DRAFT REPORT

ESTABLISHMENT OF COASTAL SET-BACK LINES FOR NMBM

April 2012.v4

Prepared on behalf of the Environmental Management Sub-Directorate of Nelson Mandela Bay Municipality by Masande Consultants and Afri-Coast Engineers SA (Pty) Ltd.

Executive Summary

Coastal areas are sensitive, vulnerable, often highly dynamic and stressed ecosystems. Increasingly coastal areas will be subjected to climate change impacts, particularly related to rising sea-levels and the potential increase in the frequency and intensity of storm events. Coastal areas therefore require specific attention in management and planning procedures, especially where the coastal areas are subject to significant human resource usage and development pressure.

Recent legislation aims to address issues relating to specific coastal management issues, namely the National Environmental Management: Integrated Coastal Management Act (ICMA), 2008 (Act No. 24 of 2008), which was promulgated on 11 February 2009. The objectives of the ICMA are:

- to determine the coastal zone of the Republic;
- to provide, within the framework of the National Environmental Management Act, for the co-ordinated and integrated management of the coastal zone by all spheres of government in accordance with the principles of co-operative governance;
- to preserve, protect, extend and enhance the status of coastal public property as being held in trust by the State on behalf of all South Africans, including future generations;
- to secure equitable access to the opportunities and benefits of coastal public property; and
- to give effect to the Republic's obligations in terms of international law regarding coastal management and the marine environment.

Amongst other management tools the ICMA provides for the establishment of coastal set-back lines and defines " a coastal setback line" as "a line determined by the Member of Executive Council (MEC) in accordance with section 25 in order to demarcate an area within which development will be prohibited or controlled in order to achieve the objectives of this Act or coastal management objectives".

Accordingly, the ICMA requires that a local municipality within whose area of jurisdiction a coastal set-back line has been established must delineate the coastal set-back line on a map or maps that form part of its zoning scheme in order to enable the public to determine the position of the setback line in relation to existing cadastral boundaries.

In addition, before making or amending the regulations referred to above, the MEC must—

(a) consult with any local municipality within whose area of jurisdiction the coastal set-back line is, or will be, situated: and

(b) give interested and affected parties an opportunity to make representations in accordance with Part 5 of Chapter 6.

Therefore by virtue of the area of jurisdiction of the Nelson Mandela Bay Municipality situated along the coast it is a legal requirement for NMBM to establish its coastal development setback lines as set out in section 25 of the Act.

In addition during the process of determining coastal set-back lines for NMBM it became evident that it would be advantageous to adjust the "coastal protection zone" ,as defined in the ICMA, as part of the process.

Masande Consultants and Afri-Coast Engineers SA (Pty) Ltd have been assigned by NMBM to undertake this commission. The methodology selected was based on a combination of national and international best practice and the consultant's experience. In addition the methodology was closely aligned with the national approach to the subject. A pragmatic approach was selected, using only available data and with limited numerical modelling. The data used included: tide data, wave data, predicted sea level rise (IPCC, 2007) Digital Terrain Model (DTM), bathymetry (SANHO) aerial photographs, cross shore profiles, cadastral data, Nelson Mandela Metropolitan Open Space System (NMB MOSS).

The summarised methodology, results and conclusion of the study are presented in the consecutive steps below.

Step 1: Determine 1:10 year storm wave height and period for NMBM coastline

From evaluation of the results of extreme wave statistics presented in table 1 above, it was decided that the predicted 17% increase in wave height due to climate change should be incorporated and thus the extreme 1:10 year return wave conditions to be used are H_o = 9.8 m as calculated for a position at 30m water depth off Cape St Francis (PRDW, 2009).

The coastal set back process which is being developed in the Western Cape has chosen the 1:100 erosion risk which is determined using the numerical model SBEACH. This type of modelling exercise was not envisaged at the start of this project. This would entail setting up the model for the entire coast and the collecting additional data. In view of this it is proposed that a 1:10 year run up event is combined with a 1:100 year shoreline retreat trend is used as separate parts rather than combining these through the SBEACH model. It must be understood that this is different to the SBEACH analysis however given the additional buffers still to be included in determining the setback lines it is unlikely that a significant difference will be found. However, it is recommended that when an SBEACH erosion model is undertaken in this region that the results of this study be re-examined in the light of this new information.

Step2: Evaluation of the run up model comparisons

The only assumption, which could make a material difference to the results of the comparisons, is the offshore wave heights. Port Elizabeth does not have a wave height recorder and so data for wave height and period, which is used in all run up models, was sourced from NOAA Wave Watch 3 (NWW3) global wave hindcast model. The NWW3 hindcast are run with the archived (historical) wind fields, which provide higher accuracy wave data than the forecast data. Hindcast wave data extracted from a position directly offshore of Cape Recife (34.25°S, 25.75°E) was then used to evaluate the 3 wave run-up models.

The comparison are based on the three proposed models of

- Nielsen and Hanslow 1991;
- Stockdon *et al.* 2006; and
- Mather *et al.* 2010.

The models have been tested for applicability in the NMBM region by applying data gathered from the region at the following sites: Maitlands beach, Pollok beach, Bluewater Bay beach and Wells Estate beach, Figure 1 below.

