for the other 13 ecosystems, there is a very long way to go in attaining adequate protection for these types in protected areas. The best conserved types (i.e. proportion in proclaimed protected areas in the City relative to targets) are Cape Estuarine Salt Marsh, Cape Lowland Freshwater Wetlands, Hangklip Sand Fynbos, North Peninsula Granite Fynbos, Peninsula Shale Fynbos, Peninsula Sandstone Fynbos and Southern Afrotemperate Forest (Table 2). These are mainly conserved in the Table Mountain National Park.

It is important to note that Elgin Shale Fynbos – a vegetation type occurring mainly outside the City – largely has been exploited for agriculture and is nationally Critically Endangered. However, within the City, a lower proportion

has been transformed and there is an opportunity to secure as much of this ecosystem as possible to improve its national conservation status.

Wetlands

The City's wetlands were studied at a much finer scale than the vegetation units and to a large extent are seasonal wetlands nested within the national vegetation units (Table 5). City wetland extent thus exceeds that recognized at the national scale as Cape Lowland Freshwater Wetland and Cape Estuarine Salt Marsh. 48 wetland types out of 54 identified types have natural or semi-natural wetlands remaining, but in some cases these are degraded by surrounding land use and are classed as "Ecological Support Areas" rather than "Critical Biodiversity Areas". This is true for Alluvium Fynbos, Renosterveld and some Granite Fynbos wetland types.

Eighty percent (38) of wetland types have the minimum target (by area) selected in the Biodiversity Network and the remainder (10) do not. Of the latter, six have no selected wetlands, as the remaining sites are all in a transformed landscape (Table 5: Alluvium Fynbos isolated depression, Alluvium Renosterveld valley bottom, Granite Fynbos depression, Granite Renosterveld isolated depression, Silcrete Renosterveld seep and valley bottom). In general, these wetlands have a lower habitat condition and will be difficult to restore given current land-use. However, they still serve important ecosystem functions.

Twelve wetland types have the minimum target conserved within protected areas. These comprise mainly the strandveld and sandstone fynbos wetland types. However, Sand Fynbos depression is also well conserved owing to waterbodies such as Princessvlei, Rondevlei and Zeekoevlei being included in this type (Table 5).

City Vegetation Types

A more detailed break-down of the conservation planning analysis results by the 59 City vegetation types is presented in Table 6. 17 types have insufficient remnant remaining to meet minimum targets. Of these, four are very small types that historically covered <100ha. The general patterns remain the same as for national vegetation types, with lowland vegetation types and those on richer soils having the lowest proportion of natural habitat remaining.

Table 3: Calculation of Critical Biodiversity Area Categories

CRITICAL BIODIVERSITY AREA CATEGORY		Habitat condition		C-plan Result		Marxan Result
Protected unless Core Flora Site only (CBA 1a)	=	High	+	Res	+	Conserved
		Medium		Res		Conserved
		Low		Res		Conserved
CBA 1a (where Core Flora Site only)		High		Res		Conserved
		Medium		Res		Conserved
		Low		Res		Conserved
CBA 1b		High		R 2		Conserved
		Medium		R 2		Conserved
CBA 1d (selection from CBA 2 sites based on expert opinion)		Low		R1_low/ R2_low		Available/ Earmarked
CBA 1c		High		R 1		Conserved
		Medium		R 1		Conserved
CBA 1e		High		0Co		Earmarked
		Medium		0Co		Earmarked
		Low		Exc		Earmarked
CBA 2		Low		R1_low		Available
		Low		R2_low		Available
		Low		R2_low		Earmarked
CESA 1a (selection from Other Natural Vegetation or Transformed areas based on expert opinion)		High		0Co/ Exc/<NULL>		Available/ Excluded/ <NULL>
		Medium		0Co/ Exc/<NULL>		Available/ Excluded/ <NULL>
		Low		0Co/ Exc/<NULL>		Available/ Excluded/ <NULL>
		Transformed		0Co/ Exc/<NULL>		Available/ Excluded/ <NULL>
Other Natural Vegetation unless CESA 1a		High				Available
		Low				Available
		High		0Co		Available
		Medium		0Co		Available
		Low		Exc		Available
Transformed unless CESA 1a		Transformed				Excluded
		Transformed		Exc		Excluded

C-Plan Outputs	
Res	Sites that are set as reserved in analysis as they have a Protected status
R 2	Mandatory sites (Irreplaceability =1) selected by C-plan when low habitat condition sites excluded from analysis
R2_low	Mandatory sites (Irreplaceability =1) selected by Minset algorithm when low habitat condition sites brought into analysis
R 1	Negotiable sites selected by C-plan
R1_low	Negotiable sites selected by Minset algorithm when low habitat condition sites brought into analysis
0Co	Sites that are not selected by C-plan
Exc	Sites that are excluded in C-plan initially due to having either Low habitat condition or having been transformed so that better condition sites are considered first

Marxan Outputs	
Conserved	Sites that are set as reserved in analysis as they have a Protected status or were selected in C-plan as R2 or R1 sites
Earmarked	Sites that were earmarked by Marxan
Available	Sites that were available for Marxan to choose from but were not earmarked by Marxan
Excluded	Sites that were excluded from the analysis as they are transformed

Table 4: CBA: Significance & Descriptions of Permissible Activities

SDF Cat	CBA Cat	CBA name	Subtype	Description	Significance of Habitat	Objective	Action	Compatible Activities
Protected	Protected	Conservation sites	National, Provincial, Local	Protected Areas (National, Provincial, Local & Contractual Nature Reserves)	Local, National & International significance: Loss of habitat will probably result in extinction of some species & inability to attain conservation targets.	Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation. Ensure site is an asset to the surrounding communities.	Statutory conservation Areas. Ensure management plans are in place & implemented.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.
Protected	Protected	Sites with Conservation Management	National, Provincial or Local government land managed but with no status	These areas are currently being managed as part of existing reserves or core flora sites, but have no legal status as yet.	Local, National & International significance: Loss of habitat will probably result in extinction of some species & inability to attain conservation targets.	Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Secure legal conservation status under the Protected Areas Act. Consolidate into existing provincial or local authority reserves where they lie adjacent. Ensure management plans are in place & implemented.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.
Protected	Protected	Conservation Areas	Private	Private Nature Reserves, some of which have been secured under the CapeNature Stewardship programme	Local, National & International significance: Loss of habitat will probably result in extinction of some species & inability to attain conservation targets.	Maintain natural ecosystems, restore degraded land to natural and manage for no further degradation.	Pursue appropriate stewardship conservation status (contractual or biodiversity agreement). Ensure management plans are in place & implemented.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.

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Critical Biodiversity Area 1	CBA 1a	Irreplaceable Core Flora sites	Non-protected core flora sites	Core Flora Sites: Irreplaceable sites of historical significance & very high priority	Local, National & International significance: Loss of habitat will probably result in extinction of some species & inability to attain conservation targets.	Obtain appropriate legal conservation status. Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Core Flora sites to be gazetted ASAP - we need action. High priority, very high urgency (immediate). Land owner negotiations. Invasive aliens to be controlled.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.
Critical Biodiversity Area 1	CBA 1b	Irreplaceable High & Medium Condition sites	Irreplaceable sites	Critically Endangered vegetation of High & Medium quality. Needed for national targets. Any loss is a permanent & irrevocable loss.	Local, National & International significance: Loss of habitat will probably result in extinction of some species & inability to attain conservation targets.	Obtain appropriate legal conservation status. Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Needed for national targets. High priority, very high urgency (immediate). Invasive aliens to be controlled.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.
Critical Biodiversity Area 1	CBA 1c	Minset High & Medium Condition sites	Minset Targets	High & Medium condition vegetation that is endangered or vulnerable & selected on the Biodiversity Network for meeting national targets (C Plan). Loss can be replaced by obtaining specific Unselected Natural Vegetation sites.	Local, National & International significance: Any loss will require specific alternative areas to be targeted for conservation, but these areas have been set as not negotiable so that the alternative sites can be freed up for development. Consequently these are not negotiable unless alternative, equivalent sites not on the Biodiversity Network are secured first.	Obtain appropriate legal conservation status. Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Needed for national targets. High priority, high urgency (5-10 year horizon). Invasive aliens to be controlled.	Conservation, low impact recreation & environmental education as outlined in the management plan for the site; hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas only.
Critical Biodiversity Area 1	CBA 1d	Irreplaceable Consolidation sites	Minset Targets	Critically Endangered vegetation of restorable condition. Essential for management consolidation & viability of CBA1a, CBA1b & protected sites.	Local, National & International significance: These areas are required to make existing remnants ecologically viable. Loss would result in higher condition remnants being lost through degradation of ecological processes & exhorbitant interventionary ecosystem management costs.	Obtain appropriate legal conservation status. Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Needed for national targets. High priority, high urgency (10 year horizon). Invasive aliens to be controlled.	As above, but higher impact activities (picnic sites, conservation offices, restaurants, EE centres etc) may be situated on highly degraded areas on existing development footprints where this does not impact negatively on ecological processes.

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Critical Biodiversity Area 1	CBA1e	Connectivity sites	Marxan & expert corridor	High, Medium & Low condition vegetation that is endangered or vulnerable & selected on the Biodiversity Network for connectivity (Marxan)	Local, National & International significance: required to maintain large-scale ecosystem processes, climate change mitigation, animal migration & other long term, large scale effects.	As above but with a focus on the maintenance of ecological processes.	Consideration can only be given if suitable alternatives exist. High priority, medium urgency (10-20 year horizon). Invasive aliens to be controlled.	Low impact recreation (hiking, environmental education, bird watching etc); higher impact activities only where environment is suitable (e.g. mountain biking; horse riding on existing roads; boating on vleis etc); hard infrastructure should not be situated in critical biodiversity areas, but outside & adjacent to these, or in existing highly degraded areas on existing development footprints only.
Critical Biodiversity Area 2	CBA 2	Restorable Irreplaceable sites	Minset Targets	Critically Endangered vegetation of restorable condition. Needed for national targets but not for management consolidation, connectivity or viability of priority Biodiversity Network sites.	Although irreplaceable these are degraded. Their loss will have Local, National & International significance but low impact on high quality remnants.	Obtain appropriate conservation status. Maintain natural ecosystems, restore degraded land to natural & manage for no further degradation.	Conserve & restore. Alternatives can be negotiated with the use of compensation for the securing of priority sites. Medium priority, low urgency. Will require a bylaw: High priority, immediate urgency. Invasive aliens to be controlled.	Some higher impact activities (playparks, braai areas, picnic sites, conservation offices, restaurants, EE centres etc) may be situated on the edges of these sites or where the activity does not impact negatively on ecological processes, provided the remainder is restored; resource harvesting may be considered in accordance with the management plan for the site, but under strictly controlled conditions only.
Critical Biodiversity Area 1	CESA 1a	Transformed/ Unselected Natural Vegetation Sites of Conservation Significance	Additional consolidation & ecological support areas	Unselected Natural Vegetation or sites transformed by agriculture or other activities. Essential for management consolidation, connectivity & viability of biodiversity elements in CBA1a, CBA1b & protected sites.	Local, National & International significance: These areas are required to make existing remnants ecologically viable & for movement of larger fauna. Loss would result in the remnants or faunal species being lost through degradation of ecological processes & exhorbitant interventionary ecosystem management costs.	Obtain appropriate legal status, such as open space zoning. Maintain as open space & where appropriate restore degraded land to natural or near-natural for consolidation of other remnants.	Map areas & check zoning is agricultural or rural. Ensure agricultural activity is compatable with ecosystem processes. Where possible, acquire, rezone & rehabilitate. High priority, but low urgency (15 year horizon).	Generally areas outside the urban edge: existing agriculture practices may continue or other compatible farming may occur but the long-term vision is to restore natural ecosystem structure to some of the area to improve ecological processes.

Critical Biodiversity Area 1	CESA 1b	Additional Wetlands, Rivers & Groundwater Recharge areas	Ecological support areas	Areas not selected on Biodiversity Network that are in natural vegetation or areas transformed by agriculture or other activities. Essential ecological support for CBA1, CBA2 & protected sites.	Local significance: These areas may be required for long-term ecological functioning of natural ecosystems. Loss would result in degradation of ecological processes & potential loss of biodiversity elements.	Maintain as open space & where appropriate restore degraded land to natural or near-natural for improved ecological functioning.	Map areas & check zoning is appropriate. Where possible rehabilitate to enhance ecosystem functioning, including invasive alien control.	Activities that do not impinge on wetland functioning & water quality are permissable; ground-water recharge areas should retain sufficient infiltration areas.
Other Natural Vegetation	Other Natural Vegetation	Unselected natural vegetation in high, medium or restorable condition	Not selected	Natural vegetation in Endangered, Vulnerable & Least Concern in high, medium or restorable condition.	Local significance. Will result in impaired ability to meet targets, given that Higher categories will not always be achievable.	Sustainable management within general rural land-use principles	Negotiable. Low priority, no urgency. Invasive alien control	Until Biodiversit Network is secured elsewhere, these areas may become important if required as biodiversity offset sites. Some higher impact activities could be considered on degraded portions, but vegetation in good condition should be subject to low impact activities only.
Transformed	Transformed	Unselected Transformed Sites	Not selected	Transformed land of no currently known conservation significance	No significance.	Sustainable management applying accepted land-use principles	In terms of biodiversity conservation, no action is required.	Agriculture & urban development

Table 5: Wetland Prioritisation Study Statistics

General statistics from the wetland prioritization study, including only the natural and semi-natural wetlands, where prioritization ranking was performed within each wetland type. Six of the 54 wetland types had no natural or semi-natural wetlands remaining. CBA = Critical Biodiversity Area; CESA = Critical Ecological Support Area; OESA = Other Ecological Support Area (updated from Snaddon & Day 2009).

Wetland type	Current Extent (ha)*	Target (24%) (ha)	Extent in proclaimed Protected Areas	Target met in selected BioNet	CBA1		CBA2		CESA		OESA		Total	
					Area (ha)	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)	Number
alluvium fynbos floodplain	4.2	1.0	0.0	2.4	3.0	4	0.0	0	1.2	2	0.0	0	4.2	6
alluvium fynbos isolated depression	1.8	0.4	0.0	0.0	0.0	0	0.9	2	0.9	2	0.0	0	1.8	4
alluvium fynbos isolated seep	15.0	3.6	2.0	2.0	2.0	1	0.0	0	13.0	16	0.0	0	15.0	17
alluvium fynbos seep	88.6	21.3	19.4	46.5	15.2	7	0.2	1	73.2	32	0.0	0	88.6	40
alluvium fynbos valley bottom	43.6	10.5	0.0	42.6	38.7	3	2.2	1	2.8	3	0.0	0	43.6	7
alluvium renosterveld valley bottom	0.7	0.2	0.0	0.0	0.0	0	0.0	0	0.7	1	0.0	0	0.7	1
cape estuarine channel	103.2	24.8	100.1	100.1	100.0	9	3.2	2	0.0	0	0.0	0	103.2	11
cape estuarine depression	133.6	32.1	131.0	131.0	131.0	14	2.7	4	0.0	0	0.0	0	133.6	18
cape river mouth	23.2	5.6	0.0	20.4	18.4	5	4.8	4	0.0	0	0.0	0	23.2	9
dune strandveld depression	74.0	17.8	35.2	53.9	35.2	6	25.7	5	13.2	7	0.0	0	74.0	18
dune strandveld floodplain	748.3	179.6	279.4	744.3	194.4	26	494.4	102	54.7	32	4.7	1	748.3	161
dune strandveld isolated depression	716.7	172.0	77.6	443.7	171.2	127	278.6	271	239.0	197	27.9	50	716.7	645
dune strandveld isolated seep	313.8	75.3	65.8	99.2	81.3	25	23.7	23	200.8	72	8.0	13	313.8	133
dune strandveld seep	84.8	20.3	74.9	83.2	81.9	23	0.7	1	0.6	1	1.6	1	84.8	26
dune strandveld valley bottom	60.8	14.6	45.3	58.7	45.1	12	12.9	3	2.0	9	0.8	2	60.8	26
granite fynbos depression	0.6	0.1	0.0	0.0	0.0	0	0.0	0	0.6	2	0.0	0	0.6	2
granite fynbos floodplain	216.0	51.8	0.0	21.0	54.8	4	25.3	11	14.5	13	121.4	1	216.0	29
granite fynbos isolated depression	1.1	0.3	0.3	0.3	0.3	2	6.5	4	0.6	2	0.3	5	7.6	13
granite fynbos isolated seep	63.5	15.2	6.9	31.0	34.0	43	0.0	0	18.4	23	4.7	7	57.1	73
granite fynbos seep	375.9	90.2	49.7	281.3	274.6	119	40.2	49	60.9	26	0.2	1	375.9	195
granite fynbos valley bottom	148.5	35.6	23.4	84.2	96.7	21	1.0	3	49.1	49	1.5	1	148.5	74
granite renosterveld depression	1.1	0.3	0.0	1.1	0.0	0	1.1	1	0.0	0	0.0	0	1.1	1
granite renosterveld floodplain	2.4	0.6	0.0	0.0	2.4	1	0.0	0	0.0	0	0.0	0	2.4	1
granite renosterveld isolated depression	0.5	0.1	0.0	0.2	0.2	1	0.0	0	0.3	1	0.0	0	0.5	2

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Wetland type	Current Extent (ha)*	Target (24%) (ha)	Extent in proclaimed Protected Areas	Target met in selected BioNet	CBA1		CBA2		CESA		OESA		Total	
					Area (ha)	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)	Number
granite renosterveld isolated seep	6.2	1.5	0.0	1.7	4.8	2	0.4	1	1.0	4	0.0	0	6.2	7
granite renosterveld seep	51.8	12.4	0.0	15.1	0.7	1	8.8	4	42.3	18	0.0	0	51.8	23
granite renosterveld valley bottom	78.5	18.8	0.0	66.8	37.2	3	26.3	2	15.0	13	0.0	0	78.5	18
sand fynbos depression	561.5	134.8	515.0	542.3	159.7	13	48.2	11	347.3	12	6.3	8	561.5	44
sand fynbos floodplain	800.6	192.1	249.6	694.3	494.3	34	44.3	10	253.5	58	8.6	11	800.6	113
sand fynbos isolated depression	454.7	109.1	10.8	213.3	55.8	35	187.4	128	122.5	132	89.0	145	454.7	440
sand fynbos isolated seep	665.3	159.7	57.2	213.9	76.7	36	141.8	73	383.6	171	54.7	47	656.8	327
sand fynbos seep	210.9	50.6	1.2	107.4	15.2	9	86.9	34	89.1	51	19.7	17	210.9	111
sand fynbos valley bottom	319.9	76.8	107.2	221.1	153.2	8	14.7	12	77.9	30	74.0	33	319.9	83
sandstone fynbos isolated depression	20.7	5.0	7.5	15.6	20.4	35	0.1	2	0.2	1	0.0	0	20.7	38
sandstone fynbos isolated seep	230.3	55.3	165.3	214.9	210.5	377	16.6	36	3.3	3	0.0	0	230.3	416
sandstone fynbos seep	485.9	116.6	275.6	477.4	453.8	371	26.3	46	5.1	6	0.7	1	485.9	424
sandstone fynbos valley bottom	330.4	79.3	180.3	326.8	312.4	94	13.0	7	4.8	2	0.2	1	330.4	104
shale band seep	17.1	4.1	0.0	17.1	17.1	5	0.0	0	0.0	0	0.0	0	17.1	5
shale fynbos valley bottom	21.2	5.1	1.6	16.2	12.0	4	4.2	4	4.2	1	0.8	2	21.2	11
shale renosterveld depression	18.0	4.3	0.0	12.6	0.0	0	6.0	9	12.0	6	0.0	0	18.0	15
shale renosterveld floodplain	161.6	38.8	0.0	15.4	3.0	1	140.8	22	17.8	9	0.0	0	161.6	32
shale renosterveld isolated depression	21.6	5.2	0.0	6.0	4.2	3	1.8	1	15.6	22	0.0	0	21.6	26
shale renosterveld isolated seep	128.3	30.8	0.3	52.4	16.8	1	18.2	11	93.3	74	0.0	0	128.3	86
shale renosterveld seep	226.2	54.3	0.4	59.4	12.7	8	38.8	15	164.5	89	4.4	2	220.3	114
shale renosterveld valley bottom	319.6	76.7	0.0	157.5	102.5	5	72.1	13	145.0	52	0.0	0	319.6	70
silcrete renosterveld isolated seep	1.8	0.4	0.0	0.4	0.1	1	0.3	1	1.5	1	0.0	0	1.8	3
silcrete renosterveld seep	1.0	0.2	0.0	0.0	0.0	0	0.0	0	1.0	2	0.0	0	1.0	2
silcrete renosterveld valley bottom	2.7	0.7	0.0	0.0	2.3	1	0.0	0	0.5	1	0.0	0	2.7	2
Total	8599.5	2063.9	2482.9	5694.6	3545.8	1500	1820.8	929	2546.2	1246	424.6	348	8337.4	4023

* Note: historical extent for wetlands is unknown, therefore targets are based on current extent. For highly transformed environments, such as the Cape Flats, the target should be set higher

Table 6: Statistics from Conservation Planning Analysis for City vegetation types

Units are hectares unless specified.

City Vegetation Type	Historic extent	Current extent	% Remaining from historic extent	National Ecosystem Target %	Target	Selected in BioNet	% Selected in BioNet from current extent	Target met in selected BioNet	Extent in proclaimed Protected Areas	% Target met in proclaimed Protected Areas	Ecosystem Status (calculated)
Atlantis Sand Fynbos: Strandveld/Fynbos transition (on calcareous/acidic/neutral sands)	8930	7612	85	30	2679	6918	91	Yes	0	0	LT
Atlantis Sand Fynbos: on marine-derived acid sands	10799	6668	62	30	3240	4562	68	Yes	0	0	LT
Atlantis Sand Fynbos: on older non-aeolian colluvium	2817	1096	39	30	845	878	80	Yes	0	0	EN
Atlantis Sand Fynbos: on recent non-aeolian colluvium	2688	338	13	30	806	338	100	No	0	0	CR
Boland Granite Fynbos: on Granite	3542	2626	74	30	1063	2102	80	Yes	165	16	LT
Boland Granite Fynbos: on older non-aeolian colluvium	180	58	32	30	54	57	97	Yes	0	0	EN
Boland Granite Fynbos: on recent non-aeolian colluvium	5853	3382	58	30	1756	2649	78	Yes	189	11	VU
Cape Estuarine Salt Marshes: Wetlands	40	26	65	24	10	26	99	Yes	26	268	LT
Cape Flats Dune Strandveld: False Bay: on Granite	14	7	50	24	3	6	88	Yes	6	184	VU
Cape Flats Dune Strandveld: False Bay: on Mudstone	9	8	80	24	2	6	79	Yes	0	0	LT
Cape Flats Dune Strandveld: False Bay: on Sandstone	320	289	90	24	77	274	95	Yes	204	266	LT
Cape Flats Dune Strandveld: False Bay: on sands	24948	7605	30	24	5987	6269	82	Yes	1522	25	EN
Cape Flats Dune Strandveld: False Bay: on sands over or on limestone	1970	815	41	24	473	718	88	Yes	124	26	VU
Cape Flats Dune Strandveld: West Coast: on Shale	296	184	62	24	71	72	39	Yes	13	18	LT
Cape Flats Dune Strandveld: West Coast: on recent non-aeolian colluvium	80	7	9	24	19	7	100	No	0	0	CR
Cape Flats Dune Strandveld: West Coast: on sands	10093	8474	84	24	2422	5135	61	Yes	0	0	LT
Cape Flats Dune Strandveld: West Coast: on sands over or on limestone	2230	1938	87	24	535	1678	87	Yes	54	10	LT
Cape Flats Sand Fynbos: Strandveld/Fynbos transition (on	267	8	3	30	80	8	100	No	0	1	CR

City Vegetation Type	Historic extent	Current extent	% Remaining from historic extent	National Ecosystem Target %	Target	Selected in BioNet	% Selected in BioNet from current extent	Target met in selected BioNet	Extent in proclaimed Protected Areas	% Target met in proclaimed Protected Areas	Ecosystem Status (calculated)
calcareous/acidic/neutral sands)											
Cape Flats Sand Fynbos: on marine-derived acid sands	49601	7284	15	30	14880	7280	100	No	460	3	CR
Cape Flats Sand Fynbos: on older non-aeolian colluvium	4108	1038	25	30	1232	1038	100	No	3	0	CR
Cape Flats Sand Fynbos: on recent non-aeolian colluvium	435	139	32	30	130	139	100	Yes	0	0	EN
Cape Lowland Freshwater Wetlands: Wetlands	1464	1095	75	24	351	1069	98	Yes	787	224	LT
Cape Winelands Shale Fynbos: on Scree	698	697	100	30	209	697	100	Yes	0	0	LT
Cape Winelands Shale Fynbos: on Shale	1962	1011	52	30	589	692	68	Yes	218	37	VU
Cape Winelands Shale Fynbos: on recent non-aeolian colluvium	8	0	0	30	2	0	100	No	0	0	CR
Elgin Shale Fynbos: on Shale	841	310	37	30	252	283	91	Yes	5	2	EN
Hangklip Sand Fynbos: on marine-derived acid sands	2261	1138	50	30	678	942	83	Yes	929	137	VU
Hangklip Sand Fynbos: on sands	1041	773	74	30	312	548	71	Yes	434	139	LT
Kogelberg Sandstone Fynbos: on Sandstone	9500	9261	97	30	2850	8814	95	Yes	1944	68	LT
Lourensford Alluvium Fynbos: on recent non-aeolian colluvium	4819	410	9	30	1446	410	100	No	190	13	CR
North Peninsula Granite Fynbos: on Granite	1140	783	69	30	342	748	95	Yes	617	180	LT
North Peninsula Granite Fynbos: on recent non-aeolian colluvium	857	656	77	30	257	596	91	Yes	370	144	LT
Peninsula Sandstone Fynbos: on Mudstone	868	778	90	30	260	766	98	Yes	684	262	LT
Peninsula Sandstone Fynbos: on Sandstone	20455	20011	98	30	6137	19439	97	Yes	16098	262	LT
Peninsula Sandstone Fynbos: on marine-derived acid sands	31	31	100	30	9	31	100	Yes	0	0	LT
Peninsula Sandstone Fynbos: on sands	542	526	97	30	163	526	100	Yes	525	323	LT
Peninsula Shale Fynbos: on Shale	457	316	69	30	137	315	100	Yes	314	228	LT
Peninsula Shale Fynbos: on recent non-aeolian colluvium	805	374	46	30	242	374	100	Yes	373	155	VU
Peninsula Shale Renosterveld: on Shale	1883	305	16	26	490	305	100	No	253	52	CR
Peninsula Shale Renosterveld: on recent	492	12	2	26	128	12	100	No	8	6	CR

CCT Biodiversity Network 2009 Analysis

City Vegetation Type	Historic extent	Current extent	% Remaining from historic extent	National Ecosystem Target %	Target	Selected in BioNet	% Selected in BioNet from current extent	Target met in selected BioNet	Extent in proclaimed Protected Areas	% Target met in proclaimed Protected Areas	Ecosystem Status (calculated)
non-aeolian colluvium											
South Peninsula Granite Fynbos: on Granite	3258	1046	32	30	977	998	95	Yes	842	86	EN
South Peninsula Granite Fynbos: on marine-derived acid sands	233	114	49	30	70	106	93	Yes	90	129	VU
South Peninsula Granite Fynbos: on recent non-aeolian colluvium	3658	1303	36	30	1097	1187	91	Yes	838	76	EN
Southern Afrotemperate Forest: on Granite	31	31	100	34	10	31	100	Yes	27	254	LT
Southern Afrotemperate Forest: on Mudstone	31	31	100	34	10	31	100	Yes	24	229	LT
Southern Afrotemperate Forest: on Sandstone	44	44	100	34	15	44	100	Yes	38	259	LT
Southern Afrotemperate Forest: on Shale	13	13	100	34	4	13	100	Yes	13	294	LT
Southern Afrotemperate Forest: on marine-derived acid sands	2	2	100	34	1	2	100	Yes	2	294	LT
Southern Afrotemperate Forest: on recent non-aeolian colluvium	228	227	100	34	78	227	100	Yes	174	224	LT
Swartland Alluvium Fynbos: on Malmesbury Sandstone	1742	76	4	30	523	76	100	No	0	0	CR
Swartland Alluvium Renosterveld: on recent non-aeolian colluvium	62	0	0	26	2	0	0	No	0	0	CR
Swartland Granite Renosterveld: on Granite	5757	1491	26	26	1497	1491	100	No	36	2	CR
Swartland Granite Renosterveld: on older non-aeolian colluvium	2148	417	19	26	558	417	100	No	0	0	CR
Swartland Granite Renosterveld: on recent non-aeolian colluvium	154	44	29	26	40	44	100	Yes	0	0	EN
Swartland Shale Renosterveld: on Shale	41492	3746	9	26	10788	3746	100	No	381	4	CR
Swartland Shale Renosterveld: on older non-aeolian colluvium	21	0	0	26	5	0	0	No	0	0	CR
Swartland Shale Renosterveld: on recent non-aeolian colluvium	5200	273	5	26	1352	273	100	No	27	2	CR
Swartland Silcrete Renosterveld: on recent non-aeolian colluvium	1067	188	18	26	277	188	100	No	0	0	CR
Western Shaleband Vegetation: on Cedarberg Shale Band	329	329	100	30	99	329	100	Yes	31	32	LT

Note 1: Reclaimed areas & beach were excluded as little to no vegetation exists there; Note 2: Selected in BioNet: excludes Other Natural Vegetation & CESA 1a areas

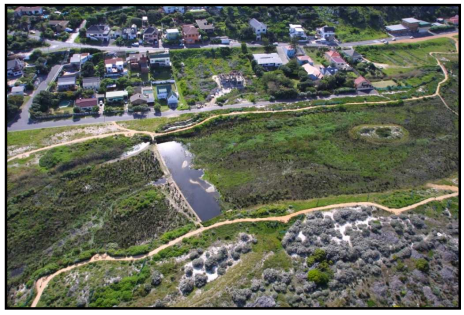


ROADS & STORMWATER DEPARTMENT



Catchment, Stormwater and River Management Branch

Floodplain and River Corridor Management Policy



Balancing flood risk, ecological and socio-economic considerations in developments near watercourses and wetlands



Version 2.1

Approved by Council
27 May 2009
C 58/05/09

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

(Previously entitled: Floodplain Management Guidelines)

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1 Preamble

There is a developing worldwide view in many cities that watercourses and wetlands, whether natural or constructed, form an integral component of urban stormwater management systems, are important for sustaining the aquatic ecology of the city, and are an essential element in restoring the urban fabric of the city by providing both recreational and socio-economic opportunities to all citizens.

A well managed watercourse / wetland is a valuable resource for improving the quality of life and aesthetic nature of an urban area and provides benefits for public health, recreation and economic growth. This is particularly important in the context of changing weather patterns and the associated local, national and international strategies targeting sustainability issues.

This policy document is an enhancement of the former Floodplain Management Guidelines (Version 1.0) published in September 2003. Various improvements have been effected to align the policy principles to corporate strategic objectives. It outlines the procedure for managing development adjacent to watercourses and wetlands taking cognisance of the flood regime, aquatic and riparian ecology as well as socio-economic factors.

2 Definitions

In this policy, unless inconsistent with the context:–

"Council" means the City of Cape Town;

“development” means any man-made change to property, including but not limited to construction or upgrading of buildings or other structures, filling, paving, municipal services, or the associated preparation of land;

“ecological buffer” means a strip of land adjacent to a watercourse, wetland or vlei required for the protection and enhancement of these ecosystems;

"fill" means the placement of fill material such as natural sands, dirt, soil or rock and may include concrete, cement or other waste materials at a specified location to bring the ground surface up to a desired elevation;

“floodlines” mean lines on a map or drawing depicting water levels likely to be reached by a flood having a specified recurrence interval;

“floodplain” means the land adjoining a watercourse which is susceptible to inundation by floods up to the one hundred year recurrence interval;

“floor” means the inner, lower surface of a room, garage or basement to which the occupants of a building have access;

“recurrence interval” means the average interval between rainfall or flood events equaling or exceeding a specified severity;

“river corridor” means a mixed-use corridor comprising a watercourse and/or associated wetlands, the floodplain, the ecological buffer and the area required for specific aesthetic, recreational and/or socio-economic needs. This combined area must be managed in an integrated manner which balances the flooding, environmental, social and economic issues;

“stormwater” means water resulting from natural precipitation and/or the accumulation thereof and includes groundwater and spring water ordinarily conveyed by the stormwater system, as well as sea water within estuaries, but excludes water in a drinking water or waste water reticulation system;

“stormwater system” means both the constructed and natural facilities, including pipes, culverts, watercourses and their associated floodplains, whether over or under public or privately owned land, used or required for the management, collection, conveyance, temporary storage, control, monitoring, treatment, use and disposal of stormwater;

"structure" means any man-made feature affixed to the ground or attached to something located on the ground, including but not limited to fences, walls, berms, levees, fill, storage tanks, shelters or buildings;

“top of bank” of a watercourse means a position identifiable by scour lines, vegetation limits, changes in bed and bank materials, the presence of flood deposited silt, or abrupt changes in slope;

“water sensitive urban design” is an approach which seeks to ensure that development in urban areas is holistically planned, designed, constructed and maintained so as to reduce negative impacts on the natural water cycle and protect aquatic ecosystems.

“watercourse” means a river, stream, channel, canal, vlei, wetland, dam or lake in or into which water flows regularly or intermittently. Reference to a watercourse includes, where relevant, its bed and banks;

“wetland” means land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil. This definition thus includes, but is not necessarily limited to, water bodies such as lakes, salt marshes, coastal lakes, estuaries, marshes, swamps, vleis, pools, ponds, pans and artificial impoundments.

“wetland delineation” means the determination and marking of the boundary of a wetland using nationally accepted guidelines / methodologies.

3 Introduction

Watercourses and wetlands are integral to the stormwater management system, are an important component of the City’s biodiversity network, and represent an essential element in restoring the urban fabric of the City by providing both recreational and economic opportunities.

This policy supports the Roads and Stormwater Department objectives incorporated in the Integrated Development Plan for the City of Cape Town, namely to;

- Reduce the impact of flooding on community livelihoods and regional economies
- Safeguard human health, protect natural aquatic environments, and improve and maintain recreational water quality

The management of land use, development or activity adjacent to watercourses and wetlands is important for the following reasons:

- It is far more cost effective, in the long term, to develop in areas where the threat of flooding is infrequent and the severity of flooding is minimal as opposed to the retrospective

implementation of flood mitigation works which would generally be extremely costly and sometimes prone to catastrophic failure when flood flows exceed the design capacity of infrastructure

- Climate change predictions indicate greater variability in the intensity and magnitude of storm events coupled with accelerated sea level rise. These uncertainties pose significant challenges for the management of major drainage systems.

- Encroachments result in ecological degradation, often reducing water quality and precipitating loss of ecological resources irreversibly.

- Since modifications to natural systems may disrupt natural aquatic and geomorphological processes they require a long term maintenance commitment. Therefore urban activity must be managed in such a way that maintenance activities can be adequately conducted.

- To promote a sense of place and recreational enjoyment for communities.

This policy describes a merit based approach for dealing with land use, development or activity proposals near watercourses and wetlands.

4 Legislative Context and Legal Mandate

Land use, development and associated activities influenced by this policy are dealt with in terms of the statutes and planning frameworks highlighted in the following sections.

4.1 National

- National Building Regulations & Building Standards Act, 1997 (Act 103 of 1977)
- Conservation of Agricultural Resources Act (Act 43 of 1983)
- National Water Act (Act 36 of 1998)
- National Environmental Management Act (Act 107 of 1998)
- Disaster Management Act (Act 57 of 2002)
- National Environmental Management: Biodiversity Act (Act 10 of 2004)
- National Environmental Management: Protected Areas Act (Act 57 of 2004)

4.2 Provincial

- Western Cape Planning & Development Act (Act 7 of 1999) (This Act will apply upon its coming into operation).
- Land Use Planning Ordinance, 1985 (Ordinance 15 of 1985)

4.3 City of Cape Town

- Integrated Development Plan (2007/8 to 2011/12)

  The Roads and Stormwater Department objectives are incorporated in the Integrated Development Plan for the City of Cape Town:

  - Reduce the impact of flooding on community livelihoods and regional economies

  - Safeguard human health, protect natural aquatic environments, and improve and maintain recreational water quality

- By-law relating to Stormwater Management (Promulgated September 2005 – PG 6300) together with which this policy is to be read and interpreted.

The City's By-law relating to Stormwater Management defines the stormwater system to mean "both the constructed and natural facilities, including pipes, culverts, watercourses and their associated floodplains, whether over or under public or privately owned land, used or required for the management, collection, conveyance, temporary storage, control, monitoring, treatment, use and disposal of stormwater".

Clauses 4 and 5 of the By-law deal with the protection of the stormwater system (which includes the natural and built systems and associated floodplain) and the prevention of flood risk.

It is in terms of this By-law therefore that Council may prohibit or conditionally permit development in areas adjacent to watercourses and wetlands.

In addition, a number of other documents have been produced over the years which have referred to the management of development adjacent to watercourses and wetlands, either directly or by implication, and considered how these areas should be managed. Some of the more pertinent are listed below.

- Greening the City: Open Space and Recreation Plan for Cape Town (1982)
- Roads and Stormwater Department: Catchment, Stormwater and River Management Strategy (2002)
- Biodiversity Strategy (2003) and Biodiversity Report (2008)
- Coastal Zone Strategy (2003) and Coastal Zone Management Review and State of the Coast Report Year 3 (2006)
- CMOSS – An Open Space Strategy (2005)
- Planning for Future Cape Town (2006)

5 Policy Rationale

Within the confines of the Cape Town Metropolitan Area the pressure to develop is significant and requires careful management to avoid developing in high flood risk areas, to protect the environmental integrity of aquatic resources and to ensure that permitted development enhances the aesthetics and character of the adjacent watercourses / wetlands.

In order to achieve this, a new approach is required where engineering, environmental and socio-economic elements are assessed and integrated as the vision for a particular watercourse / wetland system.

In this Policy a merit based approach is advocated for dealing with proposals within and adjacent to floodprone areas and environmental buffers. In addition, socio-economic considerations are also introduced whereby any permitted development will take cognizance of the presence of the watercourse / wetland and thereby holistically enhance the urban fabric of the area.

This Policy is important in achieving the service outcomes (refer to Section 3) namely; reducing the impact of flooding on people and properties, and of safeguarding human health, aquatic environments and improving and maintaining recreational water quality.

6 Policy Statement

"In order to ensure sustainable development and associated activities within or adjacent to natural and built stormwater systems, and that there is a balanced consideration of potential flood risk, environmental impacts and socio-economic needs, all developments within these areas shall be planned and designed in accordance with best practice and the requirements and conditions laid down in this policy."

This policy supports the service outcomes as highlighted in Section 3 above. It furthermore ensures administrative actions with respect to land use planning applications that are lawful, reasonable and procedurally fair.

7 Scope and Application

This policy is applicable to land use, development or building or activity proposals adjacent to watercourses or wetlands. The principles regarding flood management can also be applied to development in the vicinity of formal stormwater management systems.

8 Objectives

The objectives of this policy are to manage development in a manner that;

- Limits or reduces exposure to flood risk by avoiding hazardous, uneconomic or unwise use of floodplains, thereby protecting life, property and community infrastructure.
- Protects the natural flood carrying capacity of watercourses and wetlands.
- Protects and enhances the intrinsic value and the environmental goods and services provided by watercourses, wetlands and associated riparian areas and floodplains.
- Facilitates the beneficial integration of watercourses into the urban landscape by creating an aesthetically pleasing public resource which will ultimately allow for the social and economic up-liftment of communities adjacent to watercourses and wetlands.
- Provides an effective decision making tool for officials, developers and consultants by introducing an element of predictability with regard to applications for development along watercourses / river corridors and adjacent to wetlands.
- Promotes sustainable development from engineering, environmental and socio-economic perspectives.

9 Planning, Safety, Environmental and Socio-economic Considerations

Land use, development or activities near watercourses and wetlands must be appropriate for the anticipated degree of flood risk whilst minimising concomitant environmental impacts and sustaining a sense of place and urban form. The following sections outline the planning, safety, environmental and socio-economic aspects to be considered when evaluating applications as envisaged in Section 7 above.

9.1 Plans / Sectoral plans

Cognisance must be taken of applicable requirements and recommendations contained in various plans / related documents. Various categories of plans that should be consulted where

available are listed below. Sound engineering and environmental judgment should be applied in the absence of these guide plans.

- Roads and Stormwater Department: Catchment, Stormwater and River Management Strategy 2002 – 2007
- Catchment & River Management Plan
- Stormwater Master Plan

9.2 Flood Management and Public Safety

Watercourses and their associated floodplains can convey significant volumes of water under flood conditions. For the purposes of this policy, a floodplain is defined as the area susceptible to inundation by the 100-year flood, as indicated in Figure 1 below.

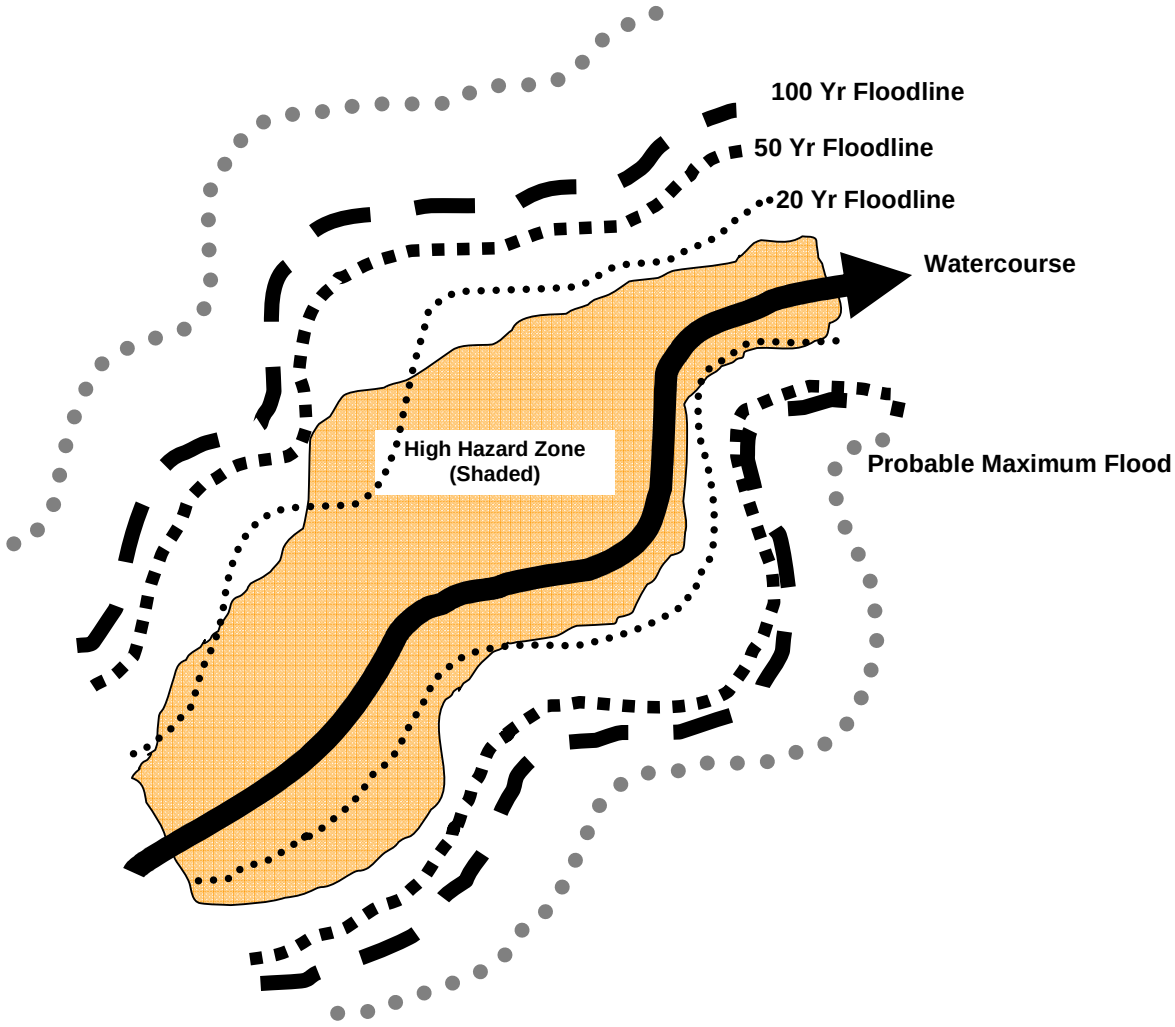


Figure 1: Schematic representation of floodplain depicting watercourse and significant floodlines

The high hazard zone within a floodplain, based on an analysis of the expected flow characteristics of the 100-year flood, is graphically indicated in Figure 2 below. The ability to wade or gain vehicular access as well as the stability of structures such as dwellings or boundary walls are deemed seriously compromised under these conditions. No new or additional rights or the exercising of existing development rights will be granted to properties located within the high hazard zone.

The permissible extent and nature of land use, development or activities within floodplains must be subject to stringent evaluation and control in the interests of public safety. In particular, obstruction to the free flow of water within the 20-year floodline area shall not be permitted. However, between the 50 and 100-year floodlines, some developments or activities may be permitted, subject to such conditions as the City may in its discretion impose, while developments with particular evacuation or emergency response issues and high risk developments will only be permitted above the 100-year floodline (refer to Table 1).

Any proposed development or redevelopment within the floodplain must be supported by a report by a registered professional engineer to ensure that any new or existing structure can withstand the forces and effects of floodwaters (refer to requirement R1 in Table 1). If building plans are submitted in respect of proposed buildings within the floodplain and such a report has not previously been submitted, it must be included with the building plans.

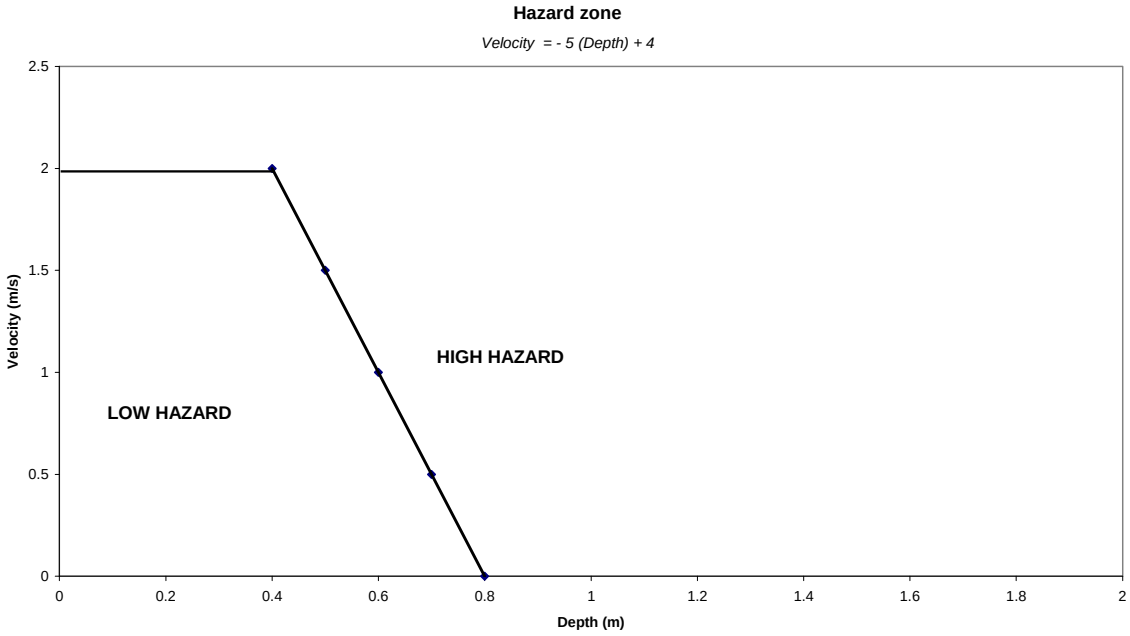


Figure 2: Flood hazard zones

9.2.1 Floodline Determination

Where floodlines have not previously been determined for a particular location, the developer will be required to procure the services of a suitably qualified registered engineering professional to undertake such determinations at own cost and to submit a report in connection therewith together with such planning or building plan approval applications he or she may lodge with the City. This should take place prior to any detailed planning being undertaken and must be in accordance with generally accepted practice.

In determining catchment runoff, the foreseeable ultimate development scenario for the catchment must be considered. All floodlines must be based on the theoretical energy level as opposed to the water surface level.

Permissible landuse / development / activity and applicable conditions within the floodplain are indicated in Table 1: Framework for the assessment of proposals (section 10). Depending on the type of application a range of floodlines must be determined as indicated below:

Floodline (Annual Probability)	Rationale
2 year (50%)	Determine if required (see Table 1)

Floodline (Annual Probability)	Rationale
20 Year (5 %)	Required for parking and other activities
50 Year (2%)	Controls a number of development activities
100 Year (1%)	Controls floor levels and high risk development activities

Note: Other legislation (e.g. NEMA) may require additional floodline determinations and therefore further restrictions may apply.

9.3 Ecological Buffers

Watercourses and wetlands with their adjacent riparian areas and associated fauna and flora must be protected or "buffered" from the impacts of adjacent development or activity. Often referred to as ecological buffers, these protected zones / set backs provide continuous corridors and habitat for flora and fauna. Buffers also provide other benefits such as water quality improvement of point or diffuse sources of pollution, stream bank and erosion protection from the hydrological impacts associated with hardened catchments in urban areas, and space for implementation of appropriate water sensitive urban design elements. In addition buffer areas can provide socio-economic benefits in the form public open space, opportunities for recreation and environmental education / awareness, and enhancement of waterway, visual and property values. In instances where watercourses have been canalized, buffers are still required to aid maintenance and, in some instances, to allow adequate space for possible future restoration activities.

Determination of ecological buffer widths is based on classification of the watercourse or wetland in terms of a recognized national classification system followed by an assessment of the ecological condition and importance of the system (using nationally recognized methods). Watercourses and wetlands with high ecological condition and importance require a wider buffer than those which have been exposed to considerable modification. For watercourses, buffer width may also be adjusted on the basis of the width of the active channel. The buffer is measured from watercourse "top of bank" or outer edge of the wetland (which must be delineated according to nationally accepted guidelines / methodologies e.g. DWAF 1999 and 2005). They have been determined for several of the significant watercourses and certain wetlands within the metropolitan area and vary in width between 10 m and 40 m for watercourses, and up to 75 m for wetlands. A minimum buffer of 10 m is required for concrete canals. Buffers must be adjusted to accommodate wetlands in close association with a watercourse as indicated schematically in Figure 3.

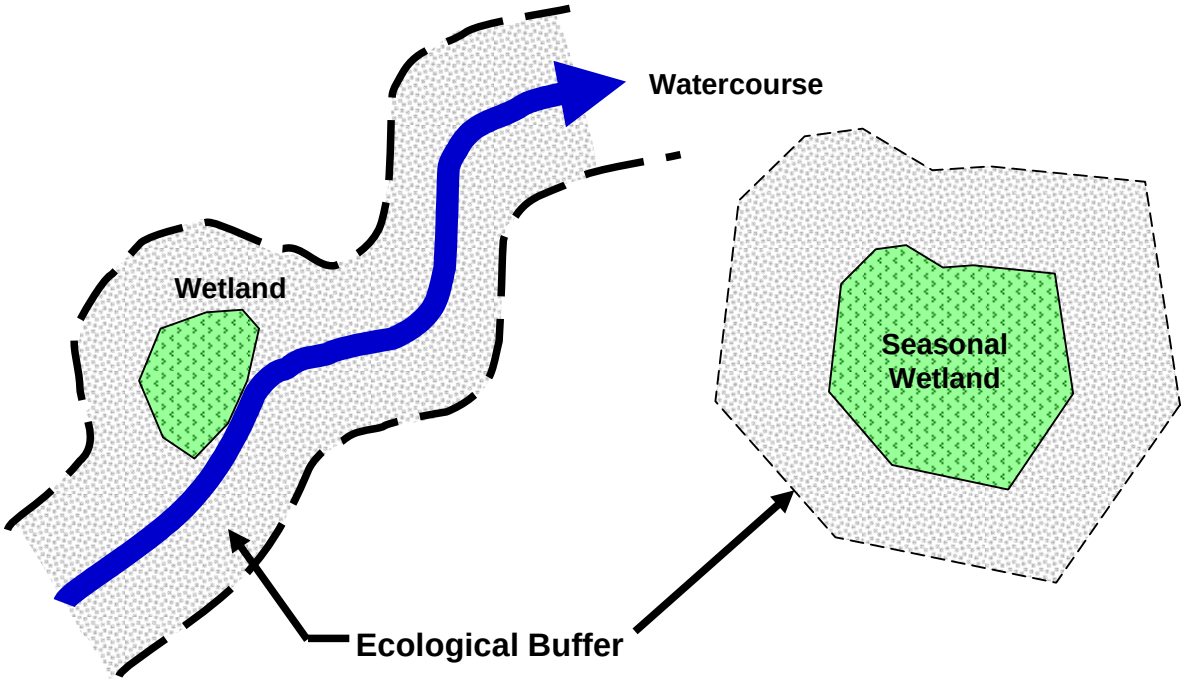


Figure 3: Schematic representation of ecological buffers

Where ecological buffers have not yet been determined for a particular watercourse or wetland, either the City may determine a buffer width by extrapolation if calculated buffer widths are available for similar situations elsewhere, or the developer is required to procure the services of a suitably qualified freshwater ecologist to recommend buffer widths in terms of Council guidelines or approved best practice at own cost and to submit a report in connection therewith together with such planning and building plan approval applications as he or she may submit to the City. This must take place prior to any detailed planning being undertaken.

Site / case specific adjustment of the recommended minimum buffer width may be necessary to allow for exceptional circumstances such as the presence of sensitive habitats, fauna or flora which may require wider buffers for adequate protection; the intensity of adjacent landuse and the nature of anticipated impacts; and the physico-chemical and/or botanical characteristics of the buffer area which may alter the efficacy of the buffer to mitigate against identified impacts.

Permissible landuse / development / activity and applicable conditions within the ecological buffer are indicated in Table 1: Framework for the assessment of proposals (section 10).

9.4 Geomorphological Processes

Cognisance must also be taken of the fact that the beds of many watercourses, particularly on the Cape Flats, are dynamic and prone to erosion, sedimentation and meandering. Where the ecological buffer width and/or floodplain setback requirement is considered an inadequate allowance for these natural processes, additional site-specific studies and setback width may be required in the discretion of the City prior to planning and building plan approval. In these instances, the developer will be required to procure the services of a suitably qualified geomorphologist to determine setback widths at own cost and to submit a report in connection therewith upon request.

9.5 Socio-economic Considerations

Watercourses and wetlands are public resources which have the remarkable potential to stimulate local economies and to break down political, social and economic barriers if managed

and used with this goal in mind. Assessment of developments adjacent to watercourses and wetlands must therefore take cognizance of this potential and promote developments which actively incorporate these systems into the urban fabric of the area.

Without derogating from the general nature of what is stated in this clause, the following specific issues must be considered:

- Water Sensitive Urban Design principles
- Layout / configuration and nature of adjacent development and/or associated activities
- Watercourse / wetland frontage with adjacent development
- Areas of passive and active open space
- Areas for walkways, cycle tracks, picnic facilities
- Aesthetic improvement of degraded systems with appropriate indigenous landscaping
- Public access
- Safety and security
- Economic upliftment
- Environmental education and awareness
- Environmental standards and best practice

Socio-economic considerations such as those listed may be taken into consideration by the City when evaluating planning and building plan approval applications, in its discretion.

9.6 River Corridor

The “River Corridor” comprises the watercourse and/or associated wetlands (as applicable), the floodplain, the ecological buffer and the area required for specific aesthetic, recreational and/or socio-economic needs. This combined area must be managed in an integrated manner which balances the flooding, environmental, social and economic issues (as outlined in the preceding sections 9.2 to 9.5) . The City shall strive to develop river corridor plans for all river corridor areas within its jurisdiction, in order to give effect ultimately to this holisitic vision.

An allowance of up to 10 m (measured from the top of bank or outer edge of the wetland) dependent on the current or future maintenance strategy for the watercourse / wetland must be made for maintenance access.

10 Assessment of Proposals and Applications

This policy advocates a merit-based approach to the assessment of proposals and applications pertaining to property near watercourses and wetlands. Any new land use, development, activity or building must be appropriate for the anticipated flood risk and geomorphological process requirements and compatible with the ecological buffer and socio-economic requirements, whilst allowing access for maintenance. Table 1 provides acceptable land use for the various floodplain zones and buffer, as well as specific requirements in instances where conditional approval is considered.

Proposed land-use / development / activities / buildings must be set back beyond the greater of the applicable floodplain, geomorphological and ecological buffer requirements.

Typical proposals requiring input and approval may be divided into three broad categories as described in the following sections.

10.1 Zoning Schemes, Structure Plans and Related Policies

Only land uses considered appropriate within the applicable floodplain and ecological buffer (Refer Table 1) can be contemplated. In addition geomorphological, maintenance as well as social and economic aspects must be considered.

10.2 Land Use Planning Applications

10.2.1 New Development Rights

Developments or activities falling within this category typically require additional and/or amended land use rights to proceed, such as:

- Rezoning
- Sub-division
- Land use departures
- Consent use
- Amendment of plans or conditions of approval

Only land uses, developments or activities considered appropriate within the applicable floodplain and ecological buffer (Refer to Table 1) can be contemplated. In addition geomorphological, maintenance, social and economic aspects must be considered where appropriate.

10.2.2 New Development Rights on Existing Building Footprint

Where no increase in existing building footprint or usage is proposed, as in the case of the redevelopment of an existing building, deviation from this could be considered, where the development or activity is located outside the high hazard zone, subject to compliance with the following:

- Fulfillment of requirements R1 and R2 on Table 1.
- Implementation of appropriate flood protection and mitigation works, including but not limited to the flood proofing of buildings and flood evacuation plans if appropriate. The developer must make adequate provision for future maintenance or operation.
- The registration of a Notarial Deed of Restraint against alienation, which provides that the registered owner shall not be entitled to alienate his/her property without the consent of the City. Such consent shall be withheld until such time as the new owner/purchaser signs an indemnity on terms and conditions acceptable to council. The issuing of a clearance certificate in terms of section 118(1) of the Municipal Systems Act No. 32 of 2000 shall not constitute consent for the abovementioned purpose.
- Endorsement of all Building Plans to the effect that the owner is aware of the consequences of developing within a floodplain and floodlines to be depicted on all applicable building plans.

10.3 Building Plan Applications (Exercising of Existing Development Rights)

Consideration of building plans for structures, submitted in terms of existing development rights, will be conditional on the following:

- Location of buildings on the higher lying portions of the property with floors above the 100-year flood level where practically possible, the flood proofing of buildings and flood evacuation plans where necessary.
- No buildings will be permitted within the high hazard zone.
- Limitation of all construction / development activity within the ecological buffer.
- Consideration of measures to mitigate potential maintenance impacts as appropriate.
- The registration of a Notarial Deed of Restraint against alienation, which provides that the registered owner shall not be entitled to alienate his/her property without the consent of the

City. Such consent shall be withheld until such time as the new owner/purchaser signs an indemnity on terms and conditions acceptable to council. The issuing of a clearance certificate in terms of section 118(1) of the Municipal Systems Act No. 32 of 2000 shall not constitute consent for the abovementioned purpose.

- Endorsement of all Building Plans to the effect that the owner is aware of the consequences of developing within a floodplain and floodlines to be depicted on all applicable building plans.

10.4 Development Layouts

In preparing development layouts cognisance must be taken of the various considerations outlined in the previous sections (10.2 and 10.3) as well as Council's Stormwater Management Planning and Design Guidelines for New Developments. Where appropriate, a servitude protecting the floodplain and / or ecological buffer from alteration or obstruction on completion of the development must be registered in favour of Council by the developer at own cost. Where maintenance access is required, this must also be incorporated in the conditions of servitude.

Buildings must be located above the appropriate flood level or buffer zone, or on the upper extremities of the property if the site is entirely located within the relevant floodline, and must front or provide views onto the watercourse or wetland to ensure adequate visual surveillance and integration of the system into the fabric of the development and the City as a whole. Perimeter fencing below the 50-year floodline must be visually permeable from ground level and not adversely affect the free flow of water and movement of aquatic fauna (e.g. palisade fencing).

10.5 Table 1: Framework for the Assessment of Proposals

Table Shading Key	
Colour Coding	**Description**
Clear	Permitted
	Conditionally Permitted
	Not Permitted

Additional Requirement Key	
Code	**Requirement**
R1	A registered Engineering Professional must be engaged by the developer to satisfactorily demonstrate and certify that: ▪ The activity / development will not materially increase flood hazards for other property owners or adversely affect flood behavior or the stability of river channels. ▪ Any structure can withstand the forces and effects of flowing floodwaters, including scour of foundations, debris forces and buoyancy forces.
R2	Floors above 1:100 year flood level. Basements (non-habitable purposes) to be flood-proofed to 1:50-year flood level.
R3	Floors above 1:50 year flood level.
R4	A registered Environmental Professional (Aquatic Ecologist) must be engaged by the developer to determine the ecological buffer (if not available) and to satisfactorily demonstrate and certify that: • The activity / development will not negatively impact on the present condition of the watercourse or wetland OR • The activity or development will improve the condition of the watercourse or wetland from its present state

The land use / development / activity must be set back beyond the *greater* of the applicable floodplain zone / geomorphological or ecological buffer requirements

Land use / Development / Activity		**Requirements and Conditions**							
		Floodplain Zone (Flood Recurrence Interval in Years)						**Ecological Buffer (Width in meters)**	
Category	**Typical Examples**	**< 2**	**2–20**	**20–50**	**50-100**	**>100 (Note 1)**	***Explanatory Notes***	**Up to 75m (Note 2,3)**	***Explanatory Notes***
Industrial Development	Light, General, High Risk								
	Extractive (Mining)		R1	R1	R1				
Business Development	General				R2				
	Commercial (CBD)								
	Service Stations								
Residential Development	Formal				R2				
	Informal								
Community & Public Facilities	Hospitals, Clinics, Nursing Homes, Old Age Home								

Land use / Development / Activity		Requirements and Conditions							
		Floodplain Zone (Flood Recurrence Interval in Years)						Ecological Buffer (Width in meters)	
Category	**Typical Examples**	**< 2**	**2–20**	**20–50**	**50-100**	**>100 (Note 1)**	***Explanatory Notes***	**Up to 75m (Note 2,3)**	***Explanatory Notes***
	Prisons, Military Bases, Police Stations, Fire Stations								
	Cemeteries								
	Educational Facilities								
	Public Halls, Places of Worship								
Utility / Infrastructure Services (incl. Private)	Stormwater Management Facilities	R1	R1					R4	
	Underground Sewers, Services						Manhole cover levels above 1:50 year flood level. Structure to be suitably protected and integrated into surrounds		
	On Site Sewage Treatment								
	Water & Wastewater Works, Pump Stations								
	Solid Waste Disposal Sites								
	Power Generation, Electrical Substations								
	Telecommunication Exchanges & Transmitters.								
Environment, Open Space & Recreation	Nature Reserves and Conservancies						All structures/earthworks to be subject to conditional approval		All structures/earthworks to be subject to conditional approval
	Sports Fields, Golf Courses, Picnic Areas		R1	R3			All club houses and similar structures to be above the 50 year floodline	R4	
	Public & Private Open Space						All structures/earthworks to be subject to conditional approval		All structures/earthworks to be subject to conditional approval
Agriculture	Cultivation, Free-range animal husbandry		R1	R1			Subject to Conservation of Agricultural Resources Act (CARA) Regulations		

Land use / Development / Activity		Requirements and Conditions							
		Floodplain Zone (Flood Recurrence Interval in Years)						Ecological Buffer (Width in meters)	
Category	**Typical Examples**	**< 2**	**2–20**	**20–50**	**50-100**	**>100 (Note 1)**	***Explanatory Notes***	**Up to 75m (Note 2,3)**	***Explanatory Notes***
	Agricultural Processing / Industry				R1,R2				
	Feedlots, Piggeries and Battery Farming			R1	R1		Subject to Conservation of Agricultural Resources Act (CARA) Regulations		
Resorts	Hotels, Holiday Resorts and Bungalows,				R2				
	Caravan and Camping Sites		R1	R3			All ablution facilities to be located above the 20 year floodline	R4	
Transport Systems	Roads and Railways elevated above NGL		R1	R1	R1				
	Modal Interchanges, Bus Depots, Railway Stations								
	Parking Areas			R1					
Bank Protection Works, Flow Diversion Structures, & Earthworks	Revetments, Training Walls, Levees	R1	R1	R1				R4	
	Dams, Weirs, Bridges	R1	R1	R1	R1	R1	Dam-break analysis to be performed where required in terms of National Water Act	R4	
	Filling				R1	R1	In exceptional circumstances minor "smoothing" of the 50 / 100 year floodline may be considered, provided equivalent compensatory stage storage volume is provided within the development precinct		

Note 1: The effects of the 100-year storm event on all developments and infrastructure, including adjacent and downstream properties, must be evaluated to comply with the above requirements.

Note 2: Watercourses: 10 to 40 m; Wetlands: up to 75 m

Note 3: Conditional approval may be granted for certain low impact social needs / activities, appropriate landscaping, indigenous planting, pathways

11 Commencement and Implementation

11.1 Commencement Date

Unless otherwise specified, the commencement date for this policy will be the date of adoption by Council

11.2 Existing Policies / Guidelines Repealed

The following existing policies / guidelines are repealed:

Title	Commencement Date	Resolution
Floodplain Management Guidelines: Version 1.0	September 2003	MC37/11/03

12 General

12.1 Statutory Permits and Approvals

Certain developments or activities may be subject to approvals in terms of national legislation by Provincial and National Government Departments.

Examples include, but are not limited to:

- Storing water
- Impeding or diverting the flow of water in a watercourse
- Altering the bed, banks, course or characteristics of a watercourse
- Using water for recreational purposes
- Abstraction
- Land reclamation
- Agricultural cultivation in close proximity to watercourses.

12.2 Indemnity

The degree of flood and/or environmental protection recommended by this policy is considered reasonable for regulatory purposes and is based on engineering and scientific methods of study. Mere compliance with its provisions cannot ensure complete protection from flooding particularly from high order events or reduced environmental impact and must therefore not be construed as a warranty.

This policy shall not create liability on the part of the City of Cape Town or any officer thereof, for any damage that may result from reliance thereon.

12.3 Copyright

All rights reserved by the City of Cape Town, South Africa. No part of this document may be reproduced in any form without the written permission of the City of Cape Town, with the exception of photocopying for educational purposes.

12.4 References

Flood Risk Reduction Measures, Alexander WJR, Department of Civil Engineering, University of Pretoria, April 2000

Development Control Guidelines in Floodprone Areas (Prepared for the former Cape Metropolitan Council), VKE Consulting Engineers (Pty) Ltd in association with Barker and Louw Town and Regional Planners, Dr J. Neethling (Environmental Specialist), Prof A. Rooseboom (Hydraulics and Hydrology Specialist) Du Plessis and Hofmeyer Attorneys, Dr C. Brown (Freshwater Ecologist), June 2000

National wetland inventory – development of a wetland classification system for South Africa. WRC REPORT: KV 174/06 Ewart-Smith, J.L., Ollis, D.J., Day, J.A. and Malan, H.L. 2006.

River and vlei assessment and monitoring in the CMA – revisiting and refining the river importance and sensitivity maps. Southern Waters, 2002.

Resource Directed Measures for Protection of Water Resources: Wetland Ecosystems. Appendix W6: Guidelines for the delineation of wetland boundary and wetland zones. Editor: H. Mackay. Department of Water Affairs and Forestry. 1999.

A practical field procedure for identification and delineation of wetlands and riparian areas. Department of Water Affairs and Forestry 2005.

STORMWATER MANAGEMENT BY-LAW

APPROVED BY COUNCIL : 30 AUGUST 2005
C 35/08/05

PROMULGATED 23 SEPTEMBER 2005
PG 6300; LA 31420

CITY OF CAPE TOWN

BY-LAW RELATING TO STORMWATER MANAGEMENT

(Approved by Council on 30 August 2005—C35/08/05)

To provide for the regulation of stormwater management in the area of the City of Cape Town, and to regulate activities which may have a detrimental effect on the development, operation or maintenance of the stormwater system.

1. Definitions

In this by-law, unless inconsistent with the context:—

"Council" means the municipal council of the City of Cape Town, or any political structure, political office-bearer, committee, councillor, or official of the Council, delegated to exercise powers or perform duties in terms of this by-law;

"floodplain" means the land adjoining a watercourse which, in the opinion of the Council, is susceptible to inundation by floods up to the one hundred year recurrence interval;

"private stormwater system" means a stormwater system owned, operated or maintained by a person other than the Council;

"stormwater" means water resulting from natural precipitation and/or the accumulation thereof and includes groundwater and spring water ordinarily conveyed by the stormwater system, as well as sea water within estuaries, but excludes water in a drinking water or waste water reticulation system;

"stormwater system" means both the constructed and natural facilities, including pipes, culverts, watercourses and their associated floodplains, whether over or under public or privately owned land, used or required for the management, collection, conveyance, temporary storage, control, monitoring, treatment, use and disposal of stormwater;

"water pollution incident" means an incident or occurrence which has a detrimental impact or a potential detrimental impact on the quality of the water in the stormwater system to such an extent that public health or the health of natural ecosystems may be threatened, and

"watercourse" means:—

(a) a river, spring, stream, channel or canal in which water flows regularly or intermittently, and

(b) a vlei, wetland, dam or lake into which or from which water flows,

and includes, where relevant, the bed and the banks of such watercourse.

2. Application

(1) This by-law binds any organ of state.

(2) Any provision in any other by-law dealing specifically with stormwater, is subject to the provisions of this by-law.

3. Prohibited discharges

No person may, except with the written consent of the Council and subject to any conditions it may impose, discharge, permit to enter or place anything other than stormwater into the stormwater system.

4. Protection of stormwater system

No person may, except with the written consent of the Council and subject to any conditions it may impose—

(a) damage, endanger, destroy or undertake any action likely to damage, endanger or destroy, the stormwater system or the operation thereof;

(b) discharge from any place, or place onto any surface, any substance other than stormwater, where that substance could reasonably be expected to find its way into the stormwater system;

(c) discharge, permit to enter or place anything likely to damage the stormwater system or interfere with the operation thereof or contaminate or pollute the water therein;

(d) construct or erect any structure or thing over or in such a position or in such a manner so as to interfere with or endanger the stormwater system or the operation thereof; or

(e) make an opening into a stormwater pipe, canal or culvert; or

(f) drain, abstract or divert any water directly from the stormwater system, or

(g) fill, excavate, shape, landscape, open up or remove the ground above, within, under or immediately next to any part of the stormwater system.

5. Prevention of flood risk

No person may, except with the written consent of the Council and subject to any conditions it may impose—

(a) obstruct or reduce the capacity of the stormwater system;

(b) change the design or the use of, or otherwise modify any aspect of the stormwater system which, alone or in combination with other existing or potential land uses, may cause an increase in flood levels or create a potential flood risk; or

(c) undertake any activity which, alone or in combination with other existing or future activities, may cause an increase in flood levels or create a potential flood risk.

6. Studies and assessments

(1) The conditions which the Council may impose in terms of Sections 3, 4, and 5, may include, but are not limited to—

(a) the establishment of flood lines;

(b) the undertaking of impact assessments, and

(c) environmental impact studies or investigations which may be required by any applicable environmental legislation.

(2) The costs of any study undertaken in terms of the provisions of subsection (1), will be for the account of the applicant.

7. Water pollution incidents

In the event of an incident contemplated in Section 3 or Section 4(b) and (c)—

(a) the owner of the property on which the incident took place, or is still in the process of taking place, or

(b) the person responsible for the incident, if the incident is not the result of natural causes,

shall immediately report the incident to the council, and at own cost, take all reasonable measures which, in the opinion of the Council, will contain and minimise the effects of the pollution, by undertaking cleaning up procedures, including the rehabilitation of the environment, as required by the Council.

8. Stormwater systems on private land

(1) Every owner of property on which private stormwater systems are located, shall—

(a) not carry out any activity which will or which, in the opinion of the Council, could reasonably be expected to impair the effective functioning of the stormwater system, and

(b) at own cost, keep such stormwater systems functioning effectively, including undertaking the refurbishment and reconstruction thereof if, in the opinion of the Council, it should be reconstructed or refurbished.

(2) The provisions of subsection (1) do not apply to the extent that the Council has accepted responsibility for any of the duties contained therein, either in a formal maintenance agreement or in terms of a condition of a servitude.

9. Provision of Infrastructure

(1) The Council may—

(a) construct, expand, alter, maintain or lay any drains, pipes or other structures related to the stormwater system on or under any immovable property, and ownership of these drains, pipes or structures shall vest in the municipality;

(b) drain stormwater or discharge water from any municipal service works into any natural watercourse, and

(c) do any other thing necessary or desirable for or incidental, supplementary or ancillary to any matter contemplated by subsection (a).

(2) When the Council exercises its powers in terms of subsection (1)(a) in regard to immovable property not owned by the municipality, it shall comply with the provisions of the By-law Relating to the Management and Administration of the City of Cape Town's immovable Property.

10. Powers of the Council

(1) The Council may—

(a) demolish, alter or otherwise deal with any building, structure or other thing constructed, erected or laid in contravention of the provisions of this by-law;

(b) fill in, remove and make good any ground excavated, removed or placed in contravention with the provisions of this by-law;

(c) repair and make good any damage done in contravention of the provisions of this by-law or resulting from a contravention;

(d) remove anything discharged, permitted to enter into the stormwater system or natural watercourse in contravention of the provisions of this by-law;

(e) remove anything damaging, obstructing or endangering or likely to obstruct, endanger or destroy any part of the stormwater system;

(f) seal off or block any point of discharge from any premises if such discharge point is in contravention of the provisions of this by-law, irrespective of whether the point is used for lawful purposes;

(g) cancel any permission granted in terms of this by-law if the conditions under which the permission was granted are not complied with;

(h) by written notice, direct any owner of property to allow the owner of a higher lying property to lay a stormwater drain pipe or gutter over his or her property for the draining of concentrated stormwater;

(i) by written notice, direct any owner of property to retain stormwater on such property or, at the cost of such owner, to lay a stormwater drain pipe or gutter to a suitable place indicated by the Council, irrespective of whether the course of the pipe or gutter will run over private property or not, and

(j) discharge stormwater into any watercourse, whether on private land or not.

(2) The Council may, in any case where it seems that any action or neglect by any person or owner of property may lead to a contravention of the provisions of this by-law, give notice in writing to such person or owner of property to comply to such requirements as the Council may deem necessary to prevent the occurrence of such contravention.

(3) The Council may recover all reasonable costs incurred as a result of action taken in terms of subsection (1) from a person who was responsible for a contravention of the provisions of this by-law or the owner of the property on which a contravention occurred.

11. Offences and penalties

(1) Any person who—

(a) contravenes any provision of this by-law;

(b) fails to comply with the terms of any notice issued in terms of this by-law;

(c) threatens, resists, hinders or obstructs or uses foul, abusive or insulting language towards or at a councillor or an employee or contractor of the Council in the exercise of any powers or performance of any duties or function in terms of this by-law, or falsely holds himself or herself to be a councillor or an employee or a contractor of the Council,

shall be guilty of an offence and be liable, on conviction, to the payment of a fine. 31420

STAD KAAPSTAD

VERORDENING OP VLOEDWATERBESTUUR

(Deur die Raad op 30 Augustus 2005 goedgekeur—C35/08/05)

Om voorsiening te maak vir die regulering van vloedwaterbestuur in die gebied van die Stad Kaapstad, en om die aktiwiteite te reguleer wat 'n nadelige uitwerking op die ontwikkeling, werking of instandhouding van die vloedwaterstelsel kan hê.

1. Woordomskrywings

In hierdie verordening, tensy uit die samehang anders blyk, beteken—

"private vloedwaterstelsel" 'n vloedwaterstelsel wat deur 'n persoon buiten die Raad besit, bedryf of in stand gehou word;

"Raad" die munisipale raad van die Stad Kaapstad, of enige politieke struktuur, politieke ampsdraer, komitee, raadslid, of amptenaar van die Raad wat gemagtig is om ingevolge ierdie verordening bevoegdhede uit te oefen of pligte uit te voer;

"vloedplein" die grond wat aan 'n waterloop grens en wat volgens die Raad se mening nie bestand is teen oorstroming tot by die honderdjaar-herhalingsinterval nie;

"vloedwater" water afkomstig van natuurlike neerslag en/of die opgaring daarvan en behels grondwater en bronwater wat gewoonlik deur die vloedwaterstelsel vervoer word, asook seewater in riviermondings, maar sluit water in 'n drinkwater- of afvalwaterretikulasiestelsel uit;

"vloedwaterstelsel" die opgerigte en natuurlike geriewe waaronder pype, duikslote, waterlope en hulle meegaande vloedpleine, hetsy oor of onder grond in openbare of private besit, wat vir die bestuur, versameling, vervoer, tydelike berging, beheer, monitor, behandeling, gebruik en wegvoer van vloedwater gebruik of vereis word;

"waterbesoedelingsvoorval" 'n voorval of gebeurtenis wat 'n nadelige uitwerking of 'n moontlike nadelige uitwerking op die gehalte van die water in die vloedwaterstelsel het tot so 'n mate dat openbare gesondheid of die gesondheid van natuurlike ekostelsels bedreig mag word, en

"waterloop"

(a) 'n rivier, bron, stroom, sloot of kanaal waarin water gereeld of met tussenposes vloei, en

(b) 'n vlei, moeras, dam of meer waarin of waaruit water vloei,

en behels, waar tersaaklik, die bedding en oewers van sodanige waterlope.

2. Toepassing

(1) Hierdie verordening bind enige staatsorgaan.

(2) Enige bepaling in enige ander verordening spesifiek ten opsigte van vloedwater, is onderworpe aan die bepalings van hierdie verordening.

3. Verbode afvoer

Geen persoon mag, behalwe met die geskrewe vergunning van die Raad en behoudens enige voorwaardes wat dit mag oplê, enigiets anders as vloedwater in die vloedwaterstelsel afvoer, daarin toelaat of daarin plaas nie.

4. Beskerming van vloedwaterstelsel

Geen persoon mag, behalwe met geskrewe vergunning van die Raad en behoudens enige voorwaardes wat dit mag oplê—

(a) die vloedwaterstelsel of die werking daarvan beskadig, bedreig, vernietig of op enige wyse optree wat die vloedwaterstelsel of die werking daarvan waarskynlik sal beskadig, bedreig of vernietig nie;

(b) enige ander materie behalwe vloedwater van enige plek afvoer of op enige oppervlakte plaas as daar redelikerwys verwag kan word dat daardie materie daarin sal slaag om in die vloedwaterstelsel te beland nie;

(c) enigiets wat waarskynlik die vloedwaterstelsel kan beskadig of inmeng met die werking daarvan of die water daarin besmet of besoedel, afvoer of daarin toelaat of daarin plaas nie;

(d) enige struktuur of ding oor of in so 'n posisie of op so 'n manier bou of oprig dat dit inmeng met of die vloedwaterstelsel of die werking daarvan bedreig nie; of

(e) 'n opening in 'n vloedwaterpyp, kanaal of duiksloot maak nie; of

(f) enige water regstreeks uit die vloedwaterstelsel afvoer, onttrek of aflei nie, of

(g) die grond bokant, binne-in, onder of onmiddellik langsaan enige deel van die vloedwaterstelsel vul, uitgrawe, vorm, tuinuitleg doen of die grond bo-op oopmaak of verwyder nie.

5. Voorkoming van vloedgevaar

Geen persoon mag, behalwe met geskrewe vergunning van die Raad en behoudens enige voorwaardes wat dit mag oplê—

(a) die kapasiteit van die vloedwaterstelsel versper of verminder nie;

(b) die ontwerp of die gebruik van enige aspek van die vloedwaterstelsel wat op sigself of tesame met ander bestaande of moontlike grondgebruik aanleiding gee tot 'n toename in vloedvlakke of 'n moontlike vloedgevaar skep, verander of andersins wysig nie; of

(c) enigiets doen wat op sigself of tesame met ander bestaande of toekomstige aktiwiteite 'n toename in vloedvlakke kan veroorsaak of 'n moontlike vloedgevaar kan skep nie.

6. Studies en beoordelings

(1) Die voorwaardes wat die Raad ingevolge artikels 3, 4 en 5 mag oplê, mag behels, maar is nie beperk tot—

(a) die vasstelling van vloedlyne;

(b) die doen van impakbeoordelings, en

(c) omgewingsimpakstudies of ondersoeke wat deur enige toepaslike omgewingswetgewing vereis mag word.

(2) Die koste van enige studie wat ingevolge die bepalings van subartikel (1) gedoen word, is vir die rekening van die aansoeker.

7. Waterbesoedelingsvoorvalle

In die geval van 'n voorval beoog in artikel 3 of artikel 4(b) en (c) moet—

(a) die eienaar van die eiendom waarop die voorval gebeur het, of nog aan die gang is, of

(b) die persoon wat vir die voorval verantwoordelik is indien die voorval nie die gevolg van natuurlike oorsake is nie,

die voorval onmiddellik by die Raad aanmeld en op eie koste alle redelike maatreëls tref om, volgens die Raad se mening, die uitwerking van die besoedeling in bedwang te hou en te verminder deur skoonmaakprosesse in werking te stel, waaronder die rehabilitasie van die omgewing, soos deur die Raad vereis.

8. Vloedwaterstelsels op private grond

(1) Elke eienaar van eiendom waarop private vloedwaterstelsels geleë is, moet—

(a) niks doen wat die doeltreffende funksionering van die vloedwaterstelsel benadeel of wat, volgens die Raad se mening, redelikerwys van verwag kan word om dit te benadeel nie, en

(b) op eie koste sodanige vloedwaterstelsels doeltreffend laat werk en om dit onder meer op te knap en te rekonstrueer indien dit volgens die Raad se mening gerekonstrueer en opgeknap moet word.

(2) Die bepalings van subartikel (1) is nie van toepassing in die mate dat die Raad enige verantwoordelikheid aanvaar vir enige van die pligte daarin vervat nie, hetsy in 'n formele instandhoudingsooreenkoms of ingevolge 'n voorwaarde van 'n serwituut nie.

9. Voorsiening van infrastruktuur

(1) Die Raad mag—

(a) enige dreine, pype of ander strukture ten opsigte van die vloedwaterstelsel op of onder enige onroerende eiendom uitbrei, verander of lê nie en die eienaarskap van hierdie dreine, pype en strukture berus by die munisipaliteit;

(b) vloedwater afvoer of water uit enige munisipale diensaanlegte in enige natuurlike waterloop afvoer nie, en

(c) niks anders doen wat nodig of wenslik is vir, of toevallig, aanvullend of bykomend is tot enige ander saak beoog in subartikel (a) nie.

(2) Wanneer die Raad sy bevoegdhede betreffende onroerende eiendom wat nie deur die munisipaliteit besit word nie, ingevolge subartikel (1)(a) uitoefen, moet dit voldoen aan die bepalings van die Verordening op die Bestuur en Administrasie van die Stad Kaapstad se Onroerende Eiendom.

10. Bevoegdhede van die Raad

(1) Die Raad mag—

(a) enige gebou, struktuur of enige ander ding wat is strydig met die bepalings van hierdie verordening gebou, opgerig of gelê is, afbreek, verander of andersins daaraan aandag skenk;

(b) enige grond wat strydig met die bepalings van hierdie verordening uitgegrawe, verwyder of geplaas is, opvul, verwyder en die skade vergoed;

(c) enige skade wat strydig met die bepalings van hierdie verordening aangerig is of wat spruit uit sodanige oortreding, herstel en die skade vergoed;

(d) enigiets verwyder wat strydig met die bepalings van hierdie verordening afgevoer is of toegelaat is om in die vloedwaterstelsel of natuurlike waterloop te beland;

(e) enigiets verwyder wat skade aan enige deel van die vloedwaterstelsel kan berokken of dit versper of bedreig of dit waarskynlik kan versper, bedreig of vernietig;

(f) enige afvoerpunt uit enige perseel afdig of afsluit indien sodanige afvoerpunt strydig is met die bepalings van hierdie verordening ongeag of die afvoerpunt vir wettige doeleindes gebruik word;

(g) enige toestemming wat ingevolge hierdie verordening verleen is, kanselleer indien die voorwaardes ingevolge waarvan die toestemming verleen is, nie nagekom word nie;

(h) enige eienaar van 'n eiendom skriftelik opdrag gee om die eienaar van 'n hoërliggende eiendom toe te laat om 'n vloedwaterafvoerpyp of afloopsloot oor sy of haar eiendom aan te lê vir die afvloei van gekonsentreerde vloedwater;

(i) enige eienaar van 'n eiendom skriftelik opdrag gee om vloedwater op sodanige eiendom terug te hou op koste van die eienaar of om 'n vloedwaterafvoerpyp of afloopsloot aan te lê na 'n geskikte plek deur die Raad aangedui, ongeag of die pyp of afloopsloot oor private grond loop al dan nie, en

(j) vloedwater in enige waterloop afvoer hetsy private grond al dan nie.

(2) Die Raad mag in elke geval waar dit skyn asof enige doen of late deur enige persoon of eienaar van 'n eiendom tot 'n oortreding van die bepalings van hierdie verordening mag lei, skriftelik kennis gee aan sodanige persoon of eienaar van 'n eiendom om aan sodanige vereistes te voldoen as wat die Raad as noodsaaklik beskou om 'n herhaling van sodanige oortreding te verhoed.

(3) Die Raad mag alle redelike koste wat opgeloop is as gevolg van optrede ingevolge subartikel (1), verhaal van 'n persoon wat verantwoordelik was vir 'n oortreding van die bepalings van hierdie verordening of van die eienaar van die eiendom waarop die oortreding begaan is.

11. Misdrywe en strawwe

(1) Enige persoon wat—

(a) enige bepaling van hierdie verordening oortree;

(b) versuim om te voldoen aan die voorwaardes van enige kennisgewing uitgereik ingevolge hierdie verordening;

(c) 'n raadslid of 'n werknemer of 'n kontrakteur van die Raad in die uitoefening van enige bevoegdhede of uitvoering van enige pligte of funksie ingevolge hierdie verordening dreig, verset teen, hinder of dwarsboom of vuil of skeltaal of beledigende taal gebruik teen of met hulle gebruik, of hom of haar valslik as 'n raadslid of werknemer of kontrakteur van die Raad voordoen,

is aan 'n misdryf skuldig en is by skuldigbevinding strafbaar met 'n boete.

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ISIXEKO SASEKAPA

UMTHETHO KAMASIPALA OPHATHELELE KULAWULO LWAMANZI ESITSHI

(Owamkelwa liBhunga ngomhla wama-30 Agasti 2005—C35/08/05)

Ukubonelela ngomthetho olawula amanzi esitshi kummandla weSixeko saseKapa, nokulawula imisebenzi enokuba nempembelelo eyonakalisayo kuphuhliso, ekusebenzeni okanye kulondolozo lwemijelo yamanzi esitshi.

1. Iinkcazelo

Kulo mthetho kamasipala, ngaphandle kokuba ayingqinelani nomxholo:—

"IBhunga" kubhekiselelwe kwibhunga lomasipala weSixeko saseKapa, okanye nawuphi na umbutho wezopolitiko, igosa le-ofisi yezopolitiko, ikomiti, uceba, okanye igosa leBhunga, eligunyaziselwe ukusebenzisa ulawulo okanye ukwenza imisebenzi ngokwemigaqo yalo mthetho kamasipala;

"ithafa elinamanzi" kubhekiselelwe kumhlaba owayame emlanjeni nothi, ngokwembono yeBhunga, uvumele ukuzaliswa ngamanzi eempuphuma kwisithuba esifikelela kwiminyaka elikhulu ilandelelana;

"umjelo wamanzi esitshi wabucala" kubhekiselelwe kumjelo wamanzi esitshi olawulwa, osetyenziswa okanye olondolozwa ngumntu ozimeleyo ingelilo iBhunga;

"amanzi esitshi" kubhekiselelwe kumanzi athi ngenxa yokuwa kwemvula ngokwendalo kunye/okanye ngenxa yokonyuka kwamanzi yaye oku kuquka namanzi aphantsi komhlaba namanzi atsaza kumaqula naveliswa ngumjelo wamanzi esitshi, ngokunjalo namanzi olwandle akumachweba emilambo, kodwa akuqukwa amanzi akwimijelo yamanzi aselwayo okanye kwimijelo eyahlulelwe amanzi amdaka;

"umjelo wamanzi esitshi" kubhekiselelwe kumijelo eyokhiweyo naleyo yendalo, kuqukwa imibhobho, imijelo enqumla phantsi kweendlela, imilanjana namathafa anamanzi akufuphi nawo, nokuba akumhlaba ophantsi kolawulo loluntu okanye kulawulo lwabucala, osetyenziselwa okanye oyimfuneko ukuze kulawulwe, kuqokelelwe, kuhanjiswe, kugcinwe okwethutyana, kulawulwe, kukhangelwe, kucocwe, kusetyenziswe kunye nokulahlwa kwamanzi esitshi;

"isehlo sokungcoliseka kwamanzi" kubhekiselelwe kwisehlo okanye kwimeko enempembelelo eyonakalisayo kumgangatho wamanzi akwimijelo yamanzi esitshi kangangokuba impilo yoluntu okanye impilo yezinto eziphilileyo nendawo eziphila kuyo ngokwendalo zibe sengozini, yaye

"indawo enamanzi" kubhekiselelwe:—

(a) Kumlambo, kwiqula, umsinga, umjelokazi nalapho amanzi ahamba rhoqo okanye ngokweziqabu, kunye

(b) Umgxobhozo, indawo emanzi, idama okanye ichibi apho kuhamba khona amanzi,

yaye kuqukwa, xa kufanelekile, iintsele neendonga zeendawo ezinamanzi/ zemilambo.

2. Ukusetyenziswa

(1) Lo mthetho kamasipala ubophelela nawuphi na umbutho karhulumente.

(2) Naluphi na ubonelelo komnye umthetho kamasipala ojongene ngokukodwa namanzi esitshi, uxhomekeke kwimiqathango yalo mthetho kamasipala.

3. Iimvume ezithintelweyo

Akukho mntu uvumelekileyo, ngaphandle kokuba unemvume ebhaliweyo yeBhunga nangokuxhomekeke kwimiqathango emiselwe lilo, unemvume yokungena okanye yokufaka nantoni na ngaphandle kwamanzi esitshi kumjelo wamanzi esitshi.

4. Ukhuseleko lwemijelo yamanzi esitshi

Akukho mntu, ngaphandle kokuba unemvume ebhaliweyo yeBhunga nangokuxhomekeke kwimiqathango emiselwe lilo—

(a) unokonakalisa, abeke engozini, atshabalalise okanye enze nasiphi na isenzo esinokonakalisa, esinokubeka engozini okanye esinokutshabalalisa, umjelo wamanzi esitshi okanye isimo sokusebenza kwawo;

(b) unokukhulula kuyo nayiphi na indawo, okanye abeke nakuwuphi na umgangatho, nantoni na ngaphandle kwamanzi esitshi, nalapho kulindelekileyo ukuba lo nto inokuqengqelekela kumjelo wamanzi esitshi;

(c) unokukhulula, avumele ukungena okanye ukubeka nantoni na enokonakalisa umjelo wamanzi esitshi okanye iphazamise ukusebenza kwawo okanye idyobhe okanye ingcolise amanzi kuyo;

(d) unokwakha okanye amise nasiphi na isakheko okanye nantoni na ngaphezu komjelo okanye ngendlela enokuphazamisa okanye enokubeka engozini umjelo wamanzi esitshi okanye imeko yokusebenza kwawo emva koko; okanye

(e) unokuvula intunja kumbhobho wamanzi esitshi, kumjelo okanye kumjelo onqumla phantsi kweendlela; okanye

(f) unokufunxa, ukukhupha okanye ukujika indlela yawo nawaphi na amanzi ukusuka ngqo kumjelo wamanzi esitshi; okanye

(g) unokuzalisa, ukugromba, ukwenza milo yimbi, ukwenza imbonakalo-mhlaba, ukuvula okanye ukususa umhlaba ongaphezulu, omelene, ongaphantsi okanye okufuphi kanye nayo nayiphi na inxalenye yomjelo wamanzi esitshi.

5. Ukuthintelwa kwengozi yeempuphuma

Akukho mntu, ngaphandle kokuba unemvume ebhaliweyo yeBhunga nangokuxhomekeke kwimiqathango enokumiselwa lilo—

(a) unokuthintela okanye unokunciphisa umthamo womjelo wamanzi esitshi;

(b) unokutshintsha imilo okanye ukusetyenziswa, okanye unokulungisa nayiphi na inkangeleko yomjelo wamanzi esitshi, nenokuthi iyodwa okanye idibene neminye imisebenzi yomhlaba ekhoyo, ibangele ukwanda kwamaqondo eempuphuma okanye enokubangela ingozi yeempuphuma; okanye

(c) unokwenza nawuphi na umsebenzi, onokuthi uwodwa okanye udibene neminye wandise amaqondo eempuphuma okanye udale ingozi yeempuphuma.

6. Imisebenzi yophando nohlolo

(1) Imiqathango enokumiselwa liBhunga ngokwemigaqo yeCandelo 3, 4, neCandelo le-5, inokuquka, kodwa ingalinganiselwanga kule—

(a) ukumiselwa kwemida/kwemilinganiselo yamanzi;

(b) ukwenziwa kohlolo lwempembelelo, kunye

(c) nophando lwempembelelo kokusingqongileyo okanye uphando olunokuba yimfuneko ngenxa yomthetho wokusingqongileyo osebenzayo.

(2) Iindleko zalo naluphi na uphando olwenziweyo ngokwemigaqo yemiqathango yecandelwana (1), ziza kuhlawulwa ngumfaki-sicelo.

7. Izehlo zokungcoliseka kwamanzi

Kwimeko yesehlo esichazwe kwiCandelo 3 okanye kwiCandelo 4(b) no-(c)—

(a) umnini wepropati apho eso sehlo senzeke khona, okanye esisenzekayo, okanye

(b) umntu obangele ukwenzeka kweso sehlo, ukuba eso sehlo asibangelwanga ziimeko zendalo,

kuyimfuneko ukuba axele kwangoko eso sehlo kwiBhunga, ngezakhe iindleko, athabathe onke amanyathelo afanelekileyo nathi, ngokoluvo lweBhunga, abe aza kubandakanya aze anciphise iziphumo zongcoliseko, ngokwenza amanyathelo okucoca, kuqukwa nokubuyiselwa kwimeko yesiqhelo kwendawo esingqongileyo, njengoko kuyimfuneko ngokomthetho weBhunga.

8. Imijelo yamanzi esitshi kumhlaba wabucala

(1) Umnini wepropati ngamnye apho kumiswe khona imijelo yamanzi esitshi—

(a) akavumelekanga ukuba enze nawuphi na umsebenzi, ngokoluvo lweBhunga, ekuza kulindeleka ukuba wonakalise indlela efanelekileyo yokusebenza komjelo wamanzi esitshi, yaye

(b) ngezakhe iindleko, uza kugcina lo mijelo yamanzi esitshi isebenza ngokukuko, kuqukwa nokwenza umsebenzi wokuhlaziya nokwakha ngokutsha lo mijelo, ukuba ngokoluvo lweBhunga, kuyimfuneko ukuba yakhiwe ngokutsha okanye ihlaziywe.

(2) Izibonelelo zecandelwana (1) azibhekiselelanga kuluvo lokuba iBhunga lamkele uxanduva layo nayiphi na imisebenzi ebandakanywe kulo, nokuba kukwisivumelwano solondolozo olumiselekileyo okanye ngokwemigaqo yomqathango yokunikezelwa kwepropati.

9. Ubonelelo ngezixhobo zokusebenza

(1) IBhunga linakho—

(a) ukwakha, ukongeza, ukulungisa, ukulondoloza okanye ukufakela imibhobho yemisele, iimpompo okanye ezinye izakheko ezinento yokwenza nomjelo wamanzi esitshi phezu okanye ngaphantsi kwayo nayiphi na ipropati engenakususwa, yaye ulawulo lwale mibhobho, lwezi mpompo okanye lwezi zakheko kuphantsi kwegunya likamasipala;

(b) amanzi esitshi kwimisele okanye amanzi aphuma kuyo nayiphi imisebenzi yeenkonzo zikamasipala ukuya kuyo nayiphi na indawo enamanzi ngokwendalo/umlambo, kunye

(c) ukwenza nayiphi na enye into eyimfuneko okanye enqwenelekayo ngokwesehlo, eyongeza okanye encedisa nawuphi na umbandela ochazwe kwicandelwana (a).

(2) Kwimeko apho iBhunga lisebenzisa amagunya alo ngokwemigaqo yecandelwana (1)(a) ngokuphathelele kwipropati engenakususwa engekho phantsi kolawulo lukamasipala, umnini-propati kuyimfuneko ukuba athobele imiqathango yoMthetho kaMasipala oPhathelele kuLawulo lwePropati ezingenakususwa kwiSixeko saseKapa.

10. Amagunya eBhunga

(1) IBhunga linakho-

(a) ukuchitha, ukulungisa okanye ukwenza ngolunye uhlobo nasiphi na isakhiwo, isakheko okanye nantoni eyokhiweyo, emisiweyo okanye eyenziwe ngokuchasene nemiqathango yalo mthetho kamasipala;

(b) ukuzalisa, ukususa nokubuyisela kwimeko entle nawuphi na umhlaba ogrunjiweyo, osusiweyo okanye obekwe ngokuchasene nemiqathango yalo mthetho kamasipala;

(c) ukulungisa nokwenza ibe nenkangeleko entle nawuphi na umonakalo owenziwe ngokuchasene nezibonelelo zalo mthetho kamasipala okanye umonakalo obangelwe kukuchasa le miqathango;

(d) ukususa nantoni na ekhululweyo, evunyelwe ukungena kumjelo wamanzi esitshi okanye kwindawo enamanzi ngokwendalo/umlambo ngokuchasene nezibonelelo zalo mthetho kamasipala;

(e) ukususa nantoni na eyonakalisa, enqanda okanye ebeka engozini okanye enokunqanda, enokubeka engozini okanye enokutshabalalisa nayiphi na inxalenye yomjelo wamanzi esitshi;

(f) ukutywina okanye ukuvingca nayiphi na indawo yokuphuma kuwo nawaphi na amasango ukuba lo ndawo yokuphuma ichasene nezibonelelo zalo mthetho kamasipala, nokuba lo ndawo isetyenziselwa iinjongo ezisemthethweni kusini na;

(g) ukunqumamisa nayiphi na imvume enikiweyo ngokwemigaqo yalo mthetho kamasipala ukuba imiqathango ekwanikwa imvume phantsi kwayo ayithotyelwa;

(h) ngesaziso esibhaliweyo, iBhunga linakho ukuyalela nawuphi na umnini-propati ukuba avumele umnini wepropati emi ngasentla kweyakhe ukuba afakele umbhobho ofunxa amanzi esitshi okanye igatha okanye enze umjelo kwipropati yakhe ukuze kufunxwe amanzi esitshi azalise lo ndawo;

(i) ngesaziso esibhaliweyo, iBhunga linakho ukuyalela nawuphi na umnini-propati ukuba agcine amanzi esitshi kulo propati okanye, ngeendleko zalo mnini-propati, afakele umbhobho ofunxa amanzi esitshi okanye igatha okanye enze umjelo kwindawo efanelekileyo neyalathwe liBhunga, nokuba indlela yalo mbhobho okanye yalo mjelo/igatha iza kuhamba phezu kwepropati yabucala okanye akuzi kuba njalo, yaye

(j) linakho ukukhuphela amanzi esitshi aye nakuyiphi na indawo enamanzi/kumlambo, nokuba ukumhlaba wabucala okanye akunjalo.

(2) IBhunga, nangayiphi na indlela xa kubonakala ukuba isenzo okanye ukungakhathali kwako nawuphi na umntu okanye komnini-propati kunokusingisela ekuchasweni kwezibonelelo zalo mthetho kamasipala, linakho ukukhupha isaziso ngembalelwano esiya kulo mntu okanye kumnini-propati lowo esaziswa ukuba athobele iimfuno zalo mthetho kamasipala njengoko iBhunga linokubona kuyimfuneko ukuthintela ukuqhubeka kwale nkcaso yomthetho.

(3) IBhunga linakho ukufumana kwakhona intlawulo yazo zonke iindleko ezenziweyo ngenxa yamanyathelo eliwathabathileyo ngokwemigaqo yecandelwana (1) kumntu obenoxanduva lokuchasa izibonelelo zalo mthetho kamasipala okanye kumnini-propati ekwenzeke kuyo isenzo senkcaso yomthetho.

11. Amatyala nezohlwayo

(1) Nawuphi na umntu—

(a) ochasa nawuphi na umqathango walo mthetho kamasipala;

(b) ongaphumeleliyo ukuthobela imigaqo yaso nasiphi na isaziso esikhutshwe ngokwemigaqo yalo mthetho kamasipala;

(c) owenza intsongelo, oxhathisa, othintela okanye onqanda okanye osebenzisa ulwimi olungcolileyo, olunukunezayo okanye oluthukayo olusingiswe kuceba okanye kumsebenzi okanye kunokontraka weBhunga xa esenza ngokusemthethweni okanye enza nayiphi na imisebenzi ngokwemigaqo yalo mthetho kamasipala, okanye ozibiza ngokungeyonyaniso ngokuba unguceba okanye umsebenzi okanye unokontraka weBhunga,

uya kuba netyala lolwaphulo-mthetho yaye uya kujongana, ngokwesigwebo, nentlawulo yesohlwayo.

NATIONAL BIODIVERSITY ASSESSMENT 2011

Volume 3: Estuary Component

Technical Report







environmental affairs
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agriculture,
forestry & fisheries
Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA



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This report forms part of a set of six reports on South Africa's National Spatial Biodiversity Assessment 2011. The full set is as follows:

Synthesis Report

Driver, A., Sink, K.J., Nel, J.L., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. & Maze, K. 2012. *National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report.* South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

Technical Reports

Volume 1: Terrestrial Component

Jonas, Z., Daniels, F., Driver, A., Malatji, K.N., Dlamini, M., Malebu, T., April, V. and Holness, S. 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 1: Terrestrial Component*. South African National Biodiversity Institute, Pretoria.

Volume 2: Freshwater Component

Nel, J.L. and Driver, A. 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 2: Freshwater Component*. CSIR Report Number CSIR/NRE/ECO/IR/2012/0022/A. Council for Scientific and Industrial Research, Stellenbosch.

Volume 3: Estuary Component

Van Niekerk, L. & Turpie, J.K. (eds). 2012. *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.

Turpie, J.K., Wilson, G. and Van Niekerk, L. 2012. *National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa*. Anchor Environmental Consulting, Cape Town. Report produced for the Council for Scientific and Industrial Research and the South African National Biodiversity Institute.

Volume 4: Marine Component

Sink, K.J, Holness, S., Harris, L., Majiedt, P.A., Atkinson, L., Robinson, T., Kirkman, S., Hutchings, L., Leslie, R., Lamberth, S., Kerwath, S., von der Heyden, S., Lombard, A.T., Attwood, C., Branch, G., Fairweather, T., Taljaard, S., Weerts, S., Cowley, P., Awad, A., Halpern, B., Grantham, H. and Wolf, T. 2012. *National Biodiversity Assessment 2011: Technical Report. Volume 4: Marine and Coastal Component*. South African National Biodiversity Institute, Pretoria.

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The NBA 2011 Estuary Component project benefited considerably from the guidance and oversight provided by the NBA project team. The overarching coherence and integration between components achieved in the 2011 round of the NBA represents the collective vision and insights of the NBA project team:

Individual	Role	Institute
A Driver	Project leader	South African National Biodiversity Institute (SANBI)
Dr K Sink	Marine and Coastal	South African National Biodiversity Institute (SANBI)
Dr S Holness	Coastal and Climate Change	SANParks/Nelson Mandela Metropolitan University (NMMU)
Dr J Nel	River and Wetlands	Council for Scientific and Industrial Research (CSIR)
L van Niekerk	Estuaries	Council for Scientific and Industrial Research (CSIR)

The core NBA 2011 Estuaries Component project team comprised:

Individual	Role	Institute
L van Niekerk	Project leader, estuary health, processes and policy	Council for Scientific and Industrial Research (CSIR)
Dr JK Turpie	Estuary conservation planning	Anchor Environmental Consultants
C Petersen	Spatial Analysis	Council for Scientific and Industrial Research (CSIR)
Dr J Nel	River conservation planning	Council for Scientific and Industrial Research (CSIR)

The following group of estuarine scientists served as members of the Estuary Reference Group and generously contributed of their time and knowledge to the project:

Individual	Role	Institute
Prof JB Adams	Estuarine vegetation and health	Nelson Mandela Metropolitan University (NMMU)
N Forbes	Invertebrates	Marine and Estuarine Research (MER)
Dr SJ Lamberth	Fish, nursery function and fisheries management	Fisheries Research, Department of Agriculture, Forestry and Fisheries (DAFF)
F MacKay	Invertebrates	Oceanographic Research Institute (ORI)
Dr S Taljaard	Water Quality and pollution	Council for Scientific and Industrial Research (CSIR)
Prof AK Whitfield	Fish	South African Institute for Aquatic Biodiversity

Individual	Role	Institute
Prof TH Wooldridge	Invertebrates	Nelson Mandela Metropolitan University

In addition to the Estuary Reference Group the input of the following specialists was essential for an integrative and accurate assessment of the estuarine biophysical processes, health and biodiversity conservation requirements:

Individual	Role	Institute
Prof G Bate	Nutrients, microalgae	Diatom and Environmental Management (DEM)
Dr T Bornman	Vegetation and floods	Sout African Earth Observation Network (SAEON)
A Childs	Nursery function	South African Institute of Aquatic Biodiversity (SAIAB)
Dr BM Clark	Conservation planning	Anchor Environmental Consultants
Dr P Cowley	Fish	South African Institute of Aquatic Biodiversity (SAIAB)
Prof D Cyrus	Fish	University of Zululand
B Escott	Spatial delination and naming	Ezemvelo KZN Wildlife
Dr F Engelbrecht	Climate change	Council for Scientific and Industrial Research (CSIR)
Prof A Forbes	Invertebrates	Marine and Estuarine Research (MER)
P Huizinga	Physical processes	Private
Dr K Hutchings	Fish exploitation and desalination	Anchor Environmental Consultants
B James	St Lucia health and managment	iSimangaliso Wetland Park Authority
Dr N James	Climate change	South African Institute of Aquatic Biodiversity (SAIAB)
B Mann	Fish exploitation	Oceanographic Research Institute (ORI)
M McCord	Nursery function, Zambezi sharks	South African Shark Conservancy (SASC)
Dr A Meyer	Climate change	Council for Scientific and Industrial Research (CSIR)
P Morant	Estuarine ecology	Council for Scientific and Industrial Research (CSIR)
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Executive Summary

The National Biodiversity Assessment (NBA) 2011 follows the first National Spatial Biodiversity Assessment (NSBA) in 2004. The primary purpose of the NBA is to provide a regular high-level summary of the state of South Africa's biodiversity, with a strong focus on spatial assessment. It covers terrestrial, freshwater, estuarine and marine environments, and reports on two headline indicators for assessing the state of South Africa's biodiversity: ecosystem threat status and ecosystem protection level. Ecosystem threat status tells us how threatened our ecosystems or habitats are, and ecosystem protection level indicates how well- or under-protected our ecosystems or habitats are.

The NBA is intended for decision makers both inside and outside the biodiversity sector. Technical component reports were compiled for terrestrial, freshwater, estuarine and marine ecosystems, as listed at the beginning of this report on page ii. Technical component reports target a specialist audience, whilst the NBA 2011 summary report (Driver et al. 2012) summarises the results across all components and targets a wider audience.

A key starting point for a meaningful assessment of estuarine ecosystems was to delineate the estuarine functional zone for every estuary, which had not previously been done in South Africa. In addition national-scale pressure data were collated on freshwater inflow modification, water quality (effluent discharges, agricultural activities), artificial breaching, habitat modification and living resources exploitation.

A desktop national health assessment was concluded for nearly 300 estuaries in South Africa to address shortcomings in previous country-wide biodiversity assessments. The health assessment was based on the Estuarine Health Index developed for South African ecological water requirement studies that has been applied systematically to over 30 estuaries at various levels of data richness and confidence. National experts, all familiar with the index, were used to evaluate the systems in their region. The individual estuarine health assessment scores were then translated into health categories and aggregated for the various estuarine ecosystem types to reflect the overall ecosystem status of South Africa's estuaries. One of the major findings of the study was that while a large number of South Africa's estuaries were still in an "excellent" to "good" condition, they represented very small systems, while the larger, important nursery systems were predominantly of "fair" to "poor" quality, indicating a general decline in the health of these larger systems.

The NBA uses two headline indicators for assessing the state of South Africa's biodiversity: "ecosystem threat status" and "ecosystem protection level". Ecosystem threat status gives an indication of how threatened ecosystems are, and ecosystem protection level informs on how well- or under-protected ecosystems are. Key findings of the 2011 NBA were that about 43% of estuary types (20 types out of 46 types) are threatened, representing 79% of SA estuarine area, while 59% (27 out of 46 types) of South Africa's estuarine ecosystem types are not protected. If protection levels are evaluated as a percentage of the area protected the picture becomes even more serious, with 83% of the area of ecosystem types not protected.

The 2011 NBA also developed the National Estuary Biodiversity Plan which identifies which South African estuaries require full or partial protection. This plan represented a significant milestone in that it is the first biodiversity planning study to include all the estuaries of South Africa. Nearly 300 estuaries from the Cool Temperate, Warm Temperate and Subtropical regions were included.

The report also provides a collation of information on harvested, exploited or Red Data estuarine species. It mainly looks at plants, invertebrates and fish. The assessment highlights the loss of mangroves from a number of estuaries along the South African coast as a result of harvesting and mouth closure. It also highlights the fact that a number of overexploited fish species should be listed as Red Data Species. Many of the fish species caught in South Africa coastal waters are estuary-dependent in that they have to use estuaries to complete all, or part, of their lifecycle where they are vulnerable to intense exploitation by recreational, subsistence and commercial fishers as well as being subject to other anthropogenic and environmental pressures. In general, fish species with both an estuarine and marine phase to their lifecycle tend to be severely depleted (e.g white steenbras), while those with freshwater, estuarine and marine components to their lifecycle (e.g. eels), being exposed to cumulative pressures in these different environments, tend to be the worst off.

The NBA 2011 provides a collated species list of invasive aliens in estuaries as part of this assessment. It also highlights invasive aliens as an emerging concern, especially for plants, invertebrates and fish communities.

A review of how climate change will affect the process drivers in estuaries identified some of the vulnerabilities of South African estuaries on a regional scale. Climate change pressures on estuaries include flow modification, sea-level rise and increased temperatures and coastal storminess, leading to changes in physical processes and biological responses with an ultimate

impact on ecosystem services. The review indicate that the Subtropical and Cool Temperate estuaries will be the most effected by climate change from a structural and functional perspective, while the Warm Temperate estuaries will be most vulnerable to temperature regime shifts and the associated species range extensions/contractions and community composition changes.

A number of management processes have been developed in terms of national legislation to manage pressures on estuaries and assist with biodiversity conservation, e.g. ecological flow requirements under the National Water Act (Act 36 of 1998) and Estuary Management Plans under the Integrated Coastal Management (Act 24 of 2008). The assessment discusses South Africa's legislative framework with regards to estuaries, highlights some of the key legal instruments and reports on the limited status of their implementation. Estuaries play a critical role in linking terrestrial, freshwater and marine ecosystems. The multiple pressures of flow reduction, development and overfishing call for integrated estuarine management and strong collaboration between key government departments from local to national level that deal with water, coastal development and fisheries management. The current roll out of Estuary Management Plans according to the Estuary Management Framework and National Estuarine Management Protocol has the potential to achieve this.

Key findings

1. There are nearly 300 functional estuaries in South Africa.

- In South African an estuary is considered 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 or salinity penetration. 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 a lagoon or lake which may become fresh or hypersaline.

2. The Lake St Lucia system represents over 55% of the estuarine area of South Africa, but is in a very poor condition.

- Although situated within the iSimangaliso Wetland Park protected area, a World Heritage Site, St Lucia is impacted upon by activities in its catchment and reduction in freshwater flows from the rivers feeding the lake.

- The most significant impact has been the artificial separation of the uMfolozi river mouth from Lake St Lucia, dating from the 1950s, reducing freshwater inflow to the lake by more than half in low flow periods.
- Combined with drought conditions, this has resulted in St Lucia being closed to the sea for much of the last decade, unable to fulfil its role as the most important nursery area for marine fish along the south-east African coastline, among other impacts.

3. Based on the proportion of estuaries in good ecological condition, 43% of estuary ecosystem types (20 types out of 46 types) are classified as threatened, representing 79% of SA estuarine area.

About 39% of South Africa's 46 estuarine types (18 types) are classified as critically endangered, 2% as endangered (1 type), 2 % as vulnerable (1 type) and 57% as least threatened (26 types). If this is considered in terms of estuarine area the situation is even more dire as 79% of South Africa's estuarine area falls within estuary types classified as critically endangered, compared with less than 1% in types that are endangered or vulnerable and 21% in types that are least threatened.

- A very small percentage (1%) of the total estuarine habitat area in South Africa is in an excellent condition. About 14% is in good condition, 31% is in a fair condition, and 54% is in a poor condition.
- About 83% of the estuarine area that falls within Ramsar sites (57 000 ha) is in a poor state, while none is in an excellent condition. Similarly, none of the 70 400 ha that falls within Important Bird Areas is in an excellent condition and 67% is in a poor condition. Collectively 72% of estuaries in Marine or other Protected Areas (65 900 ha) are in a poor condition.

4. 59% (27 out of 46 types) of South Africa's estuary ecosystem types are not protected. These unprotected types make up 83% of the total estuarine area.

- 69 estuaries in South Africa enjoy some form of formal protection, accounting for 60% (56 000 ha) of the estuarine area within South Africa. Only 14 estuaries have full no-take protection.
- The Lake St Lucia system contributes 90% of the protected estuarine area, and covers about 51 000 ha. The other protected estuaries cover a total area of just under 10 000 ha.

- Nearly 59% (27 out of 46 types) of South Africa's estuary ecosystem types are not protected. About 33% of estuary ecosystem types are considered to be well protected (15 types), while 4% are moderately protected (2 types) and 4% are poorly protected (2 types).
- If protection levels are evaluated in terms of percentage area, the unprotected types make up 83% of total area, while the estuary types that are poorly protected, moderately protected and well protected make up 2%, 14% and 2% of area, respectively.
- The National Estuary Biodiversity Plan identified 58 estuaries (20%) that require full protection and 62 (22%) estuaries that require partial protection (this includes those that already have partial protection).

5. The total freshwater inflow of the 20 largest catchments in South Africa has been reduced by nearly 40% from the pristine condition, and freshwater flow requirements have been determined for only 12% of all estuaries.

- The larger catchments tend to be subjected to significant water resources development, such as large dam developments and inter/intra-basin transfer schemes. These catchments often exhibit a significant decrease in resetting floods with a related significant decrease in mean annual runoff. Related ecosystem responses include increased sedimentation as a result of reduced flushing, loss of queuing effect to the marine environment and reduced nursery function.
- Smaller catchments are most often subjected to more localised water resource development such as run-of-river abstraction and forestation, leading to loss, or reduction of, base flows in summer. While the net reduction in mean annual runoff is less severe than for larger catchments, related ecosystem responses include increased mouth closure, reduced connectivity with the marine environment, reduced nursery function, and reduced production.

6. Flow reduction, habitat modification, fishing and pollution are cumulative pressures in need of management interventions. Invasive alien species (plants, invertebrates and fish), mariculture and desalination are emerging pressures that could pose a significant risk to estuarine biodiversity.

- Nearly 4% of all estuaries are under significant flow modification pressure, with most of these being large permanently open estuaries. An additional 18% of estuaries have experienced a moderate degree of flow modification. Flow modification is causing ecosystem type changes, for example, the Kobonqaba in the Eastern Cape and Uilkraals in the Western Cape closed for the first time in recorded history in 2010.

- 13% of South Africa's estuaries are under significant habitat modification or development pressure.
- The mouths (outlets) of about 16% of estuaries are artificially managed, but these estuaries (which include the Lake St Lucia system) account for 62% of the total estuarine habitat. Inappropriate low-lying developments are necessitating artificial mouth manipulations (e.g. breaching), of particular concern in the large lake systems like Verlorenvlei, Bot/Kleinmond, Klein, Wilderness (Touws), Swartvlei and Lake St Lucia system.
- 1% of South Africa's estuaries are under tremendous fishing pressure (Olifants, Berg, Bot and Kosi) such that fish stocks have declined significantly in these systems. Another 13% are under major fishing pressure. Fishing effort is relatively evenly distributed around the coast, but proportionately (in terms of tonnes per ha removed) much higher in the Cool Temperate estuaries.
- Approximately 2 000 tonnes of fish, comprising 80 species, are caught in South African estuaries each year.
- 84% of all estuaries are influenced by bait collection activities.
- Mangroves have been completely lost from 14 estuaries in South Africa due to excessive harvesting or ecosystem changes. In the smaller estuaries, where mangrove strands consist of one to three rows of trees, harvesting can result in complete removal of mangroves. Developmental pressures have also caused the loss of mangroves, e.g. from the Mhlanga, Little Manzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mahlongwa, Kongweni, Bilanhlolo, Mhlangankulu and Khandandlovu.
- 15% of estuaries are under significant pollution pressure and 40% under a moderate degree of pollution pressure. Fewer than 1% of all estuaries have no pollution pressures on them.

7. Freshwater (surface and groundwater) flowing into the sea is not wasted and is vital to the productivity of the nearshore coastal environment.

- Changes in freshwater flow and associated variations in turbidity, nutrients and sediment supply can impact on important ecological processes such as nursery functions, environmental cues, productivity and food web processes.
- Fisheries resources in South Africa that have, or may have been, compromised by reduced freshwater input include linefish, prawns, and filter feeding invertebrates in the intertidal and shallow subtidal zones.

- The reduction of river flow leads to a reduced sediment supply to the coast with implications for beach and subtidal habitats. Many of these habitats are also important for ecological processes.

8. While there are a range of invasive alien species (e.g. 13 plants, 11 invasive alien and 7 extra-limital fish species) in South Africa's estuaries, they do not represent a significant overall pressure as yet.

- Thirteen invasive alien plant species, ranging from trees to water weeds, have been identified in South Africa's estuaries.
- There are at present 11 invasive alien fish species and 7 extra-limital fish species identified in the 130 estuaries for which there were data. The spreading of especially invasive predatory fish acts as a barrier to migratory species (e.g. eels and freshwater mullet) and influences the species composition and abundance of species, many of which are commercially important, in the river-estuary interface zone.
- There is a significant and growing threat to the estuarine subtidal benthic environment through the invasion and proliferation of the mollusc *Tarebia granifera* in at least 30% of KwaZulu-Natal estuaries.

9. Climate change can have serious ecological, resource and social implications

Climate change pressures include flow modification, sea-level rise and increased temperatures and coastal storminess, leading to changes in physical processes (e.g. modification in mouth conditions, salinity regimes, nutrient pulses, sediment regimes) and biological responses (e.g. production, species composition) with an impact ultimately on ecosystem services.

- The KwaZulu-Natal and West Coast estuaries will be the most affected by climate change from a structural and functional perspective, e.g. mouth state, nutrient supply, salinity distribution and ultimately production (e.g. fisheries).
- The Wild Coast, Eastern and Southern Cape estuaries will be most vulnerable to temperature regime shifts (both nearshore and land) and the associated range extensions/contractions of species and community composition changes.
- Climate change is one of many pressures acting on estuaries and should be viewed as an additional form of anthropogenic alteration (rather than a separate pressure) in an already stressed ecosystem type, i.e. climate change acts as an accelerator of ecosystem change.

10. Estuary Management Plans are developed, or in progress, for 9% of South Africa's estuaries

Over the past decade legislative responses have increased, but flow-related measures are starting to lag behind other planning processes.

- The finalisation of the National Estuarine Management Protocol, the roll out of the Estuary Management Planning Framework and the provision of resources, both human and funding, is needed to sustain this effort. At present there are 26 Estuary Management Plans in the process of being developed as part of the implementation of the Integrated Coastal Management Act (Act 24 of 2008). This includes the establishment of 12 Estuary Forums which form the vital communication platform between coastal communities and the various government departments that play a role in estuary management.
- Key legal instruments, such as the determination of the ecological water requirements of individual estuaries, provide the scientific basis for local and regional water resources planning and implementation frameworks and assist with identifying critical over-allocations of resources.
- Unfortunately, ecological water requirement studies have been undertaken for only about 12 % of all estuaries over the last decade.