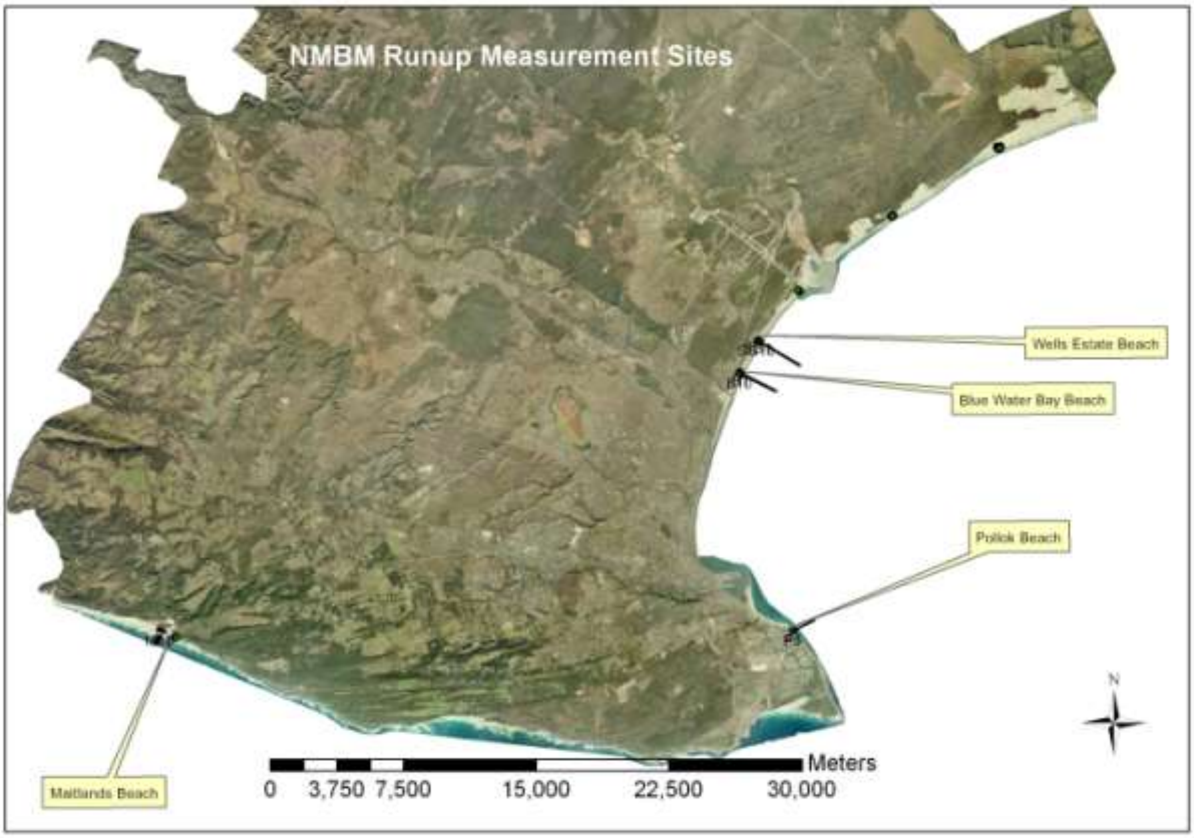

Figure 1: Map of NMBM coastline and run-up measurement sites

Bathymetric data, from the South African Navy Hydrographic Office (SANHO), and beach survey data were utilized to produce all other data for input into the three models. 10 shore normal transects were measured at Maitlands Beach, Bluewater Bay Beach and Wells Estate Beach, only 5 shore normal transects were measured at Pollok Beach due to limited data coverage at this site. Along each transect the following measurements were made: measured runup level, lower-beach level, distance between 0 msl and -15 m depth contour. From the measured runup level and lower-beach level the beach face slope could be calculated.

From this evaluation it was evident that the worse performing model for this area is the Nielsen and Hanslow (1991) model. The best performing model was that of Stockdon *et al.* (2006) which while under predicting did give a tighter distribution of results at all four locations. However, this model requires a significant amount of data, which needs to be provided to populate their equation shown below:

$$R_{max} = 1.1\left[0.35\beta_f\sqrt{H_0L_0} + 0.5\sqrt{H_0L_0\left(0.563\beta_f^2 + 0.004\right)}\right]$$

In order to provide the input data for this model a survey would be required along the entire 102 km of coastline to establish the beach face slope βf. This would entail significant additional costs beyond the scope of the current appointment and therefore while the model provides good results the additional costs involved appear to be excessive in terms of the improved prediction of wave run up.

This leaves the Mather et al. (2010) model that uses readily available data and the simple formulae as follows:

$$R_{max} = CH_0S^{2/3}$$

In this assessment calibration studies have determined a value of C=6 for the coastline west for Cape Recife, and C=11 for the coastline east of Cape Recife will be used. The wave run up position will be buffered by additional environmental and social requirements and so the position of the set back line will in all cases be inland of this line and therefore it is recommended that the Mather *et al*. (2010) model be used given the constraints to data availability.