Key Messages

1. Estuaries, unlike many other ecosystems, can be restored to a well-functioning, productive state.

- Estuaries are by nature resilient systems, because their fauna and flora are adapted to living in conditions of extreme change.

2. Recovery of South Africa's iconic estuary, the Lake St Lucia system, is possible.

The very poor condition of the Lake St Lucia system, which represents over half the estuarine area in South Africa, is reversible and ecosystem recovery is possible. Due to Lake St Lucia's international and national significance, the iSimangaliso Wetland Park Authority has raised funding from the Global Environment Facility (GEF) to investigate and implement a long-term solution to the

hydrological issues facing the Lake St Lucia system. In parallel to this investigation the management strategy for 2011/2012 will result in the reversal of the 60 year old approach to managing Lake St Lucia; that is, allowing the uMfolozi and Lake St Lucia estuary mouths to join to form a combined mouth, and thereby allowing it to function as naturally as possible. In keeping with adaptive management, an ongoing review and evaluation based on monitoring of salinity, lake levels and ecosystem health will continue as these interventions are implemented. Ongoing national government support for the rehabilitation of the Lake St Lucia system is important.

Other specific management recommendations include:

- reducing the fishing effort within the system;
- resolving the issue related to the backflooding of the low-lying sugar cane farms so that conflict over breaching of the combined mouth does not occur (e.g. securing or protecting the properties along the lower uMfolozi);
- improving farming practices in the uMfolozi catchment and floodplain to improve water quality and limit sediment input to St Lucia.

3. Increase protection levels through the implementation of the National Estuary Biodiversity Plan

- DEA, in collaboration with SANBI, DWA and DAFF, should lead the process of endorsing and implementing the National Estuary Biodiversity Plan.

4. To adequately protect an estuary, it needs to be in a formal protected area with effective no-take zonation, and its freshwater requirements must be guaranteed.

- The Lake St Lucia system is an example of a system which is poorly protected. While being fully protected on paper, St Lucia's current ecological condition is poor (Category E) and uMfolozi is only in fair condition (Category D).

5. Estuaries provide a focal point for co-ordinated and integrated natural resource management.

- Estuaries form the link between the land and the sea and are therefore the receivers of most resource-use pressures from the surrounding land- and seascape. Estuaries should be the focal point for natural resource management and planning in the coastal domain, e.g. in the

classification of water resources in terms of the National Water Act, the class of a river should be influenced by the class assigned to the estuary.

6. Estuaries are valuable national assets providing essential ecosystem services, such as nursery functions to coastal fisheries, freshwater flows to the marine environment, replenishment of nutrients and organic material to coastal habitats, flood and sea storm protection, carbon sequestration, safe bathing areas and cultivation of plants for biofuels without freshwater.

- Estuaries provide an important nursery function for fish, with some of the more muddy Temperate estuaries such as the Mbashe, Umtata, Keiskamma and Great Kei being particularly important for supporting collapsed marine fish resources such as white steenbras and dusky kob.
- Estuaries provide freshwater (both surface and groundwater), nutrients, detritus and sediments to the coastal environment, thereby supporting important ecological processes and the productivity of some fisheries (e.g. prawns and line fishery).
- Estuaries offer easy access, warmer waters, shallow depths, shelter and weak currents that make them very attractive to bathers.
- Estuaries contribute to the regulation of greenhouse gases and provide opportunities for carbon trading.
- South Africa's estuaries provide a significant buffer against floods with a total open water area of 61 000 ha and flood plain storage, as represented by the estuarine functional zone, of nearly 171 000 ha, of which 60% is in the Subtropical biogeographic region.
- Halophytes (salt tolerant plants such as *Sarcocornia*) can be used as an alternative energy or food source due to their high oil and protein content. By far the greatest benefits of halophyte culture is that, unlike much current biofuel production, it does not displace food crop production or use excessive quantities of fresh water.

7. Future introduction and spread of invasive species in estuaries can be prevented.

- While invasive alien species do not represent a significant overall pressure as yet, it is critically important that there is timeous intervention to ensure that the situation remains under control (e.g. control invasive predatory fish that act as a barrier to migratory species, and the total eradication of the alien invasive grass *Spartina alterniflora,* which is currently known to be present in only the Groot Brak estuary but which may otherwise spread).

8. Healthy estuaries support ecosystem resilience and adaption to climate change.

- Stressed ecosystems have a lower resilience to change. By increasing or maintaining the resilience of estuaries, the ability of a system to recover, for example after a flood or drought, is enhanced.
- The resilience of an estuary is influenced by the intactness of its catchment and estuarine habitats. A way to ensure resilience is the determination and implementation of estuarine ecological water requirements and the protection/rehabilitation of the estuarine functional zone.
- The processes underpinning the ecosystem services provided by estuaries, such as the assimilation and cycling of nutrients, also need to be protected if resilience is to be maintained.

Priority actions for estuarine biodiversity management and conservation

- **Restore the health of St Lucia and conserve the other estuarine lake systems.** South Africa's estuarine lake systems (St Lucia, Verlorenvlei, Bot, Klein, Wilderness, Swartvlei, Kosi) are all under tremendous pressure, and need to be managed in a more holistic manner. They are important national biodiversity assets, which often pay the price for inappropriate short-term local-level decision-making. In particular, the St Lucia system holds a major share of South Africa's estuarine biodiversity. As discussed above, the iSimangaliso Wetland Park Authority has initiated measures to combine the uMfolozi with Lake St Lucia with funding support from the Global Environment Facility (GEF) in order to restore the health of the greater ecosystem.
- **Increase protection levels through the implementation of the National Estuary Biodiversity Plan.** The development of the National Estuary Biodiversity Plan was the first step in the planning process. DEA, in collaboration with SANBI, DWA and DAFF, should lead the implementation of the National Estuary Biodiversity Plan. This should include the setting of protected area targets for Estuarine Protected Areas in the short- to medium-term, e.g. 5% of all ecosystem types will be formally protected by 2020 and 20% of all ecosystem types will have Estuary Management Plans by 2020. This also requires the integration of the National Estuary Biodiversity Plan in strategic processes such as the classification of water resources led by the DWA and the upcoming revision of the National Protected Area Expansion Strategy led by DEA.

- **Respond rapidly to emerging invasive species.** Develop protocols and procedures for the early detection, risk assessment and management of invasive alien species. For example, certain invasive alien fish species can act as a barrier to migratory species (eels and fresh water mullet) and influence the species composition and abundance of species, many of which are commercially important, in the river-estuarine interface.
- **Develop a National Coastal Biodiversity Plan.** Estuaries are not separate from the coast. To ensure their long-term functioning also requires the development of a National Coastal Biodiversity Plan that integrates marine, estuarine, freshwater and terrestrial aspects. Such a plan should be conducted at a fine enough scale to support integrated coastal development at the municipal level.
- **Ensure the total eradication of the alien invasive *Spartina alterniflora* from the Groot Brak estuary before it spreads to other estuaries.** Progress has been made, since early 2011, but it is very important that the initial field tests for chemical and mechanical control be followed up with full eradication and continuous follow up removal to ensure that this highly invasive and damaging plant species does not spread to adjacent systems along the coast.
- **Ensure that the legal definition of estuaries in South Africa includes the estuarine functional zone.** The GNR 546 Listing Notice 3 under the NEMA EIA Regulations (2010) identifies the estuarine functional zone as a sensitive area that requires environmental authorisation before a development may proceed. It is important that this consideration is also taken up by the Integrated Coastal Management Act and the National Water Act, both of which need to recognise the value of the estuarine floodplain and the threat of (back) flooding within this zone.
- **Determine ecological water requirements for all estuaries within 10 years and implement flow requirements within 5 years of their classification.** This process is likely to require a two-tiered approach in which the findings of the NBA 2011 form the basis for allocation on a national level in the classification of water resources in terms of the National Water Act. While more detailed ecological water requirement studies will be needed for water-stressed catchments or biodiversity priority areas, there is also an urgent need for strategic assessments (such as the National Water Resources Strategy) to take cognisance of estuarine flow requirements which are often substantially higher than the flow requirements of the river entering the estuary. This little-recognised fact leads to national and catchment scale water resource plans that over-estimate the water resources available for development, thus compromising the ecosystem processes that coastal communities depend upon.

- **Ensure resilience to climate change and other global change pressure through the appropriate management of the estuarine functional zone. Finalise the National Estuary Management Protocol** to ensure cooperative governance between the lead authorities that manage estuaries and roll out the development and implementation of Estuary Management Plans in terms of the Integrated Coastal Management Act.
- **Finalise and implement the National Estuary Monitoring Programme** currently being developed by DWA. This multi-tier, multi-parameter (include biotic and abiotic components) programme is based on current best practice and with sufficient funding, and support from other organs of state, could go a long way in addressing data deficiencies in future NBA assessments.
- **Development of a National Sustainability Plan for Estuarine Resources** that will ensure alignment between sectoral objectives for estuaries on a national scale. The plan should be developed in consultation with lead authorities (DEA, SANBI, DWA and DAFF) and assist with facilitating the co-operative governance between the lead agents. Once in place, it should serve as the "blue print" for a number of key sectoral resource plans and processes at various levels of governance, e.g. allocation of water resources or Total Allowable Catch in coastal fisheries.

Knowledge gaps

- **Refine estuary ecosystem types:** The NBA 2011 has started the process of refining the typing of South Africa's estuaries at a more detailed level than has previously been available. However, higher resolution input data on catchment hydrology, bathymetry, sediment structure and water quality (turbidity and salinity) is required to address the needs articulated by specialists in the execution of this study.
- **Quantification of the modification in freshwater flow to the coast on a watershed scale.** There is an urgent need for a quantification of the modification in freshwater flow to the all estuaries of South Africa. This analysis should include all current land-use, transfer schemes, discharges, dam developments and be based on the true catchment area of each individual system. These data will also form the basis of an analysis of the degree to which freshwater flow to the coast has been modified.
- **Taxonomic surveys of the invertebrates in all South African estuaries:** There is no up-to-date national dataset for South African estuarine invertebrates. Invertebrate data were last collated at a national scale more than a decade ago but little effort has been made to

address this. Future assessments and biodiversity plans cannot be refined without filling this gap in a systematic manner.

- **Taxonomic surveys of the plants in all South African estuaries:** Taxonomic revision of salt marsh species should be supported and funded so that macrophyte species lists can be updated for all estuaries. From these data, sites of rare and threatened species can be identified. Updated GIS spatial data of the habitat areas data for all estuaries is needed. This is especially important where data are older than 10 years. This would include field surveys to ground truth the data. For example detailed habitat maps for the Rietvlei/Diep system and Richards Bay Harbour are urgently required for planning proposes and to address deficiencies in the current databases. This should include the development of a database with information presented in this study plus GIS maps of all South African estuaries. This spatial data could also feed into the estuary management planning processes.
- **Invasive Species:** With the exception of plants, very little is known about invasive species in South Africa's estuaries. There is an urgent need to have a census on the occurrence of invasive alien species in different estuaries and the potential environmental impact of these on both the ecosystem function and the value derived from the estuary in question. All invasive species (freshwater, marine and estuarine) should be included in the census.
- **Nursery function for exploited and collapsed fish species.** Recent work has indicated that while most estuaries serve as nurseries, some of the more sediment rich systems are associated with "sediment deltas" in the nearshore environment which serve as nurseries for some species which represent collapsed stocks. It is of the utmost importance that these systems are identified and their nursery function quantified to ensure sustainable resource utilisation into the future. Future biodiversity plans should also include these systems explicitly to align management and conservation priorities.
- **Pollution data:** There is no systematic record of the discharges into estuaries. There is also a need to evaluate the monitoring stations above the estuaries to develop a clear perspective on what is flowing into estuaries and coastal waters.
- **The value of estuaries in South Africa:** There is very little national scale data available on the value of estuaries. As this is one of the key requirements for communicating the relevance of estuaries to coastal communities, and the country as a whole, this lack of data hinders the ability to motivate for rational decision-making.
- **Climate change:** Climate change has the potential to change the processes and functioning of South Africa's estuaries dramatically. Large and local scale climate models are becoming better at accurately predicting the drivers of change in the future. The estuarine research

community needs to make this one of their research priorities over the next decade to facilitate better adaptation strategies and ensure ecosystem resilience.

- **Sediment data:** Very little information is available on the sediment structure of South Africa's estuaries. This is a significant data gap as grain size distribution and the mud:sand ratios influence biodiversity patterns. The lack of sediment information also makes it very difficult to assess environmental change in relation to some of the major pressures such as dam development and sand mining.
- **Mapping the 3-dimensional nature of South Africa's estuaries:** Detailed systematic topographical and bathymetrical surveys are needed for all South Africa's estuaries. Cross-sectional survey data are available for less than a third of the estuaries in the country. In most cases these data are over 20 years old. Most planning processes (e.g. ecological water requirement studies, Estuary Management Plans, setback lines, spatial development plans) are of low confidence as they lack this basic information. Assessment of change (sedimentation, erosion sensitivity to flow modifications, structural developments) is therefore mostly inferred from pressure data. Improved planning and assessments urgently require a significant effort to address these basic data requirements.
- **Up-to-date surveys of the fish and bird fauna of estuaries:** National scale surveys on fish and birds in all South African estuaries were last carried out in the early 1980s. These surveys urgently need to be repeated in a once-off effort that is comparable with the earlier surveys.

Acronyms Symbols, Abbreviations and Notations

~	Approximately
< / ≤	less than / less than or equal to
> /≥	greater than / greater than or equal to
DAFF	Department of Agriculture, Forestry and Fisheries
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
ha	Hectare
m	Metre
MAR	Mean annual run-off
MSL	Mean sea level
$x10^6m^3$	Million cubic metres

Glossary of Terms

Anthropogenic	Having to do with man, or caused by humans
Aquifer	Underground layer of permeable rock, sand or gravel that conveys water
Baseflow	Baseflow consists of water derived from the intermediate and groundwater catchment/subcatchment. Baseflows constitute "dry weather" flows and are hydrologically significant in that they sustain flows into the non-rainy seasons, are important for ecological flows and also have a different water chemistry to that of stormflows.
Benthic invertebrates	Organisms living in or on sediments of aquatic habitats
Biodiversity	The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems
Catchment	In relation to a watercourse or watercourses or part of a watercourse, this term means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points
Community	Assemblage of organisms characterised by a distinctive combination of species that occupy a common environment and interact with one another
Community composition	All taxa present in a community
Cumulative impact (or effect)	Cumulative impact is the impact on the environment which results from the incremental or combined effects of one or more developmental activities in a specified area over a particular time period, which may occur simultaneously, sequentially, or in an interactive manner.
Dilution	The reduction in concentration of a substance due to mixing with water
Dry and Wet years	"Dry" years are generally represented by the 10th percentile of a distribution, i.e. the "driest" year in 10 or the lowest flows in 10 years. Conversely, "wet" years are represented by the 90th percentile, i.e. the "wettest" year in 10 or the highest flows in 10 years.
Ecological integrity	Maintaining a diverse, healthy and productive natural system

Ecological water requirements (also called the Reserve)	The quantity and quality of water required: • to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997), for people who are now or who will, in the reasonably near future, be relying upon, taking water from, or being supplied from the relevant water resource, and • to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource.
Ecosystem	A community of plants, animals and organisms interacting with each other and with the non-living (physical and chemical) components of their environment
Ecosystem protection level	Indicates the extent to which ecosystems are protected, based on the proportion of each ecosystem's biodiversity target that is met in formal protected areas recognised by the Protected Areas Act.
Ecosystem threat status	Ecosystem threat status tells us how threatened South Africa's ecosystems are. Ecosystems are assessed as critically endangered, endangered, vulnerable or least threatened. Ecosystem threat status is a key headline indicator of the state of biodiversity
Effluent	Liquid fraction after a treatment process (i.e. preliminary, primary, secondary or tertiary) in a wastewater treatment works
Habitat	The natural home of an organism or community of organisms (this also includes the surrounding area)
Macroinvertebrates	Animals that have no backbone and are visible without magnification
Macrophytes	Macrophytes are (aquatic) plants that are large enough to be apparent to the unaided eye
Pollution	The direct or indirect alteration of the physical, chemical or biological properties of the natural environment, including the marine environment, so as to make it less fit for any beneficial purpose for which it may reasonably be expected to be used, or to make it harmful or potentially harmful to the welfare, health or safety of human beings or to any aquatic or non-aquatic organisms
Resource quality objectives (RQOs)	Management Objectives for a resource relating to quality of all the aspects of a water resource including: • the quantity, pattern, timing, water-level and assurance of instream flow; • the water quality, including the physical, chemical and biological characteristics of the water;

	• the character and condition of the instream and riparian habitat; and • the characteristics, condition and distribution of the aquatic biota. These objectives are set by the Department of Water Affairs and Forestry in terms of the NWA
Runoff	Runoff is the water yield from an individual catchment – the subcatchment plus the runoff from all upstream subcatchments. Runoff includes any seepage, environmental flow releases and overflows from the reservoirs in a catchment, if they are present - which is not the case in any of the simulations in this project in which baseline catchment conditions are assumed.
Temporal Terms	Inter- : between, e.g. inter-annual variability denotes variability between one year and the next. Intra- : within, e.g. intra-seasonal differences are differences within a season, i.e. from one month to the next.
Stormwater run-off	Stormwater run-off from paved areas, including parking lots, streets, residential subdivisions, of buildings, roofs, highways, etc.
Sustainability	In terms of water quality management (DWAF), this means: 'Fitness for use by other users and future generations' and the ability to assimilate waste means the ability to receive and process waste to such an extent that the water remains fit for use by its other intended users.
Waste	Any solid material or material that is suspended, dissolved or transported in water (including sediment) in such volumes, composition or manner that, if spilled or deposited in the natural environment, will cause, or is reasonably likely to cause, a negative impact
Wastewater	Water containing solid, suspended or dissolved material (including sediment) in such volumes, composition or manner that, if spilled or deposited in the natural environment, will cause, or is reasonably likely to cause, a negative impact

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1. INTRODUCTION

1.1 What is the National Biodiversity Assessment?

The National Biodiversity Assessment (NBA) 2011 follows the first National Spatial Biodiversity Assessment (NSBA) that was led by the South African National Biodiversity Institute (SANBI). The NSBA 2004 was the first comprehensive national spatial assessment of the state of biodiversity, covering terrestrial, freshwater, estuarine and marine environments. It introduced two new headline indicators for assessing the state of South Africa's biodiversity: ecosystem threat status (referred to as ecosystem status in 2004), and ecosystem protection level. Ecosystem threat status tells us how threatened ecosystems or habitats are, and ecosystem protection level indicates how well- or under-protected ecosystems or habitats are. For the first time, these indicators were comparable across aquatic and terrestrial environments.

SANBI's mandate includes reporting on the state of biodiversity in South Africa. For this reason, the decision was made to broaden the National Spatial Biodiversity Assessment to incorporate non-spatial or thematic elements, and to produce a National Biodiversity Assessment. The intention is to review the National Biodiversity Assessment at five to seven year intervals.

The primary purpose of the NBA is to provide a regular high-level summary of the state of South Africa's biodiversity, with a strong focus on spatial assessment. The NBA is intended for decision-makers both inside and outside the biodiversity sector. It feeds into and links with other policy-related processes such as state of environment reports, identification of threatened ecosystems for listing in terms of the Biodiversity Act, the National Protected Area Expansion Strategy, and the National Biodiversity Strategy and Action Plan.

The NBA 2011, like the NSBA 2004, was led by SANBI in partnership with a range of organisations. The overall results are summarised in the report: *National Biodiversity Assessment 2011: A report on the state of South Africa's biodiversity* (Driver et al. 2012).

A technical reference group was convened by SANBI in April 2009 to guide the approach taken for the NBA 2011. This group was reconvened in January 2011 to review outputs and provide guidance on key messages that should be highlighted in the NBA summary report.

The marine and coastal component is one of four components of NBA 2011. A technical report is available for each component, as listed at the front of this report. While the NBA 2011 summary report is intended for a wide audience, this technical report is intended for a more specialist audience. It explains the data used and the analysis undertaken in the 2011 assessment, highlighting advances made since 2004, and discusses the results.

Common features across the components of the NSBA 2004 and the NBA 2011 are the use of the systematic approach to biodiversity assessment and planning, and the focus on the two headline indicators of ecosystem threat status and ecosystem protection level. Each of these is discussed briefly below.

Working in an integrated and aligned way across aquatic and terrestrial environments can be challenging, as disciplines in these environments have historically developed separately, with separate sets of terminology, methods and approaches. Insisting on compatible approaches can be seen as a constraint on conventional approaches. However, the benefits are numerous, including enabling comparison across environments as well as providing a stimulus for interdisciplinary learning and innovation.

1.2 Biodiversity planning[1] in South Africa

There are several possible approaches to biodiversity assessment and planning. The approach used most often in South Africa, including in the NBA, is systematic biodiversity planning. It is based on three key principles:

- The need to conserve a **representative sample** of biodiversity pattern (the principle of representation);
- The need to conserve the **ecological and evolutionary processes** that allow biodiversity to persist over time (the principle of persistence);
- The need to set quantitative **biodiversity targets** that inform us how much of each biodiversity feature should be kept in a natural condition in order to maintain functioning landscapes and seascapes.

South Africa is at the forefront of biodiversity planning internationally, and the methods and techniques used in this assessment are at the cutting edge of the discipline. The NBA rests

on over 30 years of research, development and practice by South African scientists, often in collaboration with colleagues from other countries.

1.3 Headline indicators: ecosystem threat status and ecosystem protection level

As explained above, the NSBA 2004 introduced two new headline indicators for assessing the state of South Africa's biodiversity: ecosystem threat status and ecosystem protection level. Ecosystem threat status gives an indication of how threatened ecosystems are, and ecosystem protection level informs on how well- or under-protected ecosystems are.

These two headline indicators have been carried forward in the NBA 2011, and will be updated again in future revisions of the NBA in order to provide a time series comparison of the state of ecosystems in South Africa. Between 2004 and 2011, methods for assessing ecosystem threat status have been refined, meaning that the results are not strictly comparable over this time period. The implications of this are discussed in greater detail in Section **Error! Reference source not found.**.

These headline indicators provide not only a way of comparing results meaningfully across the different aquatic and marine environments, but also a standardised framework which links with policy and legislation in South Africa, facilitating the interface between science and policy. There is growing recognition within government and other institutions of this framework and the need to respond to these headline indicators in planning and decision-making.

The assessment of ecosystem threat status is **completely independent** of the assessment of ecosystem protection level. As shown in Figure 1.1, ecosystem threat status is based on the condition of an ecosystem type, while ecosystem protection level is based on the extent to which an ecosystem type is formally protected. A well protected ecosystem type may thus be in poor condition, and equally an ecosystem in good condition may not be formally protected.[2]

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[1] Biodiversity planning is sometimes referred to as conservation planning. We prefer to use biodiversity planning because many people associate the term conservation planning purely with planning for the establishment and

[2] In practice, highly threatened ecosystems are often poorly protected. However, this correlation emerges not from the nature of the analysis itself but because ecosystems in which large amounts of natural habitat have

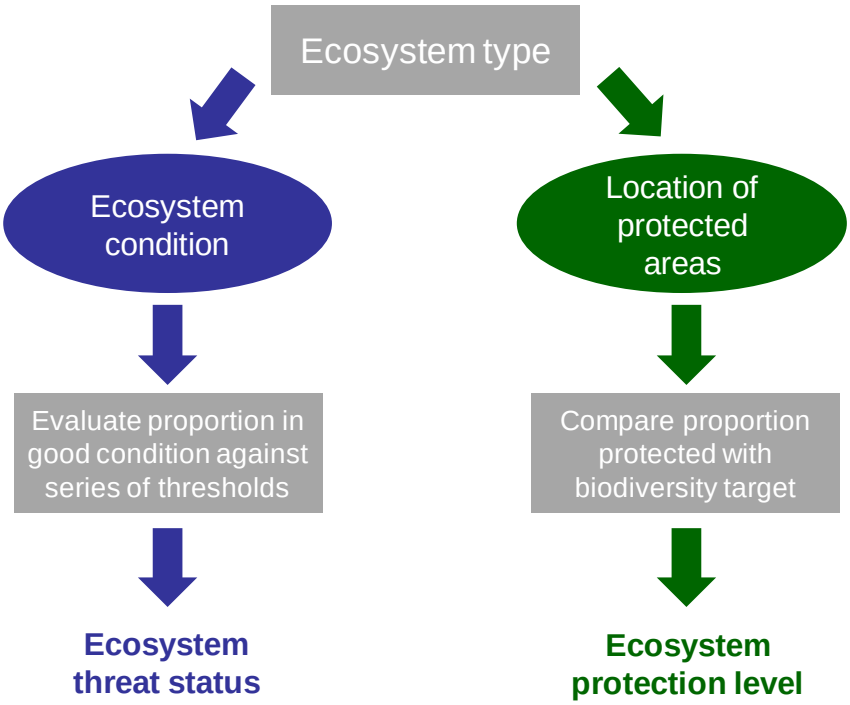


Figure 1.1 The headline indicators, ecosystem threat status and ecosystem protection level, are assessed independently of one another. Ecosystem threat status is based on the proportion of an ecosystem type in good condition, while ecosystem protection level is based on the proportion of an ecosystem type that is formally protected.

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been lost, or which have become severely degraded, tend to be those under pressure from a range of socio-economic activities that are incompatible with maintaining a well functioning ecosystem and that raise the opportunity costs of establishing protected areas.

2. STRUCTURE OF THIS DOCUMENT

An overview of the tasks undertaken as part of the NBA 2011: Estuaries Component is outlined here:

- Ecosystem services
- Estuarine functional zone
- Physical characteristics of South Africa's estuaries
- Estuarine habitat
- NBA 2011 Estuarine Typing
- Key pressures on estuaries
- Health status of estuaries
- Ecosystem threat status
- Estuary protection levels
- National Estuaries Biodiversity Plan
- Species of special concern
- Invasive alien species
- Climate change
- Legislative responses

Ecosystem services: Estuaries provide a host of ecosystem services at local, regional, national and global scales. This report briefly touches on a few important services to highlight the benefits society derive from this aquatic ecosystem type: nursery function, freshwater flows to the marine environment, carbon sequestration, flood regulation, storm protection, safe bathing areas, and estuarine plants as food, fuel and building resources.

Estuarine functional zone: This task required the delineation and mapping of South Africa's estuaries based on their physical features or processes to allow for spatial interrogation of the pressure and health data. All open water and flood plain areas were delineated using Google Earth and Spot5 imagery for 291 estuaries. The spatial delineation also provided the basis for the predicting the present ecological health status and in adding resolution to the conservation planning.

Physical characteristics of South Africa's estuaries: This section sets out to define some of the key physical characteristics of South Africa's estuaries. Important features are highlighted, and in some cases categorized to provide a more detailed perspective on

estuarine biodiversity distribution and the forces that drive it. Categorization was done to reflect the dominant condition of an estuary.

Estuarine habitat: The objectives of this task were to determine the habitat surface areas of South Africa's estuaries (with a particular focus on Temperate salt marshes); provide a species list of dominant estuarine macrophytes; and identify the sites of rare and endangered species. The emphasis during this task was on those estuaries where no data are available or where the data was older than 10 years.

NBA 2011 Estuarine Typing: The current South African Estuarine Classification system (Whitfield 1992) is very broad and a more detailed analysis is required to provide more in-depth insights into the sensitivity of the individual systems to change (i.e. system resilience) and the physico-chemical drivers for species occurring in them.

Key pressures on estuaries: The Estuaries NBA 2011 made a special effort to provide a spatial indication of the current and potential future pressures (and severity) on South Africa's estuaries. Where data were available, the information was captured in an Excel spreadsheet, otherwise expert judgment (high, medium, low) was used to indicate the level of pressure. The following pressures were evaluated on a national scale:

- Flow modification;
- Pollution;
- Fishing effort; and
- Habitat destruction.

Health status of South Africa's estuaries: A key step in biodiversity management planning is the development of an understanding of the health, or condition, of an ecosystem. This aspect was not addressed as part of estuarine component of NSBA 2004 (Turpie 2004) due to a lack of funding. A 3-day national health assessment workshop was held to determine the current health status of South Africa's estuaries based on expert opinion. The estuaries of South Africa was be divided into three sections: West and South Coast (including Transkei) and KwaZulu-Natal and evaluated by regional experts.

Ecosystem Threat Status: Ecosystem threat status is one of the two headline indicators reported on in the NBA. It informs us about the degree to which our ecosystems are still intact, or alternatively losing vital aspects of their structure and functioning. Ecosystem types

are categorised as critically endangered (CR), endangered (EN), vulnerable (VU) or least threatened (LT), with CR, EN and VU ecosystem types collectively referred to as threatened.

Estuary Protection Levels: Ecosystem protection level indicates the extent to which ecosystems are protected, based on the proportion of each ecosystem's biodiversity target that is met in formal protected areas recognised by the Protected Areas Act or Marine Living Resources Act. For these calculations, targets for protection were set at 20% of the estuarine habitat area of each ecosystem type. Ecosystem protection level is divided into four categories: well protected, moderately protected, poorly protected and not protected.

National Estuary Biodiversity Plan: This section presents the findings of the national biodiversity plan for the estuaries of South Africa. This assessment represented a significant milestone in that it is the first biodiversity planning study to include all the estuaries of South Africa. Nearly 300 estuaries from the Cool Temperate, Warm Temperate and Sub-tropical regions were included (Appendix A). The main objective was to identify which South African estuaries should be assigned protected area status.

Species of special concern: The report provides a collation of information on harvested, exploited or Red Data species. It mainly looks at plants, invertebrates and fish. It also highlights the fact that a number of overexploited fish species should be listed as Red Data Species.

Invasive alien species: As part of South Africa's international biodiversity obligations, it needs to report on the status of invasive aliens species every five years. The NBA 2011 provides a collated species list of invasive aliens in estuaries as part of this assessment.

How vulnerable are South Africa's estuaries to Climate Change: This section offers an overview of how climate change will affect the process drivers in estuaries and highlights some of the vulnerabilities South African estuaries display on a regional scale.

Legislative responses: A number of management processes have been developed under key legislation to manage pressures on estuaries and assist with biodiversity conservation. This final section discusses South Africa's legislative framework with regards to estuaries, highlights some of the key legal instruments and reports on the status of their implementation.

The NBA 2011 report concludes with:

- A summary of key findings and recommendations,
- Identification of the information gaps, research priorities and future assessments; and
- Recommendation for the next NBA.

Further to the above mentioned tasks, this project set out to integrate the findings of the Estuaries NBA 2011 with the recommendation and findings of the other components, especially the rivers and marine component. An essential part of this integration process is the iterative interaction throughout the life of the project between the terrestrial, freshwater and marine components. The project aimed to leave SANBI and the broader conservation planning community with a much deeper understanding of the pressures and issues related to estuary management and biodiversity conservation. This will facilitate improved integrated planning across terrestrial and aquatic ecosystems in the future.

3. ECOSYSTEM SERVICES

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3.1 What are ecosystem services?

The natural environment provides a range of valuable ecosystems services (also termed goods and services) to society, including provisioning services (such as food, water and other resources), regulating services (e.g. climate regulation, as well as air and water purification), cultural services (e.g. aesthetic, spiritual, recreational, educational and cultural benefits), and life-support services (such as nutrient cycling and soil formation) (Millennium Ecosystem Assessment 2005).

The terms “goods” and “services” originate in the field of Ecological Economics. Daily (1997) defines an ecosystem service as the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life. Ecosystem goods (provisioning services), on the other hand, represent the material products that are obtained from natural systems for human use (DeGroot *et al.* 2002). Ecosystem services occur at multiple scales, from climate regulation at the global scale, to water supply at the local and regional scales (DeGroot et al. 2002). They also contribute direct or indirectly to human welfare, with those listed above being less directly connected, while food, raw materials, recreational opportunities, and aesthetic and cultural values are more directly connected.

Estuaries, in particular, are recognised as being among the most productive types of ecosystems worldwide. They are focal points for community and business activities along the coast, as they provide a wide range of opportunities and benefits. For example, Costanza et al. (1997) estimated that estuaries provide US$22,832 worth of goods and services per hectare per annum (in 1997 values), more than any other ecosystem. In South Africa, a number of studies have shown that estuaries contribute significantly to the local and national economy (Cooper et al. 2003; Lamberth and Turpie 2003; Turpie and Hosking 2005; Turpie and Clark 2007).

Local governments benefit by generating substantial revenue from higher rates that result from elevated property values along estuary shores and related economic activities, such as estuary tourism (Mander 2001). As a consequence of these benefits, coastal communities, tourists and local governments along the coast depend on estuaries as an important source

of revenue. Because estuaries are natural features, the opportunities that they provide are free. Estuary services are just like any other that may be bought, except that these are generated through the functioning of the estuary ecosystem. These services can be used directly or indirectly, or they can be left as an option for future use. However, estuaries are seldom considered a local government asset, even though they generate considerable revenue for local government and communities. Because of the failure to appreciate their value, little is spent on their management. Estuaries should be regarded as an asset and managed to maintain their value. Failure to do so can have major cost implications for local governments (Mander 2001; Lamberth & Turpie 2003).

The use of estuaries should be balanced with the ability of estuaries to deliver services. There is a need to manage the demands placed on estuaries to ensure that they do not exceed the natural ability of the ecosystem. If demand exceeds supply, future well-being is reduced. If demand equals or is less than supply, the estuary will continue to supply services sustainably. This should not be seen as a constraint to economic development but should rather be seen as an opportunity to diversify the local economy. By focusing on a wide range of complementary and sustainable uses, the greatest benefits can be generated for the greatest number of people by an estuary at minimised cost to society (Mander 2001; Turpie & Lamberth 2003).

3.2 Key ecosystem services provided by estuaries

Estuarine habitats and the species they contain provide a host of important ecosystem services as summarized in Table 3.1. This section briefly touch on a few of the more important services to highlight the benefits society derive from this aquatic ecosystem type, e.g. nursery function, freshwater flows to the marine environment, carbon sequestration, flood regulation, storm protection, safe bathing areas, and estuarine plants as food, fuel and building resources.

3.2.1 Nursery Function

Lamberth and Turpie (2003) estimate that about 50% of the 160 species of fish that occur in South Africa estuaries are utilised in fisheries (subsistence, recreational and commercial). At least 60% of these species are considered entirely or partially dependent on estuaries, and are thus likely to be affected by changes in runoff.

Table 3.1 Ecosystem services of aquatic and water-dependent ecosystems, adapted from Costanza et al. (1997) and Turpie and Clark (2007), and their importance in South African estuaries.

Ecosystem services		Description	Importance in estuaries
Provisioning services (goods)	**Water**	Provision of water for subsistence and agricultural use (only applicable in fresher upper reaches)	Low
	Food, medicines	Production of fish and food plants; medicinal plants	High
	Raw materials	Production of craftwork materials, construction materials, fodder and biofuel (especially important in rural and arid areas)	Medium to high
Regulating services	**Climate regulation**	Carbon sequestration, oxygen and ozone production, urban heat amelioration	High
	Disturbance regulation	Flood control, drought recovery, refuges from pollution events	High
	Water regulation	Provision of dry season flows for agricultural, industrial and household use (only applicable in fresher upper reaches)	Low
	Erosion control and sediment retention	Prevention of soil loss by vegetation cover and capture of soil, e.g. reeds and sedges preventing bank erosion	High
	Ecological regulation	Regulation of malaria, bilharzia, liver fluke, black fly, invasive plants as salinity assist with pest control.	High
Supporting services	**Waste treatment**	High retention makes is effective in breaking down waste and detoxifying pollution. Tidal and fluvial flushing assist with dilution and transport of pollutants	Medium to high
	Refugia/ Nursery areas	Critical habitat for migratory fish and birds, important habitats or nursery areas for species	High
	Export of materials and nutrients	Export of nutrients and sediments to marine ecosystems	High
	Genetic resources	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species	Low
Cultural services (attribute)	**Structure and composition of biological communities**	The characteristics, including rarity and beauty, that lend an area its aesthetic qualities or make it attractive for recreational, religious or cultural activities	High

The total landed catch of fish taken directly from estuaries (2 480 tons per annum) is considerably lower than the total estimated catch of inshore marine fisheries (28 000 tons per annum). However, depending on bioregion and fishery sector, up to 83 % of the catch by inshore fisheries may comprise estuary-associated species. These authors estimate that the

total value of estuary fisheries and the contribution of estuary fish to the inshore marine fisheries, is about R1.2 billion per annum in 2011 Rands.

The life-history characteristics of most of South Africa's coastal fish species are fairly well known allowing them to be categorised into the various levels of estuary-association developed by Whitfield (1994). Less well known is the degree of intra-specific variation in estuary-dependence between the different biogeographical regions or whether suitable nursery or spawning areas are limited due to the narrow or critical habitat requirements of some species.

For some species, the level of estuary-association appears to vary across biogeographical regions. This may have been selected for at the population level and/or a result of the behavioural and physiological plasticity of the species concerned. Knysna sandgoby *Psammogobius knysnaensis* range from having mostly estuary-resident populations on the subtropical and warm Temperate east coast to equivalent estuary and surf-zone populations on the cool Temperate west coast. On the east and south coast, dusky kob *Argyrosomus japonicus* are obligate estuary-dependent species whereas silver kob *Argyrosomus inodorus* are not and never enter estuaries there. On the cool west coast where the warm-Temperate *A. japonicus* do not occur, *A. inodorus* utilize the Orange and other estuaries, probably for feeding or as a warm-water refuge. The Angolan dusky kob *A. coronus* occurs in the sea on the cool-Temperate west coast, until the warm-Temperate Cunene, where it is dominant in estuaries and *A. inodorus* no longer occur (Lamberth et al. 2008).

Although there are close to 300 estuaries along South Africa's coast, the specific habitat requirements of some fish at certain stages of their life may make the choice of juvenile nursery habitat or spawning ground extremely limited. Small juvenile dusky kob *A. japonicus* less than 1-year old prefer the fine sediments of highly turbid estuaries being adapted to find refuge in a "viscous" environment from which other predatory fish are physiologically excluded. This type of habitat comprises less than 5 % of the total estuarine area in South Africa. Of the 20 largest catchments in the country, only four, the Mbashe, Great Kei, Mzimvubu and Mtata have estuaries with the suitable sediment and turbidity characteristics as do an undetermined number of smaller systems such as the Kwelera and Nahoon. For adolescents, the habitat requirements appear to be broader with at least 50% of large and medium size estuaries being suitable nursery environments.

White steenbras *Lithognathus lithognathus* occur from the Orange River to the warm-Temperate / subtropical transition zone on the east coast. There is an annual spawning migration to this bioregion transition zone, spawning occurring late July to September on the fluvial fans off selected estuary mouths. These fluvial fans appear to be limited with the Mbashe as the only confirmed spawning area and the Mtata, Mzimvubu and Great Kei as the only other systems having similar catchment and sediment characteristics. If *L. Lithognathus* are restricted to spawning on these few fluvial fans, the entire South African spawning habitat may be less than 50 hectares. Historically, there may have also been a west coast spawning population with the Orange having a suitable fluvial fan. Intensive beach-seine and gillnet fishing over the last 100 years may have seen this population become extinct or indiscernible.

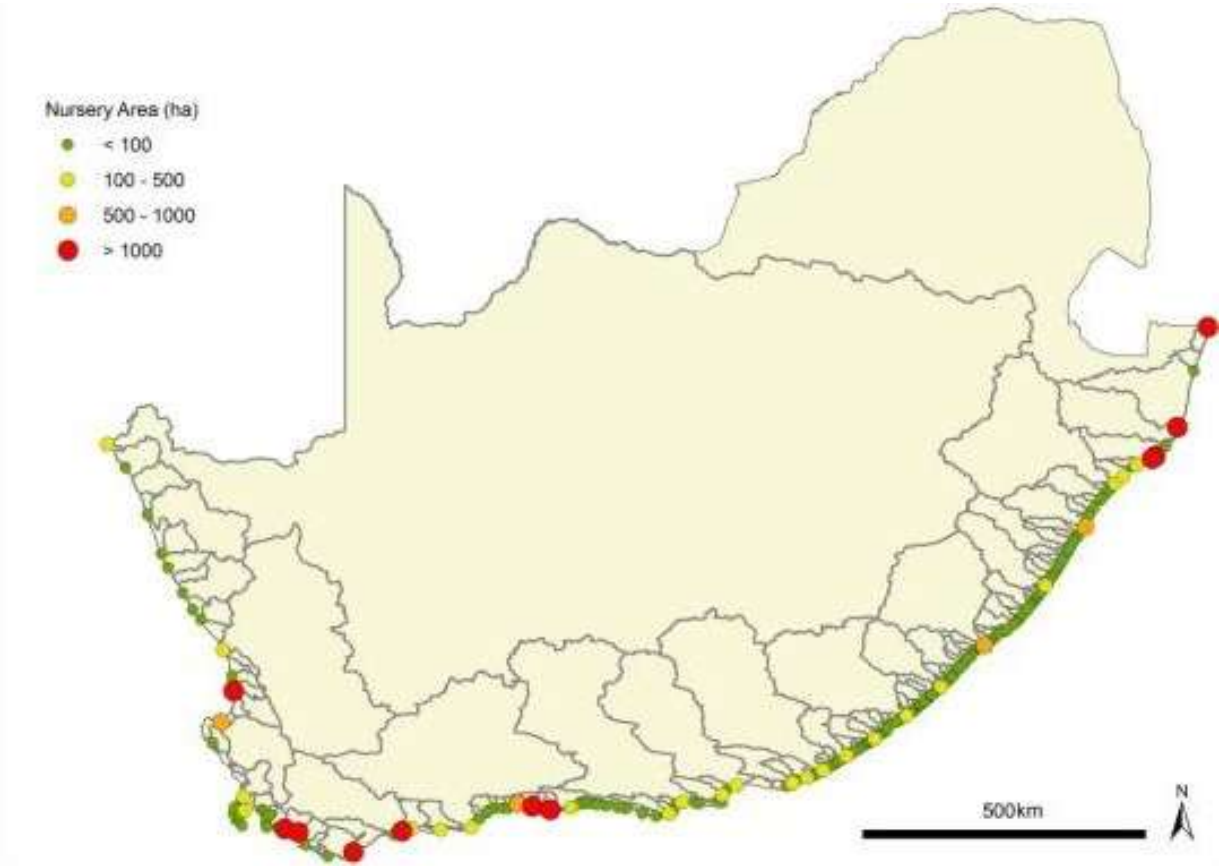


Figure 3.1 Important estuaries for nursery function

Zambezi (bull) sharks, *Carcharhinus leucas*, are a large predatory shark species commonly occurring in coastal waters of warm-Temperate, tropical and subtropical seas. It is one of few shark species physiologically capable of inhabiting salt- and freshwater systems, and is thought to utilize estuarine systems and freshwater rivers as pupping and nursery grounds. As such, estuaries are considered critical habitat for Zambezi sharks. Recent evidence suggests that, in certain parts of their distribution, Zambezi sharks exhibit philopatry to estuarine and river systems although the degree and nature of philopatry remain unknown. Studies utilizing satellite technology and acoustic telemetry have also demonstrated this species can undertake large-scale migrations, moving several thousand kilometres in a relatively short timeframe.

Zambezi sharks are taken as bycatch in fisheries throughout their range, and are increasingly targeted for the shark fin market and trophy fishing industry. Combined with increasing human-induced degradation of critical habitats Zambezi shark populations are becoming locally depleted in many areas. The species is currently listed as Near Threatened by the IUCN Red List.

In South Africa, Zambezi sharks occur from the Mozambican border to the Breede River on the southwest coast. Their occurrence in estuarine systems in South Africa is well-documented, although there is limited data available on pupping and nursery grounds. To date, the St Lucia Estuary remains the only known pupping ground for Zambezi sharks; however human activities in the estuary have likely compromised the reproductive capacity of this species.

In South Africa no studies have examined habitat requirements for neonatal, juvenile and adult Zambezi sharks. It is likely, however, that physico-chemical factors – as well as the physical characteristics of an estuary (e.g. depth, prey availability) – determine the suitability of a system for reproductive purposes. Based on these characteristics, several other estuaries have been identified as possible pupping and nursery grounds, including the Umzimvubu and Breede River systems. A rapid assessment of the physico-chemical and physical characteristics of South Africa's rivers – and therefore suitability for Zambezi sharks – indicates several of major river systems may be suitable habitat. These include (from West to East) the: Breede, Gouritz, Gamtoos, Sundays, Great Fish, Great Kei, Umtata, Umzimvubu, Mngazana, Thukela and Lake St Lucia systems. Although several of these systems may not be used for reproductive purposes, they should be considered critical

habitat for ensuring the health of Zambezi shark populations in South Africa. Table 3.2 provides a summary of South Africa's important nursery areas. All estuaries larger than a 100 ha in total habitat were included in the list. In addition some smaller estuaries with known endemic fish or invertebrate species, e.g. East Kleinmonde that is the prime nursery for the Estuarine Pipefish, were also incorporated. Confirmed importance is indicated by a X, while a X? indicates unconfirmed status (but likely) as estuary and catchment characteristics indicate suitable habitat.

Table 3.2 Summary of South Africa's very important nursery estuaries

	Biodiversity	Kob species		Steenbras spawning grounds	Zambezi sharks	
		Juveniles	Sub-adults		Pupping	Juveniles
Orange (Gariep)	X		X			
Buffels	X					
Olifants	X		X			
Groot Berg	X		X			
Rietvlei/Diep	X					
Wildevoëlvlei	X					
Sand	X					
Bot/Kleinmond	X		X			
Klein	X		X			
Uilkraals	X					
Heuningnes	X		X			
Breëde	X		X		X?	X?
Duiwenhoks	X		X			
Goukou (Kaffirkui	X		X			
Gouritz	X		X			X?
Klein Brak	X		X			
Groot Brak	X		X			
Swartvlei	X					
Knysna	X	X	X			X?
Keurbooms	X		X			
Kromme	X		X			
Seekoei	X					
Kabeljous	X	X?	X			
Gamtoos	X	X?	X			X?
Swartkops	X		X			
Sundays	X		X			X?
Bushmans	X		X			
Kariega	X		X			X?
Kowie	X		X			
East Kleinemonde	X		X			
Great Fish	X		X		X?	X?

	Biodiversity	Kob species		Steenbras spawning grounds	Zambezi sharks	
		Juveniles	Sub-adults		Pupping	Juveniles
Mpekweni	X		X			
Mtati	X					
Mgwalana	X					
Bira	X					
Keiskamma	X		X	X?		X?
Tyolomnqa	X		X	X?		
Nahoon		X?	X			
Kwelera		X?	X			
Great Kei	X	X?	X	X?		X?
Nxaxo/Ngqusi	X					
Nqabara/Nqabarana	X					
Mbashe	X	X	X	X		X?
Xora	X					
Mtata	X	X?	X	X?	X?	X?
Mtakatye	X					
Mngazana	X		X		X?	X?
Mzimvubu	X	X?	X	X?	X?	X?
Mzimkulu	X		X			X?
Durban Bay	X		X		X?	
Thukela						X
Matigulu/Nyoni	X					
Mlalazi	X					
Mhlathuze	X		X		X?	X?
Richards Bay	X	X	X		X?	
uMfolozi	X	X	X		X?	X?
St Lucia	X	X	X		X	X
Kosi	X					

3.2.2 Freshwater flows to the marine environment

Freshwater flow reduction has severe consequences for marine biodiversity and resources through impacts on physical habitat, reduced nutrient inputs and alterations to important ecological processes (Gillanders and Kingford 2002, Lamberth and Turpie 2003, van Ballegooyen et al. 2007, Lamberth et al. 2009, Porter 2009). In South Africa, reduced river inputs have a significant impact on coastal and marine ecosystems around the entire South African coastline although impacts are expected to be more severe in the more nutrient poor marine environment of the east coast (van Ballegooyen et al. 2007). The impacts of altered fresh water flow reduction extend offshore with correlations between flow reduction and patterns in catches of commercial linefish documented more than 40 km offshore on the Thukela Banks (Lamberth et al. 2009).

Based on reductions in the 20 largest catchments in South Africa (those that contribute approximately1% or more of total MAR in the region), the total freshwater flow to the marine environment has been reduced by about 40% (more than 11 000 million m^3/year) (see Table 3.3). The greatest reduction is on the west coast (approximately 6 900 million m^3/year) but there are significant reductions along both the south (1 100 million m^3/year) and east coasts (2 900 million m^3/year). The larger river systems have experienced the greatest flow reduction and are therefore expected to have driven the most change in marine ecosystems. These include the Orange River on the west coast, the Thukela and Mzimvubu rivers in KwaZulu-Natal and the Breëde River in the Agulhas Bioregion.

Table 3.3 Summary of the flow modification for the 20 major cathment in South Africa

Catchment	MAR (Mill m^3/a)	% Change	% of SA Runoff
Orange/Gariep	10 833.0	56	28.6
Thukela	3 753.6	27	9.9
Mzimvubu	2 893.8	10	7.7
Breëde	1 785.0	42	4.7
Mzimkulu	1 478.2	25	3.9
Olifants	1 070.1	34	2.8
Great Kei*	1 064.1	15	2.8
Mkomazi*	1034	15	2.7
Groot Berg	916.0	46	2.4
uMfolozi	885.0	19	2.3
Mbashe*	836.0	10	2.2
Mgeni	682.9	61	1.8
Mhlathuze	645.0	20	1.7
Gouritz*	539.1	40	1.4
Great Fish**	525.4	30	1.4
Gamtoos*	500.6	35	1.3
Mvoti*	482.0	25	1.3
St Lucia	417.9	30	1.1
Mtata	377.8	54	1.0
Mtamvuna*	303.8	15	0.8

**Flow estimates provided by WSAM model and modified by expert opinion*
*** Great Fish Estuary receives additional flow through the Orange-Fish River Tunnel Transfer Scheme, but no detail is available on exactly how much (pers. comm. Prof Denis Hughes)*

The reduction of river flow leads to a reduced sediment supply to the coast with implications for beach and subtidal habitats. Reduced sediment input can change beach morphodynamic state, altering the beach biodiversity, accelerating beach erosion and can even lead to the

loss of beach habitat (Harris et al. 2010). In the subtidal environment, riverine inputs provide important sediment inputs for the maintenance of unconsolidated sediment habitats. Reduced river inputs reduce the spatial extent of such habitats (van Ballegooyen et al. 2007).

Many of these habitats are also important for ecological processes. For example the endemic and imperiled white steenbras *Lithognathus lithognathus* spawns on submarine fluvial fans, a localised habitat of limited extent, associated with mixed mud and sand banks deposited by rivers in the southeast Cape coast (Bennett 1993). Changes in salinity and water temperature linked to flow alteration also impact thermohaline fronts which affects plankton feeding communities and the fish, birds and mammals that feed on the concentrated food associated with these habitats (van Ballegooyen et al. 2007).

Important processes that can be compromised through altered fresh water flow include nursery functions, environmental cues, productivity and food web processes. Increased frequency of estuary mouth closures and associated conditions due to reduced freshwater flow can also disrupt lifecycles and connectivity, and deprive fish and invertebrates of the important nursary function of estuaries (Whitfield 1998). Sediment input leads to turbidity providing an important refuge for fish which is a key component of estuarine, coastal and offshore nursary areas (Whitfield 1998, Lamberth et al. 2009). Reduced turbidity can alter predation pressure and the catchability of fisheries resources (van Ballegooyen et al. 2007). Altered freshwater flow leads to changes in important environmental cues such as those relevant for spawning, recruitment and migration (Lamberth et al. 2009). Changes in spawning intensity have been correlated with altered fresh water flow (QuiÑores and Montes 2001, Demetriades et al. 2000).

Catchment derived nutrients are an important component of coastal and marine foodwebs stimulating phytoplankton production. The impacts of reduced nutrient supplies will travel through coastal and marine ecosystems via foodwebs (van Ballegooyen et al. 2007). Reduced detritus may also impact on coastal and marine foodwebs as river-associated detritus and associated epiphytes are believed to be an important food source for microorganisms, filter feeders, detritivorous fish and invertebrates (Berry et al. 1979, Schleyer 1981, Berry and Schleyer 1983, Whitfield 1998, Porter 2009). In KwaZulu-Natal, an isotope study showed that suspended riverine particulate organic matter (terrestrial, aquatic plant material and plankton) plays an important role in supporting inshore filter-feeder

communities, i.e intertidal and subtidal assemblages dominated by the sea-squirt known as red bait *Pyura stolonifera*, mussels *Perna perna*, and oysters *Striostrea margaritacea* and *Saccostrea cucullata* (Porter 2009). Porter (2009) found that between 8 and 33% of filter-feeder diets consisted of material introduced to the sea by rivers and concluded that rivers play an important trophic role in promoting filter-feeder biomass in the Natal Bioregion. He also demonstrated the links between river, inshore and pelagic ecosystems, highlighting the need for adequate freshwater supplies for the maintenance of the integrity of coastal and marine ecosystems.

Changes in freshwater flow and associated variations in turbidity, nutrients and sediment supply can impact fisheries resources, alter catch composition and reduce the economic returns of fisheries (Lamberth and Turpie 2003, Lamberth et al. 2009). Fisheries resources in South Africa that have, or may have been compromised by reduced fresh water input include linefish (Lamberth et al. 2009), prawns (Demetriades et al. 2000), and filter feeding invertebrates in the intertidal and shallow subtidal (Porter 2009).

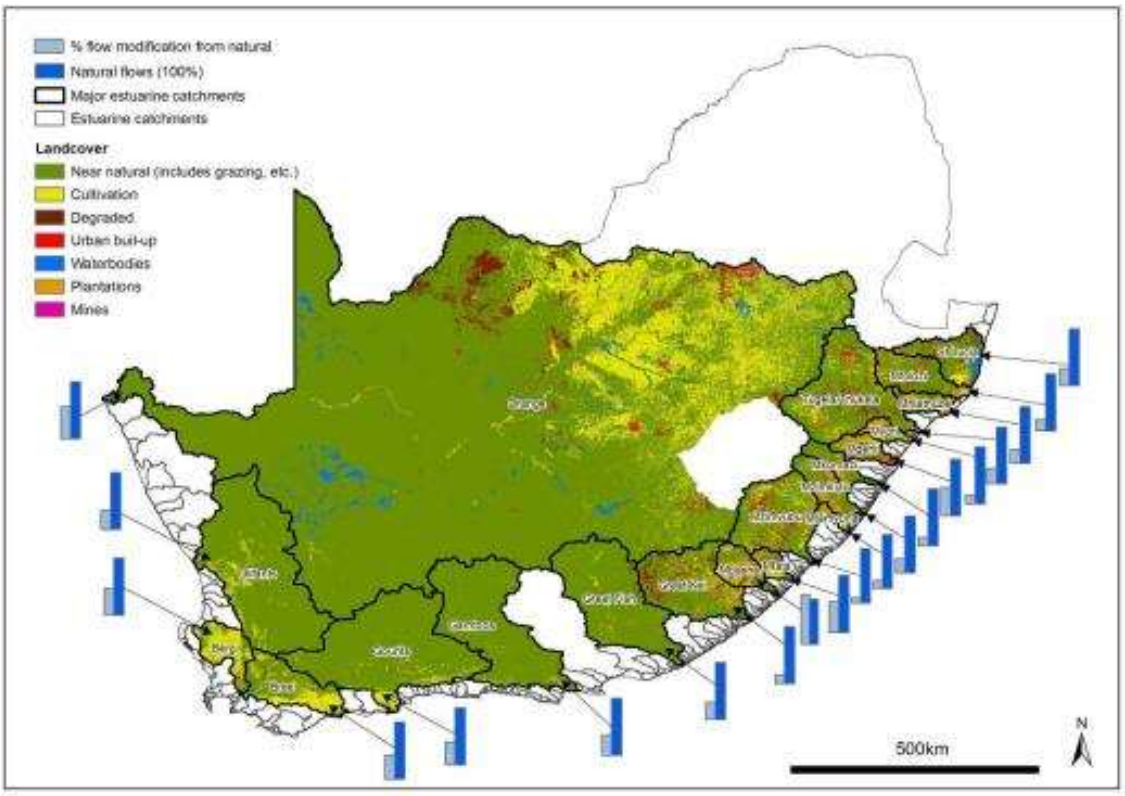


Figure 3.2 Freshwater flow modification of the 20 largest catchments of South Africa

Lamberth et al. (2009) identified significant relationships between flow and the catches of 14 linefish species (more than 90% of the total catch) on the Thukela Banks in KwaZulu-Natal. Most fish responded negatively, with reduced catches correlating with reduced flow (after a lag phase), slinger *Chrysoblephus puniceus* and squaretail kob *Argyrosomus thorpei,* the most important species in the fishery, showing the most marked response.

The ecological needs of the coastal and marine environment must be considered in the allocation of fresh water resources to ensure healthy functioning marine ecosystems that support productive and sustainable fisheries.

3.2.3 Carbon sequestration

Coastal wetlands and marine ecosystems are gaining increased attention for the carbon they store in biomass and especially sediments (Crooks et al 2011). These ecosystems sequester carbon within standing biomass, but even more within soils. Soil organic matter contains more than three times as much carbon as either the atmosphere or terrestrial vegetation (Schmidt et al. 2011). Wetlands in saline environments have the added advantage of emitting negligible quantities of methane, a powerful greenhouse gas, whereas methane production in freshwater systems partially or wholly negates short-term carbon sequestration benefits. This makes them potential sources of significant greenhouse gas (GHG) emissions if disturbed, but also valuable for nature-based approaches to climate change mitigation.

Table 3.4 Summary of potential greenhouse gas (GHG) reductions due to soil building in coastal wetlands (Source: Crooks et al 2011)

Wetland Type	Carbon Sequestration	Methane Production	Net GHG Sink
Mudflat (saline)	Low	Very Low	Low to Medium
Salt Marsh	High	Very Low	High
Freshwater Tidal Marsh	Very High	High to Very High	Neutral or variable
Estuarine Forest	High	Low	High
Mangrove	High	Low to High*	Low to High*
Sea grass	High	Low	High

**salinity dependent*

Mangroves, marshes and submerged macrophytes remove carbon from the atmosphere and lock it into the soil, where it can stay for millennia. Unlike terrestrial forests, estuarine ecosystems are continuously building carbon pools, storing significant amounts of carbon in the sediment below them. When these systems are degraded due to drainage or conversion

for agriculture and mariculture, they emit large and continuous amounts of CO_2 to the atmosphere.

The most effective way to maintain wetland carbon pools and prevent emissions to the atmosphere is avoiding degradation through protection and sustainable management. Restoration of degraded estuarine ecosystems has a twofold benefit: reducing ongoing losses and rebuilding carbon stores.

Globally the current rates of degradation and loss of coastal wetlands are up to four times those of tropical forests (Crooks et al. 2011). Salt marshes and freshwater tidal marshes have lost more than 50% of their historical global coverage. Destruction of about 20% of the world's mangroves, has led to the release of centuries of accumulated carbon. This has also disturbed natural protection against storm surges and other weather events.

Protecting these estuarine ecosystems, and the carbon they store, can be of significant benefit to coastal communities, with shoreline protection and increased fisheries productivity among the co-benefits provided by healthy estuaries. Thus estuaries contribute to the resilience of coastal community while sequestering CO_2. If wetlands conservation can be linked to carbon markets, communities will have a way to pay for conservation which will generate local and global benefits (Crooks et al. 2011).

South Africa have about 11 400 ha of salt marsh, 4 300 ha of mangroves, 1 300 ha of submerged macrophytes, 6 300 ha of swamp forest, and 4 000 ha of sand and mud banks. South Africa's current climate policies, unfortunately, contain few incentives for the protection and/or restoration of degrade coastal wetlands and estuaries. These ecosystems need to be protected and incentives provided to avoid their degradation and improve their condition in order to be included into carbon emission reduction strategies and in climate negotiations.

3.2.4 Flood regulation

South Africa's estuaries provide a significant buffer against floods with a total open water area of 61 000 ha and flood plain storage, as represented by the estuarine functional zone, of nearly 171 000 ha, of which 60% is in the Subtropical biogeographic region.

The different types of estuaries in the different rainfall zones vary in how much flood regulation (attenuation) they can provide. Large, permanently open systems, such as the Knysna Estuary, can have such a significant storage to runoff relationship that a 1:50 year flood event will only raise the water level in the estuary by a few centimeters. In contrast, the relatively small, incised temporarily open estuaries of the KZN region provides substantially less flood regulation as a result of much lower storage to runoff relationships. Nevertheless, the estuarine functional zone still tends to provide more storage than that of most rivers channels.

Unfortunately, inappropriate development in the estuarine space is hindering the ability of estuaries to buffer the surrounding landscape against floods. Flow reduction is increasing mouth closure and thereby increasing the risk of flooding. Artificial breaching at low water levels is reducing the flushing of sediments during breachings and causing cumulative sediment buildup, thereby creating constricted outflow channels and increasing the risk of high flood levels.

An example of the unintended consequences of the disruption of these ecosystem services are the recent floods occurring at the Slang Estuary near Oesterbaai (Figure 3.3). The Slang is a very small, temporarily open/closed estuary along the south coast. The estuary runs through a dune belt and is fed by a very small catchment. Water resources development in the catchment removed the baseflows that ensured the sustained erosion of the dunes encroaching on it, and caused dune formation in the estuarine functional zone. During the floods of August 2011 the system created a new outlet channel that cut through some low lying adjacent developments.

Wetland destruction in estuary catchments is also increasing the magnitude of floods. A case in point is the destruction, through poor agricultural practices, of the peat wetlands in the Goukou and Duiwenhoks catchments. The loss of these wetlands upstream of the estuaries has changed the magnitude and duration of floods and reduced/removed baseflows during the low flow period (pers. comm. Jean Du Plessis, CapeNature).

Preventing development in the estuarine functional zone and ensuring the baseflows required to maintain open mouth conditions will ensure the continuous provision of this ecosystem service.

3.2.5 Storm protection

The sand berms that develop in front of more than 75% of South Africa's estuaries during low-flow periods, provide significant protection against elevated water levels and wave action generated by coastal storms. With the exception of the winter rain fall zone, most South African estuaries are closed during the winter, which is generally when the highest risk of severe sea storms occur. The higher the sand berm at the mouth, the greater the protection from the wave action generated by storms.



(a) Oesterbaai 1 hour before the flood



(b) New mouth being scoured



(c) Flood damage

Figure 3.3 Collage of images illustrating the power of water under flood conditions at the Slang Estuary, August 2002 (Source: T Bornmann)

For example, the second and fourth highest water levels ever recorded at the Groot Brak Estuary, 2.4 m MSL on 1 September 2008 and 2.24 m MSL on 25 May 2002 respectively, was the result of sea storms. Over-wash from the sea side caused a breaching that left the system unprotected from coastal waves. Low lying properties sustained substantial damages due to this event. Artificial breaching, development in the coastal zone, stabilization of

windblown sand, sand mining and sediment trapping by dams can all reduce the ability of estuaries to provide this service.



Figure 3.4 Coastal storm overtopping sand berm at mouth and causing flooding at Groot Brak, 1 September 2008 (Source: J Kriel, DWA)

3.2.6 Safe bathing areas

South Africa's very exposed, high energy coastline has few sheltered beaches that are safe for bathing. High wave action and strong currents are more the norm than the exception.

In contrast, South Africa's nearly 300 estuaries offer easy access, warmer waters, shallow depths and weak currents that make them very attractive to bathers. These natural assets have, regrettably, been largely compromised in most urban areas (e.g. City of Cape Town and eThekwini) through poorly planned storm water runoff systems and Waste Water Treatment Works discharges.

Significant bacteriological contamination of water resources requires that local authorities prohibit access and prevent certain recreational activities to ensure human well being. The loss of safe estuary bathing areas directly impacts children and weak swimmers who are forced to use the more exposed marine environment.

3.2.7 Estuarine plants as food, fuel and building resources

Elsewhere in the world, halophytes (salt tolerant plants) are used as an alternative energy or food source due to their high oil and protein content. Oil yield of these species may be up to 30% more than conventional vegetable-oil crops such as canola and sunflowers. *Salicornia* and *Sarcocornia* are salt marsh species used as a source of oil. These and similar plants

are also used as a food source, both as a staple diet and sought after culinary delight. The leaves of *Sarcocornia* species (samphires) are used in some parts of the world (e.g. USA and England) and either eaten in salads or pickled with oil and vinegar. They are also traditionally used as ingredients in soap and glass, hence the other common name, glassworts.

Traditional use of *Sarcocornia* and *Salicornia* in South Africa (see Figure 3.5) is limited, but the aquaculture industry has expressed an interest and begun exploring their potential culture. In particular there are a number of examples from around the world where halophytes have been successfully used as biofilters to remove nutrients and salts from effluent water from land based mariculture activities such as shrimp farming. Most harvesting takes place from the wild but with increased salinisation of agricultural lands halophytes are a possible future food source.



Figure 3.5 *Sarcocornia tegetaria* in Groot Brak Estuary (Source: T Riddin)

Because halophytes display rapid growth, they can be valuable in the biofuel industry, as they are a productive source of good quality ligno-cellulosic biomass, which is used to produce ethanol. An added benefit is that they are a persistent crop, not needing to be resown each growing season, nor do they require fertilizers or pesticides. By far the greatest

benefits of halophyte culture are that, unlike current biofuel production, it doesn't displace food crop production nor use excessive quantities of freshwater. In many instances, halophytes are been cultured in nutrient farms to reduce elevated nutrient levels in estuary waters before these reach the sea. The resultant crops are harvested for biofuel.

Two other species from the reed and sedge community, *Juncus kraussii* and *Phragmites australis*, are commonly used in KwaZulu-Natal by the local community for mat and basketry. In the St Lucia Estuary and Umlalazi Estuary near Mtunzini, Ezemvelo KwaZulu-Natal Wildlife in collaboration with the iSiMmangaliso Wetland Park Authority, have implemented a harvesting license programmes to collect material from these systems as part of a sustainable development initiative are implemented. These and similar plants are also used in the thatching industry.

Mangroves are intensively harvested (mostly illegally) for firewood (the white mangrove *Avicennia marina*) and for building purposes (the red and black mangrove). See Section 14.1 Species of special concern for more detail on the harvesting of estuary plants.

3.3 Summary

Estuaries provide a host of ecosystem services upon which local and coastal communities depend, including:

- Nursery function for estuarine and marine fish, with some of the more muddy Temperate estuaries such as the Mbashe, Umtata, Keiskamma and Great Kei being highlighted for collapse resources such as the White Steenbras and Dusky Kob.
- Provision of freshwater (both surface and groundwater), nutrients, detritus and sediments to the coastal environment that is linked to fisheries (e.g. prawns and line fishery) and important ecological processes. Freshwater flow reduction has severe consequences for marine biodiversity and resources through impacts on physical habitat, reduced nutrient inputs and alterations to ecological processes.
- Estuaries offer easy access, warmer waters, shallow depths and weak currents that make them very attractive to bathers. These natural assets have, regrettably, been largely compromised in most urban areas through poorly planned storm water runoff systems and Waste Water Treatment Works discharges.
- Coastal wetlands and marine ecosystems are gaining increased attention for the carbon they store in biomass and especially sediments. Healthy estuaries contribute to the regulation of greenhouse gasses and provide opportunities for carbon trading.

- South Africa's estuaries provide a significant buffer against floods with a total open water area of 61 000 ha and flood plain storage, as represented by the estuarine functional zone, of nearly 171 000 ha, of which 60% is in the Subtropical biogeographic region.
- The sand berms that develop in front of more than 75% of South Africa's estuaries during low-flow periods, provide significant protection against coastal storms.
- Halophytes (salt tolerant plants such as *Sarcocornia*) can be used as an alternative energy or food source due to their high oil and protein content. By far the greatest benefits of halophyte culture are that, unlike current biofuel production, it doesn't displace food crop production nor use excessive quantities of freshwater.
- Mangroves, reeds and sedges are also used as building material and basketry.

4. THE ESTUARINE FUNCTIONAL ZONE

L van Niekerk, C Petersen, V April, F Daniels, A Maherry & T Malebu

In 2010, the estuarine functional zone – encapsulating not only the estuary water body but also supporting physical and biological processes and habitats necessary for that estuarine function and health – was listed as Notice 3 (GN R 546) under the National Environmental Management Act (NEMA), Environmental Impact Assessment (EIA) Regulations (2010). This notice stipulates that estuaries (defined by the spatial delineation of the estuarine functional zone) are "sensitive areas" that require environmental authorisation before developments within this zone may proceed. These regulations are not backdated but are meant to curb inappropriate future development in the estuarine functional zone.

The spatial demarcation of the estuarine functional zones will enable, for the first time, their explicit incorporation into planning and approval processes, such as Provincial conservation plans and municipal Integrated Development Plans. Importantly the estuarine functional zone increases the "traditional estuary" considerably, now including habitats such as floodplain areas, previously not considered essential for estuary functioning. A summary of the extent of the estuarine functional zone in South Africa is provided in Table 4.1 and Figure 4.1.

Table 4.1 Extent of the Estuarine Functional Zone per biogeographically region

Biogeographically region	Proportional Estuarine functional zone (ha)	Percentage of Total Estuarine functional zone
Cool Temperate	26 516	16
Warm Temperate	41 785	24
Subtropical	102 746	60
Total	**171 046**	**100**

This chapter details the approach and methods that were adopted in the delineation of the estuarine functional zone for South African estuaries, as well as the advantages thereof.

4.1 Approach and method

Estuaries have little permanent habitat structure; unlike for example a rainforest, as estuarine habitats are constantly forming and eroding at various temporal and spatial scales. Over longer time scales the total habitat area occupied by the various estuarine habitat types tend to remain more or less constant, while the actual spatial location of the various

estuarine habitats is highly likely to change between resetting events (e.g. larger floods). This relative ephemeral nature of estuarine habitat presents an assessment and planning challenge. Biodiversity protection requires the protection of habitat and ecological and evolutionary processes. In order to do this it is important to define the space within which estuaries function to ensure their present and future health. In international literature, an estuary is defined as a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage (Elliott and McLusky 2002; Cameron & Pritchard 1963; Pritchard 1967). Most South African estuaries are relatively small in comparison with those of the northern hemisphere.

The mean annual runoff of most South African rivers is very variable, fluctuating between floods and extremely low to zero flow; which has led to a number of different definitions for South African estuaries that recognise that these systems may not necessarily have a 'free connection with the sea' but are 'either permanently or periodically open to the sea' (Day 1980; Day 1981; Heydorn 1989, CSIR 1992). While Fairbridge (1980) proposed setting the upstream extent of an estuary as the limit of tidal rise, in some instances in South Africa, e.g. the Bot and Klein estuarine lakes, salinity penetration can be detected further upstream than tidal variation. This phenomenon stems from the fact that South African estuaries are microtidal (< 2 m tidal range) and in large systems the tidal rise can be barely discernible (< 5 cm) and easily masked by wind action, while more subtle hydrodynamic processes, such as diffusion, drive salinity penetration further upstream. In such cases the inland limit of salinity penetration represents the upstream boundary of an estuarine system. Back flooding under closed mouth conditions also increase the upstream penetration of salinity beyond that of the open (tidal) state.

In this assessment an estuary is defined 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 or salinity penetration. 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 a lagoon or lake which may become fresh or hypersaline".

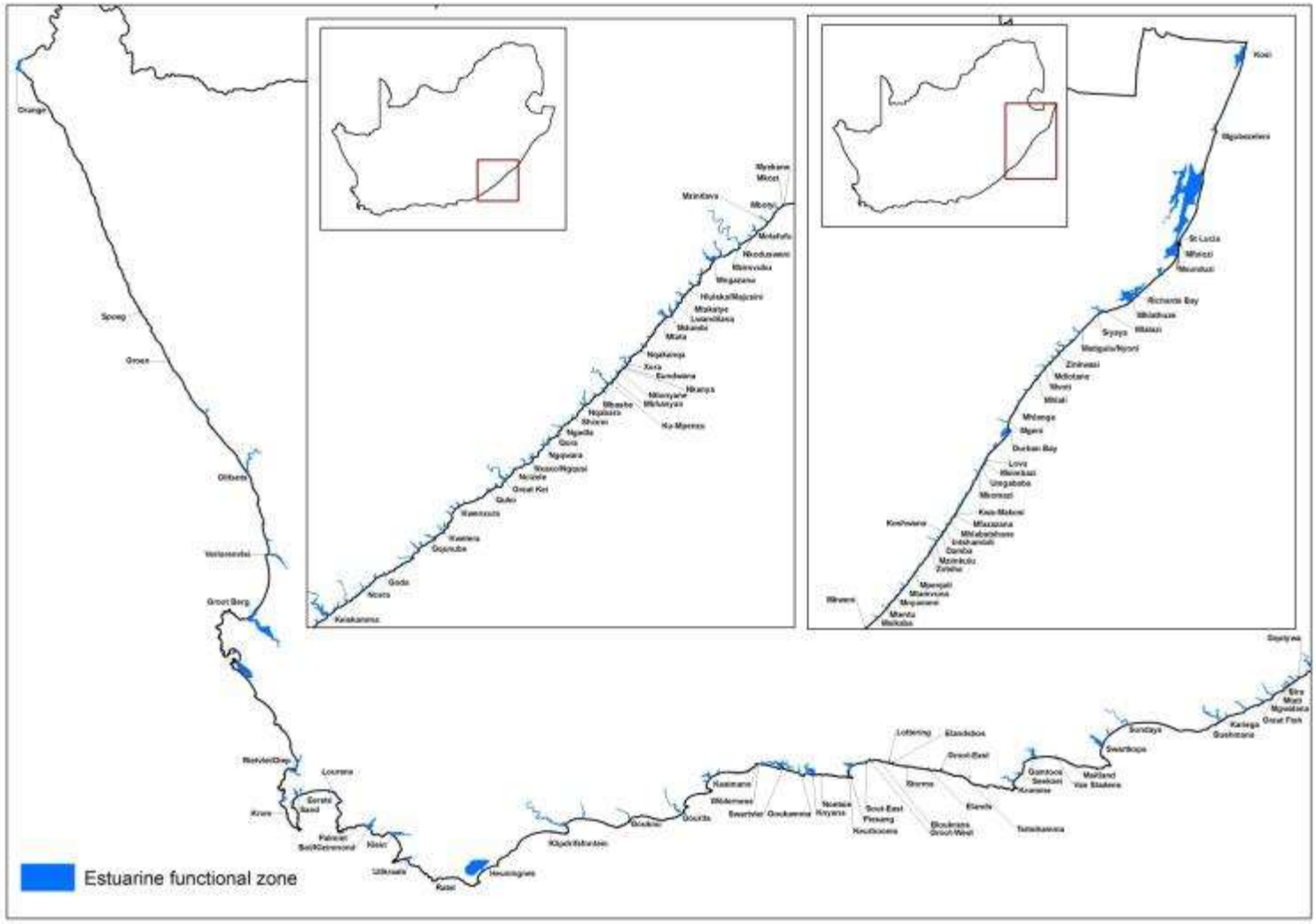


Figure 4.1 Estuarine Functional Zone for South Africa's estuaries

There are over 371 river outlets along the SA coast (see Appendix A for full list), but not all of these are deemed functional estuarine systems, i.e. representative of significant biological activity (Harrison et al. 2000). Since South Africa has a very variable climate and high energy coastal conditions, even systems that only open sporadically to the sea (e.g. every 4 – 10 years) are utilised by estuarine associated or dependent biota, e.g. by fish as nursery areas. The assessment therefore considered all permanent coastal water bodies (i.e. water bodies that do not dry out) that are sporadically or permanently linked to the sea as potentially estuarine systems, e.g. the Groen and Spoeg estuaries along the arid West coast were included, while ephemeral systems such as the Holgat, which dries out, were excluded from the assessment. In addition, using existing information and data sets (vegetation and fish) and anecdotal information, all systems were evaluated by a panel of national experts and listed as functional or not (Harrison et al. 2000). Some very small (< 500 m in length) permanent coastal water bodies that link rivers or streams to the sea were excluded from this assessment until such time as field studies have indicated that they should be considered as functional estuaries, i.e. only small systems that had data indicating they were biologically significant were included. Rivers entering the sea as waterfalls, e.g. those along the Tsitsikamma coast, were also excluded. In addition, a few small highly modified systems in urban areas were also excluded from the assessment on the basis that they were not functional systems.

In total 71 coastal inlets were not assessed, 20 in the Cool Temperate, 33 in the Warm Temperate and 28 in the Subtropical biogeographical region. It is important to note that not including these systems in the NBA assessment means that they lack adequate protection from future developments. It is therefore recommended that a separate study be under taken to demarcate these smaller and/or more ephemeral outlets and integrate them into current planning frameworks.

Mapping was undertaken for nearly 300 functional estuarine systems along the South African coastline. For each estuary the estuarine functional zone (estuarine ecosystem area) and open water areas were digitized using Spot 5 imagery (2008) and Google Earth. For the most part the images were relatively cloud free, but where cloudy conditions occurred on SPOT 5 images, Google images were used. The lateral boundaries included all the associated wetlands, intertidal mud and sand flats, beaches and foreshore environments that are affected by riverine or tidal flood events (Edgar 2000).The 5 m topographical contour (obtained from Chief Directorate Surveys and Mapping) was used as the boundary to

delineate the estuarine functional zone. Where the 5 m contour was not available in digital format, orthophotos (1:10 000) were scanned, georeferenced and the 5 m contour was digitized. Where no orthophotos were available (13 systems), floodplains were mapped from Spot 5 imagery using changes in topography and vegetation types as indicators. From the estuarine functional zone delineation, spatial data such as area, length and perimeter (estuary coastline) and distance to the next system could be inferred.

The 13 estuaries for which there were no topographical data available were:

- Mngazana
- Mngazi
- Mntafufu
- Mzimvubu
- Mzintlava
- Nkodusweni
- Spoeg
- Ntlupeni
- Sinangwana
- Steenbras
- Buffels (Oos)
- Rooiels
- Groen

The estuary mouth was taken as the downstream boundary of an estuary or, where the mouth was closed, the middle of the sand berm between the open water and the sea. The upstream boundary was determined as the limits of tidal variation or salinity penetration, whichever penetrates furthest. This is in line with recent scientific studies and the administrative definition of a South African estuary (see Figure 4.4) (Van Niekerk and Taljaard 2007, DWAF 2008).

Wherever possible the upstream boundary was derived from the literature, expert judgment or field observations. In a number of systems no data were available and the upper boundary was taken as the 5 m topographical contour (bearing in mind that the tidal range in South Africa is microtidal (< 2 m) and sand bars at closed estuary mouths can sometimes build up as high as + 4.5 m MSL). The upper boundaries were also screened against other existing spatial delineations, e.g. the KwaZulu-Natal Estuaries database (Version 1.00.02) and the delineation developed for Durban estuaries (Forbes and Demetriades 2008) with preference given to data from the larger scale studies. Spatially files were converted to GoogleEarth (KMZ formats) and mailed for review to members of the Consortium for Estuarine Research and Management (CERM) for comment.



Figure 4.2 Example of spatial delineation using Google Earth. Light blue areas delineate the estuarine floodplain <5 m above msl.



Figure 4.3 Example of spatial delineation using Spot 5 (note the presence of cloud cover in the southwestern portion of the image).

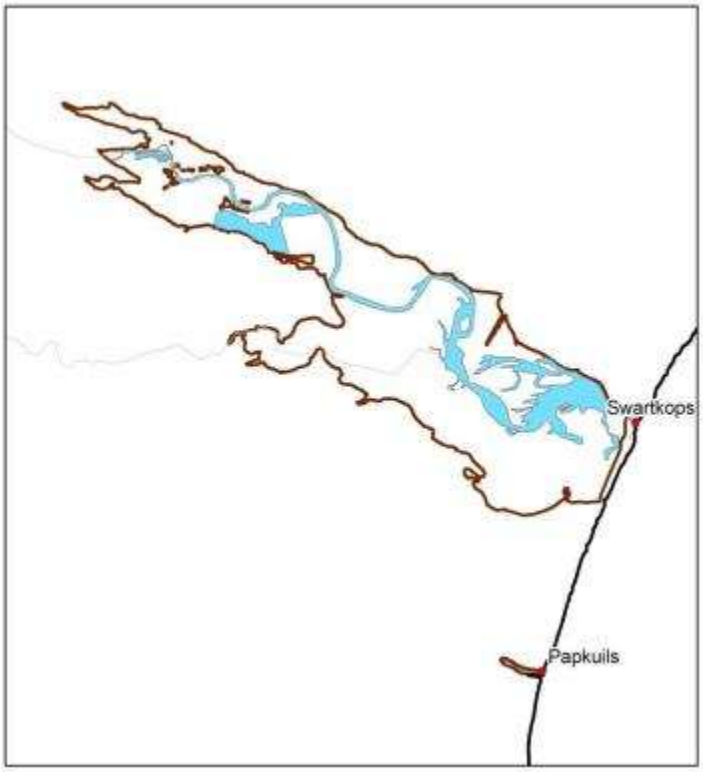


Figure 4.4. Example of openwater and estuarine functional zone delineation.

4.2 Advantages of the delineation of the Estuarine Functional Zone

South African estuaries have long suffered a lack of national scale spatial data for planning purposes. Using the 5 m topographical contour as a delineation boundary holds the following biodiversity and planning advantages:

a) The 5 m contour encapsulates most dynamic areas influenced by long-term estuarine sedimentary processes, i.e. sediment stored or eroded during floods, changes in channel configuration, aeolian transport processes, and changes due to coastal storms. Allowing for natural variability is important as these are some of the key physical processes that drive biodiversity along the South African coastline;
b) The 5 m contour encompasses the floodplain and estuarine vegetation that contribute detritus (food) and provide refuge during high flow events from strong currents. Salt-marsh vegetation can occur at distances greater than 500 m away from the surface water at a number of the larger estuaries, e.g. Olifants, Berg, Goukou and Klein Brak. Most estuarine-associated biota occurs under the 5 m contour, as this is as far as the influence of the ocean can be detected on land, even during storm conditions.

c) Temporarily open/closed estuaries (75% of South African systems) can close at water levels of between 2.5 and 4.5 m above msl. The 5 m contour allows for water-level increases due to backflooding under closed mouth conditions or wave action from high winds or exceptionally high tides;
d) In most cases, the 5 m contour allows for the inclusion of a buffer zone of terrestrial vegetation that represents the transition between terrestrial and coastal ecosystems;
e) The 5 m contour should provide a buffer zone that can allow an estuary to retreat in the event of sea-level rise due to climate change. It also allows for the inclusion of some terrestrial fringe vegetation that contribute detritus to the system and refuge areas for many animal species during floods;
f) An accurate delineation of the high-water mark is not available for the entire South African coastline;
g) Flood lines (1:50/1:100) for estuaries are often inaccurately determined under open mouth conditions, which leads to underestimation of flood heights. In the absence of long-term berm height data (which can vary substantially under different climatic conditions) the 5 m contour provides the best protection against natural hazards such as floods and storms;
h) The 5 m contour minimizes the risk of pollution to estuaries. Septic tanks are sunk about 2 m into the ground. During closed mouth conditions (and very high tides) density differences between fresh and salt water causes drainage problems or infrastructure damages if tanks are not situated not above 5 m;
i) Water resources development and land-use change in the catchment can lead to changes in mouth behaviour (e.g. change in Uilkraals Estuary type from permanently open to temporarily open/closed);
j) The 5 m contour data is available from the Chief Directorate: Surveys & Mapping, Mowbray, as a GIS layer or on black-and-white 1:10 000 orthographic maps. More detailed topographical data are not available on a national scale.

For all the above mentioned reasons it should be clear that, in some cases, the estuarine functional zone goes beyond the 5 m contour for one or more of the following reasons. In deeply incised floodplains, where the river/estuary bed may be meters below the mapped floodplain area, tidal action and/or backflooding may be detected further upstream than indicated by the 5 m contour on the topographical map. This is an artefact of the mapping process and may need site-specific data to correct.

For some narrow, deeply-incised estuaries with very large catchments the 1:20 year flood lines may be above the 5 m contour (i.e. limited floodplain area in relation to significant flood volume), e.g. Mzimkulu. In such cases it is recommended that a detailed topographical survey be conducted and the flood line estimated following engineering principles to demarcate more dynamic areas and indicate flood risk on a more local scale. The littoral active zones adjacent to an estuary can stretch beyond the 5 m contour, e.g. dune fields next to the Duiwenhoks and Sundays estuaries, and should be incorporated in the estuarine functional zone in site specific cases.

In summary, the delineation of the estuarine functional zones for South African estuaries elevated the status of estuaries from merely a points layer (X,Y data set) to spatially demarcating the space where most functions occur. While the incorporation of the estuarine functional zone under the NEMA Regulations is a major achievement, it is important that the estuarine functional zones are also recognised and incorporated into regulations to be drafted under the ICM Act (specifically Chapter 4 of the Act).

5. PHYSICAL CHARACTERISTICS

L van Niekerk, C Petersen & A Maherry

This section sets out to define some of the key physical characteristics of South Africa's estuaries. Important features are highlighted, and in some cases categorized to provide a more detailed perspective on estuarine biodiversity distribution and the forces that drive it. Categorization was done to reflect the dominant condition of an estuary. For example, categorising an estuary as a marine dominated system does not imply that it never has mixed or freshwater characteristics, but rather that it is predominantly in a saline state and that its biota should reflect that.

The project was initiated with a literature review of all the physical information available on South African estuaries. Special attention was given to grey literature as most large- scale data sets were generated as part of engineering studies to various government departments and authorities (Noble and Hemens 1978; Jezewski, Pyke and Roberts 1984, Jezewski and Roberts 1986; Allansonet al. 1990; CSIR 1986; 1987a, 1987b, 1987c; 1988). Few of these datasets were ever published. The project therefore set out to tabulate available information and update these with more recent studies, especially the more detailed ecological water requirements studies (referred to as Resource Directed Methods or Reserve studies) conducted for the Department of Water Affairs (DWA).

5.1 Rainfall Patterns

According to Brown and Jarman (1978) the South African coast spans three biogeographical regions (or climatic zones), namely the cool Temperate west coast, warm Temperate south coast and subtropical east coast. Rainfall patterns in the different regions vary greatly as a result of South Africa's highly variable climate. River inflow to the estuaries is determined by these climatic conditions, as well as the size and shape of the catchment, the latter controlling the magnitude and flow distribution of runoff (Reddering and Rust 1990). Catchment size varies significantly, ranging from very small (less than 1 km^2) to very large (greater than 10 000 km^2), with those in the cool Temperate region tending to be larger than those in the warm Temperate and subtropical regions.

The overall feature of the Mean Annual Precipitation (MAP) distribution over South Africa is that it decreases fairly uniformly westwards from the Drakensberg escarpment across the interior plateau, with rainfall patterns strongly affected by irregularities of terrain between the

escarpment and the ocean along the southern and the eastern coastal margins. According to Lynch (2004), approximately 20% of South Africa receives less than 200 mm MAP, and 47% receives less than 400 mm per annum (Figure 5.1), the result of the presence of subtropical high pressure cells which inhibit rainfall generation because of predominantly subsiding air. Only about 9% of South Africa receives a MAP in excess of 800 mm. KwaZulu-Natal is the wettest region of South Africa while the Western Cape has the highest range of MAP, and the highest individual point rainfall at an estimated 3 198 mm per annum (Lynch 2004). Because rainfall-runoff processes are nonlinear, with a larger proportion of rainfall being converted to runoff as a catchment becomes wetter, it should be clear that the rainfall to runoff relationship is much higher in the Subtropical regions than in the Temperate regions. This, in turn, also suggests that on average the smaller, temporarily open/closed estuaries of the Subtropical region should be open to the sea significantly more than similar sized estuaries (fed by similar size catchments) in the Temperate coastal areas (in areas of similar wave exposure and sediment availability).

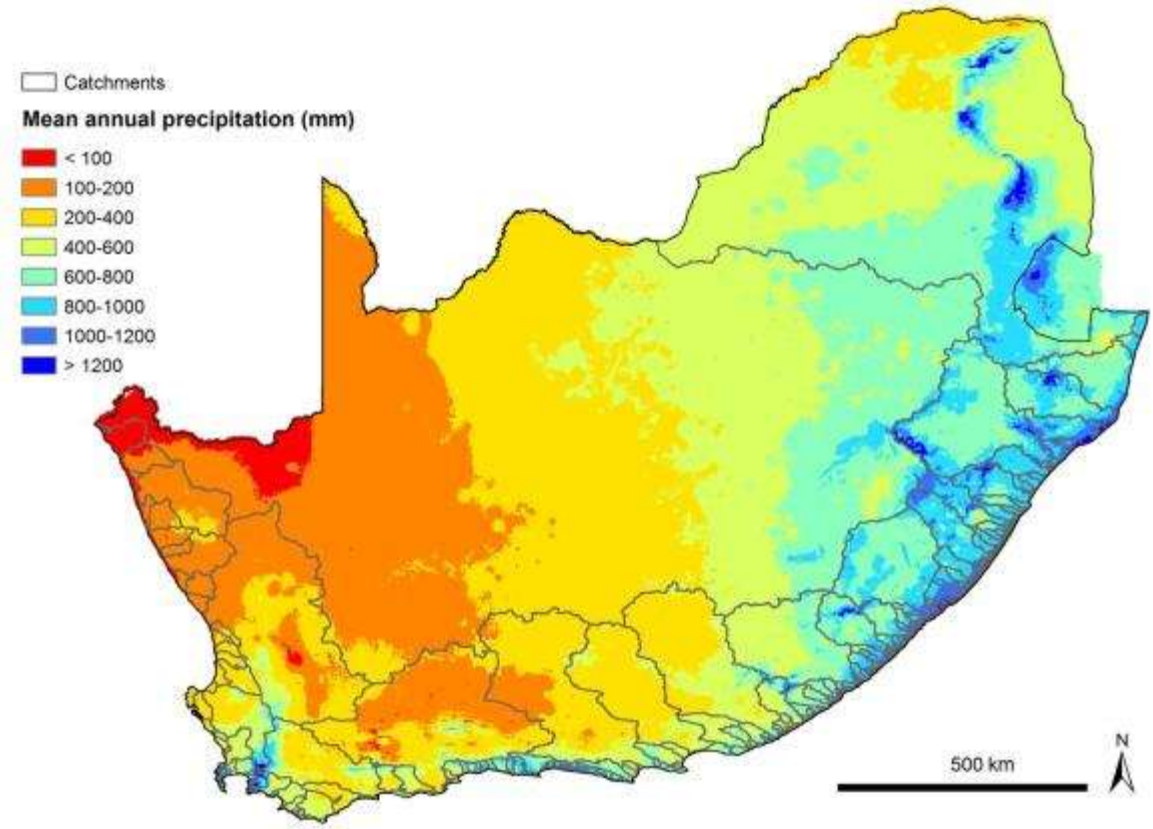


Figure 5.1 Mean Annual Precipitation of South Africa (Source: Schulze and Lynch 2007).

An area may have high or low average rainfall, a high or relatively low variability in rainfall from one year to the next, or its rainfall may be concentrated over a short rainy season or spread over a longer period. That does not, however, indicate anything about the season in which the rain falls - be it predominantly in winter, throughout the year or in summer; and if in summer whether it be in early, late or very late summer. Rainfall seasonality is an important hydrological consideration (Schulze and Maharaj 2007), particularly when viewed in light of estuarine ecological functioning and recruitment processes which predominantly occur in spring and early summer (Lamberth et al. 2008).

Rainfall seasonality, by primary catchment, is shown on the accompanying map (Figure 5.2). The winter rainfall regions have peak runoff during the winter months June, July and August. The early summer regions have rainfall concentration in December or earlier, the mid-summer rainfall region peaks in January, late summer peaks in February, and the very late summer regions rainfall peaks from March to May (Schulze and Maharaj 2007, Davies and Day 1998). The winter rainfall region in the west and the all year rainfall region in the south are seasonally clearly defined, while over the summer rainfall region the general trend is for rains to fall later as one moves towards the west (Schulze and Maharaj 2007).

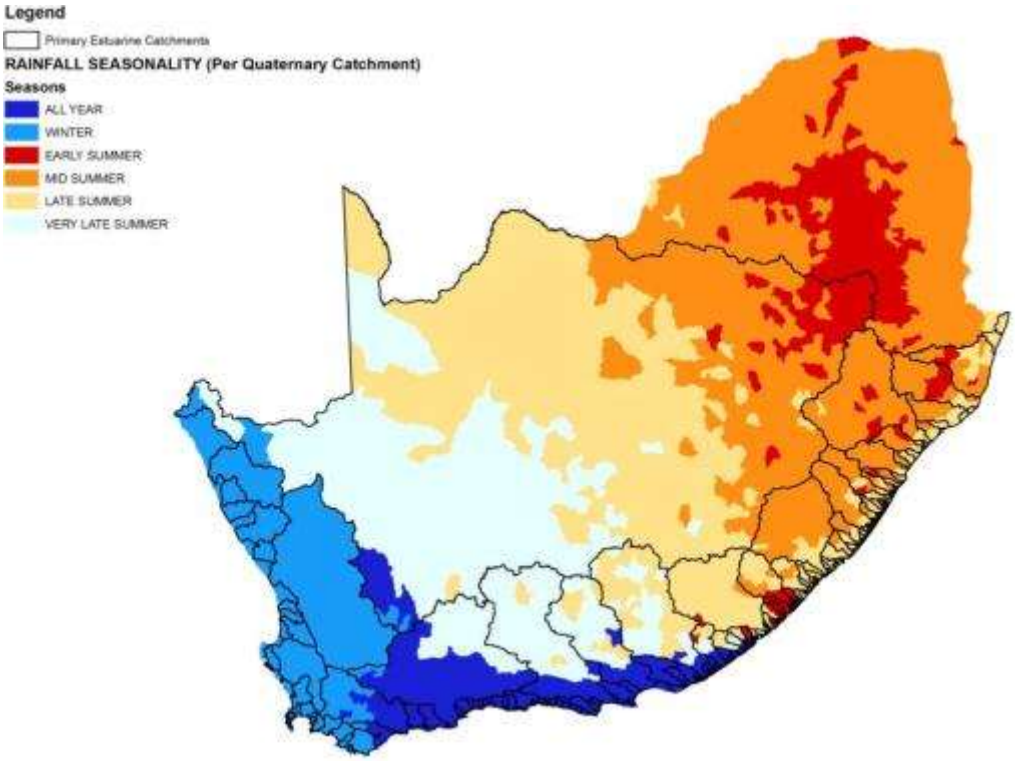


Figure 5.2 Rainfall regions in South Africa (Source: Schulze and Lynch 2007).

From the seasonality in rainfall it becomes clear that connectivity between rivers, estuaries and the sea is more established in the Subtropical region during the biological active period of spring and summer, than for the Temperate west coast and south coast regions. Estuaries fed by larger catchments spanning more than one rainfall zone represent anomalies from a coastal connectivity perspective, often sending recruitment signals when their adjacent neighbours are in low flow. For example, the Orange Estuary's peak flow is during the summer on a winter rainfall coast, the Breede is bimodal with both all year round and winter runoff peaks, the larger south coast system (Gouritz, Gamtoos, Sundays, Great Fish and Keiskamma) receive mainly late summer runoff in addition to all year round runoff, while the larger subtropical catchments deviate away from the coastal signal of late summer to mid- or early summer peaks in runoff.

5.2 Dominant catchment characteristics

The dominant catchment characteristics determining the character of river inflow to estuaries was derived from spatial data. Quaternary catchments were subdivided on a national scale into smaller primary catchments and overlaid by Super Group surficial geology[3] to determine the dominant geology type influencing water quality, e.g. Basement Complex, Carbonate Terrains, Extrusives, Fractured Metasedimentry, Karoo Dykes and Silts, Natal Group Sandstones, Surficial Deposits, Table Mountain Group Sandstone, Unclassified. Some descriptive statistics were then applied on a catchment scale to highlight physical differences along the coastline (Figure 5.3).

Following the example of Nobel and Hemens (1978), the inflowing river types were recognised: clear water, turbid water and black water (tannin rich, nutrient poor rivers) systems. The analyses showed that using absolute percentage of the geological layer coverage in a catchment could be misleading, as it is often the relative position of a feature that matters (i.e. not the percentage of runoff correlated with the feature) that ultimately drives the inflowing waters characteristics. For example, while the Duiwenhoks catchment has very little Sandstone (14%), the lower river reach and estuary is predominantly flanked by this geological formation/vegetation type and therefore displays a very clear black water signal during most of the year.

[3] Surficial geology, also referred to as Quaternary geology, refers to those unconsolidated geologic materials overlaying the bedrock.

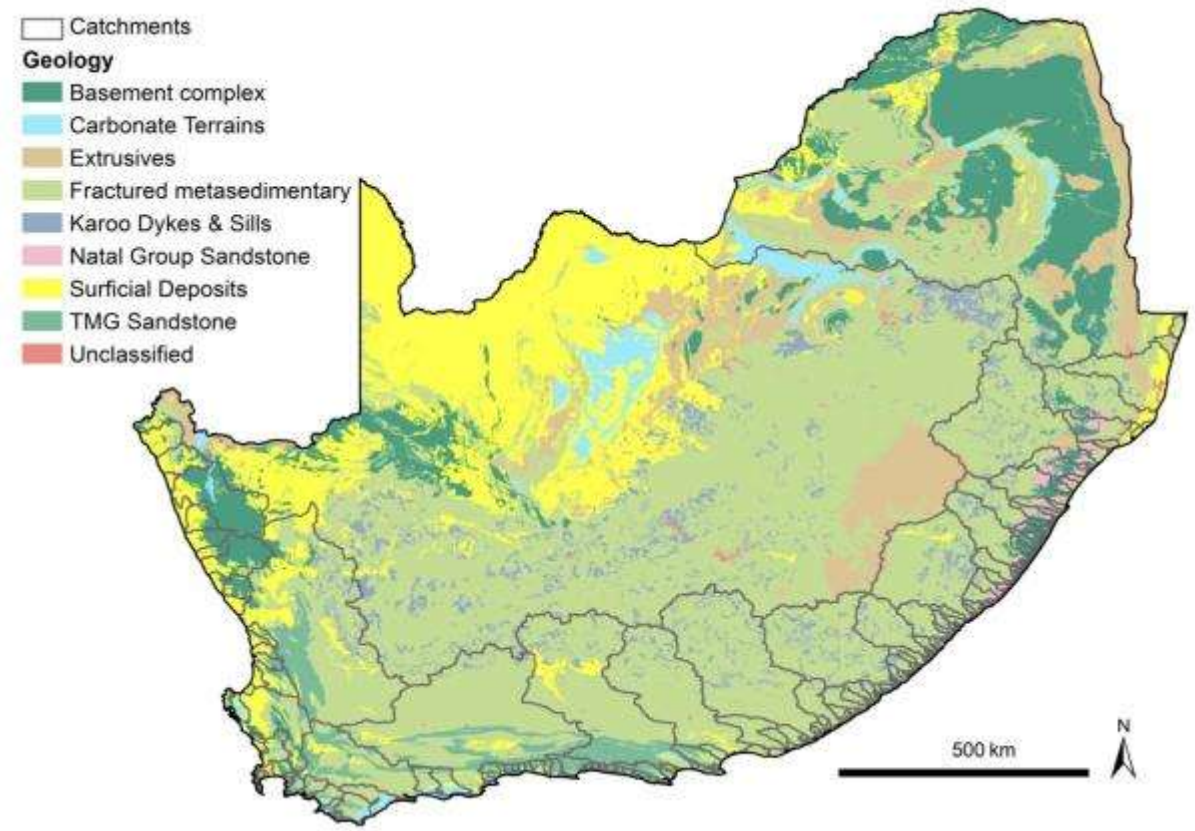


Figure 5.3 The geology of South Africa categorised according to the Super Group formations.

Only during high river flows does it exhibit the more turbid characteristics of its upper catchment. Therefore the catchments with sandstone geology (generally occurring along the coast) of more than 10% were considered black water systems unless field data or specialist opinion indicated otherwise.

After evaluating the spatial data in consultation with estuarine specialists and a terrestrial vegetation specialist (pers. comm., D Le Maitre, CSIR) it became apparent that the Pondoland estuaries were very similar in water quality and terrestrial vegetation type characteristics (CB4 Pondoland-Ugu Sandstone Coastal Sourveld) to the Cape black water systems (Mucina and Rutherford 2006). Therefore the Natal Group Aronites of the Wild coast area were classified and evaluated at a finer scale to accommodate the identified anomaly, especially since most specialists felt they represented a unique feature on that coast line and that the small Pondoland estuaries were very different from the small KwaZulu-Natal estuaries in terms of biota and water type.

Turbid estuaries were typed on the basis of their MAR, where larger catchments would cut back into the more erodible formations (e.g. Karoo formations) and flow velocities would

generally be higher throughout the year than for small coastal systems. While geology was the key feature under consideration, assumptions around erodiblity were informed by the sediment yield atlas for the various regions (1 to 10) (Rooseboom et al. 1992, Le Roux et a.l 2008, updated in Msadala et al. 2010).

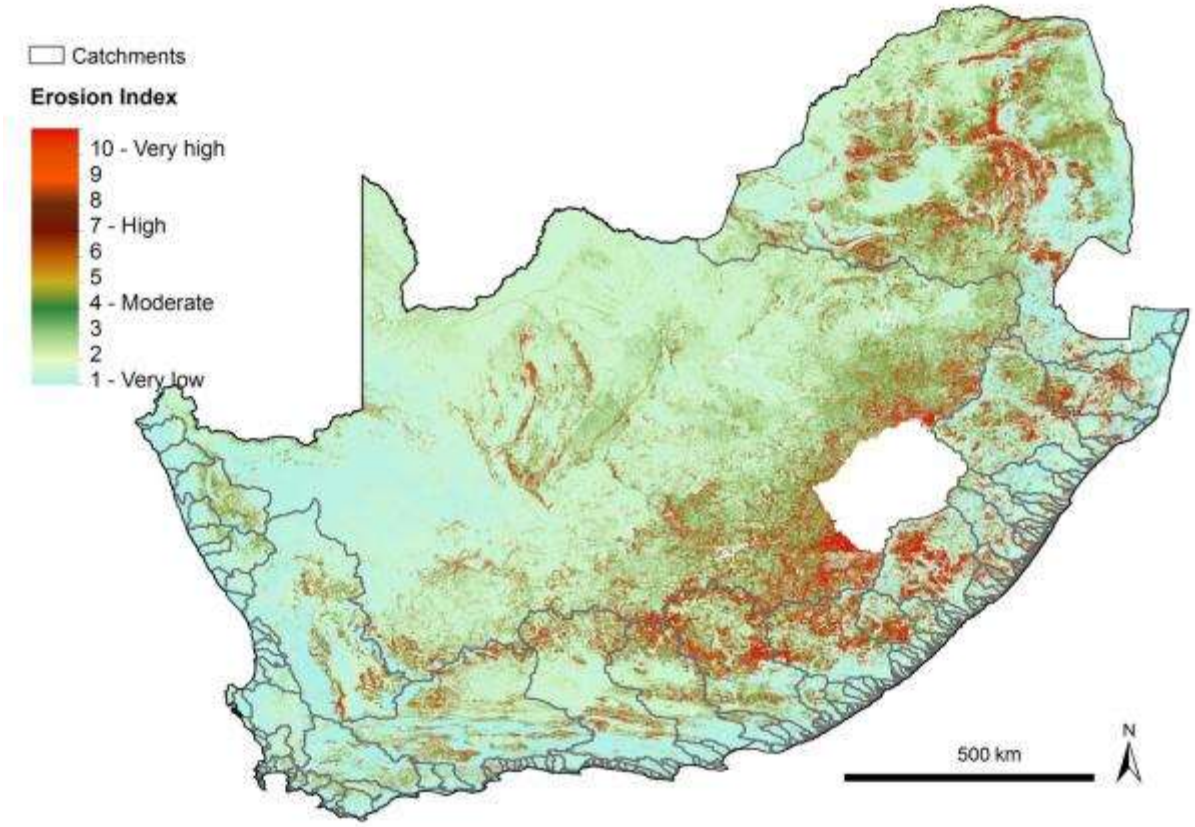


Figure 5.4 Updated sediment yield regions showing erodibility (Modified: Le Roux et al 2008).

Systems with a MAR >30 x10^6 tend to be permanently turbid, while the smaller catchments tend to have lower flow velocities in the dry season, which facilitates the development of clear water for much of the year (Figure 5.5). In some estuaries, large amounts of mud and silt are deposited by floods into estuaries, where tide and wind action causes resuspension for a significant period after the event. These more ephemeral conditions were not seen as representative of the majority state. This did raise the question whether the Wild Coast systems which drain some of the county's most erodible soils, in combination with current poor land-use practises, should be classified as turbid or clear water types. Presently floods deposit significantly more sediment in these systems leading to the perception that some of these estuaries are turbid throughout the year. In the absence of data, the classification kept

to the general rule that while the estuaries might act as a sediment sink (delivered in pulses during floods), the rivers were in general running clear.

While there is value in identifying the catchment water type, it is very important that *in situ* water clarity and Secchi disk readings be done on a national scale at regular intervals to facilitate the refinement of this catchment derived classification.

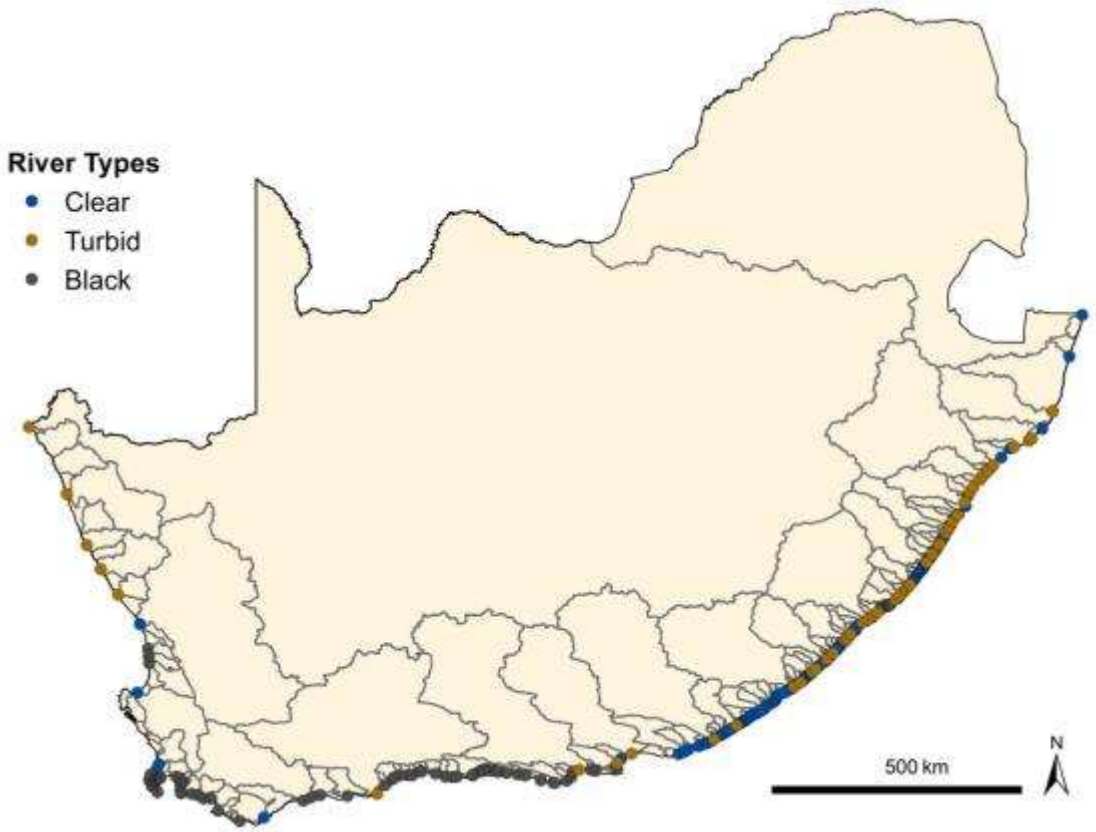


Figure 5.5 Dominant catchment type flowing into South Africa's estuaries.

5.3 Topography and size

Most estuaries in South Africa are located in incised bedrock valleys and thus are laterally confined (Cooper 2001). Some estuary channels fill their entire bedrock valley while others have a substantial floodplain, but most are confined by their bedrock valley. Only a few examples of coastal plain estuaries (i.e. estuaries formed in semi-consolidated alluvium on coastal plains) are present on the South African coast. These are mainly confined to northern KwaZulu-Natal, the Southern Cape coastal lakes area, and parts of the Cape West coast. Coastal plain estuaries are generally associated with substantial water bodies (i.e. estuarine lakes and large permanently open estuaries; Figure 5.6).

Size influences a number of estuarine characteristics, including being a predictor of community composition and abundance, with smaller systems having fewer species and lower absolute abundance. Larger estuaries also tend to have a higher diversity of habitat types than smaller systems. Estuary size can be loosely correlated with Mean Annual Runoff and catchment size but this is not always the case, e.g. Orange (Gariep) has a large catchment but relatively small estuary whereas the Kosi has a large estuarine area but small catchment.

From a process perspective large and small estuaries tend to respond differently to resetting event, i.e. major floods. Large estuaries are generally more buffered against flood scouring as they have more storage, which translates into less loss of substrate and habitat. Larger estuaries also tend to have more refugae within them (in the form of main channel areas, slack water areas and floodplains) which act as refugae during flood events. Therefore large systems can normally recruit/restock individuals from within the system after a flood (e.g. Gamtoos) while smaller estuaries tend to need recruitment from the marine environment after a major resetting event. Large systems, excluding estuarine lakes, tend to be permanently connected to the sea, while smaller systems tend to close during low seasonal flows (dry season) and drought cycles. Along the Subtropical coast, large systems are often associated with high runoff, i.e. high current velocities and resetting floods, which tend to negate the benefits larger estuaries tend to provide in the more Temperate regions.

These differences in the functioning between large and small systems are seen as more important for the less mobile species (invertebrates and plants) that recruit and establish at a slower rate after a resetting event. More mobile species such as fish and birds seem to be responding to these differences on a continuum (Turpie and Clark 2007). For example, using the data set from Harrison et al. (2000), Turpie and Clark (2007) estimated the total populations of fish for each species for each estuary and found that while larger estuaries contain more fish there was no significant difference in fish density between small and large estuaries from a total fish abundance perspective. A SIMPER analysis of this estimated total fish abundance demonstrated that, within each biogeographical zone, fish communities of smaller systems are subsets of larger systems, rather than certain types of systems having distinct types of fish communities (Turpie and Clark 2007). Their analysis suggested that the principle determinant of fish community characteristics, apart from geographic location, was estuary size.

For the NBA 2011 size was initially classified exponentially on the basis of the primary physical processes in estuaries (Large >1000ha, Medium 1000 - 100ha, Small 100-10ha, Very Small <10 ha), but this typology was further aggregated for the NBA 2011 in order to reduce the number of overall number of ecosystem features (see Chapter 7 on NBA 2011 typology for more detail).

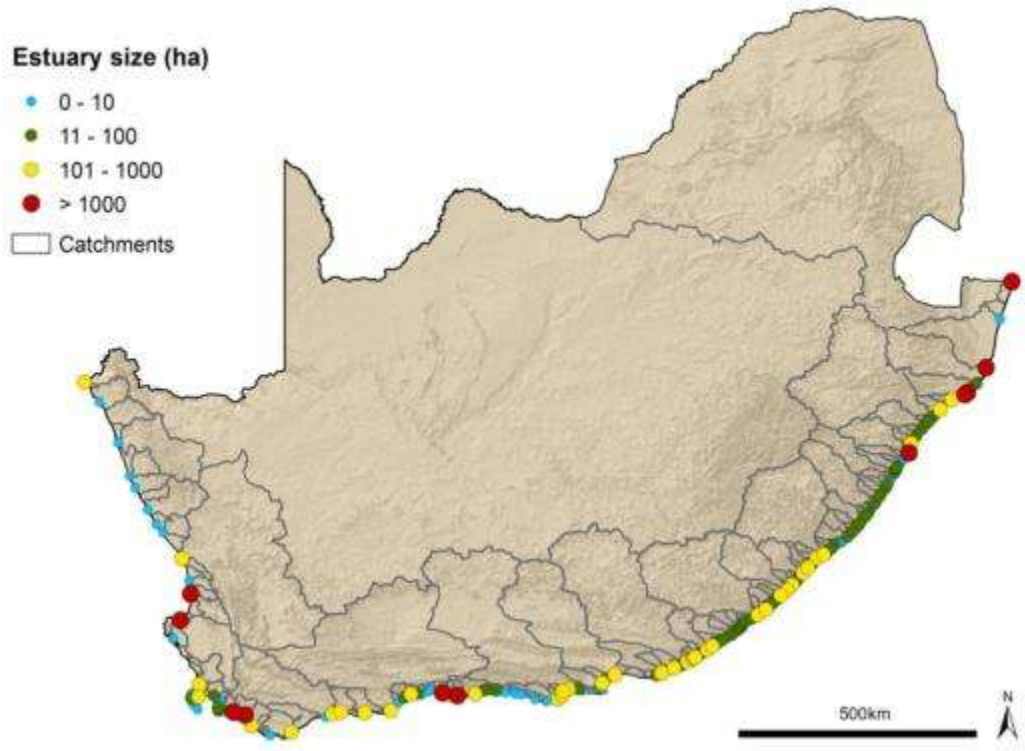


Figure 5.6 Topography of South Africa in relation to estaury size.

5.4 Physical dynamics

5.4.1 Tidal variation

South Africa's coast is generally characterised by low tidal ranges and high wave energy, making it a wave-dominated coast (Cooper 2001). Therefore the approximately 300 functional estuaries are predominantly microtidal systems (tidal range < 2 m) that are highly dynamic and shallow (average depth of 2–3 m). Owing to strong wave action and high sediment availability, more than 90% of the estuaries have restricted inlets, with more than 75% closing for varying periods of time when a sand bar forms across the mouth (Whitfield 1992). Perched estuaries tend to have more restricted mouths with limited tidal range due to their elevation relative to sea level (Figure 5.7). An additional feature is that small perched estuaries tend to drain between 30 – 70 % of their water under open mouth conditions, i.e.

they have more water column habitat when closed than open. These types of estuaries also tend to be more productive (and better nurseries) during the closed phase.

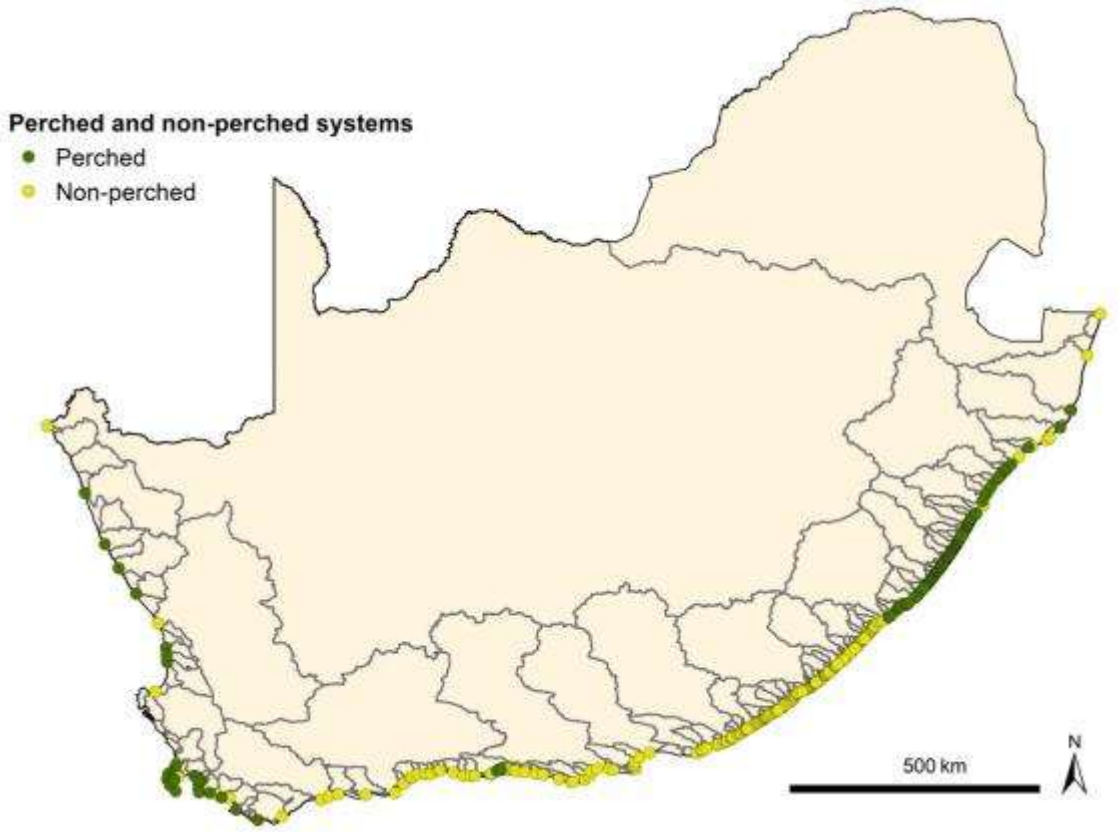


Figure 5.7 Mouth position on berm (perched, non-perched) in South Africa's estuaries.

Cooper (2001) generalized the wave energy and sediment availability along the coast of South Africa, indicating that most of the estuaries along the west coast and KZN coastline are perched. More information is required to disaggregate these general features in a meaningfully manner. Nevertheless the following generalization can be made from measured data along the coast: in permanently open estuaries the tidal range is normally greater than 1.5 m (e.g. Berg, Olifants, Sundays), between 1.5 – 0.5 m for a large temporarily open estuary (Groot Brak, Seekoei); and between 0.5 to 0.2 m for a perched or small temporarily open estuary (e.g. Buffels, Lourens, East Kleinemonde, Little Amanzimtoti). All estuaries become more constricted during the low flow season (the exceptions are Knysna and Mhtlathuze) and tend to be more open to the sea during the rainy season.

5.4.2 Mouth states

The major forces that maintain open mouth conditions are river inflow and tidal flows, while the major closing forces are wave energy and sediment availability (both marine and fluvial).

South Africa's estuaries are sensitive to changes in river runoff, the reason being that they generally discharge into a coastline with comparatively high energy, where the relatively low runoff produces rather limited scouring forces. Only about 25% of South Africa's estuaries are permanently connected to the sea (Whitfield 1992) and these systems normally have relatively high runoff throughout the year. The area covered by these estuaries is normally large enough for the tidal prism to play a significant role in maintaining open mouth conditions. In some cases the mouths are protected from high wave energy or little sediment is available to promote mouth closure (e.g. Mgazana Estuary). The majority (~75%) of South Africa's estuaries are not permanently open to the marine environment (Whitfield 1992). These types of systems are isolated from the sea by the formation of a sand berm across the mouth during periods of low river inflow or when river inflow has stopped altogether. Such estuaries stay closed until their basins fill up and the berm is breached, either as a result of high water levels in the estuary or following increased river flow. Mouth breaching may result in the removal of significant amounts of sediment. However, as soon as river flows decrease again, infilling from marine and fluvial sediment can be rapid. The Whitfield classification (1992), augmented by field observations, estuary size data (this study) and MAR was used as a basis for categorising estuaries into either open (permanently open) of closed systems (can close from time to time) (see Figure 5.8).

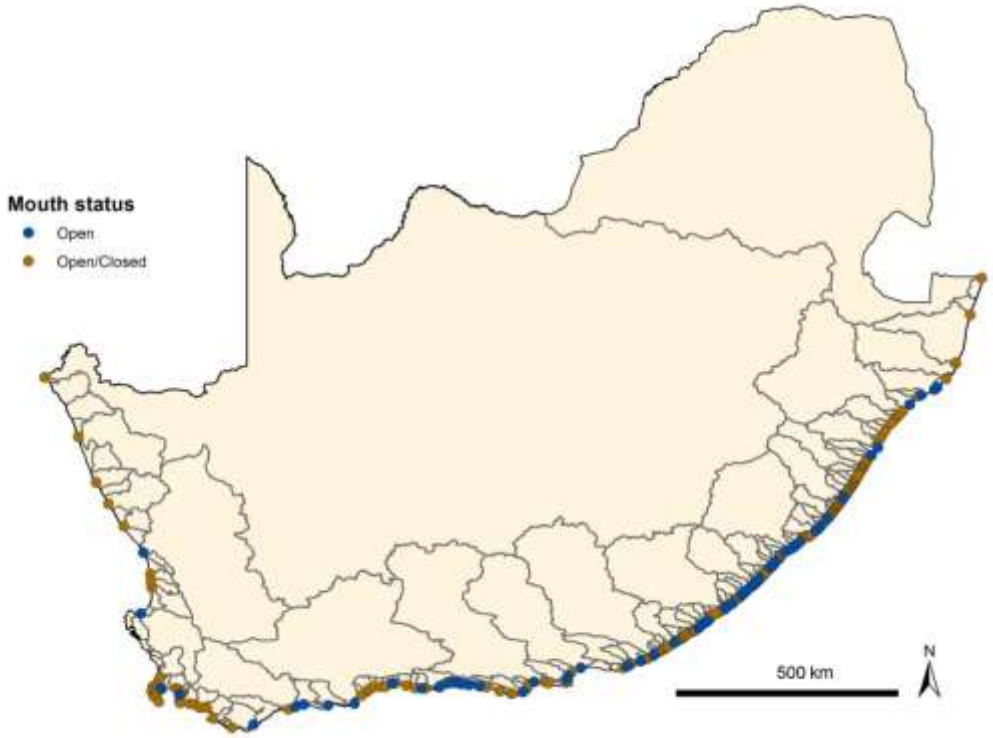


Figure 5.8 Location of permanently open (indicated in blue) versus temporarily open/closed (indicated in brown) estuaries.

5.4.3 Dominant salinity structures

The dominant salinity structure was determined by dividing the MAR by the volume of the estuary. Volume was calculated on the open water area multiplied by an average depth. Average depth in itself was problematic as most research papers report “average channel depth” and not “average estuary depth”.

For most small systems an average depth was assumed of 1.5 m and for larger estuaries 2 – 3 m depending on information and observations. While accurate bathymetry data is not available (available for less than 10% of SA estuaries) the project team had visited most of the larger systems in the course of their careers and this anecdotal information was used in the absence of data.

A major effort was made to refine the MAR. Ideally one would need to know the seasonal distribution of runoff to calculate the salinity structure of an estuary, but in the absence of that if the *MAR/Volume > 365* the estuary was considered as fresh water dominated, while *MAR/Volume < 10* was considered as marine dominated. The remaining estuaries were classified as mixed. In all cases, known systems were used to test assumptions, e.g. Breede (mixed), Kromme (marine dominated), Thukela (fresh water dominated) and anomalies were interrogated to evaluate if the findings were an artifact of the coarseness of the data or possibly real.

Some adjustments were made, in consultation with specialists, based on field experience and the bathymetry of each estuary, e.g. long shallow estuaries flush more readily than deep basin shaped estuaries.

It was felt that the methods had merit but that a higher resolution was still needed to truly inform biodiversity studies, for example defining the “% mixed state” versus “% fresh water dominated state”. As this information is dependent on seasonal inflow ranges and more accurate depth data, this request could not be addresses as part of the NBA 2011.

5.5 Future research requirements

This section provided an overview of key catchment characteristics (i.e. flow volume, seasonality of flow, and river type) and estuarine features (size, mouth state, salinity structure, tidal variation).

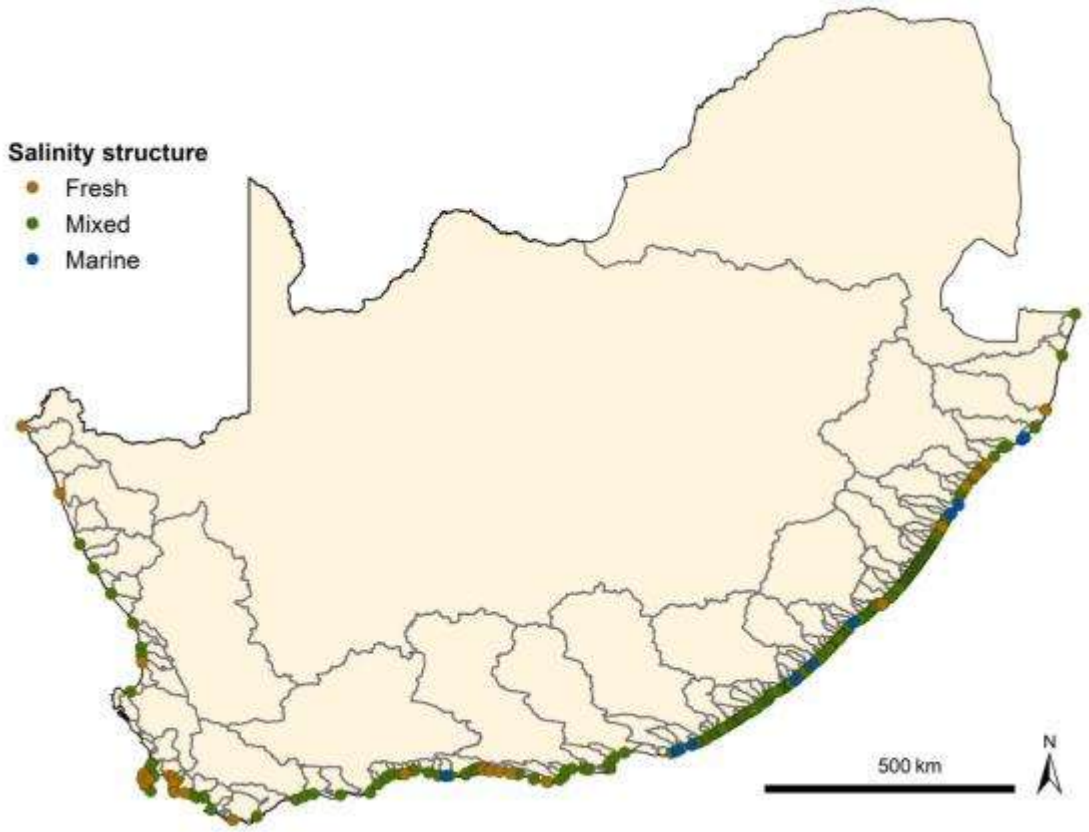


Figure 5.9 Dominant salinity structure (i.e. freshwater dominated, mixed, marine dominated) in South Africa's estuaries.

To assist with refining the key physical processes and feature of South Africa's estuaries the following high resolution input data is required:

- Catchment hydrology (Monthly flow data for natural and present conditions),
- Bathymetry (estuary volume and depth),
- Sediment structure (mud, sand and organic content), and
- Water column geochemistry (salinity structure and turbidity).

6. ESTUARINE HABITAT

JB Adams, GC Snow and DA Veldkornet

Estuaries are generally made up of a high diversity of habitat types, which include openwater area, sand and mudflats, rock and plant communities. Plant community types can be subdivided into salt marsh, mangroves, submerged macrophytes, reeds and sedges. A habitat rarity score (HR) was designed to take into consideration the number of habitats in an estuary, and the extent to which rare communities occur. This score, based on habitat area, is an essential component when determining the Estuary Importance Score, a score used to rank estuaries in terms of their conservation importance.

Panel 1: Description of estuary habitat types

Water surface area (estuary channel): This represents the habitat associated with the water column of an estuary and is measured as the water surface area. The primary producers are the phytoplankton consisting of flagellates, dinoflagellates, diatoms and blue-green algae which occur in a wide range of salinity from freshwater to marine conditions.

Sand / mudflats / rock: Habitat mapping from aerial photographs cannot distinguish between sand and mud habitats and therefore this is presented as a single area in the Botanical Database. However rock can be mapped as a separate habitat. The dominant primary producers of these habitats are the benthic microalgae.

Macroalgae: Macroalgae may be intertidal (intermittently exposed) or subtidal (submerged at all times), they may be attached or free floating (Adams et al. 1999). Filamentous macroalgae often form algal mats and increase in response to nutrient enrichment or calm sheltered conditions when the mouth of an estuary is closed. Typical genera include *Enteromorpha* and *Cladophora*. Many marine species can get washed into an estuary and providing the salinity is high enough, can proliferate. These include *Codium*, *Caulerpa*, *Gracilaria* and *Polysiphonia*.

Submerged macrophytes: Submerged macrophytes are those plants that are rooted in the bottom substrate with their leaves and stems completely submersed (e.g. *Stukenia pectinata* and *Ruppia cirrhosa*) or exposed on each low tide (e.g. the seagrass *Zostera capensis*). Zostera capensis occupies the intertidal zone of most permanently open Cape estuaries whereas *Ruppia cirrhosa* is common in temporarily open/closed estuaries. *Stukenia pectinata* occurs in closed systems or in the upper reaches of open estuaries where the salinity is less than 10 ppt.

Salt marsh: Salt marsh plants show distinct zonation patterns along tidal inundation and salinity gradients. Zonation is well developed in estuaries with a large tidal range e.g. Berg, Knysna and Swartkops estuaries. Common genera are *Sarcocornia*, *Salicornia*, *Triglochin*, *Limonium* and *Juncus*. Halophytic grasses such as *Sporobolus virginicus* and *Paspalum* spp. are also present. Intertidal salt marsh occurs below mean high water spring and supratidal salt marsh above this. *Sarcocornia pillansii* is common in the supratidal zone and large stands can occur in estuaries such as the Olifants.



***Spartina maritima* in the Swartkops estuary and intertidal salt marsh in the East Kleinemonde Estuary (Source: T Riddin)**

Reeds and sedges: Reeds, sedges and rushes are important in the freshwater and brackish zones of estuaries. Because they are often associated with freshwater input they can be used to identify freshwater seepage sites along estuaries. The dominant species are the common reed *Phragmites australis*, *Schoenoplectus scirpoides* and *Bolboschoenus maritimus* (sea club-rush).



Reeds in the upper reaches of the Bushmans Estuary (Source: G Snow) and *Bolboschoenus maritimus* in the East Kleinemonde Estuary (Source: T Riddin)

Mangroves: Mangroves are trees that establish in the intertidal zone in permanently open estuaries along the east coast of South Africa north of East London where water temperature is usually above 20°C. The white mangrove *Avicennia marina* is the most widespread, followed by *Bruguiera gymnorrhiza* and then *Rhizophora mucronata*. *Lumnitzera racemosa*, *Ceriops tagal* and *Xylocarpus granatum* only occur in the Kosi Estuary.



Mangroves in the Mngazana Estuary (Source: T Riddin)

Swamp forest: Swamp forests, unlike mangroves are freshwater habitats associated with estuaries in KwaZulu-Natal. Common species include *Syzygium cordatum*, *Barringtonia racemosa* and *Ficus trichopoda*. It is often difficult to distinguish this habitat from coastal forest in aerial photographs.

(Source: T Riddin & JB Adams)

Estuarine importance indices require data on most estuaries. The available dataset for the macrophytes and habitat was in most cases taken from the old “Green book” reports of CSIR for the CAPE estuaries. These data are in most cases 30 years old, there have been substantial changes in estuaries since then, and the habitat types have been reclassified. There is therefore an urgent need for the real data for those estuaries that were included in the Green series, in addition to the other estuaries where no data are available.

This project task set out to update the Estuary Botanical Database. The habitat data provided input to the National Health Assessment, Ecosystem Threat Status, Protection Level assessment and National Biodiversity Plan.

6.1 Method

Images of the estuaries were downloaded from Google Earth and the different habitat types (intertidal salt marsh, supratidal salt marsh, reeds and sedges, channel (water surface area, sand & mud banks) were identified, using information from field trips or available photographs (see Figure 6.1). These were highlighted as polygons, saved as *.kml files and then the areas calculated using the Program GE Path 1.4.4.

The Bokramspruit, Schuster, Krom (west), Maalgate, Kaaimans, Blinde, Gwaing, Klein Brak, Rufane and Klein Palmiet estuaries were visited in 2009 to ground truth the areas covered by the different habitat types. No site visits took place for the following estuaries mainly because of inaccessibility; Ratel, Klipsdrifsfontein, Bloukrans, Lottering, Elandsbos, Elands, Groot (east), Klipdrif, Slang.

Recently completed Department of Water Affairs Resource Directed Measures (RDM) reports were checked and the areas covered by the different habitat types were updated in the Botanical Database using this new information. For most Intermediate and Comprehensive ecological water requirement studies the vegetation would have been mapped using GIS to indicate changes in the habitat types over time.

The area covered by mangroves in the Wild Coast and KwaZulu-Natal estuaries was updated from recent mapping and research studies of Pillay (CSIR) and Rajkaran (NMMU).



Figure 6.1 Example of habitat mapping using Google Earth.

Data for the Eastern Cape estuaries; Blinde, Cunge, Hlozi, Ross's and Shelbertstroom estuaries (Table 6.1) were obtained from Walker (2003). He completed a PhD study on estuaries in the East London region i.e. that area occurring between the Ciskei and Transkei coast. The study included details on the physical characteristics of the estuaries, areas for different habitat types and the areas covered by the dominant macrophytes species.

Table 6.1 Data sources for estuaries where no data were previously available.

Estuary	Reference	Estuary	Reference
Rietvlei/Diep	Management plan	Lottering	NBA 2011
Bokramspruit	NBA 2011	Elandsbos	NBA 2011
Schuster	NBA 2011	Elands	NBA 2011
Krom	NBA 2011	Groot (East)	NBA 2011
Ratel	NBA 2011	Klipdrif	NBA 2011
Klipdrifsfontein	NBA 2011	Slang	NBA 2011
Blinde	NBA 2011	Rufane	NBA 2011
Klein Brak	NBA 2011	Klein Palmiet	NBA 2011
Maalgate	NBA 2011	Shelbertstroom	Walker 2003
Gwaing	NBA 2011	Ross's Creek	Walker 2003
Kaaimans	NBA 2011	Hlozi	Walker 2003
Matjies	RDM study	Blind	Walker 2003
Bloukrans	NBA 2011	Cunge	Walker 2003

6.2 Update of the plant species list and taxonomy

Species were collected for identification in five estuaries in August 2009. These data were used to update the Botanical Database which includes species lists for the plants found in all estuaries and the area covered by the different habitat types. Macroalgae were not collected. In the Groot Brak Estuary only the salt marsh in the lower reaches was investigated. In the Kaaimans Estuary species were collected from a small intertidal patch of salt marsh accessible from the N2 road. Species were also recorded along the banks of the estuary. The Blinde Estuary was largely inaccessible and plants were only collected near the mouth. Due to greater accessibility the Klein Brak and Gwaing estuaries were sampled along the entire length.

The species data in the Botanical Database were also updated using available literature. Species were added for the Berg River Estuary (Boucher and Jones 2007), Uilkraals Estuary (Mucina et al. 2003), and the Olifants Estuary (Bornman 2002). Recent data of Prinsloo (2009) (unpublished data) was used to update the macroalgae in terms of occurrence and species name changes. For all plants taxonomic names were checked using Germishuizen and Meyer (2004). The following websites were used in conjunction with the above literature: Plantzafrica (www.plantzafrica.com); zipcodezoo (www.zipcode.com); Algaebase (www.algaebase.org).

Prof L Mucina, Curtin University, Western Australia was consulted to determine which macrophyte genera were currently undergoing taxonomic revision. Mucina also provided input on the estuaries which have important plant populations, i.e. rare, endangered, endemic, newly identified.

6.3 Results

6.3.1 Habitat Areas

Habitat area data is now available for nearly all of South Africa's estuaries. The list of estuaries included in the Botanical Database are those that were included in the National Estuary Health Assessment. Figure 4.2 provides an overview of the dominant vegetation types along the coast. While a summary of the distribution per biogeographic region is provided in Table 6.2.

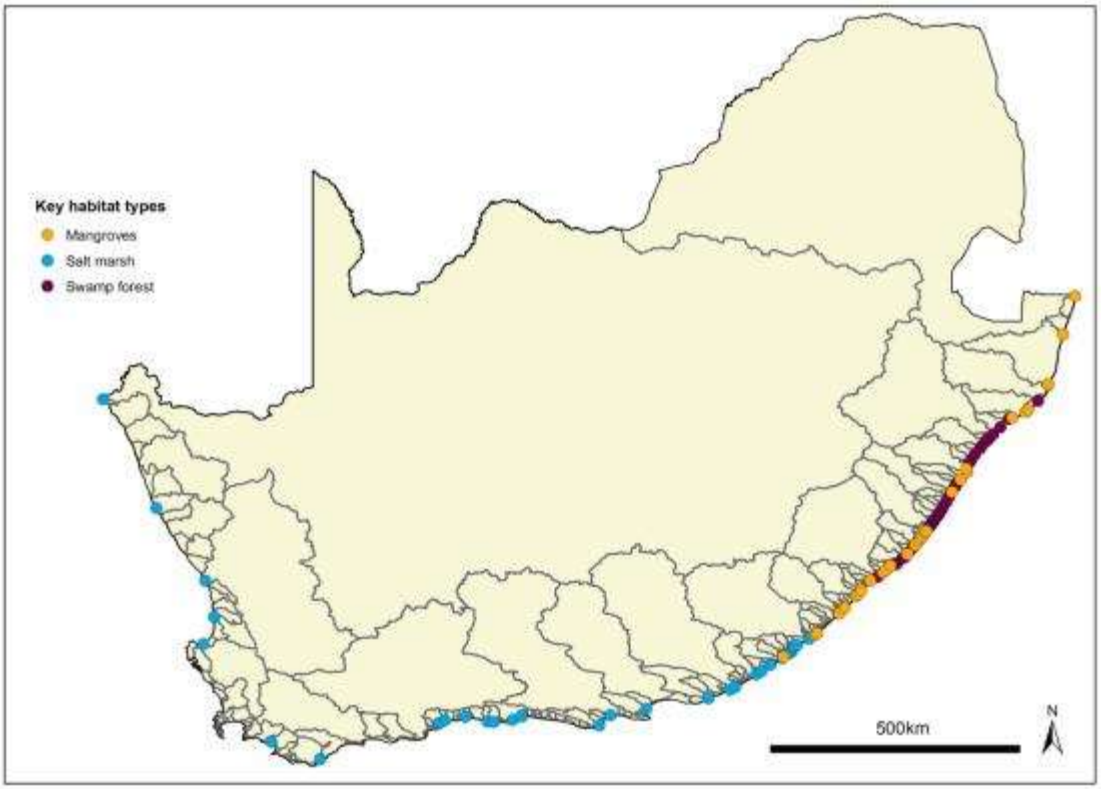


Figure 6.2 Dominant habitat types in South Africa's estuaries.

The following estuaries were added to the original estuary list and now have no area cover data: Mendwana, Kwa-Suka, Sundwana (all Transkei), Nkomba, Rocky Bay, Umlazi (canal), Bob's stream (all KwaZulu-Natal). The Baakens and Papenkuils were also added. An analysis of historical photographs would be necessary to establish whether these systems had estuarine habitat in the past as both systems are severely degraded at present as a result of canalisation and diversion and have no functional habitat. These two estuaries fall within the metropolitan area of Nelson Mandela Bay (Port Elizabeth). Habitat area data are still missing for Sout (Wes). Data for Rietvlei / Diep were obtained from a recent report on the estuary management plan. Julian Conrad provided data from a recently completed GIS map. Large supratidal salt marsh areas and reed and sedge habitats occur at Rietvlei.

Table 6.2 Summary of the total estuarine habitat in South Africa.

Habitat	Total Habitat (ha)			
	Cool Temperate	Warm Temperate	Subtropical	Total
Supratidal salt marsh	3 805	1 427	1 818	7 051
Intertidal salt marsh	1 903	1 774	634	4 310
Mangroves	0	26	2085	2111

Habitat	Total Habitat (ha)			
	Cool Temperate	Warm Temperate	Subtropical	Total
Swamp forest	0	1	4841	4841
Submerged macrophytes	495	615	217	1 327
Sand/mud banks	1 039	1 692	1286	4017
Channel	4 306	6 149	44828	55284
Rocks	6	74	16	96
Reeds and sedges	2 165	1 091	8550	11806
Total Habitat	**13 720**	**12 849**	**64275**	**90844**

Data for Richards Bay Harbour were obtained from a 1996 report “An environmental review of the Master Plan for the Port of Richards Bay” (EAS 1996). The present 1996 area cover data have been used in the Botanical Database. However it is important to note that this report indicates major loss of estuary habitat due to port expansion. Richards Bay Harbour is known to have the oldest area of mangroves in the country.

The area cover data for mangroves in KwaZulu-Natal was updated in the Botanical Database using new data from Pillay (CSIR, Table 6.3). Mangroves have been completely lost from a number of estuaries, including the Mhlanga, Little Manzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mahlongwa, Kongweni, Bilanhlolo, Mhlangankulu and Khandandlovu. These revised data may influence the national prioritization of South African estuaries in future.

Table 6.3 Updated mangrove area data for KwaZulu-Natal estuaries (Pillay unpublished).

	Area (ha)	
Name of estuary (north to south)	Ward and Steinke (1982)	Pillay (CSIR)
Kosi Bay	59	60.7
Mgobezeleni	2.5	4.5
St Lucia	160	571.0
uMfolozi**	26	-
Richards Bay/ Mhlathuze	427.5	652.1
Mlalazi	30	60.7
Mhlanga	0.5	0
Mgeni	44*	20.3
Durban Bay	15	16.0
Sipingo	12.5	3.8
Little Manzimtoti	0.5	0
Lovu	2	0
Msimbazi	0.5	0
Mgababa	0.5	0

	Area (ha)	
Name of estuary (north to south)	**Ward and Steinke (1982)**	**Pillay (CSIR)**
Ngane	0.5	0
Mkomazi	2	2.0
Mahlongwa	1	0
Kongweni	0.5	0
Bilanhlolo	0.5	0
Mhlangankulu	0.5	0
Khandandlovu	0.5	0
Mtamvuna	0.25	0.3

**Mgeni EWR (2011) study indicate that this might be mapping error*
***uMfolozi separated to indicate complete loss of mangroves from that estuary.*

The habitat areas that were calculated from Google Earth images using GE Path 1.4.4., from estuary site visits, Walker (2004), and from recent Resource Directed Measures reports (Table 6.4). These data were used to update the Botanical Excel Database (including the metadata indicating the source of the data).

Table 6.4 Revised habitat area data for South African estuaries.

Estuaries (west to east)	**Length (km)**	**Water area**	**Submerged Macrophytes**	**Intertidal salt marsh**	**Supratidal salt marsh**	**Reeds & sedge**	**Sand / mud bank**	**Mangrove**	**Swamp forest**
Bokramspruit	0.24	0.60				0.60			
Schuster	0.43	0.46				0.14			
Krom	0.90	7.28				1.42			
Ratel	0.97	0.94					0.39		
Klipdrifsfontein	0.49	0.60							
Blinde	0.73	1.66				0.04	0.05		
Klein Brak		77		17	278	2	10		
Maalgate	1.40	14.96					1.00		
Gwaing	1.05	3.65		1.58		0.14	2.13		
Kaaimans	2.82	15.54		0.02		0.60	5.36		
Bloukrans	0.57	2.88					0.63		
Lottering	0.32	1.66					0.38		
Elandsbos	0.64	2.09					3.04		
Elands	1.28	5.79					1.70		
Groot (East)	3.10	8.70					0.92		
Klipdrif	0.53	0.53				0.04	0.01		
Slang	0.50	0.04				0.01			
Rufane	0.30	0.01				0.80			
Klein Palmiet	0.30	0.29	0.02						
Blind	0.40	0.40		0.10	0.10	0.22			
Cunge	0.20	0.30		0.20		0.30			
Hlozi	0.20	0.40		0.30		0.20			
Ross's	0.10	1.00	0.20	0.40		0.10			
Shelbertstroom	0.05	0.30	0.10	0.14					
Updated as part of Ecological water requirement studies									
Olifants	36		47.72	91.94	143.00	60.05			
Knysna		945.52	65.94	551		38.00	265.49		
Matjies	0.6	0.51				0.19			

Estuaries (west to east)	Length (km)	Water area	Submerged Macrophytes	Intertidal salt marsh	Supratidal salt marsh	Reeds & sedge	Sand / mud bank	Mangrove	Swamp forest
Palmiet		21.4		0.1			11		
Sout	1.10	2.36		0.37	2.13				
Sundays	23	314		21.8		31.5	118.4		
Mtata	8.5				21.03	6.23		33.5	
Mhlanga	2.5	12.0					0.68		0.2
Mhlathuze	12.3	679	5	60		205	90	652	29
St Lucia		31610		516	1706	3789		279	
Thukela		55				12	11		1
In addition Mhlathuze had 103 ha of hygrophilous grasses and sedges									

6.3.2 Update of species list and taxonomy

The species list in the Botanical Database was updated after identification of the plants collected in the Blinde, Gwaing, Klein Brak, Groot Brak and Kaaimans estuaries. In most cases the number of species compared to that contained in the Botanical Database doubled or even trebled indicating the importance of taxonomic surveys.

The species list in the Botanical Database had 84 species occurring in 256 estuaries. Results from the recent update shows the total number of species, including intraspecific taxa is now 228 (including macroalgae). The large increase in the number of species in some estuaries may be due to the inclusion of terrestrial fringe species. The dependency of these species on the estuary requires further investigation. Of the 228 macrophyte species in the Botanical Database, 11 species had outdated names. Most of the name changes occurred for the reeds and sedges (*Cyperaceae*) (six species). It is important that estuary researchers and managers take note of these changes to ensure accurate communication.

Mucina has started to revise the taxonomy of South African salt marsh species. Work has been completed on the *Salicornia*, *Sarcocornia* and *Triglochin* genera. Research on the genus *Limonium* will commence soon. This is research in progress and therefore the macrophyte species list for South African estuaries was not used for conservation planning and prioritisation of estuaries. Mucina has identified Langebaan Lagoon, Uilskraals, Heuningnes, Gouritz, Knysna and Kromme as estuaries that have important macrophyte populations. In addition to the above mentioned a saline *Felicia* species was also found in the Heuningnes Estuary (De Mond).

Taxonomic surveys should be conducted of the plants in all South African estuaries. Taxonomic revision of salt marsh species must be supported and funded so that macrophyte

species lists can be updated for all estuaries. From these data, sites of rare and endangered species can be identified.

6.4 Key Findings and Future Research requirements

South Africa's estuarine habitat comprises about 90 800ha in total. Figure 6.3 provides an overview of the size distribution of the "core" estuarine habitat in South Africa. This area data do not include the estuarine functional zone, e.g. extended flood plain areas. To allow for consistency across all evaluation and planning processes in the NBA 2011, the habitat data were used as input to the National Health Assessment, Ecosystem Threat Status, Protection Level assessment and National Biodiversity Plan.

It is strongly recommended that habitat area data should be revised for all estuaries where data are older than 10 years. This would include GIS mapping and field surveys of the identified estuaries. A database should be developed comprising the data presented in this study, including all present and future GIS maps depicting the habitats found in all South African estuaries.

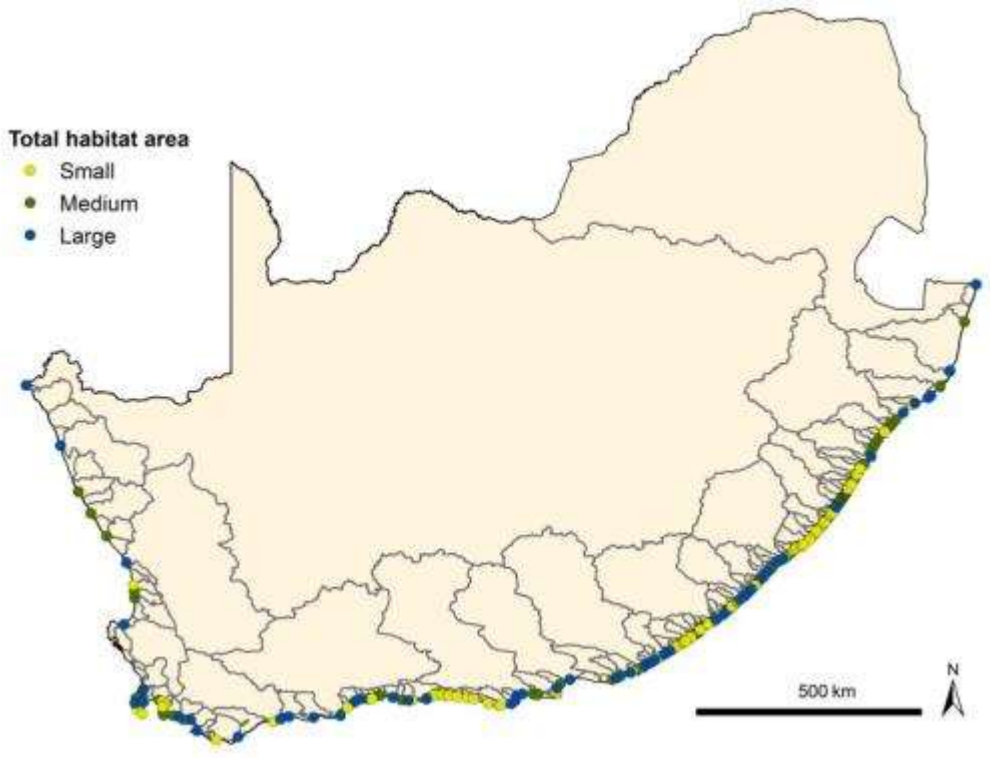


Figure 6.3 Size distribution of estuarine habitat along the South Africa coast.

7. NBA 2011 ECOSYSTEM TYPING

L van Niekerk

To allow for a comparison between estuaries and to set a framework within which it would be possible to predict the possible characteristics and biota of an estuary, a typology or classification system is required.

Estuary ecosystem types serve as surrogates for ecosystem processes and the biodiversity associated with them. In turn, the understanding of estuary ecosystem type processes facilitates the broad scale assessment of estuary resilience to anthropogenic pressures. The typing of estuaries also strives to identify which systems are similar to provide a proxy for the lack of species and abundance data for some components of the ecosystem biodiversity, e.g. meiofauna. Typing or classification schemes also assist with the identification of monitoring requirements for management purposes.

7.1 Typing or classification of estuaries

Estuaries have traditionally been traditional typed by key processes or features, or a combination thereof, eg tidal patterns, topographical, geomorphological or salinity characteristics or ecosystem energetics (Kennish 1986). Davies (1964) classified estuaries by tidal range (Microtidal (<2 m), Mesotidal (2 – 4 m), Macrotidal (6 – 4 m) and Hyper tidal (> 6m)). Nichols and Biggs (1985) focused on the tidal prism (volume of water between high and low tide) with Hypersynchronous estuaries showing an increase in tidal amplitude towards the head, Synchronous estuaries displaying and equal tidal range along their length and Hyposynchronous estuaries having a diminishing tidal range along their lengths.

A number of topographical classifications have been proposed, typing estuaries in to Drowned river valleys, Fjords, Bar build estuaries and others (Prichard 1952b and Dyer 1997). Morphological classifications in turn are generally based on the physical features resulting from the interplay between catchment runoff and sediment loads; and tides, waves and other coastal processes. These include the Dalrympie et al (1992) evolutional classification of Wave dominated or Tide dominated estuaries.

Pritchard (1955) and Cameron and Prichard (1963) classifications based on salinity structure are also very useful focussing on Highly stratified (salt wedge and Fjord types), Partially Mixed and vertically homogenous estuaries. While Hansen and Rattray (1966) proposed a

stratification–circulation classification based on the densimetric Froude number. Fischer (1972) categorised estuary stratification by the estuarine Richardson number, which evaluates the ratio of the gain of potential energy due to the runoff discharge to the mixing power of the tide. In contrast, Simpson et al 1990 categorised the degree of stratification in an estuary by the amount of energy input needed to break down the stratification.

Unfortunately most of the typologies describe above are data intensive and require extensive field collection and monitoring to determine accurately in what category or type a specific estuary falls.

7.2 Applicable international regional scale classifications

National or regional level geomorphic classification schemes also need to recognise environmental parameters that are not strongly reflected in physical processes and morphology alone, such as variations in climate, vegetation, and other biological aspects. Two national classification systems that explicitly incorporate the temporarily open/closed estuary type that dominate the South African coastline are that of Australia and California.

The Australian estuaries typology are based on geomorphology as determined by the relative influence of wave, tide, and river energy (Boyd et al. 1992, Dalrymple et al. 1992, Kench 1999), with each type containing a distinctive suite of geomorphic and sedimentary features (Ozcoasts, 2012). Seven key types were identified using a systematic and quantitative geomorphological approach. These seven types were in turn inbedded in five major coastal regions that conforms to the general distribution of wave- and tide-dominated shelf environments (Harris et al. 2002).

The Australian typology links geomorphic types (Harris et al. 2002) and climate and rainfall characteristics (Heggie et al. 1999) to account for a range of coastal depositional environments. The Australian estuarine typology account for seasonality and climatic variation by identifying both positive (freshwater-dominated) and negative (evaporation-dominated) hydrodynamic examples of tide-and wave-dominated estuaries. In strongly seasonal areas that alternate between relatively high runoff and arid conditions (e.g. the wet/dry tropical climatic zone), the typology varies between the two climatic extremes. For example, in the moist tropical climatic region, an estuary that exhibits the hydrodynamic function of a tide-dominated estuary during the wet season, may exhibit the hydrodynamic function of a tidal creek (no freshwater runoff) during the dry season. Alternatively, during the

dry season, the estuary may function as a 'negative' tide-dominated estuary, due to higher rates of evaporation (Heggie et al. 1999). Kench (1999) advocated a similar but parallel typology for Australian estuaries based on a morphodynamic approach that evaluates morphology-process responses such as estuarine geomorphic development, hydrodynamic processes and sedimentation. Characteristics such as climate and hydrology, wave energy, tidal energy, sediment availability, and biological processes were deemed defining features.

Jacobs et al. (2010) propose a typology for California estuaries based on their geomorphic history and the dominant physical features and processes that define it. This typology used geological origin, exposure to littoral process, and catchment size and runoff characteristics to model the likely frequency and duration of closure of the estuary mouth. Eight close mouth condition states, based on the elevation of barriers (or berms) to tidal exchange, were defined. These states were determined from historic, maps descriptions and photography.

The typology indicate that under natural conditions, the vast majority of California estuaries experienced some degree of closure, and concluded that river inflow rather than tidal influence is the most critical variable controlling mouth opening. This classification system also recognised that estuaries exist in a variety of closure states over multiyear to multi-decadal time frames and that an estuary may exist in a given closure state for periods of time ranging from days to years.

7.3 South African typologies or classification systems

At present, there are two classification systems recognised for estuaries in South Africa. The geomorphological classification used by Harrison et al. (2000) and the Whitfield (1992) classification based on physical characteristics. The geomorphological classification used by Harrison et al. (2000) recognises six main types based on mouth condition (open or closed), size and the presence of a bar.

Whitfield (1992) classified South Africa's estuaries based on their physiographic (tidal prism, size), hydrographic (mouth state and mixing process) and salinity characteristics. Whitfield's (1992) classification recognises five types: estuarine bay, permanently open, river mouth, estuarine lake, and temporarily open/closed estuaries.

Panel 2: Langebaan Lagoon – an estuarine bay, lagoon or coastal embayment?

Langebaan Lagoon has many of the characteristics of an estuary, including calm coastal waters that are protected from marine wave action (see photograph) and a biota that reflects many of the species usually found in estuaries. However, the system lacks a conventional estuarine salinity gradient due to the absence of any inflowing river, although there is groundwater that feeds into certain sections of the 'lagoon'. Lagoon is a poor description for the system since Langebaan (16 km long, 2-4 km wide and up to 5 m deep) is much larger and deeper than conventional coastal lagoons which are usually small and shallow.

Because Langebaan does receive a freshwater inflow from land drainage (aquifer input), and also has typical estuarine biota, Whitfield (2005) suggested that the term "coastal embayment" type of estuary be used to describe the system. Such a term would separate it from "estuarine bays" along the South African coast, all of which are fed by rivers.

Whether viewed as an estuary or as a marine ecosystem, Langebaan Lagoon, separates out as a unique coastal ecosystem type. The 2011 NBA recognised the "transitional" nature of Langebaan Lagoon and assessed it as part of the Marine Component for consistency reasons.



Source: AK Whitfield

7.4 NBA 2011 Typology

Four physical features (see Section 5 for more detail), i.e. size, mouth state, salinity structure and catchment type, of South African estuaries were combined into 46 ecosystem types comprising permutations of the features for each of the biogeographical regions (listed in Table 5.1).

Size was initially classified exponentially on the basis of the primary physical processes in estuaries (Large >1000ha, Medium 1000 - 100ha, Small 100 -10ha, Very Small <10 ha), but

this typology was further aggregated for the NBA 2011 in order to reduce the number of overall number of ecosystem features. For the NBA 2011, estuary size classes were: Large >100ha, Medium 100 - 10ha, and Small <10 ha.

To further reduce the number of overall ecosystem types, features with a low occurrence (i.e. only one or two estuaries representative of a that combined ecosystem type) and had features that were straddling category boundaries, or were of a low confidence, were forced into nearby categories (e.g. Storms Estuary (12 ha) was forced into the Small category and the Spoeg (9ha) into the Medium category).

Under *catchment type* the Bushmans and Mngazana estuaries was changed from *Turbid* to *Clear*, as they were not that dissimilar from the Kariega to warrant their own type. It should also be noted that the typing focuses on natural inflow patterns and therefore from a salinity structure perspective types both the Kromme and Great Fish as *Mixed* while at present they are *Marine dominated* and *Freshwater dominated* respectively due to modified inflow regimes.

It should be clear from the discussions in Section 5 that the ecosystem typing developed for the NBA 2011 can be further refined by addressing some of the underlying drivers, namely hydrology, sedimentology and bathymetry. Nevertheless, the typing still provides a useful framework for evaluating the ecosystem threat status, condition and protection levels. The higher resolution afforded by this classification system versus the Whitfield classification allows for a more detailed assessment of the very large temporarily open/closed systems category. It is hoped that this could be refined and validated in the near future.

Table 7.1 Refined ecosystem types based on key physical features

Cool Temperate Types (12)	Warm Temperate Types (18)	Subtropical Types (16)
LargeClosedFreshTurbid	LargeClosedMarineClear	LargeClosedFreshTurbid
LargeClosedMixedBlack	LargeClosedMixedBlack	LargeClosedMixedClear
LargeClosedMixedClear	LargeClosedMixedClear	LargeClosedMixedTurbid
LargeOpenMixedClear	LargeOpenMarineBlack	LargeOpenMarineClear
MediumClosedFreshBlack	LargeOpenMarineClear	LargeOpenMarineTurbid
MediumClosedMixedBlack	LargeOpenMixedBlack	LargeOpenMixedClear
MediumClosedMixedClear	LargeOpenMixedClear	LargeOpenMixedTurbid
MediumClosedMixedTurbid	LargeOpenMixedTurbid	MediumClosedFreshTurbid
SmallClosedFreshBlack	MediumClosedMixedBlack	MediumClosedMixedBlack
SmallClosedMixedBlack	MediumClosedMixedClear	MediumClosedMixedClear

Cool Temperate Types (12)	Warm Temperate Types (18)	Subtropical Types (16)
SmallOpenFreshBlack	MediumOpenMixedBlack	MediumClosedMixedTurbid
SmallOpenMixedBlack	MediumOpenMixedClear	MediumOpenMarineClear
	MediumOpenMixedTurbid	MediumOpenMixedTurbid
	SmallClosedFreshBlack	SmallClosedFreshBlack
	SmallClosedMixedBlack	SmallClosedMixedBlack
	SmallClosedMixedClear	SmallClosedMixedClear
	SmallOpenFreshBlack	
	SmallOpenMixedBlack	

8. KEY PRESSURES ON ESTUARIES

L van Niekerk, S Lamberth, P Cowley, P Huizinga, K Hutchings, B Mann, C Petersen & S Taljaard

The threats to estuarine health and biodiversity can ultimately be grouped as follows:

- Flow modification;
- Pollution (e.g. agriculture, waste water treatment works (WWTW), industrial, sediment);
- Exploitation of living resources (fish and invertebrates);
- Habitat destruction (within estuarine functional zone); and
- Climate change (dealt with in more detail in Section 12).

The desktop assessment of the pressures that estuaries in South Africa are facing were based on readily available data and expert opinion. The estuarine functional zones of all estuaries were visually inspected on Google Earth for noticeable signs of pressures (e.g. canalisation, development, infilling, discharges). The national data sets, namely NMMU (Botanical Database; Colloty 2000, Adams et al. 2010) and CSIR (Harrison fish surveys; 2000, Harrison 2004, 2005) and unpublished reports (CSIR Series III Green reports), were used to ground truth and supplement visual observations where possible. Critical pressures were also identified during the National Health Assessment workshop (2009). Pressure data were collated, rated and captured in a spreadsheet for each estuary. This information, in combination with the estuary typing (type is indicative of resilience and sensitivity to change), were used for the National Health Assessment (Section 9).

8.1 Flow modification

Flow modification refers to both increases and decreases in freshwater inputs to an estuary. A decrease in freshwater flow results from direct abstraction (e.g. Keurbooms), dam development (e.g. Orange, Palmiet, Kromme), and the accumulative effects of small farm dams (e.g. Bushmans). While an increase in inflow results from inter-basin transfer schemes (e.g. Sundays, Great Fish), Waste Water Treatment Works (e.g. Mhlanga), and hardening of a catchment (e.g. Kuils/Eerste). Changes in Mean Annual Runoff (MAR) often hide the degree to which flows are modified, while the MAR may only be reduced by 10%, the seasonal baseflows (low flows) may be reduced by as much as 50% (due to baseflow abstraction) or elevated by 50% (e.g. by agricultural return flow).

There are no good data available on the degree to which freshwater flow to the estuaries of South Africa has been modified (i.e. increased or decreased) on a national scale. The last study of this nature was done in 1986 (DWA 1986). For the NBA, two primary sources were used to quality flow modification, i.e. recent estuary ecological water requirement studies (also known as Reserve studies) and the Water Situation Assessment Model (WSAM) (using WR2005 data).

The most accurate data available were from recent (past 10 years) ecological water requirements studies (completed for about 25 systems). Where available, this information was the preferred source for the NBA. If not, the output of the WSAM hydrological model was used. The Department of Water Affairs (DWA) developed the WSAM as a macro-scale water resource planning tool. The model provides users with a systematic approach for reconnaissance-level planning and scenario testing, while efficiently managing large volumes of information. The purpose of WSAM is to summarise information, on the availability, supply and utilisation of water resources at a national, regional and catchment level for both current and projected future situations. While considerable testing and validation of various WSAM sub-models and algorithms was undertaken as part of the model development process, this study found that the models were relatively accurate (within about 10%) in catchments where water resources were primarily developed through small farm dams, direct abstraction and land-use change. Unfortunately, the WSAM significantly under reported flow reduction in catchments where large dam development occur, and if no alternative information source was available, expert judgment was used to reflect the estimated reductions or increases (see Figure 8.1 for spatial distribution of flow modifications).

Increasing populations and a rapidly growing demand for freshwater supplies is a major threat to South African estuaries. Freshwater abstraction can result in the closure of the mouth of an estuary that is normally permanently open to the sea. The Kobonqaba Estuary in the Eastern Cape and Uilkraals in the Western Cape were recorded closing for the first time ever in 2010, with the closure of the Kobonqaba causing a major die-back of of mangrove trees *Aviciennia marina* in this system. High water level due to mouth closure resulted in flooding of the pneumatophores and drowning of the trees. Extended mouth closure is generaly associated with reduced freshwater inflow to an estuary. Baseflows are

important in raising water level and keeping the mouth open and these have probably been reduced due to drought conditions and freshwater abstraction in the catchment.

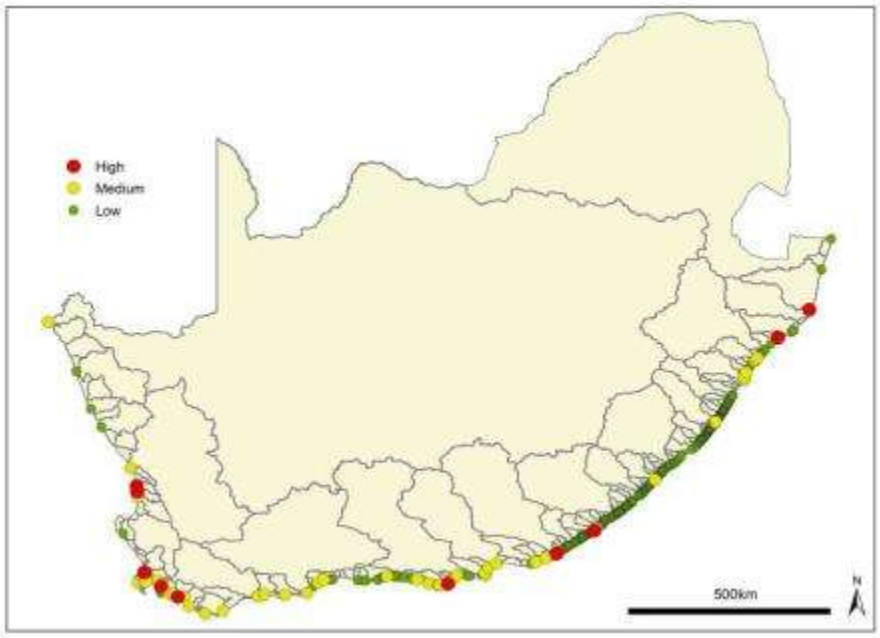


Figure 8.1 Locality map showing the degree to which freshwater inflow has been modified to the estuaries of South Africa.

Alternatively, an increase in freshwater input (e.g. waste water treatment works) can prevent the occurrence of regular mouth closure and prevent the related back-flooding and increase in estuarine habitat. An example of this is the Eerste Estuary that discharges into False Bay. This aspect was not captured by the WSAM and was therefore incorporated into the NBA assessment based on expert opinion.

The results (Figure 8.2) of the assessment indicate that 4 % of South Africa's estuaries are under significant flow modification pressure, with the 15 % of the estuaries in the Cool Temperate region under severe pressure, comprising mostly the large permanently open estuaries such as the Orange, Groot Berg and Olifants. An additional 18 % of estuaries in South Africa is under a moderate degree of flow modification pressure with the Cool Temperate (47% of estuaries in that region) and the Warm Temperate (19 % of estuaries in that region) being the most affected. Less than 5% of all estuaries in South Africa have no flow modification pressures on them – most of these are systems fed by small catchments with limited developments in their immediate environments, and are confined to either the Warm Temperate or southern Subtropical biogeographically region.

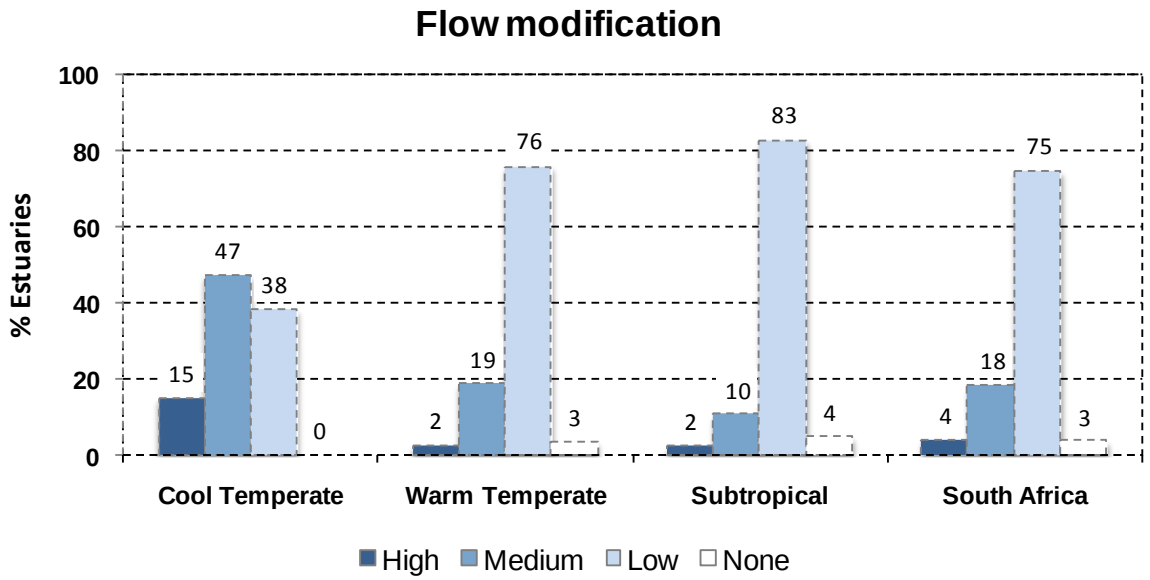


Figure 8.2 Quantification of flow modification pressures for the three biogeographical regions in South Africa.

There is an urgent need for a quantification of the modification in freshwater flow to the estuaries (all 291) of South Africa. This analysis should include all current land-use, transfer schemes, discharges, dam developments and be based on the true catchment area of each of the individual systems.

8.2 Pollution

South Africa's *National Programme of Action for Protection of the Marine Environment from Land-based Activities* list a number of key sources of pollution in estuaries (DEAT 2008), namely:

- Municipal wastewater;
- Industrial wastewater;
- Stormwater runoff (including solid waste); and
- Agricultural runoff (increased nutrients, suspended solids, herbicides and pesticides).

Numerous **municipal wastewater treatment works** (WWTW) discharge effluent into estuaries (Table 8.1). A comparison between data from 1991 and 2004 indicates that WWTW discharge volumes to estuaries have almost doubled over this period, reflecting the rapid population growth in coastal areas (DEAT 2008). While most of these discharges are subject to treatment (sometimes secondary or even tertiary), many of the WWTWs are malfunctioning thus causing pollution in estuaries (e.g. Eerste Estuary). The larger urban

centres along the coast have collecting systems for municipal wastewater although problems are being encountered where deterioration of older structures result in regular spillage and seepage. Overflowing sewage pumpstations are a specific concern and regular pump failures have been recorded in systems such as the Lourens, Onrus, Klein, Bilanhlolo, Uvuzana and Mbango. Sewage pump stations are usually located close to the shore, usually the lowest point from where wastewater is pumped to WWTWs.

Smaller coastal communities often do not have reticulated sewage systems and non-sewered systems such as septic tanks and French drains are typically used for the treatment of sewage. A concern with non-reticulated systems used in these communities situated next to sensitive areas such as estuaries, is the potential impact that spillage or seepage from these systems could have on the aquatic ecosystem and other users (e.g. recreation) of the estuary. The risk of impact often increases markedly with an increase in number and density of non-sewered systems in a particular area. Where reticulated systems have been installed in some smaller coastal communities, the large seasonal fluctuation in the population (i.e. population increasing markedly during holiday seasons) is often problematic.

In addition to WWTWs discharging directly into estuaries (Table 8.1) there are also a number of WWTWs discharging into rivers just upstream from estuaries but close enough to influence estuarine health, e.g. Olifants (Lutzville), Breede (Swellendam), Gwaing (George), Qinira, Kandandhlovu, Zotsha, Mahlongwa, Mahlongwane, Msimbazi, Little Manzimtoti, Mgeni, Thukela and Mlalazi rivers. Untreated municipal wastewater also enters estuaries through stormwater runoff from informal settlement areas (e.g. Swartkops) (DEAT 2008). The installation of effective collecting systems in rapidly expanding informal settlements is also difficult to implement and results in estuarine pollution following rainfall events. Untreated municipal wastewater also enters estuaries through diffuse stormwater runoff from informal settlement areas (e.g. Swartkops) (DEAT 2008).

Table 8.1 Direct wastewater discharges into estuaries along the South African coast (updated from DEAT, 2008)

Estuary (location)	Effluent type	Estimated flow (m^3/day)
Berg (Marine Product, Laaiplek)	Industrial (Fish)	130 000
Diep (Milnerton, Cape Town)	WWTW	44 126
Wildevoëlvlei (Kommetjie, Cape Town)	WWTW	11 577
Eerste (Macassar, Cape Town)	WWTW	54 494
Hartenbos (Mossel Bay)	WWTW	6 471
Knysna (Knysna)	WWTW	3 955

Estuary (location)	Effluent type	Estimated flow (m^3/day)
Piesang	Industrial (Brine)	50*
Bushmans (Albany Water Supply, Easten Cape)	Industrial (Brine)	50
Papenkuils (Fish Water Flats, Eastern Cape**)	Industrial (General)	35000
Mvutshini (Ramsgate Kwazulu Natal)	WWTW	100
Kongweni (Margate Kwazulu Natal)	WWTW	1 900
Vungu (Uvongo Kwazulu Natal)	WWTW	100
Mpambanyoni (Park Rynie Kwazulu Natal)	WWTW	1 000
Umkomaas (Umkomaas Kwazulu Natal)	WWTW	500
Mhlanga (Mhlanga Rocks Kwazulu Natal)	WWTW	25 000
Mdloti (Mdloti Kwazulu Natal)	WWTW	400
Mvoti (Stanger Kwazulu Natal)	WWTW	1 800
Tongaati (Tongaat Kwazulu Natal)	WWTW	200
Mhlali (Ballitoville, Kwazulu Natal)	WWTW	500

**Currently discontinued*
***Generally viewed as a marine outfall*

Stormwater runoff is a major concern specifically in estuaries situated within urban areas. Contaminated stormwater runoff originates from built-up area, gardens, golf courses, parks, roads, and commercial and industrial areas. Stormwater runoff contains an array of pollutants ranging from microbial contaminants, excessive nutrients and organic matter (e.g. linked to sewage from informal settlement areas) to high suspended solid loads and toxic chemicals such as trace metals and hydrocarbons (e.g. originating from runoff draining roads, and industrial and commercial areas). Solid waste or litter is also a major pollutant component in stormwater. Other diffuse sources of litter include solid waste disposal facilities that are managed inadequately or that are illegal. Examples of estuaries where this is a problem range from larger estuaries such as Swartkops to smaller systems such as Groot Brak.

While **industrial wastewater** discharges into South African estuaries are limited (Table 8.1), there are concerns in terms of discharging such effluent into less physically dynamic and ecologically sensitive areas such as estuaries. An emerging concern is the disposal of brine (e.g. Piesang, Knysna, Bushmans estuaries) that can have detrimental impacts on these sheltered and sensitive coastal environments. Concerns with brine effluents arise form an increased demand for desalination plants (discharging brine wastewater) to provide freshwater in areas either not serviced by piped water, or to supplement limited supplies. In addition to industrial wastewater discharging directly into estuaries (Table 8.1), there are also a number of industries discharging into rivers just upstream from estuaries close

enough to influence estuarine health, such as discharges into the Mzimkulu (sugar mill) and Thukela (paper mill) rivers.

Panel 3: Quantification of toxic pollutants in South African estuaries

Despite the potential ecological and human health risks posed by toxic substances such as trace metals and persistent organic pollutants (e.g. herbicides and pesticides), very little research and monitoring are being conducted on the distribution and accumulation of these compounds in South Africa estuaries.

For example, recent research detected substantial and concerning increases in the concentrations of many trace metals in some Eastern Cape estuaries (e.g. Binning & Baird 2001, Orr 2007). Jackson et al. (2009) noted that both water column and sediment concentrations of most metals in the Diep Estuary exceeded recommended local and international guidelines. Hutchings and Clark (2010) confirmed this and identified trace metal concentrations in estuarine fish from both the Berg and Diep estuaries as being in excess of South African food quality standards, thus indicating that there may be existing ecotoxic impacts and human health risks associated with consuming fish caught in these estuaries.

In general very few studies have measured toxic contamination in South African estuarine biota. For example, Watling and Watling (1982) reported on levels in some bivalve and gastropod molluscs from the Knysna Estuary, and more recently Vermeulen and Wepener (1999) and Mzimela et al (2003) reported on trace metal concentrations in mussels and fish (*Liza dumerili*) from Richards Bay harbor and the Mhlathuze Estuary respectively. Jackson et al. (2005) conducted laboratory experiments to assess the ecotoxicity of lead and zinc on the estuarine invertebrate *Callianassa kraussi* (sand prawns) and found that elevated levels of these metals, particularly at low salinities exhibited a significant detrimental influence on the brood and larval development of sand prawns. This species is ecologically (major component of benthic invertebrate biomass, important link in estuarine food webs, bio-turbator etc) and economically (sought after bait item) important.

The lack of baseline data on toxic pollutants in the sediments and biota of many South African estuaries in the face of increasing urban development and estuary utilization makes the undertaking of such studies a matter of priority. This aspect was not dealt with in a systematic manner in the NBA 2011 study, but highlighted where identified as possible pressure.

Source: Dr K Hutchings

Inappropriate agricultural practices in catchments result in contaminated agricultural runoff draining into estuaries introducing toxic substances (e.g. inappropriate use of herbicides and pesticides), excessive nutrients (e.g. inappropriate use of fertilizers), and increased suspended solid loads as a result of soil erosion. There are no data or comprehensive studies available on pollutants loads introduced to estuaries through agricultural sources. However, specific studies have shown that runoff from catchments used extensively for agriculture can contribute significantly to pollutant loading in estuaries, e.g. Olifants, Breede, Sundays. Poor agricultural practices can also contribute to increased sediment loading to the estuaries, e.g. ploughing activities on the flood plains, over grazing and trampling of riparian vegetation by livestock. An example of harmful agricultural practises is sugar cane farming along the KwaZulu-Natal coast that encroaches onto river banks and results in excessive sedimentation of estuaries, as well as the pollution of coastal aquatic systems.

Inappropriate planting in flood plains also leads to demands for the artificial breaching of estuaries when these fields become flooded. The former homelands (Transkei and Ciskei) have significant land transformation (e.g. forests to grass lands, grasslands to bare soil) leading to increase turbidity and sedimentation in these otherwise relatively pristine estuaries.

The Department of Water Affairs' operational policy for the disposal of land-derived waste water to the marine environment aims to prohibit (new) wastewater discharges into sensitive coastal areas such as estuaries (DWAF 2004). However, it will require a serious commitment from the department to enforce this policy in the light of the ever-increasing demand for municipal services (e.g. wastewater facilities) and fresh water (e.g. desalination plants) in coastal areas.

The pressure assessment attempted to derive a measure of catchment transformation by using the 2006 SA land-cover layer. Unfortunately, the data was found to be of a poor quality, with highly degraded or transformed land often classified as natural or near natural. The project therefore had to abandon this more rigorous approach for a visual evaluation of the catchment status for each estuary. It would add significant value if the national land cover map were more accurate in this regard and form the basis for future assessments.

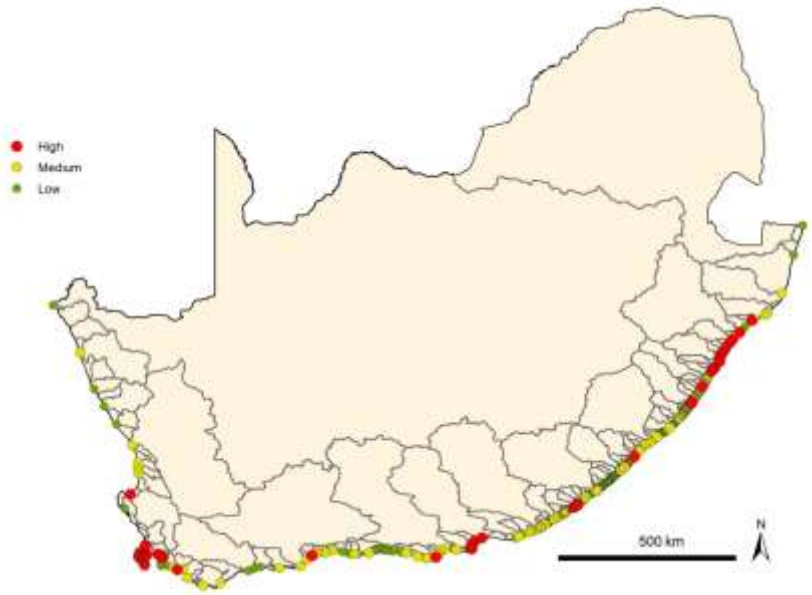


Figure 8.3 Locality map indicating the level of pollution pressure on individual estuaries

The results of the assessment indicate that 15 % of South Africa's estuaries are under significant pollution pressure, with 44% of the estuaries in the Cool Temperate region, 13% in the Subtropical region and 9% in the Warm Temperate region under severe pressure. An additional 40% of estuaries in South Africa are under a moderate degree of pollution pressure with the Subtropical (46% of estuaries in that region) and the Warm Temperate (37% of estuaries in that region) being the most affected. Less than 1% of all estuaries in South Africa have no pollution pressures on them – most of these are estuaries fed by small catchments confined to national or provincial protected areas.

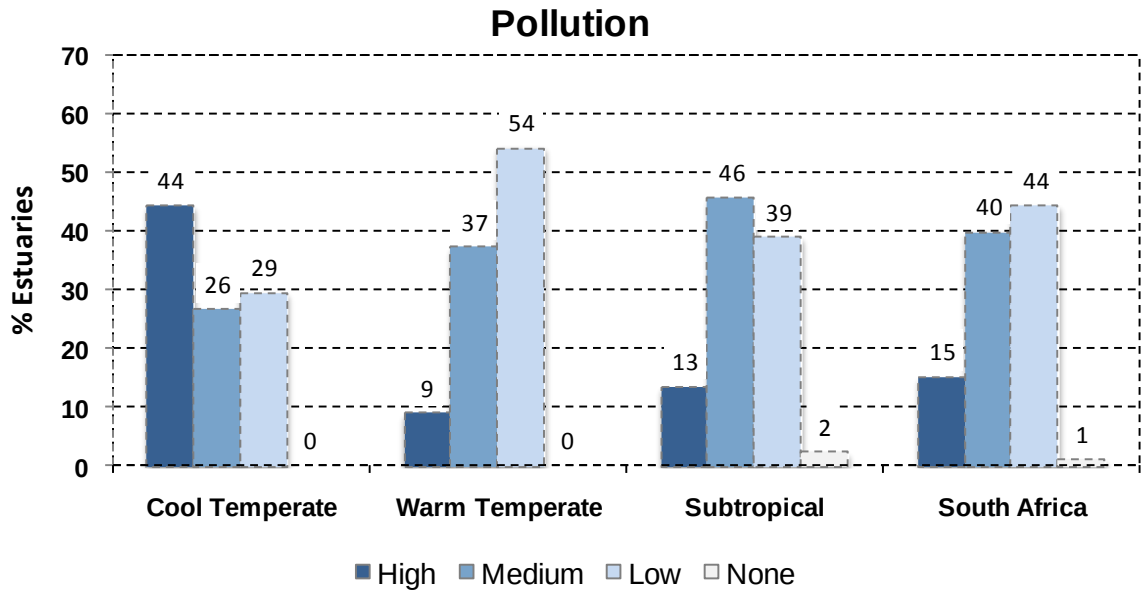


Figure 8.4 Quantification of the level of pollution pressures for the three biogeographically regions.

8.3 Exploitation of living resources

Overexploitation of living resources, predominantly fish and invertebrates in South African estuaries, influences changes in population size, biomass, sex-ratios, size/age distributions, community composition and trophic structure. In extreme cases, overexploitation can lead to recruitment failure whereby recruiting fish are systematically "mined out" after entering the estuarine nursery environment and there is no return migration to the sea or recruitment into the fisheries that depend upon them. Depending on the complexity of life-history strategies and the level of "natal" homing, recruitment back into the parental estuary may be reduced to such an extent that local extinction may occur.

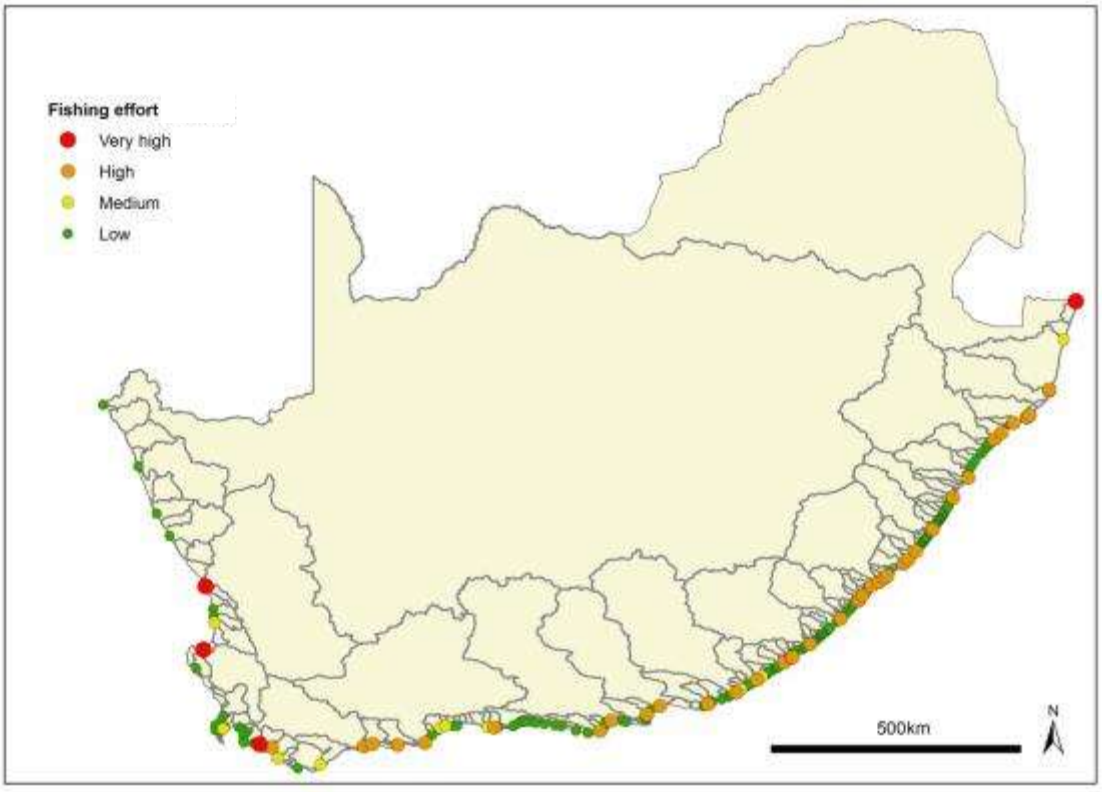


Figure 8.5 Locality map indicating fishing effort on South African estuaries.

All the large estuarine systems in South Africa are heavily overexploited, especially in terms of their linefish. Fishing effort in the Olifants, Berg, Bot and Kosi systems is extremely high and requires urgent management interventions to reduce the pressure on key nursery areas and collapsed stocks of estuary-associated species (see
Figure 8.5). Most of the catches are illicit and could be significantly reduced by dedicated compliance initiatives. Both legal and illegal effort is dominated by the use of gillnets which are cheaply available and efficient but also the most damaging in terms of selectivity and very high mortality of both juveniles and adults of prohibited bycatch species.

The results (Figure 8.6) of the assessment indicate that 1% of South Africa's estuaries are under excessive fishing pressure; especially alarming is that 9% of all Cool Temperate estuaries fall within this category. Another 13% of South Africa's estuaries are under significant fishing pressure, with 13% of estuaries in the Subtropical, 13% in the Warm Temperate and 3% in the Cool Temperate region under significant pressure. An additional 4% of South African estuaries are under a moderate degree of fishing pressure. Only about 14% of all estuaries in South Africa have no fishing pressures on them – most of these are located in national, provincial or municipal protected areas.

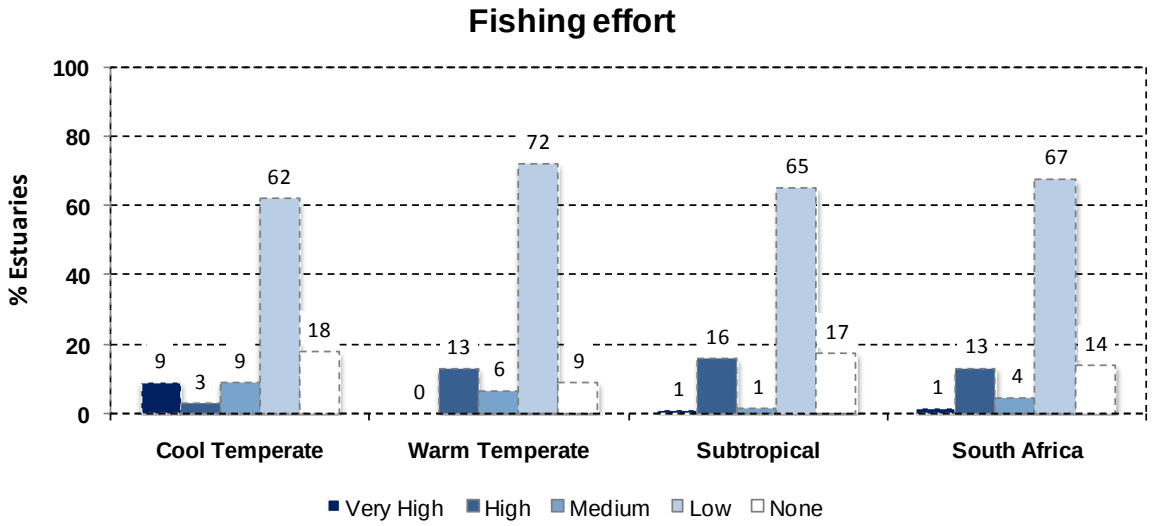


Figure 8.6 Quantification of the level of fishing pressures for the three biogeographically regions.

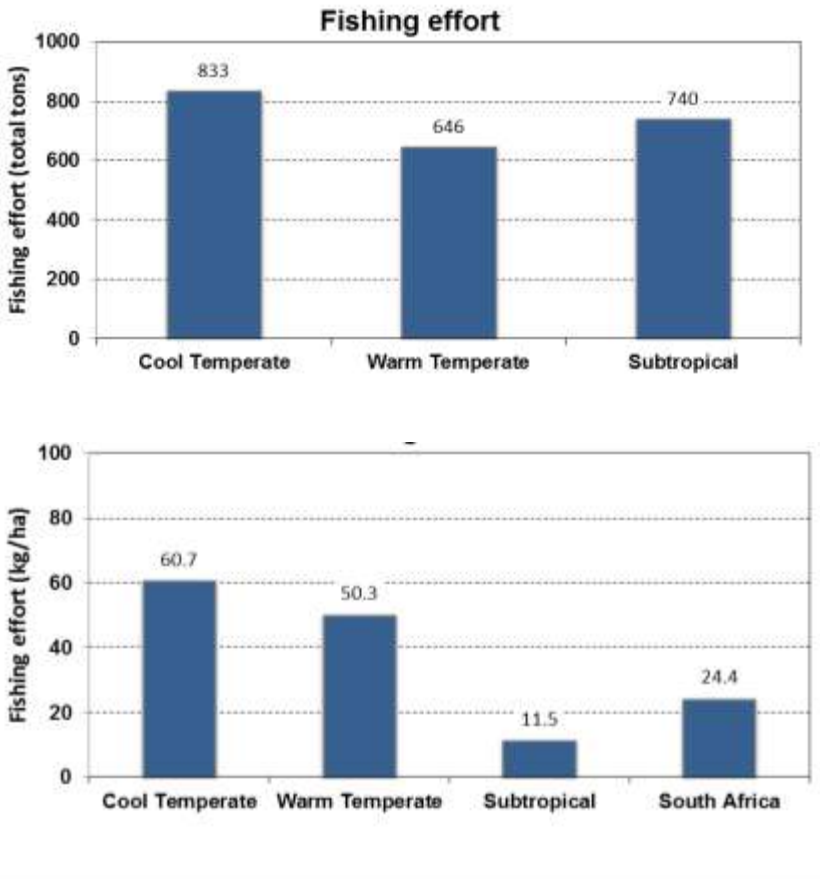


Figure 8.7 Fishing effort for the three biogeographically regions as Total annual catch (tonnes per region) and kilogram per hectare of estuarine area in each bioregion.

Figure 8.7 clearly indicates that while fishing effort is relatively equally distributed around the coast in the three biogeographical regions at 833 t, 646 t and 748 t for the Cool Temperate, Warm Temperate and Subtropical biogeographical regions respectively, the fishing pressure is significantly more in the Cool Temperate region where more than 60 t/ha in comparison with the national average of 24 t/ha is harvested annually.

Exploitation of invertebrates used as bait by recreational and subsistence anglers is a focal activity in most estuaries around the South African coast. Utilization of these living resources and the impact on other organisms and associated habitats may be persistent (e.g. close to urban environments) or more seasonal in nature (e.g. holiday resorts). In some estuaries, the impact of bait collection is considered to be very severe. Patterns of bait usage are obviously dependent on the estuary and fish species being targeted, but mud- and sand-prawns (*Upogebia africana* and *Callianassa kraussi* respectively) often emerge as the most sought after organisms (Wooldridge 2007). Pencil bait (*Solen* spp.) and bloodworm *Arenicola loveni* are also popular bait organisms.

Bait collection pressure was evaluated during the National Health Assessment on an estuary-by-estuary basis. About 84% of all South African estuaries have bait collection pressure on them but bait species are not considered overexploited in most systems as bait populations are quite resilient (Figure 8.8).

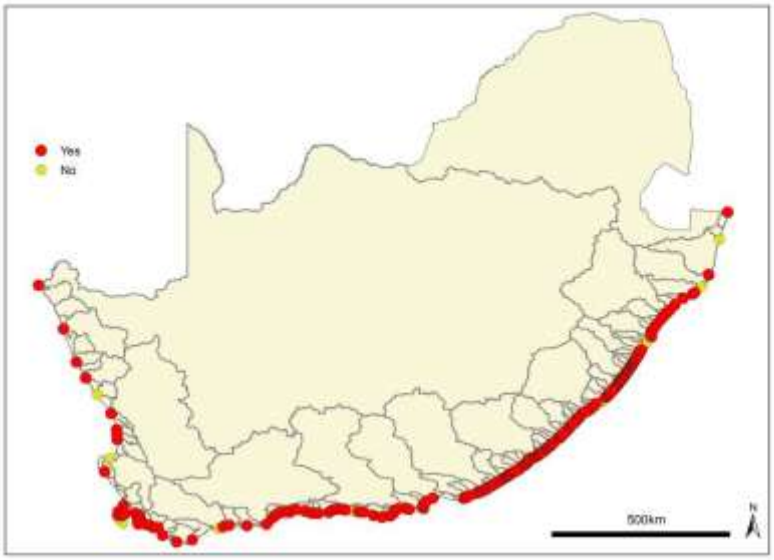


Figure 8.8 Locality map indicating estuaries that have some form of bait collection.

What is of concern is the related destruction and loss of habitat cause by inappropriate gear (e.g. bait-digging with spades). Bait collection also reduced biomass in both targeted and non-targeted invertebrate species. Small temporary open estuaries are seen as more sensitive to overexploitation than large permanently open systems and in some systems it may be appropriate to restrict bait collection, especially if water levels remain low for significant periods before breaching.

8.4 Land-use and development

Inappropriate land-use and development in and around an estuary, i.e. in the estuarine functional zone, can lead to habitat degradation, or loss, within an estuary. Low-lying developments, land reclamation, mining, infrastructure developments such as roads, bridges and jetties; or the remodelling of part of an estuary for harbour or marina construction, all create pressures (see Figure 8.9 for spatial distribution). Harbours and marinas usually involve major alteration of estuarine habitats and tidal flows. Land-use changes within the catchment and surrounding floodplain areas of the estuary are also of importance and can alter the sediment load to the coast. In addition, reduction of freshwater inflows to an estuary can also lead to alteration or loss of habitat, e.g. changing the sediment composition from sandy to muddy. Ultimately change in the structural habitat of an estuary can result in local extinctions, change in population size or biomass, change in community composition and structure, change in the ratios of generalist to specialist biota, and change in life-history strategies. It can also reduce the carrying capacity of an estuary for species higher up the food chain. Habitat degradation can also render an estuary more prone to alien invasions.

Habitat degradation or loss is above all a serious threat because of the risk of irreversible change. The degree to which each estuary's functional zones were modified were largely visually determined (Google Earth, Spot 5) and augmented where possible by national data sets, flow requirements studies and field observations from specialists.

Some of the activities listed above are discussed in more detail as they represent ubiquitous pressures or a significant emerging pressure. One such pressure is road infrastructure, specifically bridges. There are a large number of case studies in South Africa where **bridges** across rivers and estuaries were built with little consideration of the environmental consequences (Morant and Quinn 1999).

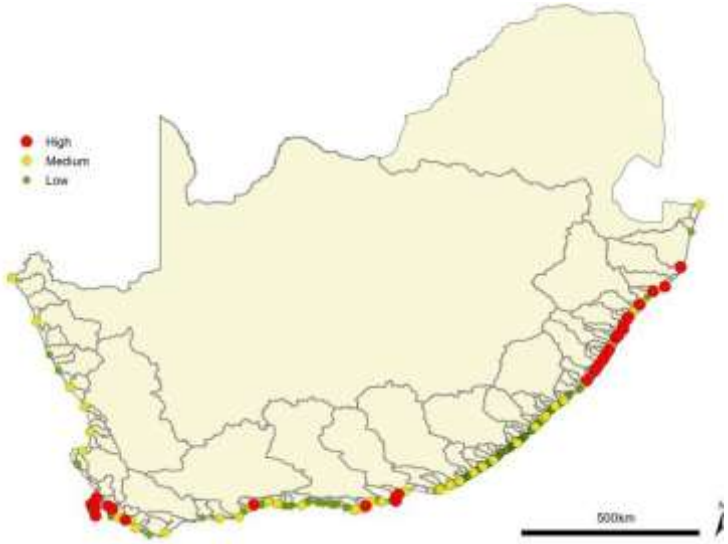


Figure 8.9 Locality map indicating habitat degradation within the estuarine functional zone.

The minimum and cheapest structure to convey a road or railway over a river or estuary, while still meeting safety requirements (e.g. 1:50 year flood), usually results in a comparatively narrow multi-span bridge with long-approach embankments. One of the obvious impacts of such bridges on estuaries is that in most cases it stabilises dynamic estuarine channels. In turn, the combination of stabilised channels and heavy floods being forced through constricted areas, leads to the extensive erosion of sediments underneath the bridge. Erosion beneath the bridge can also occur in conjunction with extensive deposition downstream from the bridge. The changes in flow velocity, and related sediment distribution, can lead to changes in habitat and biota. A typical example is the bridge spanning the Uilkraals Estuary. The 220 m long bridge compromises a 120 m causeway and a 100 m multi-span concrete bridge. It is notable that since the construction of the bridge over the Uilkraals Estuary the bloodworm *Arenicola loveni* has disappeared from the estuary upstream of the bridge (Heydorn and Bickerton 1982).

The approaches to a multi-span bridge are typically built over the floodplain vegetation (e.g. salt marshes), which are filled in with rubble and the road contructed on top (Day and Grindley 1981). Solid fill acts as an obstruction to tidal flows and an area of dead water can develop either side of the bridge span. Such dead water areas act as silt traps. In time, sandbanks and muddy shoals grow, which can reduce the tidal prism or volume of tidal water in and out of an estuary mouth. The changes in substrate can, in some instances cause the higher levels of marsh above a bridge to dry out and their production be lost to the estuary, e.g. Kromme. If tidal flows are impaired through the build-up of sediment, or bad bridge construction, this can lead to premature mouth closure in smaller temporarily open

and closed estuaries, e.g. Seekoei. The most extensive series of bridges over estuaries in South Africa are those spanning systems on the KwaZulu-Natal South Coast. The South Coast railway spans every estuary, usually very close to the sea, for the entire distance from Durban to the Zothsa Estaury some 150 km to the south (Begg 1978). In addition, the N2 arterial highway and ancillary roads span the same rivers or estuaries.

The extensive and sometimes large scale physical alteration of estuarine habitat as a result of **mining** is also an important consideration as the long-term impacts on the environment have not been fully quantified and verified. The impacts of mining include: smothering by sediment deposition, increased turbidity causing reduced sunlight penetration of the water column and consequent possible reduced primary production; increased sediment concentrations resulting in decreased efficiency of filter feeders, clogging of fish gills, and other effects. There is a concern that the cumulative effect (spatially and temporally) of discharges from several mining operations may be severe.

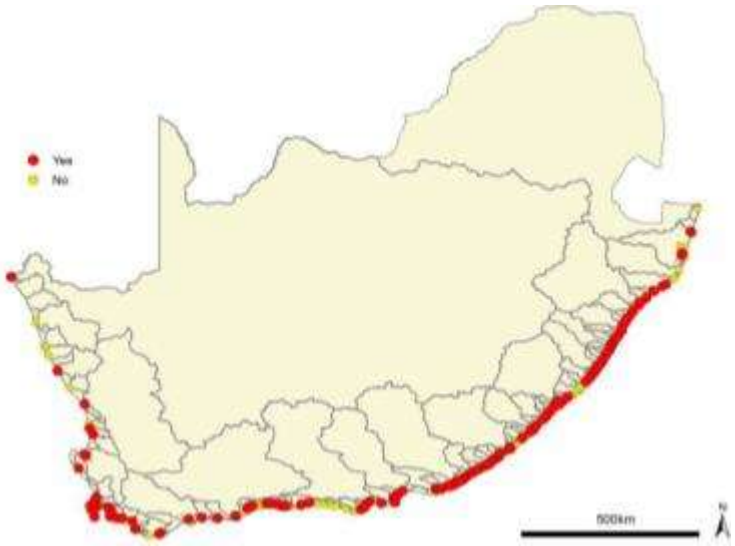


Figure 8.10 Locality map indicating estuaries that have infrastructure development (roads and bridges) within the estuarine functional zone.

The problems resulting from **sand mining** activities include aesthetic and ecological impacts (Figure 8.11) but also the long-term sustainability of the sand resource and potential implications for coastal stability (i.e. over time these cause erosion of the coastline). Of the 64 systems surveyed along the KwaZulu-Natal coast in 2007, 18 supported sand-winning operations (Demetriades 2007). These activities modify flows, produce high suspended solid loading in rivers and estuaries, as well as cause destruction of riparian and instream habitat.



Figure 8.11 Example of estuarine sand mining operations in the Mzimkulu Estuary - note the sediment plumes (Source: Google Earth).

The construction of **ports and marinas** may not be as prevalent in terms of infrastructure development but a number of large commercial ports are situated in or near estuaries, i.e. Port Elizabeth, Ngqura, East London, Durban and Richards Bay. All of these developments coincided with significant habitat destruction and/or modification. Major upgrades are currently under way to increase handling capacity and to absorb the rapid increase in commercial traffic (DEAT 2008). In addition, there are 12 proclaimed fishing harbours located mainly along the southern and western Cape coast, one of which is in an estuary, the Groot Berg. Several dedicated yacht harbours and marinas have also been built along the South African coastline from the Berg River in the west towards Port Alfred in the east. .

Dredging is vital for harbour and marina construction/expansion and maintenance of the channel and basin depths required for shipping and sailing. Potential dredging impacts include increased turbidity, smothering, changes in mouth stability, contaminated sediment (e.g. trace metals and hydrocartbons) released into the environment (DEAT 2008). Harbours and marinas, particularly those situated adjacent to cities and larger towns, are also vulnerable to pollution. Structures (e.g. quays) create areas of poor water circulation and as a result pollutants entering the sheltered areas, either from the land (e.g. contaminated stormwater runoff) or from activities in the harbour or marina (e.g. dredging), often accumulate with detrimental consequences to marine and estuarine life (e.g. causing fish kills).

The results (Figure 8.12) of the assessment indicate that 13% of South Africa's estuaries are under significant habitat modification or development pressure, with 32% of the estuaries in the Cool Temperate region, 16% in the Subtropical and 5% in the Warm Temperate region under significant pressure. An additional 33% of estuaries in South Africa are under a moderate degree of habitat modification pressure with the Subtopical (43% of estuaries in that region) and the Warm Temperate (38% of estuaries in that region) being the most significant.

Less than 10% of all estuaries in South Africa have no development pressures – most of these are estuaries confined to national, provincial or municipal protected areas.

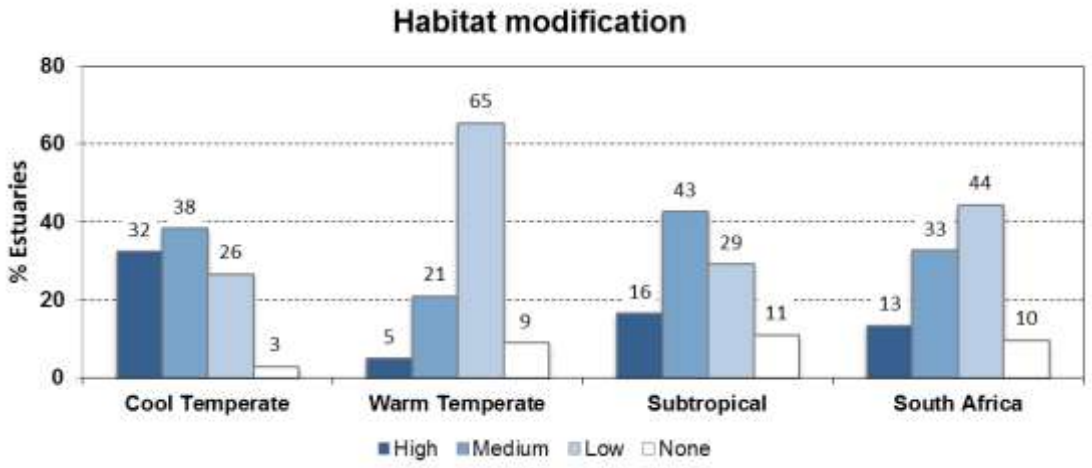


Figure 8.12 Quantification of the level of habitat modification pressures for the three biogeographical regions.

8.5 Estuary mouth manipulation

Estuary mouth manipulation can take a number of forms: artificial breaching (e.g. Bot, Swartvlei), channelisation (e.g. Seekoei, Zandvlei, Berg), or redirecting/diversion of the outlet (e.g. combined St Lucia/uMfolozi mouth). Estuary mouth manipulation may change the type of estuary, e.g. from temporarily open to permanently open. In most cases the need for mouth manipulation stems from inappropriate development in the estuarine functional zone.

The most pervasive of these manipulations is artificial breaching. Mouth manipulations are often also driven by an increase in closed mouth conditions, which in turn is linked to water resources development. For example, reduction in freshwater flow could lead to an estuary mouth being closed more frequently and for longer periods, leading to increased back-flooding of adjacent low-lying developments. This, in turn, will increase the pressure on

authorities to artificially breach the mouth. A change in mouth dynamics usually results in an increase sedimentation and premature closure. This results in changes in salinity and other water quality factors. In addition, increased mouth closure can result in changes in productivity and recruitment of fish and invertebrates, impeded migration and genetic exchange and changes in the distribution of organisms (loss from certain estuaries).

Expert opinion and the KwaZulu-Natal Estuaries database were used to identify estuaries where some form of mouth manipulation was practiced. The mouths (outlets) of about 16% of South Africa's estuaries are artificially managed, but these account for 62% of the total estuarine habitat. It is apparent that inappropriate low-lying developments are forcing artificial mouth manipulations (e.g. breaching). This is partly because the backflooding area (encapsulated in the estuarine functional zone) under closed mouth conditions is not recognized explicitly by any South Africa legislation. Nearly 75% of all estuaries in South Africa close. When an estuary is closed, the water level in the estuary rises above sea level; but legally only the high water mark is recognized, not the backflooding mark. The result is pressure to artificially breach the estuary (because of inundation of housing, infrastructure, golf courses, or agricultural land that is inundated). **It is thus of the utmost importance that the ICM Act recognize backflooding explicitly i.e. the area above the high water mark up to the natural breaching level.**

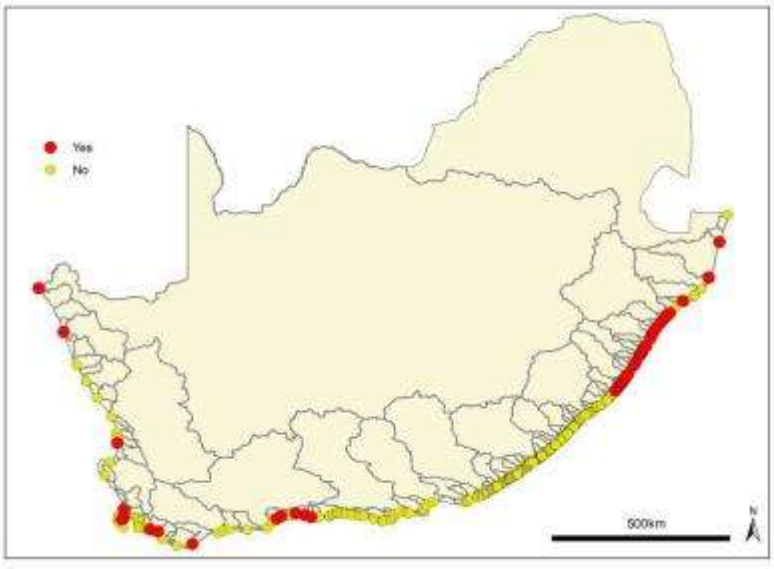


Figure 8.13 Locality map indicating estuaries known to be subjected to mouth manipulations.

Panel 4: Emerging pressure… Desalination plants

South African coastal municipalities are increasingly turning to reverse osmosis (RO) desalination technology to meet bulk water demands. RO desalination plants can be turned off during periods of low demand and are therefore particularly appealing to municipal managers of coastal resort towns where extensive, seasonal water requirement fluctuations are the norm. Recent technological advancements (improved pre-treatment, membrane material, plant design and energy recapture) have made RO technology more affordable and it is possible to commission a plant in a relatively short time period, particularly when compared to accessing other traditional bulk water supplies. Recent drought and a lack of traditional water sources in arid coastal regions (e.g. the Western Cape) have resulted in a proliferation of RO desalination plants in recent years. Conceptually, the process of RO is straightforward: high pressure pumps are used to force saline water through a semi-permeable membrane, dissolved salts and other impurities are retained and discharged as a brine waste stream and fresh product water is produced. Typical efficiency of modern RO plants utilizing sea water results in about half the volume of intake being produced as fresh water.

In reality, plants design can be complex, with extensive pre-treatment of source water required to prevent clogging and biofouling of plant infrastructure and the RO membranes. Pre-treatment typically includes filtration (aided by the addition of coagulants), pH control, the addition of anti-scalents, biocide, cleaning chemicals (weak acids and detergents) and neutralizer (if an oxidizing biocide is used). Any residual chemicals or other additives used in pre-treatment are frequently co-discharged after dilution with the brine into the receiving environment (usually the sea). Provided the brine is discharged into a suitable area with adequate mixing and offshore dilution, and a sufficient distance from sensitive habitats (reefs, estuaries, surf zones etc), impacts on the marine environment should be spatially limited and can be mitigated to some extent by discharge design. Data on the monitoring of the impacts of RO plants on the South African marine environment is however, almost nonexistent. International studies report impacts of varying significance, largely dependent on the plant size and characteristics of the receiving environment.

In terms of estuarine impacts, the development of RO desalination plants to purify sea water is preferable to extracting river or ground water and further reducing freshwater flow to estuaries. Poorly designed or situated RO desalinization plants may, however, have significant negative impacts on estuaries. The sheltered nature of many estuary mouths makes these areas appealing to marine engineers for the placement of plant infrastructure. Reducing the height of the plant above mean sea level can reduce pumping costs and avoiding the exposed shore can help protect pipelines, intake wells and discharge structures from waves and storm surges. Direct or beach well abstraction of source water from an estuary, and/or RO plant waste discharged directly into an estuary (or the adjacent nearshore from where it may enter the estuary prior to sufficient dilution), may have severe negative impacts on estuarine functioning.

To date three RO plants are known to have impacted on South African estuaries. A relatively small RO plant (0.2 million liters per day) extracts water from beach wells near the mouth of the Bushmans Estuary in the Eastern Cape and discharges brine via a pipeline directly into the estuary. Monitoring the impacts detected no elevation in salinity above background within ten meters of the discharge pipeline (Bornman & Klages 2004). This was attributed to low volumes of brine discharged relative to the total volume of the estuary water and good dispersion due to turbulent tidal mixing. The Bushmans River Estuary is also permanently open and frequently hypersaline, somewhat reducing the impacts of brine discharge.

A larger (1.5 million liters per day) RO plant was recently commissioned in Plettenberg Bay near the mouth of the temporary open Piesang Estuary in the Western Cape. Contrary to recommendations from the EIA process, extraction wells were sunk in the mouth of the estuary as sufficient depth of sand was not found on the adjacent Robberg Beach. Over a two-month trial period during the summer holiday period, the salinity of water extracted from the wells dropped from 22 PSU to 12 PSU and a substantial drop in the estuary water level took place. The estuary mouth was closed at this time and very little freshwater was entering the system. Partly out of concern about the impacts on the estuary, the plant was shut down and the municipality is currently seeking funds for an alternative marine water intake.

At Mossel Bay, pumping water from the construction site of the relatively large RO plant (15 million liters per day) drastically reduced water levels in the small temporary open Tweekuilen inlet (not assesses as part of this study). This impact was significant, but temporary in nature as operational impacts of this RO plant that has both marine pipeline intake and discharges are not expected to adversely impact the estuary.

These examples show that RO desalination plants can have impacts of varying significance on estuaries. Increasing demand for limited bulk water supplies will cause and increase in the number of desalination plants along the South African coast and involvement of estuarine scientists during the planning and construction phases and monitoring of the operational impacts will be required to mitigate against potential negative impacts on estuaries.

Source: Dr K Hutchings

Panel 5: Emerging pressure… Aquaculture and Mariculture

Aquaculture can be divided into freshwater aquaculture and marine aquaculture or mariculture (DEAT 2008). Freshwater aquaculture potentially can have an impact on the coastal marine environment when such activities lead to the pollution of river water that ultimately enters estuaries and the sea. As far as could be established, detrimental impacts of freshwater aquaculture are currently not evident in estuaries. Of greater concern is mariculture, especially land-based marine aquaculture which is growing in South Africa and includes intensive farming practices involving re-circulation and flow-through systems which include the use of ponds and brackish water environments, e.g. linked to estuarine environments.

Finfish culture, in particular, is moving towards land-based grow-out operations because of the high risk and cost of installing cages in rough seas typical of the South African coast (DEAT 2008). Inappropriate mariculture activities can contribute to the destruction of estuarine habitats, as well as to the pollution of coastal waters. For example, the construction of inlet and effluent pipelines can result in the excavation or disturbance of sensitive dunes and sandy shores. Large areas containing coastal indigenous vegetation may also be removed to make way for infrastructure. Waste from the marine aquaculture operations can also contribute to pollution of estuarine and coastal marine waters. For example, nutrient enrichment associated with the disposal of faecal matter can contribute to eutrophication, particularly in sheltered environments.

If not managed effectively, marine aquaculture operations can promote the spread of microbial contaminants, thus introducing disease to wild populations. Genetic contamination has become a major problem in the Norwegian fjords where escaped farmed salmon have interbred with, and consequently affected, the survival of wild salmon populations. This mixing of stocks has mostly been associated with sea cages but there is also the possibility that flow-through systems can have the same impact through juvenile fish escaping into the near shore environment.

9. HEALTH STATUS OF ESTUARIES

L van Niekerk, JB Adams, G Bate, D Cyrus, N Demetriades, A Forbes, P Huizinga, SJ Lamberth, F MacKay, C Petersen, S Taljaard, S Weerts, AK Whitfield & TH Wooldridge

The National Estuarine Health Assessment was a desktop procedure during which a national team of 13 regional specialists, covering the full suite of disciplines, evaluated estuary health based on the general (desktop-derived) characteristics of the estuaries. The method used was a standardized approach developed for determining the ecological water requirements of South Africa's estuaries which has been applied to about 30 systems along the coast. All the specialists that contributed to the assessment were familiar with the Estuarine Health Index from previous DWA studies.

For the National Health Assessment, the Lake St Lucia system was disaggregated into two sections (see text box below), the Lake St Lucia and the uMfolozi Estuary respectively. This was done to develop a clearer understanding of their relative contribution to the total health status of South Africa's estuaries. For a similar reason, Mhlathuze and Richards Bay Harbour were evaluated as separate estuaries, though they used to be a single system. While this is a somewhat artificial division, it was deemed necessary as collectively these systems provide for more than half of South Africa's estuarine area and could distort the results significantly. The national health assessment was therefore conducted on 291 systems in total.

Note:
The technical separation of the St Lucia and uMfolozi estuaries in this assessment was done to assist with gaining a deeper understanding of a very complex estuarine system that comprises a multitude of ecosystem processes and a range of habitat types. Throughout the assessment, the underlying assumption was that under natural conditions the two systems would have been connected, with the uMfolozi flowing into St Lucia during periods of mouth closure, i.e. St Lucia would have been more open and uMfolozi at times closed for longer periods. This technical approach should not been misconstrued as an argument for managing them as separate systems. At all times the interactions and dependencies between these two estuary mouths should be recognized and the Lake St Lucia system management as one. In other words, all management plans, ecological water requirements studies and Health Assessments should be done within the context of the high degree of connectivitly between these two estuaries - what is done to the one is done to the other - it is just the degree of resilience to a specific pressures that could differ between the two estuaries.

9.1 The estuarine health determination process

The health condition (also called the Present Ecological State) of an estuary is typically defined on the basis of current condition (i.e., the extent to which it differs from its reference or natural condition). Based on the above, estuary condition is described using six "Present Ecological State (PES)" categories, ranging from natural (A) to critically modified (F) (Table 9.1). The fact that the physical conditions in estuarine systems are more dynamic than those of other aquatic ecosystems means that severe degradation of an estuary may involve a shift from a dynamic to a more stable, or unidirectional, system. This means that the loss of dynamic function *per se* is an important indication of declining estuarine health (DWAF 2008). Thus, in an estuarine health assessment, measures of these different states need to be sufficiently robust so that different practitioners/disciplines will arrive at the same categorisation.

Table 9.1 Ecological Management Categories (DWAF 2008).

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

The Estuarine Health Index was calculated through consideration of the following components (DWAF 2008):

A. Abiotic
- Hydrology (% change in MAR)
- Hydrodynamics and mouth condition
- Water chemistry (salinity and combined score for other variables)
- Sediment processes

B. Biotic
- Microalgae
- Macrophytes
- Invertebrates
- Fish
- Birds

The assessment was undertaken by a multidisciplinary group of estuarine scientists (the chapter authors) in a workshop setting, based on their collective understanding of the likely impacts affecting each system. Expert knowledge and available information were all used to build up a "picture" of the probable pristine state of each estuary and the changes under current conditions. The Estuarine Health Index is applied to all levels of ecological water requirement studies (comprehensive, intermediate or rapid), with only the level of information supporting the study and level of confidence varying. For each variable the conditions are estimated as a percentage (0 – 100%) of the pristine health. Scores are then weighted and aggregated (the rules are provided in Table 9.1 and Table 9.2) so that the final score reflects the present health of the estuary as a percentage of the pristine state. Both abiotic and biotic variables are included as the relationships between the abiotic and biotic variables are often not well understood and because the biotic response to certain abiotic variables can be lagging.

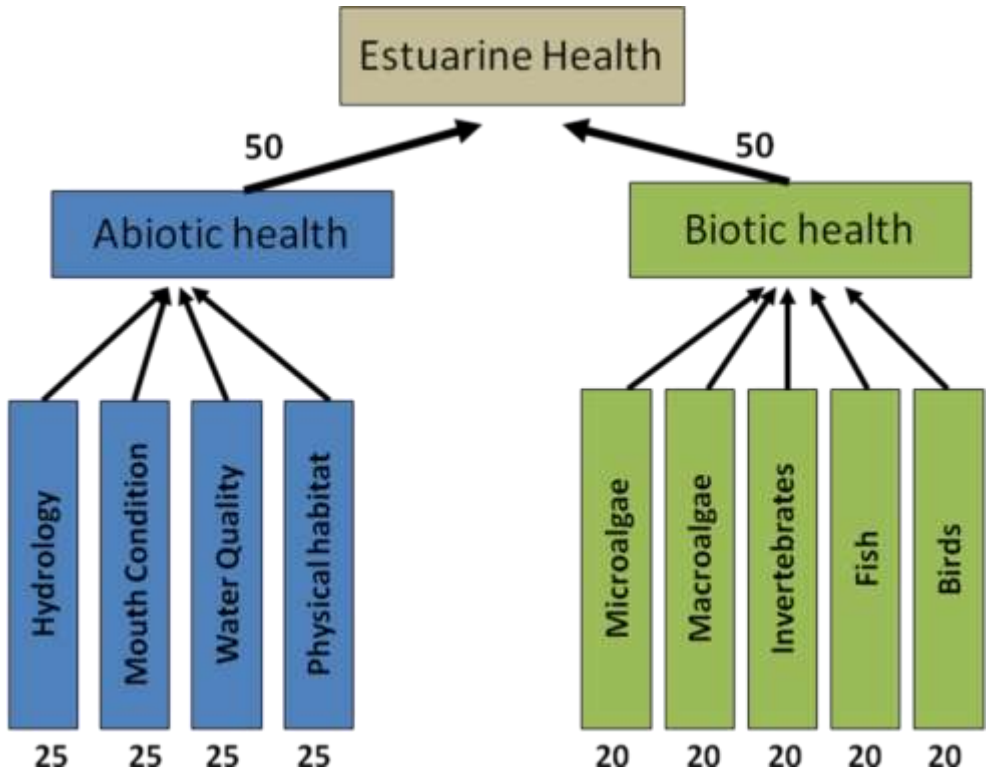


Figure 9.1 Components and weightings of the Estuarine Health Index (DWAF 2008).

Table 9.2 Calculation of the Estuarine Health Score (DWAF 2008).

No.	Variable	Example Score	Weight
Abiotic (habitat) variables			
1	Hydrology	41	25
2	Hydrodynamics and mouth condition	80	25
3	Water quality	59	25
4	Physical habitat	80	25
A. Habitat health score = weighted mean		**65**	**50**
Biotic variables			
1	Macrophytes	60	20
2	Microalgae	60	20
3	Invertebrates	70	20
4	Fish	60	20
5	Birds	90	20
B. Biological health score = weighted mean		**70**	**50**
ESTUARINE HEALTH SCORE = weighted mean of A & B		**67.5**	

For comparative reasons (with previous assessments) the individual health scores were aggregated as illustrated in Table 9.3. In estuaries, unlike in the terrestrial environment, degradation or loss of habitat seldom means a complete loss of an estuary. This can only happen if an estuary becomes completely degraded, e.g. changed into a parking lot or golf course. In most cases, degradation means loss of processes or loss of biological functionality, e.g. the estuarine space is filled with a different salinity condition or different species composition. This loss of functionally happens on a continuum, with estuaries which retain more than 90% of their natural processes and pattern being rated as Excellent and estuaries degraded to less of 40% of natural functionality rated as Poor.

Table 9.3 Schematic illustration of the relationship between loss of ecosystem condition and functionality.

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

9.2 Health status of estuaries per biogeographical region

To allow for comparison with previous health assessments, the number of estuaries in different health states were aggregated for each biogeographical region (see Table 9.4).

Using "*number of estuaries"* as a measure, the NSBA 2004 analyzed the condition of South Africa's estuaries as a percentage of the total number of systems (259) (Turpie 2004). The general conclusion drawn was that the overall health of South African estuaries was considered to be relatively good. A total of 28% of estuaries were considered to be in excellent state and another 31% were in a good state. About 25% were in a fair state and only 15% were in a poor state.

Table 9.4 Summary of Estuarine health status as percentage of estuaries in the three biogeograpical regions for the NSBA 2004 (adapted from Whitfield 2000).

Biogeographical region	Condition				Total Number
	Excellent	Good	Fair	Poor	
Cool Temperate	9	9	36	45	11
Warm Temperate	27	43	18	12	127
Subtropical	31	21	32	16	121
Total	**28**	**31**	**25**	**15**	**259**

The NBA 2011, using "*number of estuaries"* as a measure (see Table 9.5 for detail), similarly found that a total of 17% of estuaries were considered to be in excellent state and another 41% were in a good state. About 35% were in a fair state and 7% were in a poor state, with this analyses being very sensitive to the condition of the large number of temporarily open/closed estuaries.

Table 9.5 Summary of the Estuarine health status as a percentage of estuaries in the three biogeograpical regions (NBA 2011).

Biogeographical region	Condition				Total
	Excellent	Good	Fair	Poor	
Cool Temperate	6	15	50	29	34
Warm Temperate	19	50	28	2	124
Subtropical	17	39	38	5	133
Total	**17**	**41**	**35**	**7**	**291**

A comparison between the 2004 and 2011 studies shows about a 10% reduction in the number of estuaries in excellent state, but also that there were fewer estuaries in a really poor state. While the decline in excellent condition estuaries can be contributed to increase

pressure and degradation, some of these shifts can be contributed to the more systematic approach followed during the NBA 2011 national health assessment.

This relative optimistic picture changes dramatically if "total estuarine area" (expressed as hectares habitat) is used as the measure. Table 8.6 provides a summary of the state of South Africa's estuaries expressed as a percentage of the total habitat (ha). From this analysis it is very clear that only a very small percentage of estuarine habitats are in an excellent condition, with most of this area being located in the Warm Temperate region, i.e. the numerous small Wild Coast estuaries. Only about 1% of estuarine area is in an excellent state and only 14% of the total estuarine habitat is in a good state, once gain mostly represented by systems in the Warm Temperate biogeographical region. The NBA 2011 determined that most – 85% - of the estuarine habitat in South Africa is in a poor to fair state as illustrated in Figures 8.3 to 8.6.

Table 9.6 Summary of Estuarine health status as a percentage of total estuarine habitat in the three biogeograpical regions (number of estuaries in brackets).

Biogeographical region	Condition				Total area (ha)
	Excellent	Good	Fair	Poor	
Cool Temperate (34)	0	1	96	3	13 720
Warm Temperate (124)	7	49	45	0	12 849
Subtropical (133)	0	10	14	75	64 275
Total area (ha)	**1**	**14**	**31**	**54**	**90 844**

As the Lake St Lucia system (St Lucia and uMfolozi combined) represents more than 56% of South Africa's estuarine habitat (51 0000 ha), its poor condition significantly influences this assessment. St Lucia's condition is a result of the artificial diversion of the uMfolozi River from St Lucia since 1952 and an extended drought in the region with the resultant reduction in freshwater inflow. As this is a reversible state of affairs, the iSimangaliso Authority is currently implementing a strategy to join the uMfolozi and St Lucia mouths, and has also raised funding from the Global Environment Facility to investigate and implement long-term solutions. Continued national support to restore this national asset with international status will be required. (see Panel 6 for more detail).

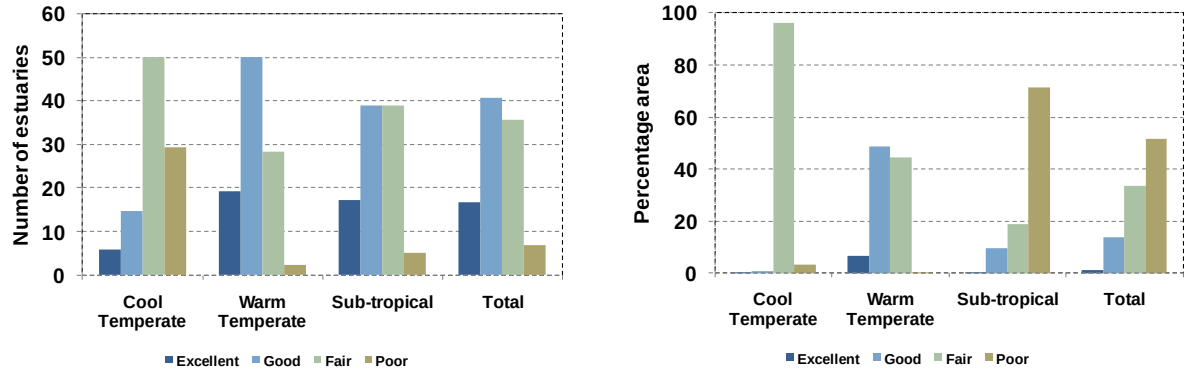


Figure 9.2 A graphic illustration of the different perspectives arising when the National Health Assessment is presented as "Number of estuaries" or "Percentage Area". The latter analysis highlights the fact that the majority of South Africa's estuarine area is in a poor to fair state.

Panel 6: Lake St Lucia system: An estuary in crisis!

Lake St Lucia is the largest estuarine system in Africa, it forms part of a World Heritage Site and is a Ramsar Site of international importance. The ecological importance of the system is well documented with its major role being that of a nursery ground for marine fish species which spawn at sea and whose juveniles are either wholly or partially dependant on St Lucia to complete their life cycles. The system is the most important juvenile fish nursery on the south-east African coastline, contributing to the fish populations over a large area of the offshore continental shelf, particularly adjacent to the Thukela Bank and Richards Bay area. In addition, it is an important nursery ground for penaeid prawns that come from South Africa's only breeding population on the Thukela Banks.

While changes in the catchments of the rivers feeding the Lake St Lucia system have affected the amount and quality of water entering the lake, the major impacts on the system have arisen through human intervention in the uMfolozi catchment. In 1911 the uMfolozi floodplain began to be converted into agricultural land for sugarcane farming. In the late 1920s, a system of drainage canals was built. By the 1940s concern was being expressed about sedimentation in the mouth region, which was attributed to the canalization of the uMfolozi River. In the early 1950s the combined mouth closed and there was extensive backflooding. This was dealt with by artificially breaching the mouth. From 1956 a separate mouth was opened for St Lucia, and since then the separation of the uMfolozi and St Lucia estuary mouths has been actively maintained. This separation was considered necessary to prevent the threat of sediment accumulation in the lake. Due to the separate mouth policy, the benefits of the uMfolozi water were lost to the estuary system. The inflow from the uMfolozi river is the driver of the combined system as it plays an important role in maintain open mouth conditions and preventing/reducing the occurrence of lethal hypersalinty levels in the Lake St Lucia system. Extensive dredging in the Narrows took place in an attempt to increase exchange with the Lake and keep the mouth open. Dredging operations lasted for over 40 years.

In June 2002 the St Lucia Estuary mouth closed as a result of drought conditions and lack of freshwater inflow from the uMfolozi River, and remained so for four years and nine months. During this period salinities throughout the system increased dramatically, with False Bay and North Lake reaching beyond 200 (seawater = 35) and Charters Creek in the South Lake going beyond 120. Such high salinity levels have never before been recorded in the system. At the same time, as the salinities were increasing due to evaporation, the water level decreased rapidly and by December 2003 the

lake had separated into four compartments with only 25% of the surface area being covered by water. Due to the ongoing drought, by July 2006 only 10% of the lake's entire 350 km^2 was covered by water.

At the beginning of March 2007 cyclonic activity off the southern tip of Madagascar in the form of Cyclone Gamede resulted in a major storm surge along the entire KwaZulu-Natal Coastline. The effect on St Lucia was that the storm surge breached the estuary mouth and with levels at the time being in excess of half a meter below mean sea level, seawater poured into the system. It continued to do so for six months before finally closing again during August 2007, with the lake some 75% full and salinities throughout the system being close to that of seawater. The system remains closed to the sea with the water level only covering <50% of the lake's 350 km^2 surface area (November 2011).



During the period since closure there have been major mortalities of invertebrates, a number of fish kills, as well as a large algal bloom in the north of the system. Research results indicate that there has been a substantial decrease in the diversity of the zooplankton community, whilst benthic invertebrates showed a decline in the number of taxa, with the community composition also having changed over time. The fish fauna has shown a significant decrease in both species and numbers. In addition, the prolonged closure of the link to the sea has resulted in the nursery function for marine fish and prawn species, whose life cycle requires that their juveniles enter the estuary, being totally unavailable. Results from research in the nearshore marine environment have now linked population decreases in some adult breeding stocks to the closure of the St Lucia estuary.

Fish populations in the St Lucia system have long been subject to intensive exploitation by recreational, subsistence and commercial fishers. Prior to the extended closure, the subsistence gillnet fishery had developed to an unsustainable commercial-scale and was in the process of being phased out. This was expedited by most of the fishing area drying up. However, fishing pressure remained high and overexploitation exacerbated by fish becoming concentrated and more easily caught in some areas. This lead to an emergency closure of the lower reaches to fishing to protect some species in the early 2000s. This protection came from a ministerial level. Consequently, It is felt that although the response was quick, it could have been even more so had the iSimangeliso Authority the power to implement local fishery control measures at their discretion.

Due to Lake St Lucia's international and national significance, the iSimangaliso Authority has raised funding from the Global Environment Facility (GEF) to investigate and implement a long-term solution to the hydrological issues facing the Lake St Lucia system. In parallel to this investigation the management strategy for 2011/2012 will result in the reversal of the 56 year old approach to managing Lake St Lucia; that is, allowing the uMfolozi and Lake St Lucia estuary mouths to join to form a combined mouth, and thereby allowing it to function as naturally as possible. In keeping with adaptive management, an ongoing review and evaluation based on monitoring of salinity, lake levels and ecosystem health will be continue as these interventions are implemented.

This management strategy has been based on the review of current scientific knowledge, particularly the recent research on sources and dispersal of sediments. The proceedings of the 2010 Consortium for Estuarine Research and Management (CERM) workshop endorsed the relinkage of the uMfolozi and St Lucia estuaries and the implementation of measures that will reduce any excessive input of sediment from the former into the latter system (Bate et al. 2010). This endorsement states that: ***"Historical evidence from early maps and anecdotal evidence indicate that changes in the uMfolozi/Msunduzi floodplain have had profound impacts on the uMfolozi Estuary and indeed on the whole St Lucia lake system. The separation of the uMfolozi from St Lucia in the early 1950s resulted in a major change in the way that St Lucia functioned. Only now are we beginning to see and experience the full implications of that separation for the well-being of the ecosystem, with the lake virtually drying out completely for the first time in living memory."***

A major concern in the short- and even medium-term is that the mouth of the Lake St Lucia will remain closed for a number of years to come unless a major rain/cyclonic event delivers sufficient water to the lake for it to fill to above its normal mean lake level. This may not be the case as since 30 July 2011 the uMfolozi mouth has moved about 370 meters north towards Lake St Lucia and the park are investigating ways of expediting the joining of the systems.

Source: Prof D Cyrus (with input from B James and SJ Lamberth)

Along the West Coast the predominantly closed estuaries tend to be in a good state while the large permanently open estuaries on average were in a fair state. The numerous small temporarily open/closed estuaries around Cape Town were generally in a poor state. The National Health Assessment once again confirmed that estuaries along the south and south-east coast tend to be healthier than those in the rest of the country. The numerous small estuaries along the former Transkei/Ciskei coastal area have the best overall health. The KwaZulu-Natal south coast had the highest number of estuaries in a poor state. This was largely due to direct habitat loss and artificial breaching related to development pressures in the estuarine functional zone, as well as intensive sugar cane farming in most of the catchments. In general, urban estuaries tend to be in fair to poor health along the intensively developed areas of the Cape south-west coast, around Port Elizabeth, and along almost the entire KwaZulu-Natal coast.

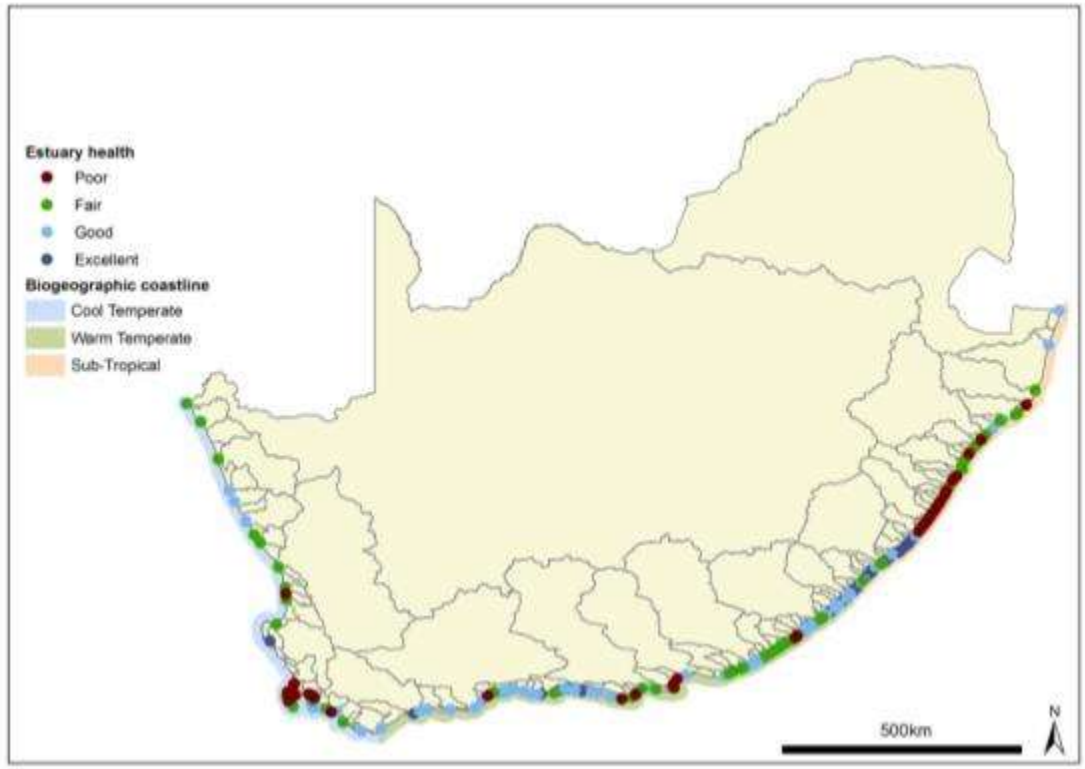


Figure 9.3 Health status of South Africa's estuaries.

The temporarily open/closed estuarine habitat types were predominantly in a good (28%) to fair (65%) state. Smaller estuaries (and their related smaller catchments) generally tend to be subjected to fewer pressures. If there were no direct development pressures (i.e. urban development), these systems tend to be healthier than larger estuaries. Large estuaries (both permanently and temporarily open) tend to have more catchment and direct development pressures and are therefore predominantly in a fair to poor state (>80%). Freshwater dominated estuaries (river mouths) tend to have the most natural resilience, but also have significantly more catchment and development pressures, with the majority (99%) of the habitat being in a fair state. The very large permanently open estuaries (estuarine bays) faired the best as they are buffered against development through strong tidal exchange, tending towards a good (38%) to fair state (40%).

The large temporarily open/closed systems (estuarine lakes) were in the worst state, with 84% of their habitat being in a poor condition. As stated above, this was largely the result of the poor condition of the St Lucia system, but it should be noted that only 10% of the estuarine lake habitat in South Africa is in a good condition. As estuarine lakes represent about 60% of South Africa's total estuarine habitat, and are very vulnerable to catchment

and development pressures, it is strongly recommended that they be more effectively management and protected.

Panel 7: Verification of National Health Assessment

The findings of previous health assessments (about 30), conducted as part of ecological water requirement studies or estuary management plans (e.g. Verlorenvlei), are listed in blue in the summary table of the desktop National Health Assessment (Appendix C). Workshop participants used these more in-depth studies to bench mark their scoring under the more streamlined method of the National Health Assessment. In general, workshop participants felt that they were scoring conservatively and overestimating the condition, or current health state, of estuaries by about 5 to 10 percent. This was seen as a positive outcome, as the results of the National Health Assessment are to be used for biodiversity planning, the ecosystem threat status Assessments and the Protection Levels determinations. In this context, estuaries should not be discounted or ignored if they could contribute to biodiversity targets or headline indicators. Reasons for the elevated health scores were: lack of good hydrology (inflow data) as the WSAM did not incorporate dam developments and discharges accurately; lack of good water quality data; and the large spatial scale at which the study was conducted (i.e. estuaries were evaluated on Google Earth/Spot 5 images versus field visits).

In addition, the results of the National Health Assessment were further affirmed against a number of more detailed EWR studies conducted subsequent to this initial assessment. The results show that the National Health Assessment estimates deviated by between 1 and 14 percent from the more in-depth assessments. The desktop assessments were more accurate if the flow data was accurate, with the degree of deviation being lower in categories Excellent and Good, but less accurate in the case of highly modified systems (i.e. categories Poor and Heavily degraded).

Table 9.7 A comparison between the National Health Assesment and more detailed ecological water requirement studies.