Step3: Determination of inland maximum scour envelope

The wet-line and algal line gives the approximation of the shoreline at the time of the aerial photograph. The wet-line was digitized along sandy sections of beach and the algal line was digitized along rocky sections of coast for 2004 and 2007 aerial photographs. The wet-line and algal line could not be distinguished clearly on the lower resolution 1996 aerial photographs therefore these were excluded from this exercise. All wet-line data and algal line data was then used to create a composite wet-line at the most landward position of all lines along the entire NMBM coastline. Due to the fact that only two data sets 3 years apart were available this data was not considered suitable for shoreline regression analysis. It has been recommended that this step be revised.

The vegetation line was digitized for 1996, 2004 and 2007 aerials and these data were assessed for suitability for regression trend analysis. Several limitations were encountered with this data:

- Limited record of 11 years between 1996 and 2004
- Large tracts of mobile coastal dunefields along the NMBM coastline, where the vegetation line is controlled by aeolian processes rather than wave processes.
- Uncontrolled access across foredunes has destabilized vegetation in many areas and in some instances lead to blow-outs affecting the position of the vegetation line.

For the reasons stated above it was decided that this data could not be used to calculate regression trends with reasonable accuracy, therefore regression trends would not be included in this study at this stage.

The only cross section data available is that collected over the past 12 years as part of the long term monitoring of the affect of the Port of Ngqura by Transnet National Ports Authority (TNPA). Analysis of this data showed no significant trend and the time period was considered too short for use in extrapolating an erosion trend for 100 years. Cross section data was compared with the composite wet-line data to verify the maximum scour envelope.

Step 4 - Determination of current HWM in terms of the ICMA for sandy portion of coastline

The photogrammetric data from aerial photography conducted in July 2004 for the NMBM had to be processed and interpolated to create a Digital Terrain Model (DTM) for the coastline. In addition the -15m depth contour was digitized from the Navy Chart SAN125 and added to the DTM data.

According to the ICMA the theoretical High Water Mark (HWM) is the level reached by storm waves occurring at no less than a 1:10 year return period, therefore in order to calculate the HWM the wave conditions selected in step 1 were modelled using Mather *et al.* 2010. Data points were produced at 20m intervals. Overlaying the outputs of the aerial HWM modelling over the DTM and aerial photographs allowed for model data and DTM verification.

The image below shows the full extent of the NMBM coastline divided at Cape Recife as defined in Figure 2 and the input parameters and formula used for this exercise.

Figure 2 Map of the NMBM coastline divided at Cape Recife and the input parameters for the Mather *et al.* (2010) formula used to model the HWM

Step 5 - Determination of current theoretical High Water Mark in terms of the ICMA for rocky portion of coastline

For the rocky portions of coast the wave runup was calculated using the 1:10 year wave data (step 1) and the Eurotop manual[1]. The modeling was undertaken along the selected sections of rocky shoreline. The results were supplied as a GIS shapefile.

Step 6 – Determination of the predicted future High Water Mark (HWM)

The regression due to predicted sea level rise associated with global warming was simulated differently for sandy and rocky coastline. For sandy coastline vulnerable to erosion, where greater regression is expected, the Bruun rule was used. This was conducted using the DTM data and three sea level rise scenarios, 300mm, 600mm and 1000mm. Examples of Bruun regression shoreline modelling are shown in Figure 3 below.

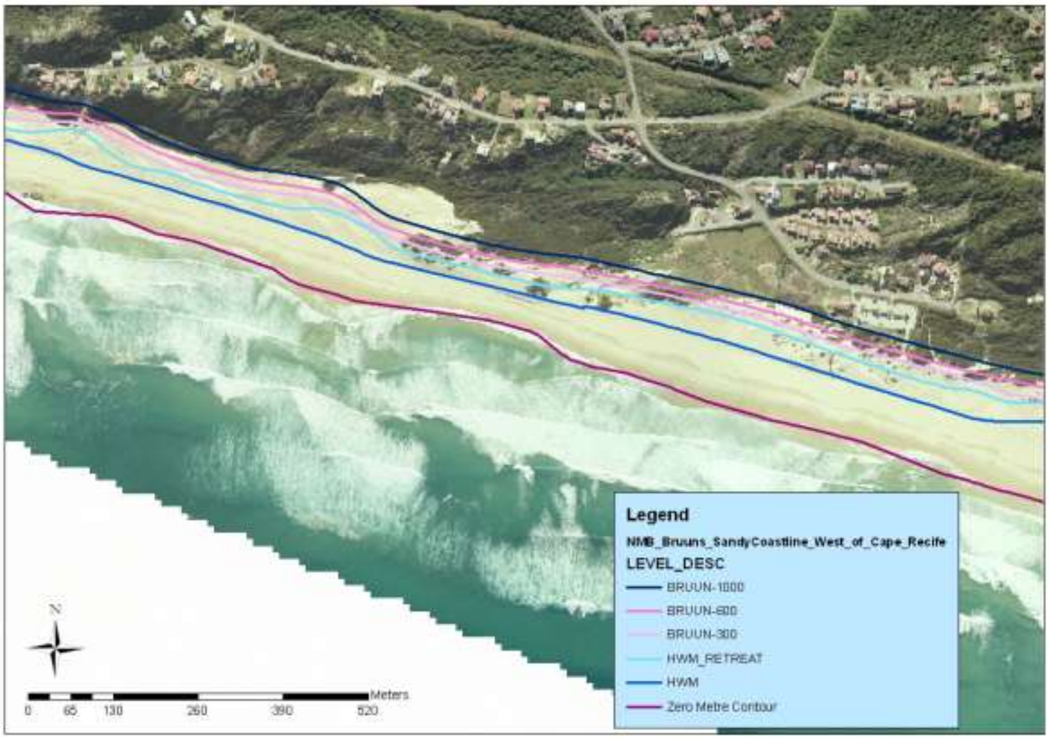

Figure 3 Shoreline regression modelling west of Cape Recife

For rocky coastline resilient to erosion, the Eurotop wave runup modelling output surface was shifted vertically by 1000mm and the intersection with the DTM data was calculated in the Auto Cad environment. An example of sea level rise for rocky shoreline is presented in Figure 4 below.