EWR Study	Level	NBA Score	EWR Score	Score difference
Sundays (2010)	Intermediate	C (68)	C (67)	-1
Groot Berg (2010)	Intermediate	C (62)	D (59)	+3
Bushmans (2010)	Rapid	C (73)	C (72)	-1
Bot (2011)	Rapid	C (62)	C (71)	-9
Little aManzimtoti (2011)	Rapid	D (43)	E (38)	+5
Mbokodweni (2011)	Rapid	E (35)	E (33)	+2
Umzimkulu (2011)	Rapid	C (70)	B (79)	-9
Mgeni (uMngeni) (2011)	Rapid	D (47)	E (33)	+14

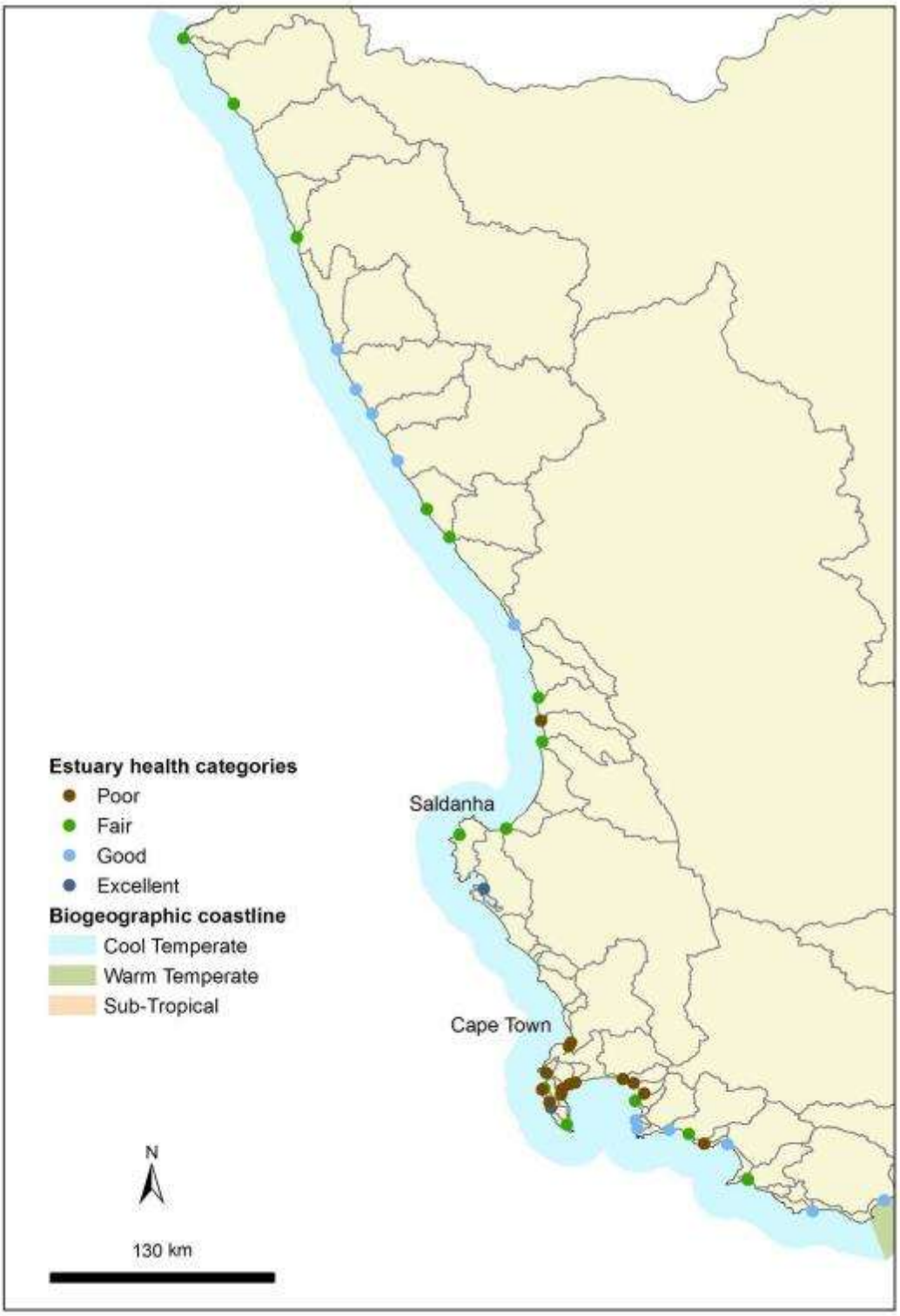


Figure 9.4 Health status of estuaries in the Cool Temperate biogeographical region.

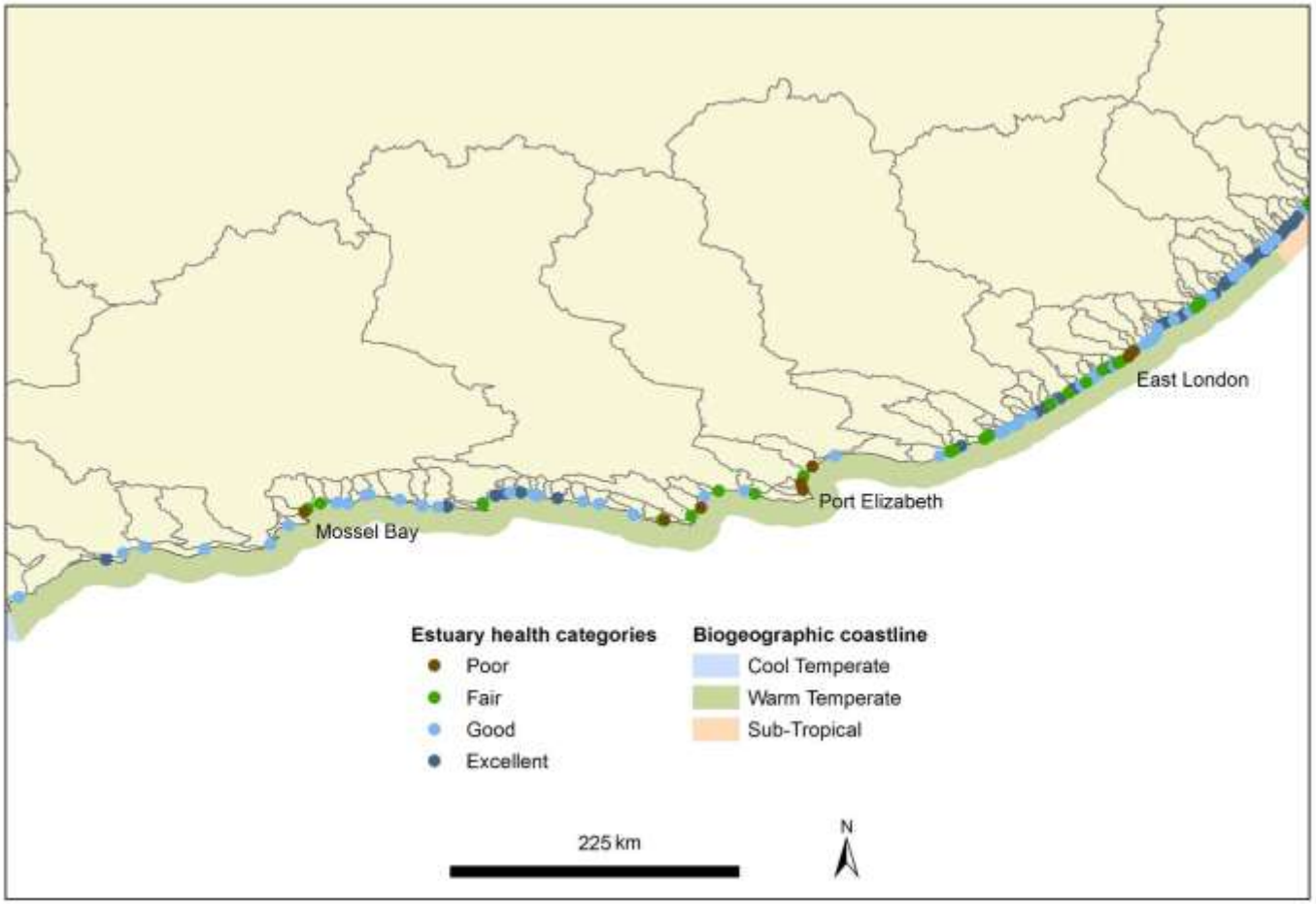


Figure 9.5 Health status of estuaries in the Warm Temperate biogeographical region.

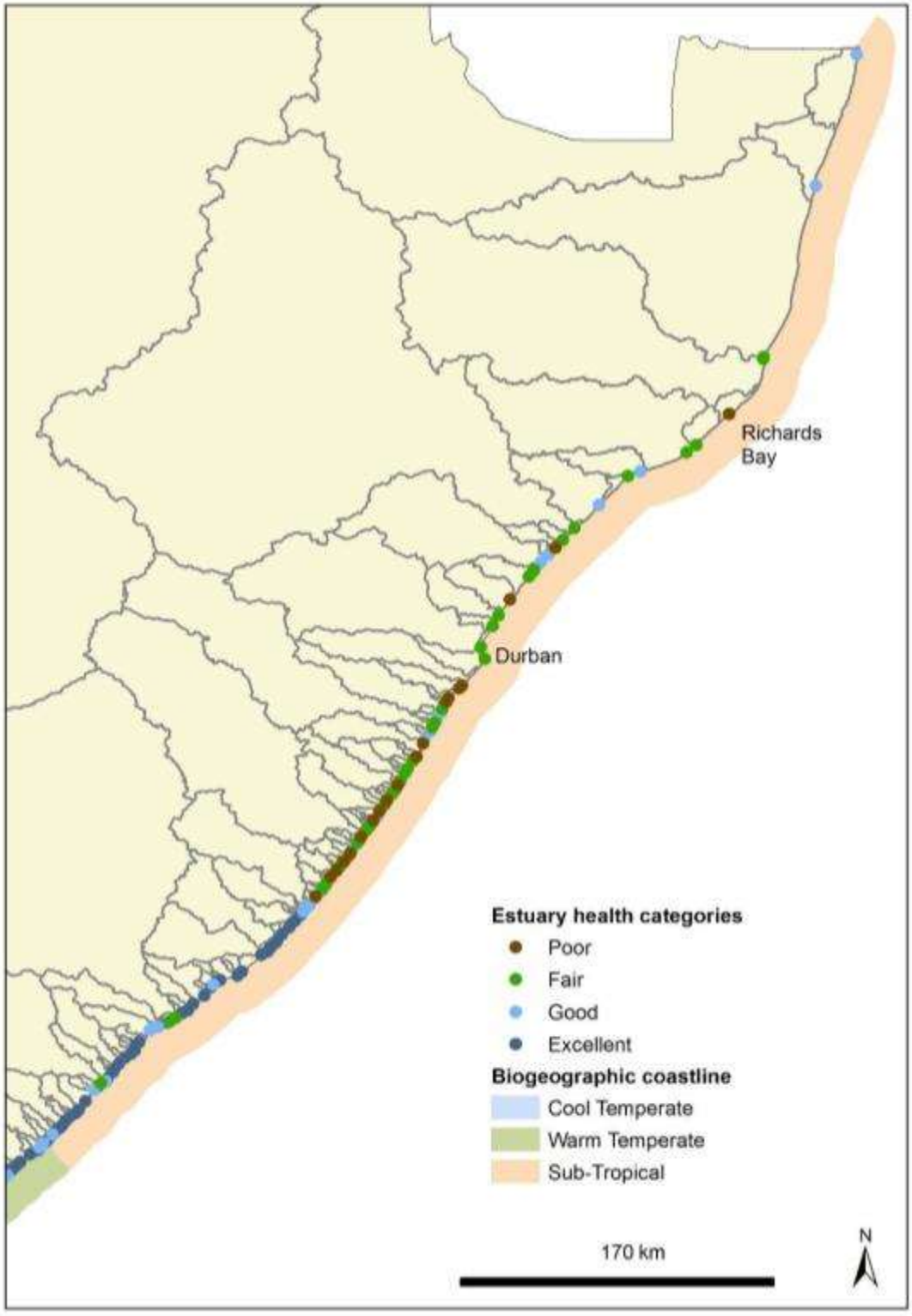


Figure 9.6 Health status of estuaries in the Subtropical biogeographical region.

9.3 Health status of Estuaries within various Coastal District Municipality

To develop a better understanding of where the most urgent need for intervention on the local authority level is required, the National Health Assessment data was also aggregated at the District / Metropolitan Municipality level (see Table 9.8 and Figure 9.7).

The Eden District Municipality has the most excellent and good condition estuarine habitat at 13% and 69% respectively. The O.R.Tambo District Municipality also comprises of a high percentage excellent (13%) and good (62%) state estuarine area. The Amatole District Municipality comprise 5% excellent and 60% good state estuarine habitat. In contrast, the Umkhanyakude, eThekwini and City of Cape Town are the three municipalities with the most estuarine habitat in a poor condition, at 85%, 72% and 44 % respectively. The Nelson Mandela Bay Metro, Ugu, Overberg and West Coast Municipalities also manage some poor condition estuaries, representing between 1 and 3% of the total estuarine area in South Africa. In addition it should be noted that the West Coast and Nelson Mandela Bay Metro had no excellent or good estuarine habitat within their municipal areas.

Table 9.8 Summary of Estuarine Health as a percentage of total estuarine habitat in the coastal District / Metropolitan Municipalities (number of estuaries in brackets).

District municipality	% of SA estuarine area	Health Condition			
		Excellent	Good	Fair	Poor
Amatole (83)	4	5	60	36	0
Cacadu (26)	3	1	8	91	0
City of Cape Town (16)	1	1	0	55	44
Eden (20)	6	13	69	17	0
eThekwini (16)	2	0	6	22	72
iLembe (9)	0	0	45	55	0
Namakwa (4)	1	0	4	96	0
Nelson Mandela Bay Metro (5)	1	0	0	97	3
O.R.Tambo (45)	2	13	62	25	0
Overberg (11)	5	0	11	88	1
Ugu (41)	1	0	26	72	2
Umkhanyakude (4)	61	0	8	7	85
Uthungulu (5)	4	0	6	94	0
West Coast (6)	9	0	0	99	1
% of total SA estuarine habitat	**100**	**1**	**14**	**31**	**54**

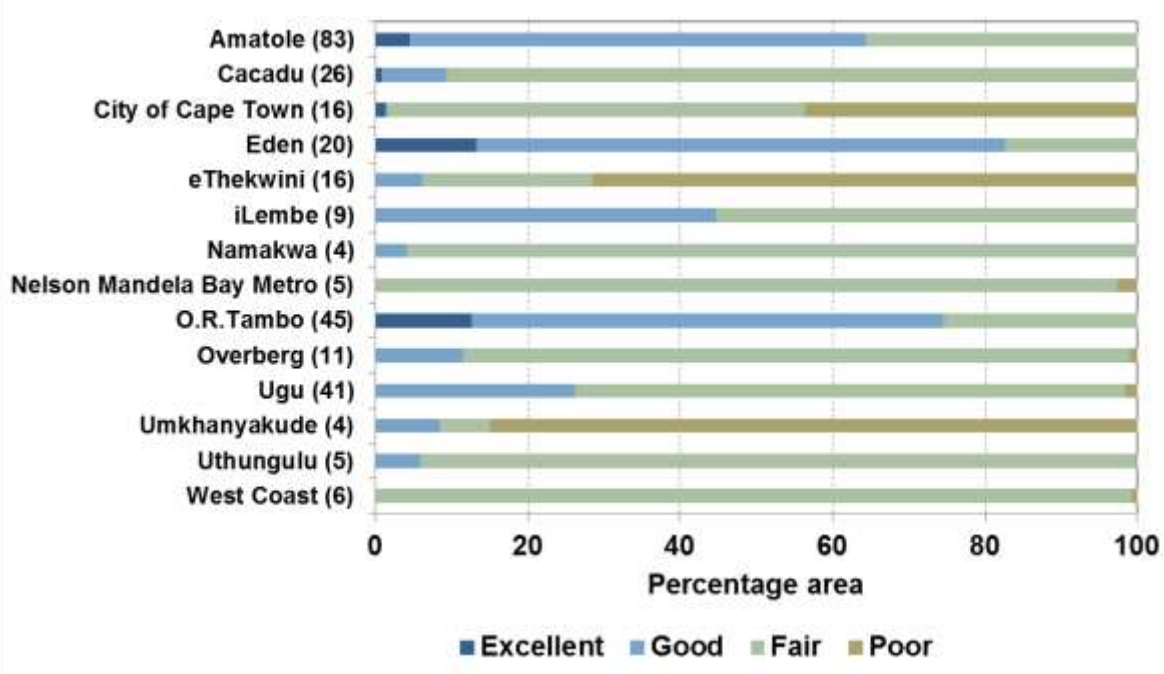


Figure 9.7 A graphic illustration of the percentage estuarine area in the coastal District / Metropolitan Municipalities in an excellent, good, fair or poor condition.

9.4 Health status of Estuaries per Catchment Management Agency

To highlight areas where flow interventions may be required, the estuary health assessment analysis was also conducted from a Catchment Management Agency perspective (see Table 9.9 and Figure 9.8). The Gouritz Catchment Management Agency had the most excellent and good condition estuarine habitat at 13% and 69 % respectively. The Mzimvubu to Kieskamma Catchment Management Agency also comprise a high percentage excellent (7%) and good (60%) state estuarine area.

Usutu to Mhlathuze and Mvoti to Umzimkulu are the two Catchment Management Agencies with the most estuarine habitat in a poor condition, at 79% and 45% respectively. The Berg, Olifants/Doorn and Breede Catchment Management Agencies also manage some poor state estuaries, representing between 1 and 4% of the total estuarine area in South Africa. It is strongly recommended that ecological water requirement studies be undertaken in the Catchment Management Agencies with a high percentage of fair to poor condition estuarine area in an attempt to halt the overall slide in condition currently being observed.

Table 9.9 Summary of Estuarine Health as a percentage of total estaurine habitat in the coastal Catchment Management Agencies.

Catchment Management Agencies	% of SA estuarine area	Health Condition			
		Excellent	Good	Fair	Poor
Berg (17)	9	0	0	96	4
Breede (11)	5	0	11	88	1
Fish to Tsitsikamma (30)	4	1	7	92	0
Gouritz (21)	6	13	69	17	0
Lower Orange (4)	1	0	4	96	0
Mvoti to Umzimkulu (64)	3	0	14	41	45
Mzimvubu to Kieskamma (128)	6	7	60	33	0
Olifants/Doorn (5)	2	0	0	96	4
Thukela (1)	0	0	0	100	0
Usutu to Mhlathuze (10)	66	0	8	13	79
% of total SA estuarine habitat	**100**	**1**	**14**	**31**	**54**

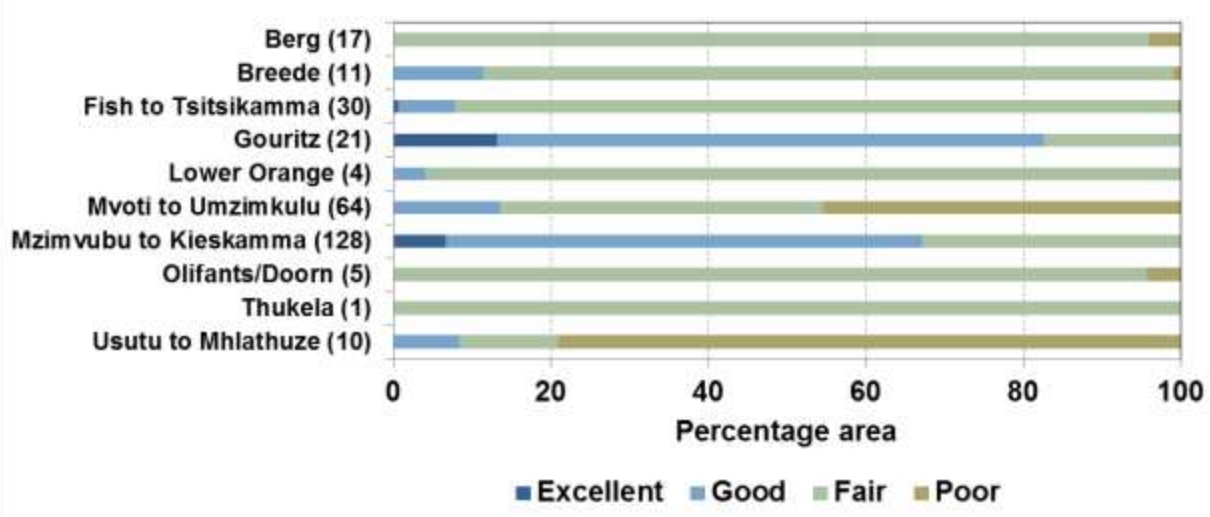


Figure 9.8 A graphic illustration of the percentage area per coastal Catchment Management Agency in an excellent, good, fair or poor condition.

9.5 Health status of Estuaries in areas of Conservation Importance

Finally, to provide an overview of the health status of estuaries in areas of conservation importance – protected areas, marine protected areas, Ramsar sites and Important Bird Areas (IBA) the percentage area in each health category was calculated. Sixty-nine estuaries form part of national, provincial or municipal protected areas or marine protected areas (refer to Section 11.1 for more details on these estuaries)

The following estuaries are listed Ramsar sites under the Ramsar convection:

- Heuningnes
- Kosi
- Orange (Gariep)
- St Lucia (including a part of uMfolozi)
- Verlorenvlei
- Wilderness

The following estuaries form part of Important Bird Areas (IBA) sites:

- Bot/Kleinmond
- Cebe
- Gamtoos
- Groot Berg
- Heuningnes
- Kosi
- Maitland
- uMfolozi
- Mhlathuze
- Mlalazi
- Msunduzi
- Mtamvuna
- Olifants
- Orange (Gariep)
- Rietvlei/Diep
- St Lucia
- Swartkops
- Van Stadens
- Verlorenvlei
- Wilderness

Of deep concern is the lack of sufficient estuarine habitat in excellent and good condition. Estuaries that fall within Ramsar sites represent 57 000 ha, of which none is in excellent condition, 8% in good condition, 9% in a fair state and the majority at 83% are in a poor state. Similarly estuaries that form part of Important Bird Areas represent about 70 400 ha, of which none are in an excellent condition, 7% in a good state, 26% in a fair state and 67% in a poor state. Collectively marine/protected areas represent about 65 900 ha, of which only 1% are in excellent health, 13% in good condition, 14% are in a fair state and 72% in a poor state.

It should once again be noted that the “St Lucia effect” is pronounced as the lake system represents a significant portion of the estuarine habitat in Ramsar sites, IBAs and marine/protected areas within South Africa. An improvement in the health of the Lake St Lucia system will result in a significantly more positive outlook as it is quite feasible to restore St Lucia to a fair or even good condition through a re-linking with the uMfolozi River.

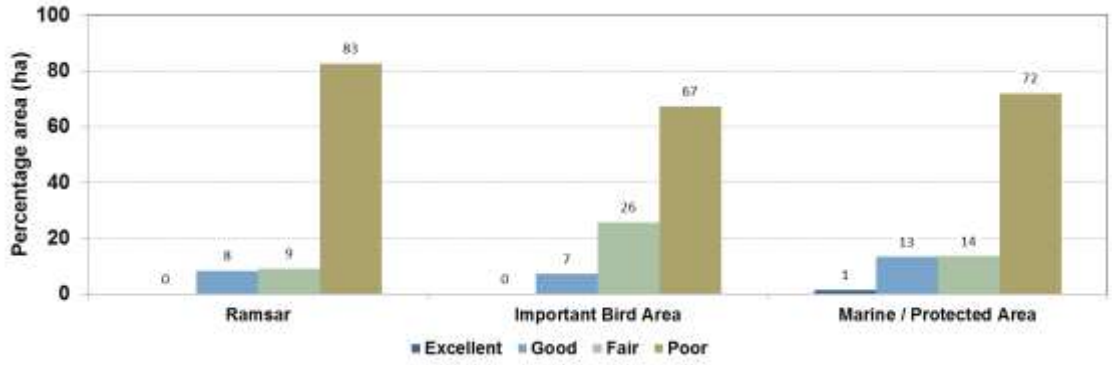


Figure 9.9 A graphic illustration of the percentage estuarine habitat in areas of conservation concern in an excellent, good, fair or poor state.

10. ECOSYSTEM THREAT STATUS

L van Niekerk and J Nel

Ecosystem threat status is one of the two headline indicators reported on in the NBA. It informs us about the degree to which our ecosystems are still intact, or alternatively losing vital aspects of their structure and functioning. Ecosystem types are categorised as critically endangered (CR), endangered (EN), vulnerable (VU) or least threatened (LT), with CR, EN and VU ecosystem types collectively referred to as threatened. For definitions of the ecosystem threat status categories, see Panel 8.

Panel 8: Definitions of ecosystem threat categories (CR, EN, VU, LT)

Critically endangered ecosystems are ecosystem types that have very little of their original extent (measured as area, length or volume) left in natural or near-natural condition. Most of the ecosystem type has been severely or moderately modified from its natural state. These ecosystem types are likely to have lost much of their natural structure and functioning, and species associated with the ecosystem may have been lost. We are in danger of losing the last remaining natural examples of these ecosystem types. Any further loss of natural habitat or deterioration in condition of the remaining healthy examples of these ecosystem types must be avoided, and the remaining healthy examples should be the focus of urgent conservation action.

Endangered ecosystems are ecosystem types that are close to becoming critically endangered. Any further loss of natural habitat or deterioration of condition in these ecosystem types should be avoided, and the remaining healthy examples should be the focus of conservation action.

Vulnerable ecosystems are ecosystem types that still have the majority of their original extent (measured as area, length or volume) left in natural or near-natural condition, but have experienced some loss of habitat or deterioration in condition. These ecosystem types are likely to have lost some of their structure and functioning, and will be further compromised if they continue to lose natural habitat or deteriorate in condition. Identified biodiversity priority areas should guide planning, resource management and decision-making in these ecosystems types.

Least threatened ecosystems are ecosystem types that have experienced little or no loss of natural habitat or deterioration in condition. Identified biodiversity priority areas should guide planning, resource management and decision-making in these ecosystems types.

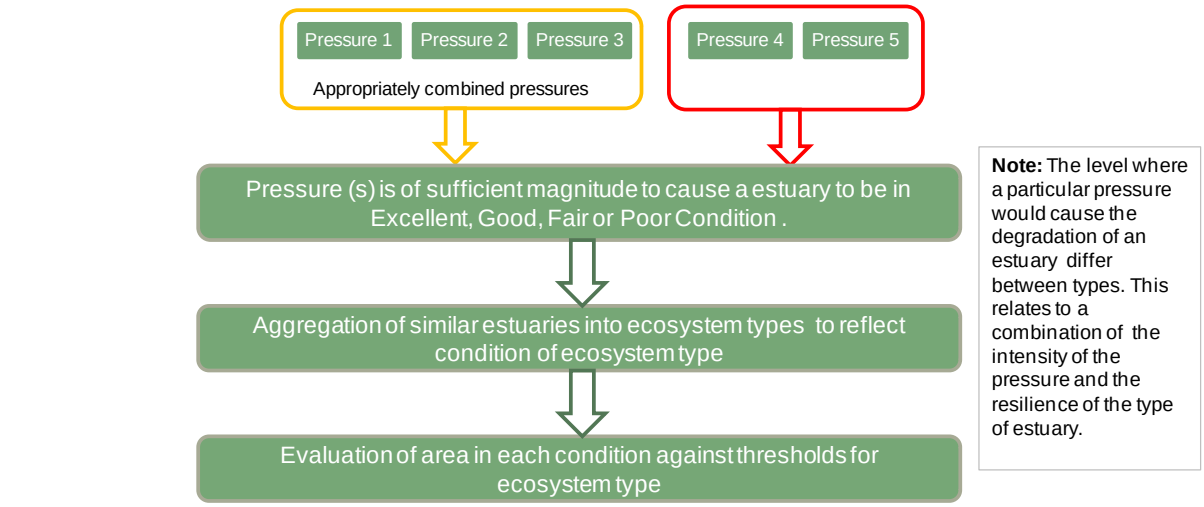
Threat status has been traditionally assessed for species, in the form of national or global Red Lists that draw attention to species threatened with extinction. It is more unusual for threat status to be assessed at the ecosystem level. Initial attempts to assess ecosystem threat status in the NSBA 2004 have been built on and refined in the NBA 2011, which provides a baseline for comparisons going forward.

A group of similar-type estuaries within a biogeographical zone, herein referred to as an ecosystem type, is implicitly assumed to represent a single 'ecoregional' type, supporting a characteristic suite of processes and biodiversity. The NBA 2011 identifies the status of ecosystems on the basis of their current ecological condition (Section 9). In the case of estuaries, the ecosystem threat status does not relate to the complete loss of an ecosystem type (i.e. loss due to development or infilling of the entire estuarine area) but rather to the loss or degradation of ecosystem processes and the abundance, community composition or species richness of associated biota (i.e. pattern). Critically endangered and endangered refer to a significant loss of process and pattern, while vulnerable indicate some loss of ecosystem processes and/ or abundance and distribution of biota. As a result of direct harvesting of living resources, ecosystem processes may still be intact, while the biota associated with that ecosystem type are severely degraded so the two aspects are not necessary related.

How is ecosystem threat status assessed? Figure 10.1 provides a diagram of the processes followed to aggregate condition status to ecosystem threat status. Once ecosystem types have been identified and pressures assessed, the condition or ecological integrity of ecosystems can be established. The proportion of each ecosystem type that remains in good condition is then evaluated against a series of thresholds to determine ecosystem threat status.

The first of these thresholds (often set at 20%) defines the cut-off for critically endangered ecosystems. The threshold for CR ecosystems is also known as the biodiversity target, and is the proportion of each ecosystem type that should ideally be formally protected in the long term. The second threshold (set at the biodiversity target plus 15%) defines the cut-off for endangered ecosystems, and indicates ecosystems that are close to becoming critically endangered. It acts as a warning bell. The third threshold (set at 60%) defines the cut-off point for vulnerable ecosystems. Ecosystem types that have reached this point are likely to

have lost some of their structure and functioning, and will be further compromised if they continue to lose natural habitat or deteriorate in condition.



Status	Critically endangered	Endangered	Vulnerable	Least threatened
Pattern	Largely lost	Heavy impacted	Mostly intact	Intact
Process	Heavily modified	Largely modified	Moderately modified	Largely natural
Condition vs thresholds	A+B < Biodiversity Threshold*	A+B < Biodiversity Threshold plus 15%**	A+B+C < 60%***	A+B+C >= 60%

*Biodiversity pattern target (representation threshold) – 20% for estuary types
**Biodiversity target plus 15% - a warning bell that one is approaching the Biodiversity Threshold
***Ecological Function Threshold (persistence threshold) beyond which function is lost – currently set at 60%

Figure 10.1 Process and criteria by which ecosystem threat status is determined.

The assessment of ecosystem threat status links directly to the Biodiversity Act. Chapter 4 of the Act allows the Minister or an MEC to list threatened or protected ecosystems, thus providing a powerful mechanism to address biodiversity conservation effectively at an ecosystem scale. The ecosystem threat status categories used in the NBA (CR, EN and VU) have been deliberately aligned with the terms and definitions used in the Biodiversity Act.

10.1 Ecosystem threat status based on the Whitfield classification

Two estuarine classification systems for estuaries are generally recognised in South Africa. The geomorphological classification used by Harrison et al. (2000) which comprise six main types based on mouth condition (open or closed), size and the presence of a bar. The Whitfield (1992) classification is also based on physical characteristics (mainly mouth

condition and size of tidal prism), and has become the more widely used classification system.

Whitfield's (1992) classification recognises five types: Estuarine Bays, Permanently Open Estuaries, River Mouths, Estuarine Lakes, and Temporarily Open/Closed Estuaries. The Whitfield (1992) classification was used in the 2004 National Spatial Biodiversity Assessment and is therefore presented here for comparative purposes. The ecosystem threat status is, however, derived from the "percentage area" and not "number of estuaries" as done in the earlier study (Turpie 2004).

Based on data and information provided in Table 10.1 it appears that most of the zonal types in the Cool Temperate and Subtropical biogeographical region are critically endangered, with only the permanently open and temporarily closed types in the Subtropical biogeographical area being least threatened. In the Warm Temperate biogeographical zone, permanently open estuaries are endangered but other estuary types are in a better position (Table 10.2). From an estuarine area perspective, 80% (7 types) are critically endangered, 7% are endangered (1 type) and 13% least threatened (6 types) (Figure 10.2).

Table 10.1 Summary of ecosystem threat status based on the Whitfield classification (percentage habitat in A, B and C categories are indicated).

Zonal Type		Total Area (ha)	A+B	A+B+C	Ecosystem Threat Status
Cool Temperate	Estuarine lake	3072	0	99	Critically endangered
	Permanently open	8351	0	16	Critically endangered
	River mouth	975	0	0	Critically endangered
	Temporarily closed	1323	7	28	Critically endangered
Warm Temperate	Estuarine bay	1926	100	100	Least threatened
	Estuarine lake	1339	100	100	Least threatened
	Permanently open	6425	27	84	Endangered
	River mouth	40	100	100	Least threatened
	Temporarily closed	3120	67	90	Least threatened
Subtropical	Estuarine bay	3192	0	0	Critically endangered
	Estuarine lake	51794	9	9	Critically endangered
	Permanently open	3168	35	94	Least threatened
	River mouth	3932	0	6	Critically endangered
	Temporarily closed	2188	44	77	Least threatened

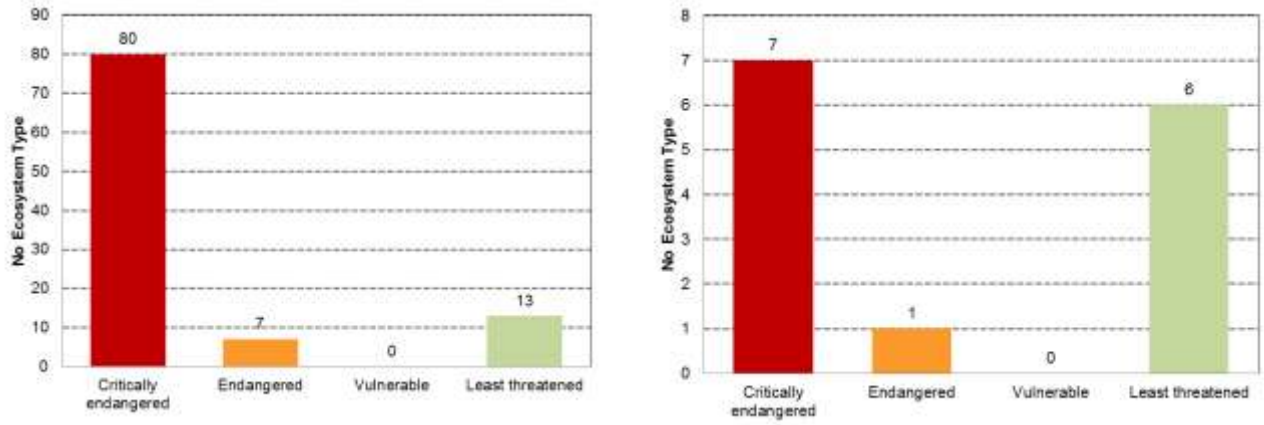


Figure 10.2 Graphic illustration of ecosystem threat status based on the Whitfield classification using percentage area and number of ecosystems types.

10.2 Ecosystem threat status based on NBA 2011 Estuarine Typing

While the Whitfield's (1992) typology was used in the 2004 NSBA, the 2004 assessment also highlighted that some estuarine researchers struggle to work within the Whitfield classification. It stressed the need to devise a more robust system of classification that will also be useful in applied conservation research. This view point was supported by the C.A.P.E. Estuaries conservation plan in which Turpie and Clark (2007) found that while the Whitfield's (1992) estuary typology is widely used, it does not necessarily explain finer nuances of the similarities and differences between different types.

The NBA 2011 therefore set out to refine the existing typology based on the characteristics described in Section 5, thus adding resolution and increasing biodiversity representation. The four main subdivisions were based on estuary size, mouth status, salinity structure and river type. While the consensus was that both "mouth condition" and "salinity structure" should be further subdivided to be truly predictive of biodiversity distribution, this was not possible within the constraints of this project. It was nevertheless felt that the higher resolution provided by the disaggregation of the Whitfield classification would allow for a more refined analyses of the ecosystem threat status and could therefore form the basis for further analyses (Table 10.2).

About 39% of South Africa's 46 estuarine types (18 types) are critically endangered, 2% are endangered (1 type), 2% are vulnerable (1 type) and 57% are least threatened (26 types). If analysed by estuarine area the situation is even more dire, with 79% of South Africa's

estuarine area being critically endangered, less than 1% endangered and vulnerable and 21% least threatened (Figure 10.3 and 10.4).

Table 10.2 Summary of ecosystem threat status based on the NBA 2011 classification (percentage habitat in A, B and C categories indicated)

	Ecosystem Type	% habitat in A + B	% habitat in A+B+C	Ecosystem Threat Status
Cool Temperate	Large ClosedFreshTurbid	0	20	Critically endangered
	Large ClosedMixedBlack	0	86	Critically endangered
	Large ClosedMixedClear	0	0	Critically endangered
	Large OpenMixedClear	0	16	Critically endangered
	Medium ClosedFreshBlack	15	43	Critically endangered
	Medium ClosedMixedBlack	8	8	Critically endangered
	Medium ClosedMixedClear	0	0	Critically endangered
	Medium ClosedMixedTurbid	65	65	Least threatened
	Small ClosedFreshBlack	3	52	Critically endangered
	Small ClosedMixedBlack	56	56	Vulnerable
	Small OpenFreshBlack	100	100	Least threatened
	Small OpenMixedBlack	0	0	Critically endangered
Warm Temperate	Large ClosedMarineClear	100	100	Least threatened
	Large ClosedMixedBlack	63	88	Least threatened
	Large ClosedMixedClear	100	100	Least threatened
	Large OpenMarineBlack	100	100	Least threatened
	Large OpenMarineClear	17	100	Critically endangered
	Large OpenMixedBlack	70	78	Least threatened
	Large OpenMixedClear	0	0	Critically endangered
	Large OpenMixedTurbid	0	100	Critically endangered
	Medium ClosedMixedBlack	50	87	Least threatened
	Medium ClosedMixedClear	89	99	Least threatened
	Medium OpenMixedBlack	100	100	Least threatened
	Medium OpenMixedClear	40	62	Least threatened
	Medium OpenMixedTurbid	100	100	Least threatened
	Small ClosedFreshBlack	93	93	Least threatened
	Small ClosedMixedBlack	94	94	Least threatened
	Small ClosedMixedClear	76	99	Least threatened
	Small OpenFreshBlack	100	100	Least threatened
	Small OpenMixedBlack	70	70	Least threatened
Subtropical	Large ClosedFreshTurbid	0	0	Critically endangered
	Large ClosedMixedClear	100	100	Least threatened
	Large ClosedMixedTurbid	0	0	Critically endangered
	Large OpenMarineClear	16	16	Critically endangered
	Large OpenMarineTurbid	0	46	Critically endangered
	Large OpenMixedClear	100	100	Least threatened
	Large OpenMixedTurbid	47	84	Least threatened
	Medium ClosedFreshTurbid	0	72	Critically endangered
	Medium ClosedMixedBlack	81	100	Least threatened
	Medium ClosedMixedClear	54	86	Least threatened
	Medium ClosedMixedTurbid	23	45	Endangered
	Medium OpenMarineClear	0	0	Critically endangered

	Ecosystem Type	% habitat in A + B	% habitat in A+B+C	Ecosystem Threat Status
	Medium OpenMixedTurbid	100	100	Least threatened
	Small ClosedFreshBlack	100	100	Least threatened
	Small ClosedMixedBlack	100	100	Least threatened
	Small ClosedMixedClear	60	84	Least threatened

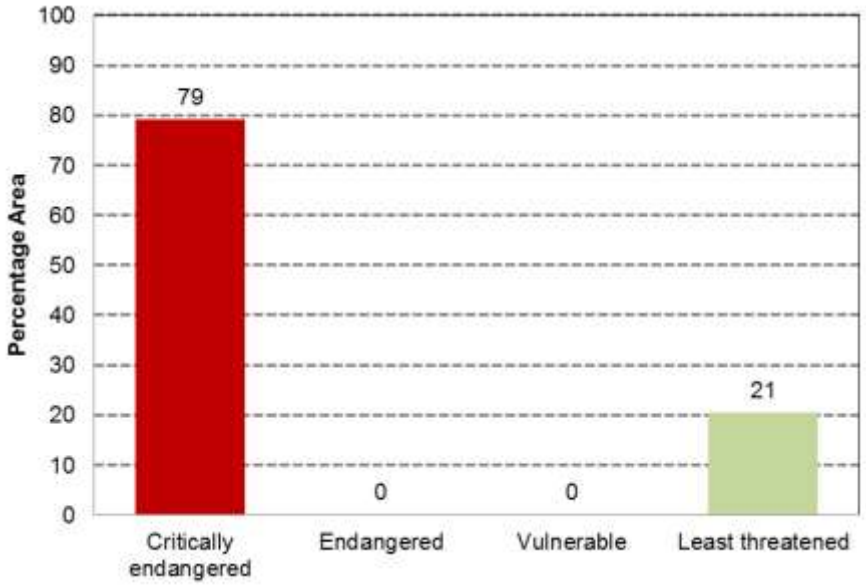


Figure 10.3 Graphic illustration of ecosystem threat status based on the NBA 2011 classification presented as percentage area of ecosystems types.

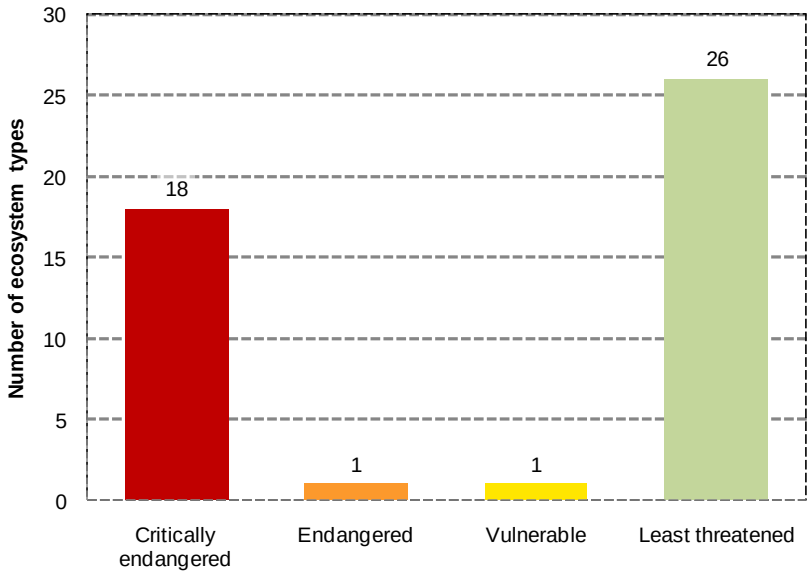


Figure 10.4 Graphic illustration of ecosystem threat status based on the NBA 2011 classification presented as number of ecosystems types.

10.3 Summary of ecosystem threat status by biogeographical region

Nearly 100% of the Cool Temperate biogeographical region habitat (represented by 12 ecosystem types) is critically endangered, while less than 1% is vulnerable and least threatened respectively. In contrast most of the ecosystem types in the Warm Temperate (18 types) are least threatened, representing 68% of the habitat in this zone, while 32% of the habitat is critically endangered. About 87% of the Subtropical estuarine habitat (16 ecosystem types) is critically endangered, while only 12% is least threatened (Table 10.3 and Figure 10.5 to Figure 10.10).

Table 10.3 Ecosystem threat status for the three biogeographical regions of South Africa estimated as a percentage of the total habitat (number of estuaries are indicated in brackets).

Biogeographical region	No of ecosystem types	Ecosystem threat status				
		CR	EN	VU	LT	Total area (ha)
Cool Temperate (34)	12	99.3 (27)	0.0	0.1 (3)	0.6 (4)	13 720
Warm Temperate (124)	18	31.9 (12)	0.0	0.0	68.1(122)	12 849
Subtropical (133)	16	87.42 (11)	0.8 (13)	0.0	11.8 (109)	64 274
Percentage area (291)	46	79.2 (54)	0.1 (13)	0.2 (3)	20.5 (225)	100
Area (ha)		71 932	81	186	18 645	90 844

10.4 Summary of ecosystem threat status by Water Management Agencies Area

To provide an indication of how effective the various Water Management Area (WMAs) are in promoting wise use of their water resources and protecting estuaries, the ecosystem threat status was calculated per individual WMA. Note that some estuaries fall on the boundaries of WMAs, in this case the estuary was allocated to the WMA within which the river catchment falls. This is especially pertinent in the case of the Gouritz WMA as the mouth and lower third of the Duiwenhoks Estuary falls within the Breede WMA, while the river and upper reaches of the estuary are within the Gouritz WMA. It is strongly recommended that DWA address this discrepancy within the delineation of the WMA boundaries on the coast.

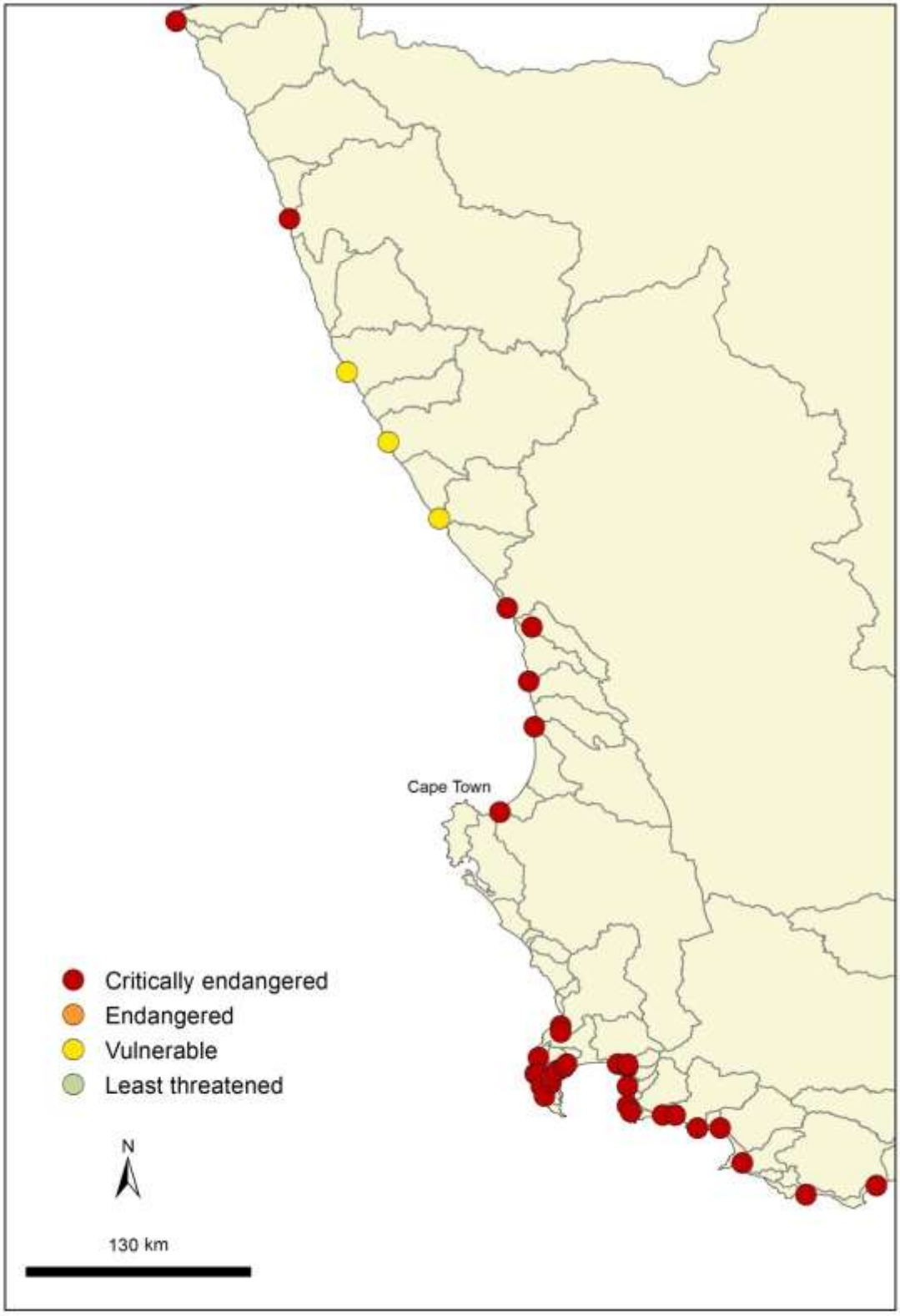


Figure 10.5 Ecosystem threat status of estuaries in the Cool Temperate biogeographical region.

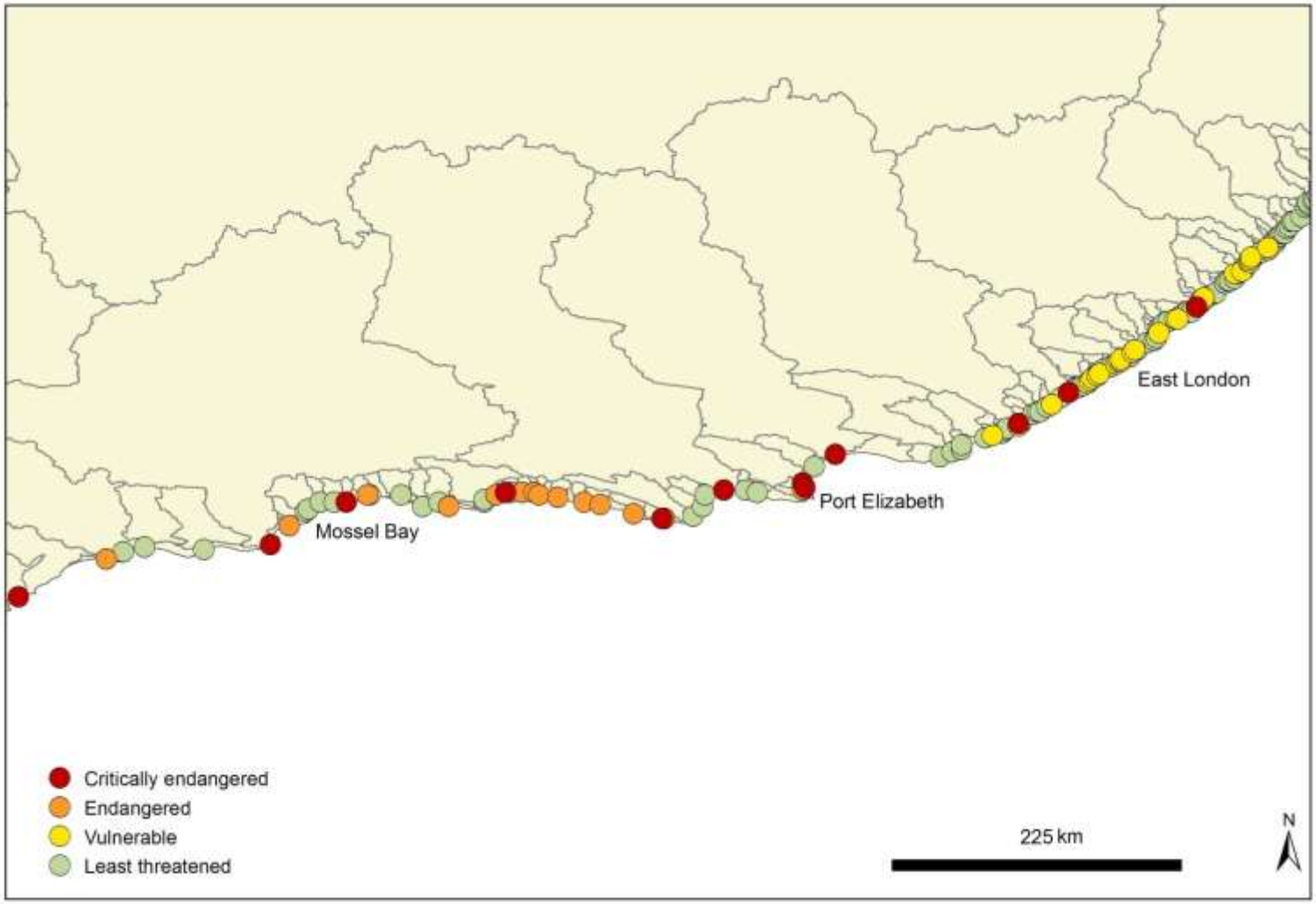


Figure 10.6 Ecosystem threat status of estuaries in the Warm Temperate biogeographical region.

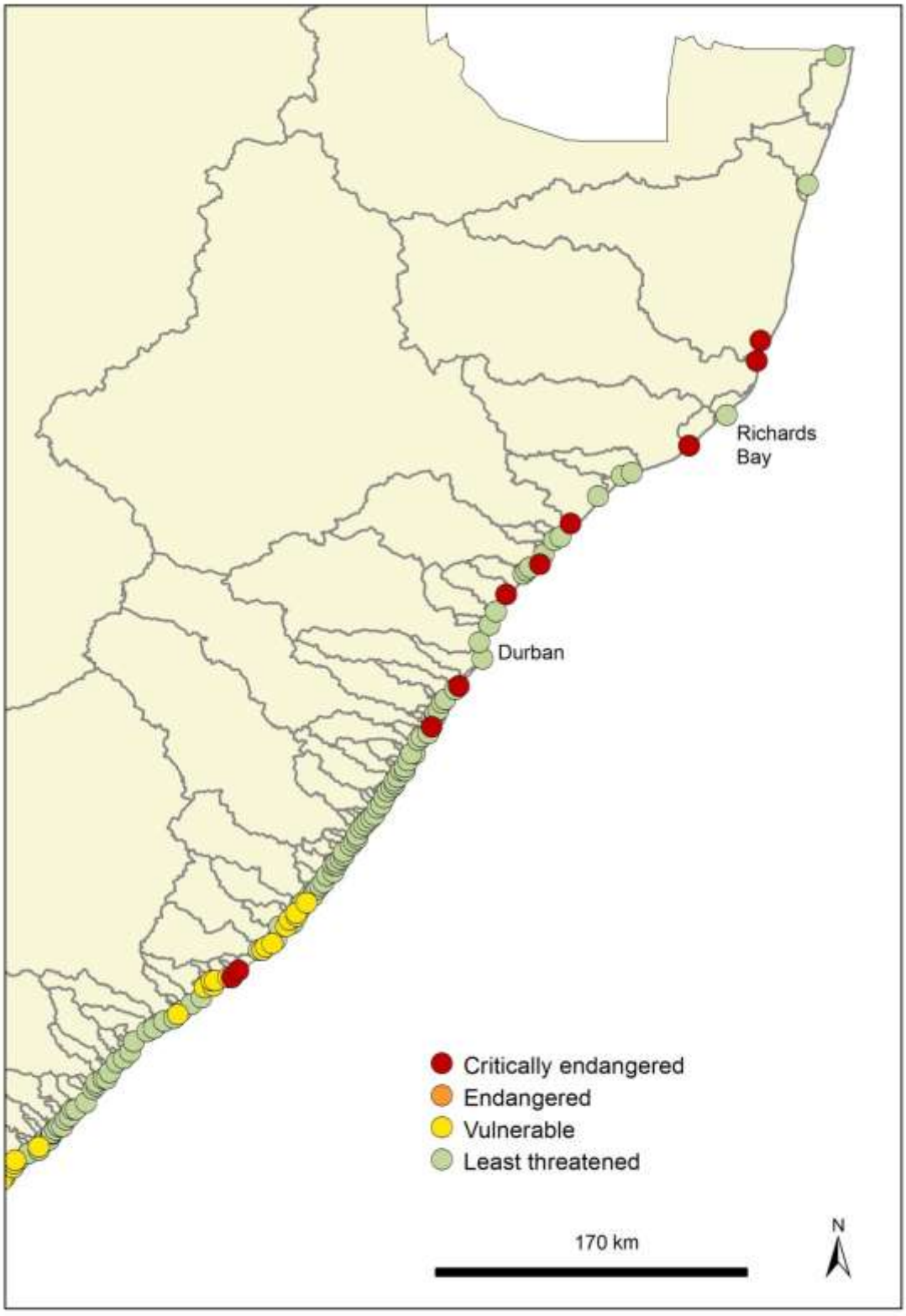


Figure 10.7 Ecosystem threat status of estuaries in the Subtropical biogeographical region.

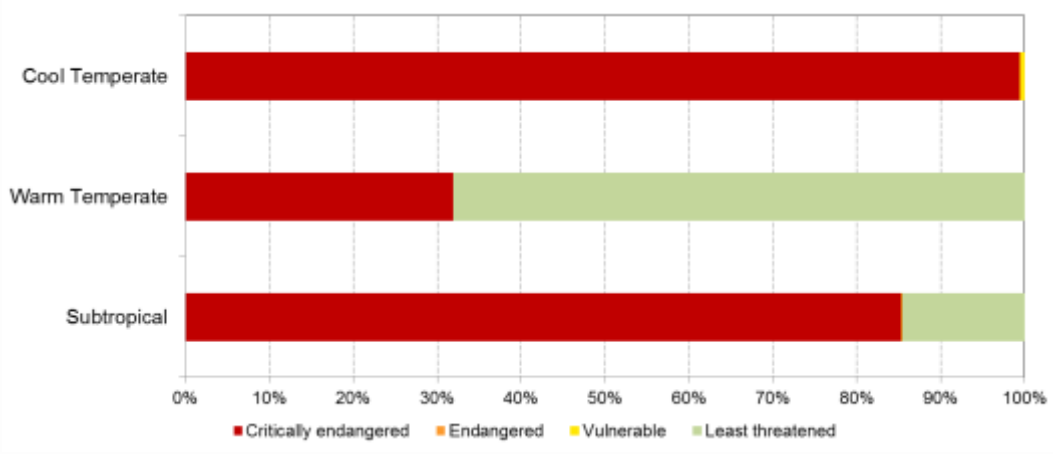


Figure 10.8 Ecosystem threat status for the three biogeograpichal regions, illustrated as a percentage of the total habitat within a region.

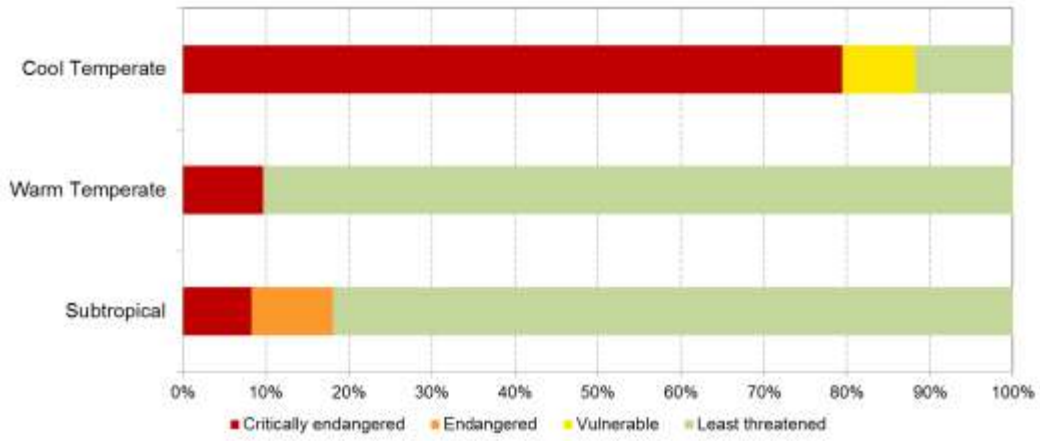


Figure 10.9 Ecosystem threat status for the three biogeograpichal regions, summarized as percentage of the total number of estuaries occurring within a region.

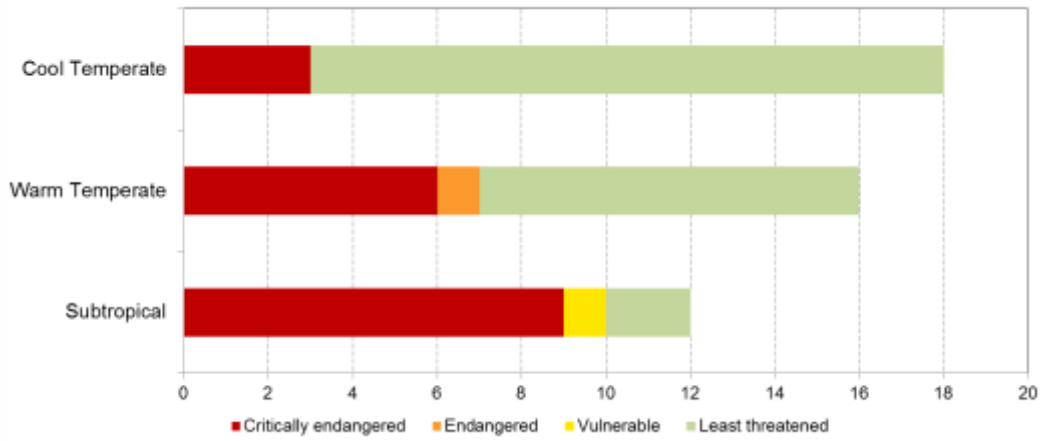


Figure 10.10 Ecosystem threat status of ecosystems types, based on the NBA 2011 classification.

The Berg, Olifants/Doring, Lower Orange, Usutu to Mhlathuze and Thukela WMAs had the greatest percentage estuarine area in the Critically endangered category, while the Gouritz and Mzimvubu to Kieskamma WMAs had the largest percentage least threatened habitats in their management domains.

The poor condition of the Lake St Lucia system is largely responsible for the Usutu to Mhlathuze's high percentage habitat in the critical endangered category. The Thukela WMA comprises only one estuary. The overall high percentage of critically endangered habitat reflects the predominantly fair to poor status of South Africa's large estuaries and the need to utilise, and protect, them more effectively.

Table 10.4 Ecosystem threat status for the 10 coastal Catchment Management Agencies, presented as percentage habitat (number of estuaries are indicated in brackets).

Catchment Management Agency	No of ecosystem types	CR	EN	VU	LT	Total area (ha)
Berg (17)	10	99.8 (14)		0.2 (2)	0.0 (1)	7 725
Breede (11)	7	89.2 (9)			10.8 (2)	4 219
Fish to Tsitsikamma (30)	11	71.1 (7)			28.9 (23)	3 370
Gouritz (21)	10	2.2 (1)			97.8 (20)	5 162
Lower Orange (4)	2	95.8 (2)			4.2 (2)	1 267
Mvoti to Umzimkulu (64)	9	47.8 (5)	17.2 (11)		35.0 (48)	2 736
Mzimvubu to Kieskamma (128)	12	25.1 (4)	0.9 (2)		74.0 (122)	5 176
Olifants/Doorn (5)	5	97.9 (3)		0.2 (1)	1.9 (1)	1 483
Thukela (1)	1	100.0 (1)				79
Usutu to Mhlathuze (10)	8	91.5 (4)			8.5 (6)	59 626
Total in SA	**46**	**81.4 (50)**	**0.6 (13)**	**0.0 (3)**	**18.1 (225)**	**90 844**

An evaluation of the percentage estuaries in the critical endangered category shows that Breede, Thukela, Usutu to Mhlathuze and Fish to Tsitsikamma have the greatest number in that catogory. While the Gouritz, Lower Orange, Mzimvubu to Kieskamma and Olifants/Doorn have the greatest percentage estuaries in the least threatened category.

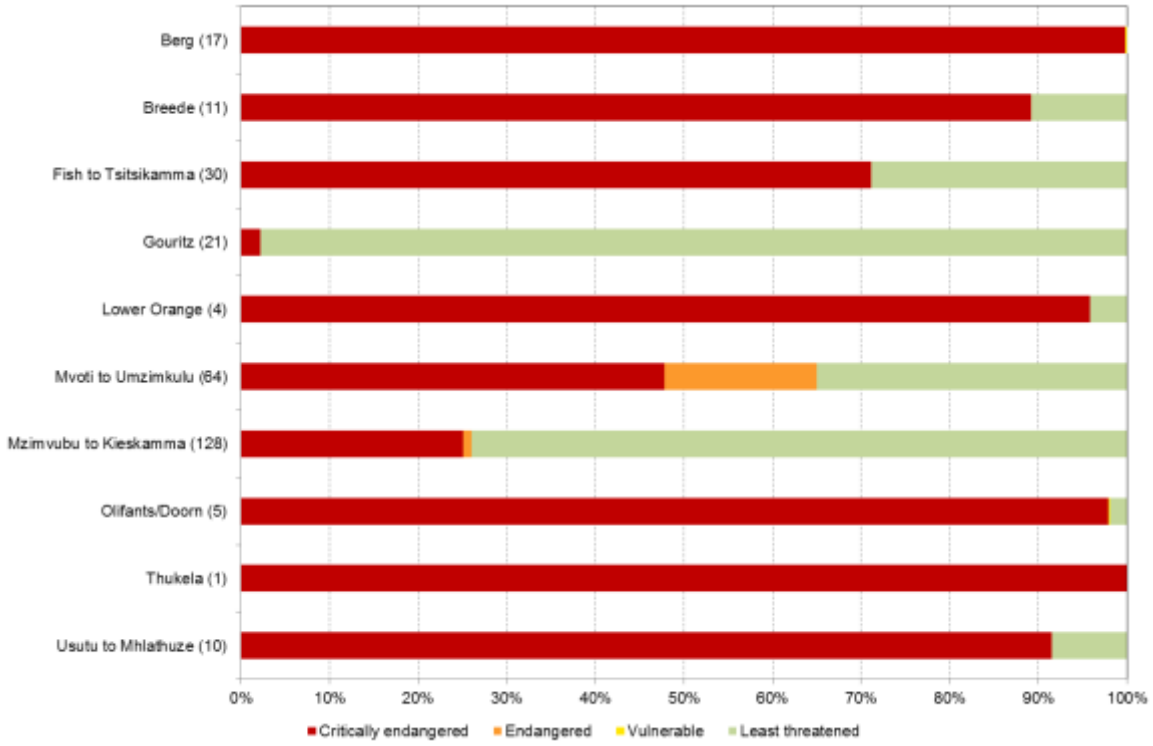


Figure 10.11 Ecosystem threat status for the 10 coastal Catchment Management Agencies, illustrated as a percentage of the total estuarine habitat in the CMA.

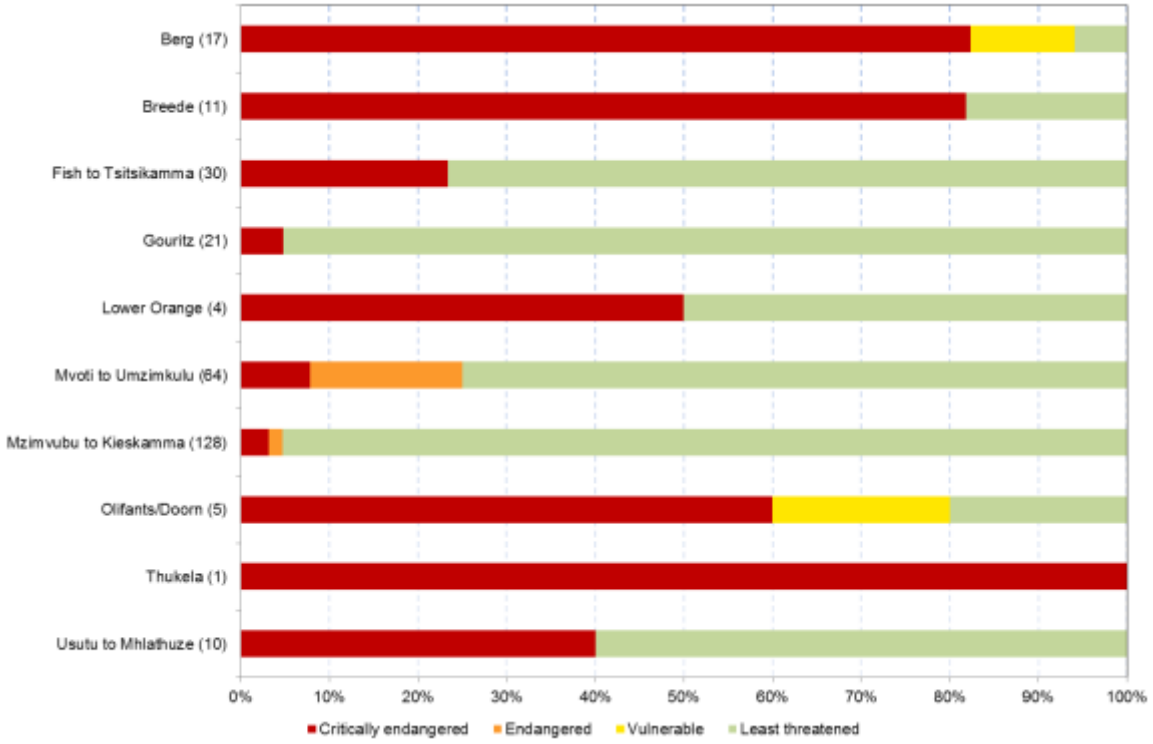


Figure 10.12 Ecosystem threat status for the 10 coastal Water Management Areas, summarized as a percentage of the total number of estuaries occurring within the WMA.

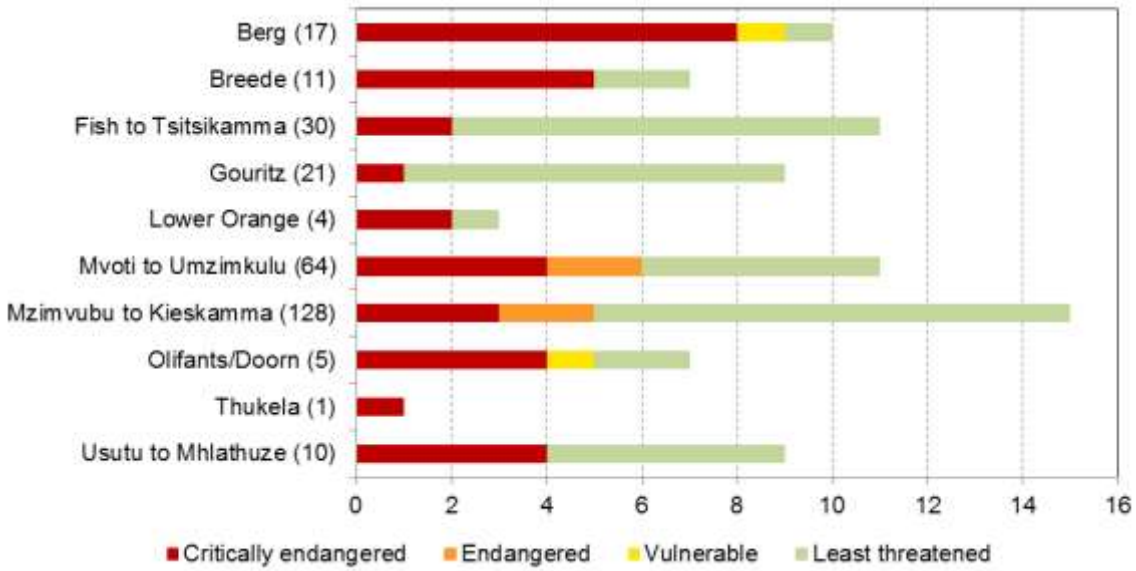


Figure 10.13 Ecosystem threat status of ecosystems types based on the NBA 2011 classification for the 10 coastal Water Management Areas.

10.5 Summary of ecosystem threat status by District/ Metropolitan Municipality

The Berg, Olifants/Doring, Lower Orange, Usutu to Mhlathuze and Thukela WMAs have the greatest percentage ecosystem area in the critical endangered category, while the Gouritz and Mzimvubu to Kieskamma WMAs have the largest percentage of least threatened habitats in their managed areas (see Table 10.5 and Figures 10.11 to 10.13 for more detail) . The poor condition of the Lake St Lucia Sytem is largely responsible for the Usutu to Mhlathuze WMA's high level of critically endangered areas. This high percentage of critically endangered habitat areas reflects the fair to poor status of South Africa's large estuaries and the need to utilise, and protect, them better. The Gouritz, Lower Orange, Mzimvubu to Kieskamma and Olifants/Doorn have the greatest percentage estuaries in least threatened category.

Table 10.5 Ecosystem threat status for the 15 Coastal District/ Metropolitan Municipalities (percentage habitat). The number of estuaries is indicated in brackets.

District Municipality	No of types	CR	EN	VU	LT	Total area (ha)
Amatole (83)	9	28.5.0 (3)			71.5 (80)	3 769
Cacadu (26)	10	66.8 (6)			33.2 (20)	2 842
City of Cape Town (16)	9	98.0 (13)		1.7 (2)	0.3 (1)	732

District Municipality	No of types	CR	EN	VU	LT	Total area (ha)
Eden (20)	9	2.2 (1)			97.8 (19)	5 159
eThekwini (16)	6	74.9 (4)	11.6 (4)		13.5 (8)	1 718
iLembe (9)	5	25.2 (2)	17.2 (2)		57.6(5)	402
Namakwa (4)	2	95.8 (2)			4.2 (2)	1 267
Nelson Mandela Metro (5)	5	93.9 (1)			6.1 (4)	532
O.R.Tambo (45)	9	16.0 (1)	3.2 (2)		80.8 (42)	1 407
Overberg (11)	7	89.2 (9)			10.8 (2)	4 219
Ugu (41)	6		24.5 (5)		75.5 (36)	822
Umkhanyakude (4)	4	91.6 (2)			8.4 (2)	55 474
Uthungulu (5)	4	93.5 (2)			6.5 (3)	4 025
West Coast (6)	5	99.6 (4)		0.0 (1)	0.3 (1)	8 476
Total for SA	**46**	**81.4 (50)**	**0.6 (13)**	**0.0 (3)**	**18.1 (225)**	90 844

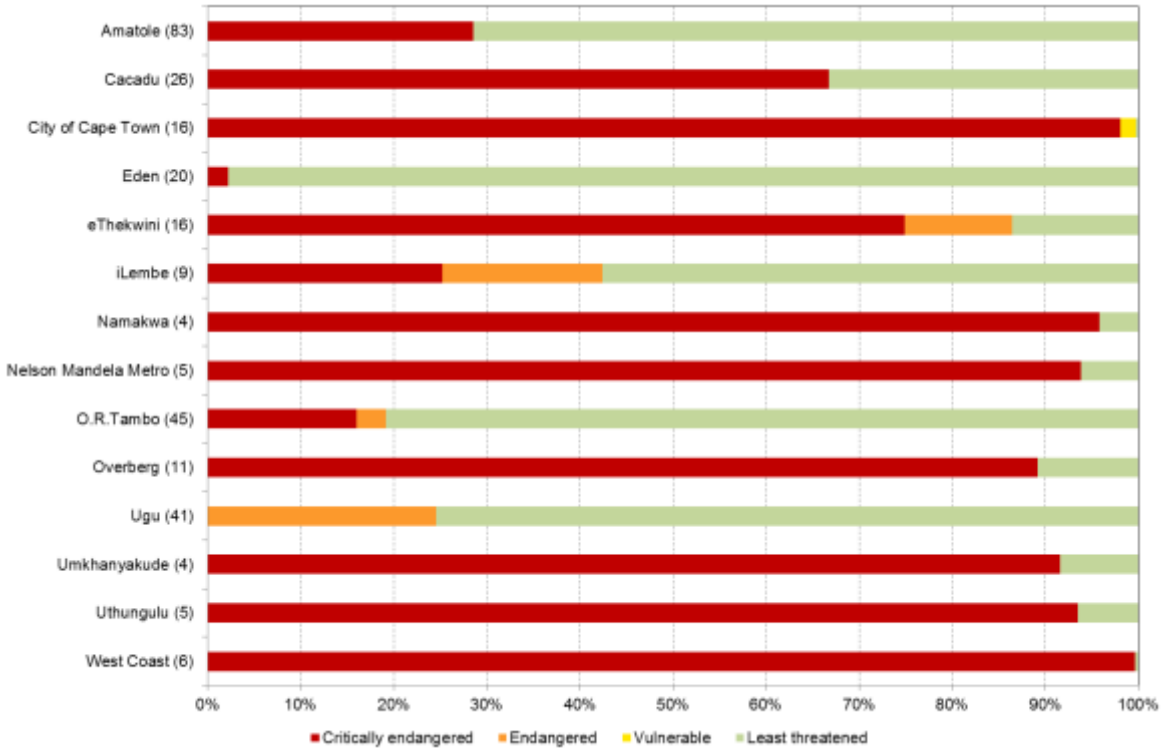


Figure 10.14 Ecosystem threat status for the Coastal District/Metropolitan Municipalities, illustrated as a percentage of the total habitat within the municipality.

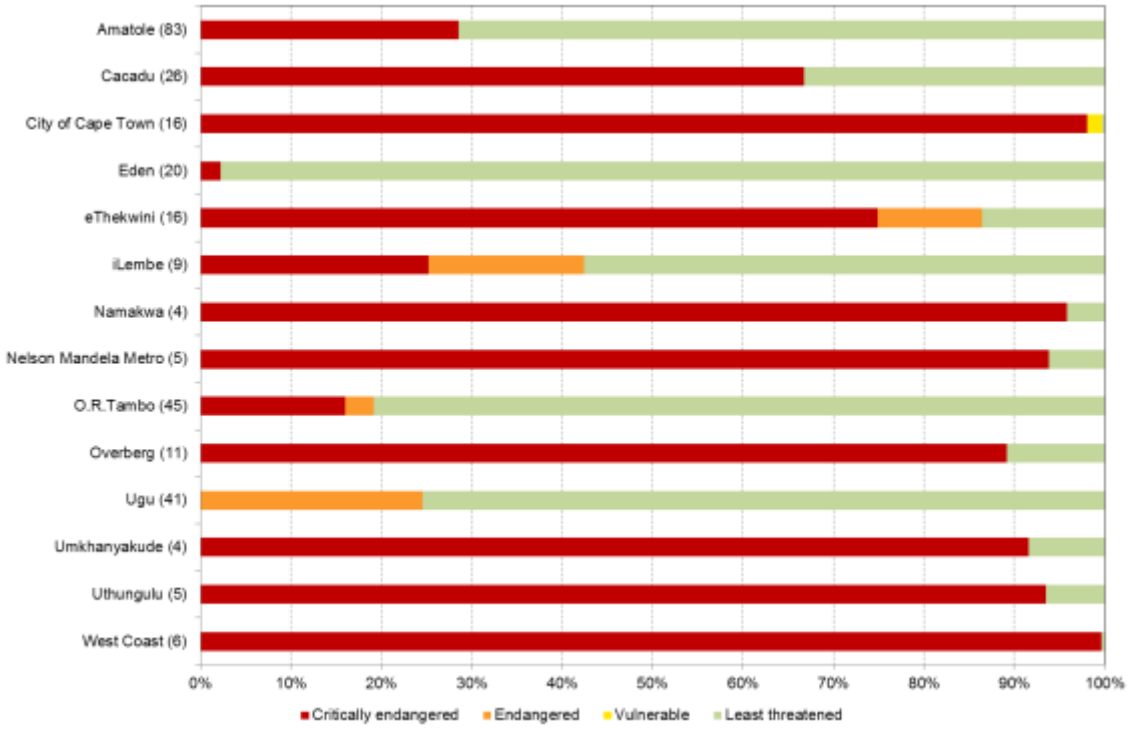


Figure 10.15 Ecosystem threat status for the Coastal District/Metropolitan Municipaliies summarized as percentage estuaries of the total number of estuaries occurring in the municipality.

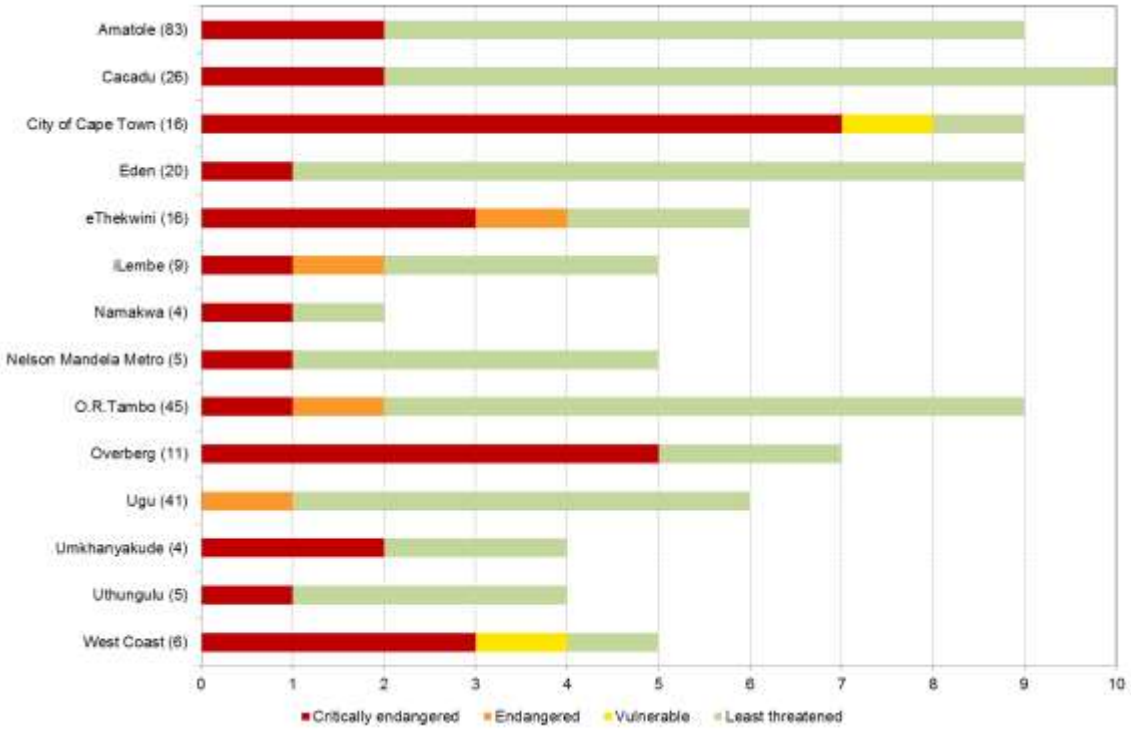


Figure 10.16 Ecosystem threat status summarised as number of ecosystems types based on the NBA 2011 classification for the Coastal District/Metropolitan municipalities.

11. ECOSYSTEM PROTECTION LEVELS

L van Niekerk and JK Turpie

11.1 Degree of protection

A total of 70 estuaries in South Africa already have some level of protection (Figure 11.1 and Table 10.1). However, only the Krom in the Western Cape, the 7 small estuaries within Tsitsikamma National Park/Marine Protected Area, Mbashe (under dispute and currently only partly protected in practice), Msikaba and Mtentu in the Eastern Cape, and Mhlanga, Mlalazi and Kosi in KwaZulu-Natal have full no-take protection. It should also be noted that although the Lake St Lucia system is listed as being fully protected in law, fishing is permitted and St Lucia Estuary's current health status is an E and that of uMfolozi Estuary is a D, thus indicating that the system is in fact poorly protected. The above-mentioned estuaries were the only estuaries considered to be fully protected by formal legislation.

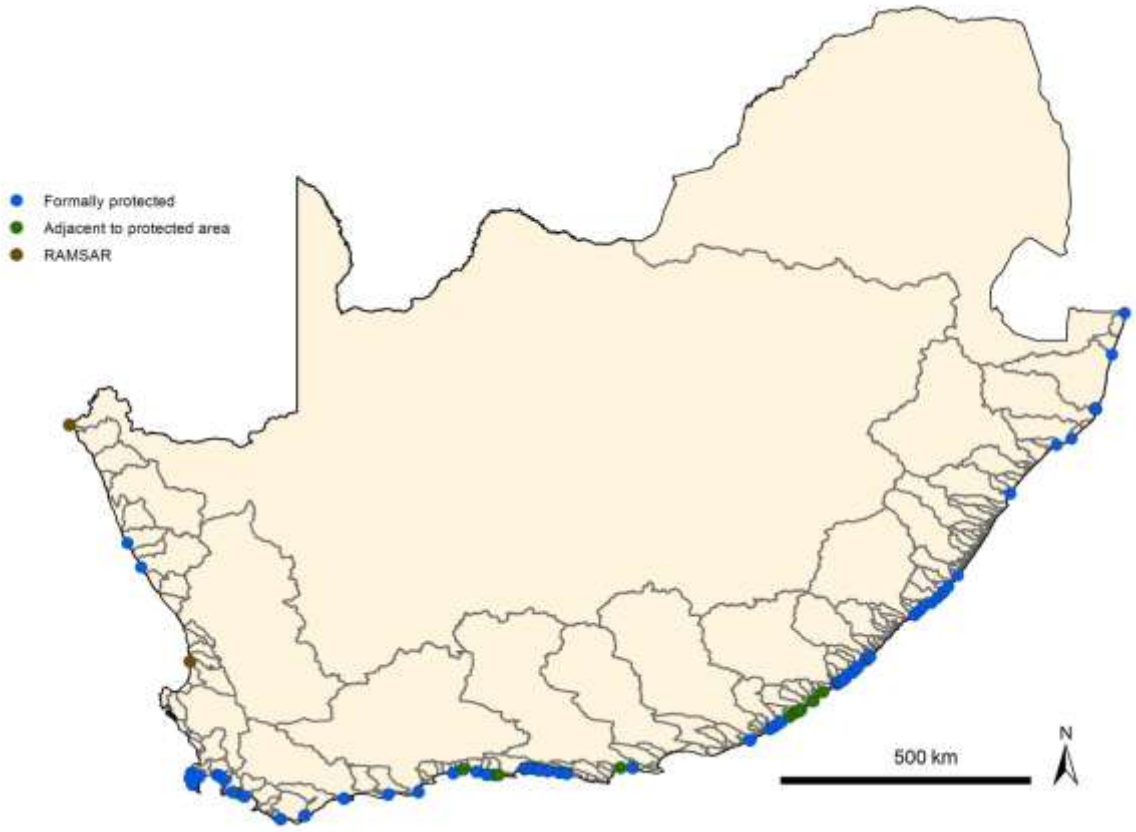


Figure 11.1 Location of formally protected and partially protected estuaries in South Africa.

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Table 11.1 Estuaries within South Africa that have some level of protection, giving the amount in a protected area, the extent of no-take protection, whether ecological water requirements have been secured, whether an estuary management plan is in place, the condition of the estuary, and the effective level of protection of the estuary (Turpie et al. 2012).

#	Estuary	Protected area	Agency	Amount of estuary in protected area	No Take Restrictions	Ecological water requirement	Estuary Management Plan	Condition	Level of protection*
1	Orange	Planned	Provincial	Part	Boat restriction	Yes		D	Medium
2	Spoeg	Namaqualand NP	SANParks	All				B	Medium
3	Groen	Namaqualand NP	SANParks	All				B	Medium
4	Diep	Rietvlei NR	Municipal	Part	Part			E	Low
5	Krom	Table Mountain NP	SANParks	Entirely				A	High
6	Wildevoëlvlei	Table Mountain NP	SANParks	Part				D	Low
7	Sand	Sandvlei NR	Municipal	<10% of estuary (Top)				D	Low
8	Heuningnes	De Mond NR	CapeNature	Part			Yes	D	Medium
9	Goukou	Stilbaai MPA	CapeNature	Part	Part		Yes	C	Medium
10	Wilderness	Wilderness Lakes NP	SANParks	Part				B	Low
11	Swartvlei	Wilderness Lakes NP	SANParks	Part		Yes		B	Low
12	Goukamma	Goukamma NR	CapeNature	Most		Yes (to A/B)		B	Medium
13	Knysna	Knysna NP	SANParks	Part		Yes	Yes	B	Low
14	Keurbooms	Keurbooms River NR	CapeNature	Part (upper reaches)		Yes	Yes	A	Low
15	Sout	De Vasselot NP	SANParks	All				A	Medium
16	Groot (W)	Tsitsikamma NP	SANParks	All	Yes			B	High
17	Bloukrans	Tsitsikamma NP	SANParks	All	Yes			A	High
18	Lottering	Tsitsikamma NP	SANParks	All	Yes			A	High
19	Elandsbos	Tsitsikamma NP	SANParks	All	Yes			A	High
20	Storms	Tsitsikamma NP	SANParks	All	Yes			A	High
21	Elands	Tsitsikamma NP	SANParks	All	Yes			B	High
22	Groot (E)	Tsitsikamma NP	SANParks	All	Yes			B	High

#	Estuary	Protected area	Agency	Amount of estuary in protected area	No Take Restrictions	Ecological water requirement	Estuary Management Plan	Condition	Level of protection*
23	Tsitsikamma	Huisklip NR	ECParks	Lower reaches		Yes		B	Low
24	Seekoei	Seekoei River NR	Municipal	Part (upper)		Yes		D	Low
25	Gamtoos	Gamtoos R. Mouth NR	Municipal	Part			Yes	C	Low
26	Van Stadens	Van Stadens NR	Municipal	All				B	Low
27	Sundays	Addo Elephant NR	Municipal	Part		Yes	Yes	C	Medium
28	Nahoon	Nahoon Estuary NR	Municipal	Very small part		Yes	Planned	C	Low
29	Mendu[#]	Dwesa-Cwebe MPA	DEA/DAFF	Undefined as yet	Yes			A	Medium
30	Mendwana[#]	Dwesa-Cwebe MPA	DEA/DAFF	Undefined as yet	Yes			A	Medium
31	Mbashe	Dwesa-Cwebe MPA	DEA/DAFF	All, but half in practice	Yes		Yes	C	High
32	Ku-Mpenzu	Dwesa-Cwebe NR	ECParks	Undefined as yet	Yes			B	Medium
33	Ku-Bhula Mbhanyana	Dwesa-Cwebe NR	ECParks	Undefined as yet	Yes			A	Medium
34	Kwa-Suka[#]	Dwesa-Cwebe NR	ECParks	Undefined as yet	Yes			B	Medium
35	Ntlonyane	Dwesa-Cwebe NR	ECParks	Undefined as yet	Yes			B	Medium
36	Nkanya	Dwesa-Cwebe NR	ECParks	Undefined as yet	Yes			B	Medium
37	Hluleka	Hluleka Nature Reserve	ECParks	All				A	Low
38	Nkodosweni	Pondoland MPA	DEA	Part				B	Low
39	Mtafufu	Pondoland MPA	DEA	Part				B	Low
40	Mzintlava	Pondoland MPA	DEA	Part				B	Low
41	Mzimpunzi[#]	Pondoland MPA	DEA	Part				B	Low
42	Kwa-Nyambalala[#]	Pondoland MPA	DEA	Part				B	Low
43	Mbotyi	Pondoland MPA	DEA	Part				B	Low
44	Mkozi[#]	Pondoland MPA	DEA	Part				A	Low
45	Myekane[#]	Pondoland MPA	DEA	Part				A	Low
46	Sitatsha[#]	Pondoland MPA	DEA	Part				A	Low

#	Estuary	Protected area	Agency	Amount of estuary in protected area	No Take Restrictions	Ecological water requirement	Estuary Management Plan	Condition	Level of protection*
47	Lupatana#	Pondoland MPA	DEA	Part				A	Low
48	Mkweni	Pondoland MPA	DEA	Part				A	Low
49	Msikaba	Mkambati Nature Reserve	ECParks	All				A	High
50	Butsha#	Mkambati Nature Reserve	ECParks	All	Yes			A	High
51	Mgwegwe#	Mkambati Nature Reserve	ECParks	All	Yes			A	High
52	Mgwetyana#	Mkambati Nature Reserve	ECParks	All	Yes			A	High
53	Mtentu	Mkambati Nature Reserve	ECParks	All	Yes		Yes	A	High
54	Sikombe#	Pondoland MPA	DEA	Part				A	Low
55	Kwanyana#	Pondoland MPA	DEA	Part				B	Low
56	Mtolane#	Pondoland MPA	DEA	Part				A	Low
57	Mnyameni	Pondoland MPA	DEA	Part				B	Low
58	Mpahlanyana#	Pondoland MPA	DEA	Part				A	Low
59	Mpahlane#	Pondoland MPA	DEA	Part				A	Low
60	Mzamba#	Pondoland MPA	DEA	Part				B	Low
61	Mtentwana#	Pondoland MPA	DEA	Part				C	Low
62	Mtamvuna	Pondoland MPA	DEA	Part				B	Low
63	Mpenjati	Mpenjati Nature Reserve	EKZNW	Part				B	Medium
64	Mgeni	Beechwood Nature Reserve	EKZNW	Part				D	Medium
65	Mhlanga	-	EKZNW	All	Yes	Yes		D	High
66	Mlalazi	Mlalazi Nature Reserve	EKZNW	All	Yes			B	High
67	Mhlathuze	-	EKZNW	Part				C	Medium
68	St Lucia/uMfolozi	iSimangaliso Wetland Park	ISWP Authority	90%		Yes		E/D	High/Medium
69	Mgobozeleni	iSimangaliso Wetland Park	ISWP Authority	All				B	Low
70	Kosi	iSimangaliso Wetland Park	ISWP Authority	All				B	Medium

*High = no-take for fish and invertebrates, medium = contains invertebrate no-take area

estuaries not named in the official gazette notices, but which occur within the protected area and are being managed as such.

The above-mentioned protected areas account for 65 900 ha[4] or 73% of the estuarine area within South Africa, and represent all of the eight targeted habitat types (Table 11.2). However, the St Lucia system contributes 90% towards the protected estuarine area or 56% of the total estuarine area, and covers a total of about 51 000 ha. The other fully protected estuaries cover a total area of just under 15 000 ha or only 16 % of the remaining estuarine area in South Africa. Turpie et al. (2012) found that protected areas met less than 5% of all habitat targets for Temperate estuaries. Estuaries that fall within Ramsar sites encompass about 57 000 ha, but not all Ramsar sites are formally protected in law. For example, the Orange and Verlorenvlei currently have no formal protection, although the plan for the Orange River Mouth Protected Area is in an advanced stage, with the potential of expanding it into a transfrontier park in the near future. It is hoped that Verlorenvlei would be granted similar legal protection in the near future to arrest the decline in its health and ensure an adequate supply of good quality water.

Table 11.2 Representation of habitats within fully protected estuaries and percentage of total area met (adapted from Turpie et al. 2012).

Habitat type	Total SA Habitat	Total area in fully protected estuaries (ha)	% of total SA habitat	Total fully protected estuaries minus St Lucia (ha)	% minus St Lucia	Total area in all protected & Ramsar estuaries (ha)	% of total habitat
Intertidal salt marsh	4 310	531	12	15	3	1 633	38
Supratidal salt marsh	7 051	1 757	25	51	3	2 356	33
Mangroves	2 111	898	43	393	44	1 591	75
Reeds and sedges	11 806	7 333	62	383	5	8 265	70
Channel	55 284	40 662	74	4 329	11	45 155	82
Swamp forest	4 843	4 577	95	180	4	4 619	95
Sand/mud banks	4 017	329	8	103	31	1 651	41
Submerged macrophytes	1 327	185	14	4	2	617	47
Rocks	96.2	16.1	17	16	100	16	17
Total	90 844	56 287	62	5 473	10	65 904	73

[4] This estimate was not based on a spatial analysis as the boundaries of some of the protected areas were not available for this assessment. This study therefore treated an estuary as either fully included or excluded in the protected area, while in some cases only some of the estuarine area may be formally protected.

11.2 Ecosystem Protection Levels

Ecosystem protection level indicates the extent to which ecosystems are protected, based on the proportion of each ecosystem's biodiversity target that is met in formal protected areas recognised by the Protected Areas Act or Marine Living Resources Act. For these calculations, targets for protection were set at 20% of the estuarine habitat area of each ecosystem type. Only optimum functional estuaries (not in health categories C, D, E and F) that are in formally protected areas (i.e. in national, provincial or municipal marine/protected areas) were considered as protected (i.e. contributing to biodiversity targets). Ecosystem protection level is divided into four categories: well protected, moderately protected, poorly protected and not protected (according to Table 11.3).

Table 11.3 Categories of ecosystem protection levels with all targets at 20% of area based on estuarine habitat.

Protection levels	Description
Well protected	≥100% of target in an MPA or PA
Moderately protected	50 to 99.99% of target in an MPA or PA
Poorly protected	5 to 49.99% of target in an MPA or PA
Not protected	0 to 4.99% of target in an MPA or PA

Ecosystem protection levels for the 46 NBA ecosystem types calculated according to the above-mentioned criteria are listed in Tale 11.3. Table 11.4 provides a summary of the degree of formal protection (excluding degraded estuaries, i.e. those systems not in an A or B category) and protection levels per ecosystem type for each of the three biogeographical regions.

Table 11.4 Ecosystem protection levels per ecosystem type.

Ecosystem Type	Total area (ha)	Degree of protection				% Protected	Protection level
		High	Low	Medium	None		
Cool Temperate	**13 720**	**9**		**53**	**13659**	**0.4**	
LargeClosedFreshTurbid	1 215				1215	0.0	**Not protected**
LargeClosedMixedBlack	3 528				3528	0.0	**Not protected**
LargeClosedMixedClear	224				224	0.0	**Not protected**
LargeOpenMixedClear	8 346				8346	0.0	**Not protected**
MediumClosedFreshBlack	116				116	0.0	**Not protected**
MediumClosedMixedBlack	134				134	0.0	**Not protected**
MediumClosedMixedClear	36				36	0.0	**Not protected**
MediumClosedMixedTurbid	81			53	28	65.2	**Well**
SmallClosedFreshBlack	20				20	0.0	**Not protected**
SmallClosedMixedBlack	15	9			7	56.3	**Well**

Ecosystem Type	Total area (ha)	Degree of protection				% Protected	Protection level
		High	Low	Medium	None		
SmallOpenFreshBlack	2				2	0.0	**Not protected**
SmallOpenMixedBlack	3				3	0.0	**Not protected**
Warm Temperate	**12 849**	**79**	**3970**	**47**	**8753**	**31.9**	
LargeClosedMarineClear	159				159	0.0	**Not protected**
LargeClosedMixedBlack	2 034		1286		748	63.2	**Well**
LargeClosedMixedClear	925				925	0.0	**Not protected**
LargeOpenMarineBlack	1 926		1926			100.0	**Well**
LargeOpenMarineClear	654				654	0.0	**Not protected**
LargeOpenMixedBlack	1 896		675		1221	35.6	**Well**
LargeOpenMixedClear	518				518	0.0	**Not protected**
LargeOpenMixedTurbid	2 930				2930	0.0	**Not protected**
MediumClosedMixedBlack	302	39	77	18	167	44.5	**Well**
MediumClosedMixedClear	954			24	930	2.5	**Poorly**
MediumOpenMixedBlack	22				22	0.0	**Not protected**
MediumOpenMixedClear	259				259	0.0	**Not protected**
MediumOpenMixedTurbid	138				138	0.0	**Not protected**
SmallClosedFreshBlack	8				8	0.0	**Not protected**
SmallClosedMixedBlack	29	10	7		13	56.0	**Well**
SmallClosedMixedClear	56			0	56	0.0	**Not protected**
SmallOpenFreshBlack	30	30				100.0	**Well**
SmallOpenMixedBlack	7			5	2	69.8	**Well**
Subtropical	**64 275**	**322**	**373**	**4774**	**58806**	**8.5**	
LargeClosedFreshTurbid	3 680				3680	0.0	**Not protected**
LargeClosedMixedClear	4 645			4645		100.0	**Well**
LargeClosedMixedTurbid	47134				47134	0.0	**Not protected**
LargeOpenMarineClear	1 373				1373	0.0	**Not protected**
LargeOpenMarineTurbid	3 764				3764	0.0	**Not protected**
LargeOpenMixedClear	127				127	0.0	**Not protected**
LargeOpenMixedTurbid	1 076	239			837	22.2	**Well**
MediumClosedFreshTurbid	213				213	0.0	**Not protected**
MediumClosedMixedBlack	116		94		22	81.2	**Well**
MediumClosedMixedClear	1 169		30	121	1017	13.0	**Moderately**
MediumClosedMixedTurbid	514		92		423	17.8	**Moderately**
MediumOpenMarineClear	27				27	0.0	**Not protected**
MediumOpenMixedTurbid	262	68	118		76	71.0	**Well**
SmallClosedFreshBlack	11		11			100.0	**Well**
SmallClosedMixedBlack	49	15	28		7	86.5	**Well**
SmallClosedMixedClear	114			8	107	6.7	**Poorly**
Total	90 844	410	4343	4874	81218	10.6	

Based on the criteria listed in Table 11.3, nearly 59% (27 out of 46 types) of South Africa's estuarine ecosystem types are not protected. About 33% of estuarine ecosystem types are well protected (15 types), while about 4% are moderately protected (2 types) and 13% are 4% is poorly protected (2 types) (Figure 10.3).

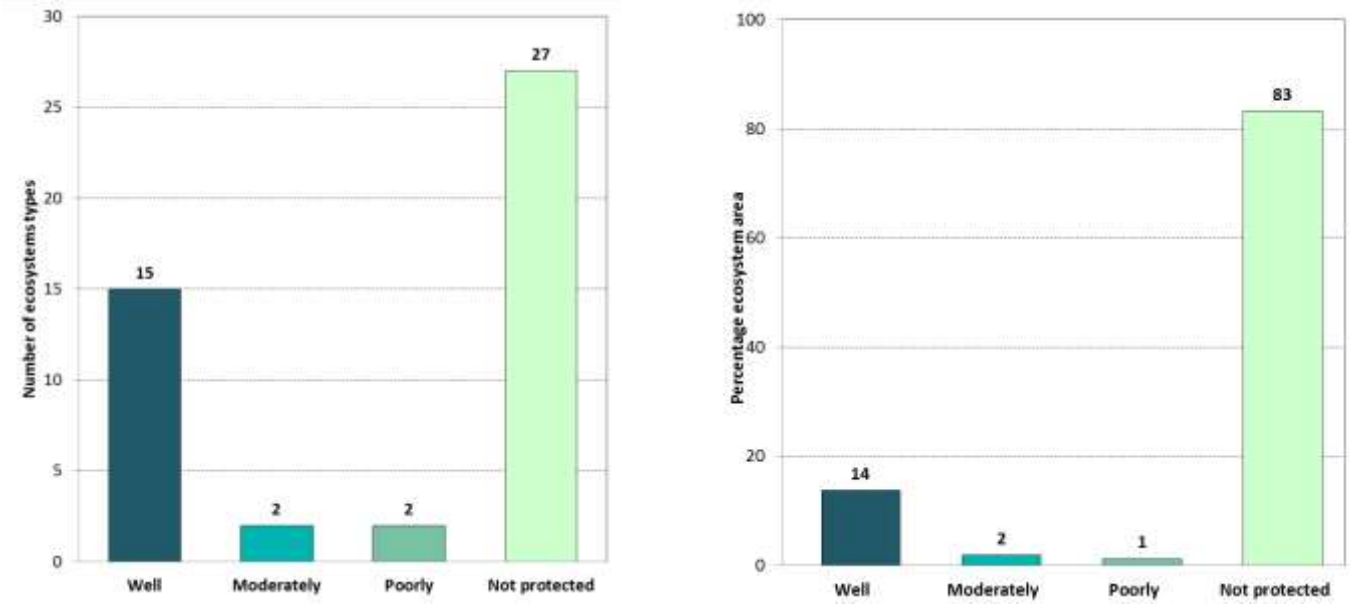


Figure 11.2 Protection levels of estuarine ecosystem types by percentage types and by percentage area in well, moderately, poorly or not protected category.

If protection levels are evaluated as the percentage area protected then the outcome becomes even more serious, with 83% of ecosystem types not protected, 1% poorly protected, 2% moderately protected and only 14% well protected.

Table 11.5 Protection levels of estuarine ecosystem types by biogeograpihical region.

Bioregion	Well	Moderately	Poorly	Not protected	Total
Cool Temperate	2	0	0	10	12
Warm Temperate	7	0	1	10	18
Subtropical	6	2	1	7	16
Total Number	**15**	**2**	**2**	**27**	**46**
SA %	**32.6**	**4.3**	**4.3**	**58.7**	**100**
Total area	**12 480**	**1 683**	**1 068**	**75 613**	**90 844**
SA %	**14**	**2**	**1**	**83**	**100**

If protection levels are evaluated as the percentage area protected, then the Cool Temperate biogeographical region has 99% of its ecosystem types not protected, followed by the Subtropical region at 88%, while the Warm Temperate region has about 44% of ecosystem types not protected. The Warm Temperate region has 48% of its ecosystem types as well protected, while the Subtropical region has only 10% it becomes clear that the Cool Temperate biogeographical region has the highest percentage, at 83%, of ecosystem types not protected (Figure 11.4), followed by the Warm Temperate region at 56% of types (see

Figure 11.5). At 44% the Subtropical region has the lowest number of ecosystem types not protected (Figure 11.6). The Subtropical region and the Warm Temperate region both have the highest number of well protected ecosystem types at 39% and 38% receptively, while the Cool Temperate on features 17% well protected ecosystem types. If protection levels are evaluated as the percentage area protected, then the Cool Temperate biogeographical region has 99% of its ecosystem types not protected, followed by the Subtropical region at 88%, while the Warm Temperate region has about 44% of ecosystem types not protected. The Warm Temperate region has 48% of its ecosystem types as well protected, while the Subtropical region has only 10% well protected. No ecosystem types are well protected in the Cool Temperate biogeographically region.

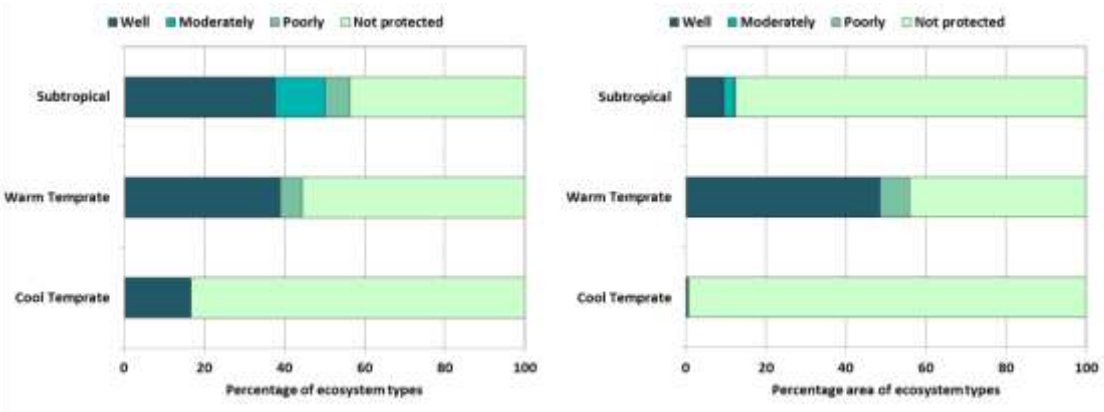


Figure 11.3 Protection levels of estuarine ecosystems by percentage types and by percentage area in well, moderately, poorly or not protected category for the three biogeographical regions.

An interesting and important finding was that if the health condition of the current degraded PA and MPA (i.e. estuaries in a C to F category) were to improve, the current protection levels of the well protected category would increase dramatically from 33% (15 types) to 46% (21 types). In terms of percentage ecosystem area, the well protected category would increase from 14% to 72%!!!! This finding indicates that a number of the current protected areas are in the correct location and, with the sound management interventions, significant progress can be achieved in the short term. It is therefore strongly recommended that degraded estuaries currently enjoying some form of formal protection (Lake St Lucia system, uMfolozi, Mgeni, Mhlanga, Seekoei, Heuningnes, Sand, Wildevoëlvlei, Diep, Orange) be restored to a functional status that allows them to fulfill their role in contributing to biodiversity targets.

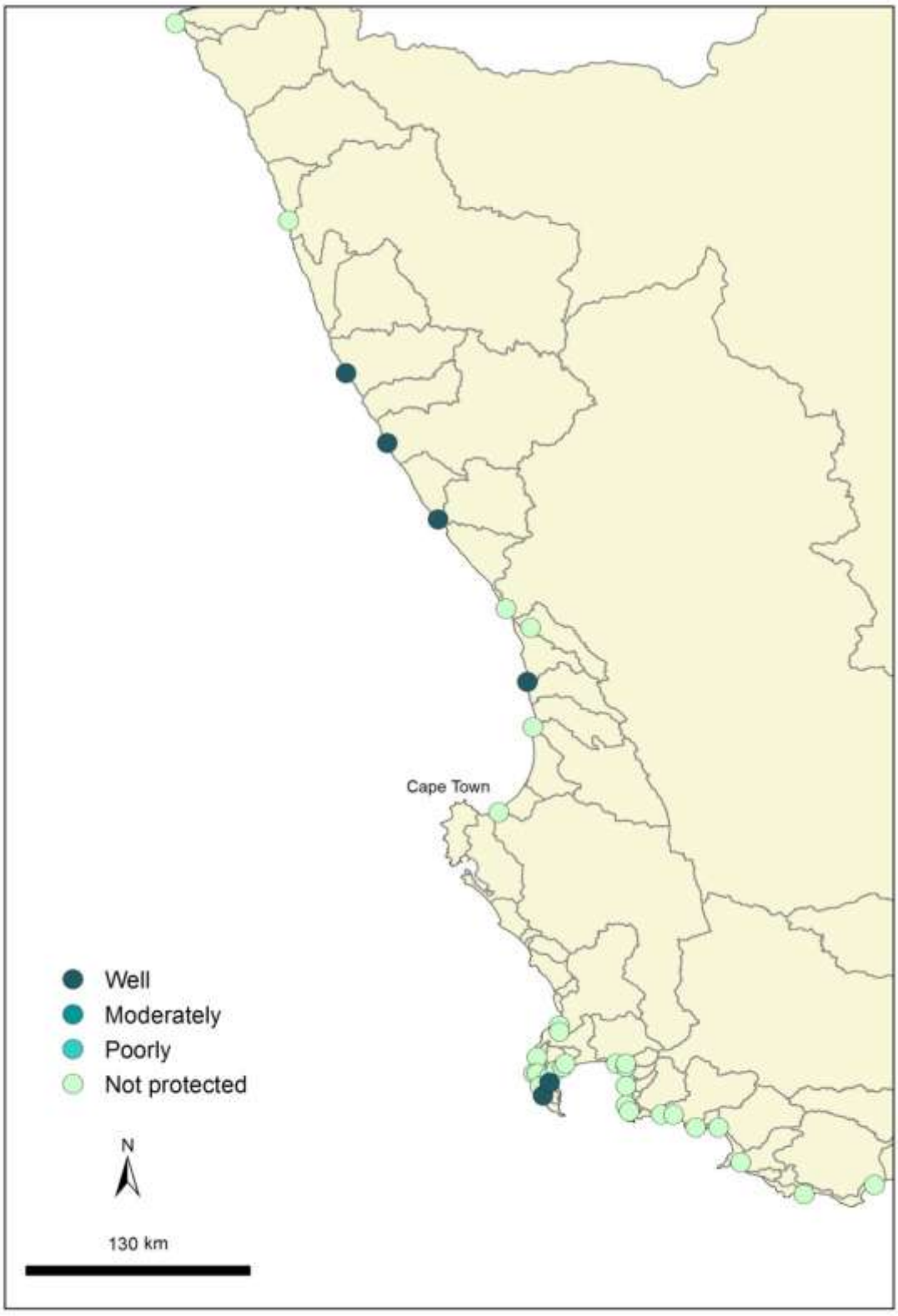


Figure 11.4 Ecosystem protection Levels in the Cool Temperate biogeographical region.



Figure 11.5 Ecosystem protection levels in the Warm Temperate biogeographical region.



Figure 11.6 Ecosystem protection levels of the Subtropical biogeographical region.

12. NATIONAL ESTUARIES BIODIVERSITY PLAN

JK Turpie, G Wilson & L van Niekerk

The main objective of this assessment was to develop a biodiversity plan for the estuaries of South Africa by prioritising and establishing which of them should be assigned partial or full Estuarine Protected Area (EPA) status. This assessment represents a significant milestone in that it is the first conservation planning exercise to include all South African estuaries. This chapter summarises the main report (Turpie et al. 2012).

12.1 Overall approach

Biodiversity planning is an evolving field that has allowed a move from *ad hoc* protection to systematic planning that takes pattern, process and biodiversity persistence into account. More recently, attention has been focused on incorporating socio-economic realities into conservation planning, particularly in terms of minimising the management and opportunity costs of protection. While we have not explicitly taken social and economic costs and benefits into consideration, we have taken ecosystem health into account, which provides a surrogate for the former to some extent. This is because estuaries where the opportunity costs of protection are likely to be high are also likely to be heavily-utilised systems that are in a lower state of health.

Biodiversity planning typically involves the following steps (expanded from Pressey & Cowling 2001):

1. Define the planning domain: This involves defining the region within which the conservation sites will be chosen, and may have a biogeographical or political basis.
2. Define the planning units: These are the sites that may be selected for conservation. In many cases these are defined by grid squares, hexagons or cadastral units (properties).
3. Set targets: Identify conservation goals for the region and set quantitative biodiversity targets for the biodiversity features (e.g. species, macrophyte communities and ecosystem types), and quantitative targets for minimum size, connectivity or other design criteria.
4. Gap analysis: Review existing protected areas, assessing the extent to which quantitative targets have already been achieved.

5. Select new sites: Select additional areas using algorithms to identify preliminary sets of new conservation areas for consideration by managers as additions to established areas.

Having initially concentrated on the representation of species, biodiversity planning has generally evolved to incorporate ecosystem processes and now gives greater emphasis to biodiversity persistence (e.g. Cabeza & Moilanen 2001). One of the biggest challenges is setting spatially-explicit targets for the maintenance of ecological and evolutionary processes. This involves identifying the processes, finding spatial surrogates for them and then setting targets (Pressey et al. 2003). Another key challenge is delivering a plan that not only achieves representativeness but which also ensures the persistence of targeted populations and maintenance of biodiversity (Reyers et al. 2002).

The overall goals of the core Estuarine Protected Area network to be developed here were as follows (Turpie & Clark 2007):

- Representativeness: all estuary-dependent species should be represented in viable numbers in the protected areas network;
- Maintenance of ecological processes: the protected area network should allow for connectivity and interaction with other adjoining ecosystems;
- Maintenance of fishery stocks: the protected area network should provide enough protection to exploited species that they are able to act as source areas for surrounding exploited areas; and
- Feasibility of implementation: consideration should be given to the practicalities of protection in each estuary. In this assessment we considered this through decisions about whether the estuary was able to achieve full or partial protection and by favouring, where possible, healthier estuaries that offer a lower rehabilitation and opportunity cost of protection.

Conservation planning involves defining the planning domain and units, then setting targets, assessing how well the current protected areas meet those targets and selecting new planning units to meet the targets subject to some constraint such as minimising the number of sites or the costs. A variety of sophisticated algorithms have been developed for this purpose. We made use of MARXAN (operated via CLUZ).

This assessment builds largely upon the C.A.P.E. Estuaries Conservation Plan that covered the Temperate regions of South Africa only.

12.2 Planning units

A total of 289[5] estuaries from the cool Temperate, warm Temperate and sub-tropical regions were included. The main objective was to identify which South African estuaries should be assigned protected area status. Where feasible, estuaries were divided into two (non-spatially-explicit) planning units, each theoretically representing 50% of the biodiversity features of an estuary. This allowed for the possibility of partial protection, as opposed to only having the option of conserving whole estuaries.

12.3 Biodiversity targets

Targets are often defined in terms of achieving representivity in ecosystem types, habitats and species, as well as meeting population targets that ensure their viability. The overall target was to conserve a minimum of 20% of total estuarine area. Targets for ecosystem type are sometimes used as a surrogate for biodiversity for which data are lacking. In the case of estuaries, ecosystem type is generally defined using Whitfield's (1992) five estuary types (bay, river mouth, permanently open, temporarily open and lake). In this assessment estuary type was redefined on the basis of mouth state, salinity structure and freshwater type, with a total of 25 types. A target of 20% was set for the total area of each type. Sensitivity analyses were conducted by excluding type and by expanding the number of types to 46 by including size.

Habitat targets were set at 20% of the total area of each type, except for mangroves and swamp forest habitats. Nationally, mangrove and swamp forest utilisation is regulated under the National Forests Act and destruction or harvesting of indigenous trees is prohibited. While the mangrove trees and swamp forest are protected, the area under the forests and the associated estuarine habitat in many cases is not. Because of this, targets were not set for mangroves or swamp forest per se, but instead protection was given to all estuaries that contained >5 ha of these habitats by automatically including them into the core set of estuaries, thereby offering formal protection to estuaries where swamp forest or mangroves occur. Population targets, based on numbers of individuals per species, were set for estuary dependent fish and bird species (84 and 35 species, respectively) as follows: 50% of the population for red data species, 40% for exploited species and 30% for the rest. Ecosystem and landscape level processes were accommodated by ensuring that the protected area set

[5] For practical planning purposes the St Lucia/UMfolozi and Mhlathuze/Richards Bay estuaries were treated as single systems, like all other joint systems, reducing 291 to 289 systems.

had a good geographic spread, included large as well as small estuaries, and favoured healthier estuaries. Alignment with existing and/or proposed terrestrial and marine protected areas was also taken into consideration.

12.4 Site selection procedure

Biodiversity planning algorithms are used to find the most efficient, or lowest cost, solution required to meet defined biodiversity targets. We used the MARXAN site optimisation algorithm, run through a GIS interface programme called CLUZ. MARXAN starts by selecting a random set of planning units, and then makes iterative changes to the set of sites by randomly adding or subtracting planning units. At each iteration within a run, the new set is compared with the previous set, and the better one is selected. Up to 50 runs of the MARXAN application were conducted at 1 million iterations per run. The programme then selected the best output from of the 50 runs.

While socio-economic costs and benefits were not included into the analysis, estuary health was incorporated as a cost, in that more degraded estuaries were assigned exponentially increasing cost values. Highly impacted estuaries probably also have relatively high costs in terms of conservation – both rehabilitation costs as well as forgone opportunity costs.

To account for data limitations, the opinions of the scientific and management community were also taken into account. Estuary scientists and managers participated in a workshop to finalise the definition of the planning units and their feasibility for protection, and to agree on which planning units should be automatically included into the final set, giving reasons. Finally, sensitivity analyses were conducted, in which the inclusion or definition of targets for estuary types was varied.

12.5 Results and recommendations

The primary analysis, which included targets for estuary type and size, suggested that 121 planning units in 116 estuaries would be required to meet the defined targets (see Figure 12.1 and Appendix C for more detail). This amounts to about 40% of estuaries and 80% of estuarine area. Variation of targets for estuary types did not have a significant impact on the result, and thus the results from the primary analysis were used. In total 58 estuaries require full protection (20%) while 63 estuaries require partial protection (22%). Fully-protected estuaries are taken to be full no-take areas. Partial protection might involve zonation that includes a no-take area, or it might address other pressures with other types of action. In both these cases, the management objective would be to protect 50% of the biodiversity

features of the partially protected estuary. Fully protected and partially protected estuaries can be considered Estuarine Protected Areas, whereas all other estuaries should be designated Estuarine Management Areas. All estuaries require a Management Plan, and these plans should be guided by the results of this assessment.

Based on the list of estuaries generated in this analysis, plus preliminary estimates of their present ecological status (health; this analysis) and their importance rating (Turpie & Clark 2007), the national and regional priorities for conservation can be determined. National priorities provide recommendations regarding the extent of protection required for each estuary, the recommended extent of the estuary perimeter that should be free from development to an appropriate setback line, and the preliminary Recommended Ecological Category (or recommended future health class) as required under the National Water Act.

Estuaries that require full protection include:

Orange	Lottering	Ku-Mpenzu	Mtamvuna
Spoeg	Elandsbos	Ku-Bhula/	Umgababa
Groen	Storms	Mbhanyana	Msimbazi
Krom	Elands	Ntlonyane	Mhlanga
Eerste	Groot (Oos)	Nkanya	Mvoti
Lourens	Tsitsikamma	Sundwana	Mdlotane
Palmiet	Maitland	Ngakanqa	Siyaya
Ratel	Gqutywa	Lwandilana	Mlalazi
Heuningnes	Ncera	Hluleka	St Lucia/ uMfolozi
Klipdrifsfontein	Kwenxura	Mntafufu	Mgobezeleni
Kaaimans	Quko	Mzintlava	Kosi
Goukamma	Ncizele	Mkozi	
Sout (Oos)	Nxaxo/ Ngqusi	Myekane	
Groot (Wes)	Ngqwara	Msikaba	
Bloukrans	Ngadla	Mtentu	

Estuaries that require partial protection include:

Olifants	Bot / Kleinmond	Gouritz	Keurbooms
Verlorenvlei	Klein	Wilderness	Kromme
Berg	Uilkraals	Swartvlei	Seekoei
Rietvlei/ Diep	Breede	Knysna	Gamtoos
Sand	Goukou	Piesang	Van Stadens

Swartkops	Qora	Mnyameni	Lovu
Sundays	Nqabara	Mpenjati	Durban Bay
Bushman's	Mbashe	Zotsha	Mgeni
Kariega	Xora	Mzimkulu	Mhlali
Great Fish	Mtata	Damba	Zinkwasi
Mgwalana	Mtakatye	Koshwana	Matigulu/ Nyoni
Bira	Mngazana	Intshambili	Mhlathuze/
Keiskamma	Mzimvubu	Mhlabatshane	RichardsBay
Gqunube	Nkodusweni	Mfazazana	
Kwelera	Mbotyi	Kwa-Makosi	
Great Kei	Mkweni	Mkomazi	

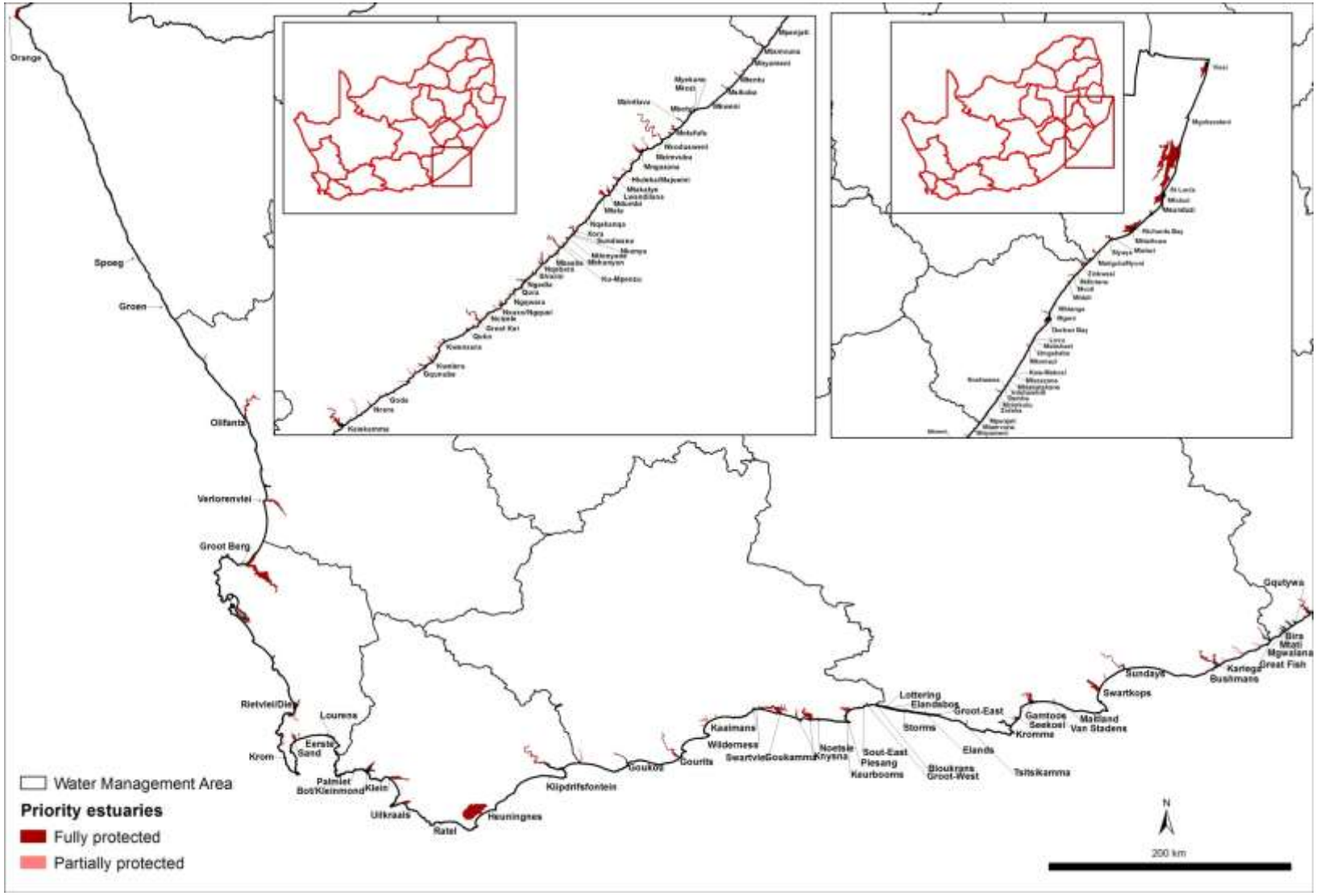


Figure 12.1 National priority estuaries for biodiversity conservation.

13. HOW VULNERABLE ARE SOUTH AFRICA'S ESTUARIES TO CLIMATE CHANGE ?

L van Niekerk, F Engelbrecht, N James, A Meyer & A Theron

Estuaries form an interface between the land and sea and are strongly influenced by runoff, wind, wave action, air and water temperatures from the land and sea. Consequently, climate change is likely to have a profound effect to the structure and functioning of estuaries, and may have a range of implications for estuarine biota (Kennedy, 1990).

13.1 Processes by which climate change may alter South Africa's estuaries

13.1.1 Ocean processes

Large scale coastal currents determine, to a large degree, coastal climate which in turn will impact on estuarine dynamics. The physical properties and circulation features of South Africa's coastal zone are determined by the two large scale ocean currents which are located very close to the South African coast, i.e. the Agulhas Current along the east and south coasts and the Benguela Current along the west coast. Any change in both currents' average positions will impact not only on the properties and circulation of the coastal zone, but will also impact on the coastal flora and fauna (including estuarine species),

It was recently demonstrated using hydrographical and satellite observations, as well as state of the art climate models, that both green house gas (GHG) induced global warming and the anthropogenic induced ozone hole have caused an intensification and southwards shift of the Southern Hemisphere Sub-tropical gyres over the last 40 years (Cai et al. 2006, and references therein). Modern global climate models based on present day atmospheric CO_2 levels and projected levels of increasing CO_2 levels, motivated by the IPCCs estimates of a 1% increase in CO_2 per year up to the year 2100, show that the above trend in the ocean circulation will continue (Saenko et al. 2005). These global predictions for oceanic climate change will have a definite impact on the coastal-open ocean circulation around South Africa.

Lutjeharms and de Ruijter (1996) argue that with global warming the Agulhas Current will exhibit increased meso-scale meandering which will force the current on average further offshore from its mean position. In the present global climate regime the Agulhas Current is located within 15 km from the shore 77% of the time. However, perturbations in the form of large-amplitude intermittent meanders (Natal Pulses) can force the current's core up to

300 km offshore. The meander modes of the Agulhas Current occur between 4 to 6 times per year. Lutjeharms and de Ruijter (1996) suggest that the meander modes will increase in frequency due to global warming and that the current will be located on average further from the coast line. This will lead to cascading impacts on the coastal climate and dynamics, e. g. rainfall and the movement of marine flora and fauna along the coast and into/out of estuaries.

The exchange of large quantities of warm water from the Indian to the Atlantic Ocean (Agulhas Leakage) via the Agulhas Retroflection influences the south and west coasts of South Africa (Figure 13.1). Agulhas Leakage occurs via the intermittent occlusion of the Agulhas Retroflection loop to form the world's largest anti-cyclonic vortices, called Agulhas Rings. Each year between 4 to 8 rings of varying sizes (200 to 400 km in diameter) are pinched off and advected north-westward into the south eastern Atlantic Ocean along the west coast of South Africa.

Two modes of the Agulhas Retroflection exist, a downstream (normal) mode (Figure 13.1a) and an upstream mode (Figure 13.1b). During the upstream mode the Agulhas Leakage is markedly reduced, which leads to cooler sea surface temperatures for the southern and western oceanic and coastal regimes, compared to during the normal Agulhas Retroflection mode. An increase occurrence in the average upstream mode will lead to drier coastal climates along the west and south of South Africa, thus impacting on river run-off and estuarine dynamics.

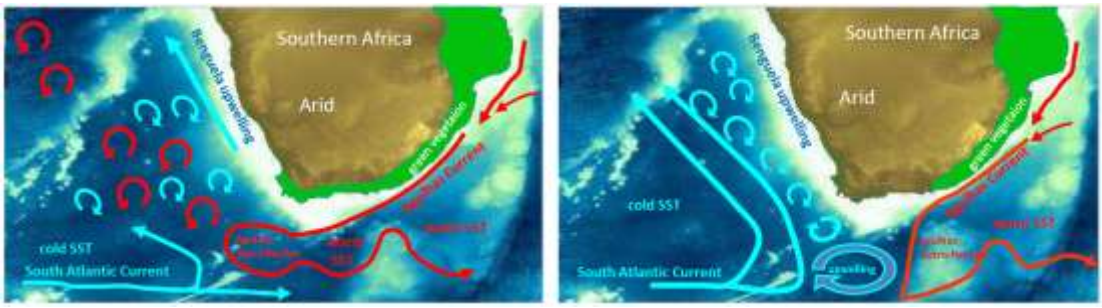


Figure 13.1 Current regimes around South Africa; (a) normal downstream mode of the Agulhas Retroflection, leading to Agulhas Leakages via warm core Agulhas Rings, (b) Upstream Retroflection mode leading to a reduction in Agulhas Leakage and cooler temperatures.

Stronger Agulhas Current transport has been predicted due to global warming. The impact of a stronger Agulhas Current on the retroflection mode is still unclear. Cai et al. (2007) and Rouault et al. (2009) indicate that the increase in Agulhas Current transport will lead to an associated stronger Agulhas Leakage with more warm Indian Ocean water passing the southern and western coasts of South Africa. The model study of Van Sebille et al. (2009)

show the opposite - that an increase in Agulhas Current transport will lead to a higher frequency of Upstream Retroflections, with a concomitant decrease in Agulhas Leakage. Either way, the impact of a stronger Agulhas Current will have definite effects on the coastal climate of South Africa.

On the western coast of South Africa the Benguela Current (or drift) will intensify and lead to more intense upwelling due to the spinning up of the Supergyre (Roemich 2007; Saenko et al. 2005). This will induce much cooler sea surface temperatures along the west coasts of South Africa than present. However, the intensification of the South Atlantic Sub-tropical gyre may also lead to increase atmospheric subsidence, less clouds, increase insolation and higher air temperature over the Benguela Upwelling System (Lutjeharms et al. 2001). The latter will result in warming of the surface water which may negate the increase upwelling of cooler waters. Another mechanism that may influence the Benguela coastal region are Agulhas Rings and filaments which drift sometimes very close up the west coast, raising the temperature of the nearshore waters and occasionally interacting with upwelling plumes, both of which have important consequences for fish recruitment (Duncombe Rae et al. 1992).

13.1.2 Rainfall and Runoff

Climate change will alter precipitation patterns which will affect the quality, rate, magnitude and timing of freshwater runoff to estuaries and will exacerbate existing human modifications of river inflows (Alber 2002; USEPA 2009). Estuarine functioning is strongly influenced by the magnitude and timing of freshwater runoff (Meynecke et al. 2006). Downscaled regional climate models (RCMs) derived from global climate models (GCMs) indicate the likelihood of increased summer rainfall over the eastern part of South Africa, the interior and the Drakensberg Mountains. The greater rainfall projected for the east would be in the form of more rain days and more days with bigger rainfalls. If these scenarios are correct, the combination of wetter antecedent conditions and larger rainfall events would result in more runoff being generated. Less rainfall is projected along the west coast and the adjacent interior, with the possibility of a slight increase in inter-annual variability. If correct, this would result in a decrease in flows and an increase in flow variability, since changes in precipitation are amplified in the hydrological cycle (Lumsden et al. 2009. Hewitson & Crane, 2006). The models also show an increase in heavy / extreme precipitation events in the summer over the east coast of KwaZulu-Natal along with an increase in rain days for much of the country, excepting possibly the extreme west / southwest (Hewitson et al. 2005). Schultze et el. (2005) predict that climate change may cause hydrological “hotspots” of change, one being

the present winter rainfall region in the Western Cape. Changes in precipitation and runoff ultimately also drive changes in nutrient and sediment supply to estuaries and the coast. It will also affect related human adaptation strategies to reduce risk, e.g. increase impoundment and land use change, which will increase the rate of change in primary inputs (flow, sediment and nutrients) to estuaries and the coast.

13.1.3 Increase in the frequency and intensity of sea storms

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change predicts, an increasing frequency and intensity of extreme weather events in the 21st Century (IPCC 2007). The frequency and magnitude of severe weather events such as tropical cyclones, hailstorms, droughts and floods appears to be on the increase globally and possibly in South Africa (IPCC 2007). In South Africa, increases in either intensity or frequency, or changes in seasonal storm intensity have been recorded at a local scale albeit on a very short time-scale (Guastella and Rossouw 2009, Harris et al. 2010).

Preliminary findings indicate that there may be long-term trends in regional metocean climates, while sea level rise alone will greatly increase the impacts associated with extreme sea-storm events (Theron 2007). The regional variation in the global wave climate was demonstrated by Mori et al. (2010), who, in simulating future trends, predicted that the mean wave height might generally increase in the regions of the mid latitudes (both hemispheres) and the Antarctic ocean, while decreasing at the equator. Wang et al. (2004), Komar and Allan (2008) and Ruggerio et al. (2010) provide further evidence of a general wave height increase and increasing storm intensities in the Northern hemisphere. Such changes in the regional metocean climates are expected to have significant impacts on local coastal areas. It is therefore important to also investigate possible future climatic changes off the southern African coastline as well as the expected associated impacts. As can be anticipated, a more severe wave climate (or related oceanic wind climate) will result in more storm erosion, potentially more coastal sediment transport, and greater coastal impacts.

Preliminary analyses conducted by Rossouw and Theron (2009) found that the annual mean significant wave height (Hm_0) for the wave data collected off Richards Bay and Cape Town indicate no real progressive increase. This may appear to contradict the findings of the IPCC, as presented in PIANC (2008), but the South African results may reflect a regional aspect of the impact of climate change. Although the averages appear to remain constant, there seems to be some change in the individual storms. For example, considering the peaks of individual storms off Cape Town during the more extreme winter period (June to August), an increase of about 0.5 m over 14 years is observed. This result may be indicative

of a significant increase in the “storminess” over the next few decades. It is also worth noting that the opposite occurs during summer: there has been a general decrease over the last 14 years with regard to individual storms off Cape Town. However, it must be noted that the South African wave record is too short to make any firm conclusions at present. To some extent it could be said that the preliminary “trend” indicated by the South African wave data is supported by the model predictions of Mori et al. (2010), which appear to show an increase in wave height for the South African coast of roughly 6% for extreme events (Theron et al. 2010, submitted).

Wave climate and conditions are determined by ocean winds (velocity, duration, fetch, occurrence, decay, depth, etc.). Predicted values for potential changes in oceanic wind regimes off southern African are lacking. In view of this shortcoming and to enable an assessment of the potential impacts of stronger winds, a relatively modest increase of 10% could be assumed. Thus, a modest 10% increase in wind speed, means a 12% increase in wind stress, a 26% increase in wave height, and as much as an 80% increase in wave power (Theron 2007). This means that a modest 10% increase in wind speed could also result in a potentially significant increase in coastal sediment transport rates and consequently impact on estuarine mouth regimes.

13.1.4 Sea level rise

Recent calibrated observations from satellites, are that global sea level rise over approximately the last decade has been 3.3+/- 0.4 $mm.yr^{-1}$ (Rahmstorf et al. 2007). The IPCC AR4 Report (IPCC 2007) concludes that anthropogenic warming and sea level rise will continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations are stabilised. Comparisons between approximately 30 years of South African tide gauge records and the longer term records elsewhere, show substantial agreement with global trends (Theron 2007). A recent analysis of sea water levels recorded at Durban confirms that the local rate of sea level rise falls within the range of global trends (Mather 2008). Present South African SLR rates are: west coast +1.87 $mm.yr^{-1}$, south coast +1.47 $mm.yr^{-1}$, and east coast +2.74 $mm.yr^{-1}$ (Mather et al. 2009).

The probability of sudden large rises in sea level (possibly several metres) due to catastrophic failure of large ice-shelves (e.g. Church and White 2006) is still considered unlikely this century, but events in Greenland (e.g. Gregory 2004) and Antarctica (e.g. Thomas et al. 2004) may soon force a re-evaluation of this assessment. In the longer term

the large-scale melting of large ice masses is inevitable. Recent literature (subsequent to IPCC 2007) give a wide range of SLR scenarios, but most "physics/process based" projections for 2100 are in the 0.5 m to 2 m range (Rossouw and Theron 2009; Shore & Beach Special Review Issue, November 2009).

13.2 Quantification and mapping of risks

13.2.1 Changes in precipitation and runoff

In principle, all estuaries are sensitive to changes in river inflow. The four major consequences of modifications in river inflow are: changes in the extent of seawater intrusion; changes in the frequency and duration of mouth closure, decrease/increase in nutrients fluxes, and changes in the sediment deposition/erosion cycles.

i) Changes in the extent of seawater intrusion

Reduction of fluvial flow into estuaries may have a range of effects on the salinity regime. The degree to which seawater will enter an estuary is dependent on river inflow and the bathymetry of the system, i.e. seawater penetration into the more constricted upper reaches is often constrained by river inflow, with relative easy penetration into the deeper middle reaches; and with the lower reaches generally dominated by tidal flows. Often it is thus the middle reaches of an estuary that shows the most sensitivity to changes in flow (river and tidal).

For example, in large systems flow reduction may initially result in a reduction in the extent of the estuarine mixed zone i.e. that section of an estuary with salinity between 20 and 10. Further reduction in stream flow can result in the complete elimination of this mixed zone so that, effectively, the system functionally becomes an arm of the sea e.g. the Kromme Estuary (Scharler and Baird 2000; Snow, Bate and Adams 2000; Wooldridge and Callahan 2000; Strydom and Whitfield 2000; Bate and Adams 2000). If there is no inflow at all a reverse salinity gradient may develop, where the salinity at the head of the estuary may exceed that of seawater e.g. the Kariega Estuary (Bate et al. 2002; Whitfield and Paterson 2003).

In addition to supporting a resident estuarine fish assemblage, estuaries are important nursery, refuge and feeding areas for numerous marine fish species (Elliot et al. 2007). Reduced freshwater inflow may reduce the (primary) productivity of an estuary, thereby reducing the food available to juvenile fishes (Strydom and Whitfield 2000). This will have an adverse effect on fish recruitment, growth, survival and production or recruitment into the

adult population (Dolbeth et al. 2010). Reduction in stream flow in temporarily open/closed systems may lead, paradoxically, to a reduction in salinity in many small systems. Reduction in inflow can lead to mouth closure and, provided that the river inflow still exceeds evaporation and seepage losses, a progressive freshening of the estuary until such time as rising water levels lead to a breaching of the berm closing the mouth, e.g. Groot Brak. The impact is an almost complete loss of the marine species with only a few estuarine and freshwater species remaining (Whitfield 2005). Mass mortalities of marine fish species have been recorded in the Bot when salinities declined to 2-3 and temperature was less than 18°C (Bennett 1985).

Increased stream flow will also reduce, or prevent salinity penetration into an estuary, i.e. increase the estuarine mixed zone. In a very small system, or if there is a significant increase in river flow, an estuary with a full salinity gradient may be turned into a fresh water dominated system, with a related reduction in water residence times and associated primary production.

ii) Changes in the frequency and duration of mouth closure

Temporarily open/closed estuaries (TOCEs) become isolated from the sea by the formation of a sand berm across the mouth during periods of low or no river inflow. Such estuaries stay closed until their basins fill up and their berms are breached by increased river flow. A major consequence of stream flow reduction is, therefore, a change in the frequency and duration of estuary mouth closure in TOCEs. In extreme cases fresh water reduction can cause permanent mouth closure.

The consequences of these physical changes for the biota can be severe. For example the mudprawn *Upogebia africana* has an obligatory marine phase of development during the larval stages. Estuary mouth closure, particularly for extended periods (e.g. >1 year), disrupts the life cycle and can result in local extinction of the mudprawn (Wooldridge and Loubser 1996). Some demersal zooplankton species exhibit tidally-phased migratory behaviour (Schlacher and Wooldridge 1995). Mouth closure removes the tidal signal and thereby disrupts the life cycles of these organisms.

Prolonged closed phases in TOCEs result in a low recruitment potential for juvenile marine fish and effectively prevent the emigration of adults back to sea (Vorwerk et al. 2003). During extended closed phases, fish populations may also decrease considerably due to predation (by other fishes, birds and mammals). For example, predation by piscivorous birds

(cormorants, darter and heron) reduced the size of the Cape stumpnose *Rhabdosargus holubi* population in the West Kleinemonde Estuary by 80% (1971) and 20% (1972) respectively over a six to seven month period (Blaber 1973). In severe cases the number of fish will be so greatly reduced by predation that, should the mouth eventually open, their numbers will be so low as to make an insignificant addition to the adult population in the open sea. Alternatively the fishes may simply die in the estuary without ever having had the opportunity to breed.

In the case of birds, mouth closure will lead to a loss of tidal action which, in turn, will adversely affect the quantity and availability of intertidal benthic organisms to waders that forage mainly on intertidal mudflats. Many of these waders are Palaearctic migrants; therefore mouth closure can have an international impact on the populations of such birds. Other effects of reduced stream flow include the loss of shallow water habitats, favoured by herons, flamingos and other wading birds, and the loss of islands, which provide roosts and breeding sites safe from terrestrial predators.

iii) Changes in nutrients

Changes in river flow regimes also affect the nutrient loads entering estuaries. Freshwater flowing into estuaries is an important source of nutrients, both dissolved and particulate. Dissolved nutrients include nitrates, phosphates, silica and trace metals essential for primary production. Particulates such as organic detritus derived from riparian vegetation may, in some systems, be an important source of carbon for the estuarine food web.

Reduction in freshwater inflow (as a consequence of dam development or climate change) will reduce the quantity of nutrients entering the estuary, with the resultant impoverishment of the biota. In particular primary producers such as phytoplankton and benthic diatoms, will be adversely affected with a consequent “knock-on” effect through the entire food chain (Allanson and Read 1987). Increased freshwater inflow will likewise increase the quantity of nutrients entering the estuary, but the biological response will depend on retention. In the shallow perched estuaries of KwaZulu-Natal increased inflow goes hand in hand with, decreased retention time and therefore often results in decreased production.

iv) Decrease in the dilution and or flushing of pollutants

A decrease in river flow into some of the urban systems could extend the closed mouth conditions in some of the temporarily open/closed estuaries, where the combination of high

water retention time and warmer water would provide the ideal breeding ground for some disease-causing bacteria.

An increase in inflow from rural areas, associated with higher nutrient loads from fertilizers, will increase nutrient loads to estuaries with a related increase in eutrofication. Similarly, an increase in storm runoff from urban catchments would lead to an increase in fertilisers, herbicides, pesticides, hydrocarbons and solid litter to estuaries.

v) Changes in sediment processes

Floods in estuaries scour sediment deposited during periods of low flow. This accumulated sediment is both catchment derived and brought in from the sea by flood tides. Soil erosion in catchments poses a major threat to estuaries, particularly those in KwaZulu-Natal and those in the former Ciskei and Transkei regions of the Eastern Cape Province (Morant and Quinn 1999). The potential denuding of vegetation in arid catchments (i.e. increasing the erodibility of soils) coupled with an increase in the frequency of high intensity rain events due to climate change would lead to a significant increase in the deposition of sediment in estuaries.

It is also foreseen that the potential water shortage, especially in the Western Cape, would lead to the need to build more dams to secure water supplies to urban areas and agriculture. Major dams may have the effect of capturing minor (annual) flood peaks entirely and attenuating major flood peaks. The degree to which this will occur depends on the ratio of dam volume to the MAR, the level in the dam preceding the flood, and the size of the flood. Therefore, if floods are reduced in intensity and frequency, sediment deposition and accumulation occurs and the estuaries are reduced in water volume and surface area.

Numerous small farm dams, as well as barrages and weirs, collectively may also have a major impact on the variability and duration of stream flow and consequently on estuaries. Instead of being available as stream flow the water is stored and subjected to consumption and losses, including evaporation and seepage. It is estimated that as little as 8% of the total annual runoff reaches the coastal zone (Department of Water Affairs 1986). Higher temperatures, with the related increase in evaporation due to climate change, will not only increase the need to build more farm dams but also will exacerbate the impact of existing dams on the aquatic environment.

13.2.2 Rising temperatures

Projected temperature increases in the average global surface atmosphere range from a low scenario of 1ºC to 3ºC with a potential upper rage of 6ºC by 2100 (IPCC 2007). Shallow water, such as estuaries, will exhibit greater increases in temperature than deeper waters (Rijinsdorp et al. 2009, James et al. 2008a).

Temperature influences the biology of organisms (mortality, reproduction, growth, and behaviour). Temperature can also influence interactions among organisms (e.g. predator prey, parasite-host, competition for resources)). Species are adapted to, and distributed within, specific ranges of environmental temperatures (Harrison and Whitfield 2006, Maree et al. 2000, Elliot 2002). Many organisms are more stressed near their species range boundaries (Sorte and Hoffman 2004). As temperature changes, the geographical distribution of species, depending on their tolerances or preferences, may contract or expand, leading to new and unpredictable species interactions (Murawski 1993, Harley et al. 2006, Clark 2006, Perry et al. 2005, USEPA 2009). Areas of cooling may, however, limit the ability of species to shift their distribution resulting in a decrease in the range of certain species in South Africa. Ultimately, the present species, community and assemblage composition of many South African estuaries may change.

In recent years a number of subtropical species such as the coachman *Heniochus acuminatus*, checked goby *Redigobius dewaali* and blacktip kingfish *Caranx heberi* have extended their range 200 to 1000 km south to the Breede Estuary (Lamberth, unpublished data). James et al. (2008b) and Mbande et al. (2005) highlight the increased occurrence of tropical fish species in estuaries along the East Coast of South Africa (e.g. East Kleinemonde and Mngazana). Of the six tropical species recorded in the East Kleinemonde Estuary, longarm mullet *Valamugil cunnesius* and robust mullet *Valamugil robustus*, have been recorded consistently in the estuary every year after 2002, and are found in both summer and winter indicating that water temperatures are continually within the tolerance range of these species (James et al. 2008b). In the Mngazana Estuary the proportion of tropical species recorded in winter increased from 1975 to 2002. Higher average temperatures would favour tropical species during winter, while limiting the northward penetration of certain Temperate species (Mbande et al. 2005).

Species that are unable to migrate, or compete with other species for resources, may face local or global extinction. Although higher temperatures might not result in the extinction of a species throughout its range, the species may be eliminated from part of its range.

Communities do not shift their distribution as a unit. Movement into newly suitable habitats depends on: 1) the number of adults available in the original habitat and their ability to bear young; 2) an adequate number of potential colonisers; 3) the ability of potential colonizers to move into new habitats; 4) the survival of an adequate number of individuals in the new habitat to ensure genetic diversity to meet challenges and to produce succeeding generations (Kennedy et al. 2002). Thus the loss of species from an estuary that has become too warm may reduce species diversity in that estuary in the short term, depending on the mobility of new colonizers, their ability to tolerate higher temperatures and their tolerance for the higher salinities of the marine environment. Warming is likely to result in new mixes of foundation species, predators, prey and competitors (USEPA 2009, James and Hermes 2011). For example, fishes with the most temperature sensitive distributions include many key prey species of non-shifting predators (Perry et al. 2005).

Mobile organisms such as fish, swimming crabs, and shrimp can quickly colonise new habitats, while immobile or relatively immobile invertebrates such as oysters will disperse more slowly. Changes in temperature will also affect coastal vegetation with more subtropical species moving further south, i.e. the invasion of salt marsh habitats by mangrove species (Steinke 1999, Adam 2002, Gilman et al. 2008).

Temperature also influences the amount of oxygen that water can hold, warmer water holds less oxygen than cooler water. Most aquatic organisms extract oxygen from the waterbody they live in. The effect of higher temperatures and less oxygen could be to constrict the available habitat for certain species. Temperature changes can even influence water circulation patterns within an estuary (Kennedy et al. 2002).

13.2.3 pH change

The reduction in pH that accompanies elevated CO_2 concentrations may have profound implications for coastal and marine ecosystems (Harley et al., 2006, James and Hermes 2011). The pH of surface waters may decrease by 0.3-0.4 units by 2100 under the influence of rising atmospheric CO_2 levels (Caldeira and Wickett 2003). The resulting decrease in pH will affect all calcifying organisms, as structures made of calcium carbonate would start to dissolve requiring more metabolic energy for an organism to maintain its exoskeleton. Estuarine organisms that may be affected include coralline algae, echinoderms, crustaceans and molluscs (USEPA 2009, James 2010).

13.2.4 Increase in the frequency and intensity of sea storms

A number of small to medium sized estuaries (e.g. Groot Brak) show great sensitivity to increased wave action. In general, large storms at sea create the wave conditions that will close such estuaries, unless there is significant river flow to maintain the open mouth condition. An increase in storminess due to climate change would, therefore, increase the occurrence of mouth closure and generally transport more marine sediment into an estuary than at present. Estuaries along an exposed, sediment rich coastline (e.g. parts of KwaZulu-Natal) would be more likely to close than estuaries that are fairly protected, or those located on sediment starved coastlines (e.g. the Transkei and Tsitsikamma coastlines).

13.2.5 Sea level rise

Sea level rise can either counteract the reduction in runoff to an estuary or exacerbate the effect depending on the size of the estuary, the sediment availability, and the wave energy near or at its mouth. In the case of small, temporarily open/closed estuaries sea level rise could assist in maintaining open mouth condition through increasing the tidal prism, if the system is sheltered from wave action and/or little sediment is available near its mouth. Alternatively, sea level rise could merely reset the level at which an estuary closes to the same relative height above mean sea-level, without significantly affecting the amount or duration of mouth closures. Alternatively, an increase in storminess might actually increase the frequency and or duration of the mouth closure due to increased marine sediment transport into the mouth area during sea storms. In the case of permanently open estuaries, sea level rise may lead to an increase in the saline penetration (especially in the middle reaches) and require additional freshwater to maintain the same salinity gradient as at present, i.e. it may be necessary to increase the ecological flow requirement to maintain present ecological production levels.

Climate change and sea level rise will increase the pressures on management agencies to implement assisted (and often premature) breaching as increasingly properties will be below the level of the sand berm near the mouth. The response of humans to sea-level rise may take the form of actions destructive to estuaries, such as armouring the coastline with berms or dykes that will prevent biological systems from adjusting naturally (e.g. by inland retreat of wetland). An example of an impact on the biophysical processes is the loss of salt marsh and mangroves leading to a decrease in estuarine habitat and food supply. An indirect impact is an increase in turbidity as sediment is no longer trapped by the fringing vegetation around an estuary. This, in turn, reduces light penetration thus causing a decrease in primary production by microalgae, while “tactile” feeders will benefit at the expense of

"visual" feeders (e.g. estuarine round herring *Gilchristella aestuaria* vs Cape silverside *Atherina breviceps*). Furthermore, some mangrove and salt marsh systems may not be able to keep pace with more rapid levels of sea-level rise. Mangroves may out compete saltmashes in the subtropical areas in response to rising sea level (Adam 2002).

13.3 Key findings

In summary, the impacts of climate change on estuaries include:

- Changes in precipitation and runoff with the following consequences for estuaries:
    - Modifications in the extent of saline water intrusion;
    - Changes in the frequency and duration of mouth closure;
    - Decrease or increase in nutrients fluxes; and
    - Changes in the magnitude and frequency of floods and related sediment deposition/erosion cycles.
- Changes in the dilution and or flushing of pollutants;
- Rising temperatures from both the land and sea;
- Sea level rise;
- Changes in ocean circulation patterns; and
- Increase in frequency and intensity of coastal storms.

The details of this assessment are presented in **Error! Reference source not found.**. The esultant analysis shows that the KwaZulu-Natal and West Coast estuaries will be the most effected by climate change from a structural and functional perspective. In the case of KwaZulu-Natal the major driver of change is increased runoff into the numerous small, perched (estuary volume decrease by 50 to 90% when open to sea) temporarily open/closed estuaries, which will result in more open mouth conditions, a decrease in retention time and a related decrease in primary productivity and nursery function.

Table 13.1 Summary of the responses of the South African estuaries to climate change drivers

Drivers	Response	Sub-Tropical		Warm Temperate		Cool Temperate
		KwaZulu Natal	Transkei	Eastern Cape	Southern Cape	Western Cape
Changes in ocean circulation patterns	Current speed	Intensification of the Agulhas Current	Intensification of the Agulhas Current	Intensification of the Agulhas Current	Possible increase in divergence of the Agulhas Current from the coast due to Upstream Retroflection, or increase in warm saline water leakage from the Indian to the Atlantic via the Agulhas retroflection. Unclear which process will dominate.	Benguela Current (Drift) will increase with global warming due to the spin up of Southern Hemisphere Subtropical Gyres, which will lead to intensification of eastern boundary upwelling. However, this may be counteracted by increase insolation due to clear skies over the upwelling region, or the leakage of warm Agulhas waters due to rings and filaments.
	Current position	Intensification of Agulhas Current may lead to increase meso-scale meandering in this very stable current due to Natal Pulses. This will force the current on average futher off-shore	Intensification of Agulhas Current may lead to increase meso-scale meandering in this very stable current due to Natal Pulses. This will force the current on average futher off-shore	Intensification of Agulhas Current may lead to increase meso-scale meandering in this very stable current due to Natal Pulses. This will force the current on average futher off-shore	Still unclear whether upstream or down stream mode of the Southern Agulhas Current will dominate. An upstream mode will lead to an absence of the Agulhas Curent along the south western coast of south Africa.	Unknown, assume similar to present
	Upwelling	Increase shelf upwelling - due to increase pulses, topographic upwelling and Ekman veering. Increasing nutrient input and related primary production in the nearshore and lower reaches of open estuaries	Increase shelf upwelling. Increasing nutrient input and related primary production in the nearshore and lower reaches of open estuaries	Increase shelf upwelling but the coastal shelf is very wide so the effect of increased nutrient input and production on the nearshore and lower reaches of open estuaries is less apparent	Increase upwelling downstream from prominent capes due to local wind regimes. Increasing nutrient input and related primary production in the nearshore and lower reaches of open estuaries	More upwelling due to a increased wind stress, causing increase nutrient input and related primary production in nearshore and estuaries. Also a related decrease in black tide events (i.e. Berg Estuary)
Changes in precipitation	Changes in runoff	Significant increase in runoff, both in base flow and in flood events.	An increase in runoff both in base flow and in flood events.	Similar to present, with a slight increase in runoff (base flow and floods)	Similar to present, with a slight decrease in runoff with especially baseflows reduced	Significant decrease in runoff, with especially baseflows severely reduced.
	Changes in the frequency and duration of mouth closure	Temporarily open systems close less often in decreasing periods of high productivity. These system most productive when closed.	Increased flow causing a slight decrease in closed mouth conditions in temporarily open systems is expected. This could be offset by increased sedimentation.	Similar to present, but some decrease in closed conditions in temporarily open systems depending on the size of the system and the inflow regime.	Similar to present, with a some increase in closed conditions in temporarily open systems depending on the size of the system and the inflow regime.	Decrease in runoff causing a significant increase in closed conditions in temporarily open systems
	Modifications in the salinity regime	Less salinity penetration in large permanently open and smaller temporarily open systems. (KZN characterise by limited saltwater penetration under open mouth conditions resulting in fresh closed conditions.)	Some decrease in salinity penetration of permanently open systems. An increase in open mouth conditions for some smaller temporarily open systems depending on the size of the system and the inflow	Similar to present, but could have a slight decrease in salinity penetration in some large open estuaries. A slight increase in open mouth conditions for some smaller temporarily open systems depending on the size	Similar to present, but limited increase in salinity penetration in some large permanently open estuaries. Some freshening (decline in average salinity) under increased closed mouth conditions in some smaller	Significant increase salinity penetration in large permanently open estuaries, but some freshening (decline in average salinity) under increased closed mouth conditions in smaller temporarily open systems

Drivers	Response	Sub-Tropical		Warm Temperate		Cool Temperate
		KwaZulu Natal	Transkei	Eastern Cape	Southern Cape	Western Cape
			regime	of the system and the inflow regime	temporarily open systems.	
	Decrease/ increase in nutrients fluxes	Increased nutrient supply, but less retention in the large number of smaller perched systems that drain > 50 % of volume when open. Decrease in primary production. The exceptions are the estuarine lakes and bays which have higher retention and will likely have an increase in production.	Some increase in nutrient supply, more retention as systems are less perched, increased primary production	Very similar to present, but with some increase in nutrient supply, more retention as systems are less perched, increased primary production	Very similar to present, but with some decrease in nutrient supply which is not likely to be offset by increased retention. Resulting in a some loss of primary production	Decrease in nutrient supply which is not likely to be offset by increased retention. Resulting in a significant loss in primary production
	Changes in floods (magnitude, duration and frequency) and sediment deposition/erosion cycles	Increase in flooding with related increased erosion in catchments will lead to more infilling and decreased substrate stability – resulting in depauperate biotic communities as there is little floodplain habitat available on the KZN coast – floodplains mostly confined to estuarine lakes and bays.	Some increase in flooding with related increased erosion in catchments (exacerbated by current land use). This will lead to more infilling, changes of sandy habitats to muddy habitats and a decrease in substrate stability – resulting in changes in the biotic community composition	Very similar to present, with some increase in flooding and related erosion in catchment. This will lead to some infilling, changes of sandy habitats to muddy habitats and a decrease substrate stability – resulting in some changes in the biotic community composition	Very similar to present, with slight increase in flooding with a related increased erosion in catchments. This will lead to some infilling, changes of sandy habitats to muddy habitats and a decrease in substrate stability – resulting in some changes in the biotic community composition	Slight increase in flooding with some increased in erosion (exacerbated by land use changes under climate change). This will lead to some infilling, changes of sandy habitats to muddy habitats and a decrease in substrate stability – resulting in some changes in the biotic community composition
	Changes in the dilution and or flushing of pollutants	Increased flushing of pollutants from the water column and sediment. Urban nodes: Durban, Richards bay.	Increased flushing of pollutants from the water column and sediment	Very similar to present, with slight increase in flushing of pollutants from the water column and sediment. Urban nodes: East London, Port Elizabeth.	Very similar to present, with slight decrease in flushing of pollutants from the water column. Increased flooding might still assist with flushing of pollutants from sediment. Urban nodes: Cape Town.	Significant decrease in flushing of pollutants from the water column. Increased flooding might still assist with flushing of pollutants from sediment. Urban nodes: Cape Town.
Sea level rise (+0.5 – +1.0 m MSL)	Increase salinity penetration	Effect of sea level rise is offset by increased runoff.	Increased salinity penetration in the middle and lower reaches. In the upper reaches salinity penetration will be mostly similar to present, or slightly less, as runoff is generally the major driver especially if steep topography dominates.	Increased salinity penetration in the middle and lower reaches. In the upper reaches salinity penetration will be mostly similar to present mostly similar to present, or slightly less, as runoff is generally the major driver where steep topography dominates.	Increased salinity penetration in the middle and lower reaches. In the upper reaches salinity penetration will be mostly similar to present - or slightly more- as runoff is generally the major driver in the upper reaches where steep topography dominates.	Significant increase in salinity penetration in the lower, middle and upper reaches. (The topography is less steep and runoff is also likely to decrease overall in the region, the saline water could therefore penetrate significantly further upstream.)
	Increased tidal flushing/prism	Very similar to present as the region has predominantly small systems with steep topography. The exception to the rule is the large estuarine lakes and bays which have extensive flood	Very similar to present as the regional has predominantly small systems with steep topography. The exception to the rule is the larger permanently open systems that	Significant increase as the topography is less steep, especially in the case of the larger permanently open systems. The smaller systems with steep topography will be	Significant increase as the topography is less steep, especially in the case of the large estuarine lakes, bay and permanently open systems. A few small systems with steep	Significant increase as the topography is less steep, especially in the case of the large permanently open systems.

Drivers	Response	Sub-Tropical		Warm Temperate		Cool Temperate
		KwaZulu Natal	Transkei	Eastern Cape	Southern Cape	Western Cape
		plains.	have some flood plains.	similar to present.	topography will be similar to present.	
	Changes in the frequency and duration of mouth closure	Increased tidal prisms in the estuarine lakes will together with increased runoff lead to an increase in open mouth conditions.	Increase in open mouth conditions will mostly be driven by increased runoff as tidal prisms will only increase marginally. Benefits of increased sea level rise in some cases may also be offset by changes in the degree to which mouths are protected from wave action by submerged coastal features.	Increased tidal prisms in medium to larger temporarily open stems will assist with maintaining open mouth conditions. Benefits of increased sea level rise in some cases may be offset by changes in the degree to which mouths are protected from wave action by submerged coastal features.	Increased tidal prisms in medium to larger temporarily open stems and estuarine lakes will assist with maintaining open mouth conditions. Benefits of increased sea level rise in some cases may be offset by changes the degree to which mouths are protected from wave action by submerged coastal features.	Increased tidal prisms in medium to larger temporarily open stems will assist with maintaining open mouth conditions in the face of lfow reductions, but the benefits of increased sea level rise may be offset by changes in mouth protection.
Rising temperatures	Species range extensions	Slight increase in temperature from present	Significant increase in the temperature of the nearshore environment is causing a significant increase in subtropical species and a related loss of Temperate habitat	Significant increase in the temperature of the nearshore environment is causing a significant increase in subtropical species and a related loss of Temperate habitat	An increase in the temperature of the nearshore environment is causing a significant increase in subtropical species and a related loss of Temperate habitat	Slight decrease in temperature from present due to increase upwelling, Species distribution likely to remain the same.
	Changes in community composition along land – sea gradients	Similar to present	Subtropical species dominate fresh and brackish communities in the upper reaches, while Temperate species dominate lower reaches in invertebrates.	Subtropical species dominate fresh and brackish communities in the upper reaches, while Temperate species dominate lower reaches in invertebrates.	Similar to present	Similar to present
Decrease pH	Calcifying organisms require more energy to maintain dissolving exoskeleton	Reduce production in calcifying organisms	Reduce production in calcifying organisms	Reduce production in calcifying organisms	Reduce production in calcifying organisms	Reduce production in calcifying organisms
Increase in frequency and intensity of coastal storms	Changes in the frequency and duration of mouth closure	Similar to present, as KZN is largely wave dominated and increased storminess is likely to be offset by increased runoff.	Similar to present, as the estuaries in the region are generally very sheltered and increased storminess is likely to be offset by increased runoff.	Increased closure as sediment is readily available and there are less changes in runoff.	Increased closure as sediment is readily available. The exception is the Tsitsikamma coast which is generally protected and with limited sediment.	Similar to present, as smaller systems is predominantly closed due to a lack of runoff. Larger systems should remain open. The Diep which close more often.
	Changes in the frequency and duration of overwash	Increase overwash. Berm height presently 3 – 3.5 m MSL. Can increase by 0.5 – 1.0 m if sediment is available .	Increase overwash. Berm height presently 2.5– 3.0 m MSL. Can increase by 0.5 – 1.0 m if sediment is available.	Increase overwash. Berm height presently 2.5– 3.0 m MSL. Can increase by 0.5 – 1.0 m if sediment is available.	Increase overwash. Berm height presently 2.5– 3.0 m MSL. Can increase by 0.5 – 1.0 m if sediment is available.	Increase overwash. Berm height presently 2.5– 3.5 m MSL. Can increase by 0.5 – 1.0 m if sediment is available.
	Marine sediment	Increased sediment transport potential; actual increase where sufficient sediment is available.	Increased sediment transport potential; actual increase where sufficient sediment is available.	Increased sediment transport potential; actual increase where sufficient sediment is available.	Increased sediment transport potential; actual increase where sufficient sediment is available.	Increased sediment transport potential; actual increase where sufficient sediment is available.

In contrast, the West Coast estuaries will be negatively affected as a result of reduction in runoff (with a related decrease in nutrient supply) and an increase in sea level rise. This in turn will increase salinity penetration in the permanently open systems and increase mouth closure in the temporarily open estuaries. Similar to KwaZulu-Natal, the West Coast estuaries will display a decrease in primary production and a loss of nursery function.

Although the Wild Coast, Eastern and Southern Cape estuaries will also show some shifts in mouth states, nutrient supply, salinity distribution and ultimately production (e.g. fisheries), the most obvious impacts of climate change along these coastal regions will be the change in temperature (nearshore and land) and the associated range extensions of species and community composition changes. The effect of sea level rise, and related increase in tidal prism, will be less apparent along the KwaZulu-Natal coastline, where the majority of the estuaries are perched (the exception here are the estuarine lakes and bays), while it will be more apparent along the Southern and Western Cape coast with their more extended coastal floodplains.

In summary, contrary to the current monitoring programmes which are focusing on biotic responses in the biogeographic transition zones (e.g. Transkei and western Southern Cape) the most significant structural and functional changes will be in the estuaries of KwaZulu-Natal (subtropical) and the Western Cape (cool-Temperate). These changes are likely to advantage generalist species over specialist and may lead to localised extinctions.

13.4 Key climate change messages

Some of the key climate change messages for estuaries are that:

- Climate change is one of many pressures acting on estuaries and should be viewed as an additional form of anthropogenic alteration (and not a separate pressure) in an already stressed ecosystem type, i.e. climate change acts as an accelerator of ecosystem change in estuaries. It is necessary to understand the potential amplification of variability that climate change may have on the existing freshwater resource (and its use), together with the potential impact on estuarine and marine production, as well as the harvesting of resources in the marine and estuarine environments. It is thus necessary to integrate climate change and non-climate change threats. Climate change should be seen as a catalyst to fast track freshwater resource issues that need addressing, e.g. ecological water allocations (Day and Moore 2009).

- The ability to predict the response of estuaries to climate change, and to plan for how to assist estuaries to adapt to these changes is still hindered by a lack of good prediction tools and the lack of a fundamental understanding of many of the effects of climate variability on the physical, chemical and biological characteristics of the aquatic domain (Meyer, Sale Mulholland and Poff 1999). We are limited by the availability of both data (e.g. long term flow data, temperature data, mouth conditions, wave height, species data) and models (e.g. flow changes, linking hydrological regimes to ecosystem processes, large scale ocean current changes). At the same time, this uncertainty around forecasting change should not be seen as an impossible obstacle to understanding and developing adaptive mechanisms to reduce the effects of climate change on estuarine resources. Accurate forecasting is not obligatory to begin the process of adapting to climate change, as major trends are often obvious and meaningful actions can be instigated based observed trends.

- Stressed ecosystems have a lower resilience to change. By increasing or maintaining the resilience of estuaries, the ability of a system to recover after, for example an exceptional flood or drought, is enhanced. The resilience of an estuary is influenced by the intactness of its catchment and estuarine functional zone. The processes underpinning the goods and services, such as the assimilation and cycling of nutrients in estuaries, also needs to be protected if resilience is to be maintained. For example, developments within the estuarine functional zone will reduce the resilience of the system to extreme flooding, as little lateral movement would be possible. A way to ensure resilience is the determination and implementation of the Estuarine ecological water requirements (Reserves) and the protection/rehabilitation of the estuarine functional zone. Healthy estuaries equate to estuaries resilient to change.

- It is essential that climate change, and the projected effects thereof, be integrated into current plans and policies dealing with management and governance of estuaries, e.g. the water and coastal management sector. Current planning tools need to focus on integration of the synergistic effects of global change. In addition, adaptation includes adjusting to situations, developing coping strategies and impact responses. Adaptation may be behavioural or involve mitigation such as engineering solutions. This requires an adaptive management approach which is supported by monitoring and frequent review..

14. SPECIES OF SPECIAL CONCERN

J Adams, S Lambeth, J Turpie and L van Niekerk

This section provides a summary of estuarine species of special concern (i.e. species that are being harvested, exploited or Red data species).

14.1 Plants

The South African National Estuary Biodiversity Plan (Section 12, Turpie et al. 2012) sets national conservation targets for supra- and intertidal salt marsh at 20% of each estuarine habitat type at the national level. So far only 25% of the supratidal and 12% of the intertidal salt marsh is formally protected within estuaries.

The use of mangrove and swamp forest is regulated under the National Forests Act No. 84 of 1998 (RSA 1998) and destruction or harvesting of indigenous trees requires a licence. The mangrove trees and swamp forest are protected under this act but the sediment environment under the forests and the associated estuarine habitat is not designated as a nature reserve or protected area (Traynor and Hill 2008).

The taxonomy of some salt marsh species is under currently under review; this makes it difficult to determine their population sizes, report on their threat status or set targets for protection. However according to the Coastal Act 2008 all coastal wetlands, which include salt marshes and mangroves, form part of the coastal protection zone. The purpose of establishing this zone is to restrict and regulate activities in order to achieve the aims as set out in the Act. Other laws pertaining to species in these areas:

- National Environmental Management Act 1998
- Marine and Living Resources Act 1998
- The National Environmental Management: Biodiversity Act 2004
- National Forestry Act 1998

14.1.1 Status of salt marsh species

Threats to salt marsh habitats include modified river flow, grazing, invasive aliens, sea level rise, inappropriate coastal development, poor catchment practices (e.g. agricultural), trampling, mouth manipulations and pollution.

Mucina et al. (2003) noted that salt marshes, where a variety of macrophytes are found, are important in the overall functioning of estuaries. These areas are extremely stressful habitats that results in distinct zonation patterns along a tidal inundation gradient. Characteristic of a stressful environment is a low species richness and diversity and coarse vegetation patterns where only a few or single species are dominant. Some salt marsh species have been place on the National Red Data List by SANBI and these are described in the table below (Table 14.1). Mucina (Table 14.2) provided a preliminary indication of those estuaries where endemic salt marsh species may occur.

Table 14.1 Salt Marsh species that were considered important for protection due to their status on the National Red Data List.

Species	2009 National Red Data list categories**	Family	Description	limited of distribution
Cotula filifolia Thunb.	CR	Asteraceae	Intertidal salt marsh	17 estuaries
Limonium scabrum (L.f.) Kuntze	DDT	Plumbaginaceae	Supratidal salt marsh	33 estuaries
Prionium serratum (L.f.) Drége ex E.Mey.	Declining	Prionaceae		6 estuaries
Limonium depauperatum (Boiss) R.A. Dyer	EN	Plumbaginaceae	Supratidal salt marsh	1 estuary

CR=Critically endangered; EN=Endangered; DDT=(Data deficient-Insufficient information; Declining=Taxon declining but does not meet any of the five IUCN criteria but threatening processes are causing a decline; LC=Least concerned.

14.1.2 Status of mangrove species

Potential threats to mangroves in South Africa include: wood harvesting, modified freshwater flows, prolonged mouth closure (and subsequent changes to the intertidal habitat), inappropriate coastal development and poor catchment practises. An assessment of mangroves in the estuaries of KwaZulu-Natal showed that mangroves only occurred in those estuaries where the mouth was open for more than 56% of the time, with the exception of St Lucia where the mouth has been closed for longer durations but the mangrove communities have persisted because the roots of the trees were not submerged (Rajkaran et al. 2009). This study also showed that natural recruitment is taking place for all mangrove species except *Xylocarpus granatum* which consists of a few individuals in the Kosi Estuary.

Table 14.2 Preliminary identification of estuaries (west to east) where important populations of macrophytes occur (Mucina pers. comm.) The genera present and the reason for the importance are indicated.

Estuary	*Limonium*	*Plantago*	*Poecilolepis ficoidea*	*Salicornia*	*Sarcocornia*	*Spergularia*	*Triglochin*
Langebaan	-	New species	-	2 lineages	Highest diversity on west coast	New species	-
Uilskraals	1 species	New species	-	2 lineages	High no. of spp.	New species	-
Heuningnes	1 species	New species	Present	1 lineage	5 spp.	New species	2 spp.
Gouritz	1 new endemic sp. found	-	-	-	-	-	-
Knysna	1 new endemic sp. found	New species	-	Endemic lineage *S. knysnaensis*	-	New species	-
Kromme	-	New species	-	Endemic lineage *S. macrocarpa*	3 spp.	New species	2 spp

The greatest threat to the survival of mangroves is removal through harvesting. Kosi Bay and Mhlathuze Estuary were two of the larger forests that showed signs of harvesting (for example the presence of tree or branch stumps in Figure 14.1).



Figure 14.1 Stumps of harvested mangroves at Wavecrest.

In the smaller Wild Coast estuaries where mangrove strands consists of one to three rows of trees, harvesting can have a serious impact and in severe cases completely remove the mangrove habitat resulting in erosion of estuary banks. An assessment of mangroves in the Eastern Cape estuaries showed that there was complete loss of mangroves in the Mnyameni, Mzimvubu and Bulungula estuaries, while at the Mdumbi, Mzamba and Kobonqaba estuaries harvesting had resulted in more than 50% of the trees being removed (Adams et al. 2004).

However, the greatest threat to smaller estuaries seems to be altered water flow due to freshwater abstraction and the change in land use from estuarine vegetation to sugar-cane plantations. These threats affect the hydrology of estuaries and the sediment characteristics (particle size, redox, pH, salinity, temperature) of the mangrove forests, which in turn influence plant recruitment and survival rates. Flow modification can cause ecosystem type changes, e.g. the permanently open Kobonqaba Estuary closed for the first time in recorded history in 2010 causing die-back of mangroves (Figure 14.2). In KwaZulu-Natal development pressures have resulted in the complete loss of mangroves from the Mhlanga, Little Manzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mahlongwa, Kongweni, Bilanhlolo, Mhlangankulu and Khandandlovu estuaries (Rajkaran and Adams 2011). A loss of mangrove habitat has potentially decreased the diversity of organisms found in estuaries, the nursery function of the forests has been reduced and there has been a loss of protection value given by the mangroves (Gilbert and Janssen, 1998; Fondo and Martens, 1998; Laegdsgaard and Johnson, 2001; Mumby *et al.* 2003).



Figure 14.2 Dead mangroves at the Kobonqaba Estuary due to mouth closure in 2010.

Table 13.3 summarises the information on the mangrove species found in South Africa. All mangrove species, except *Avicennia marina*, occur on the DWA Protected Tree list (Gazette 835 (2010) Notice of the list of protected tree species under the National Forests Act (Act No. 84 of 1998).

Table 14.3 The status of mangrove species in South Africa.

Species	Family	No of estuaries	Max density (no of individuals per ha).	Estuary with highest density.	Average density (no of individuals / ha)*	Red Data categories
Avicennia marina (Forsk. Vierh.)	Avicenniaceae	24	37 933	Echwebeni – Richards Bay	19 839	Least Concerned
Bruguiera gymnorrhiza (L.) Lam	Rhizophoraceae	33	22 119	Kosi Bay	16 533	Least Concerned
Ceriops tagal Perr. C.B.Robinson	Rhizophoraceae	1	28 800	Kosi Bay	-	Least Concerned
Lumnitzera racemosa Willd.	Combretaceae	1	2 866	Kosi Bay	-	Least Concerned
Rhizophora mucronata (Lam).	Rhizophoraceae	12	78 000	Echwebeni – Richards Bay	34 967	Least Concerned
Xylocarpus granatum König 1784	Meliaceae	1	Only 1 individual found	Kosi Bay	Only 1 individual found.	Least Concerned

* These values are taken from data collected at Kosi Bay, St Lucia, Echwebeni and Mhlathuze Estuary (Rajkaran and Adams, *in press*).
**http://www.sanbi.org/index.php?option=com_content&view=article&id=250:red-data-lists-project&catid=125:part-of-biodiversity-topics&Itemid=793

14.2 Invertebrates

Exploitation of invertebrates used as bait by recreational and subsistence anglers is a focal activity in most estuaries around the South African coast. The burrowing prawns *Callianassa kraussi* and *Upogebia africana* are the most common bait organisms targeted by collectors (Wooldridge 2007), although pencil bait (Solen spp.) and bloodworm *Arenicola loveni* are also popular bait organisms. Sand and mud prawns are particularly abundant in warm and cool Temperate estuaries. *C. kraussi* generally occurs in sand and *U. africana* in more muddy sediments. The sand prawn is found in both permanently open and temporary open estuaries, while the mudprawn is only abundant in permanently open estuaries. Mud prawns are generally absent from estuaries that close for 'extended' periods.

Bivalve molluscs are relatively scarce in South African estuaries and they do not reach the high densities recorded in Europe. Pencil bait species such as *Solen capensis* and *S. cylindraceus* may be locally common in some estuaries (Hodgson 1987), with the former species present in sandy substrata and *S. cylindraceus* occurring in more muddy areas. Both Solen species concentrate around the inter- and sub-tidal interface. The bloodworm *Arenicola loveni loveni* is also a popular bait organism, although distribution is not restricted to estuaries. Estuarine abundance levels are highly variable and the species is easily over-exploited in some estuaries where it occurs. Bloodworms prefer sandy substrata and relatively high salinities and are therefore found on sandbanks near the mouth of open estuaries.

The Marine Living Resources Act (No. 18 of 1998) provides for the sustainable use of our marine living resources to ensure that estuaries in South Africa remain productive and biologically diverse. Bait collection is seen as an integral part of resource management and focuses on the way in which bait is collected and the maximum number of organisms that may be removed per day by collectors. The most common legal method used by invertebrate bait collectors is the prawn or suction pump. Pencil bait is more commonly collected using a length of hooked wire. In both these methods, sediment core disturbance is minimal when compared to the amount of sediment turnover using a spade or forked shovel. However, it is important to distinguish between the number of bait organisms removed and the longer term effects on the target species, associated benthic communities and birds utilizing the former undisturbed habitat.

Although a relatively small proportion of the targeted species is removed annually, bait collecting inflicts serious damage on other components of the macrofaunal assemblage (Wooldridge 2007). Those species not utilized by fishermen were negatively impacted through avian or fish predation and physical injury caused by harvesting activities. Long-term effects of bait-collecting on biota inhabiting the sediment are also apparent. The impact of bait pumping and trampling of mudflats may affect the sediment down to at least 20 cm. The impact of illegal bait collecting using a spade and overturning large volumes of sediment will also have severe negative consequences for many benthic species.

14.3 Fish

Approximately 2 000 tonnes of fish, comprising 80 species, are caught in South African estuaries each year. The harder *Liza richardsonii* (32%), spotted grunter *Pomadasys commersonnii* (20%), dusky kob *Argyrosomus japonicus* (18%) and mixed mullet

(predominantly *Mugil cephalus*, *Liza dumerili* and *L. tricuspidens* 10%) provide the bulk of this catch. Most (540 t) of the harder catch is from west coast estuaries, of which more than 80% is due to illicit gillnetting. All dusky kob and spotted grunter catches are from the warm Temperate and subtropical east coast. Historically, white steenbras *Lithognathus lithognathus* contributed significantly (>20%) to estuary (and surf-zone) catches on the west and east coasts but stock collapse has since seen this drop to <3%. Harder and spotted grunter are also overexploited.

Although fishing is the predominant cause of population decline of most exploited species, other anthropogenic influences such as altered freshwater flows, aquaculture and loss of estuary habitat through development, may play an equal or greater role. The current status of the harder stock on the west coast is almost entirely a result of illegal gillnetting in the Berg Estuary where approximately 400 t of mostly small immature fish are landed annually. This has resulted in a 500-600 t drop (or halving) of catches and a substantial loss of livelihood by the legitimate commercial harder fishery in the sea.

Altered freshwater flows have influenced the recruitment success of most estuary-associated species but one of the best examples is the Natal stumpnose *Rhabdosargus sarba*. Already overexploited, prolonged drought and persistent closure of the St Lucia Estuary over the last 10 years has prevented juveniles of these estuary-dependent fish from recruiting into the system, resulting in population collapse (Mann et al. 2007, James et al. 2004),

Marine and freshwater aquaculture have the potential to directly and indirectly impact the wild populations of estuary-associated species through genetic, pathogen and parasite contamination, to the overexploitation of fry and larvae for ranching purposes. Continent-wide collapse of European and Asian anguillid eel populations has been directly attributed to a combination of all these factors. Since then, industry attention has shifted to the southern hemisphere, especially South Africa where eel populations are deemed healthier than elsewhere. Despite strict control and an embargo on imports from across this country's borders, some east coast river systems have become contaminated by parasites and other pathogens that have been traced back to illegally imported Madagascan eels **(**Weyl et al. 2010).

It is internationally acknowledged that there is difficulty in categorizing exploited fish species according to IUCN criteria, as well-managed stocks are kept at levels that automatically relegate them into the vulnerable category. An attempt to overcome this problem for fish caught by the inshore fisheries in South Africa was made in a prioritization exercise that

used both fisheries and conservation criteria ranging from fishery participation and economic value to vulnerable life-history characteristics (Lamberth and Joubert 1998). Eleven of the top 30 fish species countrywide in terms of vulnerability, conservation and fisheries importance, and needing management attention, were estuary-associated. Seven of these; dusky kob *Argyrosomus japonicus*, white steenbras *Lithognathus lithognathus*, harder *Liza richardsonii*, spotted grunter *Pomadasys commerrsonii*, Natal stumpnose *Rhabdosargus sarba*, Cape stumpnose *Rhabdosargus holubi* and leervis *Lichia amia* are obligate estuary-dependent fish whose juveniles have to spend their first year or two in estuaries to complete their lifecycle.

Table 14.4 The stock status (% of reference or near pristine breeding potential, catch-per-unit-effort or catch composition) of important utilized estuarine-associated species in South Africa.

Species	Common Name	% Pristine	Stock Status
Argyrosomus japonicus	Dusky kob	4	Collapsed
Lithognathus lithognathus	White steenbras	6	Collapsed
Rhabdosargus globiceps	White stumpnose	20	Collapsed
Lutjanus argentimaculatus	River snapper	30	Overexploited
Pomatomus saltatrix	Elf	34	Overexploited
Diplodus capensis	Dassie/blacktail	35	Overexploited
Rhabdosargus sarba	Natal stumpnose	34 *	Overexploited
Acanthopagrus vagus	Perch/riverbream	24**	Overexploited
Anguilla spp.	Anguillid eels (4 species)	<40	Overexploited/vulnerable
Rhabdosargus holubi	Cape stumpnose	40	Optimally exploited
Myxus capensis	Freshwater mullet	<40	Overexploited/vulnerable
Liza richardsonii	Harder	<40	Overexploited
Pomadasys commersonnii	Spotted grunter	<40	Overexploited/ Optimally
Carcharhinus leucas	Zambezi shark	<40	Overexploited/vulnerable

*(James et al. 2004), ** (James et al 2008)

Given the difficulties outlined above, as well as those arising from uncertain taxonomic status, few South African estuary-associated species (especially those exploited) have been evaluated for inclusion on the IUCN Red List. The only exploited species to have made it on to the list is the white steenbras *Lithognathus lithognathus* but in the lower risk category. The Knysna seahorse *Hippocampus capensis* is endangered whereas the river pipefish *Syngnathus watermeyeri*, largetooth sawfish *Pristis microdon*, smalltooth sawfish *Pristis pectinata* and green sawfish *Pristis zijsron* are critically so. Currently the entire families of pipefish and seahorses Syngnathidae and sawfish Pristidae are on the South African Prohibited List (MLRA 1998).

Once given attention, it is likely that many more South African estuary-associated fish will find their way on to the IUCN Red List. Amongst these, are four species of the genus

Argyrosomus, all having experienced population collapse and all four local eel species of the Anguillidae which, similar to their Northern Hemisphere counterparts, are declining due to overexploitation, aquaculture related issues and changes in the quantity and quality of freshwater flow.

14.4 Birds

Turpie and Clark (2007) indicate that 107 non-passerine waterbird species have been counted in South African estuaries. Although estuary dependence is not defined for estuarine bird species listed by Hockey & Turpie (1999), bird species were considered dependent on estuaries if more than 15% of their regional population (as per Hockey et al. 2005) was found in coastal lagoons and estuaries (Turpie et al. 2012).

Thirty-five bird species were therefore considered to be estuary dependant, with eight of them listed as threatened (Table 13.4). Of the latter, the Great White and Pinkbacked Pelican are particularly dependent on the St Lucia estuary within South Africa, the former for breeding, and the latter during the non-breeding period (Turpie et al. 2012). Greater and Lesser Flamingos, while present in many wetlands throughout southern Africa, are particularly abundant at a small number of estuaries, such as the Berg and St Lucia estuaries. The African Black Oystercatcher is predominantly coastal in distribution, but many estuaries support one or more pairs of this species, and estuaries such as the Olifants estuary are frequently utilised by nonbreeding flocks of oystercatchers during winter. Caspian Terns occur at the coast and interior, but along the coast they are found mostly in estuaries, with important breeding colonies in estuaries such as the Berg and St Lucia. Damara Terns breed mainly in Namibia, and their South African population numbers only about 125 pairs. While these are mainly along the coast, some make use of the Heuningness Estuary in the Cape.

Table14.5 Threatened estuary-dependent bird species (Source: Turpie et al. 2012).

Bird species	Scientific name	Red Data Status
Pink backed Pelican	*Pelecanus rufescens*	Vulnerable
Great White Pelican	*Pelecanus onocrotalus*	Near-threatened
Greater Flamingo	*Phoenicopterus roseus*	Near -threatened
Lesser Flamingo	*Phoeniconaias minor*	Near-threatened
African Black Oystercatcher	*Haematopus moquini*	Near-threatened
Caspian Tern	*Sterna caspia*	Near-threatened
Damara Tern	*Sterna balaenarum*	Endangered
Mangrove Kingfisher	*Halcyon senegaloides*	Vulnerable

14.5 Summary

Mangroves have been completely lost from 14 estuaries in South Africa.

- In smaller Eastern Cape estuaries, where mangrove strands consist of one to three rows of trees, harvesting can have a serious impact and in severe case completely depopulate an estuary of mangroves. Complete loss of mangroves is evident in the Mnyameni, Mzimvubu and Bulungula estuaries, while at the Mdumbi,Mzamba and Kobonqaba harvesting has resulted in more than 50% of the trees being removed (Adams et al. 2004).
- In KwaZulu-Natal development pressures, changes in mouth state and water quality have resulted in the complete loss of mangroves from the Mhlanga, Little Manzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mahlongwa, Kongweni, Bilanhlolo, Mhlangankulu and Khandandlovu (unpublished data).

A total of 18 iconic estuarine associated or dependant fish species (17%) are under severe pressure.

- The stock status of important utilized estuarine-associated species in South Africa list 4 collapsed species, 13 overexploited species, and 1 optimally exploited species.
- Approximately 2 000 tons of fish, comprising 80 species, are caught in South African estuaries each year.The Natal stumpnose *Rhabdosargus sarba* population collapsed as a result of overexploitation and the persistent closure of the St Lucia Estuary.
- While few South African estuary-associated species are listed on IUCN Red List and South African Prohibited List (MLRA 1998), it is likely that many more will find their way on to the lists once attention is given, e.g. four species of the genus *Argyrosomus* and all four local eel species of the Anguillidae.

15. INVASIVE ALIEN SPECIES

L van Niekerk, S Lambeth, J Adams, and F MacKay

Invasive alien species pose a significant threat to estuaries where they cause both ecological and economic damage. Alien species can exert a significant impact upon community structure and functions, by modifying spatial and food chain resources, with direct or indirect effects on the occurrence of indigenous species (Drake et al. 1989; Leppa¨ Koski et al. 2002, Elton 1958). Economic concerns include, for example, burrowing activities that can result in damage to banks and dykes (causing embankment erosion), clogging of water intake filters of industrial cooling water and drinking water plants (during mass occurrences), and alien species preying heavily upon native species of commercial importance. . In recent years, national and international environmental policy and legislation has begun to reflect these threats and respond accordingly (e.g. CBD 1992; IMO 2004, European Commission 2008).

There are four main arguments for explaining observed settlement characteristics in estuaries (Nehring 2006), namely:

(1) Estuaries have a higher potential infection rate than other aquatic zones as a result of their high degree of exposure to direct vectors e.g. proximity to international shipping lanes and ports (ballast water and invasive species attached to the ship hulls); aqua and mariculture industries, the aquarium trade and live bait associated with fishing activities.

(2) Estuarine species have, due to their physiological characteristics, a better chance of being transported alive than marine or freshwater species and they also probably have a higher penetration and establishment potential after release.

(3) Estuaries have the greatest natural 'indigenous species minimum' or lowest number of indigenous species of all aquatic domains so that more alien species can potentially establish in this domain. This may be especially true in South Africa due the sporadic flushing (resetting) of system by relatively large floods. Allowing for potentially unsaturated ecological niches at times.

(4) Salt-tolerant freshwater alien species, introduced into inland waters, reach the coast in the estuaries.

The combination of brackish waters colonised by physiologically generalist species, potentially unsaturated ecological niches, and high exposure to international ship traffic in some of the larger estuaries, leads to the highest potential infection rate for any aquatic

system. In addition, estuaries are also subjected to a two-sided invasion pressure by alien species, via the ocean and via inland waters. The identification of such patterns is an important prerequisite for the development of a forward-looking alien monitoring and management strategy. Terms and definitions used in this section are based on the Convention on Biological Diversity (CBD 1992, 2000): an “Alien species” is defined as a species, subspecies, or lower taxon introduced outside its normal past or present distribution. An “Established alien species” is an alien species that is reproducing in the wild and has established a durable population in an area. An “Invasive alien species” is an alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm. “Introduction” is defined as the movement, by human agency, of a species, subspecies, or lower taxon outside its natural range (past or present). “Cryptogenic species” may be either a native species or an introduced species, with clear evidence for either origin being absent.

15.1 Alien Plants

Alien plants in South African estuaries can range from aquatic plants e.g. water hyacinth, water fern, parrot’s feather to terrestrial examples such as *Sesbania* and Australian *Acacia* species (Adams et al. 1999). Estuary habitats are stressful environments where plants need to be adapted to high salinity and waterlogged conditions. This limits the extent of invasive plants, particularly in the intertidal zone. The status of invasive plants in South African estuaries has received little attention in recent years. Coetzee et al. (1997) assessed the condition of estuarine macrophyte habitats in Cape estuaries. The most common impact in supratidal salt marshes was encroachment by invasive plants, followed by trampling. Invasive plants were present in 75% of the 33 Cape estuaries investigated. In a study of the False Bay estuaries, O’Callaghan (1990) showed that alien vegetation encroachment was a major factor causing changes in the estuarine vegetation. This occurred in response to disturbance, particularly when there was a restriction in tidal exchange. The Conservation of Agricultural Resources Act 43 of 1983 (CARA) classifies invasive plant species into three categories; Category 1 are prohibited weeds that must be controlled by all means; Category 2 includes plants with commercial value that may be planted in demarcated areas subject to a permit and providing that steps are in place to control them and Category 3 are ornamental plants that may no longer be planted or traded but may remain in place provided a permit is obtained and steps are taken to control their spread. The CARA status of plants found in estuaries is indicated in Table 15.5 as summarised in Richardson and van Wilgen 2004, Coetzee 1995; van Wyk and van Wilgen 2002; Zimmermann et. al.2004; Henderson et al. 2006.

Table 15.1 Invasive, alien or non-endemic species in South African estaurine habitats (modified from Coetzee 1995).

Botanical name	Common name	Estuarine plant community impacted	CARA
Acacia cyclops A.Cunn. ex G.Don	Rooikrans, Red-eye	Invades upper reaches of estuaries and rivers	1
Acacia longifolia (Andr.) Willd.	Long - leaved wattle	Invades upper reaches of estuaries and rivers	1
Acacia mearnsii De Wild.	Black wattle	Invades upper reaches of estuaries and rivers	1
Acacia saligna (Labill.) H.L.Wendl.	Port Jackson willow	Invades upper reaches of estuaries and rivers	2
Eichhornia crassipes (C.Mart.) Solms	Water hyacinth	Water column/ submerged macrophyte habitat	1
Salvinia molesta D.S.Mitch.	Kariba weed	Water column/ submerged macrophyte habitat	1
Myriophyllum aquaticum (Vell.) Verdc.	Parrot's feather	Water column/ submerged macrophyte habitat, intertidal salt marsh	1
Pennisetum clandestinum Hochst. Ex Chiov.	Kikuyu grass	Invades supratidal salt marsh	-
Pereskia aculeata Mill.	Barbados gooseberry	Supratidal salt marsh Invades riparian habitats	1
Spartina alterniflora	Smooth cord grass	Intertidal and supratidal salt marsh	?
Psidium guajava L.	Guava	Supratidal salt marsh Invades riparian habitats	2
Ricinus communis L	Castor-oil plant	Supratidal salt marsh Invades riparian habitats	2
Sesbania punicea (Cav.) Benth.	Red sesbania	Supratidal salt marsh Invades riparian habitats	1

15.2 Fish

All of the introduced or translocated fish in South African estuaries are freshwater species (Table 15.2 and Table 15.3). Most of these, e.g. smallmouth bass *Micropterus dolomieu* and carp *Cyprinus carpio*, were introduced from the northern hemisphere in the late 1800s until the 1970s to enhance freshwater angling, as indigenous fish were regarded as unsuitable. Smaller species such as bluegill sunfish *Lepomis macrochirus* and mosquitofish *Gambusia affinis* were imported either as fodder fish to feed the larger introduced species or as mosquito control. Some, e.g. guppy *Poecilia reticulata*, are home aquaria escapees that established wild populations. A similar philosophy was followed with regards to southern African species, which were translocated either as angling fish or in the hope of establishing an aquaculture industry. Range expansion of both introduced and translocated species throughout South Africa was further facilitated by interbasin transfer schemes, irrigation and stormwater networks as well as intentionally or inadvertently by recreational anglers and other water users as they moved between water bodies.

Panel 8: Emerging Pressures….. First record of the intertidal invasive plant Spartina alterniflora

In 2004, the intertidal invasive salt marsh grass, *Spartina alterniflora*, was observed for the first time in a temporarily open/closed system in South Africa, at the Groot Brak Estuary. It is a perennial, deciduous, salt tolerant grass that can grow up to 2 m tall and is found in the intertidal areas of estuaries. Its leaves are bright green to grey-green, up to 60 cm long, pointed and protrude from the stem at an angle. The plant is wind pollinated with large amounts of seed produced, sometimes in the first year. However the main form of spread is vegetative, i.e. through rhizomes/underground stems. The deep roots are capable of growth if broken off. The root system biomass is as much as five times that of the above ground biomass. *Spartina alterniflora* has spread at an alarming rate of 0.15 ha yr-1 since 2004 to occupy a present cover of 0.87 ha (2010), spreading laterally at a rate of 1.1 m yr-1 (unpublished data). If left uncontrolled, *Spartina alterniflora* has the potential to replace 42.9 ha of habitat, or 41% of the total estuarine vegetation. When the grass first establishes in an estuary, it forms monospecific circular stands. These later coalesce to form larger stands until entire open mudflats are transformed to closed habitats. It is an aggressive invader due to its ability to accrete sediment and its fast lateral expansion rates. Expansion is currently taking place in habitats in the lower to upper intertidal marsh area, displacing salt marsh species. Changes in the benthic community abundance and composition can be expected. *Spartina alterniflora* invasions also cause a trophic shift from an algal- to a detritus-based food web resulting in a loss of species richness and diversity of fish, as well as a reduction in shore and wading birds. The movement of seeds and vegetative material by tides and currents to other estuaries when the mouth is open is a significant future threat to the biodiversity of South Africa's estuaries.

It is of concern that it has taken more than 6 years to mobilize action to eradicate this highly invasive species. After much deliberation between the different management authorities, the Working for Water programme in 2011 initiated 3 trial approaches investigating eradication through hand removal and digging at some sites and chemical treatment with the non-selective systemic herbicide, glyphosate, at other sites. This is the best suited herbicide for the aquatic environment. A 0.5% foliar application was used and initial findings indicate that foliar application of herbicides is a good option for control. At the mechanical control sites which involved physical removal of Spartina there is some salt marsh growth already in cleared areas which is very encouraging. Unfortunately, there is also quite a lot of regrowth of the Spartina. At the chemical control sites there is still a lot of dead biomass which should be removed.



Tall *Spartina alterniflora* adjacent to native salt marsh in the Groot Brak Estuary.

Ongoing follow-up monitoring and control will still be required over the following years to ensure its total eradication from the Groot Brak Estuary, and the country as a whole. Working for Water will be responsible for ongoing operational aspects, such as chemical treatment. While SANBI and MNNU have entered into a five year Memorandum of Understanding (MoU) under which SANBI will support the ongoing annual monitoring and research (e.g. rate of regrowth and extend of infestation) of the Spartina to ensure the success of the eradication programme.

Source: T Riddin & JB Adams

Table 15.2 List of introduced fish species in the estuaries of South Africa

Species name	Common name	% occurrence (130 estuaries)	SA range
Micropterus salmoides	Largemouth bass	31	Olifants -Mhlathuze
Micropterus dolomieu	Smallmouth bass	24	Olifants - Thukela
Cyprinus carpio	Carp	23	Orange - Thukela
Lepomis macrochirus	Bluegill sunfish	14	Olifants - Thukela
Micropterus punctulatus	Spotted bass	14	Olifants - Thukela
Oncorhynchus mykiss	Rainbow trout	10	Sand - Thukela
Gambusia affinis	Mosquitofish	9	Berg - Knysna
Salmo trutta	Brown trout	3	Olifants - Thukela
Tinca tinca	Tench	2	Lourens - Breede
Poecilia reticulata	Guppy	2	Mgeni - Tongati
Ctenopharyngodon idella	Grass carp	2	Zeekoei - Thukela

Table 15.3 List of Extra-limital (translocated) fish species in the estuaries of South Africa

Species name	Common name	% occurrence (130 estuaries)	SA range (estuary northwards)
Tilapia sparrmanii	Banded tilapia	28	Orange - Mtamvuna
Oreochromis mossambicus	Mozambique tilapia	17	Bushmans
Clarias gariepinus	Sharptooth catfish	11	Orange - Mtamvuna
Tilapia rendalli	Redbreast tilapia	3	Sibaya, KZN estuaries?
Labeobarbus aeneus	Smallmouth yellowfish	3	Orange
Tilapia zillii	Redbelly tilapia	1	?
Oreochromis niloticus	Nile tilapia	1	Not from SA, Rift Valley

Given their freshwater origin, most of the impact of introduced and translocated fish occurs within the river estuary interface or the freshwater reaches of estuaries. In some systems, the suite of introduced species forms an effective barrier against the upstream migration of the young elvers of catadromous eels or facultative catadromous mullet. Recruitment of the larvae and juveniles of estuary-dependent marine species, and the survival of the eggs and young of estuary residents, may be severely compromised through predation by introduced species in estuarine headwaters. Introduced species may also have a competitive advantage but this is likely to be of minor consequence compared to predation. The exception is the Mozambique tilapia *Oreochromis mossambicus* which is tolerant of hypersalinity and is known to opportunistically invade river and estuary reaches from which other species have been excluded by adverse conditions (Lamberth et al. 2010). Territorial and aggressive reproductively active males may also exclude any fish of similar shape and size (Lamberth 2008).

Apart from facilitating the import and establishment of alien invasive species, marine and freshwater aquaculture have the potential to directly and indirectly impact the wild populations of estuary-associated species through genetic, pathogenic and parasitic

contamination, to the overexploitation of indigenous fry and larvae for ranching purposes. Continent-wide collapse of European and Asian anguillid eel populations has been directly attributed to a combination of all these factors. Since then, industry attention has shifted to the southern hemisphere, especially South Africa, where eel populations are deemed healthier than elsewhere. Despite strict control and an embargo on imports from across this country's borders, some east coast river systems have become contaminated by parasites and other pathogens that have been traced back to illegally imported Madagascan eels (Weyl et al. 2010).

15.3 Invertebrates

Until 2004 approximately 20 alien marine species were reported for South Africa, primarily restricted to the Western Cape region (Griffiths and Day 2004). By 2011, a far wider diversity of marine and estuarine introductions was documented. To date a total of 86 introduced and 39 cryptogenic species are stated (Table 15.5) with the highest numbers of species within the Ascidiacea (18), Amphipoda (17) and Cnidaria (15). Not all alien marine species have been found in estuaries in the different biogeographic regions, Mead et al. (2011) stress that even this latest number is an initial estimate of the potential species that have become established in estuarine/marine habitats. The majority of alien species are restricted to harbours (e.g. Ciona intestinalis, Carcinus maenas, Metridium senile) and sheltered estuaries (Robinson et al. 2005). Two main issues have been identified as impeding the identification of the likely, true number of alien invertebrates 1) A small number of taxonomic experts exist in the country, in the eastern subtropics in particular where relatively fewer numbers of non-indigenous species have been reported and 2) Fewer surveys have taken place on the east coast (Griffiths et al. 2009).Table 15.4. List of introduced fish species in the estuaries of South Africa.

Although Griffiths et al. (2009) also contend that much of the shipping traffic, the most likely transport mechanism of the majority of species, has originated in Temperate regions and therefore species were readily established in the Temperate areas of South Africa.

Table 15.4 Numbers of known or suspected introduced marine invertebrates through time and by major group. (After Griffiths et al. 2009). I – Introduced; C - Cryptogenic

Taxonomic group	Griffiths et al. 1992	Griffiths 2000	Robinson et al. 2005	Griffiths et al. 2009	Mead et al. 2011,
Porifera	0	0	1	1	1 (I1)
Cnidaria	0	1	4	4	15 (I13, C2)
Polychaeta	0	1	0	0	10 (I8, C2)

Taxonomic group	Griffiths et al. 1992	Griffiths 2000	Robinson et al. 2005	Griffiths et al. 2009	Mead et al. 2011,
Cirripedia	0	0	1	2	2 (I2)
Copepoda	0	0	0	0	1 (I1)
Isopoda	0	0	2	3	11 (I6, I5)
Amphipoda	0	0	11	11	17 (I11, C6)
Decapoda	3	2	1	1	2 (I2)
Pycnogonida	0	0	0	0	1 (I1)
Gastropoda	7	7	1	1	8 (I5, C3)
Bivalvia	5	5	3	4	12 (I6, C6)
Brachiopoda	0	0	0	0	1 (I1)
Bryozoa	0	0	2	2	6 (I6)
Echinodermata	0	0	1	2	2 (I2)
Ascidiacea	0	6	3	5	18 (I9, C9)

Panel 9: Emerging Pressures….. Spread of the quilted melania – Tarebia granifera

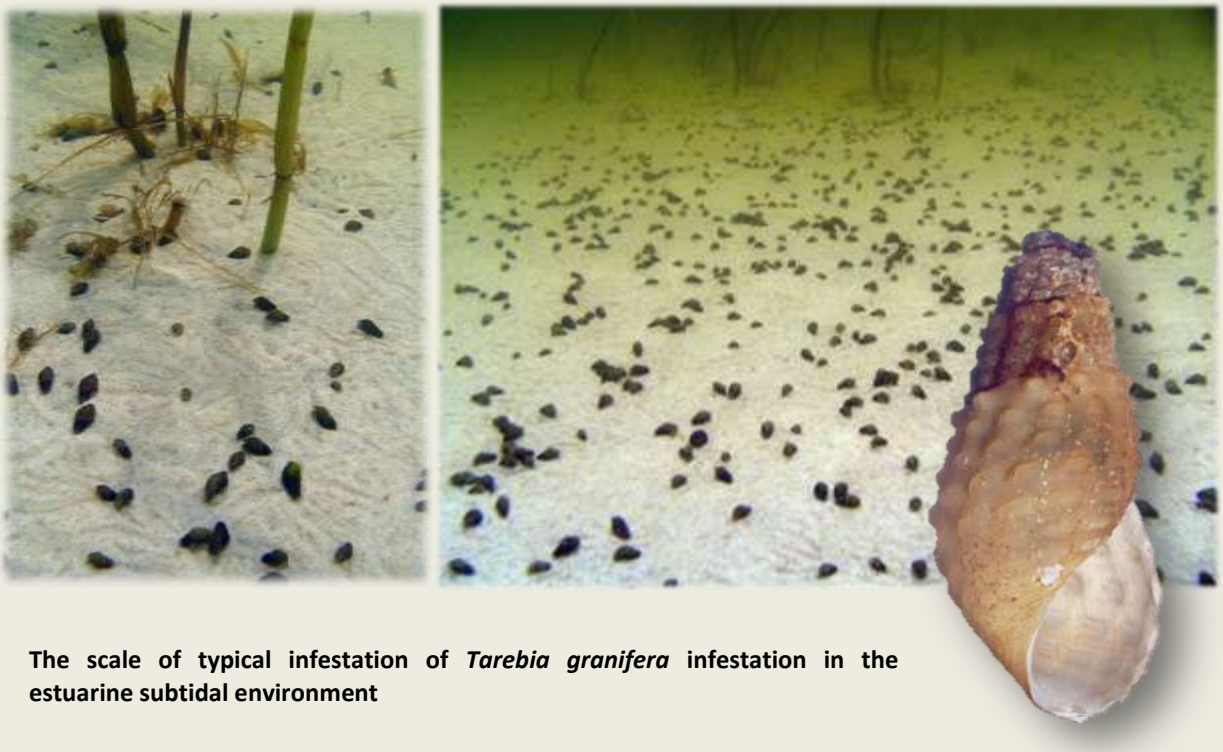
The quilted melania *Tarebia granifera* (Lamarck 1822) is an Asian mollusc species that is both parthenogenetic and ovovoviparious in reproduction nature and together with a long lifespan and slow intrinsic growth rate permits this species to be a successful invader. Being able to reproduce parthenogenetically allows this mollusc to colonise water bodies quickly where high densities form extensive mats in a variety of habitats, on both natural and artificial substrata (Appleton et al. 2009).

There has been an observable and serious invasion by the snail in coastal water bodies, including the estuaries of KwaZulu-Natal. This gastropod has a natural range from Madagascar to India, including countries in Southeast Asia, Japan and through to Hawaii. This species has been transported across the globe via the aquarium trade and is now widely distributed across the world. The appearance of *T. granifera* was first reported in South Africa in 1999 in northern KwaZulu-Natal (Appleton et al. 2009), and was most probably introduced several years earlier via the aquarium trade which receives supplies from Hong Kong and Singapore (Appleton 2003). Since then *T. granifera* has spread rapidly, occurring as far south as Port Shepstone and is spreading northwards into the Mpumalanga Province and the Kruger National Park (Appleton 2003, Wolmarans and de Kock 2006), via passive transportation by waterbirds, waterweeds on boats and trailers and through inland waterbodies (Appleton et al. 2009). *Tarebia granifera*, has been collected from 13 rivers, four lakes and two dams (Appleton et al. 2009). Moreover, this species has now been found in at least 25 estuaries within KwaZulu-Natal, including both estuarine lake systems in the iSimangaliso World Heritage Site, starting with St Lucia in 2005 (Miranda et al 2010). This rapid spread along the east coast and into the hinterland is an indication of the success of this species in being able to colonise freshwater, brack and considerably saline environments under wide ranging temperature conditions (Appleton et al. 2009, Miranda et al. 2010).

The two main concerns associated with the proliferation of *T. granifera* include firstly the changes to the lake ecology through competitive exclusion of native snail and other invertebrate populations (Chaniotis et al. 1980a; 1980b; Pointier 2001, Appleton and Nadasan 2002; Hyslop 2002; Wolmarans and de Kock 2006; Tolley-Jordan and Owen 2008). Depending on the invading environment, the full spectrum of benthic estuarine infauna and epifauna could be affected by the intense competition for space and resources inflicted by the high population densities of *T. granifera* (Appleton et al. 2009).

Other indigenous molluscs at the southern limit of their distribution may be displaced by *T. granifera* (Appleton et al. 2009). Secondly, effects on ecosystem function and processes are an issue given that *T. granifera* is not an exclusive feeder on detritus, but can use large amounts of microphytobenthos, theoretically initiating a cascade effect on the estuarine trophic environment (Miranda et al. 2011).

There are no known control measures for *T. granifera* and that the invasive process is irreversible (Pointier 2001; Appleton 2003). Molluscicides are costly and require repeated application, and are not a wise option in that they are toxic to other aquatic fauna including crustaceans and fish (Pointier 2001). While the desiccation tolerances, thermal and salinity limits, and humidity responses of *T. granifera* are known (Chaniotis et al, 1980a, Miranda et al 2010), the direct control of snails is highly unlikely because of far-reaching environmental implications (Morgan et al. 2001). There are also no known competitors or predators of *T. granifera* because it is itself a strong competitor (Cañete et al. 2004). Currently, the key suggestions for controlling the spread of *T. granifera* are methods of prevention (Appleton 2003) and making the public aware of the potential dangers of inadvertent spread of invasive molluscs (de Kock and Wolmarans 2007).



The scale of typical infestation of *Tarebia granifera* infestation in the estuarine subtidal environment

(Source: F MacKay)

16. LEGISLATIVE RESPONSES

Lara van Niekerk and Susan Taljaard

A major constraint in the effective management and wise use of South Africa's estuarine biodiversity is the fragmentation and overlap in the legislative framework. Most of current environmental legislation is aimed at providing guidance in the management and control of specific activities posing threats to the ecosystems services provided by the natural environment (including estuaries). The legislation is focuses on key sectors, rather than providing a more holistic framework within which to manage estuaries.

The large number of overlapping laws (e.g. 16 international conventions, 10 white papers, over 40 national acts (Van Niekerk and Taljaard 2003)) that define and regulate estuaries makes it difficult to conserve and manage these systems effectively. The key to resolving the legal and administrative confusion lies in aligning the institutional arrangements so that their areas of jurisdiction correspond more closely with those of the ecosystem. DEA is currently in the process of drafting the regulations to be promulgated under the Integrated Coastal Management Act. This presents an excellent opportunity to realign existing legislation and institutional arrangements and to influence pending legislation accordingly. Guiding all future management recommendations should be the fact that estuarine ecosystems are not isolated and that they function in an integrated manner at a local, regional and global scale.

16.1 National legislative framework

National legislation that is especially relevant to estuaries includes:

- National Environmental Management Act (Act 107 of 1998);
- Marine Living Resources Act (Act 18 of 1998);
- National Environmental Management: Integrated Coastal Management (Act 24 of 2008);
- National Water Act (Act 36 of 1998);
- National Environmental Management: Biodiversity Act (Act 10 of 2004);
- Local Government: Municipal Systems Act (Act 32 of 2000); and
- Conservation of Agricultural Resources Act (No. 43 of 1983).

A short summary on each of these are provided below.

16.1.1 National Environmental Management Act (Act 107 of 1998) (NEMA)

DEA is the lead agent for NEMA. NEMA provides for co-operative environmental governance through the establishment of national environmental management principles and procedures, and for their incorporation into decisions affecting the environment. NEMA emphasizes co-operative governance and assists in ensuring that the environmental and related rights in the Constitution are protected. NEMA requires the Department of Environmental Affairs to be the lead agent in ensuring the effective custodianship of the environment. In particular the Act provides that sensitive, vulnerable, highly dynamic or stressed ecosystems (such as estuaries) require specific attention in management and planning procedures, especially where subjected to significant human resource usage and development.

Various activities listed in the NEMA Environmental Impact Assessment ("EIA") Regulations (which came into effect on 2 August 2010) have a bearing on activities within the coastal zone and require environmental authorisation before they can proceed. The Regulations are especially pertinent to estuaries as many estuaries are situated within rapidly expanding development nodes along the South African coast and are under tremendous pressure from human activities. In terms of GN R 544 (listing notice 1), a Basic Assessment must be conducted and in terms of GN R 545 (listing notice 2), an EIA must be conducted. Listing notice 3 identifies activities in sensitive areas (including the estuarine functional zone) that also require environmental authorisation before they may proceed. Some waste disposal activities are also scheduled activities under these regulations.

16.1.2 Marine Living Resources Act (Act 18 of 1998) amended 2000 (MLRA)

The Department of Agriculture, Forestry and Fisheries (DAFF) is currently the lead agent for the MLRA. The objectives and principles of the MLRA deal with the utilization, conservation and management of marine living resources (including estuarine resources), the need to protect whole ecosystems, preserve marine biodiversity and minimize marine pollution, as well as to comply with international law and agreements and to restructure the fishing industry. Marine living resources includes any aquatic plant or animal, whether piscine or not, and any mollusc, crustacean, coral, sponge, holothurian or other echinoderm, reptile and marine mammals and includes their eggs, larvae and all juvenile stages, but does not include sea birds and seals.

Chapter 4 of the MLRA deals with the declaration of Marine Protected Areas (MPAs). This function is currently delegated to DEA. The Act empowers the Minister (DEA) to declare an area to be a Marine Protected Area where various activities are prohibited. These are

stipulated in the Declaration of Areas as Marine Protected Areas (No R.1429, 29 December 2000) promulgated under the Act (www.info.gov.za/documents/regulations/2000.htm).
The Goukou Estuary that forms part of the Stillbay MPA represents the only estuary that has been explicitly promulgated under this act. The LMRA also provides an avenue for special management measures such as the ban on dusky kob nigh fishing in the Breede Estuary.

16.1.3 National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008)

DEA: Chief Directorate: Oceans and Coast is the lead agent for the ICM Act. In relation to the establishment of resource objectives, the Act aims to establish a system of integrated coastal and estuarine management in South Africa. This includes setting the norms, standards and policies for management, promote the conservation of the coastal environment and ensuring the ecologically sustainable development of the coastal zone. The Act also determine the responsible organs of state in relation to coastal areas and to give effect to South Africa's international obligations in relation to coastal matters and to provide for related matters. Chapter 4 in the Act deals with estuaries. Section 33 provides for the National estuarine management protocol and Section 34 stipulates the need for individual Estuarine Management Plans under the Act.

At present there are 26 Estuary Management Plans, in various stages of completion, being developed as part of the implementation of the ICM Act (Table 16.1). This process also includes the establishment of 12 Estuary Forums which form the vital communication platform between coastal communities and the various government departments that play a role in estuarine management. It is strongly recommended that this best practice process be formalised as part of the regulation being drafted under the ICM Act.

Table 16.1. List of Estuary Management Plans currently in varouis stages of development (Source: Pierre De Villiers, CapeNature).

Estuary	Status
Orange	Ramsar plan linked to EMP process - roll out planned for 2011/12
Olifants	Plan and forum establish, but negotiating fishing community inputs
Groot Berg	Plan and forum establish
Verloren	Plan and forum establish
Diep	Plan and forum established
Zandvlei	Plan and forum to be established in 2011
Bot	Plan and forum establish
Klein	Plan and forum establish
Uilkraals	Plan and forum will be established in 2011
Heuningnes	Plan and forum established
Breede	Plan and forum establish
Goukou	Plan and forum will be completed in 2011
Gouritz	Plan still needs to be finalized by farmers and forum will be establsihed in 2011
Knysna	Plan incorporated in PA plan and PA forum exists, but not fully integrated into

Estuary	Status
	government departments
Groot Brak	Have manangnemt plan, but needs to be broadened to EMP framework. Roll out planned for 2011/12.
Klein Brak	Plan and forum will be established in 2011
Keurbooms	Plan and forum will be established in 2011
Gamtoos	Plan and forum established
Sundays	Plan to be finalised with stakeholders and forum will be established in 2011 - emp facilitation phase
Swartkops	Plan and forum established
Nahoon	Planning process initiated
Mtentu	Plan and protected area forum to be established to lead process - 2011
Msikaba	Plan and protected area forum to be established to lead process - 2011
Mbashe	Plan still needs to bedeveloped to include local fishers
Durban Bay	Plan still needs to be developed
Isipingo	Plan still needs to be developed

Chapter 8 of the Coastal Act contains exclusive provisions dealing with Marine and Coastal Pollution Control, specifically addressing 'Discharge of Effluent into coastal waters' (administered in collaboration with DWA) and 'Incineration and Dumping at sea' (e.g. dredge spoil dumping).

16.1.4 National Water Act (Act 36 of 1998) (Water Act)

DWA is the lead agent for the National Water Act. One the important objectives of the Act is to ensure protection of the aquatic ecosystems of South Africa's water resources. Estuaries are classified as a water resource under the Water Act. The Water Resource Protection Policy (under this Act) provides detailed guidelines and procedures for the classification (i.e. predefined health status) and the setting of Resource Quality Objectives for the protection of aquatic ecosystems (including objectives for water quantity, water quality, habitat integrity and biotic integrity). Section 21 of the Water Act classifies a number of activities related to water supply/demand and waste disposal (from land-based activities) as 'water uses' that require authorisation (licensing) by DWA. The Act also identifies certain land use (e.g. activities resulting in stream-flow reduction such as afforestation and cultivation of crops) and infrastructural developments (e.g. altering the bed, banks, course or characteristics of a watercourse) as 'water uses' that require authorisation by DWA.

The determination of the ecological water requirement of individual estuaries provides the scientific basis for local and regional water resources planning and implementation, and assists with identifying critical over-allocations of water resources. Unfortunately, ecological water requirement studies have only been completed on about 12 % of all estuaries (35 systems) over the last decade.

Table 16.2 Summary of Estuarine Ecological Water Requirment studies conducted under the NWA since 2000.

Estuary	Date	EWR Level
Mata	2000	Intermediate
Nahoon	2000	Intermediate
Mdloti (03)	2003	Rapid
Mhlanga	2003	Rapid
Orange	2003	Rapid
Tsitsikamma	2003	Rapid
Breede	2004	Intermediate
St Lucia	2004	Rapid
Thukela	2004	Intermediate
Kromme	2006	Comprehensive
Olifants	2006	Comprehensive
Seekoei	2006	Rapid
Tongati	2006	Rapid
Matjies	2007	Intermediate
Mdloti (07)	2007	Intermediate
Siyaya	2007	Rapid
Sout	2007	Intermediate
Tongati	2007	Intermediate
Goukamma	2008	Rapid
Groot Brak	2008	Intermediate
Keurbooms	2008	Rapid
Kleinemonde	2008	Intermediate
Knysna	2008	Intermediate
Noetsie, Gwaing Maalgate and Kaaimans	2008	Unofficial pilot test desktop
Swartvlei	2008	Rapid
Groot Berg	2010	Comprehensive
Bushmans	2010	Rapid
Palmiet	2010	Rapid
Sundays	2010	Intermediate
Bot	2011	Rapid
Little Amazintoti	2011	Rapid
Mbokedeweni	2011	Rapid
Mzimkulu	2011	Intermediate
Mgeni (uMgeni)	2011	Rapid
EZotha	2011	Rapid

16.1.5 National Environmental Management: Biodiversity Act (Act 10 of 2004)

DEA is the lead agent for the Biodiversity Act. The objective of the Biodiversity Act is to provide for the conservation of biological diversity, regulate the sustainable use of biological resources and to ensure a fair and equitable sharing of the benefits arising from the use of genetic resources. The Act states that the state is the custodian of South Africa's biological diversity and is committed to respect, protect, promote and fulfill the constitutional rights of its citizens. It also recognizes that South Africa is party to, amongst others, the Convention on Biological Diversity, the Convention on Wetlands of International Importance, especially Waterfowl Habitat (Ramsar Convention) and the Convention on Migratory Species (Bonn Convention).

16.1.6 Local Government: Municipal Systems Act (Act 32 of 2000)

Department of Provincial and Local Government is the lead agent for the Municipal Systems Act. The Act deals with Integrated Development Planning (IDPs) (municipalities are obliged to prepare and to update IDPs regularly). An IDP is intended to encompass and harmonise planning over a range of sectors such as water, transport, land use and environmental management. It requires each local authority to adopt a single, inclusive plan for the development of the municipality. Chapter 5 of the Act deals with integrated development planning that sets the social and economic objectives for a particular area. The Municipal Planning and Performance Management Regulations (Government Notice R.796, 24 August

2001) promulgated in terms of this Act describe the content requirements of IDPs. The regulations, for example state that the Spatial Development Framework (SDFs), reflected in the municipality's IDP, must 'contain a strategic assessment of the environmental impact of the spatial development framework'.

It is envisage that all Estuary Management Plans be nested into local IDPs to ensure wise use and biodiversity protection. Estuary Zonation plans should also be incorporated into the SDFs of local or district municipalities.

16.1.7 Conservation of Agricultural Resources Act (No. 43 of 1983) (CARA)

Department of Agriculture, Forestry and Fisheries (DAFF) is the lead agent for CARA. The objectives of CARA is to provide for the conservation of the natural agricultural resources of South Africa by: the maintenance of the production potential of land; the combating and prevention of erosion and weakening or destruction of the water sources (including estuaries); and the protection of the vegetation and the combating of weeds and invader plants.

16.2 Key recommendations

National legislation on estuarine management is carried out largely at a local level by state bodies such as the South African National Parks Board (SANParks), provincial departments (responsible for nature conservation and environmental impact assessment) and local authorities. This approach has resulted in fragmented and inefficient estuarine management. At present, there are uncertainties as to which laws are applicable and to which areas they apply. In addition, there are uncertainties over which government departments or agencies are mandated to enforce the various laws and, finally, there is limited enforcement capacity to enforce these laws and regulations (Van Niekerk and Taljaard 2003).

A key recommendation, therefore, is the finalization of the National Estuarine Management Protocol, the roll out of the Estuary Management Planning framework and the provision of resources, both human and funding, to sustain this effort. The framework should also address the rationalisation of the planning processes, in which one plan is developed, that encompasses the requirements of protected area legislation, Ramsar, MLRA and the ICM Act.

Key legal instruments, such as the determination of the ecological flow requirement of individual estuaries, provide the scientific basis for such local and regional planning and implementations frameworks, and assist with identifying critical over-allocations of natural resources (e.g. water or living resources). The National Estuary Biodiversity Plan provides the lens through which all present, and future, resource allocations should be evaluated to ensure that national and international biodiversity targets are achieved.

17. KEY FINDINGS AND RECOMMENDATIONS

17.1 Key findings

1. There are nearly 300 functional estuaries in South Africa.

In South African an estuary is considered 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 or salinity penetration. 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 a lagoon or lake which may become fresh or hypersaline.

2. The Lake St Lucia system represents over 55% of the estuarine area of South Africa, but is in a very poor condition.

Although situated within the iSimangaliso Wetland Park protected area, a World Heritage Site, St Lucia is impacted upon by activities in its catchment and reduction in freshwater flows from the rivers feeding the lake.

- The most significant impact has been the artificial separation of the uMfolozi river mouth from Lake St Lucia, dating from the 1950s, reducing freshwater inflow to the lake by more than half in low flow periods.
- Combined with drought conditions, this has resulted in St Lucia being closed to the sea for much of the last decade, unable to fulfil its role as the most important nursery area for marine fish along the south-east African coastline, among other impacts.

3. Based on the proportion of estuaries in good ecological condition, 43% of estuary ecosystem types (20 types out of 46 types) are classified as threatened, representing 79% of SA estuarine area.

About 39% of South Africa's 46 estuarine types (18 types) are classified as critically endangered, 2% as endangered (1 type), 2 % as vulnerable (1 type) and 57% as least threatened (26 types). If this is considered in terms of estuarine area the situation is even more dire as 79% of South Africa's estuarine area falls within estuary types classified as

critically endangered, compared with less than 1% in types that are endangered or vulnerable and 21% in types that are least threatened.

- A very small percentage (1%) of the total estuarine habitat area in South Africa is in an excellent condition. About 14% is in good condition, 31% is in a fair condition, and 54% is in a poor condition.
- About 83% of the estuarine area that falls within Ramsar sites (57 000 ha) is in a poor state, while none is in an excellent condition. Similarly, none of the 70 400 ha that falls within Important Bird Areas is in an excellent condition and 67% is in a poor condition. Collectively 72% of estuaries in Marine or other Protected Areas (65 900 ha) are in a poor condition.

4. 59% (27 out of 46 types) of South Africa's estuary ecosystem types are not protected. These unprotected types make up 83% of the total estuarine area.

- 70 estuaries in South Africa enjoy some form of formal protection, accounting for 60% (56 000 ha) of the estuarine area within South Africa. Only 14 estuaries have full no-take protection.
- The Lake St Lucia system contributes 90% of the protected estuarine area, and covers about 51 000 ha. The other protected estuaries cover a total area of just under 10 000 ha.
- Nearly 59% (27 out of 46 types) of South Africa's estuary ecosystem types are not protected. About 33% of estuary ecosystem types are considered to be well protected (15 types), while 4% are moderately protected (2 types) and 4% are poorly protected (2 types).
- If protection levels are evaluated in terms of percentage area, the unprotected types make up 83% of total area, while the estuary types that are poorly protected, moderately protected and well protected make up 2%, 14% and 2% of area, respectively.
- The National Estuary Biodiversity Plan identified 58 estuaries (20%) that require full protection and 62 (22%) estuaries that require partial protection (this includes those that already have partial protection).

5. The total freshwater inflow of the 20 largest catchments in South Africa has been reduced by nearly 40% from the pristine condition, and freshwater flow requirements have been determined for only 12% of all estuaries.

- The larger catchments tend to be subjected to significant water resources development, such as large dam developments and inter/intra-basin transfer schemes. These catchments often exhibit a significant decrease in resetting floods with a related significant decrease in mean annual runoff. Related ecosystem responses include increased sedimentation as a result of reduced flushing, loss of queuing effect to the marine environment and reduced nursery function.
- Smaller catchments are most often subjected to more localised water resource development such as run-of-river abstraction and forestation, leading to loss, or reduction of, base flows in summer. While the net reduction in mean annual runoff is less severe than for larger catchments, related ecosystem responses include increased mouth closure, reduced connectivity with the marine environment, reduced nursery function, and reduced production.

6. Flow reduction, habitat modification, fishing and pollution are cumulative pressures in need of management interventions. Invasive alien species (plants, invertebrates and fish), mariculture and desalination are emerging pressures that could pose a significant risk to estuarine biodiversity.

- Nearly 4% of all estuaries are under significant flow modification pressure, with most of these being large permanently open estuaries. An additional 18% of estuaries have experienced a moderate degree of flow modification. Flow modification is causing ecosystem type changes, for example, the Kobonqaba in the Eastern Cape and Uilkraals in the Western Cape closed for the first time in recorded history in 2010.
- 13% of South Africa's estuaries are under significant habitat modification or development pressure.
- The mouths (outlets) of about 16% of estuaries are artificially managed, but these estuaries (which include the Lake St Lucia system) account for 62% of the total estuarine habitat. Inappropriate low-lying developments are necessitating artificial mouth manipulations (e.g. breaching), of particular concern in the large lake systems like Verlorenvlei, Bot/Kleinmond, Klein, Wilderness (Touws), Swartvlei and Lake St Lucia system.
- 1% of South Africa's estuaries are under tremendous fishing pressure (Olifants, Berg, Bot and Kosi) such that fish stocks have declined significantly in these systems. Another 13% are under major fishing pressure. Fishing effort is relatively evenly

distributed around the coast, but proportionately (in terms of tonnes per ha removed) much higher in the Cool Temperate estuaries.

- Approximately 2 000 tonnes of fish, comprising 80 species, are caught in South African estuaries each year.
- 84% of all estuaries are influenced by bait collection activities.
- Mangroves have been completely lost from 14 estuaries in South Africa due to excessive harvesting or ecosystem changes. In the smaller estuaries, where mangrove strands consist of one to three rows of trees, harvesting can result in complete removal of mangroves. Developmental pressures have also caused the loss of mangroves, e.g. from the Mhlanga, Little Manzimtoti, Lovu, Msimbazi, Mgababa, Ngane, Mahlongwa, Kongweni, Bilanhlolo, Mhlangankulu and Khandandlovu.
- 15% of estuaries are under significant pollution pressure and 40% under a moderate degree of pollution pressure. Fewer than 1% of all estuaries have no pollution pressures on them.

7. Freshwater (surface and groundwater) flowing into the sea is not wasted and is vital to the productivity of the nearshore coastal environment.

- Changes in freshwater flow and associated variations in turbidity, nutrients and sediment supply can impact on important ecological processes such as nursery functions, environmental cues, productivity and food web processes.
- Fisheries resources in South Africa that have, or may have been, compromised by reduced freshwater input include linefish, prawns, and filter feeding invertebrates in the intertidal and shallow subtidal zones.
- The reduction of river flow leads to a reduced sediment supply to the coast with implications for beach and subtidal habitats. Many of these habitats are also important for ecological processes.

8. While there are a range of invasive alien species (e.g. 13 plants, 11 invasive alien and 7 extra-limital fish species) in South Africa's estuaries, they do not represent a significant overall pressure as yet.

- Thirteen invasive alien plant species, ranging from trees to water weeds, have been identified in South Africa's estuaries.

- There are at present 11 invasive alien fish species and 7 extra-limital fish species identified in the 130 estuaries for which there were data. The spreading of especially invasive predatory fish acts as a barrier to migratory species (e.g. eels and freshwater mullet) and influences the species composition and abundance of species, many of which are commercially important, in the river-estuary interface zone.
- There is a significant and growing threat to the estuarine subtidal benthic environment through the invasion and proliferation of the mollusc *Tarebia granifera* in at least 30% of KwaZulu-Natal estuaries.

9. Climate change can have serious ecological, resource and social implications

Climate change pressures include flow modification, sea-level rise and increased temperatures and coastal storminess, leading to changes in physical processes (e.g. modification in mouth conditions, salinity regimes, nutrient pulses, sediment regimes) and biological responses (e.g. production, species composition) with an impact ultimately on ecosystem services.

- The KwaZulu-Natal and West Coast estuaries will be the most affected by climate change from a structural and functional perspective, e.g. mouth state, nutrient supply, salinity distribution and ultimately production (e.g. fisheries).
- The Wild Coast, Eastern and Southern Cape estuaries will be most vulnerable to temperature regime shifts (both nearshore and land) and the associated range extensions/contractions of species and community composition changes.
- Climate change is one of many pressures acting on estuaries and should be viewed as an additional form of anthropogenic alteration (rather than a separate pressure) in an already stressed ecosystem type, i.e. climate change acts as an accelerator of ecosystem change.

10. Estuary Management Plans are developed, or in progress, for 9% of South Africa's estuaries

Over the past decade legislative responses have increased, but flow-related measures are starting to lag behind other planning processes.

- The finalisation of the National Estuarine Management Protocol, the roll out of the Estuary Management Planning Framework and the provision of resources, both human and funding, is needed to sustain this effort. At present there are 26 Estuary Management Plans in the process of being developed as part of the implementation of the Integrated Coastal Management Act (Act 24 of 2008). This includes the establishment of 12 Estuary Forums which form the vital communication platform between coastal communities and the various government departments that play a role in estuary management.
- Key legal instruments, such as the determination of the ecological water requirements of individual estuaries, provide the scientific basis for local and regional water resources planning and implementation frameworks and assist with identifying critical over-allocations of resources.
- Unfortunately, ecological water requirement studies have been undertaken for only about 12 % of all estuaries over the last decade.

17.2 Key Messages

1. Estuaries, unlike many other ecosystems, can be restored to a well-functioning, productive state.

- Estuaries are by nature resilient systems, because their fauna and flora are adapted to living in conditions of extreme change.

2. Recovery of South Africa's iconic estuary, the Lake St Lucia system, is possible.

- The very poor condition of the Lake St Lucia system, which represents over half the estuarine area in South Africa, is reversible and ecosystem recovery is possible. Due to Lake St Lucia's international and national significance, the iSimangaliso Wetland Park Authority has raised funding from the Global Environment Facility (GEF) to investigate and implement a long-term solution to the hydrological issues facing the Lake St Lucia system. In parallel to this investigation the management strategy for 2011/2012 will result in the reversal of the 60 year old approach to managing Lake St Lucia; that is, allowing the uMfolozi and Lake St Lucia estuary mouths to join to form a combined mouth, and thereby allowing it to function as naturally as possible. In keeping with adaptive management, an ongoing review and evaluation based on

monitoring of salinity, lake levels and ecosystem health will continue as these interventions are implemented. Ongoing national government support for the rehabilitation of the Lake St Lucia system is important.

Other specific management recommendations include:

- reducing the fishing effort within the system;
- resolving the issue related to the backflooding of the low-lying sugar cane farms so that conflict over breaching of the combined mouth does not occur (e.g. securing or protecting the properties along the lower uMfolozi);
- improving farming practices in the uMfolozi catchment and floodplain to improve water quality and limit sediment input to St Lucia.

3. Increase protection levels through the implementation of the National Estuary Biodiversity Plan

- DEA, in collaboration with SANBI, DWA and DAFF, should lead the process of endorsing and implementing the National Estuary Biodiversity Plan.

4. To adequately protect an estuary, it needs to be in a formal protected area with effective no-take zonation, and its freshwater requirements must be guaranteed.

- The Lake St Lucia system is an example of a system which is poorly protected. While being fully protected on paper, St Lucia's current ecological condition is poor (Category E) and uMfolozi is only in fair condition (Category D).

5. Estuaries provide a focal point for co-ordinated and integrated natural resource management.

- Estuaries form the link between the land and the sea and are therefore the receivers of most resource-use pressures from the surrounding land- and seascape. Estuaries should be the focal point for natural resource management and planning in the coastal domain, e.g. in the classification of water resources in terms of the National Water Act, the class of a river should be influenced by the class assigned to the estuary.

6. Estuaries are valuable national assets providing essential ecosystem services, such as nursery functions to coastal fisheries, freshwater flows to the marine

environment, replenishment of nutrients and organic material to coastal habitats, flood and sea storm protection, carbon sequestration, safe bathing areas and cultivation of plants for biofuels without freshwater.

- Estuaries provide an important nursery function for fish, with some of the more muddy Temperate estuaries such as the Mbashe, Umtata, Keiskamma and Great Kei being particularly important for supporting collapsed marine fish resources such as white steenbras and dusky kob.
- Estuaries provide freshwater (both surface and groundwater), nutrients, detritus and sediments to the coastal environment, thereby supporting important ecological processes and the productivity of some fisheries (e.g. prawns and line fishery).
- Estuaries offer easy access, warmer waters, shallow depths, shelter and weak currents that make them very attractive to bathers.
- Estuaries contribute to the regulation of greenhouse gases and provide opportunities for carbon trading.
- South Africa's estuaries provide a significant buffer against floods with a total open water area of 61 000 ha and flood plain storage, as represented by the estuarine functional zone, of nearly 171 000 ha, of which 60% is in the Subtropical biogeographic region.
- Halophytes (salt tolerant plants such as *Sarcocornia*) can be used as an alternative energy or food source due to their high oil and protein content. By far the greatest benefits of halophyte culture is that, unlike much current biofuel production, it does not displace food crop production or use excessive quantities of fresh water.

7. Future introduction and spread of invasive species in estuaries can be prevented.

- While invasive alien species do not represent a significant overall pressure as yet, it is critically important that there is timeous intervention to ensure that the situation remains under control (e.g. control invasive predatory fish that act as a barrier to migratory species, and the total eradication of the alien invasive grass *Spartina alterniflora,* which is currently known to be present in only the Groot Brak estuary but which may otherwise spread).

8. Healthy estuaries support ecosystem resilience and adaption to climate change.

- Stressed ecosystems have a lower resilience to change. By increasing or maintaining the resilience of estuaries, the ability of a system to recover, for example after a flood or drought, is enhanced.
- The resilience of an estuary is influenced by the intactness of its catchment and estuarine habitats. A way to ensure resilience is the determination and implementation of estuarine ecological water requirements and the protection/rehabilitation of the estuarine functional zone.
- The processes underpinning the ecosystem services provided by estuaries, such as the assimilation and cycling of nutrients, also need to be protected if resilience is to be maintained.

18. INFORMATION GAPS, RESEARCH PRIORITIES AND FUTURE ASSESSMENTS

18.1 Information gaps

- **Refine estuary ecosystem types:** The NBA 2011 has started the process of refining the typing of South Africa's estuaries at a more detailed level than has previously been available. However, higher resolution input data on catchment hydrology, bathymetry, sediment structure and water quality (turbidity and salinity) is required to address the needs articulated by specialists in the execution of this study.
- **Quantification of the modification in freshwater flow to the coast on a watershed scale:** There is an urgent need for a quantification of the modification in freshwater flow to the all estuaries of South Africa. This analysis should include all current land-use, transfer schemes, discharges, dam developments and be based on the true catchment area of each individual system. These data will also form the basis of an analysis of the degree to which freshwater flow to the coast has been modified.
- **Taxonomic surveys of the invertebrates in all South African estuaries:** There is no up-to-date national dataset for South African estuarine invertebrates. Invertebrate data were last collated at a national scale more than a decade ago but little effort has been made to address this. Future assessments and biodiversity plans cannot be refined without filling this gap in a systematic manner.
- **Taxonomic surveys of the plants in all South African estuaries:** Taxonomic revision of salt marsh species should be supported and funded so that macrophyte species lists can be updated for all estuaries. From these data, sites of rare and threatened species can be identified. Updated GIS spatial data of the habitat areas data for all estuaries is needed. This is especially important where data are older than 10 years. This would include field surveys to ground truth the data. For example detailed habitat maps for the Rietvlei/Diep system and Richards Bay Harbour are urgently required for planning proposes and to address deficiencies in the current databases. This should include the development of a database with information presented in this study plus GIS maps of all South African estuaries. This spatial data could also feed into the estuary management planning processes.
- **Invasive Species:** With the exception of plants, very little is known about invasive species in South Africa's estuaries. There is an urgent need to have a census on the occurrence of invasive alien species in different estuaries and the potential

environmental impact of these on both the ecosystem function and the value derived from the estuary in question. All invasive species (freshwater, marine and estuarine) should be included in the census.

- **Nursery function for exploited and collapsed fish species:** Recent work has indicated that while most estuaries serve as nurseries, some of the more sediment rich systems are associated with "sediment deltas" in the nearshore environment which serve as nurseries for some species which represent collapsed stocks. It is of the utmost importance that these systems are identified and their nursery function quantified to ensure sustainable resource utilisation into the future. Future biodiversity plans should also include these systems explicitly to align management and conservation priorities.
- **Pollution data:** There is no systematic record of the discharges into estuaries. There is also a need to evaluate the monitoring stations above the estuaries to develop a clear perspective on what is flowing into estuaries and coastal waters.
- **The value of estuaries in South Africa:** There is very little national scale data available on the value of estuaries. As this is one of the key requirements for communicating the relevance of estuaries to coastal communities, and the country as a whole, this lack of data hinders the ability to motivate for rational decision-making.
- **Climate change:** Climate change has the potential to change the processes and functioning of South Africa's estuaries dramatically. Large and local scale climate models are becoming better at accurately predicting the drivers of change in the future. The estuarine research community needs to make this one of their research priorities over the next decade to facilitate better adaptation strategies and ensure ecosystem resilience.
- **Sediment data:** Very little information is available on the sediment structure of South Africa's estuaries. This is a significant data gap as grain size distribution and the mud:sand ratios influence biodiversity patterns. The lack of sediment information also makes it very difficult to assess environmental change in relation to some of the major pressures such as dam development and sand mining.
- **Mapping the 3-dimensional nature of South Africa's estuaries:** Detailed systematic topographical and bathymetrical surveys are needed for all South Africa's estuaries. Cross-sectional survey data are available for less than a third of the estuaries in the country. In most cases these data are over 20 years old. Most planning processes (e.g. ecological water requirement studies, Estuary Management Plans, setback lines, spatial development plans) are of low confidence as they lack this basic information. Assessment of change (sedimentation, erosion sensitivity to

flow modifications, structural developments) is therefore mostly inferred from pressure data. Improved planning and assessments urgently require a significant effort to address these basic data requirements.

- **Up-to-date surveys of the fish and bird fauna of estuaries:** National scale surveys on fish and birds in all South African estuaries were last carried out in the early 1980s. These surveys urgently need to be repeated in a once-off effort that is comparable with the earlier surveys.

18.2 Research Priorities

- **Taxonomic surveys of the invertebrates in all South African estuaries:** There is no national dataset or specimen voucher system for the *South African estuarine invertebrates*. This significant data gap was identified more than a decade ago but little effort has been made on a national scale to address this deficiency. Future assessment and biodiversity plans cannot refine on present findings without filling this gap in a systematic manner.
- **Taxonomic surveys of the plants in all South African estuaries:** The taxonomic revision of salt marsh species should be supported and funded so that macrophyte species lists can be updated for all estuaries. From these data, sites of rare and endangered species can be identified.
- **Refining the typing of estuaries:** The NBA has started the process of refining the typing of South Africa's estuaries, but higher resolution input data on catchment hydrology, bathymetry, sediment structure and water column chemistry (turbidity and salinity) is required to address the needs articulated by specialists in the execution of the NBA 2011.
- **Invasive species as a barrier to connectivity:** The spread of invasive freshwater predatory fish acts as a barrier to migratory species (e.g. eels and freshwater mullet) and compete with estuarine associated species in the river-estuary interface. This aspect needs further investigation to quantify the extent of the problem.
- **Importance of the 71 smaller and/or ephemeral outlets not addressed in this NBA:** There are over 371 river/stream outlets along the SA coast (see Appendix A for a full list), but not all of these are deemed functional estuarine systems, i.e. representative of significant biological activity (Harrison et al. 2000). In total, 71 systems were not assessed, 20 in the Cool Temperate, 33 in the Warm Temperate and 28 in the Subtropical biogeographic region. It is important to note that the

exclusion of these systems from the NBA 2011 assessment leaves them somewhat under protected from future development. It is therefore recommended that a separate study be under taken to demarcate these smaller or more ephemeral outlets, to investigate their ecological importance, and finally integrate them into current planning frameworks.

- **Climate Change:** Climate change has the potential to change the processes and functioning of South Africa's estuaries dramatically. Large and local scale climate models are becoming better at accurately predicting the drivers of change in the near and far future. The estuarine community is urged to make this one of their research priorities over the next decade to facilitate better adaptation strategies and ensure ecosystem resilience.
- **Connectivity and regional importance:** Estuarine ecosystems are not independent and isolated from other ecosystems. Rather, estuaries form part of a regional, national and global ecosystem network through either a direct connection via water flows (the transport of nutrients, detritus, larvae, plankton, etc.) or indirectly via the movement of estuarine fauna. The links between individual estuaries and other ecosystems may span a few hundred metres or thousands of kilometres. Hence, a disturbance to a specific estuary may be reflected in effects on ecosystems remote from that estuary. Unfortunately, although there is ample evidence of the regional interaction and interdependence between estuaries, little quantification has been conducted in South Africa on the connectivity between systems and how to incorporate this into assessments and biodiversity plans.
- **Population genetics studies:** To allow for more detailed biodiversity planning in the future it is important that detailed *population genetics studies* be done on plants, invertebrates and fish to ensure the correct biodiversity protection measures. Preliminary findings indicate that there is a higher degree of isolation than is assumed for the less mobile species (such as plants). This work needs to be done systematically for the higher taxa as well.
- **Recruitment studies of fish and invertebrates:** Recruitment studies are urgently required to ensure sound strategic planning of estuarine biodiversity and resource allocation. While fisheries management measures have become more stringent over the last decade, the stock status of a number of exploited species have stayed the same or declined even further. Recruitment studies would shed light on an important bottle-neck in resource recovery plans, and identify estuaries of conservation and management importance.

- **Nursery function of exploited and collapsed fish species:** Recent work has indicated that while most estuaries serve as nurseries, some of the more sediment rich ones are associated with "sediment deltas" in the nearshore environment which serves as nurseries for some collapsed stock species such as dusky kob. It is important that these systems be identified and their nursery function qualified to ensure sustainable resource utilsation into the future. Future biodiversity plans should also include these systems explicitly to align management and conservation priorities.