Figure 4Sea level rise (100mm) for rocky shoreline

A resolution was taken during the Project Steering Committee meeting held on the 29th July 2010 for the project team to consolidate the following steps into a workshop with relevant officials from NMBM and the Department of Economic Development and Environmental Affairs (DEDEA):

Step 7 – Determine the environment buffers required inland from the HWM to maintain a functional coastal ecosystem under future sea level rise scenarios.

Step 8 – Determine of social buffers required along the coast. For example allowance for public beach access through and along the coastal frontage or for areas which have cultural significance and will need to be preserved from development.

Step 9 – Determine any economic requirements for the coast. For example, allowance for new beach facilities that will need to be placed closer than normal development to serve the public. Economic demands often require a trade off against environmental aspects at a particular site. Therefore the project team provided an acceptable methodology to deal with the possible conflicts between the desire for environmental protection and the need for economic activities.

In preparation for the workshop, broad steps of the process were followed and provided for to all the participants prior to and during the workshop. Geographic Information Systems (GIS) imagery and shape files determined in the earlier stages of this project were used to facilitate and record the decisions taken at each location. Analysis of data through a live GIS application was also undertaken. The lines that were used for the workshop included:-

- Current High Water Mark
- Maximum scour High Water Mark
- Position of the High Water Mark under 300, 600 and 1000mm of sea level rise
- The NMB MOSS coverage

At each stretch of beach examination of the HWM under the various sea level rise scenarios and determination of the hazard zone and coastal process set-back line was established. A maximum sea level rise of 1000mm in 100 years combined with a sea storm with a return period of 1:10 years was chosen as a principal determinant for the coastal process set-back line. This was the first line of importance in determining the zone in which any development placed sea ward of this line is likely to experience direct wave attack within the next 100 years.

Given that the approach in the ICMA is based around human use and activities along the coast, the balance between the opposing risk extremes of asset loss and the usage of the coast for human purposes was considered. It was agreed that the coastal process setback line should be used as the principle determinant of the coastal set-back line and this line should not be manipulated due to social, economic, ownership or zoning issues.

The process of determining the coastal protection zone limit took into account environmental, social and economic considerations with the NMB MOSS being the principle determinant. The two lines determined during the workshop are presented in the Figure 5 below.

Figure 5 Coastal set-back line and coastal protection zone limit for rocky shoreline area west of Cape Recife.

Step 10: Determine the coastal set-back line and coastal protection zone limit taking into account the information and requirements of the above steps.

The preliminary analysis of the legal frameworks and policies of the coastal management objectives and of the national government shows a lack of a common methodology for coastal setbacks at the provincial and/ local level, even though the procedure on coastal zone determination through the ICMA had been promulgated with a clear reference to coastal setbacks and the coastal protection zone.

The results of the preliminary study carried out shows that setback lines cannot be based on physical processes alone. Furthermore, the generic application of an arbitrary distance from the coastline (e.g. 100 m from high water mark) ignores the diversity of coastal characteristics and physical processes and should be only applied when more specific information is not yet available. However, it could be the starting point for the definition of a more appropriate setback line, based on scientific understanding and local knowledge, taking into consideration natural processes, landscape values, public use and accessibility.

The ICMA requires that the following process be followed in order to establish the setback lines and adjust the coastal protection zone for NMBM:

Part 7, Coastal Set-back lines, Establishment of coastal set-back lines, section 25:

(2) Before making or amending the regulations referred to in subsection (1), the MEC must—

(a) consult with any local municipality within whose area of jurisdiction the coastal set-back line is, or will be, situated: and

(b) give interested and affected parties an opportunity to make representations in accordance with Part 5 of Chapter 6.

(3)A local municipality within whose area of jurisdiction a coastal set-back line has been established must delineate the coastal set-back line on a map or maps that form part of its zoning scheme in order to enable the public to determine the position of the set-back line in relation to existing cadastral boundaries.

Part 5, Public Participation, Consultation and public participation, section 53:

(1) Before exercising a power, which this 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, MECs 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.

The amended NEMA EIA Regulations and the ICMA allows for the pro-active determination of coastal set-back lines and the adjustment of the coastal protection zone. Coastal set-back lines and the coastal protection zone must also at times be re-actively determined when considering development applications in terms of the NEMA EIA Regulations. Due to the uncertainties surrounding the exact impacts of global warming, in terms of sea level rise and increased frequency and intensity of storm events, it is recommended that the whole exercise be conducted using updated input data every 10 years.

Finally as and when funding becomes available the setback lines for estuaries within the NMBM should be determined and combined with the coastal set-back lines established during this study.