18.3 Priority actions for estuarine biodiversity management and conservation

- **Restore the health of St Lucia and conserve the other estuarine lake systems.** South Africa's estuarine lake systems (St Lucia, Verlorenvlei, Bot, Klein, Wilderness, Swartvlei, Kosi) are all under tremendous pressure, and need to be managed in a more holistic manner. They are important national biodiversity assets, which often pay the price for inappropriate short-term local-level decision-making. In particular, the St Lucia system holds a major share of South Africa's estuarine biodiversity. As discussed above, the iSimangaliso Wetland Park Authority has initiated measures to combine the uMfolozi with Lake St Lucia with funding support from the Global Environment Facility (GEF) in order to restore the health of the greater ecosystem.
- **Increase protection levels through the implementation of the National Estuary Biodiversity Plan.** The development of the National Estuary Biodiversity Plan was the first step in the planning process. DEA, in collaboration with SANBI, DWA and DAFF, should lead the implementation of the National Estuary Biodiversity Plan. This should include the setting of protected area targets for Estuarine Protected Areas in the short- to medium-term, e.g. 5% of all ecosystem types will be formally protected by 2020 and 20% of all ecosystem types will have Estuary Management Plans by 2020. This also requires the integration of the National Estuary Biodiversity Plan in strategic processes such as the classification of water resources led by the DWA and the upcoming revision of the National Protected Area Expansion Strategy led by DEA.
- **Respond rapidly to emerging invasive species.** Develop protocols and procedures for the early detection, risk assessment and management of invasive alien species. For example, certain invasive alien fish species can act as a barrier to migratory species (eels and fresh water mullet) and influence the species

composition and abundance of species, many of which are commercially important, in the river-estuarine interface.

- **Develop a National Coastal Biodiversity Plan.** Estuaries are not separate from the coast. To ensure their long-term functioning also requires the development of a National Coastal Biodiversity Plan that integrates marine, estuarine, freshwater and terrestrial aspects. Such a plan should be conducted at a fine enough scale to support integrated coastal development at the municipal level.
- **Ensure the total eradication of the alien invasive *Spartina alterniflora* from the Groot Brak estuary before it spreads to other estuaries.** Progress has been made, since early 2011, but it is very important that the initial field tests for chemical and mechanical control be followed up with full eradication and continuous follow up removal to ensure that this highly invasive and damaging plant species does not spread to adjacent systems along the coast.
- **Ensure that the legal definition of estuaries in South Africa includes the estuarine functional zone.** The GNR 546 Listing Notice 3 under the NEMA EIA Regulations (2010) identifies the estuarine functional zone as a sensitive area that requires environmental authorisation before a development may proceed. It is important that this consideration is also taken up by the Integrated Coastal Management Act and the National Water Act, both of which need to recognise the value of the estuarine floodplain and the threat of (back) flooding within this zone.
- **Determine ecological water requirements for all estuaries within 10 years and implement flow requirements within 5 years of their classification.** This process is likely to require a two-tiered approach in which the findings of the NBA 2011 form the basis for allocation on a national level in the classification of water resources in terms of the National Water Act. While more detailed ecological water requirement studies will be needed for water-stressed catchments or biodiversity priority areas, there is also an urgent need for strategic assessments (such as the National Water Resources Strategy) to take cognisance of estuarine flow requirements which are often substantially higher than the flow requirements of the river entering the estuary. This little-recognised fact leads to national and catchment scale water resource plans that over-estimate the water resources available for development, thus compromising the ecosystem processes that coastal communities depend upon.

- **Ensure resilience to climate change and other global change pressure through the appropriate management of the estuarine functional zone. Finalise the National Estuary Management Protocol** to ensure cooperative governance between the lead authorities that manage estuaries and roll out the development and implementation of Estuary Management Plans in terms of the Integrated Coastal Management Act.
- **Finalise and implement the National Estuary Monitoring Programme** currently being developed by DWA. This multi-tier, multi-parameter (include biotic and abiotic components) programme is based on current best practice and with sufficient funding, and support from other organs of state, could go a long way in addressing data deficiencies in future NBA assessments.
- **Development of a National Sustainability Plan for Estuarine Resources** that will ensure alignment between sectoral objectives for estuaries on a national scale. The plan should be developed in consultation with lead authorities (DEA, SANBI, DWA and DAFF) and assist with facilitating the co-operative governance between the lead agents. Once in place, it should serve as the "blue print" for a number of key sectoral resource plans and processes at various levels of governance, e.g. allocation of water resources or Total Allowable Catch in coastal fisheries.

18.4 Recommendations for next NBA

Based on lessons learned during the NBA 2011 process, as well as aspects addressed in lesser detail than we would have liked, the following recommendations are made with reference to future NBAs:

- **National Health Assessment:** The method (based on ecological water requirement method under the Water Act) followed for the National Health Assessment and proved a valuable assessment framework for evaluating ecosystem change on a national scale. It is recommended that this same approach be followed for future NBAs, but with an emphasis on improved pressure data (especially hydrology, catchment land-use and pollution aspects).
- **Climate Change:** While climate change was addressed on a broad-scale from a process perceptive, more detailed work is needed to understand its impact on the functioning and biodiversity of South Africa's estuaries. A better understanding of this threat will greatly enhance our ability to take the necessary management steps

and appropriate water supply decisions. It is strongly recommended that this becomes a major trust of the next NBA.

- **Maximise the value of estuaries in South Africa:** Time and funding constraints prevented this NBA assessment process to adequately define and value the benefits society derive from South Africa's estuaries. Future NBA studies should strive to address this aspect in more detail.
- **Quantifying ecosystem interactions with the marine environment:** Our understanding of estuarine ecosystem functioning is relatively well developed, but more information is required, especially with respect to interactions and connectivity with the marine coastal zone.
- **National biodiversity planning:** While not essential to future NBA assessments, the existing proposed National Estuaries Biodiversity Plan should be periodically reviewed in the light of new pressure information; improved classification/typing; improved ecosystems services data; policy changes and development initiatives. The NBA provides a perfect national platform for the coherent roll-out of biodiversity initiatives.
- **Time-line and project integration:** The high degree of interaction among the core team members added value and facilitated integration between the various components (marine, estuarine, rivers and land). While this aspect may slow down the overall delivery time, it provides for significant knowledge transfer, learning opportunities, and ultimately a better product. In addition, a longer time frame allows for the engagement of domain specialists at time-scales more suitable for smaller individual research projects and scientific curiosity.

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19. REFERENCES

Adam P (2002). Saltmarshes in a time of change. *Environmental Conservation* 29: 39-61.

Adams JB, Bate GC and O'Callaghan M (1999). Primary producers. In: Allanson BR and Baird D (eds). *Estuaries of South Africa*. Cambridge University Press, Cambridge, pp 91-117.

Adams JB, Colloty BM and Bate GC (2004). The distribution and state of mangroves along the coast of Transkei, Eastern Cape Province, South Africa. *Wetlands Ecology and Management*. 12 (5): 531-541.

Adams JB, Snow GC and Veldkornet DA (2010). Updated estuary habitat and plant species data. Report submitted to the *National Spatial Biodiversity Assessment 2011: Estuaries Component.*

Alber M (2002). A conceptual model of estuarine freshwater inflow management. *Estuaries* 25: 1246-1261.

Allanson BR and Read GHL (1987). The response of estuaries along the south eastern coast of South Africa to marked variation in freshwater inflow. Special report No. 2/87. Institute for Freshwater Studies, Rhodes University.

Allanson BR, Hart RC, O'Keefe JH and Robarts RD (1990). Inland waters of southern Africa: An ecological perspective. *Monographiae Biologicae* 64. Dordrecht: Kluwer Academicb.

Appleton CC (2003). Alien and invasive fresh water Gastropoda in South Africa. *African Journal of Aquatic Science* 28(1): 69-81.

Appleton CC and Nadasan DS (2002). First report of *Tarebia granifera* (Lamarck, 1816) (Gastropoda: Thiaridae) from Africa. *Journal of Molluscan Studies* 68: 399-402.

Appleton CC, Forbes AT and Demetriades NT (2009). The occurrence, bionomics and potential impacts of the invasive freshwater snail *Tarebia granifera* (Lamarck, 1822) (Gastropoda: Thiaridae) in South Africa. *Zoologische Medelingen Leiden* 83(4):525-536.

Bate GC and Adams JB (2000). The effects of a single freshwater release into the Kromme Estuary: Overview and interpretation for the future. *Water SA* 26: 329-332.

Bate GC, Whitfield AK and Forbes AT (2010). A review of studies on the uMfolozi Estuary and associated flood plain, with emphasis on information required by management

for future reconnection of the river to the St Lucia system. *WRC Report No: KV 255/10* ISBN No: 9781431200658 http://www.wrc.org.za.

Bate GC, Whitfield AK, Adams JB, Huizinga P and Wooldridge TH (2002). The importance of the river-estuary interface zone in estuaries. *Water SA* 28: 271-279.

Begg GW (1978). The estuaries of Natal. *Natal Town and Regional Planning Commission Report 41*. Pietemaritsburg.

Bennett BA (1993). The fishery for white steenbras Lithognathus lithognathus off the Cape coast, South Africa, with some considerations for its management. South African Journal of Marine Science 13:1-14.

Bennett BA (1985). A mass mortality of fish associated with low salinity conditions in the Bot River estuary. *Trans Roy Soc S Afr* 45: 437-448.

Berry PF and Schleyer MH (1983). The brown mussel *Perna perna* on the Natal coast, South Africa: utilization of available food and energy budget. *Marine Ecology Progress Series* 13: 201-210.

Berry PF, Hanekom P, Joubert C, Joubert F, Schleyer MH, Smale M and van der Elst R. (1979). Preliminary account of the biomass and major energy pathways through a Natal nearshore reef community. *South African Journal of Science* 75: 565.

Binning K and 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.

Blaber SJM (1973). Population size and mortality of the marine teleost Rhabdosargus holubi (Pisces: Sparidae) in a closed estuary. *Marine Biology* 21: 219–225.

Bornman TG and Klages NTW (2004). Upgrade of Kenton on Sea / Bushmansrivermouth Bulk Supply. Appendix H: Specialist Report - Effects of brine discharge from a reverse osmosis plant on the salinity and temperature of the Bushmans River Estuary, IECM Report No. C84, Institute for Environmental and Coastal Management, Environmental Consulting and Research, University of Port Elizabeth, 10pp.

Bornman TG (2002). Freshwater Requirements of Supratidal and Floodplain Salt Marsh on the West Coast, South Africa. *PhD.Thesis*. University of Port Elizabeth. 243 pp.

Boucher C and Jones L (2007). Chapter 6: Estuarine and floodplain vegetation. In: B.M. Clark (Ed.) Berg River Baseline Monitoring Programme Final Report – Volume 2. Berg River Estuary, September 2004. Unpublished report to the Department of Water Affairs and Forestry,194 pp.

Boyd R, Dalrymple R and Zaitlin B A (1992). Classification of clastic coastal depositional environments. *Sedimentary Geology* 80:139-150.

Brown AC and Jarman N (1978). Coastal marine habitats. In: Wiener, M.J.A. (Ed.), Biogeography and Ecology of Southern Africa. W. Junk, *The Hague*, pp. 1239–1277 (Chapter 8).

Cai W (2006). Antarctic ozone depletion causes an intensification of the Southern Ocean super-gyre circulation. *Geophysical Research Letters*, vol. 33, L03712, doi:10.1029/2005GL024911.

Cai W, Cowan T, Dix M, Rotstayn L, Ribbe J, Shi G and Wijffels S (2007). Anthropogenic aerosol forcing and the structure of temperature trends in the southern Indian Ocean, *Geophys*. *Res*. *Lett*., 34, L14611, doi:10.1029/2007GL030380.

Caldeira K and Wickett ME (2003). Anthropogenic carbon and ocean pH. *Nature* 425: 365-365.

Cameron, WM and Prichard DW (1963). Estuaries. M.N. Hill (Ed.), *The Sea*, Vol. 2. Wiley–Interscience, New York (1963), pp. 306–324.

Cañete R, Yong M. Sánchez J, Wong L and Gutiérrez A (2004). Population dynamics of intermediate snail hosts of *Fasciola hepatica* and some environmental factors in San Juan y Martinez Municipality, Cuba*. Memórias do Instituto Oswaldo Cruz* 99(3): 257-262.

CBD (1992). The Convention on Biological Diversity, UN Conference on Environment and Development, Rio de Janeiro. The Convention on Biological Diversity, http://www.biodiv.org.

CBD (2000). Global strategy on invasive alien species. The Convention on Biological Diversity, *UNEP/CBD/SBSTTA/6/INF/* 9:1–52.

Chaniotis Bn, Butler JM, Ferguson FF and Jobin WR (1980a). Bionomics of *Tarebia granifera* (Gastropoda: Thiaridae) in Puerto Rico, an asiatic vector of *Paragonimiasis westermani*. *Caribbean Journal of Science* 16(1-4): 81-90.

Chaniotis BN, Butler JM, Ferguson FF and Jobin WR (1980b). Thermal limits, desiccation tolerance, and humidity reactions of *Thiara (Tarebia) granifera mauiensis* (Gastropoda: Thiaridae) host of the Asiatic lung fluke disease. Caribbean Journal of *Science* 16(1-4): 91-93.

Church JA and White NJ (2006). A 20th century acceleration in global sea level rise, *Geophys*. *Res*. *Lett*., 33, L01602.

Clark BM (2006). Climate change: A looming challenge for fisheries management in southern Africa. *Marine Policy* 30: 84-95.

Coetzee JC (1995). Classification of South African estuarine based in plant communities. *M.Sc. Thesis*. University of Port Elizabeth.

Coetzee JC, Adams JB and Bate GC (1997). A botanical importance rating of selected Cape estuaries. *Water SA*, 23: 81-93.

Colloty BM (1999). Database of estuarine habitats on compact disc. Port Elizabeth: University of Port Elizabeth, Department of Botany.

Colloty BM (2000). The botanical importance rating of the estuaries in the former Ciskei/Transkei. *PhD Thesis.* University of Port Elizabeth. 202 pp.

Colloty BM, Adams JB and Bate GC (1998). The use of a botanical importance rating system to assess changes in the flora of the Swartkops estuary. Pretoria: Department of Water Affairs and Forestry.

Colloty BM, Adams JB and Bate GC (2000). *The botanical importance of the estuaries in former Ciskei/Transkei*. WRC report 812/1/00 150 pp.

Constanza R, D' Arge R, De Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P and Van Den Belt M (1997). The value of the world's ecosystem services and natural capital. *Nature, 387*: 253–260.

Cooper J, Jayiya T, Van Niekerk L, De Wit M, Leaner J and Moshe D (2003). An assessment of the economic values of different uses of estuaries in South Africa. CSIR Report No. ENV-S-C 2003-139. CSIR, Stellenbosch, South Africa.

Cooper JAG (1990). Ephemeral stream-mouth bars at flood-breach river mouths on a wavedominated coast: comparison with ebb-tidal deltas at barrier inlets. *Marine Geology* 95:57-70.

Cooper JAG (2001). Geomorphological variability among microtidal estuaries from the wave-dominated South African coast. *Geomorphology* 40, 99–122.

Crooks S, Herr D, Tamelander J, Laffoley D and Vandever J (2011). Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities" Environment Department Paper 121, World Bank, Washington, DC.

CSIR (1986). Basic physical geography/hydro data for Natal "estuaries". CSIR, Stellenbosch. *NRIO Data Report D 8607.*

CSIR (1987a). Basic physical geography/hydro data for "estuaries" of the south-western Cape (CSW 1-26). CSIR, Stellenbosch. *NRIO Data Report D 8802.*

CSIR (1987b). Basic physical geography/hydro data for "estuaries" of the southern Cape (CMSD 0-50). CSIR, Stellenbosch. *NRIO Data Report D 8802.*

CSIR (1987c). Basic physicall geography/hydro data for "estuaries" of the south-eastern Cape (CSE 1-59). CSIR, Stellenbosch. *NRIO Data Report D 8703*.

CSIR (1988). Basic physical geography/hydro data for "estuaries" of the western Cape (CW 1-32). CSIR, Stellenbosch. *NRIO Data Report D 8802*.

CSIR (1992). Building the foundation for sustainable development in South Africa. National report to the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, June 1992. Pretoria: Department of Environmental Affairs.

Daily GC 1997. *Nature's services: Societal dependence on natural ecosystems*. Washington, DC: Island Press.

Dalrymple RW, Zaitlin BA and Boyd R (1992) A conceptual model of estuarine sedimentation. *Journal Sedimentary Petrology*, 62 (1992), pp. 1130–1146.

Davies B and Day J (1998). *Vanishing waters.* University of Cape Town Press, Cape Town, South Africa.

Davies JL (1964). A morphogenetic approach to world shorelines. *Zeitschrift fur Geomorphologie*, 8 (1964), pp. 127–142.

Dallas HF and Rivers-Moore NA (2009). *Future uncertain – Climate change and freshwater resources in South Africa.* Technical Report produced for the Water Research Commission and the World Wide Fund for Wildlife. The Freshwater Consulting Group and Ezemvelo KZN Wildlife.

Day JH (1980). What is an estuary? *South African Journal of Science* 76: 198.

Day JH (ed) (1981). *Estuarine ecology*. Cape Town: A.A. Balkema.

Day JH and Gridley JR (1981). The management of estuaries. In *Estuarine ecology with particular reference to southern Africa*, ed. Day, J.H.pp373-97. Cape Town. A.A. Balkema.

De Groot R, Wilson MA and Boumans RMJ (2002). A typology for the classification, description, and valuation of ecosystem functions, goods and services. *Ecological Economics* 41:393-408.

De Kock KN and Wolmarans CT (2007). Distribution and habitats of the alien invader freshwater snail *Physa acuta* in South Africa. *Water SA* 33(5): 717-722.

Department of Environmental Affairs (2010). South Africa's second National Communication under the United Nations Framework Conversion on Climate Change.

Department of Environmental Affairs and Tourism (2008). South Africa's National Programme of Action for Protection of the Marine Environment from Land-based Activities. First Edition. Cape Town.

Demetriades NT, Forbes AT, Mwanyama N and Quinn NE (2000). Damming the Thukela River – Impacts on The Thukela Bank Shallow Water Prawn Resource. Report for Department of Water Affairs and Forestry's Thukela Water programme.

Department of Environmental Affairs and Tourism (2008). South Africa's National Programme of Action for Protection of the Marine Environment from Land-based Activities. First Edition. Cape Town.

Department of Water Affairs (1986). Management of the Water Resources of the Republic of South Africa. Government Printer. Pretoria. 483 pp.

Department of Water Affairs and Forestry (DWAF) (2000). Water use authorisation process for individual applications. Edition 1: Final draft for implementation and use. Revision 3. Chief Directorate Water Use and Conservation. Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2002). Rapid determination of the Resource Directed Measures of the Mdloti Estuary (including preliminary estimates of capping flows for the Mdloti and Mhlanga estuaries). Final draft report submitted to the Directorate Resource Directed Measures. Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2003a). Determination of the preliminary ecological Reserve on a rapid level for Mhlanga Estuary. Final report submitted to Directorate Resource Directed Measures. Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2003b). Determination of the preliminary ecological Reserve on a rapid level for the Tsitsikamma Estuary (Including a desktop assessment on other estuaries in K80 tertiary catchment). Final report submitted to Directorate Resource Directed Measures. Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2003c). Determination of the preliminary ecological Reserve on a rapid level for the Orange River Estuary.

Prepared for the Department of Water Affairs and Forestry (Republic of South Africa) and the Department of Water Affairs (Namibia). Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2004). *Water resource protection and assessment policy implementation process. Resource Directed Measures for protection of water resource: Methodology for the determination of the ecological water requirements for estuaries*. Version 2. Pretoria: Department of Water Affairs.

Department of Water Affairs and Forestry (DWAF) (2004a). National Water Resource Strategy. First edition. September 2004. Pretoria: Department of Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2004b). Breede River Basin study. Reports and GIS data. Chapter 18: Reserve determination estuary. Pretoria: Directorate of National Water Resource Planning.

Department of Water Affairs and Forestry (DWAF) (2004c). Thukela Water Project decision support phase. Reserve determination model. Volume 1, Appendices to Thukela estuarine flow requirements. PBV000-00-10307. Pretoria: Directorate of National Water Resource Planning.

Department of Water Affairs and Forestry (DWAF) (2004d). Preliminary Determination of the ecological Reserve on a rapid level for the St Lucia Estuary. Final draft report. Prepared for the Department Water Affairs and Forestry and Department Environmental Affairs and Tourism. Pretoria: Department Water Affairs and Forestry.

Department of Water Affairs and Forestry (DWAF) (2004e). Water resource protection and assessment policy implementation process. Resource Directed Measures for protection of water resource: Methodology for the determination of the ecological water requirements for estuaries. Version 2. Pretoria: Department of Water Affairs.

Department of Water Affairs and Forestry (DWAF) (2006). Olifants/Doring Catchment ecological water requirement study. Resource Direct Measures report on the estuarine component. Final report submitted to Directorate Resource Directed Measures. *Contract Report CSIR/NRE/ECO/ER/2006/0038A/L*. Stellenboch: CSIR.

Department of Water Affairs and Forestry (DWAF) (2008). Water resource protection and assessment policy implementation process. Resource Directed Measures for protection of water resource: Methodology for the determination of the ecological water requirements for estuaries. Version 2.1 Pretoria: Department of Water Affairs.

Dolbeth M, Martinho F, Freitas V, Costa-Dias S, Campos J and Pardal MA (2010). Multi-year comparisons of fish recruitment, growth and production in two drought-affected Iberian estuaries. Marine and Freshwater Research 61: 1399-1415.

Drake JA, Mooney HA, di Castri F, Groves RH, Kruger FJ, Rejmanek M, Williamson M (1989). *Biological Invasions: A Global Perspective*. Wiley, Chichester.

Driver A, Maze K, Rouget M, Lombard AT, Nel J, Turpie JK, Cowling RM, Desmet P, Goodman P, Harris J, Jonas Z, Reyers B, Sink K and Strauss T 2005. National Spatial Biodiversity Assessment 2004: Priorities for biodiversity Conservation in South Africa. Strelitzia 17. Pretoria: South African national Biodiversity Institute.

Duncombe Rae CM, Boyd AJ and Crawford RJM (1992). “Predation” on anchovy by an Agulhas Ring: a possible contributory cause of the poor year-class of 1989. In: Benguela Trophic Functioning (eds, A. I. L. Payne, K. H., Brink, K. H. Mann and R. Hilborn. South African Journal of Marine Science, 12, 167-174.

DWAF (2004). The Working for Water Programme: Annual Report 2002/3. Department of Water Affairs and Forestry, Pretoria.

Dyer KR (1997). *Estuaries: a physical introduction*. 2nd edition. John Wiley and Sons/Wiley and Sons: Chichester. ISBN 0-471-9741-4. xiv, 195 pp.

Edgar GJ, Barrett NS, Graddon DJ, and Last PR (2000). The conservation significance of estuaries: a classification of Tasmanian estuaries using ecological, physicial and demographic attributes as a case study. *Biological Conservation*. 92 (3):383-397.

Elliott E and McLusky DS (2002). The need for definitions in understanding estuaries. *Estuarine, Coastal and Shelf Science 55, 815–827.*

Elliott M (2002). An overview of the status, study and management of fishes in estuaries. In: Elliott M and Hemingway KL (eds) *Fishes in estuaries*. Blackwell Science Ltd, Oxford, pp 553-575.

Elliott M, Whitfield AK, Potter IC, Blaber SJM, Cyrus DP, Nordlie FG and Harrison TD (2007). The guild approach to categorizing estuarine fish assemblages: a global review. *Fish and Fisheries* 8, 241–268.

Elton CS (1958).*The ecology of invasions by animals and plants*. Methuen.

Emanuel BP, Bustamante RH, Branch GM, Eekhout S and Odendaal FJ (1992). A zoogeographic and functional approach to the selection of marine reserves on the west coast of South Africa. *South African Journal of Marine Science* 12: 341-354.

Environmental Advisory Services (EAS). 1996. An Environmental Review of the Master Plan for the Port of Richards Bay. *EAS Investigational Report* No. 89.

European Commission (2008). Meeting the challenge of invasive species in estuaries and coasts. Science for Environment Policy. European Commission DG Environment News Alert Service, The University of the West of England, Bristol. *European Commission* DG ENV Special Issue 6.

Fairbridge RW (1980). The estuary: its definition and geochemical role. In: Olausson E and Cato I (Eds.), *Chemistry and Geochemistry of Estuaries*. John Wiley, New York, pp. 1–35.

Fischer HB (1972). Mass transport mechanisms in partially stratified estuaries. *Journal of Fluid Mechanics*, 53, p.671-687.

Fondo EN and Martens EE (1998) Effects of mangrove deforestation on macrofaunal densities, Gazi Bay, Kenya. Mangroves and Salt Marshes 2: 75-83.

Forbes AT and Demetriades NT (2008). Estuaries of Durban, Kwazulu-Natal, South Africa. Report for the Environmental Management Department, *eThekwini Municipality*. 224 pp.

Germishuizen G and Meyer NL (Eds.) (2004). Plants of southern Africa: an annotated checklist. *Strelitzia 14.* National Botanical Institute, Pretoria.

Gilbert AJ, Janssen R (1998) Use of environmental functions to communicate the values of a mangrove ecosystem under different management regimes. Ecological Economics 25: 323-346.

Gillanders BM (2005). Using elemental chemistry of fish otoliths to determine connectivity between estuarine and coastal habitats. *Estuarine, Coastal and Shelf Science* 64:47-57.

Gillsanders BM and Kingsford MJ (2002). Impact of changes in flow of freshwater on estuarine amd open coastal habitats and the associated organisms. *Oceanography and Marine Biology*: An Annual Review 40, 233-309.

Gilman EL, Ellison J, Duke NC and Field C (2008). Threats to mangroves from climate change and adaptations options: A review. *Aquatic Botany* 89: 237-250.

Gregory JM (2004). Threatened loss of the Greenland ice-sheet. *Nature*, vol. 428, issue 616, p 257.

Griffiths C and Day J (2004). Aquatic Invasive Species in South Africa – Environmental Impacts and Management Responses. Abstract of presentation at 13th International Conference on Aquatic Invasive Species September 20-24, 2004. Hosted by Institute of Technology, Sligo, Ballinode, Sligo, Ireland.

Griffiths CL (2000). Overview on current problems and future risks. In: Best Management Practices for Preventing and Controlling Invasive Alien Species, (eds) G. Preston, G. Brown and E. van Wyk, pp. 235–241. *The Working for Water Programme*, Cape Town, South.

Griffiths CL, Hockey PAR, Van Erkom Schurink C and Le Roux PJ (1992). Marine invasive aliens on South African shores: implications for community structure and trophic functioning. *South African Journal of Marine Science* 12: 713–722.

Griffiths CL, Mead A and Robinson TB (2009). A brief history of marine bio-invasions in South Africa. *African Zoology* 44(2): 241–247.

Grobler BA (2010). As assessment of invasive *Spartina alterniflora* Loisel (Smooth cord grass) in the Groot Brak estuary, South Africa. Honours Project. Nelson Mandela Metropolitan University.

Guastella LA and Rossouw M (2009). Coastal vulnerability: are coastal storms increasing in frequency and intensity along the South African coast? *Abstracts, IMPR Conference, Jeffery's Bay, May 2009*, p. 10.

Hansen DV and Rattray M (1966). New dimensions in estuary classification. *Limnol. Oceanog* 11, 319-329.

Harley CDG, Hughes AR, Hultgren KM, Miner BG, Sorte CJB, Thornber CS, Rodriguez LF, Tomanek L and Williams SL (2006). The impacts of climate change in coastal marine systems. *Ecology Letters* 9: 228-241.

Harris LR, Nel R, Campbell EE and Schoeman DS (2010). Report to SANBI for the marine component of the National Biodiversity Assessment 2011: national beach classification and mapping. McLachlan A (ed.), Integrated Environmental Coastal Management Unit, Nelson Mandela Metropolitan University, Port Elizabeth.

Harris PT, Heap AD, Bryce SM, Porter-Smith R, Ryan DA and Heggie DT (2002) Classification of Australian clastic coastal depositional environments based on a quantitative analysis of wave, tide and river power. *Journal of Sedimentary Research*. 72 (6):858-870.

Harrison TD (2004). Physico-chemical characteristics of South African estuaries in relation to the zoogeography of the region. *Estuarine, Coastal and Shelf Science* 61: 73-87.

Harrison TD (2005). Ichthyofauna of South African estuaries in relation to the zoogeography of the region. *Smithiana* 6: 2-27.

Harrison TD and Whitfield AK (2006) Temperature and salinity as primary determinants influencing the biogeography of fishes in South African estuaries. *Estuarine, Coastal and Shelf Science* 66: 335-345.

Harrison TD, Cooper JAG and Ramm AEL (2000). State of South African estuaries: geomorphology, ichthyofauna, water quality and aesthetics. State of the Environment Series, Report No. 2. Department of Environmental Affairs and Tourism. 127pp.

Heggie DT and Skyring GW (1999) Flushing of Australian esturies, coastal lakes and embayments : an overview with biochemical commentary. AGSO *Journal of Australian Geology and Geophysics*. 17:211-225.

Henderson S, Dawson PT and Whittaker RJ (2006). Progress in invasive plants research. *Progress in Physical Geography, 30 (1)*: 25- 46.

Hewitson B, Tadross M and Jack C (2005). Scenarios from the University of Cape Town. In: Schulze RE (ed) *Climate Change and Water Resources in Southern Africa: Studies on Scenarios, Impacts, Vulnerabilities and Adaptation*. Water Research Commission, Pretoria, *WRC Report* 1430/1/05, pp 39-56.

Hewitson BC and Crane RG (2006). Consensus between GCM climate change projections with empirical downscaling: precipitation downscaling over South Africa. *International Journal of Climatology* 26: 1315-1337.

Heydorn AEF (1989). The conservation status of southern African estuaries. In: *Biotic Diversity in Southern Africa: Concepts and Conservation* (ed. BJ Huntley). Oxford: Oxford University Press.

Heydorn AEF and Bickerton IB (1982). Report no. 9. Uilkraals (CSW 17). In Estuaries of the Cape. Part 2. Synopsis of available information on individual systems, Heydorn A.E.F. and Grindley, J.R. (eds). *CSIR Research Reports*. Stellenbosch: CSIR.

Heydorn AEF and Tinley KL (1980). Estuaries of the Cape. Part 1. Synopsis of the Cape Coast. Natural features, dynamics and utilization. *Research Report 380*. National Research Institute for Oceanography. Stellenbosch: CSIR.

Hockey PAR, Dean WRJ and Ryan PG (eds) (2005). *Roberts – Birds of Southern Africa*, VIIth ed. The Trustees of the John Voelcker Bird Book Fund, Cape Town.

Hockey PAR & Turpie JK (1999). The ecology of estuarine birds. *In*: Allanson & Baird (eds) *Estuaries of South Africa*. Cambridge University Press.

Hodgson AN (1987). Distribution and abundance of the macrobenthic fauna of the Kariega estuary, South Arica. *South African Journal of Zoology* 22: 153-162.

Hutchings K and Clark BM (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 by Anchor Environmental Consultants, Cape Town. 75 pp.

Hutchings K, Clark BM, Atkinson LJ and Attwood CG (2008). Evidence of recovery of the linefishery in the Berg River Estuary (Western Cape, South Africa) subsequent to closure of commercial gill netting. *Afr. J. mar. Sci.* 30(3): 507–517.

Hyslop EJ (2002). Additions to the freshwater malacofauna of Jamaica. *Revista de Biologia Tropical* 51(1): 262-263.

IPCC (2001). *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. McCarthy JJ, Canziani OF, Leary, NA, Dokken DJ, and White KS (eds) Cambridge University Press, Cambridge.

IPCC (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* Solomon SD, Qin M, Manning Z, Chen M, Marquis KB, Averyt M, Tignor and Miller, HL (eds) Cambridge University Press, Cambridge. Downloaded from http://www.ipcc.ch on February 21, 2007.

iSimangaliso Wetland Park Authority (2011). Lake St Lucia: understanding the problem and finding the solution. *Background Information Document (BID 2011/07).*

Jackson RN, Baird D and Els S (2005). The effect of the heavy metals lead (Pb2+) and zinc (Zn2+) on the brood and larval development of the burrowing crustacean, *Callianassa kraussi*. *Water SA* 31(1): 107-115.

Jackson VA, Paulse AN, Odendaal JP and Khan W (2009). Investigation into metal contamination of the Plankenberg and Diep Rivers, Western Cape, South Africa. *Water SA* 35(3):289-29.

Jacobs D, Stein ED and Longcore T (2010). Classification of California estuaries based on natural closure patterns: templates for restoration and management. *Southern California Coastal Waters Research.*

James NC and Hermes J (eds) (2011). *Insights into impacts of climate change on the South African marine and coastal environment.* Pretoria: South African Environmental Observation Network (SAEON).

James NC, Mann BQ and Radebe PV (2004). Mortality estimates and biological reference points for the Natal stumpnose Rhabdosargus sarba (Pisces: Sparidae) in KwaZulu-Natal, South Africa. *African Journal of Aquatic Science* 29: 67–74.

James NC, Whitfield AK and Cowley PD (2008a). Preliminary indications of climate-induced change in a warm-Temperate South African estuarine fish community. *Journal of Fish Biology* 72: 1855-1863.

James NC, Whitfield AK and Cowley PD (2008b). Long-term stability of the fish assemblages in a warm-Temperate South African estuary. *Estuarine, Coastal and Shelf Science* 76: 723-738.

James NC, Whitfield AK, Cowley PD (2008). Preliminary indications of climate-induced change in a warm-Temperate South African estuarine fish community. *Journal of Fish Biology* 72: 1855–1863.

Jezewski WA, Pyke PD, and Roberts CPR (1984). Estuarine and Lake Freshwater Requirements. Department of Water Affairs and Forestry, Pretoria, South Africa. *Technical Report No TR123.*

Jezewski WA and Roberts CPR (1986). *Estuarine and lake freshwater requirements.* Directorate of Planning Services, Technical Report No. TR 129. Pretoria: Department of Water Affairs.

Kench PS (1999). Geomorphology of Australian estuaries: Review and prospect. *Australian Journal of Ecology*, 24: 367–380.

Kennedy TA, Naemm S, Howe KM, Knops JMH, Tilman D and Reich P (2002). Biodiversity as a barrier to ecological invasion. *Nature* 417: 636–638.

Kennedy VS (1990). Anticipated effects of climate change on estuarine and coastal fisheries. *Fisheries* 15: 16-24.

Kennish, MJ (1986). *Estuarine ecology.* CRC Press: Boca Raton, Fl. ISBN 0849358922.

Komar PD and Allan JC (2008). Increasing Hurricane-Generated Wave Heights along the U.S. East Coast and Their Climate Controls. *Journal of Coastal Research* 24 (2).

Laegdsgaard P and Johnson C (2001) Why do juvenile fish utilise mangrove habitats? *Journal of Experimental Marine Biology and Ecology,* 257: 229-253.

Lamberth SJ and Joubert AR (2000). Prioritising linefish species for research and management: A first attempt. Third South African Marine Linefish Symposium. SANCOR Occasional Report 5: 159 pp.

Lamberth SJ and Turpie JK (2003) – The role of estuaries in South African fisheries: economic importance and management implications. *Afr. J. mar. Sci.* 25: 131-157.

Lamberth SJ, Drapeau L and Branch GM. 2009. The effects of altered freshwater inflows on catch rates of non-estuarine-dependent fish in a multispecies nearshore line-fishery. *Estuarine, Coastal and Shelf Science* 84: 527–538.

Lamberth SJ, van Niekerk L and Hutchings K. (2008) Comparison of, and the effects of altered freshwater inflow on, fish assemblages of two contrasting South African estuaries: the cool-Temperate Olifants and the warm-Temperate Breede. *African Journal of Marine Science*, Volume 30, Number 2, pp. 311-336(26).

Lamberth SJ, Branch GM and BM Clark (2010). Estuarine refugia and fish responses to a large anoxic, hydrogen sulphide, "black tide" event in the adjacent marine environment. *Estuarine, Coastal and Shelf Science*, 86: 203-215.

Le Roux JJ, Morgenthal TL, Malherbe J, Pretorius DJ and Sumner PD (2008). Water erosion prediction at a national scale for South Africa. *Water SA,* Vol. 34, No. 3.

Leppa¨ koski E, Gollasch S and Olenin S (eds) (2002). *Invasive aquatic species of Europe—distribution, impacts and management*. Kluwer, Dordrecht

Lumsden TG, Schulze RE and Hewitson BC (2009). Evaluation of potential changes in hydrologically relevant statistics of rainfall in Southern Africa under conditions of climate change. *Water SA* Vol. 35 No. 5

Lutjeharms JRE and De Ruijter WPM (1996). The influence of the Agulhas Current on the adjacent coastal ocean: possible impacts of climate change. *Journal of Marine Systems*, 7, 321-336.

Lutjeharms JR, Monteiro PMS, Tyson PD and Obura D (2001) The oceans around southern Africa and regional effects of global change. *South African Journal of Science*, 97, 119-130.

Lynch SD (2004). Development of a raster database of annual, monthly and daily rainfall for Southern Africa. *WRC Report 1156/1/04.* pp 78. Water Research Commission, Pretoria, RSA.

Mander M (2001). The value of estuaries. In Breen, C & McKenzie, M (eds.) *Managing estuaries in South Africa: An introduction*, pp 2-9. Scottsville: Institute of Natural Resources.

Mann BQ and Pradervand P (2007). Declining catch per unit effort of a estuarine dependent, Rhabdosargus sarba (Teleostei: Sparidae), in the marine environment following closure of the St Lucia estuarine system, *South Africa. African Journal of Aquatic Science* 32 (2), 133–138.

Maree RC, Whitfield AK, and Booth AJ (2000). Effect of water temperature on the biogeography of South African estuarine fish species associated with the subtropical/warm Temperate subtraction zone. *South African Journal of Science* 96: 184-188.

Mather AA (2008). Sea Level Rise for the East Coast of Southern Africa. *COPEDEC VII*, 2008, Paper No: M-04; Dubai, UAE. 11p.

Mather AA, Garland GG and Stretch DD (2009). Southern African sea levels: corrections, influences and trends. *African Journal of Marine Science 31(2);* ISSN 1814–232X EISSN 1814–2338. NISC, South Africa.

Mbande S, Whitfield AK and Cowley PD (2005). The ichthyofaunal composition of the Mngazi and Mgazana estuaries: a comparative study. *Smithiana Bulletin* 4: 1-22.

Mead A, Carlton JT, Griffiths CL and Rius M (2011). Revealing the scale of marine bioinvasions in developing regions: a South African re-assessment. *Biological Invasions* 13(9): 1991-2008.

Meyer JL, Sale MJ, Mulholand PJ and Poff NL (1999). Impacts of climate change on aquatic ecosystem functioning and health. *Journal of the American Water Resources Association* 35 (6): 1373–1386.

Meynecke J-O, Yip Lee S, Duke NC and Warnken J (2006). Effect of rainfall as a component of climate change on estuarine fish production in Queensland, Australia. *Estuarine, Coastal and Shelf Science* 69: 491-504.

Midgley GF, Chapman RA, Hewitson B, Johnston P, de Wit M, Ziervogel G, Mukheibir P, van Niekerk L, Tadross M, van Wilgen BW, Kgope B, Morant PD, Theron A, Scholes RJ, and Forsyth GG (2005). *A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape.* Report to the Western Cape Government, Cape Town, South Africa.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-Being: Synthesis*. Island Press, Washington, DC.

Miranda NAF, Perissinotto R and Appleton CC (2011). Feeding dynamics of the invasive gastropod *Tarebia granifera* in coastal and estuarine lakes of northern KwaZulu-Natal, South Africa. *Estuarine, Coastal and Shelf Science* 91: 442-449.

Miranda NAF, Perissinotto R, and Appleton CC (2010). Salinity and temperature tolerance of the invasive freshwater gastropod *Tarebia granifera*. *South African Journal of Science*;106(3/4): Art. #156, 7 pages. DOI: 10.4102/sajs.v106i3/4.156.

Morant P and Quinn NW (1999) Influence of man and management of South African estuaries. In Allanson, BR and Baird, D (eds.) *Estuaries of South Africa*, pp 289-321. Cambridge: Cambridge University Press.

Morgan JA, Dejong RJ, Snyder SD, Mkoji GM and Loker ES (2001). *Schistosoma mansoni* and *Biomphalaria*: past history and future trends. Parasitology 123(7): 211-228.

Mori N, Yasuda T, Mase H., Tom T and Oku Y (2010). Projection of Extreme Wave Climate Change under Global Warming. *Hydrological Research* Letter, Vol. 4.

Msadala, V Gibson, L Le Roux, J Rooseboom A and Basson GR (2010). Sediment Yield Prediction for South Africa - 2010 Edition August 2010, *WRC Report No. K5/765*.

Mucina L and Rutherford MC (eds) (2006). The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19*. South African National Biodiversity Institute, Pretoria.

Mucina L, Janssen JA and O'Callaghan M (2003).Syntaxonomy and zonation patterns in the coastal salt marshes of the Uilkraals Estuary, Western Cape (South Africa). *Phytocoenologia, 33:* 309-334.

Mumby PJ, Edwards AJ, Lez JEA, Lindeman KC, Blackwell PG, Gall A, Gorczynska MI, Harborne AR, Pescod CL, Renken H, Wabnitz CCC and Llewellyn G (2003) Mangroves enhance the biomass of coral reef fish communities in the Caribbean. Nature 427: 533-536.

Murawski SA (1993). Climate change and marine fish distributions: forecasting from historical analogy. *Transactions of the American Fisheries Society* 122: 647-657.

Mzimela HM, Wepener V and DP Cyrus (2003). Seasonal variation of selected metals in sediments, water and tissues of the groovy mullet, *Liza dumerelii* (Mugilidae) from the Mhlathuze Estuary, South Africa. *Marine Pollution Bulletin* 46:659–676.

Nehring S (2006). Four arguments why so many alien species settle into estuaries, with special reference to the German river Elbe. *Helgol Mar Res* 60: 127–134.

Nichols MM and Biggs RB (1985). Estuaries. In: *Coastal Sedimentary Environments*, 2nd edn. (ed. R. A. Davis Jr), pp. 77–186. Springer-Verlag, New York.

Noble RG and Hemens J (1978). Inland water ecosystems in South Africa – a review of research needs. *Report No. 34.* South African National Science Programme. Pretoria: CSIR.

O'Callaghan M (1990). The ecology of the false Bay estuarine environments, Cape, South Africa. 2: Changes during the last fifty years. *Bothalia* 20: 113-121.

Orr K (2007). 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.

Ozcoasts, Marine and Coastal Environment Group, Geoscience Australia, CANBERRA , Australia (Online: http://www.ozcoasts.gov.au/conceptual_mods/geomorphic/wde/wde.jsp 24 January 2012).

Perry AL, Low PJ, Ellis JR and Reynolds JD (2005). Climate change and distribution shifts in marine fishes. *Science* 308: 1912-1914.

PIANC (2008). Waterborne transport, ports and waterways: A review of climate change drivers, impacts, responses and mitigation. EnviCom – Task Group 3, PIANC.

Picker M and Griffiths C (2011). *Alien and invasive animals – a South African perspective.* Random House Struik (Pty) Ltd, Cape Town 240pp.

Pointier JP (2001). Invading freshwater snails and biological control in Martinique Island, French West Indies. *Memorias do Instituto Oswald Crus*, Rio de Janeiro, 96: 67-74.

Porter S (2009). Biogeography and potential factors regulating shallow subtidal reef communities in the western Indian Ocean, PhD thesis, University of Cape Town, South Africa.

Pressey RL & Cowling RM (2001). Reserve selection algorithms and the real world. *Conservaiton Biology* 15: 275-277.

Pressey RL, Cowling RM & Rouget M 2003. Formulating conservation targets for biodiversity pattern and process in the Cape Floristic Region, South Africa. *Biological Conservation* 112**:** 99-127.

Pritchard DW (1955). Estuarine circulation patterns. Proceedings American Society Civil Engineers 81 No. 717.

Pritchard DW (1952). Salinity distribution and circulation in the Chesapeake Bay estuarine system. *Journal Marine Research* 11: 106–123.

Pritchard DW (1967). What is an estuary: Physical viewpoint. In Lauff GH (ed.) *Estuaries* pp 3-5. Washington DC: American Association for the Advancement of Science.

Quiñones RA, Montes RM. 2001. Relationship between freshwater input to the coastal zone and the historical landing of the benthic/demersal fish Eleginops maclovinus in central-south Chile. *Fisheries Oceanography* 10: 311-328.

Rahmstorf S, Cazenave A, Church JA, Hansen JE, Keeling RF, Parker DE, Somerville RCJ (2007). Recent Climate Observations Compared to Projections. *Science* Vol 316: 709. www.sciencemag.org Published online 1 February 2007; 10.1126/science.1136843.

Rajkaran A and Adams JB (2011). Mangrove forests of KwaZulu-Natal: Sediment conditions and population structure of the largest mangrove forests in South Africa. *Western Indian Ocean Journal of Marine Science* Vol 10(1): 25-38.

Rajkaran A, Adams JB and Taylor R (2009). Historic and present state (2006) of mangroves in small estuaries from Mlalazi to Mtamvuna in Kwazulu-Natal, South Africa. *Southern Forests* 71(4): 287-296.

Ray GC (2005). Connectivities of estuarine fishes to the coastal realm. *Estuarine, Coastal and Shelf Science* 64:18-32.

Reddering JSV and Rust IC (1990) Historical changes and sedimentary characteristics of southern African Estuaries. *South African Journal of Science* 86(7-10): 425-428.

Reyers B, Fairbanks DHK, Wessels KH & Van Jaarsveld AS (2002). A multicriteria approach to reserve selection: Addressing long-term

Richardson DM and Kluge RL (2008). Seed banks of invasive Australian Acacia species in South Africa: Role in invasiveness and options for management. *Perspectives in Plant Ecology, Evolution and Systematics 10:* 16–177.

Richardson DM and Van Wilgen BW (2004). Invasive alien plants in South Africa: how well do we understand the ecological impacts? *South African Journal of Science 100*: 45-52.

Richardson DM, Pysˇek P, Rejmánek M, Barbour MG, Panetta FD and West CJ (2000): Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions, 6:* 93-107.

Richardson, D.M., Macdonald I.A.W., Holmes P.M. and Cowling RM (1992). Plant and animal invasions. In *The Ecology of Fynbos: Nutrients, Fire and Diversity*, (R.M. Cowling Ed.) Oxford University Press, Cape Town. 271-308.

Riddin T (1999). The botanical importance of the Nhlabane estuary. M. Sc. Thesis. Botany Department, University of Port Elizabeth.

Rijnsdorp AD, Peck MA, Engelhard GH, Möllmann C and Pinnegar JK (2009) Resolving the effect of climate change on fish populations. *ICES Journal of Marine Science Advance Access*, 1-14.

Robinson T, Griffiths CL McQuaid CD. and Ruis M (2005). Marine alien species in South Africa - status and impacts. *African Journal of Marine Science* 27(1): 297–306

Roemich D (2007) Physical Oceanography: Super spin in the southern seas. *Nature*, 449: 34-35.

Rooseboom A, Verster E, Zietsman HL and Lotriet HH (1992). The development of the new sediment yield map of South Africa. *WRC Report No. 297/2/92*, Water Research Commission. Pretoria, South Africa.

Rossouw J and Rossouw M (1999). Re-evaluation of recommended design wave methods. *Proceedings of the 5th International Conference on Coastal and Port Engineering in Developing Countries (COPEDEC)*, Cape Town, South Africa.

Rossouw M and Theron AK (2009). Investigating Potential Climate Change Impacts On Maritime Operations Around The Southern African Coast. *28th Annual Southern African Transport Conference* (July 6-9, 2009) - ISBN 978-1-920017-39-2.

Rouault M, Penven P. and Pohl B (2009). Warming in the Agulhas Current system since the 1980's. *Geophysical Research Letters*, 36:1-5, L12602, doi: 10.1029/2009GL037987.

Ruggiero P, Komar PD and Allan JC (2010). Increasing Wave Heights and Extreme Value Projections: The Wave Climate of the U.S. Pacific Northwest. *Coastal Engineering*, Vol. 57.

Saenko OA, Fyfe JC and England MH (2005). On the response of the oceanic wind-driven circulation to atmospheric CO2 increase. *Climate Dynamics*, 25: 415-426.

SAEON (2010). South Africa's second national communication under the United Nations Framework Conversion on Climate Change. Unpublished report.

Scharler UM and Baird D (2000). The effects of a single freshwater release into the Kromme Estuary. 1: General description of the study area and physico-chemical responses. *Water SA* Vol. 26 No. 3.

Schlacher TA and Wooldridge TH (1995). Small-scale distribution and variability of demersal zooplankton in a shallow, Temperate estuary: tidal and depth effects on species-specific heterogeneity Cah. *Biol. Mar.* 36(3): 211-227.

Schleyer MH (1981). Microorganisms and detritus in thewater column of a subtidal reef in Natal. *Marine Ecology Progress Series* 4: 307-320.

Schmidt MWI, Torn, MS, Abiven S, Dittmar T, Guggenberger G, Janssens IA., Kleber M, Ko¨gel-Knabner I, Lehmann J, Manning DAC, Nannipieri P, Rasse DP, Weiner S and Trumbore SE 2011. Persistence of soil organic matter as an ecosystem property. *Nature*. Vol 478.

Schulze RE and Lynch SD (2007). Annual Precipitation. In: Schulze, R.E. (Ed). 2007. South African Atlas of Climatology and Agrohydrology. WRC Report 1489/1/06, Section 6.2. Water Research Commission, Pretoria, RSA.

Schulze RE and Maharaj M (2007). Rainfall Seasonality. In: Schulze, R.E. (Ed). 2007. South African Atlas of Climatology and Agrohydrology. *WRC Report* 1489/1/06, Section 6.5. Water Research Commission, Pretoria, RSA.

Schulze RE, Lumsden TG, Horan MJC, Warburton M and Maharaj M (2005). An Assessment of Impacts of Climate Change on Agrohydrological Responses Over Southern Africa. In: Schulze RE (ed) *Climate Change and Water Resources in Southern Africa: Studies on Scenarios, Impacts, Vulnerabilities and Adaptation*. Water Research Commission, Pretoria, WRC Report **1430/1/05**. pp 141 - 189.

Shannon LV, Crawford RJM and Hutchings L (in press). Climate change and the Benguela - fact or fiction?

Shrader-Frechette K (2001). Non-indigenous species and ecological explanation. *Biology and Philosophy: 16*: 507–19.

Simpson JH, Brown J, Matthews J and Allen G (1990). Tidal straining, density currents, and stirring in the control of estuarine stratification. *Estuaries* 13: 125 – 132.

Smith MM and Heemstra PC (1990). *Smiths sea fishes*. Johannesburg: Southern Book Publishers.

Snow GC, Adams JB and Bate GC (2000). Effect of river flow on estuarine microalgal biomass and distribution. *Estuarine, Coastal and Shelf Science* 51: 255–266.

Sorte CJB and Hofmann GE (2004). Changes in latitudes, changes in aptitudes: *Nucella canaliculata* (Mollusca: Gastropoda) is more stressed at its range edge. *Marine Ecology Progress Series* **274**: 263–268.

South African National Biodiversity Institute (SANBI) (2004). Series of Reports on National Spatial Biodiversity Assessment 2004: Priorities for biodiversity conservation in South Africa. Retrieved from http://www.sanbi.org/frames/biodiversityfram.htm.

Steenkamp Y and Smith GF (2002). Addressing the needs of the users of botanical information: Proceedings of a National Workshop for Stakeholders and End-Users of Botanical information and Herbaria. Sothern African Botanical Diversity Network Report No. 15.

Steinke TD (1999). Mangroves in South African estuaries. In: Allanson BR and Baird D (eds) *Estuaries of South Africa*. Cambridge University Press, Cambridge, pp 119-140.

Strydom NA and Whitfield AK (2000). The effects of a single freshwater release into the Kromme Estuary. 4: Larval fish response. *Water SA* 26: 319-328.

Theron AK (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. p 205-216.

Theron AK, Rossouw M, Barwell L, Maherry A, Diedericks G, De Wet P (2010). Quantification of risks to coastal areas and development: wave run-up and erosion. CSIR 3rd Biennial Conference 2010. Science Real and Relevant, CSIR International Convention Centre, Pretoria 30 August – 01 September 2010, South Africa. http://hdl.handle.net/10204/4261.

Thomas R, Rignot E, Casassa G, Kanagaratnam P, Acuña C, Akins T, Brecher H, Frederick E, Gogineni P, Krabill W, Manizade S, Ramamoorthy H, Rivera A, Russell R, Sonntag J, Swift R, Yungel Y and Zwally J (2004). Accelerated Sea-Level Rise from West Antarctica. *Science Magazine*, *pp. 255 – 258.*

Tolley-Jordan LR and Owen JM (2008). Habitat influences snail community structure and trematode infection levels in a spring-fed river, Texas, USA. *Hydrobiologia* 600: 29-40.

Traynor CH and Hill T (2008). Mangrove utilisation and implications for participatory forest management, South African. *Conservation and Society* 6(2): 109-116.

Turpie JK (2004). South African National Spatial Biodiversity Assessment 2004: Technical Report. Volume 3: Estuaries Component. Pretoria: South African National Biodiversity Institute.

Turpie JK and Hosking SG (eds). (2005). *Proceedings of a national workshop on Resource Economics as a tool for the management and conservation of estuaries in South Africa.* Rivierra Hotel, Veldrif, 10-11 March 2005. Anchor Environmental Consultants.

Turpie JK (2004). The role of resource economics in the control of invasive alien plants in South Africa*. South African Journal of Science, 100:* 87-93.

Turpie JK and Clark B (2007). The health status, conservation importance, and economic value of Temperate South African estuaries and development of a regional conservation plan. Draft Report. Anchor Environmental Consultants CC, University of Cape Town.

Turpie JK, Adams JB, Joubert A, Harrison TD, Colloty BM, Maree RC, Whitfield AK, Wooldridge TH, Lamberth SJ, Taljaard S and van Niekerk L (2002). Assessment of the conservation priority status of South African estuaries for use in management and water allocation. *Water SA* 28: 191-206.

Turpie JK, Marais C and Blignaut JN (2008). The working for water programme: Evolution of a payments for ecosystem services mechanism that addresses both poverty and ecosystem service delivery in South Africa. *Ecological Economics, 65*: 788-798.

Turpie JK, Wilson G and Van Niekerk L (2012). National Biodiversity Assessment 2011: National Estuary Biodiversity Plan for South Africa. Anchor Environmental Consulting, Cape Town.

UNCTAD (2008). Maritime transport and the climate change challenge. Note by the UNCTAD secretariat. *United Nations Conference on Trade and Development.* TD/B.C.I/MEM.1.2, 9 December 2008.

UNCTAD (2009). (United Nations Conference on Trade and Development) Multi-Year Expert Meeting on Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge. Summary of Proceedings, UNCTAD/DTL/TLB/2009/1, United Nations. 16–18 February 2009, Geneva. www.unctad.org/ttl/legal. 1 December 2009.

UNEP. (1992). *Convention on biological diversity (CBD).* CBD interim Secretariat. (www.biodiv.org) accessed January 2011).

USEPA (2009). Synthesis of Adaptation Options for Coastal Areas. Washington, DC, U.S. Environmental Protection Agency, Climate Ready Estuaries Program. EPA 430-F-08-024, January 2009.

Van Ballegooyen RC, Taljaard S, van Niekerk L, Lamberth SJ, Theron AK and Weerts SP (2007). Freshwater flow dependency in South African marine ecosystems: a proposed assessment framework and initial assessment of South African marine ecosystems. *WRC Report* No. KV 191/07. Pretoria: Water Research Commission.

Van Niekerk L and Taljaard S (2007). Proposed generic framework for Estuarine Management Plans. Version 1. Submitted to C.A.P.E. Estuaries Management Programme.

Van Sebille E, Biastoch A, van Leeuwen PJ and de Ruijter WPM (2009). A weaker Agulhas Current leads to more Agulhas leakage, *Geophys. Res. Lett., 36*, L03601

Van Wilgen BW, Schonegevel L, Henderson L and Neser S. (2004). A proposed classification of invasive alien plant species in South Africa: towards prioritizing species and areas for management action. *South African Journal of Science 100*: 53–64.

Van Wyk EV and van Wilgen BW (2002). The cost of water hyacinth control in South Africa: a case study of three options. African Journal of Aquatic Science 27: 141-149.

Vermeulen LA and Wepener V (1999). Spatial and temporal variations of metals in Richards Bay Harbour (RBH), South Africa. *Marine Pollution Bulletin* 39: 304-307.

Vorwerk PD, Whitfield AK, Cowley PD and Paterson AW 2003. The influence of selected environmental variables on fish assemblage structure in a range of southeast African estuaries. *Environmental Biology of Fishes*, 66: 237–247.

Walker DR (2004). Plant and algal distribution in response to environmental variables in selected Eastern Cape estuaries. PhD Thesis, University of Port Elizabeth, Port Elizabeth, South Africa. 176 pp.

Wang XL, Zwiers FW and Swail VR (2004). North Atlantic Ocean Wave Climate Change Scenarios for the Twenty-First Century. *Journal of Climate*, Vol. 17.

Ward CJ and Steinke TD (1982). A note on the distribution and approximate areas of mangroves in South Africa. *South African Journal of Botany 1*: 51-53.

Watling HR and RJ Watling (1976). Trace metals in oysters from Knysna Estuary.*Marine Pollution Bulletin* 7(3): 45-48.

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.

Watling RJ and Watling HR (1981). A preliminary pollution survey of the Papenkuils River, Port Elizabeth. *Water SA* 7(4), 211-215.

Watling RJ and Watling HR (1982a). Metal surveys in South African estuaries I. Swartkops River. *Water SA* 8(1), 27-35.

Watling RJ and Watling HR (1982b). Metal surveys in South African estuaries II. Knysna River. *Water SA* 8(1): 37-44.

Watling RJ and Watling HR (1982c). Metal surveys in South African estuaries III.Hartenbos, Little Brak and Groot Brak Rivers (Mossel Bay). *Water SA* 8(2): 109-113.

Watling RJ and Watling HR (1982d). Metal surveys in South African estuaries IV. Keurbooms and Bietou Rivers (Plettenberg Lagoon). *Water SA* 8(2): 115-119.

Watling RJ and Watling HR (1982e). Metal surveys in South African estuaries VI. Sundays River. *Water SA* 8(4): 193-195.

Watling RJ and Watling HR (1983a). Metal surveys in South African estuaries VII. Bushmans, Kariega, Kowie and Great Fish. *Water SA* 9(2), 67-70.

Demetriades N (2007). An inventory of sandming operations in KwaZulu Natal estuaries Mtamvuna to Thukela. Investigational report for Coastwatch, WESSA KZN.

Weis JS, Edwards J, Enger DE, Gall, GA, Hala J, Jarrar HJ, Lauritsen DD, Pixley EY, Poulson TL, Samuels E, Shafer CL, Temple, PJ, Weis, P and Young, JE (2002). Biology, Environment, and Conservation in South Africa. *BioScience, 52:* 781-789.

Weyl OLF, Taraschewki H and Parker D (2010). An assessment of the risks of parasite transfers associated with live imports of Anguilla mossambica from Madagascar. p 43, In: The annual Conference of the southern African Society of Aquatic Scientists:"Aquatic biodiversity and climate change – an arid region perspective". 13-15 June 2010, Augrabies Falls National Park.

Whitfield AK (1992). A characterization of southern African estuarine systems. *Southern African Journal of Aquatic Sciences* 18: 89-103.

Whitfield AK (1994). Abundance of larval and 0+ juvenile marine fishes in the lower reaches of three southern African estuaries with differing freshwater inputs. *Marine Ecology Progress Series* 105: 257-267.

Whitfield AK (1998). Biology and ecology of fishes in southern African estuaries. J.L.B. Smith Institute of Ichthyology. Ichtyological Monograph Number 2. Grahamstown, South Africa.

Whitfield AK (1998). Biology and ecology of fishes in Southern African estuaries. *Icthyological Monograph of the J.L.B. Smith Institute of Ichthyology* 2: 1-223.

Whitfield AK (2000). Available scientific information on individual estuarine systems. *WRC Report* no. 577/3/00.

Whitfield AK (2005). Fishes and freshwater in South African estuaries – a review. Aquatic Living Resources 18: 275-289.

Whitfield AK and Paterson AW (2003). Distribution patterns of fishes in a freshwater deprived Eastern Cape estuary, with particular emphasis on the geographical headwater region. *Water SA* 29: 61-67.

Whitfield AK (2005). Langebaan – A new type of estuary? *African Journal of Aquatic Science* 30:2: 207-209.

Wolmarans CT and De Kock KN (2006). The current status of freshwater molluscs in the Kruger National Park. Koedoe 49(2): 39-44.

Wooldridge TH (2007). C.A.P.E. Estuaries Guideline 3: Collection of bait organisms in estuaries. *Report for C.A.P.E Programme.*

Wooldridge TH and Callahan R (2000). The effects of single freshwater release into the Kromme Estuary. 3: Estuarine zooplankton response. *Water SA* 26(3): 311-318.

Wooldridge TH and Loubser H (1996). Larval release rhythms and tidal exchanges in the estuarine mudprawn, *Ubogebia africana. Hydrobiologia* 337: 113±12.

Zimmermann HG, Moran VC and Hoffmann JH (2004). Biological control in the management of invasive alien plants in South Africa, and the role of the Working for Water programme. *South African Journal of Science, 100*:34-40.

Appendix A:
List of freshwater outlets along the coast of South Africa

Table A. A comprehensive list of the freshwater outlets along the coast of South Africa. The 71 river outlets not included in NBA 2011 are indicated with a X.

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Orange (Gariep)	16° 27' 28.0943"	28° 38' 8.6783"
X	*Holgat*	16° 43' 15.6792"	28° 58' 43.946"
	Buffels	17° 3'2.26"	29° 40' 38.17"
X	*Swartlintjies*	*17°15'33.22"*	*30° 15' 47.49"*
	Spoeg	17° 21' 31.4280"	30° 28' 21.691"
X	*Bitter*	17° 26' 34.6020"	30° 35' 53.476"
	Groen	17° 34' 35.6268"	30° 50' 48.472"
X	*Brak*	17° 43' 47.2440"	31° 5' 55.9355"
	Sout	17° 50' 54.2831"	31° 14' 41.207"
	Olifants	18° 11' 13.6283"	31° 42' 3.7583"
X	*Sandlaagte*	*18°13'25.72"*	*31° 45' 52.87"*
	Jakkals	18° 18' 48.2976"	32° 5' 4.70759"
	Wadrift	18° 19' 30.9719"	32° 12' 16.509"
	Verlorenvlei	18° 19' 59.4263"	32° 18' 57.319"
X	*Papkuils*	*18° 19' 2.06"*	*32° 33' 58.53"*
	Berg (Groot)	18° 8' 37.9860"	32° 46' 11.096"
X	*Paternosterbaai*	*17° 54' 1.52"*	*32° 48' 8.96"*
X	*Langebaan*	18° 1.' 42.2831"	33° 5' 10.7196"
X	*Dwars (Noord)*	*18°13 '39.38"*	*33°24' 15.98"*
X	*Dwars (Suid)*	*18°15' 46.92"*	*33°26' 12.16"*
X	*Modder*	*18°18' 24.45"*	*33°29' 5.12"*
X	*Jacobsbaai*	*18°19' 27.45"*	*33° 31' 12.44"*
X	*Loerbaai*	*18°19' 4.72"*	*33° 32' 14.11"*
X	*Bok*	*18° 20' 2.33"*	*33° 34' 8.79"*
X	*Silwerstroom*	*18° 21' 8.74"*	*33° 34' 39.97"*
X	*Sout (Suid)*	*18°21 '21.74"*	*33° 34' 53.79"*
	Rietvlei/Diep	18° 28' 55.7148"	33° 53' 23.654"
	Sout (Wes)	18° 28' 17.7095"	33° 54' 28.925"
	Houtbaai	18° 21' 16.2000"	34° 2' 47.0075"
X	*Goeiehoop*	*18° 21' 10.15"*	*34° 5' 47.91"*
	Wildevoelvlei	18° 20' 35.8332"	34° 7' 38.6796"
	Bokramspruit	18° 19' 57.6335"	34° 8' 3.65999"
	Schuster	18° 22' 15.2651"	34° 12' 7.3619"
	Krom	18° 22' 42.2436"	34° 13' 51.391"
X	*Olifantsbos*	*18°22'58.31"*	*34° 15' 26.47"*
X	*Booiskraal*	*18°23'46.66"*	*34° 17' 14.50"*
	Buffels Wes	18° 27' 42.4151"	34° 19' 5.6532"
	Elsies	18° 25' 53.3495"	34° 9' 37.5083"
	Silvermine	18° 26' 20.1227"	34° 7' 57.9467"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Sand	18° 28' 35.4000"	34° 6' 22.9823"
	Zeekoe	18° 30' 17.7623"	34° 5' 54.3083"
	Eerste	18° 45' 13.4028"	34° 4' 43.7771"
	Lourens	18° 48' 39.0347"	34° 6' 0.18719"
	Sir Lowry's Pass	18° 51' 53.6220"	34° 9' 20.0160"
	Steenbras	18° 49' 9.88319"	34° 11' 41.348"
	Rooiels	18° 49' 15.7620"	34° 17' 44.786"
	Buffels (Oos)	18° 49' 46.3259"	34° 20' 20.209"
	Palmiet	18° 59' 38.9075"	34° 20' 43.584"
	Bot/Kleinmond	19° 5.' 49.6751"	34° 22' 6.3516"
	Onrus	19° 10' 43.2912"	34° 25' 7.1472"
X	*Mossel*	*19°16'21.25"*	*34°24'29.86"*
	Klein	19° 17' 53.3723"	34° 25' 14.354"
	Uilkraals	19° 24' 27.4859"	34° 36' 27.176"
	Ratel	19° 44' 47.4216"	34° 46' 15.668"
	Heuningnes	20° 7' 9.28560"	34° 42' 53.244"
	Klipdrifsfontein	20° 43' 52.7951"	34° 27' 6.8616"
X	*Papkuils*	*18°18'56.85"*	*32°33'52.68"*
	Breede	20° 50' 43.1951"	34° 24' 26.762"
	Duiwenhoks	21° 0' 4.25520"	34° 21' 54.107"
	Goukou (Kaffirkui	21° 25' 24.6972"	34° 22' 42.067"
	Gouritz	21° 53' 9.25440"	34° 20' 43.227"
	Blinde	22° 0' 46.6092"	34° 12' 39.060"
X	*Tweekuilen*	*22° 6'42.11"*	*34° 9'5.51"*
X	*Gericke*	*22° 6'37.50"*	*34° 8'38.35"*
	Hartenbos	22° 7' 32.8152"	34° 6' 54.4032"
	Klein Brak	22° 8' 54.9096"	34° 5' 34.5480"
	Groot Brak	22° 14' 21.4511"	34° 3' 26.1144"
X	*Rooi*	*22°17'3.51"*	*34° 3'3.31"*
	Maalgate	22° 21' 15.9803"	34° 3' 15.8039"
	Gwaing	22° 26' 2.90039"	34° 3' 23.2883"
X	*Skaapkop*	*22°29'55.88"*	*34° 2'23.97"*
X	*Meul*	*22°32'35.86"*	*34° 0'49.26"*
	Kaaimans	22° 33' 25.4015"	33° 59' 52.130"
	Wilderness (Touws)	22° 34' 52.0571"	33° 59' 44.728"
	Swartvlei	22° 47' 46.5215"	34° 1' 53.4576"
	Goukamma	22° 56' 56.8859"	34° 4' 37.7795"
	Knysna	23° 3' 41.2308"	34° 4' 57.7416"
	Noetsie	23° 7' 44.9543"	34° 4' 49.0872"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
X	*Grooteiland*	*23°12'34.55"*	*34° 5'9.14"*
X	*Kranshoek*	*23°13'30.21"*	*34° 5'11.69"*
X	*Crooks*	*23°14'44.74"*	*34° 5'28.92"*
	Piesang	23° 22' 43.5431"	34° 3' 37.6740"
	Keurbooms	23° 22' 41.4732"	34° 2' 59.4599"
	Matjies/Bitou	23° 28' 12.6552"	34° 0' 7.07399"
X	*Brak*	*23°31'49.54"*	*33°59'49.05"*
	Sout (Oos)	23° 32' 11.5548"	33° 59' 22.207"
	Groot (Wes)	23° 34' 9.04799"	33° 58' 54.411"
X	*Helpmekaars*	*23°35'57.52"*	*33°58'48.34"*
X	*Klip*	*23°37'1.35"*	*33°58'42.35"*
	Bloukrans	23° 38' 50.8884"	33° 58' 46.721"
X	*Witels*	*23°42'8.13"*	*33°59'18.40"*
	Lottering	23° 44' 9.41999"	33° 59' 43.836"
	Elandsbos	23° 46' 4.59120"	34° 0' 12.6467"
X	*Geelhoutbos*	*23°47'8.37"*	*34° 0'22.68"*
X	*Kleinbos*	*23°48'46.99"*	*34° 0'42.70"*
	Storms	23° 54' 10.7568"	34° 1' 15.5064"
X	*Bruglaagte*	*23°56'12.23"*	*34° 1'34.57"*
X	*Langbos*	*23°58'25.39"*	*34° 1'58.79"*
X	*Sanddrif*	*24° 0'17.79"*	*34° 2'13.07"*
	Elands	24° 4' 44.7096"	34° 2' 38.3387"
	Groot (Oos)	24° 11' 42.0683"	34° 3' 35.6219"
X	*Eerste*	*24°14'39.96"*	*34° 4'41.99"*
X	*Klipdrift (Wes)*	*24°16'28.50"*	*34° 5'16.61"*
X	*Boskloof*	*24°17'41.06"*	*34° 5'31.74"*
X	*Kaapsedrif*	*24°23'13.49"*	*34° 6'20.95"*
	Tsitsikamma	24° 26' 17.9736"	34° 8' 8.13480"
	Klipdrif	24° 38' 13.3764"	34° 10' 20.521"
	Slang	24° 39' 13.3271"	34° 10' 26.864"
	Krom Oos (Kromme)	24° 50' 33.8208"	34° 8' 34.6811"
	Seekoei	24° 54' 38.6748"	34° 5' 12.0119"
	Kabeljous	24° 55' 57.0108"	34° 0' 31.7051"
	Gamtoos	25° 2' 4.97040"	33° 58' 13.529"
	Van Stadens	25° 13' 13.2455"	33° 58' 13.994"
	Maitland	25° 17' 31.0271"	33° 59' 16.933"
	Baakens	25° 37' 48.0468"	33° 57' 49.427"
	Papkuils	25° 36' 49.9896"	33° 55' 2.2548"
	Swartkops	25° 37' 58.9619"	33° 51' 58.481"
	Coega (Ngcura)	25° 41' 26.6604"	33° 47' 43.368"
	Sundays	25° 51' 13.4100"	33° 43' 18.609"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Boknes	26° 35' 10.5396"	33° 43' 37.822"
	Bushmans	26° 39' 49.0392"	33° 41' 41.697"
	Kariega	26° 41' 11.0364"	33° 40' 57.975"
	Kasuka	26° 44' 7.07280"	33° 39' 14.741"
	Kowie	26° 54' 5.88240"	33° 36' 13.053"
	Rufane	26° 56' 8.97719"	33° 34' 50.995"
	Riet	27° 0' 49.8671"	33° 33' 40.330"
	Kleinemond Wes	27° 2' 46.1471"	33° 32' 28.845"
	Kleinemond Oos	27° 2' 57.5699"	33° 32' 20.493"
	Klein Palmiet	27° 7' 30.5795"	33° 30' 25.257"
	Great Fish	27° 8' 26.4624"	33° 29' 42.820"
	Old Womans	27° 8' 53.0520"	33° 28' 57.975"
X	*Thatshana*	*27°11'11.80"*	*33°27'47.74"*
	Mpekweni	27° 13' 52.2336"	33° 26' 16.843"
	Mtati	27° 15' 32.6591"	33° 25' 22.360"
	Mgwalana	27° 16' 27.1704"	33° 24' 46.886"
	Bira	27° 19' 33.7116"	33° 23' 1.5360"
	Gqutywa	27° 21' 29.0844"	27° 21' 29.084"
	Ngculura	27° 22' 4.49760"	33° 21' 29.077"
	Blue Krans	27° 22' 36.7139"	33° 21' 15.771"
X	*Freshwaterpoort*	27° 24' 50.4287"	33° 20' 6.1763"
	Mtana	27° 25' 55.7940"	33° 19' 6.9779"
	Keiskamma	27° 29' 28.4388"	33° 16' 53.328"
X	*Shwele-Shwele*	27° 31' 19.3584"	33° 15' 36.460"
	Ngqinisa	27° 31' 40.5696"	33° 15' 9.8603"
	Kiwane	27° 32' 35.4012"	33° 14' 53.887"
	Tyolomnqa	27° 35' 0.31560"	33° 13' 32.779"
	Shelbertsstroom	27° 36' 56.3903"	33° 12' 25.527"
	Lilyvale	27° 38' 12.8723"	33° 11' 34.270"
	Ross' Creek	27° 39' 27.6192"	33° 10' 36.325"
	Ncera	27° 40' 5.54160"	33° 10' 12.417"
	Mlele	27° 40' 47.8631"	33° 9' 34.963"
	Mcantsi	27° 42' 7.11719"	33° 8.' 43.832"
	Gxulu	27° 43' 53.3675"	33° 7' 8.0579"
	Goda	27° 46' 30.1188"	33° 6' 3.9239"
	Hlozi	27° 48' 42.7788"	33° 5' 8.1491"
	Hickman's	27° 50' 22.8767"	33° 4' 14.984"
	Mvubukazi	27° 50' 33.7163"	33° 4' 11.9964"
	Ngqenga	27° 51' 53.5968"	33° 3' 22.7988"
	Buffalo	27° 54' 58.7448"	33° 1' 36.476"
	Blind	27° 55' 39.6983"	27° 55' 39.698"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Hlaze	27° 56' 57.6816"	32° 59' 21.231"
	Nahoon	27° 57' 6.13439"	32° 59' 11.176"
	Qinira	27° 57' 53.3987"	32° 58' 27.130"
	Gqunube	28° 2' 5.63639"	32° 56' 1.9535"
	Kwelera	28° 4' 37.2072"	32° 54' 26.495"
	Bulura	28° 5' 36.2076"	32° 53' 28.805"
	Cunge	28° 6' 37.5263"	32° 51' 39.157"
	Cintsa	28° 7' 1.35839"	32° 49' 53.155"
	Cefane	28° 8.' 13.5528"	32° 48' 34.070"
	Kwenxura	28° 9' 5.71680"	32° 47' 55.589"
	Nyara	28° 10' 55.2611"	32° 47' 6.8279"
	Imtwendwe	28° 14' 13.1135"	32° 46' 12.133"
X	*Haga-haga*	28° 15' 11.4659"	32° 45' 42.901"
	Mtendwe	28° 17' 9.04920"	32° 44' 26.836"
	Quko	28° 18' 34.3367"	32° 43' 32.303"
	Morgan	28° 20' 38.5691"	32° 42' 30.949"
	Cwili	28° 22' 25.4531"	32° 41' 27.214"
	Great Kei	28° 23' 9.47040"	32° 40' 47.593"
	Gxara	28° 23' 56.8679"	32° 39' 58.168"
	Gqwara	28° 24'45.07"	32°39'30.25"
	Ngogwane	28° 25'17.91"	32°38'55.31"
	Qolora	28° 26'5.79"	32°37'47.70"
	Ncizele	28°26'16.68"	32°37'42.50"
	Timba	28° 26'45.16"	32°37'31.65"
X	*Mbokotwana*	28° 27'17.44"	32°37'20.21"
	Kobonqaba	28° 29' 25.2924"	32° 36' 28.209"
	Nxaxo/Ngqusi	28° 31' 34.5323"	32° 35' 5.0315"
X	*Bowkers Bay*	28°33' 16.55"	32°33'5.19"
	Cebe	28° 35' 8.97719"	32° 31' 16.273"
	Gqunqe	28° 35' 22.2396"	32° 31' 7.6836"
	Zalu	28° 36' 11.2572"	32° 30' 9.5183"
	Ngqwara	28° 36' 50.6016"	32° 29' 39.138"
	Sihlontlweni/Gcin	28° 38' 41.3627"	32° 28' 52.957"
	Nebelele	28° 39' 21.3480"	32° 27' 45.575"
	Qora	28° 40' 24.4740"	32° 26' 46.932"
	Jujura	28° 41' 38.2596"	32° 25' 51.960"
	Ngadla	28° 42' 31.2515"	32° 25' 6.0599"
	Shixini	28° 43' 31.8467"	32° 24' 11.163"
	Beechamwood	28° 45' 7.48439"	32° 22' 29.492"
	Unamed1	28° 45' 29.4371"	32° 22' 12.151"
	Kwa-goqo	28° 45' 41.4539"	32° 21' 59.050"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Ku-Nocekedwa	28° 46' 40.0655"	32° 20' 55.766"
	Nqabara	28° 47' 25.1915"	32° 20' 22.970"
X	*Gume*	28° 48' 58.97"	32°19'15.01"
X	*Ngomane*	28° 49' 32.38"	32°18'48.76"
	Ngoma/Kobule	28° 50' 14.3195"	32° 18' 4.1868"
X	*Unnamed*	28° 49' 46.22"	32°18'18.95"
	Mendu	28° 52' 40.0332"	32° 16' 51.297"
	Mendwana	28° 53' 3.25679"	32° 16' 8.1336"
X	*Unnamed*	28° 53'24.33"	32°15'45.67"
	Mbashe	28° 54' 6.84359"	32° 14' 59.946"
	Ku-Mpenzu	28° 54' 51.9012"	32° 14' 37.777"
	Ku-Bhula/Mbhanyan	28° 55' 40.8108"	32° 13' 41.185"
X	*Dakana*	28° 56' 17.94"	32° 13' 13.91"
	Kwa-Suka	28° 56' 48.78"	32°12'19.06"
	Ntlonyane	28° 57' 23.9832"	32° 11' 40.930"
X	*Nyumbazana*	*28°57'42.26"*	*32°11'16.22"*
	Nkanya	28° 58' 29.4888"	28° 58' 29.489"
	Sundwana	28° 58' 55.1280"	32° 10' 24.330"
	Xora	28° 59' 44.1059"	32° 9.' 31.082"
	Bulungula	29° 0.' 41.4647"	32° 8.' 16.828"
	Ku-Amanzimuzama	29° 2' 0.17159"	32° 6.' 53.729"
	Nqakanqa	29° 3' 44.7119"	32° 5' 55.1003"
	Unamed2	29° 4' 9.60240"	32° 5' 18.9023"
	Mncwasa	29° 4' 33.8772"	32° 4.' 57.741"
X	*Lubanzi*	29° 5' 10.83"	32° 4'28.38"
X	*Mhlalane*	29° 5' 14.87"	32° 3'50.23"
	Mpako	29° 6' 27.7019"	32° 2.' 24.853"
X	*Mtonjane*	*29° 6'43.31"*	*32° 1'59.85"*
X	*Ku-Bomvu*	*29° 8'56.27"*	*31°59'19.46"*
	Nenga	29° 9' 6.51600"	31° 59' 7.7460"
	Mapuzi	29° 10' 7.37759"	31° 58' 11.812"
	Mtata	29° 11' 1.52880"	31° 57' 10.666"
	Tshani	29° 12' 31.8960"	31° 56' 41.855"
	Mdumbi	29° 12' 58.6763"	31° 55' 53.220"
	Lwandilana	29° 14' 38.1300"	31° 53' 46.312"
	Lwandile	29° 14' 51.1296"	31° 53' 27.401"
	Mtakatye	29° 16' 12.8892"	31° 51' 33.371"
	Hluleka/Majusini	29° 18' 13.0032"	31° 49' 38.668"
	Mnenu	29° 19' 48.3239"	31° 48' 27.223"
	Mtonga	29° 20' 53.8475"	31° 47' 35.739"
	Mpande	29° 21' 25.7148"	31° 45' 44.096"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Sinangwana	29° 22' 11.6183"	31° 45' 1.7928"
X	*Ndluzula*	*29°23'13.99"*	*31°44'28.08"*
	Mngazana	29° 25' 22.2996"	31° 41' 31.837"
	Mngazi	29° 27' 47.2824"	31° 40' 37.862"
X	*Tyityane*	*29°29'29.66"*	*31°40'5.43"*
X	*Ntloloba*	*29°30'3.59"*	*31°39'33.81"*
	Gxwaleni	29° 30' 24.8148"	31° 39' 19.706"
	Bululo	29° 31' 3.89639"	31° 39' 2.4515"
	Mtambane	29° 31' 13.7316"	29.° -3' -1693."
	Mzimvubu	29° 32' 59.7443"	31° 37' 52.107"
X	*Mnenga*	*29°34'5.42"*	*31°37'0.66"*
	Ntlupeni	29°34'34.30"	31°36'42.18"
X	*Manzana*	*29°36'4.16"*	*31°36'1.38"*
	Nkodusweni	29° 36' 29.39"	31°35'39.42"
X	*Gugu*	*29°36'58.63"*	*31°35'6.44"*
	Mntafufu	29° 38' 15.8244"	31° 33' 45.068"
X	*Ingo*	*29°39'38.90"*	*31°32'56.92"*
X	*Ntyivini*	*29°40'3.39"*	*31°32'41.01"*
X	*Dakane*	*29°40'43.51"*	*31°32'6.49"*
	Mzintlava	29° 41' 23.2475"	31° 31' 21.518"
X	*Mguga*	*29°41'51.93"*	*31°30'45.14"*
	Mzimpunzi	29° 43' 23.1816"	31° 28' 47.852"
	Mbotyi	29° 44' 4.16400"	31° 28' 6.6287"
	Kwanyambalala	29° 44' 4.16400"	31° 28' 6.6287"
	Mkozi	29° 45' 41.6663"	31° 26' 54.722"
	Myekane	29° 46' 6.67920"	31° 26' 42.046"
	Sitatsha	29° 46' 17.00"	31°26'37.98"
X	*Cutweni*	*29°47'12.44"*	*31°26'18.65"*
X	*Mjihlelo*	*29°47'53.83"*	*31°26'9.95"*
X	*Mlambomkulu*	*29°49'18.66"*	*31°26'0.84"*
	Lupatana	29° 51' 5.32440"	31° 25' 23.811"
	Mkweni	29°52'22.20"	31°24'12.27"
X	*Maviti*	*29°53'41.28"*	*31°23'26.23"*
X	*Tezana*	*29°54'21.46"*	*31°22'31.97"*
X	*Magogo*	*29°55'10.02"*	*31°22'1.24"*
X	*Kilroe Beach*	*29°55'45.53"*	*31°21'34.37"*
X	*Mbaxeni*	*29°56'19.92"*	*31°21'3.61"*
	Msikaba	29° 58' 3.74"	31° 19' 9.20"
	Butsha	29°59'6.19"	31° 18' 45.17"
X	Kwa-Nondindwa	*29°59'22.58"*	*31°18'37.38"*
X	Daza	*29°59'50.39"*	*31°18'20.76"*

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Mgwegwe	30° 0.' 40.9140"	31° 17' 15.554"
X	*Mkambati*	*30° 1'26.14"*	*31°16'27.98"*
	Mgwetyana	30° 2' 22.9775"	31° 15' 42.454"
	Mtentu	30° 2' 46.5539"	31° 14' 55.885"
	Sikombe	30° 4' 9.86160"	31° 13' 19.333"
	Kwanyana	30° 6' 17.6615"	31° 11' 10.791"
	Mtolane	30° 7' 37.1135"	31° 9' 34.8192"
	Mnyameni	30° 8' 1.60800"	31° 9' 7.67520"
X	*Unnamed*	*30° 8'33.86"*	*31° 8'42.80"*
	Mpahlanyana	30° 9' 36.5831"	31° 7' 27.9768"
	Mpahlane	30° 9' 53.4240"	31° 7' 9.99840"
	Mzamba	30° 10' 26.3999"	31° 6' 31.8600"
	Mtentwana	30° 11' 15.1979"	31° 5' 17.8763"
	Mtamvuna	30° 11' 37.2984"	31° 5' 4.27200"
	Zolwane	30° 12' 17.5427"	31° 4' 31.5876"
	Sandlundlu	30° 13' 44.6087"	31° 2' 33.4319"
	Ku-Boboyi	30° 14' 8.16359"	31° 2' 4.77599"
	Tongazi	30° 15' 24.5915"	31° 0' 41.1732"
	Kandandhlovu	30° 16' 9.45480"	30° 59' 50.625"
	Mpenjati	30° 17' 2.78160"	30° 58' 25.348"
	Umhlangankulu	30° 18' 11.0699"	30° 56' 43.490"
	Kaba	30° 18' 32.3604"	30° 56' 9.4776"
	Mbizana	30° 20' 5.22239"	30° 54' 31.103"
	Mvutshini	30° 20' 49.6895"	30° 53' 38.684"
	Bilanhlolo	30° 20' 56.1479"	30° 53' 24.687"
	Uvuzana	30° 21' 32.2415"	30° 52' 42.254"
	Kongweni	30° 22' 21.8495"	30° 51' 41.288"
	Vungu	30° 23' 43.1303"	30° 50' 11.345"
	Mhlangeni	30° 24' 20.1168"	30° 49' 12.810"
	Zotsha	30° 25' 25.1687"	30° 47' 22.322"
	Boboyi	30° 26' 21.2531"	30° 46' 14.509"
	Mbango	30° 26' 51.6084"	30° 45' 27.745"
	Mzimkulu	30° 27' 29.8800"	30° 44' 23.398"
	Mtentweni	30° 28' 54.1019"	30° 42' 34.534"
	Mhlangamkulu	30° 29' 54.0420"	30° 41' 17.394"
	Damba	30° 30' 37.5335"	30° 40' 20.863"
	Koshwana	30° 31' 2.27280"	30° 39' 37.137"
	Intshambili	30° 32' 11.5223"	30° 38' 13.938"
	Mzumbe	30° 32' 52.0116"	30° 36' 50.133"
	Mhlabatshane	30° 34' 17.0363"	30° 35' 4.1208"
	Mhlungwa	30° 34' 59.6459"	30° 33' 38.926"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Mfazazana	30° 36' 25.4339"	30° 31' 54.534"
	Kwa-Makosi	30° 36' 36.8496"	30° 31' 33.085"
	Mnamfu	30° 37' 28.9991"	30° 30' 30.272"
	Mtwalume	30° 38' 8.16000"	30° 29' 6.6300"
	Mvuzi	30° 38' 51.4104"	30° 28' 11.276"
	Fafa	30° 39' 13.0068"	30° 27' 24.073"
	Mdesingane	30° 40' 17.7275"	30° 25' 33.772"
	Sezela	30° 40' 39.8747"	30° 24' 54.046"
	Mkumbane	30° 40' 58.2060"	30° 24' 20.185"
	Mzinto	30° 42' 32.9219"	30° 22' 3.5075"
	Nkomba	30° 43' 13.3608"	30° 21' 10.357"
	Mzimayi	30° 43' 38.3448"	30° 20' 47.292"
	Mpambanyoni	30° 45' 33.4655"	30° 16' 49.432"
	Mahlongwa	30° 45' 50.1336"	30° 16' 8.8968"
	Mahlongwana	30° 47' 37.4424"	30° 13' 30.478"
	Mkomazi	30° 48' 13.9248"	30° 12' 9.3203"
	Ngane	30° 49' 1.67159"	30° 10' 43.824"
	Umgababa	30° 49' 50.6171"	30° 9' 20.4120"
	Msimbazi	30° 50' 51.5724"	30° 7' 46.2863"
	Lovu	30° 51' 27.2700"	30° 6' 19.5552"
	Little Manzimtoti	30° 52' 23.7395"	30° 4' 40.9152"
	Manzimtoti	30° 53' 4.71480"	30° 3' 30.8159"
	Mbokodweni	30° 56' 12.4367"	30° 0' 34.9524"
	Sipingo	30° 57' 4.53959"	29° 59' 45.229"
X	Umlazi	30° 58' 42.6971"	29° 58' 10.588"

Not in NBA	Estuary	X_coord (E)	Y_coord (S)
	Durban Bay	31° 3.' 45.0288"	29° 51' 58.085"
	Mgeni	31° 2.' 33.4031"	29° 48' 30.585"
	Mhlanga	31° 6.' 5.30279"	29° 42' 10.832"
	Mdloti	31° 7.' 44.9328"	29° 39' 2.1348"
	Tongati	31° 11' 5.58600"	29° 34' 24.275"
	Mhlali	31° 16' 41.4119"	29° 27' 36.575"
	Bobs Stream	31° 17' 41.0496"	29° 26' 16.717"
	Seteni	31° 18' 10.4544"	29° 25' 45.667"
	Mvoti	31° 20' 5.47439"	29° 23' 30.775"
	Mdlotane	31° 22' 25.7844"	29° 21' 8.6507"
	Nonoti	31° 24' 25.4880"	29° 19' 7.8852"
	Zinkwasi	31° 26' 36.5207"	29° 16' 53.724"
	Tugela/Thukela	31° 30' 3.62160"	29° 13' 27.310"
	Matigulu/Nyoni	31° 38' 40.3872"	29° 5' 1.30559"
	Siyaya	31° 45' 47.2968"	28° 58' 0.7716"
	Mlalazi	31° 49' 22.8971"	28° 56' 40.995"
	Mhlathuze	32° 2' 59.9675"	28° 50' 55.949"
	Richard's Bay	32° 5' 51.9611"	28° 48' 51.138"
	Nhlabane	32° 15' 25.6247"	28° 39' 41.061"
	UMfolozi	32° 25' 30.1836"	28° 23' 21.390"
	Msunduzi	32° 25' 20.8020"	28° 24' 10.461"
	St Lucia	32° 25' 29.0243"	28° 22' 57.226"
	Mgobezeleni	32° 40' 50.1419"	27° 32' 22.390"
	Kosi	32° 52' 50.8404"	26° 53' 42.626"

Appendix B:
Estuarine habitat cover in South Africa

Table B. Updated listed of Estuarine habitat cover in South Africa (based on 2010 input data).

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Orange	83.9	107.8	0	22.02	0	108.3	652.5	0	0	974.52
Buffels	0	37.5	0	152	0	50	0.5	0	0	240
Spoeg	4.87	3.39	0	0.01	0	0	0.47	0	0	8.74
Groen	6.03	0	0	0	0	27.34	10.56	0	0	43.93
Olifants	91.94	849.1	47.72	60.05	0	76.99	227.86	0	0	1353.66
Verlorenvlei	16.2	7.56	3.68	2.3	0	0	4.5	0.5	0	34.74
Berg (Groot)	1667	2545	206	1588	0	?	793	0	0	6799
Langebaan	123.3	250.61	0	0	0	10.2	450.6	0	0	834.71
Rietvlei/Diep	0	0	0	0	0	0	0	0	0	0
Sout Wes	0	0	0	0	0	0	0	0	0	0
Hout Bay	0	0	0	17.15	0	2.53	1.37	0	0	21.05
Wildevoëlvlei	12.72	0	0	15.38	0	172.31	30.46	0	0	230.87
Bokramspruit	0	0	0	0.6	0	0	0.6	0	0	1.2
Schuster	0	0	0	0.14	0	0	0.46	0	0	0.6
Buffels Wes	0	0	0	0.48	0	1.67	1.58	0.02	0	3.75
Elsies	0	0	0	3.76	0	1.67	13.02	0	0	18.45
Krom Wes	0	0	0	1.42	0	0	7.28	0	0	8.7
Silvermine	0	0.19	2.02	2.21	0	2.01	0.09	0	0	6.52
Sand	11.55	0	0	39.76	0	7.02	97.15	0	0	155.48
Zeekoei	0	0	0.2	0.66	0	1.48	0.78	0.05	0	3.17
Eerste	0.29	0	0	1.36	0	6.15	2.4	0	0	10.2
Lourens	0	0	0	0.58	0	4.01	2.5	0	0	7.09
Sir Lowry's Pass	0	0.04	0	0	0	1.74	1.17	0	0	2.95
Steenbras	0	0	0	0	0	0	1.88	0	0	1.88
Rooiels	0	0	0.03	1.81	0	8	1	0	0	10.84
Buffels Oos	0	1.48	0	3.37	0	0.05	12.38	0	0	17.28
Palmiet	0.1	0	0	0	0	11	21.4	0.5	0	33
Bot/Kleinmond	0	92.4	32.3	373.8	0	152.3	1358.2	0	0	2009
Onrus	0	0	0	41.08	0	0	0.05	0	0	41.13
Klein	8.45	161.03	197.49	97.66	0	164.89	704.1	5	0	1338.62
Uilkraals	0	0	37.7	0	0	46	21	0	0	104.7
Ratel	0	0	0	0	0	0.39	0.94	0	0	1.33
Heuningnes	5.53	292.98	27.19	96.76	0	42.61	52.98	0	0	518.05
Klipdrifsfontein	0	0	0	0	0	0	0.6	0	0	0.6
Breede	20.5	29.55	6	4.8	0	136	1367.75	0	0	1564.6
Duiwenhoks	50.78	0	0	0	0	79.38	72.91	0	0	203.07
Goukou	44.2	0	0	0	0	62.78	47.78	0	0	154.76
Gouritz	21.07	0	0	0	0	0	91.51	0	0	112.58
Blinde	0	0	0	0.04	0	0.05	1.66	0	0	1.75
Hartenbos	2.04	13.62	0	0	0	9.21	15.72	0	0	40.59
Klein Brak	17	278	0	2	0	10	77	0	0	384
Groot Brak	13	26.6	0	2.5	0	29.9	33.1	0	0	105.1

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Maalgate	0	0	0	0	0	1	14.96	0	0	15.96
Gwaing	1.58	0	0	0.14	0	1.82	3.65	0.31	0	7.5
Kaaimans	0.02	0	0	0.6	0	5.36	15.54	0	0	21.52
Wilderness (Touws)	6.3	7.4	4.6	11.2	0	2.1	21.1	0	0	52.7
Swartvlei	135.57	0	219.39	167.06	0	133.36	630.91	0	0	1286.29
Goukamma	1.5	5.2	0	4.1	0	0.21	7.2	0	0	18.21
Knysna	551	?	65.94	38	0	265.49	945.52	0	0	1865.95
Noetsie	0	0	0.1	2.71	0	0	5.06	0	0	7.87
Piesang	0	0	0	3.14	0	80.6	8.5	0	0	92.24
Keurbooms	72.16	41.83	88.73	146.33	0	166.27	159.42	0	0	674.74
Matjies	0	0	0	0.19	0	0	0.51	0	0	0.7
Sout Oos	0.37	0.31	0	0	0	0	2.36	0	0	3.04
Groot Wes	0	0.76	0	2.54	0	8.12	27.86	0	0	39.28
Bloukrans	0	0	0	0	0	0.63	2.88	0	0	3.51
Lottering	0	0	0	0	0	0.38	1.66	0	0	2.04
Elandsbos	0	0	0	0	0	3.04	2.09	0	0	5.13
Storms	0	0	0	0	0	0	12.1	0	0	12.1
Elands	0	0	0	0	0	1.7	5.79	0	0	7.49
Groot Oos	0	0	0	0	0	0.92	8.7	0	0	9.62
Tsitsikamma	0	0	0	1.5	0	0.5	4.5	0	0	6.5
Klipdrif	0	0	0	0.04	0	0.01	0.53	0	0	0.58
Slang	0	0	0	0.01	0	0	0.04	0	0	0.05
Krom Oos	18.13	67.17	30.98	12.95	0	89.65	189.34	0	0	408.22
Seekoei	0	8.18	14.25	26.42	0	0	83.37	0	0	132.22
Kabeljous	0	10.45	21.51	8.56	0	0	77.42	0	0	117.94
Gamtoos	92.92	80.84	5.14	40.88	0	92.12	189.35	0	0	501.25
Van Stadens	0	0	0	5.7	0	1.1	17.4	0	0	24.2
Maitland	0	0	0	4.5	0	0.25	11.4	2.5	0	18.65
Papkuils	0	0	0	0	0	0	0	0	0	0
Swartkops	165	5	12.5	4.5	0	177	135	0	0	499
Koega	0	2.3	1.2	4.3	0	0.04	2.3	0	0	10.14
Sundays	21.8	0	0	31.5	0	118.4	314	0	0	485.7
Boknes	1.5	5	0.5	6	0	0.5	6.5	0	0	20
Bushmans	118.3	0	39.8	20.9	0	?	161.9	0	0	340.9
Kariega	12.5	18.5	9.8	10.2	0	5.2	27.4	0.5	0	84.1
Kasuka	0	0	0	2.5	0	0.5	15.4	2.3	0	20.7
Kowie	35.2	0	0	6.36	0	33.99	43.08	0	0	118.63
Rufane	0	0	0	0.8	0	0	0.01	0	0	0.81
Riet	0	17.4	2.64	12.3	0	3	36.2	1.52	0	73.06
Kleinemond Wes	0	7.1	8.2	4.1	0	0.8	19.2	8.4	0	47.8
Kleinemond Oos	4.04	6.36	14.5	1.01	0	11.61	14.5	0.1	0	52.12
Klein Palmiet	0.001	0	0.02	0.22	0	0	0.29	0	0	0.531
Great Fish	46.7	152.3	0	16.6	0	10.58	139.5	0	0	365.68
Old woman's	0	0	0	14.17	0	0.1	10.7	0.15	0	25.12
Mpekweni	0	27.2	1.59	20.98	0	13.15	63.39	15.1	0	141.41

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Mtati	0	54.25	3.2	26.2	0	1.45	180.15	21.1	0	286.35
Mgwalana	0	7.62	1.12	48.78	0	5.34	154.3	9.56	0	226.72
Bira	0	2.59	5.3	15.16	0	18.04	122.45	0	0	163.54
Gqutywa	0	1.23	2.5	3.78	0	4.47	38.1	1.56	0	51.64
Blue Krans	0	0	0	1.58	0	0.12	0.58	0.26	0	2.54
Freshwater Poort	0	0	0	0.5	0	0.1	0.15	0.15	0	0.9
Ngculura	0	0	0	0.7	0	1.15	0.5	0	0	2.35
Mtana	0	2.5	2.54	1.25	0	0.15	7.1	2.15	0	15.69
Keiskamma	210.37	91.26	11.33	103.9	0	49.18	277.82	0	0	743.86
Shwele-Shwele	0	0	0	1.34	0	0.41	5.65	0.56	0	7.96
Ngqinisa	0	0	0	2.3	0	0.12	9.05	1.2	0	12.67
Kiwane	0	0	3.56	4.56	0	0.15	8.96	1.57	0	18.8
Tyolomnqa	3.7	15.67	0	0.29	0	0.07	87.71	0	0	107.44
Shelbertsstroom	0	0	0	0	0	0	0.3	0	0	0.3
Lilyvale	0	0	0	0.5	0	0	1.8	0	0	2.3
Ross' Creek	0	0	0.2	0.1	0	0	1	0	0	1.3
Ncera	0	2.9	1	0.9	0	6.7	16.9	0	0	28.4
Mlele	0	0.4	0	0.5	0	0	2.7	0	0	3.6
Mcantsi	0	0.5	0	4	0	0.5	4	0	0	9
Gxulu	1	11.9	0	0.6	0	4	31	0	0	48.5
Goda	0	1.9	0	1.1	0	0.6	13.6	0	0	17.2
Hlozi	0	0	0	0.3	0	0	0.4	0	0	0.7
Hickmans	0	0.8	0	0.4	0	0	3.1	0	0	4.3
Mvubukazi	0	0	0	0	0	0	0.1	0	0	0.1
Ngqenga	0	0	0	0	0	0	0.1	0	0	0.1
Buffalo	0	0.1	0	0.2	0	0	97.7	0	0	98
Blind	0	0.1	0	0	0	0	0.4	0	0	0.5
Hlaze	0	0.1	0	0.7	0	0	0.7	0	0	1.5
Nahoon	2.8	0	2.3	0.2	0.6	4.5	47.3	0	0	57.7
Qinira	16.83	5.7	0	15.2	0	0	34.4	0	0	72.13
Gqunube	3.7	2.2	0.8	0.4	0	6.3	40	0	0	53.4
Kwelera	9.3	7.2	2.3	0.3	0	4.4	26.6	0	0	50.1
Bulura	2.8	5.6	0.4	2.7	0	4.6	19.4	0	0	35.5
Cunge	0	0	0	0.2	0	0	0.3	0	0	0.5
Cintsa	7	7.1	0	1	0	1.6	12.6	0	0	29.3
Cefane	28.1	21.4	0	1.9	0	8.8	22.5	0	0	82.7
Kwenxura	0	3.3	0	2.6	0	5	18.2	0	0	29.1
Nyara	1.1	6.3	0	0.6	0	1.7	7.4	0	0	17.1
Haga-haga	0	0.3	0	0.4	0	1.4	1.3	0	0	3.4
Mtendwe	0	4.1	0	5.6	0	0.2	4.2	0	0	14.1
Quko	3.9	0	0	1.2	0	0.08	31	0	0	36.18
Morgan	0	2	0	1	0	1	20	0	0	24
Cwili	0	0	0	0.6	0	0	0.6	0	0	1.2
Great Kei	5.8	6.2	0	12.3	0	8.7	189.4	0	0	222.4
Gxara	0	1.89	0	6.31	0	1.5	14.2	0	0	23.9

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Ngogwane	0	0	0	2.35	0	2.1	4.67	0	0	9.12
Qolora	0	0	0	8.7	0	1.2	7.4	5.6	0	22.9
Ncizele	0	0	0	1.23	0	0.005	5.4	0	0	6.635
Kobonqaba	2.3	4.5	0	2.4	1.5	4.6	11.1	0	0	26.4
Ngqusi\Inxaxo	2.35	8.56	0.04	4.65	15	4.56	124.32	0	0	159.48
Cebe	0	0	0	7.63	0	1.4	7.5	0	0	16.53
Gqunqe	0	0	0	9.2	0	0.89	7.85	0	0	17.94
Zalu	0	0	0	5.2	0	0.02	7.14	0	0	12.36
Ngqwara	0	2.34	0	4.68	0	2.1	10.24	0	0	19.36
Sihlontlweni	0	0	0	2.56	0	0.05	8.4	0	0	11.01
Qora	0	0	8.5	5.67	0	10.23	65.23	0	0	89.63
Jujura	0	0	0.05	1.2	0	0.07	3.45	0	0	4.77
Ngadla	0	0	0	5.23	0	0.004	8.65	0	0	13.884
Shixini	0	0	0	5.64	0	5.23	11.23	0	0	22.1
Nqabara	0	0	1.2	4.56	8.5	4.63	89.54	0	1.23	109.66
Ngoma	0	0	0	4.32	0	4.56	1.23	0	0	10.11
Mendu	0	0	0	9.51	0	0	14.32	0	0	23.83
Mendwana										0
Mbashe	2.3	0	1.5	13.45	14	6.7	89.2	0	4.8	131.95
Ku-Mpenzu	0	0	0	4.3	0	1.24	6.54	1.3	0	13.38
Ku-Bhula	0	0	0	2.7	0	0	2.6	2.3	0	7.6
Kwa-Suka	0	0	2.3	7.6	0	0.01	8.23	0	0	18.14
Ntlonyane	0	0	0	7.99	0	3.89	29.46	0	0	41.34
Nkanya	0	0	0	7.4	0	0.05	7.52	0.5	0	15.47
Sundwana	0	0	0	2.3	0	0.01	4.32	0	0	6.63
Xora	0	12.96	2.6	10.12	16.32	17.13	91.45	0	0	150.58
Bulungulu	0	2.3	0	4.7	0	2.5	8.9	0	0	18.4
Ku-amanzimuzama	0	0	0	1.2	0	1.05	1.4	0	0	3.65
Mncwasa	0	0	0	3.7	0	0.156	15.36	0	0	19.216
Mpako	0	0	0	5.13	0	0.96	7.42	0	0	13.51
Nenga	0	0	0	2.1	0	2.17	5.74	0	0	10.01
Mapuzi	0	0	0	7.45	0	0	8.45	0	0	15.9
Mtata	0	21.03	0	6.23	33.5	5.62	102.41	0	0	168.79
Tshani	0	0	0	1.23	0	0.004	2.78	0	0	4.014
Mdumbi	0	8.17	0.05	7.9	0.5	13.88	45.57	0	0	76.07
Lwandilana	0	0	0	2.4	0	0.08	7.21	0	0	9.69
Lwandile	0	0	0	7.4	0	2.4	12.4	0	0	22.2
Mtakatye	0	18.19	1.25	7.56	9	5.21	75.6	0	0	116.81
Hluleka	0	0	0	2.35	0	4.1	8.45	0	0	14.9
Mnenu	0	0	0	44	0	0.08	46.44	0	0	90.52
Mtonga	0	0	0	15.6	0	1.2	15.4	0	0	32.2
Mpande	0	0	0	6.7	0	0.5	7.84	0	0	15.04
Sinangwana	0	0	0	7.4	0	0	5.8	0	0	13.2
Mngazana	1.25	7.4	0.8	11.4	145	5.6	45.6	0	7.8	224.85
Mngazi	0	0	0	4.6	0	0	12.5	0	0	17.1

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Gxwaleni	0	0	0	5.6	0	0.02	4.5	0	0	10.12
Bululo	0	0	0	6.3	0	0.02	6.3	0	0	12.62
Mtambane	0	0	0	5.41	0	0.12	5.41	0	0	10.94
Mzimvubu	0	0	0	22.3	0	15.23	102.23	0	11.23	150.99
Ntlupeni	0	0	0	0.13	0	0.14	4.1	0	0	4.37
Nkodusweni	0	0	0	4.7	0	5.5	22.4	0	0	32.6
Mntafufu	0	0	0	1.5	13.7	0.75	7.65	0	0.47	24.07
Mzintlava	0	0	0	3.09	2.31	2.89	14.42	0	0.35	23.06
Mzimpunzi	0	0	0	1.41	0	0.6	3.07	0	0	5.08
Kwa-Nyambalala	0	0	0	0.02	0	0.01	0.57	0	0	0.6
Mbotyi	0	0	0	4.16	0	11.41	32.32	0	2.5	50.39
Mkozi	0	0	0	0.5	1.29	0.12	2.1	0	0	4.01
Myekane	0	0	0	0.3	0	0.49	1.13	0	0	1.92
Lupatana	0	0	0	0.22	0	0.15	2.73	0	0.45	3.55
Mkweni	0	0	0	0.34	0	0.15	5.19	0	1.32	7
Msikaba	0	0	0	0.49	0	2.81	10.94	0	0.89	15.13
Butsha	0	0	0	0.35	0	0	0.8	0	1.74	2.89
Mgwegwe	0	0	0	0.15	0	0.8	3.39	0	4.45	8.79
Mgwetyana	0	0	0	0.27	0	0.56	2.45	0	0	3.28
Mtentu	0	0	0	4.76	1.47	8.08	34.95	0	3.67	52.93
Sikombe	0	0	0	0.3	0	0.79	9.21	0	1.18	11.48
Kwanyana	0	0	0	0.71	0	0.1	6.32	0	0	7.13
Mtolane	0	0	0	0	0	0.14	1.15	0	0	1.29
Mnyameni	0	0	0	8.46	0	2.34	17.11	0	0.01	27.92
Mpahlanyana	0	0	0	0.74	0	0.1	3.01	0	0	3.85
Mpahlane	0	0	0	0.66	0	0.29	2.97	0	0	3.92
Mzamba	0	0	0	24.11	0.25	3.97	37.87	0	4.74	70.94
Mtentwana	0	0	0	0	0	1.22	10.21	0	0	11.43
Mtamvuna	0	0	0	15.23	0.3	2.36	45.69	0	0	63.58
Zolwane	0	0	0	0	0	2	0.3	0	0	2.3
Sandlundlu	0	0	0	3.25	0	3	4	0	0.25	10.5
Ku-boboyi	0	0	0	3	0	1	1.1	0	0	5.1
Tongazi	0	0	0	0	0	3	0.78	0	3	6.78
Kandandhlovu	0	0	0	2	0.5	1	1.8	0	0	5.3
Mpenjati	0	0	0	17	0	4.5	11.6	0	0	33.1
Umhlangankulu	0	0	0	4	0.5	1.5	5.8	0	4	15.8
Kaba	0	0	0.25	9	0	3	2.4	0	0	14.65
Mbizana	0	0	0	12	0	1	12.4	0	3	28.4
Mvutshini	0	0	0	0	0	3	0.88	0	0	3.88
Bilanhlolo	0	0	0	8	0.5	3.5	2.6	0	2	16.6
Uvuzana	0	0	0	4.5	0	1	0.6	0	0	6.1
Kongweni	0	0	0	4	0.5	1	1.42	0	0.25	7.17
Vungu	0	0	0	0	0	6	1.13	0	0	7.13
Mhlangeni	0	0	0	8	0	4	3.6	0	0	15.6
Zotsha	0	0	0	13	0	4	7.3	0	5	29.3

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Boboyi	0	0	0	9	0	4	1.3	0	0	14.3
Mbango	0	0	0	8	0	2	0.9	0	2	12.9
Mzimkulu	0	0	0	18	0	11	73.9	0	15	117.9
Mtentweni	0	0	0	5	0	1	7.98	0	4.5	18.48
Mhlanga	0	0	0	69.9	0	0	30	0	0.2	100.1
Damba	0	0	0	6.25	0	2.7	1.7	0	9	19.65
Koshwana	0	0	0	10	0	1	1.18	0	6	18.18
Intshambili	0	0	0	1.5	0	1	1.7	0	6.25	10.45
Mzumbe	0	0	0	5	0	15	15.8	0	0	35.8
Mhlabatshane	0	0	0	4	0	1.5	2.27	0	11.5	19.27
Mhlungwa	0	0	1.5	7	0	4	3	0	1	16.5
Mfazazana	0	0	0	7.5	0	1	2.1	0	5	15.6
Kwa-Makosi	0	0	0	3.5	0	2	2.45	0	7	14.95
Mnamfu	0	0	0	6	0	3	1.28	0	4	14.28
Mtwalume	0	0	0	4	0	10	24.8	0	0	38.8
Mvuzi	0	0	0	15	0	2	0.8	0	0	17.8
Fafa	0	0	1.5	8	0	7	30	0	4.5	51
Mdesingwana	0	0	0.5	6	0	0.25	0.39	0	0	7.14
Sezela	0	0	0	18	0	1	9	0	0	28
Mkumbane	0	0	0	7	0	5	0.25	0	0	12.25
Mzinto	0	0	0	14	0	4	7	0	4.5	29.5
Nkomba										0
Mzimayi	0	0	0	6	0	6	0.9	0	0	12.9
Rocky Bay (30º20'01"S; 30º44'02E)										0
Mpambanyoni	0	0	0	3	0	7	2.32	0	0.25	12.57
Mahlongwa	0	0	0	7	0	1	5.9	0	0	13.9
Mahlongwana	0	0	3	5	0	2	6.84	0	4	20.84
Mkomazi	0	0	0	5	2	4.9	62.8	0	0	74.7
Ngane	0	0	0	3	0	4	1.36	0	0	8.36
Umgababa	0	0	2.5	15	0	12	17.8	0	0	47.3
Msimbazi	0	0	0	12	0	3	13.2	0	0	28.2
Lovu	0	0	0	19	0	5	10.5	0	5	39.5
Little Manzimtoti	0	0	0	2	0	1.5	1.5	0	5	10
Manzimtoti	0	0	0	5	0	7	6.67	0	2.5	21.17
Mbokodweni	0	0	0	8	0	2.5	7.24	0	0	17.74
Sipingo	0	3	0	2	3.8	1	0.8	0	16	26.6
Umlazi										0
Durban Bay	0	0	8	2	16	37	1080	0	5	1148
Mgeni	2	0	0	2	20.3	11	48	0	0	83.3
Mhlambankulu	0	0	0	0	0	0.68	12	0	0.2	12.88
Mdloti	0	0	0	10	0	7.3	33	0	7.8	58.1
Tongati	0	0	0	17.2	0	2.8	13.9	0	3.4	37.3
Mhlali	0	0	0	6	0	8	21	0	7	42
Bob's Stream										0
Seteni	0	0	0	0.25	0	2	1.13	0	4	7.38

Estuary	Intertidal salt marsh	Supratidal salt marsh	Submerged macrophytes	Reeds & sedges	Mangroves	Sand/mud banks	Channel	Rocks	Swamp forest	Total
Mvoti	0	0	0	1	0	3	18.4	0	0	22.4
Mdlotane	0	0	0.71	6.03	0	0	6.35	0	12.33	25.42
Nonoti	0	0	2.5	2.5	0	3	18	0	1	27
Zinkwasi	0	0	0	39.51	0	0	20.37	0	11.28	71.16
Thukela	0	0	0	12	0	11	55	0	1	79
Matigulu/Nyoni	0	0	0.5	2	0	0.5	122	0	2	127
Siyaya	0	0	0.08	5.31	0	0.21	0.76	0	1.33	7.69
Mlalazi	0	39.31	0.001	19.64	60.7	19.8	95.86	0	3.46	238.771
Mhlathuze	60	0	5	205	652.1	90	679	0	0	1691.1
Richard's Bay	52	0	0	309	267	531	869	0	16	2044
Nhlabane	0	0	1.1	7.8	0	0	5.2	0	0.3	14.4
uMfolozi	0	0	0	78	26	20	8.5	0	5	137.5
St Lucia	516	1706	181	3789	571	206	31610	0	3	38582
Mgobezeleni	0	0	0	5	4.5	0.5	1.3	0	4	15.3
Kosi	0	0	0	100	60.7	18	200	12	25	415.7

Appendix C:
Assessment of the health status of South Africa's estuaries

Table C: Desktop National Health Assessment, with individual ecological components graded from Excellent (dark blue), good (blue), fair (green) to poor (brown). A Provisional Present Ecological Status is also provided. Pressure levels are indicated as very high (VH), high (H), medium (M) or low (L). A Blank indicates the absence of a pressure.

	Pressures								Health Condition											
NAME	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Orange (Gariep)	M	L	M		Y	L	5.0	Y													D
Buffels	L	M	M	Y	Y	L	0.1	Y													C
Spoeg	L	L	L			L	0.1	Y													B
Groen	L	L	L			L	0.1	Y													B
Sout	M	L	M				0.0														D
Olifants	M	M	M			VH	121.1	Y													C
Jakkalsvlei	H	M	L			L	0.1	Y													D
Wadrift	H	M	H			L	0.1	Y													E
Verlorenvlei	M	M	M		Y	M	10.0	Y													D
Groot Berg	M	H	M			VH	511.0	Y													D
Rietvlei/Diep	M	H	H		Y	L	0.1	Y													E
Sout (Wes)	H	H	H			L	0.1														F
Houtbaai	L	H	H			L	1.0	Y													E
Wildevoëlvlei	M	H	M			L	0.0	Y													D
Bokramspruit	L	H	L				0.0														C
Schuster	L	L	L				0.0														A
Krom	L	L	L				0.0														A
Buffels Wes	L	H	H				0.0														F
Elsies	L	H	H			L	0.1														E
Silvermine	L	H	H		Y	L	20.0	Y													D
Sand	M	H	M		Y	M	0.1	Y													D
Zeekoei	M	H	H			L	0.1	Y													E
Eerste	M	H	H			L	0.1	Y													E
Lourens	L	H	M			L	0.1	Y													C
Sir Lowry's Pass	M	H	H			L	1.0	Y													E
Steenbras	H	L				L	0.1	Y													B
Rooiels	L	L	L			L	0.1	Y													B
Buffels (Oos)	L	L	L			L	0.2	Y													B
Palmiet	M	L	M			L	70.0	Y													C
Bot/Kleinmond	M	M	M		Y	VH	0.1	Y													C
Onrus	H	H	H			L	80.0	Y													E
Klein	M	M	M		Y	H	2.1	Y													C
Uilkraals	M	M	M			M	0.1	Y													D

NAME	Pressures							Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Ratel	M	M	L			L	10.0	Y													C
Heuningnes	M	M	M		Y	M	0.0	Y													D
Klipdrifsfontein	L	L					80.0														A
Breëde	M	L	L			H	20.0	Y													B
Duiwenhoks	M	L	L			H	13.0	Y													B
Goukou (Kaffirkui	M	M	M			H	20.0	Y													C
Gouritz	M	M	M			H	0.1	Y													C
Blinde	L	M	L			L	2.1	Y													B
Hartenbos	M	H	M		Y	L	10.0	Y													D
Klein Brak	L	M	M			M	0.0	Y													C
Groot Brak	M	M	H		Y	M	1.0	Y													D
Maalgate	L	L				L	1.0	Y													B
Gwaing	L	M	L			L	0.0	Y													B
Kaaimans	L	L	L				0.0	Y													B
Wilderness (Touws)	L	M	M		Y		0.0	Y													B
Swartvlei	L	L	M		Y		4.1	Y													B
Goukamma	L	L	L		Y	M	70.4	Y													B
Knysna	L	M	L			H	0.2	Y													B
Noetsie	L	L	L			L	0.1	Y													B
Piesang	L	M	M			L	10.0	Y													C
Keurbooms	L	L	L			L	0.1	Y													A
Matjies	L	L	L			L	0.5	Y													B
Sout (Oos)	L	L				L	2.9	Y													A
Groot (Wes)	M	L	L			L	1.0	Y													B
Bloukrans	L	L				L	0.2	Y													A
Lottering	L	L				L	0.2	Y													A
Elandsbos	L	L	L			L	0.1	Y													A
Storms	L	L	L			L	0.1														A
Elands	L	L	L			L	0.1	Y													B
Groot (Oos)	M	M	L			L	1.8	Y													B
Tsitsikamma	M	M	L			L	0.1	Y													B
Klipdrif	M	M	M			L	0.1	Y													D
Slang	M	M	M			L	22.1	Y													D
Krom Oos (Kromme)	H	H	M			H	1.0	Y													D
Seekoei	M	M	H			L	2.0	Y													D
Kabeljous	L	M	M			L	19.3	Y													C

NAME	Pressures							Health Condition												
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Gamtoos	M	M	M			H	2.1	Y													C
Van Stadens	L	L	L			L	0.1	Y													B
Maitland	L	M	M			L	0.1	Y													C
Baakens	M	H	H			L	0.1	Y													E
Papenkuils	M	H	H			L	35.0	Y													F
Swartkops	L	H	H			H	10.0	Y													C
Coega (Ngcura)	M	H	H			L	9.0	Y													F
Sundays	M	H	M			H	0.3	Y													C
Boknes	L	L	L			L	11.5	Y													C
Bushmans	L	M	M			H	0.1	Y													C
Kariega	M	L	M			L	2.2	Y													C
Kasuka	L	L	L			L	2.0	Y													B
Kowie	M	M	M			L	0.0	Y													C
Rufane	M	M	M				0.1	Y													C
Riet	L	L	L			L	2.2	Y													B
Kleinemond Wes	L	M	L			L	2.0	Y													B
Kleinemond Oos	L	M	L			L	0.0	Y													B
Klein Palmiet	H	M	M			L	30.0	Y													D
Great Fish	M	M	M			H	0.1	Y													C
Old Womans	L	M	M			L	2.2	Y													C
Mpekweni	L	M	L			M	3.0	Y													B
Mtati	L	L	L			L	3.5	Y													B
Mgwalana	L	L	L			L	8.5	Y													B
Bira	L	L	L			L	0.2	Y													B
Gqutywa	L	L	L			L	0.1	Y													B
Ngculura	L	L	L			L	0.0														B
Blue Krans	L	L	L			L	2.1														A
Mtana	L	M	L			L	50.0	Y													B
Keiskamma	L	M	M			H	0.1	Y													C
Ngqinisa	L	M	L			L	2.0	Y													B
Kiwane	L	L	L			L	20.0	Y													B
Tyolomnqa	L	L	L			M	0.1	Y													B
Shelbertsstroom	L	M	L			L	0.1	Y													C
Lilyvale	L	M	L			L	0.1	Y													B
Ross' Creek	L	M	L			L	2.3	Y													B
Ncera	L	M	L			L	0.1	Y													B
Mlele	L	M	L			L	0.1	Y													B

NAME	Pressures							Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Mcantsi	L	M	M			L	3.2	Y													C
Gxulu	L	L	L			L	1.0	Y													B
Goda	L	L	L			L	0.1	Y													B
Hlozi	L	L	L			L	0.1	Y													B
Hickman's	L	M	L			L	0.1	Y													B
Mvubukazi	L	M	L			L	0.0	Y													B
Ngqenga	L	H	L			L	20.0														C
Buffalo	H	H	L			L	0.1	Y													D
Blind	L	H	L			L	0.1	Y													C
Hlaze	L	M	L			L	7.4	Y													C
Nahoon	M	H	M			H	2.0	Y													C
Qinira	L	M	L			M	7.7	Y													B
Gqunube	L	M	L			M	8.0	Y													B
Kwelera	L	L	L			H	2.0	Y													B
Bulura	L	M	L			H	0.1	Y													B
Cunge	L	L	L			L	3.5	Y													A
Cintsa	L	M	L			L	3.1	Y													C
Cefane	L	L	L			L	3.5	Y													B
Kwenxura	L	L	L			L	0.2	Y													B
Nyara	L	L				L	0.1	Y													A
Mtwendwe	L	L	L			L	1.0	Y													B
Haga-haga	L	L	L			L	0.1	Y													B
Mtendwe	L	L	L			L	3.8	Y													B
Quko	L	L	L			L	2.6	Y													A
Morgan	L	M	L			L	0.1	Y													C
Cwili	L	M	L			L	30.0	Y													B
Great Kei	L	M	L			H	2.3	Y													C
Gxara	L	L	L			L	0.1	Y													B
Ngogwane	L	L	L			L	1.7	Y													B
Qolora	L	L	L			L	0.1	Y													B
Ncizele	L	L	L			L	0.1	Y													B
Timba	L	L	L			L	6.0														A
Kobonqaba	L	L	L			L	3.0	Y													B
Nxaxo/Ngqusi	L	L	M			L	2.4	Y													B
Cebe	L	L	L			L	2.4	Y													B
Gqunqe	L	L	L			L	1.5	Y													A

NAME	Pressures								Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Zalu	L	L	L			L	2.4	Y													A
Ngqwara	L	L	L			L	1.5	Y													A
Sihlontlweni/Gcin	L	L	L			L	0.0	Y													B
Nebelele	L	L					7.0														A
Qora	L	L	L			L	1.3	Y													B
Jujura	L	L	L			L	1.5	Y													B
Ngadla	L	L	L			L	2.5	Y													A
Shixini	L	L	L			L	0.0	Y													B
Beechamwood		L					0.0														A
Unnamed		L					0.0														A
Kwa-Goqo		L					0.0														A
Ku-Nocekedwa		L					8.4														A
Nqabara/Nqabarana	L	L	L			L	1.0	Y													B
Ngoma/Kobule	L	L	L			L	1.0	Y													A
Mendu	L	L	L			L	0.0	Y													A
Mendwana	L	L	L				15.0														A
Mbashe	L	M	L			H	0.1	Y													C
Ku-Mpenzu	L	L	L			L	0.2	Y													B
Ku-Bhula/Mbhanyana	L	L				L	0.1	Y													A
Kwa-Suka	L	L				L	0.5	Y													B
Ntlonyane	L	M	M			L	0.1	Y													B
Nkanya	L	M	L	Y		L	0.0	Y													B
Sundwana		L				L	7.0														A
Xora	L	L	L			L	0.2	Y													B
Bulungula	L	L	L			L	0.0	Y													B
Ku-Amanzimuzama	L	L	L			L	0.0														A
Nqakanqa		L	L				0.0														A
Unnamed2		L	L				2.0														A
Mncwasa	L	L	L			L	0.5	Y													B
Mpako	L	L	L			L	0.1	Y													B
Nenga	L	M	M			L	0.1	Y													C
Mapuzi	L	M	L			L	5.5	Y													B
Mtata	M	H	M			H	0.1	Y													D
Tshani	L	M	L			L	5.0	Y													B
Mdumbi	L	L	M			H	0.1	Y													B
Lwandilana	L	L	L			L	1.0	Y													A

NAME	Pressures								Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Lwandile	L	L	L			L	5.2	Y													A
Mtakatye	L	L	L			H	0.1	Y													B
Hluleka/Majusini	L	L	L			L	6.0	Y													A
Mnenu	L	M	L			L	0.1	Y													B
Mtonga	L	L	L			L	0.1	Y													B
Mpande	L	L				L	1.0	Y													B
Sinangwana	L	L	L			L	6.7	Y													B
Mngazana	L	M	M			H	6.0	Y													B
Mngazi	L	M	L			L	0.1	Y													C
Gxwaleni	L	L				L	0.1	Y													A
Bulolo	L	L	L			L	0.0	Y													B
Mtumbane	L	L	L			L	35.2														B
Mzimvubu	L	M	L			H	0.0	Y													C
Ntlupeni	L	L	L			L	1.0														B
Nkodusweni	L	L	L			L	4.1	Y													B
Mntafufu	L	L	M			H	3.8	Y													B
Mzintlava	L	M	L			H	0.0	Y													B
Mzimpunzi	L	L	L				0.1														B
Kwa-Nyambalala	L	L	L			L	2.0	Y													B
Mbotyi	L	L	L			L	0.0	Y													B
Mkozi	L	L	L				0.0														A
Myekane	L	L					0.0														A
Sitatsha	L	L					0.0														A
Lupatana	L	L					0.0														A
Mkweni	L	L					3.2														A
Msikaba	L	M				H	0.0	Y													A
Butsha			L				0.1														A
Mgwegwe						L	0.1	Y													A
Mgwetyana						L	4.5	Y													A
Mtentu	L	L	L			H	1.0	Y													A
Sikombe	L	L				L	0.1	Y													A
Kwanyana	L	L	L			L	0.1	Y													B
Mtolane	L	L				L	3.5	Y													A
Mnyameni	L	L	M			L	0.1	Y													B
Mpahlanyana	L	L				L	0.1	Y													A
Mpahlane	L	L				L	3.7	Y													A

NAME	Pressures								Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Mzamba	L	M	L			H	0.0	Y													B
Mtentwana	L	M	H				2.5	Y													C
Mtamvuna	L	L	L		?	L	0.1	Y													B
Zolwane	L	L	M		Y	L	0.2	Y													B
Sandlundlu	L	M	M	Y	Y	L	0.2	Y													C
Ku-Boboyi	L	M	M			L	0.0	Y													B
Tongazi	L	M	M				0.2	Y													B
Kandandhlovu	L	M	M			L	0.3	Y													B
Mpenjati	L	M	M	Y	Y	L	0.3	Y													B
Umhlangankulu	L	M	M		Y	L	0.2	Y													C
Kaba	L	M	M			L	0.6	Y													B
Mbizana	L	M	M	Y	?	L	0.2	Y													B
Mvutshini	L	M	M		Y	L	0.2	Y													B
Bilanhlolo	L	M	M		Y	L	0.2	Y													C
Uvuzana	L	M	M		Y	L	0.2	Y													C
Kongweni	L	M	H		Y	L	0.0	Y													C
Vungu	L	M	L				0.2														B
Mhlangeni	L	M	M		Y	L	0.7	Y													C
Zotsha	L	M	M	Y	Y	L	0.2	Y													C
Boboyi	L	H	M			L	0.1	Y													C
Mbango	M	H	H			L	4.0	Y													E
Mzimkulu	M	M	M	Y	Y	H	0.2	Y													C
Mtentweni	L	M	M			L	0.2	Y													C
Mhlangamkulu	L	M	M			L	0.2	Y													C
Damba	L	M	M		Y	L	0.2	Y													C
Koshwana	L	M	M			L	0.2	Y													C
Intshambili	L	L	M			L	0.3	Y													B
Mzumbe	L	M	H	Y		L	0.2	Y													D
Mhlabatshane	L	L	M			L	0.8	Y													B
Mhlungwa	L	M	M			L	0.5	Y													C
Mfazazana	L	M	H			L	0.4	Y													C
Kwa-Makosi	L	M	M			L	0.2	Y													B
Mnamfu	L	M	M			L	0.2	Y													C
Mtwalume	L	M	M	Y		L	0.2	Y													D
Mvuzi	L	M	M			L	0.8	Y													C
Fafa	L	M	M	Y	Y	L	0.1	Y													D
Mdesingane	L	M	H			L	0.0	Y													C

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NAME	Pressures								Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
Sezela	L	H	M		Y		0.2														D
Mkumbane	L	M	M			L	0.6	Y													C
Mzinto	L	M	M		?	L	0.0	Y													C
Nkomba	L	M	H			L	0.2														C
Mzimayi	L	M	M			L	0.1	Y													C
Mpambanyoni	L	M	M	Y	?	L	7.6	Y													C
Mahlongwa	L	M	M	Y	Y	M	0.4	Y													C
Mahlongwane	L	M	M		?	L	7.0														B
Mkomazi	L	M	M	Y	Y	H	1.9	Y													C
Ngane	L	L	M		?	L	0.0	Y													B
Umgababa	L	L	M		Y		0.0														B
Msimbazi	L	L	L				0.0														B
Lovu	M	M	M	Y	Y		0.0														C
Little Manzimtoti	M	H	H		Y		0.0														D
Manzimtoti	L	H	H	Y	Y		0.0														D
Mbokodweni	M	H	H	Y	Y		0.0														E
Sipingo	H	H	H				53.0														F
Durban Bay	M	H	H			H	3.7	Y													E
Mgeni	M	H	H	Y	Y	L	0.1	Y													D
Mhlanga	M	H	M		Y	L	1.0	Y													D
Mdloti	L	H	H	Y	Y	L	0.6	Y													D
Tongati	L	H	H	Y	Y	L	0.6	Y													E
Mhlali	M	H	M	Y	Y	L	0.0	Y													C
Bob's Stream	M	M	M				0.1	Y													C
Seteni	M	M	M			L	1.0	Y													C
Mvoti	M	H	M	Y	Y	L	0.2	Y													D
Mdlotane	L	L	M			L	0.6	Y													B
Nonoti	L	M	M	Y	Y	L	3.0	Y													B
Zinkwasi	L	M	H	Y	Y	L	17.0	Y													C
Thukela	L	H	M	Y	Y	H	15.0	Y													C
Matigulu/Nyoni	L	L	L			H	0.1	Y													B
Siyaya	H	H	H			L	18.0														F
Mlalazi	L	M	M		Y	H	80.0	Y													B
Mhlathuze	L	M	H	Y		H	88.0	Y													C
Richards Bay	L	M	H			H	0.0	Y													D
Nhlabane (Present)	M	L	H	Y			0.0														D
Msunduzi	L	M	M				8.0														C

NAME	Pressures								Health Condition											
	Change in flow	Polution	Habitat loss	Mining	Artificial Breaching	Fishing Effort(	Fishing Effort(Catches in tones)	Bait collection	Hydrology	Hydrodynamics	Water Quality	Physical habitat	Habitat State	Microalgae	Macrophytes	Invertebrates	Fish Final	Birds	Biological State	Estuary Health State (Mean)	Ecological Category
UMfolozi	L	H	H	Y	Y	H	10.0	Y													D
St Lucia	H	M	H		Y	H	4.0	Y													E
Mgobezeleni	L	L	L		Y	M	300.0														B
Kosi	L	L	M			VH	0.0	Y													B

* *Ecological Category was determined by an ecological water requirement study, otherwise determined by desktop study.*

Appendix D:
National priority estuaries for biodiversity conservation

Table D. National and/or regional priorities, the extent of protection required (Full = full no-take protection, Partialpartial = no-take sanctuary zone where feasible), the recommended proportion of the estuary margin being undeveloped (or with a >100 m development setback line), and Recommended Ecological Category (after Turpie et al. 2012).

Estuary (West to East)	Current health category	National (SA) and regional (C.A.P.E.) priorities	Recommended extent of protection	Recommended degree of undeveloped margin	Recommended Ecological Category
Orange	D	SA/C.A.P.E.	Full	50%	C*
Spoeg	B	SA	Full	100%	A or BAS
Groen	B	SA	Full	100%	A or BAS
Olifants	C	SA/C.A.P.E.	Partial	50%	B*
Verlorenvlei	D	SA	Partial	50%	C
Berg	D	SA/C.A.P.E.	Partial	25%	C*
Rietvlei/ Diep	E	SA/C.A.P.E.	Partial	50%	C
Krom	A	SA/C.A.P.E.	Full	100%	A or BAS
Sand	D	SA/C.A.P.E.	Partial	20%	C
Eerste	E	SA/C.A.P.E.	Full	75%	D
Lourens	C	SA/C.A.P.E.	Full	75%	D
Palmiet	C	SA/C.A.P.E.	Full	50%	B*
Bot / Kleinmond	C	SA/C.A.P.E.	Partial	50%	B
Klein	C	SA/C.A.P.E.	Partial	50%	B
Uilkraals	D	SA	Partial	75%	C
Ratel	C	SA	Full	75%	C
Heuningnes	D	SA/C.A.P.E.	Full	75%	A or BAS
Klipdrifsfontein	A	SA/C.A.P.E.	Full	75%	A
Goukou	C	SA/C.A.P.E.	Partial	50%	B
Gouritz	C	SA/C.A.P.E.	Partial	50%	B
Kaaimans	B	SA	Full	50%	B*
Wilderness (Touws)	B	SA/C.A.P.E.	Partial	50%	A or BAS
Swartvlei	B	SA/C.A.P.E.	Partial	50%	B*
Goukamma	B	SA/C.A.P.E.	Full	75%	A*
Knysna	B	SA/C.A.P.E.	Partial	50%	B*
Piesang	C	SA	Partial	50%	B
Keurbooms	A	SA/C.A.P.E.	Partial	50%	A*
Sout (Oos)	A	SA/C.A.P.E.	Full	100%	A*
Groot (Wes)	B	SA/C.A.P.E.	Full	75%	A or BAS
Bloukrans	A	SA/C.A.P.E.	Full	100%	A or BAS
Lottering	A	SA/C.A.P.E.	Full	100%	A or BAS
Elandsbos	A	SA/C.A.P.E.	Full	100%	A or BAS
Storms	A	SA/C.A.P.E.	Full	100%	A or BAS
Elands	B	SA/C.A.P.E.	Full	100%	A or BAS
Groot (Oos)	B	SA/C.A.P.E.	Full	100%	A or BAS
Tsitsikamma	B	SA	Full	50%	B*
Kromme	D	SA/C.A.P.E.	Partial	25%	C*
Seekoei	D	SA/C.A.P.E.	Partial	25%	B*
Gamtoos	C	SA/C.A.P.E.	Partial	50%	A or BAS
Van Stadens	B	SA/C.A.P.E.	Partial	50%	A or BAS

Estuary (West to East)	Current health category	National (SA) and regional (C.A.P.E.) priorities	Recommended extent of protection	Recommended degree of undeveloped margin	Recommended Ecological Category
Maitland	C	SA/C.A.P.E.	Full	75%	C
Swartkops	C	SA/C.A.P.E.	Partial	25%	B
Sundays	C	SA/C.A.P.E.	Partial	50%	A or BAS
Bushman's	B	SA/C.A.P.E.	Partial	50%	A*
Kariega	C	SA/C.A.P.E.	Partial	50%	B
Great Fish	C	SA/C.A.P.E.	Partial	50%	B
Mgwalana	B	SA	Partial	50%	A
Bira	B	SA	Partial	50%	A
Gqutywa	B	SA/C.A.P.E.	Full	75%	A
Keiskamma	C	SA/C.A.P.E.	Partial	50%	B
Ncera	B	SA	Full	75%	B
Gqunube	B	SA	Partial	50%	A
Kwelera	B	SA	Partial	50%	A
Kwenxura	B	SA/C.A.P.E.	Full	75%	A
Quko	A	SA/C.A.P.E.	Full	50%	A
Great Kei	C	SA/C.A.P.E.	Partial	50%	B*
Ncizele	B	SA	Full	75%	B
Nxaxo/Ngqusi	B	SA/C.A.P.E.	Full	75%	A
Ngqwara	A	SA	Full	75%	A
Qora	B	SA/C.A.P.E.	Partial	75%	A
Ngadla	A	SA	Full	75%	A
Nqabara	B	SA	Partial	75%	A
Mbashe	C	SA/C.A.P.E.	Partial	75%	A or BAS
Ku-Mpenzu	B	SA/C.A.P.E.	Full	75%	B
Ku-Bhula/Mbhanyana	A	SA/C.A.P.E.	Full	75%	A
Ntlonyane	B	SA/C.A.P.E.	Full	75%	B
Nkanya	B	SA/C.A.P.E.	Full	75%	B
Sundwana	A	SA	Full	75%	A
Xora	B	SA	Partial	75%	A
Ngakanqa	A	SA	Full	75%	A
Mtata	D	SA	Partial	50%	C*
Lwandilana	A	SA	Full	75%	A
Mtakatye	B	SA	Partial	75%	B
Hluleka	A	SA	Full	75%	A or BAS
Mngazana	B	SA	Partial	50%	B
Mzimvubu	C	SA	Partial	50%	C
Nkodusweni	B	SA	Partial	75%	A or BAS
Mntafufu	B	SA	Full	75%	A or BAS
Mzintlava	B	SA	Full	75%	A or BAS
Mbotyi	B	SA	Partial	50%	A or BAS
Mkozi	A	SA	Full	75%	A
Myekane	A	SA	Full	75%	A
Mkweni	A	SA	Partial	75%	A or BAS
Msikaba	A	SA	Full	75%	A or BAS
Mtentu	A	SA	Full	75%	A or BAS

Estuary (West to East)	Current health category	National (SA) and regional (C.A.P.E.) priorities	Recommended extent of protection	Recommended degree of undeveloped margin	Recommended Ecological Category
Mnyameni	B	SA	Partial	75%	A or BAS
Mtamvuna	B	SA	Full	75%	A or BAS
Mpenjati	B	SA	Partial	75%	A or BAS
Zotsha	C	SA	Partial	50%	C
Mzimkulu	C	SA	Partial	50%	B
Damba	C	SA	Partial	50%	C
Koshwana	C	SA	Partial	50%	C
Intshambili	B	SA	Partial	50%	B
Mhlabatshane	B	SA	Partial	50%	B
Mfazazana	C	SA	Partial	50%	C
Kwa-Makosi	B	SA	Partial	75%	B
Mkomazi	C	SA	Partial	25%	B
Umgababa	B	SA	Full	50%	B
Msimbazi	B	SA	Full	75%	B
Lovu	C	SA	Partial	50%	C
Durban Bay	E	SA	Partial	25%	B
Mgeni	D	SA	Partial	25%	A or BAS
Mhlanga	D	SA	Full	75%	B*
Mhlali	C	SA	Partial	50%	B
Mvoti	D	SA	Full	75%	D
Mdlotane	B	SA	Full	75%	A
Zinkwasi	C	SA	Partial	50%	B
Matigulu/Nyoni	B	SA	Partial	50%	A
Siyaya	F	SA	Full	50%	B*
Mlalazi	B	SA	Full	75%	A or BAS
Mhlathuze/R.Bay	C	SA	Partial	50%	A or BAS
St Lucia/uMfolozi	D	SA	Full	75%	A*
Mgobezeleni	B	SA	Full	75%	A or BAS
Kosi	B	SA	Full	75%	A or BAS

*Recommended condition were determined by an ecological water requirement study, otherwise determined by desktop study.

Appendix E:
Estuary-associated fish species caught in South African fisheries

Table E.1 Estuary-associated fish species caught in South African fisheries, given in order of estuarine dependence category (Table 2.1) and distribution of catches around the coast. Distribution is divided into West coast (Orange River to Cape Point), South Coast (Cape Point to Port Elizabeth), East Coast (Swartkops to Kei River), Transkei and KwaZulu-Kwazulu Natal (Port Edward to Kosi Bay). The three biogeographical provinces are separated by Cape Point and roughly at the Mbashe River in the Transkei (Emanuel *et al*. 1992, Turpie *et al.* 1999, Maree *et al*. 2000a,b).

Species	Common name	Dependence category	Distribution				
			Cool Temperate	Warm Temperate			Sub-tropical
			West	South	East	Transkei	KZN
Ambassis productus	Longspine glassy	Ia					X
Ambassis gymnocephalus	Bald glassy	Ib		X	X	X	X
Ambassis natalensis	Slender glassy	Ib					X
Rhabdosargus holubi	Cape stumpnose	IIa	X	X	X	X	X
Argyrosomus japonicus	Dusky kob	IIa		X	X	X	X
Mugil cephalus	Flathead/springer mullet	IIa	X	X	X	X	X
Elops machnata	Ladyfish/tenpounder	IIa		X	X	X	X
Lichia amia	Leervis/garrick	IIa	X	X	X	X	X
Acanthropagrus berda	Perch/riverbream	IIa				X	X
Pomadasys commersonni	Spotted grunter	IIa		X	X	X	X
Lithognathus lithognathus	White steenbras	IIa	X	X	X	X	X
Monodactylus falciformis	Cape/Oval moony	IIa			X	X	X
Liza macrolepis	Largescale mullet	IIa					X
Valamugil cunnesius	Longarm mullet	IIa				X	X
Valamugil robustus	Robust mullet	IIa				X	X
Terapon jarbua	Thornfish	IIa			X	X	X
Galeichthyes feliceps	Barbel	IIb	X	X	X	X	X
Sphyraena barracuda	Barracuda	IIb					X
Caranx sexfasciatus	Bigeye kingfish	IIb					X
Caranx ignobilis	Giant kingfish	IIb				X	X
Rhabdosargus sarba	Natal stumpnose	IIb				X	X
Scomberoides lysan	Doublespotted queenfish	IIb					X
Liza tricuspidens	Striped mullet	IIb		X	X	X	X
Thryssa vitrirostris	Orangemouth glassnose	IIb					X
Gerres acinaces	Smallscale pursemouth	IIb					X
Gerres methueni/rappi	Evenfin pursemouth	IIb					X
Leiognathus equula	Slimy	IIb					X
Monodactylus argenteus	Natal/Round moony	IIb				X	X
Liza alata	Diamond mullet	IIb				X	X
Liza dumerilii	Groovy mullet	IIb		X	X	X	X
Liza luciae	St Lucia mullet	IIb					X
Platycephalus indicus	Bartailed flathead	IIc			X	X	X
Diplodus sargus	Dassie/blacktail	IIc		X	X	X	X
Pomatomus saltatrix	Elf	IIc	X	X	X	X	X
Liza richardsonii	Harder	IIc	X	X	X		
Pomadasys hasta/kakaan	Javelin grunter	IIc					X
Johnius dussumieri	Mini kob	IIc			X	X	X
Sphyraena jello	Pickhandle barracuda	IIc					X
Lutjanus argentimactulus	River snapper	IIc				X	X
Sillago sihama	Silver sillago	IIc					X
Sarpa salpa	Strepie	IIc		X	X	X	X
Rhabdosargus globiceps	White stumpnose	IIc	X	X	X		
Carcharhinus leucas	Zambezi shark	IIc					X
Strongylura leiura	Yellowfin needlefish	IIc					X
Caranx melampygus	Bluefin kingfish	IIc					X

Species	Common name	Dependence category	Distribution				
			Cool Temperate	Warm Temperate			Sub-tropical
			West	South	East	Transkei	KZN
Caranx papuensis	Brassy kingfish	IIc					X
Chanos chanos	Milkfish	IIc					X
Lutjanus fulviflamma	Dory snapper	IIc					X
Valamugil buchanani	Bluetail mullet	IIc					X
Valamugil seheli	Bluespot mullet	IIc					X
Dasyatis chrysonota	Blue stingray	III	X	X	X		
Himantura uarnak	Honeycomb stingray	III					X
Gymnura natalensis	Butterfly/diamond ray	III		X	X	X	X
Myliobatus aquila	Eagleray	III	X	X	X		
Mustelus mustelus	Smooth houndshark	III	X	X	X	X	X
Rhinobatos annulatus	Lesser guitarfish/sandshark	III	X	X	X	X	
Epinephelus andersoni	Catface rockcod	III				X	X
Epinephelus malabaricus	Malabar rockcod	III					X
Pomadasys multimaculatum	Cock grunter	III					X
Pomadasys olivaceum	Piggy	III	X				
Chelidonichthyes capensis	Gurnard	III	X	X	X		
Trachurus trachurus	Maasbanker	III	X	X	X		
Lithognathus mormyrus	Sand steenbras	III	X	X	X		
Otolithes ruber	Snapper kob	III					X
Trachinotus africanus	Southern pompano	III			X	X	X
Spondyliosoma emarginatum	Steentjie	III	X	X	X	X	X
Sparodon durbanensis	White musselcracker	III		X	X	X	X
Diplodus cervinus	Zebra/wildeperd	III		X	X	X	X
Kuhlia mugil	Barred flagtail	III			X	X	X
Muraenesox bagio	Pike conger	III			X	X	X
Thrysoidea macrura	Slender giant moray	III					X
Oreochromis mossambicus	Mozambique tilapia	IV	X	X	X	X	X
Clarius gariepinus	Sharptooth catfish	IV	X	X	X	X	X
Glossogobius giuris	Tank goby	IV					X
Anguilla bengalensis	African mottled eel	Va		X	X	X	X
Anguilla bicolor	Shortfin eel	Va		X	X	X	X
Anguilla marmorata	Giant mottled eel	Va		X	X	X	X
Anguilla mossambica	Longfin eel	Va		X	X	X	X
Megalops cyprinoides	Oxeye tarpon	Vb					X
Myxus capensis	Freshwater mullet	Vb		X	X	X	X
TOTAL	**80**		**19**	**34**	**41**	**43**	**71**

Table E.2. The stock status (abundance trend) (A), vulnerability (V), range (R), exploitation level (E) and knowledge (K) of utilized estuarine-associated species in South Africa.

Family	Species	Common name	Cate-gory	CONSERVATION IMPORTANCE				
				A	V	R	E	K
Carcharhinidae	*Carcharhinus leucas*	Zambezi shark	IIc	45	100	0	75	57
Dasyatidae	*Dasyatis chrysonota*	Blue stingray	III	60	0	10	25	71
	Gymnura natalensis	Butterfly/diamond ray	III	60	90	40	50	50
	Himantura uarnak	Honeycomb stingray	III	60	90	0	50	29
Mustelidae	*Mustelus mustelus*	Smooth houndshark	III	55	90	0	100	86
Myliobatidae	*Myliobatus aquila*	Eagleray	III	60	70	0	25	43
Rhinobatidae	*Rhinobatos annulatus*	Lesser guitarfish	III	65	70	10	25	50
Ambassidae	*Ambassis gymnocephalus*	Bald glassy	Ib	55	70	0	0	29
	Ambassis productus	Longspine glassy	Ia	55	70	10	0	29
	Ambassis natalensis	Slender glassy	Ib	55	70	10	0	29
Anguillidae	*Anguilla bengalensis*	African mottled eel	Va	50	100	10	50	50
	Anguilla marmorata	Giant mottled eel	Va	50	100	10	50	50
	Anguilla mossambica	Longfin eel	Va	50	100	10	50	50
	Anguilla bicolor	Shortfin eel	Va	50	100	10	50	50
Ariidae	*Galeichthyes feliceps*	Barbel	IIb	55	100	10	75	71
Belonidae	*Strongylura leiura*	Yellowfin needlefish	IIc	55	70	0	0	21
Carangidae	*Caranx sexfasciatus*	Bigeye kingfish	IIb	55	70	0	25	43
	Caranx melampygus	Bluefin kingfish	IIc	55	70	0	25	21
	Caranx papuensis	Brassy kingfish	IIc	55	70	0	0	21
	Scomberoides lysan	Doublespotted queenfish	IIb	55	70	0	25	7
	Caranx ignobilis	Giant kingfish	IIb	45	80	0	50	50
	Trachurus trachurus	Maasbunker	III	50	70	0	100	79
	Trachinotus africanus	Southern pompano	III	50	70	10	50	21
Chanidae	*Chanos chanos*	Milkfish	IIc	55	80	0	25	43
Charangidae	*Lichia amia*	Leervis/garrick	IIa	50	90	0	75	64
Cichlidae	*Oreochromis mossambicus*	Mozambique tilapia	IV	50	0	10	50	86
Clariidae	*Clarius gariepinus*	Sharptooth catfish	IV	55	0	0	50	86
Elopidae	*Elops machnata*	Ladyfish/tenpounder	IIa	65	100	0	25	36
Engraulidae	*Thryssa vitrirostris*	Orangemouth glassnose	IIb	55	70	0	0	36
Gerreidae	*Gerres methueni/rappi*	Evenfin pursemouth	IIb	55	70	100	50	43
	Gerres acinaces	Smallscale pursemouth	IIb	55	70	0	50	29
Gobiidae	*Glossogobius giuris*	Tank goby	IV	40	70	0	0	36
Haemulidae	*Pomadasys multimaculatum*	Cock grunter	III	45	90	0	50	29
	Pomadasys hasta/kakaan	Javelin grunter	IIc	45	90	0	50	29
	Pomadasys olivaceum	Piggy	III	50	70	0	75	57
	Pomadasys commersonni	Spotted grunter	IIa	40	100	0	100	57
Kuhliidae	*Kuhlia mugil*	Barred flagtail	III	55	0	0	0	29
Leiognathidae	*Leiognathus equula*	Slimy	IIb	55	70	0	0	36
Lutjanidae	*Lutjanus fulviflamma*	Dory snapper	IIc	50	70	0	0	29
	Lutjanus argentimactulus	River snapper	IIc	30	90	0	75	29
Megalopidae	*Megalops cyprinoides*	Oxeye tarpon	Vb	60	90	0	50	14
Monodactylidae	*Monodactylus falciformis*	Cape/Oval moony	IIa	55	70	0	0	36
	Monodactylus argenteus	Natal/Round moony	IIb	55	70	0	0	21
Mugilidae	*Valamugil seheli*	Bluespot mullet	IIc	50	70	0	0	14
	Valamugil buchanani	Bluetail mullet	IIc	50	70	0	25	29
	Liza alata	Diamond mullet	IIb	55	70	0	50	29
	Mugil cephalus	Flathead/springer mullet	IIa	65	90	0	50	50

Table E.2 continued.

Family	Species	Common name	Cate-gory	CONSERVATION IMPORTANCE A	V	R	E	K
Mugilidae	*Myxus capensis*	Freshwater mullet	Vb	40	70	40	50	36
	Liza dumerilii	Groovy mullet	IIb	50	70	0	50	36
	Liza richardsonii	Harder	IIc	45	90	10	100	26
	Liza macrolepis	Largescale mullet	IIa	50	70	0	75	29
	Valamugil cunnesius	Longarm mullet	IIa	50	70	0	0	29
	Valamugil robustus	Robust mullet	IIa	50	70	10	0	36
	Liza luciae	St Lucia mullet	IIb	50	70	100	25	14
	Liza tricuspidens	Striped mullet	IIb	65	80	40	50	0
Muraenesocidae	*Muraenesox bagio*	Pike conger	III	55	0	0	0	36
Platycephalidae	*Platycephalus indicus*	Bartailed flathead	IIc	55	70	0	0	36
Pomatomidae	*Pomatomus saltatrix*	Elf	IIc	34	100	0	100	86
Sciaenidae	*Argyrosomus japonicus*	Dusky kob	IIa	4	100	40	100	86
	Johnius dussumieri	Mini kob	IIc	55	90	0	25	29
	Otolithes ruber	Snapper kob	III	60	80	0	50	57
Serranidae	*Epinephelus andersoni*	Catface rockcod	III	13	100	60	100	29
	Epinephelus malabaricus	Malabar rockcod	III	20	100	0	75	14
Sillaginidae	*Sillago sihama*	Silver sillagio	IIc	65	80	0	0	7
Sparidae	*Rhabdosargus holubi*	Cape stumpnose	IIa	40	100	40	75	50
	Diplodus sargus	Dassie/blacktail	IIc	35	100	10	100	57
	Rhabdosargus sarba	Natal stumpnose	IIb	35	100	0	75	50
	Acanthropagrus berda	Perch/riverbream	IIa	35	100	0	75	64
	Lithognathus mormyrus	Sand steenbras	III	20	0	0	25	14
	Spondyliosoma emarginatum	Steentjie	III	70	80	40	100	21
	Sarpa salpa	Strepie	IIc	67	90	20	100	71
	Sparodon durbanensis	White musselcracker	III	30	100	40	100	71
	Lithognathus lithognathus	White steenbras	IIa	6	100	40	100	50
	Rhabdosargus globiceps	White stumpnose	IIc	20	100	20	100	57
	Diplodus cervinus	Zebra/wildeperd	III	35	100	40	100	36
Sphyraenidae	*Sphyraena barracuda*	Barracuda	IIb	50	80	0	50	50
	Sphyraena jello	Pickhandle barracuda	IIc	60	70	0	50	0
Teraponidae	*Terapon jarbua*	Thornfish	IIa	55	70	0	0	29
Triglidae	*Chelidonichthyes capensis*	Gurnard	III	60	80	10	25	50

Appendix F:
Estuary synonym list for KwaZulu Natal estuaries
(Source: Ezemvelo KZN Wildlife)

Table F.1 Estuary synonym list for KwaZulu Natal estuaries (Source: B Escott, Ezemvelo KZN Wildlife)

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

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

CAPE TOWN SPATIAL DEVELOPMENT FRAMEWORK

PHASE 3 AND FINAL PUBLIC PARTICIPATION REPORT

May 2011

CitySpace
Planning Cape Town

Metropolitan Spatial Planning Branch
Spatial Planning & Urban Design Department
City of Cape Town

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

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8. Draft response to Gavin Smith and associates.

1. INTRODUCTION

The purpose of this report is to provide an overview of the public participation process followed when drafting the Cape Town Spatial Development Framework (CTSDF) and provide evidence of the City's compliance with the legislative requirements outlined below.

On 9 March 2007 the Department of Environmental Affairs & Development Planning, Provincial Government: Western Cape (DEA&DP, PG:WC) granted the City of Cape Town authority in terms of section 4(1) of the Land Use Planning Ordinance (Ordinance no 15 of 1985) (LUPO) to proceed with the preparation of a structure plan in terms of Section 4(6) of LUPO. The DEA&DP, PG:WC further confirmed that the City is required to prepare a Spatial Development Framework (SDF) in terms of the Municipal Systems Act (Act no 32 of 2000) (MSA) and that this process would run concurrently with the approval of the SDF/ Structure Plan in terms of section 4(6) of the LUPO.

As part of the DEA&DP's authority, in terms of section 4(4) of the LUPO, the DEA&DP required the City to grant interested and affected parties the opportunity to comment and provide inputs in the drafting of the plan. In this regard, the DEA&DP required:

- notice to be given in the local media in which the City's intention to prepare the SDF is made known and in which comment and inputs are requested.
- a minimum of 60 days be set aside for the submission of inputs
- public participation be sought at milestone stages of the process as when problems and issues are identified, when goals and objectives are set and when policies and strategies are identified
- written notification be directed to the relevant/ appropriate departments and relevant parties listed in paragraph 6.3 of your letter including national and provincial government departments as well as state-owned enterprises, interested parties and ratepayer associations.
- the City's intention to withdraw historical Structure Plans be specified when making known its intention to prepare the proposed Structure Plan in terms of section 4 (6) of the LUPO

DEA&DP further recommended that additional steps be taken to bolster public participation in the process such as workshops, personal notices etc.

On 18th August 2010 the City submitted the draft CT SDF to DEA&DP, PG:WC for provisional inspection in terms of section 4(5) of the LUPO. In a letter dated 27th September 2010 DEA&DP, PG:WC indicated that the City could proceed to the third and final round of public participation.

2. PUBLIC PARTICIPATION APPROACH FOLLOWED

The City appointed an independent public engagement expert, a joint venture in the persons of David Abrahams (Distinctive Choice) and Eleanor Sonnenberg (Imvusa Trading), to facilitate the first two phases of the public engagement process on the CTSDF and the eight integrated district Spatial Development Plans/ Environmental Management Frameworks (hereafter referred to as the District Plans).

A three phase public participation process was planned and implemented.

2.1 First Phase: Launch and scoping

The purpose of this first round of public consultations was to:

- Launch the process publicly
- Create a sense of public/ stakeholder ownership and involvement in the process
- Elicit the public/stakeholders' views on the development issues facing metropolitan Cape Town and the development principles and strategic goals that should be guiding the preparation of the CTSDF and District SDPs.
- Consultations at sub-council level also sought to confirm district level development informants.

A notice inviting the public to register as interested and affected parties to participate in this process was placed in the citywide press (Cape Times, Die Burger and Weekend Argus) as well as all community newspapers in May 2007. Posters were also put up at libraries, sub-council offices and district offices of the City's Planning & Building Development Management Department.

A subsequent reminder notice was placed in the same media in January 2008.

In addition when it was decided to integrate the environmental management frameworks into the district spatial development plans, a notice was issued in September 2008 in the citywide press (Cape Times, Die Burger & Weekend Argus) inviting interested and affected parties to register their interest in participating in the drafting of the CTSDF & District Plans in terms of the National Environmental Management Act.

One database for the CTSDF & District Plans was created and used for information dissemination on the public engagement processes associated with these products. In addition to those whom registered in response to the above-mentioned advertisements, the City's existing city-wide and sub-council databases of community organisations were used, and of course ad hoc requests were included on the database.

Articles were also placed in the City of Cape Town's City News March 2008 and July 2008 editions aimed at publicising this initiative and sharing information on the project.

A project specific website was also set up in March 2008 on the City of Cape Town's website in order to share information with the public and make information on the project available to the public on an ongoing basis - please use the following link to view this website http://www.capetown.gov.za/en/sdf/Pages/default.aspx.

The following events took place between February and April 2008 in order to engage with the public:

- Stakeholder workshops were held in each of the sub-councils (a total of 31 workshops were planned, 26 took place)
- A city-wide workshop
- Workshops were also held with sub-council members.

A total of 1,299 people participated in the public events in this first round of the public engagement process.

Invitations were sent out by the facilitators to those on the database and adverts were placed in the community newspapers or on community radio stations where relevant. In exceptional circumstances loudhailers were used. Invitations were also sent to sub-councils for further

dissemination to councillors, ward forums and the sub-council's own databases of community organisations. A background information document was included with these invitations.

At the end of 2008, beginning of 2009 a newsletter was prepared and distributed to those on our database, reporting to the public on the outcome of the first phase of the process and updating the public on this project.

Evidence of the above-mentioned steps taken, as well as the report to the City's Planning & Environment Portfolio Committee (PEPCO) on this first phase of the public participation process including the facilitator's report as well as PEPCO's minute in this regard were contained in section 1 of the public participation file submitted to you on 3rd August 2010.

2.2 Second Phase: Invitation to input and comment on draft proposals

The purpose of the second round of public consultations was to:

- Table and discuss the city-wide spatial concept and policy statements contained in the SDF. Particular attention was focussed on the proposed urban edge amendments and the coastal edge and densification strategies
- Table and discuss the 8 District Spatial Development Plans and Environmental Management Frameworks.

In September 2009 a notice was placed in citywide newspapers as well as community newspapers inviting the public to comment on the draft CTSDF and District Plans, as well as the City's draft Densification Strategy & draft Development Edges Policy. The following products were prepared and made available to the public in this regard:

- draft CTSDF "Popular Document" (in English, isiXhosa and Afrikaans)
- draft CTSDF Executive Summary
- draft Cape Town Spatial Development Framework Technical Report
- draft Densification Strategy Executive Summary (in English, isiXhosa & Afrikaans)
- draft Densification Strategy Technical Report
- draft Development Edges Technical Report
- 8 District SDPs

These draft documents were made available for viewing at the City's libraries, Planning & Building Development Management district offices and sub-council offices, as well as on the project website. Where requested, hard copies of the draft documents were made available to individual organisations.

The deadline for comment on the draft policies was set for 31 October 2009 but was subsequently extended to 30 November 2009 (a subsequent notice was placed in the city-wide press notifying the public in this regard).

In addition the following events took place between August and October 2009 in order to facilitate public input and comment on the draft policies:

- 23 district level workshops
- 22 sub-council based open days (including exhibition material on the draft CTSDF, Densification Strategy, Development Edges Policy and District Plans)
- 6 city-wide workshops
- A briefing meeting was held for government departments and state-owned enterprises on 15 October 2009.
- Reports and presentations (where requested) were made to each of the sub-councils

A total of 1,150 people participated in the public events in this round of the public participation process.

Invitations to these events were sent out to those on the database, updated to include those who attended the first round of engagements as well as the City's updated city-wide and sub-council databases. Adverts were placed in the community newspapers or on community radio stations where relevant. In exceptional circumstances loudhailers were used. Invitations were also sent to sub-councils for further dissemination to councillors, ward forums and the sub-councils' own databases of community organisations. The "popular document" on the CTSDF was included with these invitations. The Director: Spatial Planning & Urban Design also provided the secretariats of the Western Cape Developers Forum, South African Planning Institute (Western Cape), the South African Association of Consulting Professional Planners, the Cape Town Partnership, Accelerate Cape Town, the Cape Chamber of Commerce, the Cape Higher Education Consortium and WESSA with schedules of the public events planned for dissemination amongst their membership.

The phase 2 process was launched at a breakfast on 14 August 2009 hosted by the City for the Western Cape Developers Forum, including members of the consulting planning fraternity, where the CTSDF and supporting policies, as well as the District Plans were presented/ exhibited. CD's of the above-mentioned documents were circulated at this breakfast. Officials from DEA&P, PG:WC were present at this breakfast.

As part of this process, presentations and discussions also took place with individual groupings where requested including the Greater Cape Town Civic Alliance on 20 June 2009 and the Cape Chamber of Commerce on 1 October 2009.

Press releases were also issued at key milestones in the process in order to facilitate public interest and awareness in this project.

Section 2 of the file submitted to you on 3rd August 2010 provides evidence of the above-mentioned steps taken, the report to the City's PEPCO on the proposed second phase of the public participation process as well as PEPCO's minute in this regard, and the facilitators report. The file also includes a CD including the documents advertised for comment as well as the above-mentioned newsletter produced, as well as hard copies of these documents where available. Files including the mailing lists, invitation letters and attendance registers are available for viewing at the office of Spatial Planning & Urban Design Department, City of Cape Town.

2.3 Provisional Inspection in terms of section 4(5) of the LUPO

In a letter dated 27 September 2010, the Director: Environmental & Spatial Planning, DEA&DP, PG:WC acknowledged that:

- every effort had been made by the City in the dissemination of the notices pertaining to the draft CTSDF and the document itself.
- Most of the comments provided were adequately addressed
- The content of the CTSDF was sufficiently aligned with the MSA, the NEMA, the LUPO and the PSDF and that the process followed, as stipulated in the Section 4(1) approval letter, met with the Section 4(4) requirements of LUPO which enabled the City to progress to the following step in terms of the LUPO approval process (section 4(5) of LUPO)

Furthermore, with regard to the next step of the public participation process, the DEA&DP commented as follows:

- It confirmed that the third and final round of public participation will take the form of 60 day period for submission of comment and input on the final draft of the plans, as discussed in the meeting of 18 August 2010, at which meeting it was also agreed that this period could take place over the festive season provided a minimum 60 day period was provided for
- The City's proposal to hold a series of city-wide workshops as well as ad-hoc presentations where requested was supported
- Notification should be enhanced through the utilisation of municipal accounts
- The historical, existing 4(6) Structure Plans to be withdrawn in terms of section 4(7) of the ordinance should again be specified in the final round public engagement
- The Department re-affirmed its commitment to assist the City in acquiring comment from Provincial and National Departments in this final round of making known the draft CTSDF.

2.4 Third & Final Phase: Invitation to input and comment on the final draft CTSDF

The third round of public consultations took place when the final draft of the Cape Town SDF had been revised following PG:WC's provisional inspection and feedback in this regard.

The purpose of the third and final phase was to:

- Provide feedback on how the public's comments had been incorporated into the final draft CTSDF
- Elicit the public's final comments on the CTSDF

In November 2010 a press release was issued and notices were placed in municipal accounts, citywide newspapers as well as community newspapers inviting the public to comment on the final draft CTSDF (see Annexure 1). In addition letters regarding the third notice for input and public comment were sent to all the interested and affected parties registered on the database. The secretariats of the Western Cape Developers Forum, South African Planning Institute (Western Cape), the South African Council for Planners, the Cape Town Partnership, Accelerate Cape Town, the Cape Chamber of Commerce, the Cape Higher Education Consortium and WESSA were also informed of the call for public comment and the public events planned for dissemination amongst their membership. In addition an invitation was sent to the relevant government departments and state owned enterprises to comment on the CTSDF in November 2010 and a reminder invitation were sent to them in February 2011. Files including the mailing lists, invitation letters are available for viewing at the office of Spatial Planning & Urban Design Department, City of Cape Town

The following documents were made available for viewing at the City's libraries, Planning & Building Development Management district offices and sub-council offices, as well as on the project website (Refer to Annexure 2). Where requested, hard copies of the draft documents were made available.

- Final Draft Cape Town Spatial Development Framework (November 2010)
- Popular document (November 2010) (in English, isiXhosa and Afrikaans)
- A schedule of the comments received in Phase 2 and the City's response to them
- Supporting studies and ancillary documentation (on website only)

On request, city officials met with organised groupings such as the Property Developers Forum and representatives of residents' associations to present and discuss the content of the final draft CTSDF in more detail.

The following events took place between November 2010 and January 2011:

- a workshop for government departments and state owned enterprises;

- five city-wide public workshops, targeted at different interest groups (e.g. property developers, civic associations, environment and heritage sector); and
- a public hearing, convened by the Planning and Environment Portfolio Committee's SDF and District Plan Task Team (held on the 28th January 2011).

A total of 127 people attended the workshops while 26 organisations/individuals made submissions at the hearings and five organisations / individuals elected to attend the hearings as observers. The attendance register and notes of the workshops are contained in Annexure 3.

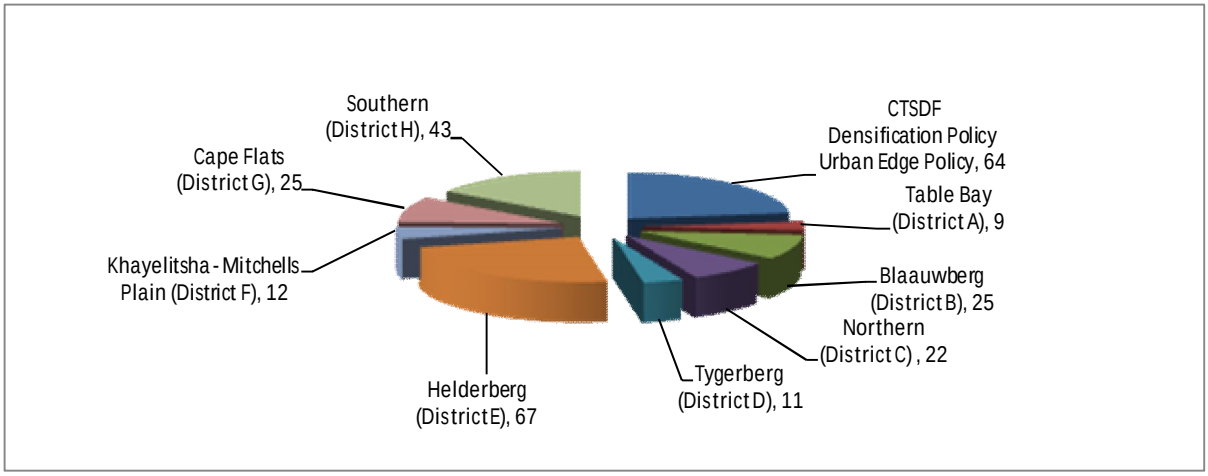
In addition the CTSDF was tabled on the agenda of all sub-councils in November 2010.

3. PUBLIC INPUT AND COMMENT RECEIVED ON THE FINAL DRAFT CTSDF

3.1. Public input phase 2 of the public participation process

In response to the notice and invitations issued as part of phase two of the public participation process, almost 300 written submissions were received from the private sector, NGO/CBO/Civic and external stakeholders. A schematic diagram of the distribution of written submissions is represented on Figure 1.

Figure 1: Distribution of written submissions phase 2 public participation process



Comment focused primarily on the draft CT-SDF, Densification Policy and Urban Edge Policy, with a large proportion of the District Plans' comment focused on the Southern and Helderberg Districts.

A substantial proportion of site specific district based comments were submitted by professional planning consultants on behalf of property owners seeking to motivate development proposals. Submissions were also received from civic organisations and NGO's, whilst state owned enterprises flagged areas of concern relating to particular land utilization requirements and long term property development agendas.

Irrespective of the author, the comments were categorized thematically and disaggregated according to collectively raised issues into a total of 1763 issue specific comments. The thematic categorization incorporates the following themes:

- *The Natural Environment;*
- *Movement;*
- *Economy;*
- *Urban Growth Management;*
- *Integrated Development;*
- *The Built Environment;*

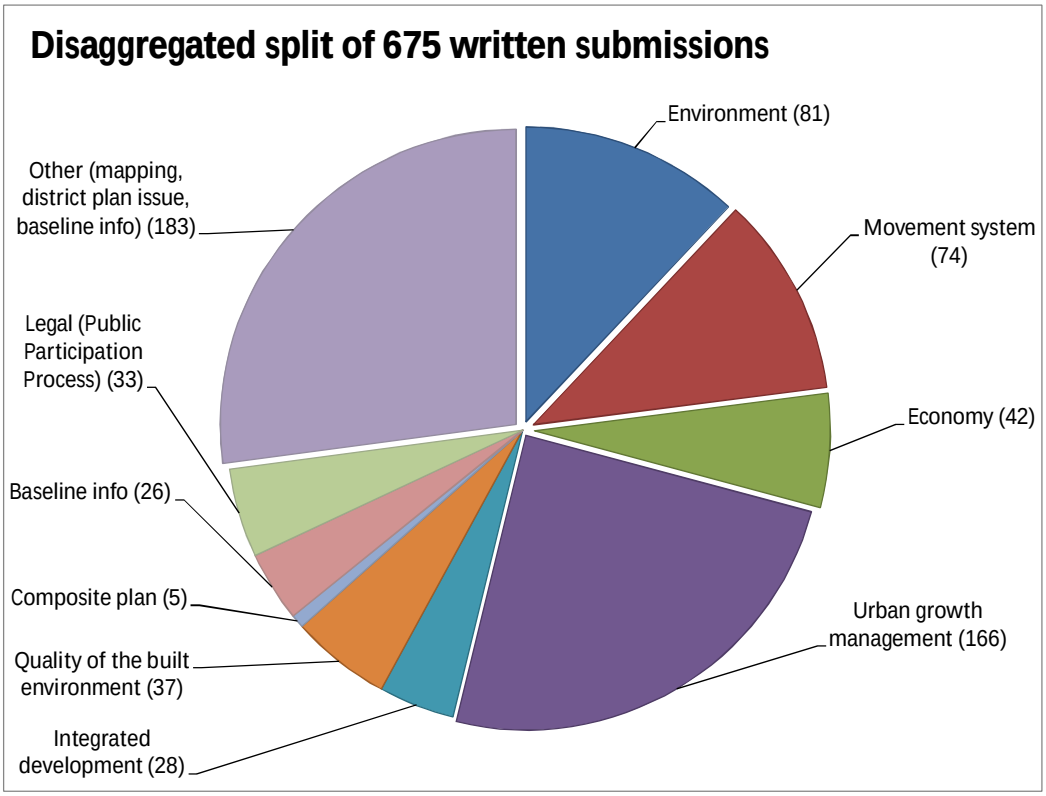
The summary schedule of comments received and the City's response to these comments were attached to our letter to your department dated 3rd August 2010.

With regards to our invitation to government departments, state-owned enterprises etc. to comment on the draft documents the City's letter to your department dated 19 July 2010 has reference. Copies of the comments received were submitted to your department as well as records of where follow up engagements took place with particular government departments or state-owned enterprises. Evidence relating to engagements held with neighbouring municipalities was also supplied to your department (also see Annexure 4).

3.2. Public input phase 3 of the public participation process

A total of 131 written submissions were received on the final draft of the CTSDF, 17 of the comments came from government departments and state owned enterprises (see Annexure 5). The comments were disaggregated into 675 separate comments and grouped in the themes mentioned above.

Figure 2: Distribution of written submissions on CTDSF phase 3 public participation process



A schedule of the comments and the City's response to them is contained in Annexure 5. Generally speaking the comments were very technical and editorial. A large number of them

were incorporated into the redrafted final CTSDF document. Some comments related to legal and process issues (e.g. the public participation process and the link between LUPO and the MSA) and others related to the legality of statements related to inclusionary housing and compliance with the National Heritage Resources Act (No 25, 1999)(NHRA) requirements. We have double checked that the public participation process complies with the relevant legislation and have addressed the other legal concerns in the redrafted CTSDF.

In addition we have improved the heritage component of the CTSDF and will submit the City of Cape Town's Heritage Inventory to Heritage Western Cape (HWC) in terms of s30(5) of the NHRA (see attachment to letter dated 30th May 2011) The submission includes:

- A 'snapshot' map of the metropolitan area reflecting the City's heritage inventory as at May 2011;
- A CD including the City's Heritage Inventory as at May 2011 including shape files and attribute data; and
- A copy of the final CTSDF and associated documentation including the above-mentioned Council resolution and a schedule of comments received on the November 2010 final draft advertised for public comment and the City's responses to these. Please refer to this schedule for the City's responses to comments received from the Director: Cultural Affairs.

A further grouping of comments related to urban growth management, urbanisation, the alignment of the urban and coastal edge, and references to tourism. The CTSDF now places greater emphasis on the opportunities and challenges of urbanisation and *Key Strategy 2: Manage urban growth and create a balance between urban development and environmental protection* has been restructured and has a greater pro-development emphasis. We have improved references to tourism. The PEPCO Urban Edge Task Team reviewed all requests to amend the urban and coastal edge. The finalised urban edge line is indicated on Map 6.1 of the CTSDF and is based on the recommendations of the Urban Edge Task Team endorsed by the City Council on the 30th March 2011 (see Annexure 7).

Mr Gavin Smith submitted a letter raising concern that the comments submitted by him and his colleagues had not been addressed in the City's comments on the comments submitted by some parties in the Phase 2 consultation process. The City's draft response to his letter is contained in Annexure 8. The detailed information referred to in the letter will be supplied by the City on request by PGWC.

4. COMMENTS RECEIVED FROM GOVERNMENT DEPARTMENTS, STATE OWNED ENTERPRISES AND SURROUNDING MUNICIPALITIES

Over the course of the CTSDF preparation process the following government departments, SOE's and surrounding municipalities submitted comments on the CTSDF (see the list below and Annexure 4 for their comments and the City's response to the comments).

National Departments

1. Department of Co-operative Governance and Traditional Affairs: Urban and Rural Development
2. Department of Correctional Services
3. Department of Home Affairs
4. Ministry of National Planning (Presidency)

Provincial Departments

5. Department of Water Affairs
6. Department of Agriculture

7. Department of Cultural Affairs and Sport
8. Department of Environmental Affairs and Development Planning
9. Department of Local Government and Housing: Social Housing Steering Committee
10. Department of Transport and Public Works
11. Department of Rural Development and Land Reform
12. Provincial Treasury
13. Department of Cultural Affairs and Sport

State Owned Enterprises

14. South African Heritage Resources Agency
15. South African Nation Parks (Table Mountain National Park)
16. Cape Nature
17. South African National Roads Agency Limited
18. Airports Company South Africa (ACSA)
19. Transnet
20. Metrorail (PRASA)
21. Eskom (Nuclear Division and Reticulation)
22. National Energy Regulator

Surrounding municipalities

23. Cape Winelands District Municipality

The significant comments received during the Phase 3 public participation process related to the CTSDF route designation, Cape Town International Airport and Koeberg Nuclear Power Station. These have been addressed to the extent that it is possible in the CTSDF and through CoCT: SOE engagements. Refer to Annexure 4 for records of the engagements with ESKOM and ACSA.

5. CITY OF CAPE TOWN INTER-DEPARTMENTAL COMMENT ON THE DRAFT CTSDF

An inter-departmental steering committee was set up to oversee and input into the CTSDF & District Plans. Seven meetings of this Corporate Steering Committee have taken place at key milestones in the plan preparation process, in the main linked to the circulation of draft documents for internal input and comment. Throughout the process there have also been bi-lateral consultations with key departments to ensure their timeous and relevant input into the drafts and debate and resolve areas of mutual interest to ensure cross sectoral alignment.

The August 2010 submission to your department included a record of consultations that took place in the formulation of the Future Cape Town discussion document, being the founding document for the draft Cape Town Spatial Development Framework.

6. OVERVIEW OF DOCUMENTS/ EVIDENCE SUPPLIED

6.1 Submission for Provisional Inspection

In August 2010 a public participation process report file was submitted to your department. It contained the following documents and these documents are not being resubmitted:

1. Evidence: First phase: Launch and Scoping
2. Evidence: Second Phase: Invitation to input and comment on the draft proposals

3. Summary schedule of comments received (Phase 2) and the City of Cape Town's responses to these
4. Comments received from government departments, state owned enterprises etc. and associated documentation (Phase 2)
5. Argument for the Long Term Development of Cape Town (Future Cape Town) – Internal and External consultation processes and interactions June 2005 – September 2006

6.2 Submission for approval

By way of evidence of the process followed in the third and final round of public participation following the DEA&DP, PG:WC's provisional inspection of the CTSDF, the following information is attached as annexures:

1. Evidence: Third Phase: Examples of notifications and invitation to input and comment on the draft proposals;
2. Evidence: Documents made available to the public (Final Draft CTSDF (November 2010) and Popular Documents (November 2010);
3. Evidence: Workshop notes and attendance registers and list of persons/ organisations that made presentations at the public hearings and a CD with copies of the presentations made at the hearings;
4. Comments received from government departments, state owned enterprises in phase 2 and 3; the City's responses to the comments and notes of meetings with the Department of Correctional Services, Western Cape Education Department, ESKOM, Air Traffic Navigation Services and Airports Company South Africa;
5. Summary schedule of all comments received on the final draft CTSDF (Phase 3) and the City's responses to them;
6. Summary of comments received from sub-councils and the response to them;
7. Council endorsed recommendations of the Planning and Environment Portfolio Committee's Urban Edge Task Team regarding requests received in Phase 3 to review the urban and coastal edge; and
8. Draft response to Gavin Smith and associates.

Please note the original copy of comments submitted to the City is available for viewing at the office of the Spatial Planning & Urban Design Department, City of Cape Town

7. CONCLUSION

We trust that the public participation process followed by the City in the compilation of the CTSDF has more than met the requirements of DEADP, PG:WC and the relevant legislation.

Annexure 1

Evidence: Third Phase: Examples of Notifications and Invitation to input and comment on the draft proposals

Annexure 2

Evidence: Documents made available to the public (Final Draft CTSDF (November 2010) and Popular Documents (November 2010)

Annexure 3

Evidence: Workshop notes and attendance registers and list of persons/ organisations that made presentations at the public hearings

Annexure 4

Comments received from government departments, state owned enterprises in phase 2 and 3; the City's responses to the comments and notes of meetings with the Department of Correctional Services, Western Cape Education Department, ESKOM, Air Traffic Navigation Services and Airports Company South Africa

Annexure 5

Summary schedule of all comments received on the final draft CTSDF (Phase 3) and the City's responses to them

Annexure 6

Summary of comments received from sub-councils and the response to them

Annexure 7

Council endorsed recommendations of the Planning and Environment Portfolio Committee's Urban Edge Task Team regarding requests received in Phase 3 to review the urban and coastal edge

Annexure 8

Draft response to Gavin Smith and associates

DRAFT COASTAL PROTECTION ZONE BYLAW

COMMENTS – RESPONSE REPORT

MARCH 2011

Introduction

The City of Cape Town has a coastline of 307km, of which it administers approximately 240km, the remaining 60km falling within the Table Mountain National Park. The City's coastline is arguably its greatest economic, social and environmental asset. The coastline is central to the City's sense of place, identity, global desirability and underpins much of our economy, provides for unique and diverse social recreation and opportunity as well as ecosystem services.

However, due to the high desirability of coastal property, the City's coastline has been extensively altered and impacted through "strip" development, the location of hard infrastructure in a highly dynamic environment and a lack of historical investment and management. As a result the City's coastline is increasingly under pressure and as a social and economic asset is in decline, - notably through increased levels of coastal erosion, permanent loss and destruction of dune systems, loss of fauna and flora and increasing levels of windblown sand problems. In addition, global climate change predictions suggest that amongst others, sea level rise and an increase in the intensity and frequency of storm events may have significant impact on coastlines across the globe. Cape Town with its extensive coastline will be particularly vulnerable to these predicted changes.

In protecting our economic future and social opportunity, lowering environmental and social risk, complying with legislation, specifically the Integrated Coastal Management Act, and ensuring equitable access and opportunities into the future, while adopting a "no regrets" approach to climate change, the City must now institute appropriate means to protect, manage and formalize its coastal zone.

In responding to this need, the City of Cape Town released the Draft Coastal Protection Zone Bylaw for public and stakeholder comment. The Draft Coastal Protection Zone Bylaw was approved for Public and Stakeholder Comment by the Planning and Environment Portfolio Committee (PEPCO) on the 2nd November 2010. On approval by PEPCO, the Public Participation Plan for the bylaw was submitted to, and approved by, the Office of the Speakers Committee (OSCOM) on the 8th November 2010.

Overview of Public Process

The Public Participation Plan for the bylaw consisted of the following components:

1) The comment period for public consultation was set by OSCOM as the 01st February 2011 to 2nd March 2011 to confirm with the City's 30 day public comment policy.
2) The Draft Bylaw was translated into Afrikaans and Xhosa
3) Submission of the Draft Bylaw for comment to all Sub Councils in January 2011.
4) The Draft Bylaw was posted to all stakeholders registered on Sub Council Databases (in excess of 1000 organisations)

5) The Draft Bylaw was advertised for public and stakeholder comment in all local newspapers and the weekend edition of the Argus and Die Burger in the week leading up to the 1st of February 2011.
6) Copies of the Draft bylaw as well as maps of the affected area were placed in 107 public libraries as well as all Sub Council offices
7) The Draft Bylaw was posted on the City's website with access to interactive maps as well as a simple mechanism for posting comments on the bylaw directly through the website.
8) In all communications to the public, a phone, fax, email address, postal address and web address were provided to ensure that the public were informed as to how they could submit their comments
9) A media release by the City indicating that the bylaw was open for public and stakeholder comment was issued on the 31st January 2011 by Corporate Communications.

Report Structure

This report provides a written response to each comment received and is intended to:

- stand as public record of formal responses to those organisations and individuals that submitted comment on the Draft Bylaw
- stand as complete information on the Public Process so as to inform the Planning and Environment Portfolio Committee
- present clear indication of how the Draft Bylaw was revised to evolve into the Final Bylaw for decision by Council.

Overview and summary of comments received

The Draft bylaw was presented to all Sub Councils for comment and information. In summary:

- No Sub Councils objected to the bylaw
- Three Sub Councils submitted amendments to the bylaw (see details in this report)
- One Sub Council requested w workshop on the bylaw which was held and the record of the workshop is detailed in this report.

Comments on the Draft bylaw from the public and stakeholders were received via direct emails to ERMD, the City's website, through the post, by fax as well as a number of comments directly from telephone calls.

In total we received 59 written submissions from the public and stakeholders, of which 23 were from organisations and 36 from individuals. Summary statistics of the comments were:

- 40.68% of all comments received were in full support of the bylaw as it was presented
- 55.93% of comments received supported the bylaw but made recommendations for amendments to the content of the bylaw
- Only 3.39% of the comments received objected to the key intention of the bylaw

Therefore, with relevant amendments made to the Draft bylaw, 96.4% of all comments received were in support of the bylaw.

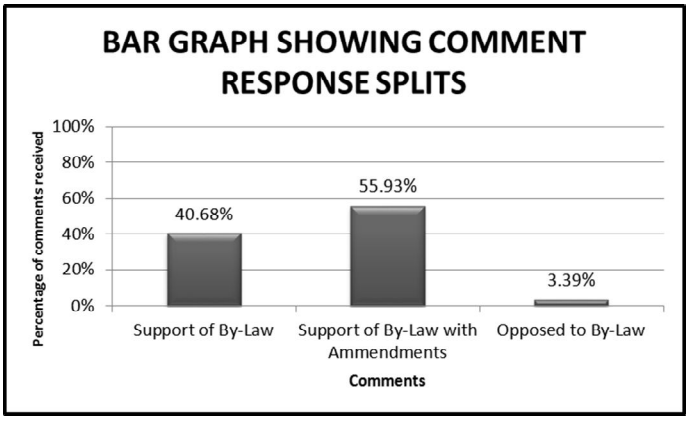
A summary of the key thematic issues raised through the public process on the bylaw include:

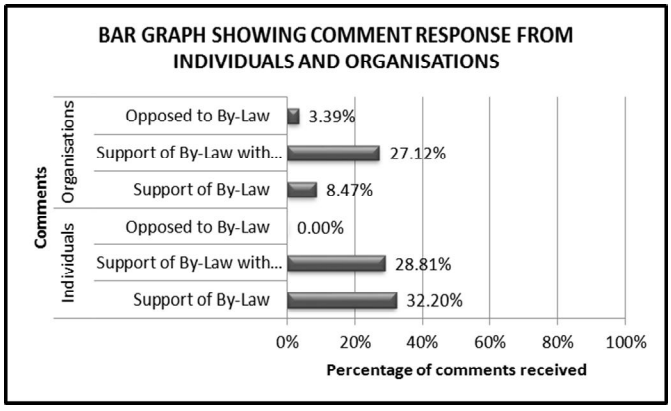
- The need to allow individuals to "beach-comb" without prejudice
- Complaints by the film industry that permitting processes are limiting their commercial opportunities and competitiveness with other coastal destinations. As noted in the responses, the bylaw does not govern or influence this issue which is regulated by the City's Filming and Events Policy
- Objections by individual landowners whose future development opportunities would be limited by the bylaw.
- The need to consider and regulate pets in the coastal zone
- Concerns regarding the condition and state of certain areas of the City's coastline
- Requests for certain areas to be either included or excluded from the coastal protection zone and thereby the regulations of the bylaw
- Various points of clarity on individual words or pieces of text in the bylaw
- Requests for the bylaw to be extended beyond the borders of Cape Town and regulate the coast of the Western Cape
- Confirmation that the bylaw will also regulate the activities and actions of the City itself and its officials
- Requests for extended comment periods on the bylaw. It should be noted here that the consultation process was done precisely and in accordance with the City's public and stakeholder policy.
- Request by Provincial and National Government to amend the name of the bylaw to that of MUNICIPAL Coastal Protection Zone Bylaw to prevent confusion with the

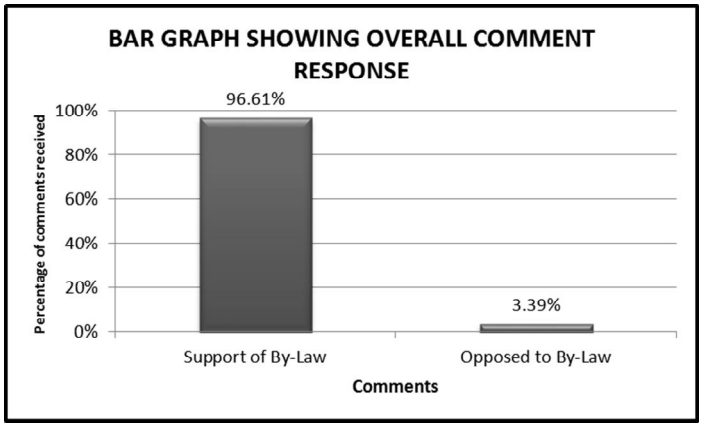
contents if the ICM Act until such time that the CPZ is declared by the MEC as per the Act.

Where relevant and appropriate, amendments to the Draft bylaw have been made based on the comments and suggestions received.
In an effort to ensure a transparent and open process that may stand as record, each comment received has been listed with a specific response to that comment detailed by City officials.

Results from the public and stakeholder consultation process are depicted in the graphics below for easy reference.







Comments and Response: Sub Councils and Ward Forums

Sub Council 1:
That the contents of the Final Draft Coastal Protection Zone By-Law BE NOTED.

Response:
Noted with thanks

Sub Council 2:
That the proposal of Ald M Nieuwoudt be SUPPORTED, namely that on p 148 of the proposed by law, "belongs to" in par. 4(a) on p 148 be amended to "be accessible to" and then that it also be included that where the Council owns coastline properties, such properties must in future not be sold.

Response:
Noted and amendments will be made accordingly

Sub Council 5:
Ms Amy Davison spoke to the report whereupon Cllr AN Abrahams enquired about Baden Powell Drive and the sand that often accumulates in the road which poses a danger hazard. Ms Davison responded that the matter should be addressed with the Department of Roads and Storm water as the By-Law does not address existing problems such as Baden Powell Drive. The intention of the By-Law is to prevent future problems such as that from occurring, i.e. to make sure that in future no more roads such as Baden Powell Drive are built in areas where they will become constantly inundated with sand which is safety hazard

Response:
Noted

Sub Council 7:
1. That the following comments be forwarded to the relevant department in regard to the City of Cape Town's Coastal Protection Zone Draft By-Law:

• That Sub council 7 requests that the implementation of the City of Cape Town's Coastal Protection Zone By-Law should not prejudice the development of the Coastal Area adjacent Atlantis, specifically the 5 km radius between Silwerstroom Strand and Koeberg.

2. That the City of Cape Town's Coastal Protection Zone Draft By-Law BE NOTED.

Response:
The City's Spatial Development Framework and Coastal Edge line makes provision for a development node in the Silwerstroomstrand area. This fits with the overall approach of

nodal coastal developments as opposed to extensive "strip" development and is represented in the City's Draft Spatial Development Framework.

Sub Council 8:
Cllr Heuvel requested that the problems with wet lands that are being filled up with building rubble and thereby restricting the flow of rivers through wet lands and into the sea, be also addressed in this By-Law.
RESOLVED: That comments on the Final Draft Coastal Protection Zone By-law BE SUBMITTED by not later than 2 March 2011 and that this By-Law be also submitted to the Ward Forums for comments.

Response:
The comment by Cllr Heuvel is noted. Infill of wetlands is a significant environmental concern with multiple impacts on the City and its ecosystems. All wetlands that fall within the area defined as the Coastal Protection Zone will be protected from infill and destruction by the bylaw; however the Coastal Protection Zone bylaw cannot address the management and protection of wetlands across the City. The infilling of wetlands is currently protected by other legislation.

Sub Council 9:
Sub Council 9 requested a workshop with the relevant officials to discuss the bylaw. The points listed below are the key comments that emerged from that workshop.

A strong sense of place exists between the locals and the coastal environment. The coastal environment is valued for its traditional and religious offerings to the people. The community members were grateful for the opportunity to voice their concerns and to be included in the process. Community representatives expressed their need to utilise the coastal environment for religious and recreational purposes. The provision of creating and maintaining access to the coast in order to allow the community to benefit from the resources of the coastal environment was appreciated by community representatives. It is understood that this would occur in the form of nodal development as opposed to strip development in order to maintain a balance between social and ecological equity.

Direct questions to address:
1. What measures will the City of Cape Town put in place to ensure that community access to the coast is retained?
2. When will the City of Cape Town inform the community on their rights to construct dwellings in the assigned development node?
3. What will the process entail to be assigned a piece of land for housing purposes?
4. What measures will the City of Cape Town put in place to ensure that community rights to conduct religious practices on the coast are not withheld?
5. Will the City of Cape Town ensure that there is a provision of basic services available when the community is utilising the beach area (eg. lifeguards, security guards and ablution facilities)?
6. What measures will the City of Cape Town put in place to ensure that the natural environment and biodiversity along the coast are not compromised by development?

Response:
Responses to each of the six points raised are listed below:
1. Community access to the coast is guaranteed by the Integrated Coastal Management Act (ICMA). Further this bylaw if implemented would require that the City demarcate public access points as part of its zoning scheme along the entire coast thereby ensuring coastal access to all people
2. The development of the Coastal Nodal Points is being managed by the Spatial Planning and Urban Design department of the City and extensive public consultation will take place as part of that process prior to any development being approved.
3. See point 2 above. The Planning process has only just been initiated and this will become clear with time.
4. The City is in the process of developing a Municipal Coastal Management Plan (MCMP) in terms of the ICMA, and religious practises and allocation of space for such practises will be included in the MCMP. Prior to finalisation the MCMP will itself undergo a public consultation process.
5. Currently these services are provided at various coastal nodes. However it is noted and agreed that these services need to be extended both geographically and beyond peak season time periods. This too will be a key point addressed in the MCMP.
6. It is the explicit intent of the bylaw to achieve the protection of the coast from over-development.

Sub Council 10:
Cllr Arendse commented that there is no nature conversation signage (e.g. no swimming, no fishing, etc) since the death of two people in Wolfgat Nature Reserve and the response was that, the implementation of signage is an ongoing process; some of the signs are either removed or ignored. Fishing is regulated by the National Department of Agriculture but the City of Cape Town is continuously liaising with fishing fraternity.

Response:
Noted

Sub Council 11:
The Sub council commented as follows:
- **Ensure protect and management of City's Coastal Protection Zone as natural space.**
- **Regulate activities taking place**
- **Manage access**

Response:
Noted

Sub Council 15:
RESOLVED that this by-law:
- **the abovementioned report be NOTED**
- **a return of NO COMMENT be SUBMITTED to the relevant department**

Response:
Noted with thanks

Sub Council 16: RESOLVED that this by-law:

- **be forwarded to ward forums**
- **Fire services be notified that Maiden's Cove is no longer a dedicated fireworks site**

Response:
Noted with thanks. Fire Services will be notified once and if the final bylaw is approved by Council

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Sub Council 17:
Cllr Chapple commented that he welcomed the By-law as Cape Town would not exist was it not for its harbour and surrounding sea area. He referred the meeting to page 44, Chapter 4A and stated that he was glad that beaches were made available for everyone. He stated that he was glad that this policy also prevents developers from closing beach accesses for entry fees. He also referred to meeting to page 45, 11f and stated that at the present time there were only two official fishermen's launch points and that was Betty's Bay and Miller's Point. He said that he was happy that the policy recognised the fact that they needed to look along False Bay as well for a safe and secure launch point for the poorer fishermen. Cllr Chapple raised his concern with regard to the protecting and managing of the Eco System and stated that too often the City of Cape Town implement good policies but fail with inadequate policing of the policies. He was pleased to notice that this policy now prevents building on the coastline.

With regard to the penalties, Cllr Chapple felt that it was too small for the Fynbos and coastal areas as developers would just pay the fine and walk. He stated that it took centuries for Milkwood trees and Fynbos to grow.

Cllr Hill supported Cllr Chapple's comments and wanted to know whether the Sub-council should not submit a recommendation regarding the penalties.

Cllr Chapple was of the opinion that this policy need to refer to the tree clauses penalty in the tree policy.

All the Councillors were in agreement with the comments.

Response:
The penalty regulations in the bylaw have been revised to make them more appropriate as a deterrent and penalty for non-compliance to the bylaw

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Sub Council 18:
Mr Tsotsobe explained that the proposed coastal protection zone by-law highlights the importance of planned developmental management in environmentally sensitive areas along the coastline. This is to preserve the coastline from further unplanned development

as it is in decline through increased levels of coastal erosion, destruction of the dune systems and wind-blown sand problems.

Members enquired whether the by-law would address the sand blown onto Baden Powell Drive and whether the by-law is written with due cognizance being taking of the prerequisites of the Spatial Development Framework.

Mr Tsotsobe advised that the by-law is written to incorporate the Spatial Development Framework and that it is an Integrated Coastal Management approach to protecting a worthy environmentally sensitive amenity.

Members thanked the official for a succinct presentation.

RECOMMENDATION
Rondevlei Subcouncil, supports the final draft City of Cape Town Coastal Protection Zone By-law, having taken due cognizance of the contents.

Response:
Noted with thanks

Sub Council 19:
Councillors requested that the following proposals be incorporated in the Draft By-Law:

Chapter 4: The Coastal Protection Zone
• Amend 4 (a) as follows (amendments in bold):"Ensure that the coastline, and associated opportunities, belongs to the citizens of South Africa and remains accessible to the public.

Chapter 6: Additional Regulations pertaining to the use of the Coastal Protection Zone
• Amend 19 as follows (amendments in bold): "No person may have in their possession or discharge, fireworks of any kind within the CPZ, subject to the permission granted, e.g. Sunrise Circle, Muizenberg.
Councillors also requested that should the issuing of fines be delegated to the Sub council, then a table of offences should be compiled, in order to guide the Sub council. RECOMMENDED ACCORDINGLY.

Response:
The request for the amendment to the statements in Chapter 4 and Chapter 6 are noted and the revised bylaw will reflect the appropriate wording. The request for a table of offences to be prepared in the event that issuing of fines is delegated to Sub Council is noted.

Sub Council 20:
Cllr Iversen referred to page 11 where several references were made to "No person" but the document failed to give a definition of "no person". In particular in Section 22, the word "company" should be included as companies often were the cause of dumping pollutants.

The Chairperson pointed out that in terms of National Environmental Legislation, the person dumping on behalf of a company should not be targeted but the manufacturer/producer of the pollutant should be charged.
Cllr Haskin requested that the word "intentionally" be removed from Sections 13 and 14. There was no way to prove that a deed was done intentionally.
The Chairperson was of the view that "intentional" strengthens the prosecution's case.
It was also pointed out that Section 25(a) should be read in conjunction with Section 27. Attention was drawn to the fact that recovering costs were relatively easy as it affected the rates and the prevention of usage of Council's facilities.
The Chairperson suggested that members send their individual comments to the Sub council Manager.
RESOLVED TO RECOMMEND
1. That Protea Sub council (20) NOTES the Final Draft Coastal Protection Zone By-law.

Response:
Noted, relevant amendments will be made

Council 21:
RESOLVED: That the City of Cape Town Coastal Protection Zone By-Law, BE NOTED.

Response:
Noted with thanks

Council 22:
Cllr Raymond had the following comments and add-ons:

- **Who will enforce this by-law?**
- **Pg 62 - (Amendment to the by-law) To ensure that the effluent and the river systems running into the sea would adhere to the Department of Water Affairs standards.**
- **Pg 62 – Why is the Blouberg Conversation Area excluded**
- **Pg 63/64 – Chapter 6 – There must be an Environmental Control Officer appointed by the City and the developer should pay for that, to oversee the building.**
- **Pg 64 – paragraph 21 – The word Environmentalist is left out.**
- **Pg 64 – paragraph 23- The word "private function" is not defined.**

Mr R Bosman said the enforcement of this by-law will rest on his department and he will consult his colleagues with regards to unclear issues.

Response:
Detailed responses are listed below:

- The bylaw will be enforced by the Strategy and Planning Directorate with the assistance where necessary of the City's Law Enforcement
- Pg 62 – Noted, however this aspect is regulated through National Water Quality legislation

- Pg 62 – the amended bylaw will include all areas under the jurisdiction of the City Of Cape Town
- Pg 63/64, noted and agreed
- Pg 64, paragraph 21, noted and amendments will be made
- Pg 64, paragraph 23 noted for amendments
-

Ward Forum for Ward 84:

- **Reference to the protection of wetland and river mouths should be included in this by-law, as there are at present many cases in the Helderberg where wetlands are being disturbed and filled up with building rubble;**

- **There should be a reference in the by-law to the National Act that prohibits motor cars and motor cycles to be used on beaches.**

Response:
In terms of the first comment, all wetlands and river mouths that fall within the Coastal Protection Area are covered by the provisions and regulations of the bylaw which would not allow any disturbance, alteration or impact of those ecosystems. However the bylaw cannot regulate wetlands beyond the Coastal Protection Zone. This issue should be addressed through a separate process driven either by Catchment Management or Biodiversity Management. With regards the second comment, noted and reference to the Off Road Vehicle Regulations will be made in the Revised Coastal Protection Zone bylaw.

Comments and Response: Public and Stakeholders

Comment:
I see the bylaw says I may not collect shells. Since when do shells belong to anyone, other than the finder and are not allowed to be picked up? I heard at a stage that there was legislation that had come out which said you may not collect, but I have a huge issue with this and would like this to be removed from the bylaw, or if it is there to stop commercial large scale collection, then to be specified as such. I collected shells as a child and would like my children to be able to do this too, without becoming criminals for no good reason. (Ms Simone De Wet)

Response:
Shells and all organic material derived form the ocean are governed by the Marine Living Resources Act. The harvesting of these resources requires a permit from National Government. The bylaw states that no person may collect or harvest these resources in line with national legislation. This is intended to govern collection of coastal and marine resources for commercial or other forms of gain. It is not intended to regulate or restrict ad hoc collection of shells etc by individuals. The Revised Bylaw will clarify and make this explicit and allow for "beach-combing".

Comment:
Clause 4.a) says "Ensure that the coastline, and associated opportunities, belongs *[sic]* to, and remains accessible, to all Capetonians and South Africans". If it is going to be insisted that the coastline is going to *belong* to Capetonians and South Africans, is there not a case to make it unequivocal that the coastline is also *accessible* to foreign visitors?

Therefore should it not be worded something like "Ensure that the coastline, and its associated opportunities, belong to all Capetonians and South Africans, and remains accessible both to them and foreign visitors"? R M LONGDEN-THURGOOD

Response:
Noted and agreed. The bylaw will be revised as such.

Comment:
Clause 4.l) says "Protect the City, and thereby the City's ratepayers, from increased financial burden resulting from the impacts of coastal erosion, predicted future sea level rise and storm surge events on coastal infrastructure and development". Surely this by-law is primarily intended to protect delineated lengths of the coastal zone from uninhibited private development? The City will presumably set out in detail what conditions any approved development must comply with. Is it not up to the private developer to decide if they want to take the risk that erosion and storms might damage their property? So where is the risk to the City, only in so far as a structure may be so badly damaged that someone has to decide who is going to remove it, if the original owner doesn't wish to rebuild. If the City rehabilitates the land it can presumably make a claim to recover its reasonable costs, not forgetting whatever land rights the original owner has or had.

The City can't escape its own risk involvement with any of its own developments, of course, which are subject to natural events. So, in its present format, I don't see what this clause is intended to achieve *for approved projects*. R M LONGDEN-THURGOOD

Response:
The comment ignores the following facts:

a) The City's coastline is an asset in its entirety and therefore has a stake in the condition of the coast. To assume that the City would allow or have no interest (financial or regulatory) in ensuring that the coast does not one day look like a lot of broken down homes is short sighted. Further 4.i speaks to the objectives and intent of the bylaw which is to not approve further development so as to negate this risk increasing from current levels.
b) Secondly, the City, although not legislated, has an interest in protecting properties and its rates base.
c) Finally, good governance requires that the City acts in a manner that not only reduces risk to itself and its ratepayers, but also put regulatory mechanisms in place to ensure that private individual risk is minimised

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Comment:
Clause 7.d), which concerns land excluded from this by-law, says "Koeberg Nuclear Power Station Land". It is known that one of the sites for further nuclear development lies just to the north of the existing Koeberg power station. Therefore should this clause be contemporaneously restrictive? In other words, should it not be worded something like "Koeberg Nuclear Power Station Land and any other *(adjoining?)* coastal land which is approved for further nuclear power station development in the future"? Does the word I have indicated in italics need to be present? R M LONGDEN-THURGOOD

Response:
The City's Draft Spatial Development Framework does "not support proposals to upgrade KNPS generative capacity or the construction of new installations". The Coastal Protection Zone Bylaw is in line with this and provides a regulatory framework to give effect to this position

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Comment:
Clause 30, the 5th dotted clause, says "• The construction and removal of non-permanent structures as approved by the City's Filming and Events Policy". OK, but suppose - if it isn't priced out of existence by the City's excessive demands, as is being claimed in press comments - the local film production company near Somerset West wants to put up some temporary set in a CPZ which, in some cases, could be quite substantial, and require access roads to be made, etc, does the City envisage permitting anything like this to be done, or what? (And, no, I don't have any interests in any film production companies!). But the point is made in the press that a thriving film industry in the Western Cape helps to put Cape Town on the "international map" for foreign visitors. Either the City is concerned about this, or it isn't. There's no two ways: it's either Cape Town or Durban. R M LONGDEN-THURGOOD

Response:
The bylaw does not add any restriction to the film industry in any way. All filming is currently approved and permitted through the City's Events Office and the bylaw explicitly exempts all activities approved by the City's events office. However no permanent structures of any kind would be approved in this manner as that would be beyond the delegation of the Events Office and the building of permanent structure (including roads) is NOT exempt from this bylaw.

Comment:
Clause 32.a) says "to remedy the harm caused". Merely using the word "remedy" risks being misinterpreted. Shouldn't there be a reference to "environmental rehabilitation", which is applied when appropriate? R M LONGDEN-THURGOOD

Response:
Noted with thanks, the bylaw will be revised as such

Comment:
I looked at the CPZ map on your website, and cannot establish the status of Erf 502 Clifton in relation to the coastal protection zone. My wife owns a bungalow on that Erf, and we need clarity on the status of that Erf. Does it fall within or outside the CPZ? If it falls within the CPZ, how do I apply for that to be changed? - Rick Shuttleworth

Response:
Erf 502 does fall within the Coastal Protection Zone. As stated in the bylaw all existing rights as of 01 November 2010 for Erf 502 are ensured and not affected by the bylaw. On review of Erf 502, a decision was made to adjust the Coastal Edge Line to exclude Erf 502 for the CPZ.

Comment:
This letter constitutes a formal objection to the City of Cape Town's Coastal Protection Zone Management By-Law from the businesses that comprise the South African Association of Stills Producers. (SAASP.)

SAASP represents and coordinates the interests of the 30 companies that specialise in the production of photographic commercials and other shoots in Cape Town, employing thousands of Capetonians and utilising the services of small businesses and suppliers across the city. Our contribution to the local economy in the Western Cape is around R500 million per annum, half of which is experienced directly in the tourism sector, on hotel rooms, car hire etc. The vast majority of productions are known as micro-shoots – small teams of 6-8 personnel travelling in two vehicles and using a number of public locations per day. The maintenance of pristine natural locations is of prime importance to our sector since it is a major selling point and attraction for international clients. We would therefore typically be in support of interventions that protect the environment. However, SAASP is forced to oppose the proposed by-law in its entirety, since it threatens to continue the existing prejudicial approach of the Coastal Coordinator to Stills Producers.

According to Point 30, integrated coastal management activities exempt from the proposed by-law include *the construction and removal of non-permanent structures as approved by the City's Filming and Events Policy*. However, we wish it to be noted for the record that the by-law's position here is entirely disingenuous. Photographic permits in this coastal zone are already actively discouraged by the City's Coastal Management department, and the potential for any filming - let alone the construction of non-permanent sets - is virtually impossible in Cape Town already. Environmental Management has instituted unilateral bans and moritoriums on photographic filming in many areas – and these were implemented without any consultation with the sector.

Furthermore, coastal areas that are open to other high-impact groups remain closed to low-impact photographic productions. As an example, riding schools may receive permits to access the dunes of Hout Bay, Noordhooek and Kommetjie, but a stills shoot with four people and only light equipment is unable to access the same dunes under any circumstances. In effect, The Stills Photographic industry in Cape Town is actively discriminated against by the Coastal Management department, and at the whims of its officers, in direct contradiction with the city's existing film policy documents.

Additionally, since December 2007, the Stills Sector has been formally requesting that the City provide clear guidelines for the legal application of Environmental Control Officers required of Stills Shoots (and at our business owners expense) by environmental management authorities. In particular we have sought clarity on the unfairly applied obligations placed on Stills Producers to pay for environmental checks in areas that are heavily frequented by tourists, bike riders and equestrians. This has also been ignored by the relevant authorities.

As mentioned above, the vast majority of SAASP shoots are micro-shoots, which cause significantly less damage than any comparable activity. Under the circumstances, the South African Association of Stills Producers has no option but to object to this by-law, since it clearly provides for the continuation of the existing prejudicial approach of the city against photographic producers as equal users of the Coastal Management Zone.

On behalf of:

*** 2 Productions – Robert McClelland 27 (0)21 438 3508**
*** Amanda Coulson Productions – Amanda Coulson 27 (0) 21 426 2183**
*** Beach House Productions – Mark Williams 27 (0) 21 789 1409**
*** Big Sky Productions – Rowan Raaff 27 (0) 21 423 2144**
*** BLM Productions – Brad Logan 27 (0)31 207 8117**
*** Cape Town Productions – Gavin Levy 27 (0)21 464 4500**
*** CMK1 – Rudi Reagon 27 (0)82 594 9438**
*** Cool Banana – Marc Beresford 27 (0)21 425 7900**
*** Episode Media Productions – Mona Nortier 27 (0)21 423 3687**
*** Euroconnection Production Services – Julie van Damme Lagoe 27 (0)21 422 0970**
*** Evidencia Africa Productions – Olivier Barrault 27 (0)21 789 2960**
*** First Productions – Melanie Bold 27 (0)21 461 5911**
*** France Productions – France Pareti 27 (0)21 419 1000**
*** Gambit Ideas – Scott Curnow-Baker 27 (0)79 6486 137**
*** Gavin Schneider Productions (PTY) Ltd – Gavin Schneider 27 (0)21 421 2200**
*** Frank – Francien van Eck 27 (0)84 702 0205**

*** Kaap Film Stills – Jeroen Vuyk 27 (0)21 461 1937**
*** Magic Mountain Productions – Sabina Jakob 27 (0)21 465 4143**
*** Nomad Productions – Damon MacDonald 27 (21) 461 1300**
*** North South Productions – Eric Gukelberger 27 (0)21 421 9905**
*** Prinz Productions – Sebastian Prinz / Graeme Allen 27 (0)21 461 7877**
*** SA Media Productions – Susan Anderson 27 (0)21 422 2855**
*** Steel Productions – Caryn van Wyk / Nolan Hooper 27 (0)21 430 5788**
*** Townsend Productions – Bruce Morrow 27 (0)21 434 4955**
*** Zoom Productions Nanette Kröker / Franck Bonnetot - 27 (0)21 789 2230**

Response:
The bylaw does not add any restriction to the film industry in any way. All filming is currently approved and permitted through the City's Events Office and in accordance with the Events Policy and the bylaw explicitly exempts all activities approved by the City's events office. However no permanent structures of any kind would be approved in this manner as that would be beyond the delegation of the Events Office and the building of permanent structure is NOT exempt from this bylaw. It is the view of the Environmental Resource Management Department that it is entirely appropriate and in accordance with Best Environmental Practise that commercial activities such as filming that take place within sensitive natural environments requires Environmental Management Plans as well as Environmental Control Officers where appropriate and at the discretion of the Coastal Coordinators.

Comment:
Congratulations on this overdue protection zone. Herewith comments

- **As the by-law, if in conflict with any other by-law or planning zoning, is supreme/overrides them this may be the cause of the exclusion of certain areas from the CPZ. I presume this because of the exclusion of the City-owned Blaauwberg Conservation Area which has separate controls. However it is most important to ensure that the restrictions that apply in such areas as the BCA are as tough or tougher than the CPZ.**
- **If I am wrong about the above point then there is no reason to exclude the BCA and the CPZ should be continuous and drawn along Otto Du Plessis Drive (the coast road) from Big Bay to Melkbos. Mere ownership is not sufficient protection – witness Green Point Common from the time of its grant to the City when it was open, not sub-divided, apart from a small part with a lease on it (I have the Land Registry Maps) to its re-designation and recreational/built present position (itself an improvement on the position 5 years ago).**
- **Finally do, please, reconsider whether it is reasonable, practical or sensible to stop beach-combing. I include in that the excitement that children get from having access to the seashore. No-one carries a map of the High Water Mark and occasional heavy seas will throw detritus and shells and rocks beyond that point into the CPZ. 6/14 – no person may collect shells and rocks without a formal licence. 7/25 The City may remove members of the public from the CPZ in the event of contravening the provisions of this by-law. 8/31 Any person who contravenes the by-law shall be guilty of an offence with, on conviction, a prison sentence or a fine or both and (8/32) a requirement to remedy the harm. Many of us sit in the sand dunes above the HWM,**

away from the wet sand and delight in the small shells or stones that our children find – are they below the age of criminal responsibility and will we be found guilty if they take the shells home? There should be an allowance for this age-old activity of recreational enjoyment. Malcolm C. Judd

Response:
In terms of your first point and second point, this is noted with thanks and the Coastal Protection Zone will be extended to include both the conservation areas of the BCA and False Bay Ecology Park. In terms of your third point, shells and all organic material derived form the ocean are governed by the Marine Living Resources Act. The harvesting of these resources requires a permit from National Government. The bylaw states that no person may collect or harvest these resources in line with national legislation. This is intended to govern collection of coastal and marine resources for commercial or other forms of gain. It is not intended to regulate or restrict "beach-combing" of shells etc by individuals. The Revised Bylaw will clarify and make this explicit.

Comment:
My query regarding the repair of the road at Strandfontein Pavilion (the road on the right side of the pavilion also known by most local users DIE BINNE PAD or Old Strandfontein road)We are frequent users of this road as anglers and holders of valid angling permits, in fact my late dad and family have brought me to this location when I was but still a child and it is obvious that this road is 50 years + old and probably forms part of a historical road and is part of history with our local population that frequent this road and at that time the only road to use by the public as well as tourist and anglers alike. (I was photographed by tourist on numerous occasions in this road) This road has deteriorated to such an extent that now the road has been closed to us, My question to you sir is why have you allowed this to happen and on occasional times patch and repair the road which is of no use and waste of taxpayers money and have deprived all of us to use this road recreationally, if this road had been repaired properly and proper road construction engineering protocol were used this would never have happened. By patching any road at the sea side is a recipe for disaster. Myself as a angler and user of this road I am strongly suggesting that you erect a sign and say use at own risk as at Kalk Bay harbour, this at the very least will give us as anglers and public entry to this very popular angling spot at own risk, and on a technicality, not depriving us of our sport. It seems that us anglers always have to bear the Brandt of the states poor decisions regarding matters of this nature, let alone the high risk of parking our vehicles elsewhere to be Brocken into and stolen, in the same breath we are given a small and narrow gravel road all along Baden Powell drive(from Strandfontein Pavilion to the first tar parking heading to Muizenburg which is also being neglected), even this has not been properly considered e.g. We parked on this road and almost got knocked over kids and all, so close this road is to the main operating road and if one stands just a foot on to the sand with your vehicle for safety the local officials harass, are rude, arrogant and don't even want to look at reason and want to write you and enormous fine for now standing on the beach .One does this to for safety reasons only to protect ones family and ones-self. It is so bad that if you opened the driver door of your vehicle the on coming vehicles can nock into you and possible cause injury and death, This tells me that the city does not take things into proper perspective and do not have the publics interest at heart and only want to listen to us during election times to gain votes and after that it is listen **and** discard **attitude, the city needs to be reminded as tax payers we have empowered the city to act justly in the publics interest as it is our money that paves the**

way for a better South Africa and have empowered you to look in our interest. - Mr N Gasant

Response:
Vehicle access to the beach is governed by the Off Road Vehicle Regulations, as stipulated by national government. The City has no authority to ignore, change or over-ride this Act. Further the City is required to enforce the Act. In terms of the road access, this road was built in a highly dynamic coastal environment and as a result, it has proved impossible to maintain. Access to the area for various recreational activities will be addressed in the development of the Overlay Zones as per (11) of the Bylaw. The City is committed to ensuring appropriate, relevant and adequate access to all its citizens to its coastal asset.

Comment:
I think the by-law is an excellent idea. More and more of "prime" property on the coastline is being sold to foreigners and the elite of SA. The rate at which developments are taking place in the Western Cape is alarming. We cannot allow developers to have all prime areas to build more houses and complexes etc. The coastline is there for all and we should keep it that way. - Tamlyn De Souza

Response:
Noted with thanks

Comment:
I'd like to enquire of residents that owns houses along the coastlines, what rights do they have against us having permits to catch crayfish, to chase us away saying this is private property: does the coast belong to them????????????? Maahir Salie

Response:
Crayfish catching is permitted under the Marine Living Resources Act. Anyone who has a permit may catch crayfish in accordance with that permit. No private landowner has the right or ability to prevent access to the marine or coastal environment or define where crayfish may or may not be caught.

Comment:
The protection of our natural resources has to date neglected out coast. This initiative is commendable and will go a long way in preventing further destruction by planners, developers and others. One only hopes that the body politic has the guts to enforce it. – Gold Home

Response:
Noted with thanks

Comment:
Well done! This is a great move forward! The sooner this by-law is implemented the better, we need to save our coastline before its to late. Keep up the good work! – Thandi Lamprecht

Response:
Noted with thanks

Comment:
Great initiative - thank you! – David Gibbons

Response:
Noted with thanks

Comment:
I support this Coastal Protection Zone By-law and pray that Cape Town will set a precedent for all of South Africa! Mr Watkyns says it perfectly: It is our responsibility as a City to ensure that this asset is managed and protected to serve the best interest of all residents and visitors and for the sake of our future generations. – Sharon Martin

Response:
Noted with thanks

Comment:
The by-law should be extended to cover the entire Western Cape Region. Cape Town is already hopelessly over developed in coastal zones. The Southern Cape needs to be included in this by-law for it's own preservation and protection. As a southern coastal property agent, I am witnessing the slow but eventual destruction of the highly sensitive river banks of the Lower Breede River Estuary as well as the potential destruction of the coastal buffer zone of San Sebastian Bay, Witsand. The Hessequa municipality has approval for a desalination plant to be erected slap bang on our most recently awarded blue flag beach which will open the doors to further coastal development. There is already an over supply of property for sale in coastal areas, we do not need more developments within the coastal and estuary buffer zones. – Joanne Attenborough

Response:
Noted with thanks. The City of Cape Town cannot extend the Bylaw beyond its area of jurisdiction. However the City is very happy to share its information with other local authorities.

Comment:
How if any will this affect the recreation SCUBA divers that use this area?

Response:
This bylaw will have no effect on SCUBA diving activity as that takes place below the high water mark.

Comment:
I think it is great that the City of Cape Town is way ahead as usual!

The only comment I have, and it may not be relevant however there is no mention of owners with pets. If you consider adding anything about pets, please be kind to pet owners. Our pets are members of our family as well and we would love them to be included in many of our activities without too many restrictions like "Pets not allowed". Tessa Chamberlain

Response:
Noted with thanks. With regards to pets in the coastal zone, the City is of the view that appropriate areas must be made available for those of our community that wish to take their pets to the beach as well as appropriate areas where pets are not allowed for those that wish to visit the coast free of other people's animals. These use zones will be defined in the Coastal Overlay Zone as stipulated in the bylaw. These overlay use zones will be available for public comment and input prior to their finalisation.

Comment:
The bylaw is warmly supported. Rowland Dale

Response:
Noted with thanks

Comment:
We strongly support this by-law.
We do wish to request some amendments:

1. We note that City of Cape Town owned land (Zoned POS Erven 22,38,45) which is closer / similar distance from the sea as adjacent private property (that is included in the Coastal protection Zone) and forms a natural extension to the Table Mountain National Park, has not been included in the Coastal Protection Zone map. Attached please see a zoning map showing the POS's marked as "POS : 22, 38 and 45" in green. We believe that it should be as it conforms to the explicit intent of the City's Coastal Protection Zone stated purposes as formulated in the By-law -under Chapter 4 number 4 a-l and Chapter 5 a-d

2. In Chapter 6 number 18 : ***No person may start or maintain a fire within the CPZ unless within a designated braai area within a Coastal Resort area.*** **We believe there is an oversight in that the wording should at the end include :** ***" or on land zoned as Private Coastal Land."*** **Otherwise the owner of private land/house within the CPZ wouldn't be able to braai !**

General comment:
We would like to know what enforcement procedures there will be and who would be responsible for this function. Would there be any benefit in appointing honorary or even permanent rangers to help oversee compliance?

Rory Sales - Chairman Noordhoek Conservancy
Response:

Noted with thanks. With regards your specific comments:
1. Agreed and noted with thanks. The Coastal Edge line has been adjusted to incorporate the three erven within the Coastal Protection Zone.

2. Agreed, the revised bylaw will be adjusted to reflect the appropriate wording.

General: The planning components of the bylaw will be enforced, monitored and regulated by the City's Coastal Coordinators and the regulatory components by the City's Law Enforcement. General coastal law enforcement and regulation remains a challenge and it is a priority issue that the Coastal Coordinators are aware of and will address the development of the City's Municipal Coastal Management Plan (MCMP) as per the ICM Act. In terms of that your suggestion of honorary rangers, this will be tabled for consideration as part of the drafting of the MCMP.

Comment:
The Directorate: Housing objects to the alignment of the proposed coastal zone protection boundary around Pelican Heights.

Housing is the custodian of Erf 829, which has been the subject of protracted EIA over the past 5years. At this stage, a biodiversity specialist has advised that limited areas immediately adjacent to the existing settlement have such limited value with respect to biodiversity and ecological systems that the areas may be developed for housing.
We refer you to fig 3 on page 17 of the attached report, which shows the extent on the extension permissible with respect to biodiversity.

We request that the CZP boundary be re- aligned to respect the boundary described above. Peter Oscroft : Head Special Housing Projects, Housing Directorate

Response:
Noted. The Coastal Edge line has been adjusted to accommodate the boundary required by Housing.

Comment:
I totally support the protection zone bylaw. William Hilliker

Response:
Noted with thanks

Comment:
A brilliant proposal, our coast line is already over developed and we run the risk of ruining the very thing that makes the area so desirable in the first place. I do have one question: what happens to existing developments that fall within the new zones, particularly council maintained structures such as Jaegers walk in Fish Hoek. When these places need repairing will this be done or will the opportunity be taken to remove them?

Response:

Noted with thanks. Existing infrastructure within the new zones will be evaluated on a case by case basis when repairs are needed. Inappropriate, problematic or infrastructure that continues to be at risk due to its location in the coastal zone will be removed and/or relocated based on that evaluation.

Comment:

As a stills photographer, I've just read about these proposed by-laws on the SAASP website (URL: http://www.saasp.co.za/coastal-protection-zone-by-law-for-public-comment/#more-604). It is of concern, as we bring a number of international clients to South Africa to shoot their summer catalogues. These are indeed micro-shoots and locations such as Kommetjie, Baden Powell, Bloubergstrand make great beach locations. We're already dealing with an excuse of a permit office that lumps us with all the heavy traffic, noise, multiple vehicle FILM shoots. We literally move with less than half a dozen people, and dont block pathways, beaches, etc. I just shot at Bloubergstrand and had to pay over R150 an hour for an ECO. Totally understandable, but each time we've hired one they laugh that they are not needed for our kind of shoot. Infact this ongoing expense has just caused a local fashion designer client to move his shoot to Durban, a city welcoming this kind of activity. I'm considering taking a small Canadian shoot we're doing later in March to Durban as their policies are a lot more real world, and actually distinguish between STILLS and film shoots. Take the SAASP example of horse riders - they do more damage in 100m that we'd do in probably a decade of shooting. I hope that at some point you do not chase away the small stills photography industry from our coastline. We respect and need it for local shoots, and those international ones we bring out. It really seems that sometimes the reality is quite far from what is proposed in these by-laws. Simon Deiner

Response:

The bylaw does not add any restriction to the film industry in any way. All filming is currently approved and permitted through the City's Events Office and in accordance with the Events Policy and the bylaw explicitly exempts all activities approved by the City's events office. However no permanent structures of any kind would be approved in this manner as that would be beyond the delegation of the Events Office and the building of permanent structure is NOT exempt from this bylaw. It is the view of the Environmental Resource Management Department that it is entirely appropriate and in accordance with Best Environmental Practise that commercial activities such as filming that take place within sensitive natural environments requires Environmental Management Plans as well as Environmental Control Officers where appropriate and at the discretion of the Coastal Coordinators.

Comment:

I am pleased to inform you that I fully support this by-law. I am a born Capetonian and going to the beach has been part of my growing up and would like that for my children and their children as well. I do however feel that this is a by-law, when implemented, should be protected and enforced on people from all walks of life. I think it is not fair to the people of Cape Town, to implement a law, and thereafter they have to learn that the land has been sold to some foreign investor during the time when the by-law was still in process. Keep on preserving our natural resources so that everyone, local and foreigners could keep on enjoying it.

Response:
Noted with thanks. The bylaw will be enforced across all sectors of society and will apply to all income groups, nationals and internationals.

Comment:
Our Association is supportive of this new by-law as we feel that the coastal zone is very vulnerable and need of protection for many reasons including the predicted sea-level rise. However, with respect to the following point in the draft by-law:
Chapter 5: Development Regulations in the Coastal Protection Zone
8. Existing lawful land use rights and lawfully approved departures from land use restrictions which are currently in force, prior to 01 November 2010, in respect of properties situated in the Coastal Protection Zone, shall be unaffected by the provisions of this by-law. We would like to make a comment.

We are concerned that the by-law will not affect existing land-use rights prior to 1 Nov 2010 and that there may be instances where it is necessary to be able to do so. We therefore draw your attention the following comment that our Association submitted to the City when commenting on the draft new Cape Town Zoning Scheme in April 2008:

LIMITED USE ZONES: These are of great concern as many are in environmentally-sensitive areas and are currently zoned 'Amenities' and, it seems, cannot be used as such but have to be rezoned to an appropriate usage before they can be developed. It appears that when they were originally zoned 'amenities' this was done because they were difficult to categorize because of the uncertainty as to what they were in fact suitable for in terms of usage and development. It was basically decided to defer the decision to when the owner wanted to rezone the erf and then decide if the usage being applied for would be appropriate.

An area which falls into this category is the Hout Bay Beach Dunefield. It is zoned 'amenities' and is now being threatened with extremely inappropriate hard development. The community has asked the Council to require a profession study of the area making sure to involving public participation. We strongly believe that this issue must be dealt with here and not ignored particularly with the new Coastal Zone legislation being aimed at protecting coastlines.

In this respect, we wish to point out a section in the existing scheme that deals with unsuitable usage. It is contained in **The Divisional Council of the Cape, TOWN PLANNING REGULATIONS, Vide, Township Ordinance No. 33 of 1934, revised December 1973, in PART II – USE ZONES, SECTION 18 (Page 27)** ***and reads as follows:***

LAND TO BE SUITABLE FOR PROPOSED USE

Notwithstanding conformity with the zoning requirements of the scheme, no building shall be erected or placed and no use shall be established on any land which is not suitable for the use proposed; and for the purpose for determining whether any land is suitable for any particular use, regard shall be had to the best use of the land and its economic servicing and development or redevelopment, to geological conditions, to liability to flooding, erosion or land slip, to stability of foundations, and to access, safety, health and amenities.

This regulation must be retained and inserted into the proposed new scheme as it will help deal with areas of such uncertain zoning (like Amenities/Limited). It neither gives nor takes away rights but it safeguards sensitive land from inappropriate development or use and is therefore a potentially powerful tool for the Council to use in the interests of the environment and the community. It must be retained and inserted in the proposed new scheme.

The development rules for Limited Use are vague and non committal – this area needs further work and consultation.

We suggest that the principle that land must be suitable for the proposed use irrespective of what the historic zoning is should somehow be entrenched in both this By-law and the new Zoning Scheme. We trust that you will be able to do this.

Should there be further discussion on this subject, we request that our Association be included and given due notice. Len Swimmer, Chairperson Residents Association of Hout Bay

Response:
Noted with thanks. The revised bylaw will include the need for land to be suitable for the proposed use.

Comment:
An extensive comment was submitted by Duncan Bates Professional Land Surveyor on behalf of Mr Peter Lancelot Liddell regarding Erven 149366 and 149367 in Kalk Bay. Both erven are currently zoned undetermined and Mr Liddell has applied for consolidation of the erven and for Single Residential Zoning with Building Line Departures. The comment is extensive and the full comment is attached to this report as Annexure A.

In summary comment argues that the property should be excluded from the Coastal Protection Zone and the provisions of the bylaw for the following reasons:

- **Existing properties to the north east of the erven have single residential rights and as such this property should be given the same rights**
- **The property, from the perspective of Mr Duncan Bates is not at risk to sea level rise**
- **The property has no coastal value from a coastal biodiversity, sense of place or public perspective**
- **Metrorail will be responsible for protecting and maintaining the revetment that protects the railway line and by default will therefore ensure the protection of Mr Liddell's property**
- **No coastal erosion is evident**
- **If approved the dwelling constructed would have a lifespan of 20 to 100 years as Mr Bates notes that sea level will only rise by 1m in that time period.**

Response:
The explicit intent of the Coastal Protection Zone is to prevent further development of hard infrastructure along the City's coastline for the reasons as defined within the bylaw. Specific responses to the comment are listed below:

- The properties in question are zoned undetermined and were purchased by Mr Liddell with the knowledge of that zoning. The rights attached to the properties north east of the erven have no bearing on the rights allocation to the erven in question.
- Mr Bates quotes a 1m sea level rise over the next 100 years. Current global scientific models indicate a mean sea level rise of 1,2m to 8m within the next 100 years with the majority of scientists agreeing that the extent will be closer to the 1,2m level. However, recent studies have concluded that the Greenland Ice Sheet will now with certainty melt completely adding 6m- 8m mean sea level rise. What is not known however is the rate of the ice sheet melt and the timeframe for that melt. As such to assume that a mean sea level rise of 1m is assured for the next 100 years has no validity.
- Mr Bates ignores the fundamental issue of predicted increased storm intensity and frequency taking place (key risk to infrastructure) and the compounding of this effect superimposed on an increasing mean sea level.
- Mr Bates assumes that Metrorail will maintain and protect the railway line in the long term (100 years) and thereby the property in question. There is not commitment from Metrorail in this regard and Metrorail may be required to evaluate the feasibility of the railway as time progresses. This is an assumed position by Mr Bates with no supporting qualification.
- In his comment Mr Bates ignores that the intention of the Coastal Protection Zone is multifaceted and includes explicitly the concepts of the need to protect the natural scenic qualities of the coastline and in particular the landscapes and vistas. This property in particular if developed would impact significantly on the landscape and vistas across Fish Hoek Bay from the perspective of motorists and pedestrians using Main Road.
- The proposed development will create a substantial visual intrusion that cannot be mitigated in any way.
- The statements in the submission that "...there are no features worthy of environmental protection..." and "...has no value to the public..." and that including this property in the CPZ is "irrational" and is being done because "...it looks like a good idea..." have absolutely no substance and demonstrate a clear lack of understanding of the purposes of the CPZ.
- Contrary to the arguments in the submission, the site in its un-built state optimises the landscape value of the Bay.

In summary, the Coastal Edge line and Coastal Protection Zone is appropriately and correctly located in this area of the City's coast.

Comment:
An extensive comment was submitted by Laas and Scholtz Attorneys on behalf of Mrs Ronelle Shuttleworth, the owner of a property registered as Erf 502 Clifton. The comment notes the general support for the concept of the Coastal Protection Zone (CPZ) but the incorporation of Erf 502 into the CPZ is questioned and suggests that there are implications for the property as a result of its inclusion. The comment is extensive and the full comment is attached as Annexure A. The summary of the concerns raised in the comment are:

- **The ground level of Erf 502 is more than 11m above sea level**
- **There is a public walkway between Erf 502 and the rocks**
- **There is no sand or beach on the Erf**
- **There are no dynamic coastal processes taking place**

Response:
Upon detailed consideration of the property in question, its location and existing rights it is agreed that including the property in the Coastal Protection Zone has no value for the intent of the CPZ and as such the coastal edge line has been adjusted here to exclude Erf 502 from the CPZ.

Comment:
The Macassar Environmental Association submitted the following comment:

1.The COAST MUST BE PROTECTED BY THE PEOPLE LIVING WITHIN THE COMMUNITY WITHIN WHICH THAT STRECH OF COAST -LINE IS FOUND AND the law enforcement authorities consult at all times with those community structures on all issues regarding coastal protection, viz. Environmental, Nature Conservation and coastal forums and interest groups.

2. This wasn't done in the formulating of this bylaws and is an injustice to the people whom government must serve.

3. The coastal protection zone should not be limited to 500m from the sea but include the Dunes and nature, river, estuaries such in Macassar and other such-like communities. This 500m stipulation, gives Government a loop-hole to allow all kinds of dangerous developments which negatively impact the coast and dunes, nature(Macassar Dunes and ELSEWHERE),and this would be only and mainly for the rich and lower-income peoples who would not be having a good idea about coastal matters & marine life, etc.

4. Housing developments should for all purposes and intent be as far removed from beach and coastal areas.

5. More intense discussion and public meetings be held before putting pressure on communities for comment on CPZ bylaws so in order to engage fairly with all real stake-holders such as in the case of Macassar, False bay, Gordan's Bay.

Thereby we as organization for ask for a more fair process of community participation as an alternate to the process you are following presently and allowing for more time to study these laws.

The laws are extensive and it will be a good thing if you can come into our or the communities to debate and discuss these laws with the citizens instead of following a rushed process.

Macassar Environmental Association: Chairperson. CW HENDRICKS

Response:
The following are responses to each of the points raised:

1) It is agreed that community engagement in coastal management and the long term protection of our coastal asset is essential. The central component of the bylaw is that the CPZ will be protected and managed as a common asset that belongs to all the people and visitors of Cape Town. Increased community engagement in this regard will be

facilitated through the implementation of the yet to be developed Municipal Coastal Management Plan (MCMP) as described in the Integrated Coastal Management Act.

2) The bylaw was formulated through a long engagement process within Council, under the guidance of the Planning and Environment Portfolio Committee and through an external legal review. Once a draft bylaw was approved, the bylaw was submitted for public engagement as per the Council policy on public and stakeholder consultation as required by the Office of the Speakers Committee (OSCOM). Further, the Coastal Edge line which defines the landward boundary of the CPZ was presented to the public through extensive consultation as part of the City's Draft Spatial Development Framework (SDF).
3) The CPZ is not limited to 500m, but has been defined by a host of informants which include dune systems, coastal dynamics, coastal processes, biodiversity, landscapes, public access points, sea level rise modelling and cadastral boundaries.
4) Agreed and it is the explicit intention of the bylaw to achieve exactly that.
5) The public consultation process was extensive and complied in detail with the Council policy and public and stakeholder engagement.
6) It is the view of the City officials that the processes has been fair, open, transparent and adequate and has allowed ample opportunity for public input and comment on the proposed bylaw.

Comment:
The following comments were submitted by attorneys BISSET BOEHMKE McBLAIN on behalf of CapeCoast landowners:

Our clients' properties would fall within the meaning of Private Coastal Land as referred to in the draft by-law. At this stage we wish to submit the following legal and constitutional comments on the proposed by-law :

1. The references in sections 8, 9, 9.1 and 11(g) to the date 1 November 2010 clearly offend against the rule on retrospectivity of subordinate legislation; are ultra vires, and, in any event, have no demonstrative rational connection to the objects of the by-law. Clearly any by-law can only take effect as from the date on which it is passed and promulgated, or a later or future date stipulated in the enactment.
2. Section 9.1 effectively, and for all practical purposes, restricts private coastal land to only use for public purposes which is the very essence of expropriation, without compensation in this instance. While the preamble to the by-law refers to the constitutional provisions regarding arbitrary deprivation of property; that is precisely what the draft by-law proceeds to do as the restrictions imposed on private coastal property are so far reaching and so absolute as to amount to nothing less than expropriation.
3. Section 9.1 fails to make it clear what changes to land use rights are over-ridden by the provisions of the draft by-law.If such is intended to refer to consents or approval etc granted by the City of Cape Town the ex post facto withdrawal thereof is arbitrary and unenforceable.If such is intended to refer to consents or approvals granted by another sphere of government it is patently ultra vires for the by-law to purport to confer upon the Municipality the capacity to override or render nugatory consents or approvals granted at Provincial or National level under other legislation.
4. Section 9.1 is vague and uncertain in the reference to the "aims and objectives" of this by-law which phrase is nowhere defined; there being only section 4 which refers to the "purpose of the coastal protection zone".

We respectfully submit that the basic premises upon which the proposed by-law has been drafted in relation to the above aspects does require to be reconsidered in the light of the arbitrary and absolute terms in which it is at present drafted; otherwise we can well see legal and constitutional challenges arising from various quarters.

Response:
Specific responses to each of the points raised are listed below:

1. Noted and agreed, the bylaw has been amended accordingly.
2. Your interpretation of section 9.1 is incorrect. All private land and existing rights are protected. By not approving or supporting landuse changes, the City is not expropriating the land. All land was purchased by property owners with existing zonings and rights and during purchase not guarantee existed as to the future use of said land. The bylaw has been amended to allow for an application for exemption from the regulations of the bylaw under explicit conditions.
3. Section 9.1 is clear that the City will not grant any new land use rights within the coastal protection zone, whether they be by way of rezoning, subdivision, consent use, reinstatement of lapsed rights or extension of the validity period of rights. The revised bylaw makes provision for application for exemption where certain conditions have been met.
4. Comment noted, Chapter 4 has been changed to refer to "aims and objectives"

Comment:
Further to our conversation of this morning, I have spoken to Johan Claassen of TNPA and we have agreed on your suggestion of a two pronged approach. He will provide comments/objections via the online web site whilst I will raise some of the issues in this email directly with yourself. In my previous emails I sent you a copy of the plan that was prepared in our office where we superimposed our cadastral and jurisdiction areas together with the proposed coastal protection zone (CWN0393m.pdf)
On this plan the areas affected are shown highlighted in a pink colour. The main areas affected are the Greenpoint lighthouse and the area of coastline form Paarden Island all the way North to the Port Jurisdiction line at Table View, with a spur going inland at Boundary road. The areas shown are owned by Transnet and should not have been included

The plan icmadata2.dwg has also been provided to enable your GIS department to plot the data onto your systems and confirm the correctness of our data.

In terms of our previous conversations and the proposed by-law (Chapter 4. Section 7.b) it would seem that the intention is not to include any TNPA property into the definition of the Coastal Protection Zone. Further to this, the statement was made that the only areas to be included were those that the City had jurisdiction over.

It is also stated in Chapter 4. Section 6 that the coastal edge line is a cadastral line, however we find in a number of places that this concept has not been followed and that the line has cut across cadastral erven in a number of places.

In Section 5 – "The Geographic area including all natural features, properties and premise between the High Water Mark and the coastal edge line."

This causes a potential problem in that the line runs around the outside of the port, but along the Quays and walls the HWM is coincident with our boundary, hence their CPZ is effectively a line of zero width, however if we were to plan any developments etc on the seaward side of our boundary we would essentially be crossing into this their CPZ, and seeing as the area would not be registered in Transnet's name yet it would theoretically be under the control of this by-law.

Thus from a Transnet perspective we object to the current placement of the CPZ and we believe that the boundary should be following the Port Jurisdiction line as shown on the proclamation diagram 6220/2008 (Copy attached). Terry Stiles, Transnet Property: Geo-Spatial Manager Western Region

Response:
Noted and agreed. The Coastal Edge Line has been altered to no longer intersect, crossover or interfere with the Port Jurisdiction Area while the phrasing in the bylaw refers only to those areas under the jurisdiction of the City of Cape Town.

Comment: I commend the City of Cape Town for going to this effort to protect our coastlines for the benefit of all present and future South Africans! It would be terrible loss to the country for them to be forever ruined in the pursuit of short-term profits. Graham Poulter

Response:
Noted with thanks

Comment:
I support the protection of our beaches. Roger Griffiths

Response:
Noted with thanks

Comment:
I fully support the adoption and implementation of the proposed Coastal Protection Zone By-law. Shaun Overmeyer

Response:
Noted with thanks

Comment:
Protection of the Coastal Zone, makes complete sense. Coastal damage proceeds unchecked and the damage is irreparable! David Reece

Response:
Noted with thanks

Comment: This by law serves as an example to other municipalities and will benefit the citizens of Cape Town in ensuring access to the coast as well as enabling development of the coast to be controlled. David Whitelaw – Cape Bird Club

Response:
Noted with thanks

Comment:
I am in favour of the bylaw. Riyaad Harris

Response:
Noted with thanks

Comment:
I am in favour of the bylaw. Isabella Hayden

Response:
Noted with thanks

Comment:
Is the mushrooming of the settlements, that is bordering the Strandfontein coastline being monitored. Eg. 7de laan in beach road is like a permanent campsite for the people residing there. From where did they come. And it seems that the settlements is just increasing and becoming a good ground for drug peddling and crime all along Spine Road. Nadia Rakiep

Response:
Noted, the bylaw will prevent inappropriate development and settlement along the City's coastline.

Comment:
I agree with everything in the by-law and feel it should be passed. We need to protect our coastline so that we can ALL enjoy the benefits of living in Cape Town, and a big part of that is being able to go to some of the most beautiful beaches in the world. The wildlife needs to be protected and the beaches and surrounding areas need to be kept clean and be patrolled. Terry Smith

Response:
Noted with thanks

Comment:
I am in favour of the bylaw. Louise Badenhorst

Response:
Noted with thanks

Comment:
The Transnet National Ports Authority land and the water area under the jurisdiction of Transnet Ltd should be excluded from the new draft coastal protection zone by-law. The draft By-law must be amended to exempt all Transnet land including the water space under Transnet jurisdiction from the draft by-law. Transnet National Ports Authority, Port of Cape Town

Response:
Noted and changes have been made to the Coastal Edge Line to reflect Transnet National Ports Authority, Port of Cape Town comments

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Comment:
The following comments were received from the organisation Seafronts For All (Janey Ball For Bennie Rabinowitz):

The recent notice calling for comment on the above by-law refers. As background to our comment...Seafront for All was established to protect and preserve the Public Open Space on the Atlantic seaboard from Bantry Bay to Granger Bay in Mouille Point. We have a related interest in the coastline that abuts the POS in this area. Although the impact of Climate Change upon our coastline is of great concern, for purposes of this comment, our concern relates in particular to the activities within the Coastal Protection Zone (CPZ) which the Draft By-Law seeks to regulate and, in particular to Chapter 4, Section 4a, viz, that "... the coastline ...remains accessible, to all...".