Acronyms:

CSL – Coastal Set-back Line

CPP - Coastal Public Property

CPSLr – Coastal Process Set-back Line rocky coastline

CPSLs – Coastal Process Set-back Line sandy coastline

CPZ – Coastal Protection Zone

CPZL-Coastal Protection Zone Limit

DTM – Digital Terrain Model

DEDEA – Department of Economic Development and Environmental Affairs

H_0 – Deepwater wave height

HWM – High Water Mark

NMBM – Nelson Mandela Bay Municipality

NMB MOSS - Nelson Mandela Bay Metropolitan Open Space System

POS – Public Open Space

SANHO – South African Navy Hydrographic Office

SLR - Sea Level Rise

TNPA – Transnet National Ports Authority

Contents

Executive Summary i

1. INTRODUCTION 1

1.1. Objective 1

1.2. Background 2

1.3 Site Description 6

2. LEGAL FRAMEWORK 15

2.1 Co-operative governance (Constitution Act 108 of 1996) 16

2.2 National Environmental Management Act (No. 107 of 1998) 16

2.3 National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) ("ICMA") 22

2.4 Marine Living Resources Act, 1998 26

2.5 Biodiversity Act 27

2.6 Environment Conservation Act and Regulations GN154 28

2.7 Conservation of Agricultural Resources Act 43 of 1983 and Conservation of Agricultural Resources Regulations. 29

2.8 Forest Act 122 of 1984 29

2.9 National Forests Act 84 of 1998 30

2.10 National Heritage Resources Act 25 of 1999 30

2.11 Eastern Cape Environmental Conservation Bill, 2003 31

2.12 Provincial Nature Conservation Ordinance (PCNO) 31

2.13 Nelson Mandela Bay Municipality's Metropolitan Open Space System (MOSS) ... 32

2.14 Metropolitan Spatial Development Framework, 2009 32

3. METHODOLOGY 32

4. RESULTS 36

Step 1: Determine 1:10 year storm wave height and period for NMBM coastline 36

Step 2: Evaluation of the run up model comparisons 37

Step 3: Determination of inland maximum scour envelope 44

Step 4 - Determination of current HWM in terms of the ICMA for sandy portion of coastline 45

Step 5 - Determination of current theoretical High Water Mark in terms of the ICMA for rocky portion of coastline 47

Step 6 – Determine the predicted future High Water Mark (HWM) for the entire NMBM coastline due to Sea Level Rise........ 50

Step 7 - Environmental Buffers, Step 8 - Social Buffers, Step 9 - Economic Requirements 55

5. RECOMMENDATIONS........ 65

6. REFERENCES 67

1. INTRODUCTION

1.1. Objective

All over the world, local managers and planners, public works officials, local and state elected officials, and community development specialists are at the forefront of making decisions that impact the social, political, and economic well-being of their local communities. Specific information and knowledge about the social, economic, and environmental conditions of a community are needed to make decisions that enhance the community's development and well-being while minimizing potentially adverse social and environmental impacts. This holds particularly true now as decision makers in coastal regions and communities worldwide must begin managing their jurisdictions to adapt to a rapidly changing climate and accelerating sea-level rise (Tribbia, 2008).

Increasingly, coastal erosion and flooding of coastal, estuarine and riparian properties has become a very serious problem, costing local and national government as well as the private sector millions of Rands every year.

One of the key mitigation measures is the proactive determination and implementation of realistic coastal set-back lines developments (Theron, 1994 in Theron and Roussow, 2008). Coastal and riparian erosion, increased intensity and frequency of flooding and wind generated storm surges that damage coastal areas must be planned for as a matter of urgency. Realistic coastal set-back lines have the potential to maintain both the economic and ecological functioning of marine and other aquatic ecosystems and to mitigate the impacts of climate change. They also provide buffers around aquatic ecosystems which can then act as important ecological corridors. Allowing developments to encroach beyond ecologically determined setback lines will often necessitate expensive protection of these developments against disasters such as flooding. Construction of structures to protect properties and other infrastructure cannot be considered long term solutions for any existing or future developments (Theron and Rossouw, 2008). These structures can also be unsightly and restrict public access to valuable and popular amenities such as beaches and waterways. Existing buildings and infrastructure that was inappropriately located in the past have no alternative but to attempt to remedy the situation, however future development can benefit from the inclusion of appropriate coastal set-backs as part of the planning process.

It is for this reason that the Nelson Mandela Bay Municipality (NMBM) through the Eastern Cape Department of Economic Development and Environmental Affairs (DEDEA) has (in responding to the call by the National Government) embarked on a mission to proactively set up guidelines and policies that will enable the realisation of the establishment of coastal setback lines and adjustment of the coastal protection zone limit for the Municipality.

Masande Environmental Health and Safety Consultants (hereafter referred to as Masande Consultants) in conjunction with Afri-Coast Engineers SA (Pty) Ltd have been commissioned by the Environmental Management Sub-Directorate within the Public Health Directorate of the NMBM to establish coastal set-back lines for Nelson Mandela Bay (NMB). The project team were required to determine the 'coastal set-back line' as defined in the Integrated Coastal Management Act (ICMA) of 2008. In the execution of this work, the team were required to work under the guidance of a project steering committee that was formed between the Nelson Mandela Bay Municipality (NMBM) and the Department of Economic Development and Environmental Affairs (DEDEA). The objective of this report is to present the background, legal perspective, methodology, results, conclusions and recommendations emanating from this project.