1. The suburbs Clifton through Bantry Bay amply illustrate the absence of such accessibility and the recent threat to the Atlantic seaboard POS provides a current reminder.
2. We see that there is provision in Chapter 5 Point 10 for a coastal overlay for the CPZ but have concerns in this regard –

a) Having been party to the scenic drive discussions, now in their tenth year of discussion and still unresolved, a timeline must be assigned to the approval of this overlay.
b) The City, despite numerous consultants and ample time, still failed to include the scenic drive overlay in the IZS now before Province. What assurance is there that the Coastal Protection Zone overlay will not face the same fate with the consequent threat to enforceability?
c) It has been our recent unfortunate and expensive experience to learn that, regulatory and legal frameworks notwithstanding, an absence of officials can render the most thorough regulatory process ineffectual.
d) And lastly, the City advised, in the context of the scenic drive overlay, that it does not have the time and resources to develop the scenic routes plan and that it will have to be introduced 'in due course'.If the City's Environmental Department is in the same position, how and when is it proposed to address effective implementation and enforcement?
3. Please can you amplify, in regard to the effect upon traders (informal or otherwise) of Point 30, bullet 1, namely the exemption from the Draft By-Law of "...the implementation or action of any City approved policy, guideline, operational procedure or protocol".
4. Please can you advise how the comments on the By-Law will be publicised and when we can expect responses.
5. Also, What is the intended timeline until implementation of the By-Law?
Response:

A response to each of the queries is listed below:
1. Agreed and it is the explicit intention of the bylaw to ensure that we do not replicate issues of perceived access where in truth development has inadvertently restricted public access.
2a) The urgency of the CPZ overlay is supported as well as the much needed inclusion of scenic drives within that overlay. The CPZ overlay zones will be available for public comment during 2011.
2b) If the bylaw is approved the City is liable in terms of its own legislation if the CPZ overlay zones are not completed and implemented. Secondly, the City is required to develop a Municipal Coastal Management Plan (MCMP) in terms of the Act and as such we are confident that due to these two processes the overlay zones will be completed and implemented.
2c) Your concerns are noted. In this case, the City has appointed two Coastal Coordinators whose explicit role is to ensure that the bylaw is developed, implemented and adhered to as well as ensuring that the City complies with the National Coastal Management Act.
2d) The regulations and enforcement of the bylaw will take effect once promulgated and will be further enhanced by the City's MCMP. In additions see point 2c above.
3) Existing permitting processes by the City will remain in place and where permits are issued for various activities those are not constrained by the bylaw.
4) This Comments-Response Report will be made public and sent to all those that commented once it has been submitted to the City Planning and Environment Portfolio Committee
5) It is the intention to submit the final bylaw for approval by the City in April 2011. If approved, the bylaw will come into effect by the middle of 2011.

Comment: An extensive comment was submitted by the Woodbridge Island Corporate Body by Chairperson Mr R Rundle.

We thank you for the opportunity afforded us to comment on the City of Cape Town Draft Coastal Protection Zone Management By-Law of September 2010, and we respectfully submit our concerns for your kind consideration, as follows:

1. Annexure 1 illustrates our primary concern. We would like to bring to your attention that the dunes as well as the lagoon/estuary inlets along the boundary of Woodbridge Island are within the property line of the Woodbridge Island Body Corporate, falling under their care and preservation.

2. The time allowed for comments was not adequate for part-time enthusiasts to study the proposal in depth or in detail, but in general we wish to register our support and delight for the intention of this bylaw.

3. And so, if I may, our second concern is the inadequacy of this bylaw. We are made to understand that the purpose of this bylaw is to "*make bylaws to provide for the implementation, administration and enforcement of the Coastal Management Program as provided for under the National Integrated Coastal Management Act 24 of 2008 (the ICM Act)*". It stands to reason therefore that any penalties arising out of non-compliance with this Act will be those contained therein, and therefore a schedule of penalties (imprisonment not exceeding a year or/and a fine – the extent of which has not been specified) in this bylaw would seem to be superfluous.

4. A further concern to us is that the tone of this bylaw appears very much to reflect prevailing and, possibly, preconceived perceptions without careful reference to the records, or to science that has been properly peer-reviewed. For example, the quoted

assertion that "strip" development has "extensively altered and affected" the coastline. In our very extensive research we can find no evidence that would support such a claim. On the other hand, we have extensive scientific evidence (also a Transnet report) showing that heedless expansion by Transnet of its port structures into the sea is directly responsible for most of the erosion of the coastline surrounding Table Bay. We have in our possession scientific reports also documenting coastal damage due to port operations and structures elsewhere along the coast of South Africa.

Nevertheless, we would be delighted to see close control and oversight of all the so-called "developments" in our Cape Town, as it was for Woodbridge Island back in 1983. We would be even more pleased if it was common knowledge that Cape Town City is itself committed to policing its own activities and functions that may harm our coastal environment.

5. Our reading of the ICM Act shows that it is not only the citizens of Cape Town that are liable and responsible for the general well-being of our coast, but also the City of Cape Town and its servants. The record shows that the pollution and soiling of our coastline is primarily attributable to failures on the part of the City. Further serious concern to us is the coastal pollution facilitated by the Port of Cape Town. Their lack of vigilance in respect of the dumping of bilge water leading to the infestation of the Australian tubeworm (*Ficopomatus enigmaticus*) in the Diep River Estuary, Milnerton, their lack of careful control of shipping movements within the Table Bay Anchorage area leading to sulphur dioxide and noxious nitrogen oxide (NOx) pollution, and their lack of concern for the Table Bay shoreline during winter months when they permit decrepit vessels to anchor within one nautical mile of the coast, despite their own statement on their website under "Anchorage" "*During the winter months, April to September, north and north-west winds are frequent and as there is no safe anchorage in the bay, it should only be used by vessels prepared to proceed to sea at short notice on the approach of bad weather*",

6. The ICM Act section 29 we read as allowing the City of Cape Town authority only over the function of "coastal access", and "coastal protection" only insofar as this access by the public would cause harm by their use of the coastal facilities. Mitigation for climate change, as far as we can see, is not included under the duties or the authority of the City of Cape Town. In September of 2006 Woodbridge Island faced seas that peaked at more than 14 meters. We survived that quite well. Do we need to worry about global warming? We now know that the United Nations' Intergovernmental Panel on Climate Change and its leading scientist, Dr R.K Pachauri, have been discredited for the fabricated data upon which they based their predictions of a global meltdown. For example their prediction of thermal catastrophe in Antarctica was based on temperature readings since 1979 from the few weather stations that were reporting temperatures since that time. The missing data was extrapolated by computer model that has not been made available for peer review. In fact the 2009 Antarctic sea-ice cover was 30 per cent above average. Also the "melting glaciers" in the Himalayas was found to be based on a magazine story, and the global warming "recorded" in Siberia is based on the rings of a single larch that the Climatic Research Unit in Cambridge chose specifically to fit their other data, purposefully dismissing contrary evidence in surrounding trees. We know from scientific reports that sea rise rates currently are at just 3mm per year. This is a figure accepted by international Insurers who insure for coastal damage. For them the so-called tipping point (at which the Insurers withdraw) is a 50cm sea rise. At that rate, (if the current rate of sea rise is sustained) we will reach it in about 170 years from now, by which time no doubt we will have solved this dilemma.

7. Chapter 4 of the proposed bylaw we presume to be simply the stated purpose of the bylaw, without it having the effect of requiring any budgetary allocation for any of the

purposes so listed. In any event, there are already laws in place dealing with these matters and so for the City to duplicate those would surely be of no effect. Also, the list does not refer to any measurable yardsticks; only to subjective values that if they become substantive in this bylaw, we fear may become the unchallengeable domain of a prescriptive martinet.

8. Chapter 5, section 9 of the proposed bylaw we read as being outside the terms of reference of the ICM Act (section 29) for a municipality, otherwise, if it is intended to be an extension of the functions ascribable to the municipality by the ICM Act, then surely section 9 may be seen as being tantamount to a suspension of section 33 of the Constitution for a period approaching a year or more while this bylaw is being finalised.

9. Chapter 6 appears to list a number of sections that are already on the books in law. Other sections under this chapter that would seemingly be difficult to enforce, for example section 14: In Kynance Cove in Cornwall in the UK, the 175,000 visitors each year have removed 500 square metres of vegetation and 150,000 kilograms of soil just in walking between the car park and the beach; while the activities of the "collector" whether for bait, food, souvenirs or educational study are even more marked. And section 21 may be taken to mean that kite surfers are "diminishing the social and recreational value" for ordinary board surfers, or that a boisterous game is categorised similarly by others simply wishing to sunbathe. Section 22 is a puzzle for us since it is primarily the City of Cape Town and has been responsible over the past number of years for sewage leaks and pollution into the sea and for pollution emanating from its stormwater drains. And if section 23 is taken seriously we could frighten our tourists away and a bride will never again become betrothed to her bridegroom on the beach in Blaauwberg without an appropriate certificate from the City of Cape Town, a proviso that will necessitate increasing layers of bureaucracy and paperwork for the long-suffering citizens of Cape Town.

10. Chapter 7 seems to contain a list of what the council may do to "prevent", "take down", "remove" et al, but the regrettably there is no mention of the City applying its resources in aid of its citizens who legitimately have a cause for concern for our coastal environment.

11. Martin Pollack's introduction also refers to "*the explicit intent of the City's Coastal Protection Zone*". We absolutely support the laudable points that follow this statement. However, as we have already noted, we would be pleased to see the City and its servants actively participating as well. If an experimental process does not work then we would want to see a return and a rejigging process until it actually works. There is more than enough science available, as well as experience from other parts of the world, that will allow us to find an appropriate solution to any environmental challenge.

The Tabletalk on 09 February 2011 reporting on "*Legislation to protect coast from destruction*" in the inside page published this letter from a reader:

Beachfront in shocking state

Last Sunday my husband and I decided to take a walk along the Blouberg beachfront from Dolphin beach to Small Bay

We were totally shocked at the state of the beachfront. Yes, we have had strong winds over the past month, but the sand has just built up out of control, blocking the so-called walkway and forcing one to walk among the parking areas which is not safe as cars come speeding along.

Also at least six areas had broken walls and there is a sheer drop down to the beach and all the litter has gathered there. Not only is this unsafe for children and the likes, but it is unsightly and unhygienic.

The environmental experiment is an absolute eyesore and obviously is not respected by the public hence the state of it.

I really do not know what visitors' impressions were over the festive season, but as a ratepayer I feel something should be done to improve this situation.

Come on municipality, let's see the beachfront return to the beautiful pristine place it used to be.

Response:
Responses to each relevant comment are listed below:

1. The Coastal Edge line is not defined by property lines and crosses properties where appropriate. Existing rights that Woodbridge Island have are not affected by the bylaw.
2. Support for the intention of the bylaw is noted with thanks. The public and stakeholder consultation on the bylaw took place as determined by Council Policy on public engagement.
3. This is a City of Cape Town bylaw that primarily seeks to "make and administer by-laws for the effective administration of the matters which it has the right to administer, and to exercise any power concerning a matter reasonably necessary for, or incidental to, the effective performance of its functions". As such the penalties and regulation of the bylaw is directly linked to the management of aspects of the coast that fall within the administration and jurisdiction of the City of Cape Town.
4. Strip development without question has had a negative impact on the coastline of South Africa as a whole and specifically in Cape Town. Examples include Table View and Strand beach fronts where the coastal systems no longer exist as functioning systems, Neptunes Isle area South of the Diep River mouth, Melkbos Strand and many others. The development of the bylaw was based on sound coastal and scientific information that includes biodiversity, sea level risk and flood risk, coastal access, landscapes, coastal processes and erosion risk.
5. The bylaw holds all City of Cape Town officials accountable to the regulations of the bylaw. However the City has no jurisdiction over the governance of the Port or related shipping activity and as such the bylaw cannot attempt to regulate such activities.
6. Climate change adaptation and mitigation is the responsibility of all spheres of government as it relates to their duties, functions and responsibilities. Current accepted global figures for mean sea level rise are in the range of 0.76cm to 1.2m by the year 2100. This is considered conservative by global scientific bodies and does not account for the increased risk of small sea level rise associated with an increase in the intensity and frequency of storms. It is interesting to note that on the north of Woodbridge Island the golf club is an significant risk while just south of Woodbridge Island the Neptunes Isle area is at similar risk.
7. Chapter 4 lists the objectives of the bylaw which is standard practise. The chapters beyond that set the regulations to give effect to the objectives.
8. We do not share this view, the bylaw as stated already is intended to govern those aspects of our coast which fall directly within the control, responsibility and jurisdiction of the City of Cape Town.

9. With reference to your comment on brides, these activities are already governed in terms of the City's events policy and no additional change is brought to bear by the bylaw, other than to ensure governance integration between the bylaw and the policy.
10. Point noted. However this is a bylaw that seeks to regulate and govern. Assistance from the City as you suggest is given in the form of annual budget allocation, Spatial Development Frameworks and council policy.
11. With respect to your comment "**There is more than enough science available, as well as experience from other parts of the world, that will allow us to find an appropriate solution to any environmental challenge".** We do not agree at all. Every country in the world is faced with environmental challenges which we are only beginning to understand now do not have solutions. The premise of this bylaw is that we must stop impacting on dynamic environments as once disturbed we have little or no solutions. Case in point includes coastal erosion and ongoing wind blown sand. The piece from the Table Talk highlights this point again where it is almost impossible to maintain infrastructure in these dynamic environments and also highlights that where we have imposed ourselves on these dynamic environments, the processes continue and are then seen as you put it as "poor management" rather than understanding that this relates directly to impacting on coastal dynamic processes.

Comment: The following comment was submitted by Werksman Attorneys in behalf of the owners of Springfontyn Property Holdings Limited:

1. Our client is the registered owner of the farm Groote Springfontein No 1, situated in the Blaauwberg Municipality, Division Cape.
2. Our client's property is situated within the jurisdiction area of the proposed Coastal Protection by-law to be promulgated in terms of the Integrated Coastal Management Act.
3. Our instructions are to record the following facts which are relevant to determining the Coastal Edge and the Coastal Protection Zone in terms of the proposed Bylaw, in respect of our client's property:
3.1 Our client has in consultation with its town planning and environmental consultants identified two nodes on the property suitable for further development.
3.2 The development of the property has at all relevant times been regarded by all relevant stakeholders as part and parcel of and indeed a catalyst to the development and economic prosperity of Atlantis.
3.3 In this regard Government in the Western Cape at Local and Provincial level has supported the development of the property.
3.4 To this extent the property was expropriated by the State in 1975 for the specific purpose of the development of Atlantis.
3.5 The intention that the property must be developed is duly recorded in correspondence from both the Ministers of Economic Development and Nature Conservation and Tourism, Western Cape, and is also supported at local authority level which recognizes the importance of the development of the property for the socio-economic upliftment of Atlantis and environs.
3.6 The development of the adjacent Silwerstroom Strand is linked to and cannot be considered separately from the development of our client's property.
3.7 Detailed plans for the subdivision, rezoning and the development of the property, which included a residential estate, harbour and hotels, were drafted and approved during 1988 – 1990. The development areas were shown as Town 4, Atlantis.

4. **Springfontein Property Holdings (Pty) Limited acquired the land under the expressed contractual obligation and condition that the property shall be developed for the benefit of the Atlantis and Environs community. This obligation was imposed by the Western Cape Government at the time of acquisition of the property by our client, as a condition of sale.**
5. **In the circumstance our instructions are that the determination of the envisaged Coastal Edge and Coastal Protection Zone in respect of our client's property, can only be finalised or considered when the nodes suitable for development have been identified and approved by the relevant planning authorities.**
6. **This letter is addressed to you following on the comments dates 1 March 2011 to the proposed Bylaw given by our client's Town and Regional Planners, First Plan CC.**

Response:
Responses to relevant points are listed below:

1. For noting, the Blaauwberg Municipality no longer exists and has been incorporated into the City of Cape Town.
2. Noted
3. Extensive discussions regarding the development nodes have been held with Mr Andre Beukes of Springfontyn Property Holdings and appropriate development nodes excluded from the provisions of the bylaw which have been agreed by Mr Beukes
4. See point 3 above. Nodal points have been identified and excluded from the Coastal Edge and regulations of the bylaw
5. See point 3 and 4 above
6. Noted

Comment:
A significant comment from Cape West Pavilion Holdings was submitted. The full comment is attached in Annexure A. In summary the comment requests that the bylaw makes allowance for the development of a Pavilion and Marina District in Blaauwberg specifically and generally to make allowances for the development of small boat harbours and marina's.

Response:
In response the following key points should be noted:

1) Overall support for the bylaw is noted with thanks
2) The City supports the concept of upgrading and re-development to optimise economic and social opportunities form our coastline.
3) The Draft bylaw is not the appropriate planning vehicle to propose the specific development of the Pavilion and Marina District. The proposal should have been submitted through the comment process on the City's Draft Spatial Development Plan.
4) The City is not the approving authority for any coastal development below the high water mark. This is a national competency and significant processes would need to be run prior to any approval being given by national government
5) The CPZ Bylaw has been revised to include a process whereby landowners may apply for exemption from the bylaw where certain criteria can be demonstrated and the coastal environment enhanced as a result of such exemption. This would be the appropriate avenue for the proponents to follow with their proposal.

6) In general the City has a position to not develop further infrastructure within the marine environment due to the possible negative impacts such development has on our coastal processes. This however does not exclude consideration by the City of appropriate plans. The bylaw process is however not the correct or appropriate process to comment in detail on such proposals.

Comment:
The City of Cape Town is to be acknowledged for its pro-active approach to dealing with the threats and risks to our coastline through both inappropriate development and the predicted increased storm frequency. Comments on the Draft for Comment are dealt with below. There are a few additional points which I believe have not been addressed and need to be considered, namely:

1 What happens to the ownership status of private land in the event that it becomes a victim of storm damage and is as a result below the high-water mark? Does it remain in private ownership? Surely it should be ceded to the City or State?

2 What is the City's duty / responsibility in situations where a section of the coast is eroding or is at risk of eroding to the extent that private development and or public infrastructure is a risk? A clear statement about responsibility, or not for coastal defense is required.

3 It must be a legal obligation for estate agents to inform prospective buyers that a property in question is inside or abuts the CPZ and what land-owners rights and responsibilities are ito the CPZ. The same should apply for all bond applications for property in the CPZ .

4 The City needs a specialist CPZ Unit to deal with monitoring, planning, development applications and pro-active management of the Coastal Zone. This Unit needs to include or have access to operational staff who have coastal engineering expertise. An assessment of the vulnerability of infrastructure close to the coast needs to be undertaken to facilitate forward planning. Too often coastal defenses and infrastructure deteriorates to a point that the repair costs are exorbitant. In addition, repair work needs to be undertaken by a team who understand coastal engineering. Fish Hoek beachfront is a case in point where the repair work to the promenade revetment wall has been undertaken repeatedly in the past 3 years by people who do not understand coastal processes – with the result that the `repair' does not last and money is wasted.

<u>Detailed comments on the documentation:</u>

Definitions: Dynamic coastal processes: include sediment movement & dune building processes

Chapter2: Conflict with other laws - the priority given to the Coastal Protection Zone by-law is supported.

Chapter 4: The Coastal Protection Zone
4. The purpose of the Coastal Protection Zone is to:

e) Protect remaining coastal systems as part of our natural heritage and as buffers to future climate change risks

7. Areas Excluded from the Coastal Protection Zone include.
When inappropriate development or coastal zone interference happens within the Excluded Areas, it often has an impact on the abutting sections of `City' coast. Notwithstanding the issue of a hierarchy of authority, the Excluded Areas need to identify a CPZ for their landholdings and manage it ito a special agreement between the City and relevant authority.

Chapter 5

11.f "Marine Access Points which shall provide explicitly for legally compliant public facilities for the launching of motorised watercraft of less than six metres in length." Presume that the historical access to and along beaches for Trek fishers will be secured ito 11 f.

Chapter 6

21. "*No person may act in <u>any way</u> that diminishes the social and recreational value of the CPZ for other members of society."* Competing beach uses such as ball games and sunbathing need use zones rather than a blanket ban of one or the other.

22. "*No person may discharge pollution into the CPZ unless such discharge is authorised in terms of a water use licence under the National Water Act No.36 of 1998 or a waste management licence under the provisions of the National Environmental Management*: *Waste Act No. 59 of 2008*. " Make this stronger to include penalties against the City in the event of sewage discharges in form of spills. There are specific weak points in the waste reticulation network and it must never be an easy option for the City to use the coastal rivers and estuaries as a sewage overflow outlet. Secondly, coastal CBDs are apathetic about their Housekeeping (litter & street run-off) with the result that polluted run-off from the CBDs goes onto the beaches - Fish Hoek Beach & Simon's Town waterfront are two well known cases.

24 This is strongly supported.

Chapter 7: Powers of the Council

28 "The response to all coastal disasters and emergencies are exempt from the provisions of this by-law, including but not limited to: " The City needs a specialist Coastal Unit which amongst other skills can respond to such emergencies so that `rescue / disaster amelioration' operations are carried out with as little additional damage to the coast as possible.

29. The delivery and provision of utility services by the City is exempt from this by-law provided that compliance to the provisions of the NEMA, where necessary, has been attained. The City must go through the process of formal Environmental Approval from the City Manager or his/her delegated authority – and with the recommendations and conditions set out by the specialist Coastal Unit.

Brief comment on some of the Maps with the designated CPZ.
http://www.capetown.gov.za/en/Documents/CoastalZones/25_St_James.pdf
Support the inclusion of railway land and private infrastructure such as Brass bell

http://www.capetown.gov.za/en/Documents/CoastalZones/24_Fish_Hoek_Kalk_Bay.pdf
Support the CPZ going up the Silvermine Estuary. Why is the City parking area and pump station behind Clovelly beach excluded? Also consider including the City Park behind the southern most cnr of Fish Hoek beach.

http://www.capetown.gov.za/en/Documents/CoastalZones/23_Glencairn_Fish_Hoek_South.pdf Support the CPZ going up the Glencairn Estuary. Why are there breaks in the CPZ line in the vicinity of the Glencairn Quarry?

http://www.capetown.gov.za/en/Documents/CoastalZones/21_Simon's_Town_South.pdf
It appears as if Boulders Nat Park is inside the CPZ. Good but isn't this inconsistent with the Exclusion Areas.

http://www.capetown.gov.za/en/Documents/CoastalZones/20_Smitswinkel_Bay_Castle_Rock.pdf It appears as if Miller's Point is inside the CPZ – good.

Kim Kruyshaar

Response:
Noted with thanks. With regards to your comments:

1. As stated by the Integrated Coastal Management Act, property or land that is eroded away and falls below the high water mark for a period longer than two years becomes the property of the state. However, if any organ of state is directly responsible for the erosion caused, that particular organ of sate is liable for that loss of land.

2. The City, or any organ of sate is not responsible for the loss of private property, or the protection of such private property, provided that the City, or any organ of state, is not responsible for that loss of land due to erosion or storm surges. It is the City's responsibility to protect public infrastructure.

3. Your comment is noted and will be considered in the amendments to the Coastal Protection Zone By-law.

4. This relates to broader coastal management within the City. The City has recently completed an Institutional Risk Assessment that determines how best the City can structure itself to more effectively promote and integrated approach to coastal management as well as managing risk into the future. This includes the identification of the relevant skills to manage this dynamic and complex environment.

Definitions: Noted and will be considered in the revision of the draft by-law.

Chapter 2: Noted

Chapter 4 - Point 4e: Noted and will be considered in the revision of the draft by-law.

Chapter 4 - Point 7: Noted and agreed. Under national legislation of the Integrated Coastal Management Act, a development setback needs to be undertaken at a provincial scale. It is envisaged that this process will 'fill the gaps' on property that has been excluded from the CPZ.

Chapter 5 – Point 11f: Historical access will be retained, provided that the management of these access points comply with the requirements of provincial legislation.

Chapter 6 – Point 21: Noted and agreed. The City is in the process of investigating appropriate mechanisms to address the increasing variety of activities taking place on the beach and the near shore surf zone.

Chapter 6 – Point 22: Noted and will be considered in the revision of the draft by-law.

Chapter 6 – Point 24: Noted

Chapter 7 – Point 28: Noted. Comment addressed in point 4, under general comments.

Chapter 7 – Point 29: Noted and will be considered in the revision of the draft by-law.

Map - St_James: Noted

Map – Fish Hoek_Kalk Bay: The position of the CPZ has been defined on the following key coastal informants:

- Risk from sea level rise and storm surges
- Biodiversity
- Access to the coast
- Coastal dynamic processes
- Coastal aesthetics/sense of place

The areas of concern are already severely altered. We cannot defend their inclusion in the CPZ from a coastal perspective based on the informants listed above. We feel that potential activities that may take place in these spaces will be sufficiently regulated through other City mechanisms.

Map – Glencairn_Fish Hoek South: The CPZ does not include these areas as this land belongs to Table Mountain National Park

Map – Simons Town South: Noted and will be considered in the revision of the draft by-law

Map – Smitswinkel Bay_Castle Rock: Noted

Comment:
WESSA, Western Cape thanks you for the opportunity to comment on the above and we acknowledge that the public participation process has been extensive and inclusive.

The Environmental Resource Management Department of the City of Cape Town is congratulated on taking a proactive approach to developing the coastal protection zone

by-law. The need for this by-law is increasingly apparent in the light of development pressures, compliance issues and the need to be responsive to climate change predictions such as sea level rise and the increasing intensity of storm events.

<u>Comments Specific to the Document</u>

Chapter 2. Conflict with other laws
2. We support the proposal that the provisions of the by-law prevail in the event of conflict as this is likely to afford more environmental protection.

Chapter 4. Coastal Protection Zone
4.a) We support the expressed need to ensure that the coastline belongs to and is accessible to all – this is of specific concern in terms of addressing access issues associated with certain private developments which effectively prevent public access to beaches and sections of the coastline.
7. The exclusions may require some explanation. Is it possible to list all the areas excluded?

Chapter 5: Development Regulations in the CPZ
11. b. Coastal Recreational Node.
The provision for "appropriate related commercial activities" would need careful regulation and enforcement.
11.g. Private Coastal Land.
Is it possible for private land owners who wish to exercise exercising rights to indemnify the City from responsibility.

Chapter 6: Additional Regulations pertaining to the use of the CPZ
15. We fully support the point made about encroachment as this is an ongoing problem and impacts on both the natural environment and on the public rights of access. The need for more enforcement is needed.

Chapter 7: Powers of the Council
30: It is of concern that a number of activities undertaken by the City or its contractors are exempt for this by-law. More explicit wording may be beneficial to prevent possible future abuse of this provision. For example the first point provides for "the implementation or action of any City approved policy, guideline, operational procedure or protocol".

- **Contractors, particularly those doing alien clearing, need a more rigorous training process, particularly when working in sensitive ecosystems such as wetlands and coastal dunes. Could provision be made for monitoring the compliance of contractors – ie that their actions are appropriate to the environment in which they are working.**
- **The beach cleaning policy – could provision be made for this to be reviewed periodically.**

Chapter 8: Offences and Penalties
We fully support the provision for penalties for offenders and call for increased capacity within the enforcement department meet this need.

WESSA reserves the right to revise initial comment or make additional comment based on new information that may come to light.
Phillipa Huntley: On behalf of WESSA, Western Cape

Response:
Noted with thanks. Comments provided to each point as follows:

Chapter 2: Noted

Chapter 4: Noted. In terms of exclusions zone: the certain areas have been excluded as the City does not have jurisdiction over these areas. The City cannot therefore apply the by-law to such areas. The areas that have been excluded have been listed in the by-law. They are identified as:

a) The Table Mountain National Park
b) National Port and Harbour Authority land
c) Naval land
d) Koeberg Nuclear Power Station Land
e) The Blaauwberg Conservation Area
f) Kogelberg Biosphere Reserve

Chapter 5: Noted and agreed. The by-law will ensure that decisions surrounding commercial activities will be an open and transparent process and in alignment with the requirements of the broader Spatial Development Framework. In terms of private coastal land, the City, provided it is not responsible for directly or indirectly causing damage to property, is not responsible for damages that may arise from storm surges or coastal erosion.

Chapter 6: Noted

Chapter 7: Noted. The City is aware that its own actions need to be carefully regulated and will strengthen the points you raise, in the by-law. With regards to the beach cleaning policy: the policy has recently been reviewed and will be subject to review based on new information and change in beach dynamics.

Chapter 8: Noted

Comment:
WOULD LIKE TO COMMENT MORE FULLY ON THIS, BUT I AM UNABLE TO ACCESS THE ACTUAL DOCUMENT THIS EVENING, ONLY THE MAP. IT IS A GREAT PITY THAT IT WAS NOT DRAWN UP MANY YEARS AGO.

1. I endorse the areas included as CPZ.
2. There must be no loop-holes for developers, or others, including Council, National Sea Rescue, or any other organization, to build in any of the demarkated areas at any time in the future. There was a section where I felt that there could be loop-holes for this to happen. (as mentioned i am unable to access this document this evening so I cant quote the section)
3. Distance from the high-water mark for any development, probably needs to be further increased.
4. Height of (new) buildings adjacent to the CPZ must be restricted to single storey.
5. How will this be able to be enforced if the DA loses control of the city?
Thank you, Dr DC Timm, Melkbos

Response:
Noted with thanks.

1. Noted

2. Noted

3. The distance of the coastal edge, which defined the landward boundary of the CPZ, is variable. The distance varies based on several key coastal informants. These informants include risk from sea level rise and storm surges, coastal biodiversity, coastal access, costal dynamic process and coastal aesthetics/sense of place. We believe that for each location along the coast where the CPZ is present, is at an appropriate distance.

4. Noted. As this falls outside of the CPZ it will be addressed by the broader coastal development guidelines.

5. The City would like to see continuity and consistency in terms of the regulation of the coast, and the Coastal Protection Zone. It is for this reason that we have adopted the strongest possible mechanism i.e. the by-law to regulate this space, and will hopefully withstand changes in political leadership.

Comment:
Herewith comments from the Mouille Point Ratepayers' Association regarding the Coastal Zone Bylaw:

The Mouille Point Ratepayers' Association has reviewed the Coastal Protection Zone By-law and endorses the classification of the Mouille Point beachfront. We request Council to confirm that the implication of this by-law is that no development will be permitted in the coastal zone. With regard to the parking area at the bottom of Fritz Sonnenberg Road on Beach Road, we specify that activities permitted here are not limited to routine maintenance, but also for upgrading and improvement of the said parking area as a parking area. It must be noted that MPRA supports all other aspects of the draft zone as it applies to this parking area, particularly with regard to the fact that no development will be permitted.

Thank you for your invitation to participate in this process. Jane Meyer, Mouille Point Ratepayers' Association

Response:
Noted with thanks.

Comment:
In general, well done on your CPZ work.

In some areas I feel the buffer allowed for sea-level rise to be excessive (and have always voiced criticism on the quality of science behind this) but nevertheless personally like the idea of restricting development on the coast.

However, I have some comments on the proposed Coastal Protection Zone at Paarden Island (the below also reflects the view of my Director, Andre van Tonder):

Apart from some roadside market activity and (very occasional) surfing at "the Wedge", this coastal strip serves an apparently limited environmental, social or economic function. The area is protected by a substantial dolos wall which provides more than adequate protection to the hinterland and thus serves no role in terms of a protective buffer (apart from allowing space for overtopped water – I think this can be accommodated or prevented relatively easily – e.g. by bolstering the seawall slightly in the event of severe sea-level rise).

The seaward area was identified as an ideal region for port expansion as (a) it is adjacent to an industrial area and (b) appropriate development in this zone would have no impact on the neighbouring beaches at Milnerton (see Strategic Evaluation for Port of Cape Town, CSIR Study, circa 2003). (note that if this area were developed, strategic planning such as strategic dredging to redirect waves and longshore drift could benefit Milnerton beach). Alternatively this would be an ideal area to allow for coastal development (e.g. marina/waterfront/recreational jetty) with a minor environmental impact.

Fostering such development in this (low environmental priority) area should alleviate pressure for development in other areas. Happy to discuss further if required. Geoff Smith, WSP Africa Coastal Engineers

Response:
Noted with thanks. We are confident in the results of our sea level rise modelling undertaken by Professor Geoff Brundrit but do acknowledge and recognise that the modelling is done on a number of predictions. As scientific information becomes available through global climate modelling we will revisit and re-run our modelling. However a number of issues should be noted with regard your comment:

- The Coastal Edge line was not determined alone by sea level rise modelling but includes aspects of biodiversity, coastal processes, coastal dynamics, public access, sense of place, landscapes and other informants. The area you note is not affected by biodiversity but has a large role to play in the coastal dynamics of Table Bay as a whole and in addition view sheds, landscapes and vista's also played a role in the line determination in this area.
- Further, we recently completed a modelling exercise that investigated the interface of the marine and freshwater systems in this area (the Salt River Catchment) under a changing climate scenario. This work done by external specialists PDRW indicated that the area in question is a flood risk from a terrestrial environment as well.
- Land in question that belongs to the National Ports Authority has been excluded from the provisions of the bylaw as required by national legislation. Development on this land is subject to approval through the National Environmental Management Act.

Comment:
We refer to your draft By-Law and fully support your initiative of preventing future development being built too close to the coast. We are also satisfied with the Coastal Protection Zone which has been defined for Gordon's Bay. Rowan Dent *Environmental Portfolio* Gordon's Bay Residents Association.

Response:
Noted with thanks.

Comment:
Chapter 1: Definitions – "Dynamic coastal processes" – include (f) ***sea level changes***
Chapter 4: The Coastal Protection Zone –

> **4. Add -** ***m) Assess existing undesirable developments and risks to CCC thereto*****.**
> **7. Areas as listed a) to f)** ***should be interfaced with the CPZ and cannot be excluded particularly where they may be in contradiction with the principles of the CPZ. Also what about select clubs, be they boating, fishing and yachting as appropriate that may have an impact on the CPZ. Harbours in particular*****.**

Chapter 5: Development Regulations in the CPZ

> **8. Interaction clause is necessary where existing lawful land use may present a risk to the CPZ.**
> **11. An overlay is suggested :** ***h) Anticipated/projected sea level rise in 20, 50 & 100 years.***

Chapter 6: Additional Regulations pertaining to the use of the CPZ –

> **22. No person may discharge pollution into the CPZ –** ***from whatever source*****, unless… etc. also, …authorization granted according to law.. include*****:-*** ***sea borne discharge/pollution, waste or litter*****. This needs to be in conjunction/interface with other government agencies.**

Chapter 7:

> **25. (a) Add;** ***this will be for the cost to the developer/ responsible party*****. This is also applicable to other clauses under Chapter 7**
> ***29. The delivery and provision of utility services by the city cannot be exempt from the requirements of the CPZ. This clause should be re-worded to say that the CCC will also comply with the requirements and where it has deviated from such requirements, laws, by-laws and required legislation, then appropriate steps will be taken, reported upon and actioned for resolution. The CCC should also include the CPZ requirements within its monitoring and auditing programme*****. Obviously the CCC is required to comply with whatever environmental and any other legislated requirements e.g. NEMA.**
> **Sewage outfalls (controlled or uncontrolled) are obvious examples. The pollution of the Disa river by uncontrolled contamination is one example, pipeline and channeled outfalls are others that may or sometimes do present a major problem to the citizens of Cape Town.**
>
> **30. The implementation or action of any City approved policy, guideline, operational procedure or protocol** ***can only be exempt if they fully comply with the appropriate legislation, laws etc. This may be appropriate to, but not limited to NEMA. Furthermore monitoring and auditing programmes must still be developed and followed in each and every case where contracts, permits etc., are issued.***

Chapter 8:

31 Please include (and not necessarily under Chapter 8*), reference to Industrial or any other deleterious discharge into drainage, systems, canals, outfalls and rivers. Such discharges may not occur at the CPZ, but inland from the impact zone*.

(2)Addition to the Draft Document

(2) Please list as an appendix to the document a list of all related legislation that this document embraces. i.e. Local, Regional and National. Include International where applicable.
(3) There is no mention of fishing
(4) There is no mention of any processing plant e.g. fishing, within the CPZ
(5) CCC to have a definitive Register of exceptions (approved or in process, or in question), to the CPZ requirements.
(6) Reference to properties, developments owned by non- SA citizens
(7) Develop/include a formal written QA/Management system to record all events, issues, deficiencies and actions, taken or initiated.
(8) Reference to boating/ water craft activities.
(9) Describe integration network with Provincial zoning controls & monitoring
(10) Describe integration network with National zoning controls & monitoring
(11) Reference to resource commitment and funding.
(12) Provide effect of sea level rise with 20, 50 & 100 year flood lines in estuaries and rivers.
(13) Provide mechanism for re-assessing the 20, 50 & 100 year flood lines due to potential increased rainfall due to climate change. (As applicable per scientific predictions)
(14) Develop and implement formal audit and monitoring programme within the CCC.
(15) Describe interaction and programme with coastal patrols – marine reserves, fishing activities, removal of shell fish (rock habitation) and poaching.
(16) Provisions of the CPZ requirements to be enforced when the status changes of permanent and non-permanent structures had been allowed prior to 1.11.2010

Paul Gray: Member Cape Environmental Trust; Hout Bay & Llandudno Environmental Conservation Group, Trustee of Cape Wetlands Trust.

Response:
Response to each comment is listed below:

Chapter 1: Noted with thanks, addition will be made

Chapter 4:
4. Noted with thanks, amendments will be made
7. Noted, infrastructure below the high-water mark is the sole responsibility of national government (harbours etc) and as such cannot be included in the bylaw

Chapter 5: Development Regulations in the CPZ
8. Noted and amendment will be made to include a principle of "the land must be suitable for the proposed development irrespective of existing rights".

11. Sea level rise modelling has already been completed and is available on our website. The results from that modelling have been a key informant to this work and will also inform future work that will look at existing development risk.

Chapter 6: Additional Regulations pertaining to the use of the CPZ –
22. Although we are in agreement with this sentiment, the City is unable to develop legislation that governs aspects outside of it jurisdiction – pollution from seaborne activities is beyond our jurisdiction

Chapter 7:
25. Noted, amendment will be made
29. Although the sentiment is supported, the City has to continue to provide services to its communities. These service provision components need to be excluded from the bylaw as if not, we would develop a situation whereby service provision will be compromised. City service provision however will be governed by national environmental legislation. This is relevant as in our urban environment much of the services are gravity fed and as such will interface with the coastal environment.
30. Noted and agreed. This bylaw does not and in fact cannot exempt any City activity from national environmental legislation. As part of approvals under that legislation, monitoring and mitigation measure swill be included in any record of decision.

Chapter 8:
31. Noted. This aspect of pollution is regulated through the City's Pollution Control but we will make reference to this in the amended bylaw.

(2)Additions to the Draft Document

2. Noted with thanks
3. Fishing is an activity that is governed through the Marine Living resources Act and is a national competency. The City may not produce legislation to govern a national competency
4. Any processing plant or commercial activity is governed within the CPZ as per the land use approvals process. As such the CPZ bylaw would not allow the development of a fish processing plant within the CPZ
5. Noted, amendments to the bylaw will include a formal permitting process
6. Not relevant as property and land use rules apply irrespective of nationality
7. Noted, the Cit is in the process of developing an extensive coastal monitoring system.
8. Boating and water craft activities will be addresses and regulated through the overlay zones as required by the bylaw.
9. Noted, it is the intention that the CPZ will be submitted to Province for approval as the CPZ under the ICM Act
10. Noted, it is the intention that the CPZ will be submitted to Province for approval as the CPZ under the ICM Act. This will ensure alignment with national legislation
11. Noted, however a bylaw cannot address this aspect. This will be addressed through the development of a City of Cape Town Coastal Policy as part of the development of the Municipal Coastal Management Plan.
12. This work is underway, modelling has been completed for the Salt River Catchment and is currently being done for the other estuary catchments across the City. Regulation based on the results will take place through the City's Stormwater Bylaw.
13. Noted and agreed. Our sea level rise modelling will be done on a regular basis to ensure that as new data and information becomes available this will be fed into our existing sea level rise model. The amended bylaw will make provision for amendments to the Coastal Edge based on the outputs of this work
14. Noted, see response regarding the City's Coastal Monitoring Programme.

15. Noted, again these are national government competencies but we are investigating the role of our local law enforcement in this regard as part of the development of our Municipal Coastal Management Plan.
16. Noted and agreed

Comment:
The Friends of Rietvlei has studied the proposed draft Coastal Protection Zone Management By-law and wish to compliment you on the contents. It is comprehensive, well written, and easy to interpret and understand (this cannot always be said of all legislation!).
The draft by-law meets the requirements of an intergrated coastal management strategy, and we fully endorse and support the promulgation of the proposed Coastal Protection Zone Management By-law. Niel van Wyk Friends of Rietvlei

Response:
Noted with thanks

Comment:
The Victoria and Alfred Waterfront submitted a comment agreeing to the exclusion of the V&A Waterfront form the provisions of the bylaw and recognising that sea ward development or sea ward protection is governed by the National Environmental Management Act.

Response:
Noted and agreed

Comment:
The Cape West Coast Biosphere Reserve (CWCBR) extends from the Diep River in the south to the Berg River in the north and inland to Malmesbury and therefore the proposed development is located within the CWCBR. One of the primary aims of the CWCBR is to implement sustainable development principles along the West Coast, in addition to integrating rapid growth with biodiversity and heritage conservation. In this regard, the CWCBR would like to comment as follows:

- **The Cape West Coast Biosphere Reserve supports the establishment of a coastal protection zone within the City of Cape Town, which will provide for a buffer zone for coastal processes and ecology and prevent inappropriate developments.**
- **The activities that are exempt from the by-laws should be subject to a separate set of regulations.**

Rhett Smart – Conservation Extension Officer

Response:
Noted with thanks

Comments and Response: Provincial and National Government

Comment:
The following comment was submitted by the Provincial Government of the Western Cape:

1.1 The Department of Environmental Affairs and Development Planning (DEADP) provides provincial leadership for promoting sustainable coastal development and integrated coastal management in the Western Cape. The policy guiding this initiative is presented in the White Paper for Sustainable Coastal Development in South Africa.

1.2 One of the requirements of the White Paper was the compilation of a new Coastal Management Act (that would largely replace the Sea Shore Act). This has resulted in the drafting and approval of a National Environmental Management: Integrated Coastal Management Act 24 of 2008 (NEM: ICM Act 24 of 2008).

1.3 The Department wishes to applaud the City of Cape Town for the initiative shown to identify, delineate and draft legislation in the regard. Given the significant challenges in the City of Cape Town, the CPZ regulations will provide much needed protection to vulnerable ecosystems, reduce cost as result of maintenance activities and result in improve planning and sighting of development in respect of the coast. The department furthermore hopes this legislation will improve coastal management in the province and create legal certainty in its application in the CPZ. The Department is committed to assisting and supporting CoCT in their endeavours.

2. Discussion

2.1 There are however a number of issues that requires deliberations and further discussion with specific reference to:

- **Legal context in terms of the NEM: ICM Act;**
- **Roles and responsibilities;**
- **Consultation and participation;**
- **Cooperative governance; and**
- **Planning the way forward.**

2.2 In so far the NEM: ICM Act, section 51 provides: "A municipality may administer its coastal management programme and may make by-laws to provide for the implementation, administration and enforcement of the coastal management programme". It is clear from this provision that By-laws in terms of the NEM: ICM Act can only be promulgated through an approved and adopted municipal Coastal Management Programmes (CMP). In this respect a municipal CMP must also conform and be in aligned with the Provincial and National CMP's. Currently there is no formally adopted Provincial or National CMP in place and the situation is accentuated by the fact that no national guidelines exist to guide the compilation of such a document. The National Department of Environmental Affairs is in the process of drafting national guidelines for compilation of CMP.

2.3 Determination and adjustment of coastal boundaries as it relates to section 26(1)(b) The coastal boundaries of the coastal protection zone may be determined

or adjusted by the MEC in accordance with section 28 by notice in the Gazette. In terms of this provision it is the responsibility of the Member of Executive Council (MEC) to determine and promulgate the CPZ in consultation with the relevant municipalities. Section 62 (1) provides for an organ of state that is responsible for implementing national, provincial or municipal legislation that regulates the planning or development of land must, in a manner that conforms to the principles of co-operative governance contained in Chapter of the Constitution.

2.4 Consultation and public participation – Section 53(1) provides that before exercising a power, which the NEM: ICM Act requires to be exercised in accordance with this section, the Minister, MEC, municipality or other person exercising that power must—

(a) Consult with all Ministers, MEC's or municipalities whose areas of responsibilities will be affected by the exercise of the powers in accordance with the principles of co-operative governance as set out in Chapter 3 of the Constitution;

(b) Publish or broadcast his or her intention to do so in a manner that is reasonably likely to bring it to the attention of the public; and

(c) By notice in the Gazette—

(i) Invite members of the public to submit, within no less than 30 days of such notice, written representations or objections to the proposed exercise of power; and

(ii) Contain sufficient information to enable members of the public to submit representations or objections.

2.5 It is crucial in the context of the above mentioned that agreement and consensus is reached in terms of planning on the way forward. Secondly, alignment of processes (national, provincial and local government) needs to happen in the spirit of cooperative governance and ensure that mandates and responsibilities are exercised in accordance with the legislation enacted for that specific purpose.

2.6 Definitions: There are a number of definitions absent and some which emerged from the document which requires further clarity or description in terms of general coastal management applications. These relate to words such as:

- **CMP and its relation to the NEM: ICM Act;**
- **Emergency incidents / measures (in terms of section 30 of NEMA;**
- **Private functions (what does it entails);**
- **Chapter 3 (relate to the scope of the NEM: ICM Act);**
- **Chapter 4 – description and definition of:**
- **Coastal Protection Zone (CPZ);**
- **Impacts on rights of foreigners;**
- **Definition of coastal property;**
- **Clause 4L only refers to erosion associated problems but does not address sand accretion problem;**
- **Clause 7C – Naval land and Admiralty reserve;**
- **Chapter 5 –**
- **Integrated Coastal Management Objectives (reference to legal and legislative instruments);**
- **Clause 10 – Expropriation in terms of the Constitution;**
- **Clause 11C –Coastal Public Property; and**
- **The issue of Boat launching sites and how it will be affected.**
- **Chapter 6 - Complying with other relevant legislation**

2.7 In order to measure the full extent and impact of the draft CPZ it needs to be considered in conjunction with the draft boundaries. This together with impacts such :

- **Dynamic coastal processes;**
- **Storm surges;**
- **Sea level rises;**
- **Climate change;**
- **Littoral movement (sand deposits)**
- **Areas prone to erosion;**
- **Wind patters**
- **Dune Profiles, etc.**

2.8 It is unclear as what areas will be included and the merits and discussion on areas that would be excluded from the CPZ.

Response:
Response to each point is listed below:

1.1 Noted
1.2 Noted
1.3 Noted with thanks

2.2 There are a number of points that need to be made in response to this issue:

- The City has an approved Coastal Zone Management Strategy adopted in 2003 by Council following a public and stakeholder consultation process
- The City is not bound only by the ICM Act but section 156(2) of the Constitution provides that a municipality may make and administer by-laws for the effective administration of the matters which it has the right to administer, and to exercise any power concerning a matter reasonably necessary for, or incidental to, the effective performance of its functions
- The rate and scale of pressure on the City's coastline does not allow for the lengthy wait that may be necessary if we as a proactive local authority are required to wait for the drafting of national and provincial guidelines
- The City's bylaw will be a cornerstone of the City's Coastal Management Programme (CMP)as per the Act
- The Act does not prescribe that proactive and progressive measures should not be undertaken or may not be undertaken in advance of the CMP
- Finally the City is of the view that the first step in developing is CMP is to define the CPZ and ensure it integrity following which various management plans should be implemented

2.3 In defining the City's Coastal Edge Line, the Provincial Authority has been consulted in a number of ways, namely:

- Through the extensive consultation on the City's Draft Spatial Development Framework that defines the Coastal Edge Line
- Through the Provincial Coastal Coordinating Committee (PCCC)
- Through a number or presentations to various departments within the Provincial government

2.4 (a) Both provincial and national government departments were requested to provide input and comment on the Draft Bylaw

2.4 (b) and (c) The draft bylaw has been through an extensive public and stakeholder consultation process (this report) and terms of the City's Public Consultation Policy

2.5. Agreed. This issue of alignment was extensively discussed with the Department of Oceans and Coasts at National Government level as well. What was agreed in those discussions as the way forward is the following:

- The City is supported to move ahead with its bylaw
- The bylaw should be renamed as the MUNICIPAL Coastal Protection Zone Bylaw
- Once adopted, the City and the Province should enter into a formal engagement to discuss the potential of the City's Coastal Edge Line being declared the boundary for the CPZ by the MEC as per the ICM Act.

2.6 Noted and amendments will be made where relevant

2.7 In defining and delimiting the City's Coastal Edge Line the informants included the following coastal aspects:

- Dynamic coastal processes;
- Storm surges;
- Sea level rises;
- Climate change;
- Littoral movement (sand deposits)
- Areas prone to erosion;
- Wind patterns
- Dune Profiles, etc.
- Social aspects
- Coastal access
- Landscapes
- Sense of place and identity
- Coastal risk and vulnerability
- Coastal biodiversity

2.8 The Coastal Edge line is clearly depicted in the City's Draft Spatial Development Framework.

Comment:
The following comment was submitted by the National Government: Department of Environmental Affairs, Integrated Coastal Management

1 I would like to thank the City of Cape Town (COCT) for the opportunity to comment on the above-mentioned draft by-law. We also appreciate the various discussions between officials in your department and officials from the Department of Environmental Affairs (DEA) Branch Oceans and Coastal Management.

2 The COCT has always played a leading role in environmental issues and we welcome the various initiatives currently being pursued by the COCT to better protect, manage and utilize the coastline. This is largely in line with the vision of the White Paper for Sustainable Development in South Africa (2000) and the requirements of the Integrated

Coastal Management Act (Act no. 24 of 2008); hence we pledge our support for this important initiative.

3 The DEA, however, have some concerns pertaining to certain terms used in the draft By-law, which may cause some confusion and potentially open the COCT to legal challenges, which we conveyed to you during our discussions. These main concerns are expanded on below.

3.1 In addition, the DEA made a number of detailed comments on the enclosed document for your further consideration.

4 As explained during our meetings with the COCT, the DEA is concerned about the use of the term Coastal Protection Zone in this By-law. In terms of the Integrated Coastal Management Act (ICM Act) there are certain powers given to the different spheres of government. These include the power for the MEC to determine set-back lines (S25), determine and adjust the coastal boundary of the coastal protection zone (S28) and make regulations (S84). The latter includes the power to make regulations relating to "the management of the coastal protection zone within the province" and "the granting of permission for the erection, placing, alteration or extension of a structure that is wholly or partially seaward of a coastal set-back line, and the process to be followed for acquiring such permission, including the authority by whom, the circumstances in which, and the conditions on which such permission may be given". These are provincial functions in terms of the ICM Act. Hence, we advise strongly that the COCT resuscitate the efforts to work cooperatively with the Provincial Department of Environmental Affairs and Development Planning (DEADP) to take this process forward, to avoid confusion and potential future legal challenges.

5 Similarly, there are certain functions and responsibilities that have been given to municipalities. These, for example, include functions related to the designation and management of coastal access land (S18 – 20) and the preparation of municipal coastal management programmes (S48 and S49). In terms of S50 of the ICM Act "a municipality may administer its coastal management programme and may make by-laws to provide for the implementation, administration and enforcement of the coastal management programme". For alignment with the ICM Act, the preferred option would have been to develop a Municipal Coastal Management Programme first and thereafter the by-law.

5.1 Further, the COCT could have worked more closely with the provincial Department of Environmental Affairs and Development Planning (DEADP) to determine the boundaries of the Coastal Protection Zone.

6 Whilst we pledge our support to the COCT in proceeding with this by-law, we advise that you align it with the ICM Act, and consider the slight amendment in terms of naming the by-law, as discussed. This could then potentially be changed at a future date once the COCT has developed their Coastal Management Programme and refined the boundary of the Coastal Protection Zone in collaboration with the DEADP. However, we sincerely hope that the COCT will succeed in finding consensus with the DEADP, to avoid name changes, which, as we articulated at our meeting, might jeopardize your local tabling process, which we want to avoid at all cost.

7 In conclusion, we would like to reiterate that we are in support of the intentions and the aims of the by-law, and hope that you give consideration to the above issues. We will

also welcome the opportunity to work cooperatively with the COCT in our integrated coastal management endeavours. Thank you once again for this worthy initiative and for the positive spirit in which our meetings were conducted.

Response:
Response to each point is listed below:

1 Noted

2 Noted with thanks

3 Noted

3.1 The City has considered these comments and referred these comments to Cormac Cullinen in the process of revising the draft by-law.

4 The City acknowledges the concern from the DEA over the use of the term Coastal Protection Zone By-law. To address this matter and to minimise confusion between the City's initiative and the ICM Act as national legislation, the City has renamed the bylaw as the Municipal Coastal Protection Zone By-law. It was agreed that the City would re-initiate discussions and pursue collaboration with the provincial authorities to align both the City's interests with the interests and mandates of the provincial authorities. It is envisaged that the Municipal Coastal Protection Zone for the City of Cape Town will be adopted by the provincial authorities within the framework of the ICM Act as a streamlined, progressive and efficient manner in which to promote integrated coastal management.

5 The City of Cape Town formally adopted its Municipal Coastal Management Plan in 2003. The City therefore sees the development of a coastal by-law as the natural progression from the management plan. The City is also entirely within its right according to both the Constitution of South Africa as well as the ICM Act to develop by-laws that regulate the coastal space. The City has developed the coastal edge and associated by-law within the framework of the City's Spatial Development Framework and Integrated Zoning Scheme.

5.1 The City believes that every effort was made to promote close cooperation and collaboration with the provincial authorities. This was undertaken through the following:

- Advising the provincial authorities on the City's intentions of developing a Coastal Protection Zone By-law through the Provincial Coastal Committee. This is a formal committee that is used to facilitate communication and integration over coastal management across different spheres of government. The City is formally represented on this committee.

- The City was also represented on the steering committee for the development of a methodology for the determination of setbacks for the Western Cape Province. The City gave valuable input into this process through the City's own experience of developing the coastal edge that defines the landward boundary of the Coastal Protection Zone. Through this process the provincial authorities were made aware of the development of the City's Coastal Protection Zone and associated by-law. Reflecting this further was the provinces request that this methodology be tested against the position of our coastal edge, where the two essentially aligned.

- A meeting well in advance of the public participation process for the draft by-law was convened with the relevant provincial authorities to facilitate dialogue and to receive feedback.

- The provincial authorities were also made aware in advance of the public participation period from the 1st of February 2011 to the 2nd of March 2011.

As agreed as the most appropriate way forward the City will re-initiate discussions with the provincial authorities to facilitate alignment of interest and mandates.

6 The City has accommodated this slight amendment by renaming the Coastal Protection Zone By-law as the Municipal Coastal Protection Zone Bylaw. As in point 5.1 above, the City will re-initiate discussions with the provincial authorities to align interests and mandates.

7 Noted with thanks

REPORT TO ECONOMIC ENVIRONMENT AND SPATIAL PLANNING PORTFOLIO COMMITTEE

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

1. **ITEM NUMBER :** **EESP 15/02/12**

2. **SUBJECT**

PROPOSED PLAN OF ACTION FOR THE DEVELOPMENT AND FORMALISATION OF THE CITY'S COASTAL ZONE REGULATORY MECHANISMS IN ACCORDANCE WITH THE REQUIREMENTS OF THE INTEGRATED COASTAL MANAGEMENT ACT (ACT No. 24 of 2008).

ISIHLOKO

ISICWANGCISO ESIPHAKANYISIWEYO SENTSHUKUMO KUMSEBENZI WOKUPHUHLISWA NOKUMISELWA NGOKUSEMTHETHWENI KWEENKQUBO ZESIXEKO ZOLAWULO LWEMIMANDLA ENGASELUNXWEMENI NGOKUNGQINELANA NEEMFUNO ZOMTHETHO WOLAWULO NGOKUHLANGENEYO KWEMIMANDLA ENGASELUNXWEMENI (UMTHETHO onguNomb. 24 ka-2008).

ONDERWERP

VOORGESTELDE AKSIEPLAN VIR DIE ONTWIKKELING EN FORMULERING VAN DIE STAD SE REGULERINGSMEGANISMES VIR KUSSONES IN OOREENSTEMMING MET DIE VEREISTES VAN DIE WET OP GEÏNTEGREERDE KUSBESTUUR (WET 24 van 2008)

LSU: C0184

3. **PURPOSE**

This report seeks support for the process, development and formalisation of a number of coastal zone regulatory mechanisms for the City of Cape Town in accordance with the requirements of the Integrated Coastal Management Act (ICMA). These regulatory mechanisms include the establishment of a Coastal

Development Setback Line, the Coastal Protection Zone, Coastal by-law, Coastal Hazard Policy and Coastal Management Plan.

4. FOR DECISION BY

Delegated: for decision by EESPCO

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5. EXECUTIVE SUMMARY

The City of Cape Town has a coastline of 307km, arguably one of its greatest economic, social and environmental assets. This coastline is increasingly under pressure due to the high desirability of coastal property and extensive "strip" development, alteration of, and impacts on, natural coastal processes and lack of historical regulations to protect coastal processes and coastal assets. Increased levels of coastal erosion, permanent loss and destruction of dune systems, loss of fauna and flora and increasing levels of windblown sand problems are additional coastal pressures facing the City. These pressures on our coastline and related infrastructure are predicted to increase into the future as a result of climate change and associated sea-level rise and storm surge events. In protecting its economic future and social opportunity, lowering environmental, economic and social risk, complying with legislation and to ensure equitable access and opportunities, the City must now institute appropriate means to protect, manage and formalize its coastal zone.

To date the City has lead a proactive response in this regard which includes:

1) Adoption of a Coastal Zone Management Strategy in 2003;
2) The completion of a sea-level rise risk assessment;
3) The determination of a Coastal Urban Edge (defined by coastal risk, social imperatives, ecological values, coastal processes and scenic values) which was incorporated into Cape Town's Spatial Development Framework and District Plans, and
4) Public consultation on a Draft Coastal Protection Zone Bylaw in February 2011 aimed at regulating this Coastal Urban Edge.

On the 1st December 2009, the Integrated Coastal Management Act (ICMA) also became legally enforceable and requires that municipalities develop coastal regulatory mechanisms to achieve the goals of the ICMA and to promote sustainable coastal management.

Much of the work completed by the City was undertaken prior to the formalization of the ICMA and as such the City has engaged extensively with the relevant departments from both National Government (Department of Environmental Affairs: Oceans and Coasts) and Provincial Government (Director: Mr. C. K. Rabie, Environmental & Spatial Planning, Dept. of Environmental Affairs

& Development Planning) in terms of defining and agreeing on the way forward with regards the City's intention to protect and manage its coastline, the existing planning work completed and ensuring that these interventions meet the needs and requirements of the ICMA.

As such the City, Provincial Government of the Western Cape and National Department of Environmental Affairs has agreed that:

1) The City's Coastal Urban Edge as spatially defined in Cape Town's Spatial Development Framework be considered for promulgation by the Government of the Western Cape as the Coastal Development Setback Line as determined and defined in the ICMA. Formal promulgation of this line is in terms of the powers vested in the MEC. This will streamline and reduce the EIA burden on building development applications;
2) As a means to formally and more effectively regulate the space between the High Water Mark and the Coastal Setback Line, the City's current Draft Coastal Protection Zone By-law be re-named and revised in consultation with the relevant provincial department as well as relevant City line functions and be re-advertised for further public comment before being put to Council for adoption;
3) The City in consultation with the relevant provincial department define a Coastal Protection Zone as the area for which the Coastal Management Programme as per the ICMA would be applicable;
4) The City proceed to draft its Coastal Management Programme as per the ICMA for review by the provincial government, and
5) The City, in consultation with the relevant provincial department, develop, draft and approve a City of Cape Town Coastal Hazard Policy. This Coastal Hazard Policy will address all coastal risk to property and infrastructure from coastal processes and hazards including sea-level rise, storm surge events and migrating dune systems. The policy will provide a platform which will strategically and systematically guide decisions relating to coastal property at risk from coastal hazards.

6. RECOMMENDATIONS

Delegated:

It is recommended that the Portfolio Committee:

a) Supports the process, development and formalisation of a number of coastal zone regulatory mechanisms for the City of Cape Town in accordance with the requirements of the Integrated Coastal Management Act (ICMA) as outlined in this report.

b) Formally supports and requests that the City's Coastal Urban Edge as defined in the Spatial Development Framework be formally considered by the Provincial Government of the Western Cape for promulgation as the Coastal Development Setback Line for the City's coastline as required by the ICMA;
c) Supports the renaming, review, revision and further public consultation of the City's Draft Coastal Protection Zone By-law as the appropriate means to regulate the coastal space between the Development Setback Line and the High Water Mark;
d) Supports the spatial definition and mapping of a Coastal Protection Zone for the City for which the Coastal Management Programme would be relevant;
e) Supports the Drafting of the City's Coastal Management Programme as required by the ICMA as well as a key City tool for managing, enhancing and protecting its valuable coastline, and
f) Supports the development of a City Coastal Hazard Policy for the City of Cape Town.

IZINDULULO

Zigunyazisiwe:

Kundululwa ukuba iKomiti yeMicimbi yeSebe:

a) Mayiyixhase inkqubo, yokuphuhliswa nokumiselwa ngokusemthethweni iqela leenkqubo zolawulo lwemimandla engaselunxwemeni zesiXeko saseKapa ngokungqinelana neemfuno zoMthetho woLawulo ngokuHlangeneyo kweMimandla engaseluNxwemeni njengoko kuchaziwe kule ngxelo.
b) Mayixhase ngokusesikweni yaye mayicele ukuba iMida yeDolophu eseluNxwemeni yesiXeko njengoko kuchaziwe kwiSikhokelo soPhuhliso lweMihlaba mayiqwalaselwe ngokusesikweni nguRhulumente wePhondo leNtshona Koloni ukuze ibhengezwe njengoMda eCuthelwe uPhuhliso olungaseluNxwemeni kwiindawo ezingaselunxwemeni zesiXeko njengoko kuyimfuneko ngokweemfuno zoMthetho woLawulo ngokuHlangeneyo kweMimandla engaseluNxwemeni;
c) Mayikuxhase ukuthiywa ngokutsha, ukuphengululwa, ukuphononongwa kunye nokubonisana okongeziweyo noluntu malunga noMthetho kaMasipala olawula ukuKhuselwa kweMimandla engaseluNxwemeni yesiXeko njengendlela efanelekileyo yokulawula amabala angaselunxwemeni phakathi koMda oCuthelwe uPhuhliso kunye noMlinganiselo woMphakamo waManzi;
d) Mayixhase intsingiselo yamabala omhlaba nokuzotywa kwemephu yoMmandla oKhuselweyo ongaseluNxwemeni wesiXeko nalapho ifanelekileyo iNkqubo yoLawulo lwemimandla engaseluNxwemeni;
e) Mayikuxhase ukuqulunqwa kweNkqubo yesiXeko yoLawulo lweMimandla engaseluNxwemeni njengoko kuyimfuneko ngokweemfuno zoMthetho woLawulo ngokuHlangeneyo kweMimandla engaseluNxwemeni ngokunjalo

njengesixhobo esiphambili sesiXeko sokulawula, ukuxhasa nokukhusela imimandla yaso exabisekileyo engaselunxwemeni, yaye

f) Mayixhase ukuqulunqwa koMgaqo-nkqubo wesiXeko ojongene nezinto ezinobuNgozi ngaseluNxwemeni kusenzelwa isiXeko saseKapa.

AANBEVELINGS

Gedelegeer:

Daar word aanbeveel dat die portefeuljekomitee:

a) Die proses, ontwikkeling en formulering steun van 'n aantal reguleringsmeganismes vir kussones vir die Stad Kaapstad in ooreenstemming met die vereistes van die Wet op Geïntegreerde Kusbestuur soos in hierdie verslag uiteengesit.

b) Formeel steun verleen aan en versoek dat die Stad se stedelike kusrand soos in die ruimtelikeontwikkelingsraamwerk omskryf, formeel deur die Wes-Kaapse provinsiale regering oorweeg word vir promulgering as die terugsettingslyn vir kusontwikkeling wat betref die stad se kuslyn, soos vereis deur die ICMA;

c) Steun verleen aan die naamsverandering, hersiening en verdere openbare konsultasie van die Stad se konsepverordening oor kusbewaringsone-bestuur as die toepaslike manier om die kusruimte tussen die ontwikkelingsterugsettingslyn en die hoogwaterlyn te reguleer;

d) Steun verleen aan die ruimtelike definisie en kartering van 'n kusbeskermingsone vir die Stad waarvoor die kusbestuursprogram tersaaklik sou wees;

e) Steun verleen aan die opstel van die Stad se kusbeskermingsprogram soos vereis deur die ICMA asook 'n sleutelmeganisme vir die Stad om sy waardevolle kuslyn te bestuur, te bevorder en te beskerm, en

f) Steun verleen aan die ontwikkeling van 'n Stadsbeleid oor kusgevare vir die Stad Kaapstad.

7. DISCUSSION/CONTENTS

7.1. Constitutional and Policy Implications

Meeting the requirements of the Integrated Coastal Management Act

7.2. Environmental implications

Does your report have any environmental implications: No ☐ Yes ☒

The recommendations of this report will greatly enhance the City's coast as a socio-economic and environmental asset as well as contribute to meeting the policy statements within IMEP.

7.3. Legal Implications

None

7.4. Staff Implications

Does your report impact on staff resources, budget, grading, remuneration, allowances, designation, job description, location or your organisational structure?

No ☒

Yes ☐

7.5. Risk Implications

None

7.6. Other Services Consulted

SPUD:	Norah Walker	021 400 9325
PBDM:	Jaco Van Der Westhuizen	021 400 7576
SR&A:	Sakhile Tsotsobe	021 400 4638

FOR FURTHER DETAILS CONTACT:

NAME	Darryl Colenbrander
CONTACT NUMBERS	021 487 2355
E-MAIL ADDRESS	Darryl.Colenbrander@capetown.gov.za
DIRECTORATE	Economic, Environment and Spatial Planning
FILE REF NO	
SIGNATURE : DIRECTOR ENVIRONMENTAL RESOURCE MANAGEMENT	Gfewans (Acting Director)

☑ REPORT COMPLIANT WITH THE PROVISIONS OF COUNCIL'S DELEGATIONS, POLICIES, BY-LAWS AND ALL LEGISLATION RELATING TO THE MATTER UNDER CONSIDERATION.

☐ NON-COMPLIANT

LEGAL COMPLIANCE

NAME JEAN ROMAN

TEL (021) 400 2753

DATE 24/01/2012

Comment:

~~Certified as legally compliant:~~

Based on the contents of the report.

EXECUTIVE DIRECTOR
Acting: Cheryl Walters

Comment:

DATE 27.1.2012

MAYORAL COMMITTEE MEMBER
Belinda Walker

COMMENT:

NAME B. WALKER

DATE 30.1.2012

Land-use will be controlled through the Cape Town Zoning Scheme and the By-law must note this during the processing thereof.

MINUTES OF THE MEETING OF THE ECONOMIC, ENVIRONMENTAL AND SPATIAL PLANNING PORTFOLIO COMMITTEE OF THE CITY OF CAPE TOWN HELD IN THE CRUSH ROOM, FIFTH FLOOR, PODIUM BLOCK, CIVIC CENTRE, CAPE TOWN ON WEDNESDAY, 8 FEBRUARY 2012 AT 11:00.

PRESENT: ALDERMAN/COUNCILLOR

DEMOCRATIC ALLIANCE

G Bloor (Chairperson)
X Limberg (Deputy Chairperson)
E Anstey
D Bryant
A Kannenberg
M Kleinsmith
J McCarthy
M Nieuwoudt
F Raymond
D Venter

AFRICAN NATIONAL CONGRESS

A Ehrenreich (left the meeting at 13:30)
V Dyanti
Z Qoba
M Sitonga

UNITED DEMOCRATIC MOVEMENT

M Taylor

OTHER COUNCILLORS PRESENT

B Walker – MAYCO member
J Krynauw

ABSENT WITH APOLOGY

D Mphila

OFFICIALS
J Hugo: ED EESP
A Arendse
O Asmal

T Siganda
C Walters
W Carelse

D Colenbrander
M Crous
C Daniels
A Davison
P Evard
N Fillies
L Gerrans
F Kolala
G Kruger
S Mosdell
E Schnackenberg
K Patte
K Palmer
N Primo
M Walker
N Walker
K Wiseman
C Wright
J van der Westhuizen
R van Eeden

PUBLIC AND PRESS

N Flaatten- WESGRO
I Blackie
J Coetzee
N Furnon-Roberts
S Kube
J Maclennin
M Mvemve
N Mqikela
G Nel
G Wehle

EXECUTIVE SUPPORT: OFFICE OF THE CITY MANAGER

R Riffel
G Josephs
Z Maginxa (Interpreter)

ACRONYMS USED IN MINUTES

ALD	Alderman
ANC	African National Congress
BCA	Blaauwberg Conservation Area
CBO's	Community Based Organisations
CLLR	Councillor
CMOSS	Cape Metropolitan Open Space System
DA	Democratic Alliance

DEAT	Department of Environmental Affairs and Tourism
EESP	Economic, Environmental and Spatial Planning Portfolio Committee
ERMD	Environmental Resource Department
EIA	Environmental Impact Assessment
FOCOS	Forum of Chairpersons of Subcouncils
HWC	Heritage Western Cape
ICLEI	International Council for Local Environmental Initiatives
IDP	Integrated Development Plan
IMEP	Integrated Metropolitan Environmental Policy
IUCN	The World Conservation Union
GPUP	Green Point Urban Park
MAYCO	Mayoral Committee
MOSS	Metropolitan Open Space System
NGO's	Non-Government organisations
NSRI	National Sea Rescue Institute
PAWC	Provincial Administration: Western Cape
SARCC	South African Rail Commuter Corporation
SDF	Spatial Development Framework
SLH	Smart Living Handbook
UDM	United Democratic Movement
WOF	Working on Fire

EESP 01/02/12 OPENING AND WELCOME

The Chairperson, Cllr Bloor welcomed everybody to the first meeting of 2012 and requested that a minute of silence be observed.

EESP 02/02/12 APPLICATIONS FOR LEAVE OF ABSENCE

None

EESP 03/02/12 CHAIRPERSONS REPORT/ADDRESS

The Chairperson addressed the Committee on the following:

(a) the opening of Parliament and the state of the Nation Speechby the President.

(b) a Sustainable environment where all role players can contribute and participate.

(c) the presentation by WESGRO (item EESP 06/02/12)

(d) Future activities of the Portfolio Committee which includes a site visit to Soil for Africa, a workshop on the Corporate scorecard, and a workshop to evaluate the impact of funds on economic development projects

Thereafter the Chairperson afforded Mr J Hugo the newly appointed Executive Director: EESP the opportunity to introduce himself to the meeting.

It was further agreed that item **EESP 10/02/12 CAPE TOWN DENSIFICATION POLICY** will be discussed as the last item on the agenda.

EESP 04/02/12 MINUTES FOR CONFIRMATION: 1 NOVEMBER 2011

RESOLVED that the minutes of the meeting held on 1 November 2011 be confirmed subject to the following amendments

AFRICAN NATIONAL CONGRESS
PRESENT
ANC

A Ehrenreich

ACTION: R RIFFEL

EESP 05/02/12 REPORT ON MATTERS OUTSTANDING

See Outstanding matters report.

PRESENTATION

EESP 06/02/12 STRATEGIC PRIORITIES AND PROGRESS REPORT FOR THE WESTERN CAPE INVESTMENT AND TRADE PROMOTION AGENCY (WESGRO) - AN EXTERNAL AGENCY FOR THE CITY OF CAPE TOWN'S INVESTMENT AND TRADE PROMOTION ACTIVITIES

Mr N Flaatten, Chief Executive Officer, WESGRO presented this matter. A copy of the presentation is attached as Annexure A to the official minutes.

Mr Flaatten elaborated on the following:

- Overview of WESGRO
- The South African Economy
- The Western Cape Economy

Members submitted the following questions and comments

- Job creation opportunities in the BPO and agro- processing sectors.
- Positive investment versus job opportunities
- Interaction with communities especially with regards to

training and education
- Responses and impact on employment
- Prioritizing sectors for job creation
- Coherent Strategy for economic development
- Co-operation with all spheres of Government
- Deployment of funds – National initiatives
- Distinguish between government funds and private funds
- Contributions of other Municipalities to WESGRO
- Status of the Wine industry
- Comparison of other Provinces re export/import
- Creation of subcommittees
- Report from the Auditor General
- Is Cape Town Gate way to Africa?

Mr Flaatten responded to the above questions and he also informed the meeting that his office will circulate the following reports to members of the Portfolio Committee:

- Statistics regarding jobs per sector over 3 years
- FDI into the City Private and Public sectors funds
- A copy of the Memorandum of Agreement between the City of Cape Town and WESGRO.

RESOLVED that the presentation by Mr N Flaatten, Chief Executive Officer of WESGRO be noted.

EESP 07/02/12 APPLICATION FOR AN AMENDMENT TO THE IMHOFF'S GIFT LOCAL STRUCTURE PLAN, REZONING AND DEPARTURE IN TERMS OF THE LAND USE PLANNING ORDINANCE NO. 15 OF 1985 AND FOR CONDITIONAL USE IN TERMS OF THE ZONING SCHEME REGULATIONS: ERF 4225 KOMMETJIE, CORNER OF ATLANTIC DRIVE AND RAMERON AVENUE

RECOMMENDED that the application for an amendment to Imhoff's Gift Local Structure Plan as set out in Paragraph 7.9 in respect of the development on Erf 4225, be supported and the competent authority (Provincial Government of the Western Cape) be advised accordingly.

ACTION: R RIFFEL, M WALKER

EESP 08/02/12 APPLICATION FOR 1) AMENDMENT OF THE GUIDE PLAN FOR THE CAPE METROPOLITAN AREA: PENINSULA OF 1988 AND 2) SUBDIVISION OF ERF 226, SCHAAPKRAAL 3) DEPARTURE FROM THE MINIMUM ERF SIZE AND SIDE SPACE IN RESPECT OF ERF 226, SCHAAPKRAAL, CORNER OF VLEI AND MIDDEL ROADS, SCHAAPKRAAL

Ms M Walker confirmed that the application for subdivision resides inside the Urban Edge after a question by Ald Nieuwoudt

Cllr Bloor confirmed that all-encompassing deliberations and consultations needs to take place regarding the greater Philippi area after Cllr Kannenberg enquired about a new study for the Philippi area.

RECOMMENDED that**:**

1 the Executive Mayor and Mayoral Committee (MAYCO) recommends to the Competent Authority that the application for the amendment of the Guide Plan for the Cape Metropolitan Area: Peninsula (deemed to be an urban structure plan) of 1988 with respect to Erf 226, Schaapkraal to permit 2 land units each smaller than 2ha in extent (8121m^2 and 8121m^2) **BE REFUSED** in terms of Section 4(7) of the Land Use Planning Ordinance, 15 of 1985 (LUPO), and Section 6A(19) of Act 88/1967 as remaining applicable under Section 37(1) of the Act 125/1991.

2 subject to the adoption of resolution 1 above by the Executive Mayor, the Spatial Planning Environment and Land Use Management Committee (SPELUM) decision making powers for the application listed under resolution 3 below, **NOT BE EXERCISED** and that resolution 3 below be referred to the Competent Authority together with the application to amend the Guide Plan in line with Provincial Circular 4/2009 (paragraph 4) which deals with development packages.

3 Subject to the adoption of resolution 1 above by the Executive Mayor, **TO RECOMMEND** to the Competent Authority:

3.1 that the application for Subdivision of Erf 226, Schaapkraal as indicated on the plan in Annexure “F” to the report **BE REFUSED** in terms of Section 25(1) of LUPO.

3.2 that the application for Departure from the minimum Erf size of 21,5ha to permit 2 land units of 8121m^2 and 8121m^2 and the side space departure of 12m in lieu of 30m, **BE REFUSED** in terms of Section 15 (1)(b) of LUPO.

ACTION: R RIFFEL, M WALKER

EESP 09/02/12 APPLICATION FOR AN AMENDMENT TO THE SIMON'S TOWN STRUCTURE PLAN, REZONING, SUBDIVISION AND DEPARTURES: REMAINDER ERF 438, PORTION OF ERF 420 AND ERVEN 439, 444,445,446,447, 465,466,467,2451,2452 AND 3735 SIMON'S TOWN, MAIN ROAD (MARINE OIL REFINERY SITE)

Cllr Kannenberg recused himself from the meeting during the discussion of this item.

RECOMMENDED that the application for an amendment to the Simon's Town Structure Plan from existing Industrial to Urban Development for Remainder Erf 438, portion of Erf 420 and Erven 439, 444, 445, 446, 447, 465, 466, 467, 2451,2452 and 3735 Simon's Town as depicted on Plan LUM/67/438 be supported and the competent authority (Provincial Government of the Western Cape) be advised accordingly.

ACTION: R RIFFEL, P EVARD , P HOFFA

EESP 10/02/12 CAPE TOWN DENSIFICATION POLICY

A replacement Annexure 3 – "**INTERIM GUIDELINES FOR THE PROVISION OF PARKING"** was tabled at the meeting, it was agreed that the Annexure be included in the policy document.

Members of the Portfolio Committee proposed the following:

- Cllr Kannenberg proposed that the comments from the Portfolio Committee be submitted to the Executive Mayor and Mayoral Committee and Council in order to haste the approval process;

- Cllr Nieuwoudt proposed that the Densification Task Team be reactivated to oversee the implementation of the policy and to further consult on matters arising from the policy.

  Both proposals were duly supported.

Members of the Portfolio Committee raised the following concerns:

Cllr Nieuwoudt requested that the Densification policy be treated as guidelines until the approval of the draft CTZS and overlay zones.

Cllr Taylor requested clarity regarding the public participation sessions that were held for the general public.

Ms Walker elaborated on Annexure 3, she informed the meeting that the parking policy is now aligned with the integrated zoning

scheme local scale overlay zones, thereafter she responded with regards to the public participation processes.

Cllr Raymond expressed the opinion and proposed that the character of small historical towns and suburbs be protected and preserved.

Cllr Raymond then referred to the term “Inclusionary housing” as reflected under Terms and Definitions (page 807 of the agenda for the meeting), he referred to a recent legal matter in Gauteng and requested that a legal opinion be obtained about the inclusion thereof in the proposed policy.

Ald Sitonga in turn stated that one of the aims of the Densification policy was to integrate the City and if possible the term “Inclusionary housing” should be substituted with another appropriate word but that the principle/ focus of housing integration should remain.

Cllr Taylor referred to the questions raised by the public and the responses thereto during the public participation process, he requested that responses should be submitted in detail along with the relevant reference documents, as an example referred to the first bullet point on page 853 of the agenda for the meeting.

Cllr Kannenberg concurred with Cllr Taylor and referred to:

- page 851 of the agenda for the meeting appendix C 1.2, relating to market realities and specifically to the lack of information referring to the expert review panel on the Blaauwberg road study, he requested more information on this matter.

- Page 830 of the agenda for the meeting DP 16 which refers to maximum parking standards, Cllr Kannenberg stated that it is a problem to limit parking in an area where there is a lack of public transport, he requested that the maximum standards be scrapped and that the minimum standards be retained.

- page 830 of the agenda for the meeting – Annexure 1 Table-: A1 Summary of mechanisms that can be used to encourage densification – incentives- increased developer contributions; he requested that the sentence be rephrased.

Ms N Walker responded to the above submissions.

Discussion ensued about maximum and minimum parking standards several officials verbally responded.

Mr J Hugo, ED Economic, Environment and Spatial Planning referred the meeting to the decline of the CBD of the City of Johannesburg, due to restrictive parking conditions and policy; he further stated that the relevant Portfolio Committees should also consult on the draft parking policy.

After further discussions it was agreed that the technical debate regarding the maximum and minimum parking standards be discussed in detail by the Densification Task team.

Ald Nieuwoudt referred to page 820 of the agenda for the meeting, specifically DP9 and requested that the word **must** in the sentence be replaced by the word **may**.

RECOMMENDED that:

(a) the Executive Mayor and the Mayoral Committee note and considers the comment as submitted by members of the Portfolio Committee;

(b) the Executive Mayor and the Mayoral Committee endorses the Cape Town Densification policy and that it is forwarded to Council for approval;

(c) the Director of Planning and Building Development be requested to circulate the policy to all land use planners within her department to ensure that the policy is used in the assessment of density related applications.

RESOLVED that :

(a) the Densification task team be re-established in order to oversee the implementation of the policy and to further consult on matters arising from the policy;

(b) the maximum and minimum parking standards be discussed in detail by the Densification Task team.

ACTION: R RIFFEL, N WALKER

EESP 11/02/12 APPLICATION FOR A TEMPORARY LAND USE DEPARTURE TO PERMIT OFFICES AND A HAIR SALON IN RESPECT OF ERF 13298, 14 MERLOT AVENUE, TABLE VIEW

Mr J van der Westhuizen confirmed that the “Non Residential Uses in Residential Areas Policy” (2000) is currently under review and that a report in this regard will be submitted to EESP in the near future.

RESOLVED that it be noted that the "Non Residential Uses in Residential Areas Policy" (2000) is currently under review and that a report in this regard will be submitted to EESP in the near future.

ACTION: J VAN DER WESTHUIZEN

EESP 12/02/12 CITY DEVELOPMENT STRATEGY FOR CAPE TOWN 2040: UPDATE AND WAY FORWARD

Ald Sitonga proposed that National Government and State owned entities also be included in the wider stakeholder engagement.

RECOMMENDED that the contents of the report be noted and that National Government and State owned entities also be included in the wider stakeholder engagement.

ACTION: R RIFFEL, SMITH ,C WRIGHT

EESP 13/02/12 BROADER TYGER VALLEY URBAN DESIGN FRAMEWORK: PROGRESS REPORT

Ald Nieuwoudt enquired whether the IRT route and Public Transport nodes have been accommodated in the design framework.

Ald Nieuwoudt enquired about the removal of the sports fields adjacent to the Velodrome, which are currently being utilised by several schools in the area.

Mr G Kruger confirmed that the IRT feeder routes have not been finalised and that the Cycle track and adjacent sports fields will remain.

Ald Sitonga enquired about the future development of the Stellenbosch University site.

Mr G Kruger responded and informed the meeting that the Stellenbosch University matter resides within the Property Management department and those negotiations and consultations are work in progress.

RESOLVED that:

(a) the broad process plan to develop the Tyger Valley Urban design framework be supported;

(b) the next report reflects clarity on the finalisation of the IRT

route and Public transport nodes as well as confirmation that the sports facilities for schools will not be removed.

ACTION: G KRUGER

EESP 14/02/12 SCHEDULE OF LOCAL AREA PLANNING INITIATIVES PRIORITISED BY THE SPATIAL PLANNING AND URBAN DESIGN DEPARTMENT

Ald Sitonga enquired about the inclusion of Khayelitsha, Harare, Site C and the Philippi areas in the Strategy; he also referred to the operations of VPUU and PEDI in the areas.

Cllr Kannenberg referred to the Mayoral Urban regeneration programme and requested clarity on the two initiatives.

Ald Walker, Mayoral Committee member responded and informed the meeting that the Mayoral Urban regeneration programme is based on VPUU principles and is separated from spatial and urban design.

It was agreed that a Task Team be established to discuss spatial and urban design matters.

Ald Nieuwoudt enquired about time frames and resources for local area plans.

Mr Daniels responded in detail about the selection of local area plans, projects current and new as well as progress reports and engagement with the relevant Subcouncils.

Ald Nieuwoudt proposed that the Voortrekker corridor be prioritized.

RESOLVED that**:**

(a) the schedule of local area planning initiatives proposed as SPUD's prioritised programme for the next three years be endorsed;

(b) a Task Team be established to discuss spatial and urban design matters;

(c) the Voortrekker Road corridor be included in the schedule as a priority project.

ACTION: C DANIELS

EESP 15/02/12 PROPOSED PLAN OF ACTION FOR THE DEVELOPMENT AND FORMALISATION OF THE CITY'S COASTAL ZONE REGULATORY MECHANISMS IN ACCORDANCE WITH THE REQUIREMENTS OF THE INTEGRATED COASTAL MANAGEMENT ACT (ACT NO. 24 OF 2008)

Members congratulated the officials for an excellent report and proposed that a coastal engineer be appointed to the department.

Mr Asmal confirmed that the administrative process for filling of the position is in progress and receiving attention.

Ald Nieuwoudt enquired whether the rights of property owners inside the coastal zone will be affected, as no proper answer was forthcoming at the meeting it was agreed that the Legal advisor would provide clarity at the next meeting.

Mr Collenbrander responded and stated that private properties in the coastal zone have been excluded and that rights of these property owners have not been affected.

Ald Nieuwoudt proposed that a report be submitted to EESP regarding the rights of property owners inside the coastal zone.

Cllr Kannenberg referred to the properties in the coastal zone and enquired about the City's operational procedures with regards to rezoning and the submission of new building plans from the property owners.

Ms Walters informed the meeting that the Coastal protection by-law has not been drafted but that it will contain all legal aspects and that the CTZS will determine the land use and rights for all affected properties,

RESOLVED that:

(a) EESP supports the process, development and formalization of a number of coastal zone regulatory mechanisms for the City of Cape Town in accordance with the requirements of the Integrated Coastal Management Act (ICMA) as outlined in this report;

(b) EESP formally supports and requests that the City's Coastal Urban Edge as defined in the Spatial Development Framework be formally considered by the Provincial Government of the Western Cape for promulgation as the Coastal Development Setback Line for the City's coastline as required by the ICMA;

(c) EESP supports the renaming, review, revision and further public consultation of the City's Draft Coastal Protection Zone By-law as the appropriate means to regulate the coastal space between the Development Setback Line and the High Water Mark;

(d) EESP supports the spatial definition and mapping of a coastal Protection Zone for the City for which the Coastal Management Programme would be relevant;

(e) EESP supports the Drafting of the City's Coastal Management Programme as required by the ICMA as well as a key City tool for managing, enhancing and protecting its valuable coastline, and

(f) EESP supports the development of a City Coastal Hazard Policy for the City of Cape Town.

ACTION: D COLLENBRANDER

EESP 16/02/12 THE EXTENT AND STATUS OF REMAINING MINERAL RESOURCES IN THE CITY OF CAPE TOWN

RECOMMENDED that the information provided in this report is noted by the Mayoral Committee and that the relevant City departments use the information in their planning and decision making processes.

RESOLVED that:

(a) the relevant officials inform EESP members as soon as an application for mining authorisation or prospecting in the City of Cape Town area and neighbouring municipalities is accepted by DME in order to afford councillors the opportunity to properly formulate comments;

(b) the result of the research be finalised in such a manner that it can be incorporated and utilised in ISIS.

ACTION: R RIFFEL, A PURVES

EESP 17/02/12 COMMENT ON THE DRAFT WESTERN CAPE AQUACULTURE IMPLEMENTATION PLAN

Members submitted the following proposals to be included as comments from the Portfolio Committee:

- proposed that Local government should be part of the consultation process going forward;

- proposed that Public access to the sea and beaches should be sustained and guaranteed;

- proposed that proper scientific research be done regarding this matter in order to formulate criteria/ guidelines on which all future decisions will be based upon;

The above proposals were duly supported.

Ms A Davison responded to a question about the composition of the Technical team;

Mr J van der Westhuizen responded to the matter of aquaculture zoning stating that property owners will have to apply for consent use.

RESOLVED that the following be put forward as comments from the Portfolio Committee.

(a) that Local government should be part of the consultation process going forward;

(b) that Public access to the sea and beaches should at all times be sustained and guaranteed;

(c) that proper scientific research be done regarding this matter in order to formulate criteria/ guidelines on which all future decisions will be based upon;

ACTION: A DAVISON

EESP 18/02/12 TABLING OF CITY'S ANNUAL REPORT AND EXECUTIVE SUMMARY 2010/2011 FOR COMMENT

Cllr Limberg (Deputy Chairperson), highlighted the following contained in the Annual report:

- 13 145 jobs created through EPWP;
- Expansion of the Cape Town Convention creating a conventions precinct, office blocks and a hospital which will more jobs and stimulate the local economy;
- Energy and Climate Change action plan has resulted that Cape Town has become a more resilient City regard to climate change.

RESOLVED that:

(a) the comments submitted by Cllr Limberg be noted;

(b) members submit comments and questions to the IDP department, for consideration during the oversight process.

ACTION: EESP MEMBERS

EESP 19/02/12 2011/2012 SECOND QUARTER'S PROGRESS REPORT ON CORPORATE PERFORMANCE AND PERFORMANCE OF THE CITY'S ENTITY

Cllr Kannenberg enquired on Annual target for indicator 1A.3 Percentage of Land Use applications finalised within statutory timeframes.

Mr Crous and Ms Walters submitted clarity with regards to the above they elaborated on the target, the submission process and circulation to other departments, 4 month application objections and delegations; lastly they invited members to an informal discussion regarding statistics.

Cllr McCarthy referred to the following indicator for Utility services: 2A.4 number of water service points (taps) installed for informal settlements and enquired what steps have been taken to rectify the situation.

As there was no representative present at the meeting it was agreed that the presentation as mentioned under the column Remedial Action be presented to EESP by the relevant official.

RECOMMENDED that:

(a) the Executive Mayor together with the Mayoral Committee considers and approves the performance of the of the second quarter of the 2011/2012 financial year;

(b) Council notes the performance of the second quarter of the 2011/2012 financial year.

RESOLVED that with reference to the Utility services indicator 2A.4 number of water service points (taps) installed for informal settlements the presentation as mentioned under the column Remedial Action be presented to EESP by the relevant official at the next meeting in March 2012.

ACTION: W STEENKAMP, P MASHOKO, B SAAYMAN.

EESP 20/02/12 ECONOMIC ENVIRONMENTAL AND SPATIAL PLANNING : 2011/21012 SECOND QUARTERS PROGRESS REPORT ON THE DIRECTORATE AND DEPARTMENT'S PERFORMANCE DIRECTORATE

Cllr Raymond requested clarity on the following indicators regarding the ERM department:

- Finalisation of nature reserve boundaries;
- Completion of a 10 year infrastructure development plan
- Management positions filled
- Percentage improvement of responsiveness in service delivery
- Percentage spend on Capital Budget spent
- Percentage Internal Audit findings resolved

Ald Sitonga concurred with Cllr Raymond and expressed his concerns over the low percentage spent on the Capital Budget.

Ald Nieuwoudt enquired on progress regarding the transfer of the Heritage delegations to the City of Cape Town.

Mr Asmal and Ms Gerrans responded to the above questions and comments.

RECOMMENDED that the Executive Mayor approves the Directorate's and Department's performance for the second quarter of the 2010/2012 financial year

ACTION: R RIFFEL, C BASSON

EESP 21/02/12 FEEDBACK REGARDING THE DISTRICT OFFICES PERFORMANCES PERTAINING TO BUILDING PLAN APPLICATIONS APPROVED AND LAND USE APPLICATIONS FINALISED FOR THE PERIOD OCTOBER - DECEMBER 2011

Ald Nieuwoudt congratulated the officials on a well prepared user friendly report; she however expressed her concern over the slow and long reaction times of other departments on applications.

Cllr McCarthy proposed that building plans be circulated electronically amongst the relevant departments and that staff should be performance managed.

Cllr Kannenberg referred to the under performance of the Table bay district office.

Cllr Bryant questioned the impact of objections on building plan

approvals and statistics.

Mr Crous responded to all of the above comments and he further informed the meeting of the time consuming process of obtaining input on building plan and land use applications from other departments he also elaborated on the project progress to electronically circulate building plans electronically amongst relevant departments.

RESOLVED that contents of the report as well as the verbal submissions by Mr Crous be noted.

EESP 22/02/12 VACANCY ANALYSIS

Cllr Raymond requested that critical posts in the Directorate be reflected in the report.

Ald Nieuwoudt referred to the upkeep and maintenance of specific skills and the ageing age analysis of the building inspectors.

Ms Walters responded and stated that resignations and retirements have not affected the department with regards to the loss of institutional knowledge; she further added that long service does not necessary mean good skill.

Ms Walters also confirmed the age analysis of the building inspectors and informed the meeting of the recruitment process.

Cllr Limberg commented on vacancies versus capacity and as an example she mentioned the local business area branch that has a shortage of staff in dealing with informal trading issues.

Mr Asmal commented on ERM vacancies and stated that younger staff members at entry level often seek advancement and move more frequently between positions.

Mr Asmal also informed that the Energy and Renewable energy as well as the Heritage sections are at risk due to the shortage of qualified staff in these areas.

Cllr Bryant referred to the alleged unlawful actions of building inspectors.

Ms C Walters responded and invited all members and the public to report all unlawful actions to the fraud line and to submit concrete evidence in order to institute further action. She also warned against unsubstantiated allegations which could put the City and staff members at a disadvantage.

Mr J Hugo, ED EESP concurred and stated that he has a zero tolerance approach to corruption and unlawful actions of all members of staff and that he will act accordingly.

RESOLVED that critical positions in EESP departments be reflected in all future reports.

ACTION: K PETERSEN, A ARENDSE

MOTION

EESP 23/02/12 ILLEGAL BUILDING WORK - CLLR C ANSTEY

Cllr C Anstey introduced this motion, duly seconded by Cllr J McCarthy.

Cllr Anstey proposed that a Task Team be established to investigate and propose new by- laws to contain and improve the current situation with regards to illegal building work for the following reasons:

(a) the large number of illegal building works continuously occurring in the City on a regular basis and disregard for building regulations;

(b) the large amount of time Councillors and officials are absorbed in dealing with these matters as opposed to promoting and approving correct development plans;

(c) the ineffective penalties applied;

(d) the disruptive nature on neighbouring ratepayers;

(e) the large number of applications through sub councils to correct illegal works which are a result of a total disregard for building regulation without any compensation to the city or ratepayers.

Several members requested that an educational component be added to the mandate of the Task Team.

The proposal was duly supported.

The following members indicated that they will serve on the Task Team:

Cllr Anstey (Chairperson)

Cllr McCarthy

Cllr V Dyantyi

RESOLVED that:

(a) the Illegal Building task team be established consisting of the following members, Cllr Anstey (Chairperson), Cllr McCarthy and Cllr V Dyantyi.

(b) The TASK Team further consult on the matter of an educational component for property and homeowners regarding illegal building work.

ACTION: C WALTERS

THE MEETING TERMINATED AT 15: 20

_____

G BLOOR
CHAIRPERSON **Date:**

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

THIS CITY WORKS FOR YOU

DRAFT

CITY OF CAPE TOWN
INTEGRATED COASTAL MANAGEMENT POLICY

GLOSSARY

Definitions used in this policy –

Accretion: Gradual accumulation of sediment.

Aeolian transportation: Carried by wind.

Biodiversity: Biological wealth of a specified geographic region: including the different marine, aquatic and terrestrial ecosystems, communities of organisms within these, and their component species, number and genetic variation.

City: The City of Cape Town established in terms of section 12 of the Local Government: Municipal Structures Act of 1998 by Provincial Notice No. 479 of 2000.

city: Cape Town metropole.

Climate adaptation: Adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Climate change: A significant and lasting change in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It may be a change in average weather conditions or the distribution of events around that average (e.g. more or fewer extreme weather events). Climate change may be limited to a specific region or may occur across the whole earth.

Coast: The inshore marine environment up to 500 metres seaward of the High Water Mark. The interface between the marine and terrestrial environments and the land directly exposed to coastal processes, tidal influence and storm surges.

Coastal Protection Zone: The Coastal Protection Zone contemplated in section 17 of the Integrated Coastal Management Act 2009.

Coastal edge: Area around the coast demarcated in Cape Town's Spatial Development Framework as the seaward extent of the City's development footprint, primarily to protect coastal resources and avoid risks pertaining to flood-prone areas.

Coastal zone: The area seaward of the Coastal Protection Zone boundary, the seashore, coastal waters and the exclusive economic zone and

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includes any aspect of the environment on, in, under and above such area.

Council: City of Cape Town Metropolitan Municipality, established in terms of the Local Government: Municipal Structures Act 1998, read with the Province of the Western Cape: Provincial Gazette 558 dated 22 September 2000.

CTSDF: The Cape Town Spatial Development Framework, as approved in terms of the Municipal Systems Act 32 of 2000 (section 34) as well as the Land Use Planning Ordinance 15 of 1985 (section 4(6)).

Development: Any process initiated by a person to change the use, physical nature or appearance of that place, and includes –

(a) the construction, erection, alteration, demolition or removal of a structure or building;
(b) a process to rezone or subdivide land;
(c) changes to the existing or natural topography of the coastal zone; and
(d) the destruction or removal of indigenous or protected vegetation.

Development footprint: The outer extent of urban development.

Disaster risk management: The continuous and integrated multi-sectoral, multi-disciplinary process of planning and implementation of measures aimed at – (a) preventing or reducing the risk of disasters; (b) mitigating the severity or consequences of disasters; (c) emergency preparedness; (d) a rapid and effective response to disasters; and (e) post-disaster recovery and rehabilitation.

Disaster risk reduction: The systematic development and application of policies, strategies and practices to minimise vulnerabilities and disaster risks throughout a society to prevent and limit negative impacts of hazards, within the broad context of sustainable development. In South Africa, disaster risk reduction is an integral and important part of disaster management.

Dynamic coastal processes: All natural processes continually reshaping the shoreline and near shore seabed, including —

(a) aeolian movement of sand;
(b) migrating dune systems;
(c) wave action;
(d) coastal storms;
(e) currents;

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(f) tidal action;
(g) river flows;
(h) erosion; and
(i) accretion

Ecosystem: A dynamic system of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.

EGS: Ecosystem goods and services: The resources and functions that accrue from the natural environment.

Exclusive Economic Zone: The Exclusive Economic Zone of the Republic referred to in section 7 of the Maritime Zones Act 1994.

High Water Mark: The High Water Mark as defined in section 1 of the Integrated Coastal Management Act 2009.

Infrastructure: Any temporary or permanent structure made by humans.

Littoral active zone: Any land forming part of, or adjacent to, the seashore that is –
(a) unstable and dynamic as a result of natural processes; and
(b) characterised by dunes, beaches, sand bars and other landforms composed of unconsolidated land, pebbles or other such material which is either unvegetated or only partially vegetated.

Public Open Space: Land zoned as open space, located in urban areas and accessible to the general public.

Risk: The measure of potential harm from a hazard or threat. Risk is usually associated with the human inability to cope with a particular situation. In terms of disaster risk management it can be defined as the probability of harmful consequences, or expected losses; including death, injury, damage to property and the environment, jobs, disruption of economic activity or social systems. Hazards will affect communities differently in terms of ability and resources with which to cope. Poorer communities will be more at risk than others.

Vulnerability: The degree to which people, property, the environment or social and economic activity – in short, all elements-at-risk – are susceptible to injury, loss of life, damage, disruption, exploitation or incapacitation by all hazards.

Zoning Scheme: Determines the zoning categories and land uses permitted within each category.

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1. Introduction and overview

1.1 The coast as an asset

The City of Cape Town ("City") has an extensive coastline of 307 km which is an important economic, social and environmental asset. Characterised by a highly sensitive, complex and dynamic coastal environment, the city's coastline provides communities and visitors to Cape Town with a multitude of social and economic benefits and opportunities as well as essential Ecosystem Goods and Services (EGS) (Table 1). These goods and services may be broadly categorised into the following coastal services:

Cultural The non-material benefits people obtain from coastal ecosystems such as spiritual enrichment, reflection recreational and aesthetic experiences etc.

Provisional The products obtained from coastal ecosystems, including sea-food, fuel, genetic resources, minerals, natural medicines, pharmaceuticals, ornamental resources etc.

Regulatory The benefits obtained from the regulation of coastal ecosystem processes, including, climate regulation, water regulation, erosion regulation from storm surges, disease regulation, pest regulation, pollination, natural hazard regulation etc.

These goods and services provided by the shoreline are key contributors to the city's economy, desirability and global recognition as one of the world's most beautiful and popular cities.

Cultural	Provisional	Regulatory
Freely accessible recreation and amenity for all from the coast	Marine resources i.e. fish	Assimilatory function for urban waste
Contribution to global desirability of Cape Town	Social development opportunities	Buffer function against storm surges, erosion and sea level rise
Cultural and spiritual sanctuaries	Educational opportunities	Regulation of ecosystems
Coastal aesthetics	Tourism	
Collective identity	Livelihood development opportunities	
Sense of place and heritage as a city	Commerce and industry	
	Enhanced property values	
	Unique and diverse biodiversity	
	Events and filming	

Table 1: Coastal Ecosystem Goods and Services.

Our coastline is an important asset for the City's economy, it is where our communities recreate and where they interact, it draws our visitors, protects our city, property and infrastructure from storm

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surges, receives our waste and supports our unique and diverse fauna and flora. It is central to our history and common identity and shapes Cape Town's unique sense of place.

Central to this value is that the City's coast is, and must remain, a common asset belonging to and accessible to all. Further, this value of the coast is determined by both its quality and functionality.

As such it is imperative that the City implements a policy that not only optimises the value of the coast and protects it as a common asset for all, but one that also creates a framework for the effective governance, decision-making and management of our coastline in the best interests of our city and its communities.

1.2 Coastline: A sensitive and dynamic space prone to risk

Waves and wind are the two dominant natural forces shaping the dynamic coast. Wave action causes erosion of sediment which long-shore winds and currents deposit along the coast, forming beaches and dunes, and further inland. Storms are drivers of rapid coastal change, often leading to abrupt erosion events and inundation of coastal areas.

These important components of healthy coastal systems are highly sensitive to change. This is particularly relevant along Cape Town's high energy coastline which is exposed to large weather systems and coastal storms and in which urban growth and coastal opportunities have created a desire to settle and develop.

Historic planning decisions made without the guidance of a City-wide integrated coastal management framework have resulted in encroachment into these areas, hardening the shoreline, restricting and altering natural processes, increasing the city's risk profile and reducing the value of the coast.

The resultant degradation or loss of ecosystem function compromises the ability of these systems to absorb the impacts of further coastal erosion and storm surge, further exacerbating risk. These problems are likely to worsen given the expected impacts of climate change, which include sea level rise and an increase in the frequency and intensity of coastal storms.

Risk may be physical, social or financial and can be transferred to coastal stakeholders over both temporal and spatial dimensions. The degradation of natural coastal processes negatively impacts the social and economic value of the coast. As the coast is a common asset, coastal risk and loss is shared between the authorities and the general public/individuals.

The decision-making processes behind coastal development are crucial to either creating a risk-prone, degraded coast or a high quality, resilient one.

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2. Rationale for policy and management framework

Coastal risk is compounded through decision-making in a policy vacuum. An effective policy environment is central to good governance, long term planning and optimising sustainable opportunities and growth. This Integrated Coastal Management Policy is therefore central to reducing risk, both to the City and its communities, and is core to retaining and enhancing the many current and future economic, social and environmental opportunities of our unique coastline into the future.

The local authority responsibilities of economic and social development, urban planning and land use management, as well as the Integrated Coastal Management Act's requirement for a Municipal Coastal Management Programme, enables the City of Cape Town to incorporate an integrated coastal management framework into its existing planning and management processes through this policy process.

3. Relevant legislation and approved Council policies

- The Constitution of the Republic of South Africa: Sections 151(3), 152(1) (d) and 156(5)
- Local Government: Municipal Structures Act, Act 117 of 1998
- Local Government: Municipal Systems Act, Act 32 of 2000
- National Environmental Management Act, Act 107 of 1998 (NEMA)
- Environment Conservation Act, Act 73 of 1989
- National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008 (ICMA)
    - Informed by the NEMA principles. These include maintaining and rehabilitating the "diversity, health and productivity of coastal ecosystems" and following a "risk averse and precautionary approach" to coastal management and planning "under conditions of uncertainty".
    - Sections 48-50 deal with municipal coastal management programmes and by-laws.
    - Section 62 deals with the implementation of land use legislation in the coastal protection zone.
- Sea Shore Act, Act 21 of 1935
- National Building Standards and Building Regulations Act, Act 103 of 1977
- Disaster Management Act, Act 57 of 2002
- Spatial Planning and Land Use Management Bill (once promulgated)
- Land Use Planning Act (once promulgated)
- Land Use Planning Ordinance, Ordinance 15 of 1985
- Cape Town Spatial Development Framework 2012
- Cape Town Zoning Scheme 2012
- Cape Town Integrated Metropolitan Environmental Policy 2001 (IMEP)
- Cape Town Floodplain and River Corridor Management Policy (2009)

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4. Strategic intent

The City envisions a coastline of the highest standard, where coastal ecosystems and our rich biodiversity are recognised as sensitive, complex, dynamic and essential to our future prosperity. The coast will be managed as core city infrastructure, valued and protected as an asset for current and future generations. The strategic focus areas of the City of Cape Town are enshrined in the City's Integrated Development Plan (IDP) and are categorised into five pillars. The city's coastal environment has the potential to support all five pillars:

An Opportunity city: by having due care for sustainability implications, this policy supports economic and social development opportunities.

A Well-Run city: through this policy, the City will be accountable to its citizens for its coastal decisions.

A Safe city: the reduction in coastal risk created through the enabling mechanisms of this policy provides a safer city for all.

A Caring city: this policy strives towards taking care of Cape Town's people, especially those most in need of assistance, by retaining and improving the state of their coastal environment.

An Inclusive city: this policy entrenches the rights of access to and enjoyment of the coast for all people and will manage the coast in the best interests of all communities.

5. Coastal policy principles

In working towards the strategic intent of this policy, the following coastal policy principles inform the City of Cape Town's coastal custodianship and will be applied in relation to all City coastal decision-making:

- The coastal environment is a shared asset held in trust for the common good of all. Equitable and ease of public access to all coastal areas and associated opportunities for the entire coastline is central to this value. The right of each individual to enjoy the coastline in the way of their choice, without impacting on other users' enjoyment must be protected.
- Economic and social development opportunities must be optimised to the benefit, and in the interest, of all communities, with on-going active investment in and management of the Cape Town coastline by the City.
- Development of coastal economic and social opportunities must be undertaken in a manner that does not reduce, harm or degrade our coastal environment or its ability to cope with climate risks in the future. The diversity and healthy functioning of natural coastal ecosystems and processes must be protected, restored and enhanced for their intrinsic as well as their economic, social and environmental values.
- Strategic, proactive, consistent and risk-averse coastal decision-making will be made in the best interests of the broader community of Cape Town, including the implementation of

proactive and progressive measures now, to reduce coastal risk from climate change, sea level rise and storm surge events in the future.

- All individuals must be accountable and responsible for their actions and must take due care to avoid creating negative impacts on our coastal environment. Our coastline must be an environment free of crime and where legal rights for sustainable resource consumption are protected while illegal resource consumption is acted against.

6. Policy statements

6.1 Common asset

The coastline is a common asset, a shared space and unique natural environment, which belongs to all South Africans.

In this regard the City will:

- Protect the rights of all people to access the coastline;
- Manage the coastline at all times in the best interests of all and not to the sole benefit or interest of individuals or groups;
- In all decisions, take due care to ensure the coastline and its value are not negatively impacted or degraded as a result of future development or urban growth; and
- Ensure that future development is appropriately set back from the coastline consistent with the City's Spatial Development Framework.

6.2 Access

Development along the coast can result in valuable spaces which should serve as central points of economic, social, cultural, spiritual, educational and recreational experience instead of becoming informally privatised space, limited to a few.

Conversely, uncontrolled or informal access to the coast is one of the primary contributors to dune erosion and disturbances of sensitive ecosystems, ultimately compounding risk from coastal processes.

Equitable access to the coast must therefore be enabled while ensuring that this access is regulated, organised and controlled in a manner that does not detract from, or negatively impact on, coastal values while also ensuring ease of access for all.

In this regard the City will:

- Formally designate Public Coastal Access Land at appropriate locations along the length of the City's coastline in accordance with the Integrated Coastal Management Act (ICMA);
- Ensure lateral coastal public access by acting against encroachment of private property into coastal public open space;

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- Generally not support sea defence mechanisms that result in the loss of public access or amenity; and
- Ensure that formalised public access points are appropriately distributed along the length of the coastline to facilitate public access for all communities.

6.3 Optimise economic and social opportunities

The coastline underpins much of Cape Town's economy and holds significant potential to contribute further economic growth and social development opportunities in Cape Town. However, the economic and social value of the coastline must be well-managed as poor decision-making, poor management, prioritising short term gains, over-development or inappropriate development can substantially diminish current economic and social value while removing the potential for any future economic and social opportunities.

In this regard the City will:

- Prioritise long term economic and social objectives;
- Address the inequalities of the past through promoting appropriate coastal nodal development as detailed in the City's Spatial Development Framework to connect communities to the coastline;
- Assess economic and social development opportunities on the coast in a holistic manner that understands the coastline as a single complex system, which has diverse opportunities and constraints determined by factors outside of our control;
- Optimise and invest the immense potential of Integrated Coastal Management to create long term sustainable employment opportunities across a range of sectors including coastal management, ecotourism, coastal risk reduction and coastal rehabilitation; and
- Invest in appropriate infrastructure that supports a wide range of economic and social development activities and opportunities.

6.4 Coastal recreation

Coastal recreation takes many forms and is one of the largest social activities in Cape Town. Coastal recreation underpins a range of economic activities in Cape Town and provides significant social development value.

In this regard the City will:

- Promote and support coastal recreation through maintaining, investing in and developing infrastructure and services that facilitate appropriate coastal recreation opportunities;
- Manage the coast as a shared environment where all forms of recreation that do not damage or degrade the coast have equal rights;
- Determine appropriate and defined use zones for various forms of coastal recreation where necessary, to reduce conflict, congestion, improve safety or reduce environmental and social impact;

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- Ban a form of coastal recreation in its entirety or from various locations, where it negatively impacts on the economy, social values and quality of the environment; and
- Regulate and enforce any recreation activities that require permits from any sphere of government.

6.5 Natural coastal processes, fauna and flora

Cape Town has a uniquely rich marine and coastal environment with significant diversity of fauna and flora. These natural systems form the foundation from which socio-economic systems benefit and community livelihoods are built, while playing an essential role in mitigating and reducing risk to the City, its infrastructure as well as private property.

In order to reduce coastal risk – especially given the future impacts of climate change on a rise in sea levels and increased frequency and intensity of coastal storm surges, whilst protecting the economic and social value of the coast, and coastal fauna and flora – it is imperative that we maintain a healthy functioning coastline.

In this regard the City will:

- Ensure that future coastal development is sensitive to the need to protect coastal processes and systems;
- Develop and implement a Coastal Overlay Zone as part of the City's Integrated Zoning Scheme to provide an appropriate land use management framework to protect our coastal systems;
- Invest in the on-going rehabilitation of degraded dune systems, beaches, estuaries, coastal corridors, rocky shores and coastal wetland systems;
- Implement Estuary Management Plans 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 protection against coastal erosion and storm surge damage;
- Designate highly valuable and sensitive natural coastal spaces or coastal heritage sites as Coastal Conservancy land; and
- Undertake coastal waste management in accordance with a Beach Cleaning Operational Protocol that recognises the importance of retaining functional ecological systems while meeting the social and economic needs of high recreation nodal points.

6.6 Heritage, identity and sense of place

Cape Town's coastline is integral to our history, our heritage, sense of place and unique identity. In addition our coastal landscapes underpin our scenic routes and global desirability and recognition.

In this regard the City will:

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- Consider all new coastal developments with regards to their potential impact on this unique and irreplaceable cultural landscape and heritage;
- Take into account architecture, colour, form and position when considering coastal development applications;
- Ensure all signage design and location does not detract from or impact on the unique and irreplaceable coastal landscape and heritage;
- Protect coastal sites and buildings of cultural and historical heritage value;
- Ensure that scenic drives and landscapes are retained and protected, and
- Ensure that any future coastal defences for the protection of private and public properties and City infrastructure are strategically managed by the City to minimise their visual and environmental impact.

6.7 Risk management and mitigation

Determining the most appropriate and sustainable course of action for response to growing coastal pressures requires sensitive navigation through the multiple and often conflicting interests of the various stakeholders, including private developers, property owners, government officials (across all three spheres), beach users, civil society and environmental pressure groups.

Further, it is a well-established fact that engineered coastal defence measures can often exacerbate the problem and cause coastal degradation at a large scale. This consideration is likely to increase in importance given the predicted climate change impacts of sea level rise and more frequent and intense coastal storm surges. Natural systems such as wind, wave action, long shore sand transport, erosion and accretion, and storm action are powerful systems that must inform and guide economic growth and development opportunities. It is therefore critical that decisions to protect any property from coastal dynamic processes are made in the interest of the broader community and after careful consideration.

In this regard the City will:

- Apply a consistent and cautious approach to coastal defences to be detailed and clearly stipulated in the City's Municipal Coastal Management Plan as a Protocol and Standard for Coastal Protection and Coastal Defences in Cape Town;
- Favour soft engineering approaches over hard engineering solutions;
- Require all new coastal developments, and changes to existing developments, to incorporate mitigation of and/or adaptation to coastal climate change impacts as part of their approval process;
- Ensure that coastal defences, to protect private property from the threat of coastal erosion, are only located on private land;
- Not approve coastal defence structures if the risk of shoreline erosion for adjacent areas is influenced;
- Retain the option of managed retreat over defence;
- Require that coastal defences be proven to reduce risk prior to being approved;

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- Favour coastal defences which are reversible, flexible, do not negatively impact on sense of place or aesthetics, and have other positive knock-on effects; and
- Undertake a broadly consultative process with the public when deciding on sea-defence interventions.

6.8 Coastal land alienation and acquisition

Where coastal land is unsuitable for development, either due to zoning or for environmental reasons, state ownership of coastal land will be consolidated. This includes acquisition of land by the City falling within its jurisdiction.

In this regard the City will:

- Guide the acquisition of coastal land in a way that reduces the risks faced by private owners affected by environmental and zoning regulations, thereby providing for enhanced management of sensitive coastal environments and establishing an enabling environment for investment; and
- Not alienate for sale or long-term leasehold any City-owned coastal land unless under exceptional circumstances.

6.9 Coastal safety and security

Illegal activity along the coast impacts negatively on the marine and coastal environment, the interests of residents, local livelihood opportunities, ecotourism potential and the safety of individuals.

Although the City's jurisdiction is determined by the High Water Mark, the City recognises that economic, recreational, environmental as well as illegal activities operate across these jurisdictional boundaries.

In this regard the City will:

- Actively seek to work with all relevant spheres of government and law enforcement agencies by promoting an inter-agency marine and coastal law enforcement approach;
- Protect and support the legal marine and coastal resource consumption activities while actively targeting all illegal resource consumption;
- Develop its own marine and coastal law enforcement capacity and resources;
- Consolidate City Regulations and By-laws to facilitate effective coastal law enforcement;
- Increase visible coastal law enforcement and policing; and
- Ensure appropriate informative regulatory signage is located along the coastline.

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7. Indemnities

The City of Cape Town is legally not responsible for, or required to protect, private property along its coastline that is at risk, becomes vulnerable to risk, or which may become vulnerable to risk as a result of coastal change which includes coastal erosion, accretion, sea level rise, storm surge events or any other coastal processes.

This includes no legal requirement of the City to provide sea defences, fund sea defences, approve or support the building of sea defences, or the financial or other forms of compensation to private property owners whose property has been damaged, destroyed or de-valued as a result of natural coastal processes.

Localised and individual sea defences by private landowners which may exacerbate problems along adjacent stretches of coastline will not be supported by the City. Furthermore, illegal construction of sea defences by private landowners will be acted against in terms of the City's land use management policies.

However, the City recognises that its coastal value is in part determined by the quality of the immediate coastal environment which includes private property. As such, the City is committed to leading open and transparent processes that will seek to find the most appropriate, effective, just and measured solutions to those parts of its coastline where coastal change has resulted in risk to the public amenity, public infrastructure and adjoining private property.

8. Giving effect to this policy – the City's Integrated Coastal Management Framework

To give effect to the policy principles, a set of implementation regulations, mechanisms and tools, which together constitute the City's Integrated Coastal Management Framework, will be developed to protect and manage Cape Town's coast in line with these policy objectives. The overview of the City's Integrated Coastal Management Framework is depicted in the flow diagram below.

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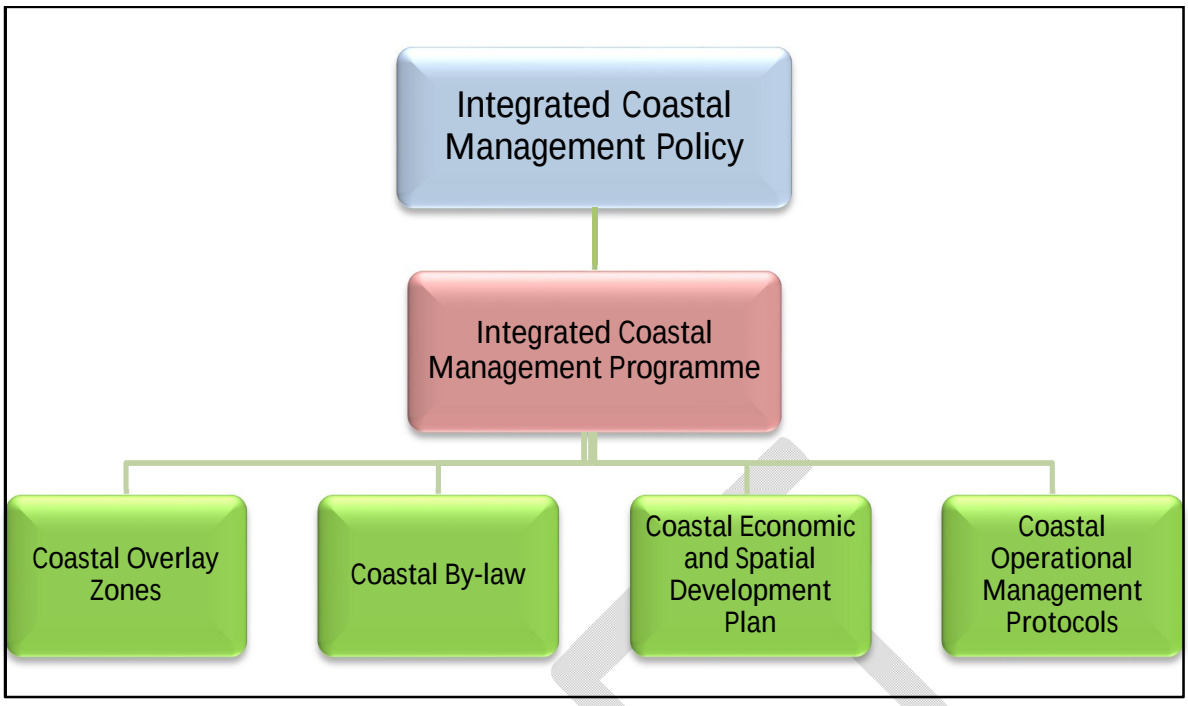


Figure 1: Integrated Coastal Management Framework for the City of Cape Town.

8.1 Coastal area

In order for the City's Integrated Coastal Management Framework to be effective, the spaces which it seeks to manage should be defined in a holistic way, taking into consideration the multitude of factors which impact on or are impacted by the dynamic interface between land and sea masses.

Recognising that social, economic and ecosystem processes take place across the High Water Mark, and given the need to ensure integrated management as well as proactive planning, the City will make an application, as allowed by the ICMA, for its area of responsibility to extend 500 metres seaward of the High Water Mark.

This application, if successful, will increase the effectiveness of the policy as well as the implementation framework. Based on this understanding, the applicability of the City's Overlay Zone and By-law may extend up to 500 metres seaward of the High Water Mark.

8.2 Integrated Coastal Management Programme

The City will develop and implement an Integrated Coastal Management Programme (ICMP), as required by the ICMA. This ICMP will be a comprehensive management and action plan detailing the City's day-to-day management approach for all aspects of the coastal environment over which it has jurisdiction. These management guidelines will be developed as Coastal Operational Protocols that will be used to set consistent standards for a range of coastal management aspects and ensure compliance with national legislation. In addition to these Coastal Operational Protocols, the ICMP

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will be given effect by coastal overlay zones, a coastal by-law and a coastal economic and spatial development plan.

8.3 Coastal overlay zones

Coastal Overlay Zones will be developed as a component of the City's Integrated Zoning Scheme. Overlay zones provide a mechanism which allows for the provision of more specific development rules to achieve the purpose of a particular City policy.

The Coastal Overlay Zones will fulfil the vision of this Integrated Coastal Management Policy, elevating its policy statements to land use regulations to reduce the City's risk profile, build resilience and promote sustainable coastal development. The overlays are considered the most appropriate mechanism to manage and regulate land use and building development.

The overlays will consist of a general overlay, covering the entire coast, to which a general set of regulations will apply; and specific overlays, in which more specific provisions will apply to particular areas.

8.4 Coastal By-law

The City will develop and implement a Coastal By-law. A by-law is the specific regulatory means for the City to regulate activities. The City is committed to ensuring that all activities carried out on the coast are conducted in a manner that is responsible, in the interests of public safety, and that such activities in no way detract from the amenity value of the coast or the natural coastal environment.

The by-law will assist in enhancing, protecting and optimising social and recreational opportunities by providing regulations that ensure socially and environmentally responsible activities along the coast.

8.5 Coastal economic and spatial development plan

The City will develop a strategic plan that examines the coast as a single, connected space and identifies appropriate public coastal development in order to optimise social and economic opportunities, including those linked to the private sector.

The plan will prioritise opportunity development and give effect to the objectives of the City's broader Economic Growth Strategy and Social Development Strategy. The plan will, among other considerations, address coastal resort development, public access, marine access points, coastal public transport and consolidation of ecotourism and other commercial and industrial marine and coastal activities. This long-term planning is especially important in the context of expected climate change impacts, including sea level rise and increased frequency and intensity of storm surges.

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