1.2. Background

Roughly two-thirds of the world population lives within close proximity to the ocean and a large proportion of the world's coastline is made up of sandy beaches, which attract thousands of visitors and are economically important to adjacent communities (Bird, 1996). Beach erosion poses a threat to all stakeholders, especially tourism which, according to the World Tourism Organisation (WTO, 2001) is the world's largest industry. Research indicates that 70% of the world's beaches are experiencing coastal erosion (Bird, 1996). Climate change, is expected to exacerbate this problem through: particularly accelerated sea-level rise (IPCC, 2007) and increased frequency and intensity of storm events (Theron & Roussow, 2008)

Whilst coastlines are often viewed as stable permanent assets, in reality they tend to be dynamic, responding to natural processes and human activities (Phillips & Jones, 2006). In many instances man has literally drawn a line in the sand and built infrastructure, with little regard for the dynamics of the highly variable littoral zone, thus when the beach retreats infrastructure is threatened (Clark, (1996)). In numerous instances erosion is caused by man-induced interruption of sediment supply by means of coastal structures such as groynes (Basco & Pope, 2004), harbour breakwaters constructed in longshore dominant sediment transport regimes ((Swart, 1996); (Dean & Dalrymple, 2002)), dune stabilisation (McLachlan, Illenberger, & Burkinshaw, 1994); (La Cock & Burkinshaw, 1994)) and river impoundment (Frihy, Essam, Debes, & El Sayed, 2003). Coastal areas therefore require specific attention in management and planning procedures, especially where the coastal areas are subject to significant human resource usage and development pressure (WSP, 2010). A number of specific motivations exist for the establishment of set-back lines, several significant motivations are presented below.

Facilitation of Development

At present, an Environmental Impact Assessment (EIA) must be conducted for development of all infrastructure within 100 m of the high water mark in urban areas, in accordance with the EIA Regulations (NEMA, 2010). This "broadbrushed" approach has certain undesirable consequences such as:

- Home owners situated within 100m of the HWM must follow the EIA process to conduct any house alterations;
- Municipalities must follow the EIA process when erecting infrastructure (e.g. toilets, even if temporary) within 100m of the HWM.
- In some instances coastal processes occur landward of the 100 m line, such as windblown sand.

Through recent coastal legislation it is intended to include flexibility in the implementation of certain coastal activities, by introducing the concept of a "set-back". In future, strategic infrastructure planning will be more appropriately informed by strategic environmental assessment with coastal set-back lines to be strategically determined, rather than disjointed project level assessments having to be done for different infrastructure projects. In addition, the determination of coastal set-back lines will enable the improvement of the coarse "within 100 metres of the high-water mark of the sea" threshold used in the NEMA listed activities, with the setback resulting in improved protection being given to the coast and resulting in unnecessary EIA being prevented (WSP 2010).

Safety of Developments

Developments situated too close to the sea are threatened by erosion (e.g. Summerstrand lifesavers club house and the adjacent parking lot and the New Brighton Beach ablutions and lifesavers facility near the Swartkops Estuary mouth are threatened by beach erosion) and wave attack (The seawall and walkway north of Hobie Beach and the clubhouses at Sardinia Bay) presented in Figure 6 below. Protection of these developments is difficult and often expensive. Development along the KwaZulu-Natal shoreline have also experienced problems especially During the storm waves of March 2007 and September 2008.

Taking into account sea-level rise and the coincident increase in vulnerability to storm waves, it is critical that coastal set-back lines are established so that such problems do not recur.

Figure 6 Threat to infrastructure placed to close to the sea through erosion at a) Summerstrand lifesavers clubhouse, b) New Brighton Beach facilities and wave attack at c) seawall and walkway east of hobie beach and d) clubhouse facilities at Sardinia Bay.

Maintenance

The establishment of setback lines can avoid problems of maintenance in the form of sand removal and/or storm debris removal. By way of example, the NMBM spends considerable effort and money on the removal of sand, e.g. on the road and parking lot at the Swartkops Estuary Mouth, because these developments are situated within the zone of active nearshore processes (windblown sand). Figure 7 below provides another example of a maintenance headache at Bluewater Bay parking lot where removal of debris due to high waves during high waters and wind-blown sand is also a major maintenance problem. Establishment of setback lines that take into account such coastal processes will avoid this type of ongoing maintenance problem.

Figure 7: left) Blue Water Bay Beach parking lot located within the zone of nearshore processes, right) inundated with sand and debris after the extreme waves experienced on 1 September 2008.

Biodiversity

Buffer zones between the high water mark and development must be provided where this is critical to protect and maintain biodiversity pattern and/or processes, and the associated ecology.

Other motivations

There are several other potential reasons to ensure adequate development setback. Amongst these are:

Adequate setback to maintain aesthetic features, such as rock formations, and sense of place. An example of the latter is Blue Water Bay where besides the parking lots the houses are well set back behind the primary dune and permanently vegetated retention ridge and the resulting experience of the beach is of a totally natural, unspoilt environment;

Adequate setback to minimise shading of beaches by tall structures;

Setback to allow for public access, in some instances.

1.3 Site Description

Nelson Mandela Bay coastline stretches for 102km between the Van Stadens River mouth in the west and the Sundays Estuary mouth in the east. The coastline is dominated by the headland of Cape Recife and the large sheltered area of Algoa Bay which is one of several large southeast facing embayments along the Sunshine Coast of South Africa (Figure 8). The city of Port Elizabeth is situated on the eastern side of Cape Recife, one of a series of headlands that lie along the coast between Cape Town and Port Elizabeth.

Figure 8: Location of NMBM on the south east coast of South Africa, Van Stadens River, Algoa Bay, Port Elizabeth Harbour, Ngqura Harbour.

The area has a temperate climate and receives 500 to 650 mm of precipitation per year, with the largest amount of rain occurring between May and October (McLachlan *et al.,*1994). The coastline in this region is mostly sandy beach (55%) followed by rocky headlands (24%) and wave cut rocky platforms (21%).

Algoa Bay and St Francis Bay are the two large bays that dominate the geography of the eastern part of the region.

The area around Cape Recife is composed of a series of cove beaches to the west, the rocky stable headland of the Cape followed by a series of beaches between rocky outcrops in the lee of the Cape and along the shore of Algoa Bay (Figure 9 below). A large volume of sand has accreted on the updrift side of the port of Port Elizabeth breakwater since its construction some 80 years ago.

Figure 9: NMBM Coastline between Sardinia bay in the west to Cape Recife and inside the bay until the Port Elizabeth Harbour.

The coast from Port Elizabeth harbour for approximately 8km to the Swartkops Estuary mouth is severely sand depleted and suffering from erosion (due to the presence of the Port), and as a result the majority of this section of the coast is dominated by man-made stone, rubble and dollosse revetments, put in place to protect the road and rail infrastructure.

Figure 10: Coastline between the Port Elizabeth Harbour and Swartkops River Mouth, roughly 8km of coast immediately north of the harbour is lined by coastal protection.

North of the Swartkops River, until the Port of Ngqura wide sandy beaches backed by coastal vegetation and sand dunes prevail (Figure 11 below). For several kilometers immediately north of the port of Ngqura wave cut platforms and pebble beach environment is dominant. However for the further 10 km towards the Sundays Estuary mouth a wide sandy beach is present and extensive coastal dunes are present in the vicinity of the Sundays Estuary mouth (Figure 12 below).

Figure 11: coastline between the Swartkops River Mouth and the deep water port of Ngqura, characterised by a wide sandy beach backed by coastal dunes.

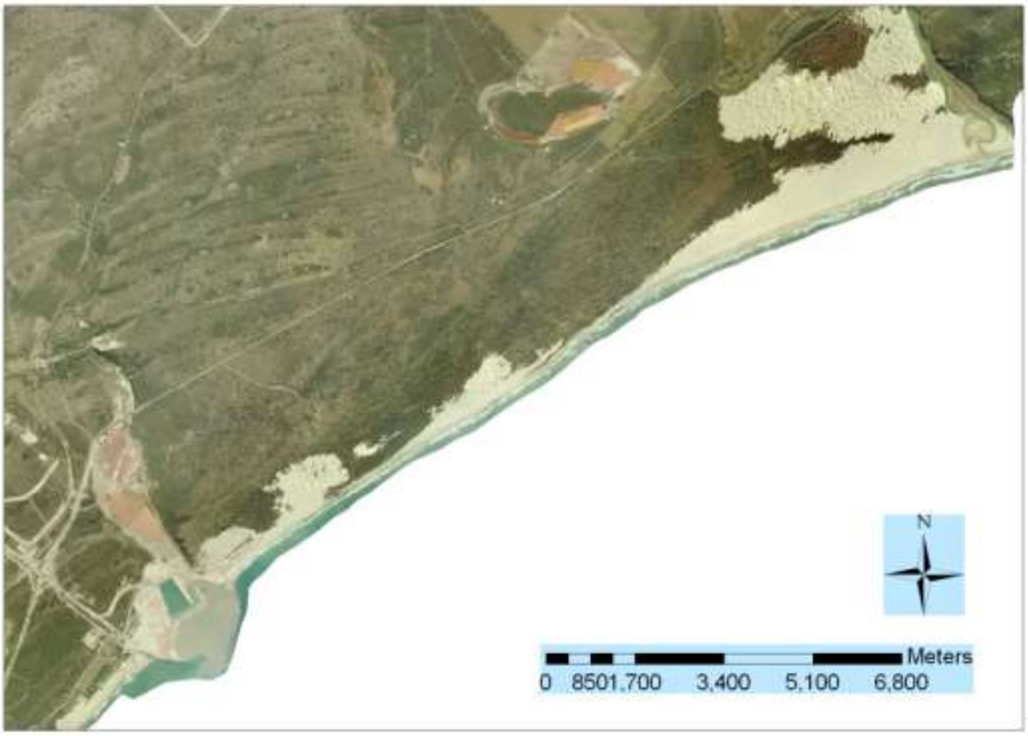

Figure 12: The coastline between the port of Ngqura and the Sundays River Mouth.

The winds in this area are predominantly from the southwest (Figure 13 below) and associated with storms traversing from the Atlantic to the Indian Oceans. However, this pattern is dominant only in the winter months. During the spring and summer, easterly winds are dominant. A third common wind direction is the north-westerly lands breezes which blow in the autumn months.

Waves emanating from the south westerly quarter are dominant offshore of the NMBM coastline. The coastline west of Cape Recife is exposed directly to waves from this direction; however once these southwesterly waves reach the shore within the bay they are reduced to approximately 1/3 of the offshore wave height due to the processes of diffraction and refraction. Within the bay locally generated short period waves from an easterly direction have a more direct approach and result in bigger waves on the coast within the bay. In addition occasional large long period swell from a easterly to southerly direction, incurring less diffraction and refraction, results in large waves and significant erosion of the beaches within the bay (ASR, 2008).

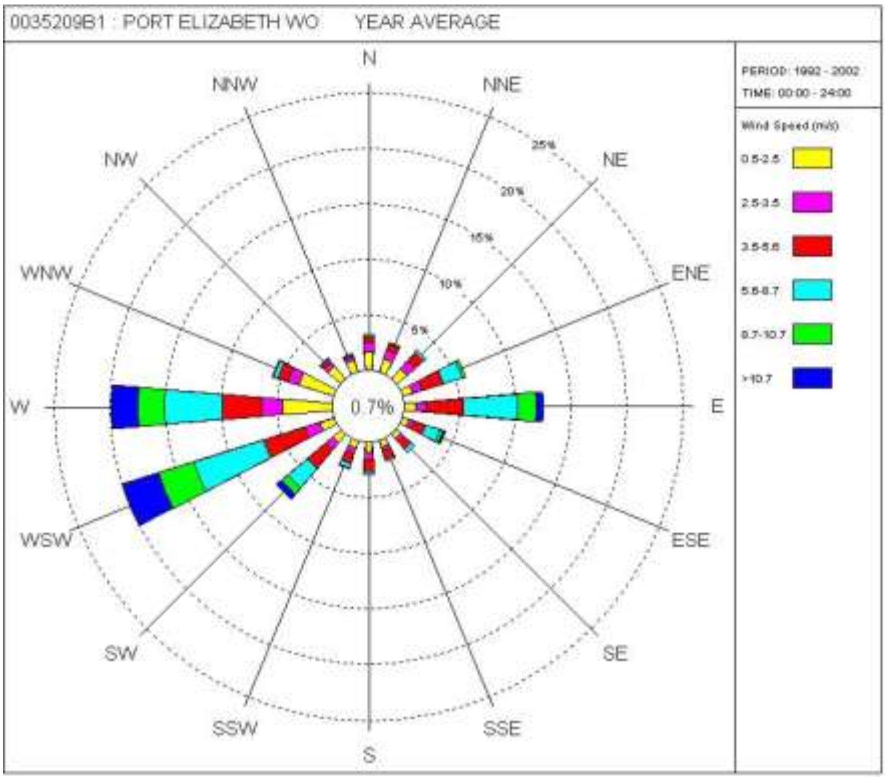

Figure 13: Wind Rose at the Port Elizabeth airport, indicating dominant wind from the westerly to south westerly direction courtesy of SAWS.

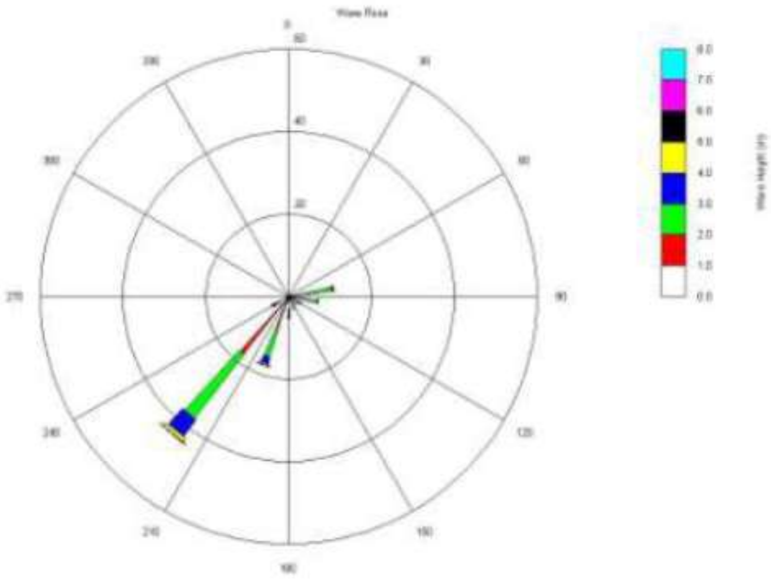

Figure 14: Wave rose for the offshore deepwater wave statistics from 1 January 1997 to 30 June 2006 (ASR, 2008).

Like its neighbor, Cape St Francis to the west, Cape Recife contains examples of headland-bypass dune systems (Figure 15). A headland-bypass dune system occurs where sand from beaches on one side of a headland is moved to the other side by wind driven transport through a system of highly mobile, transverse dune fields (McLachlan *et al,* 1994). In the case of South Africa's Sunshine Coast, predominant winds from the southwest push sand eastward over the headland and into the bays on the eastern side. Sand transport across the headlands in these systems is thought to occur in pulses over a time frame of hundreds or thousands of years rather than continuously across the entire length of the dune field. In the intervening period of time the dunes may be come partially or totally vegetated, especially around wetlands or where the water table is close to the surface.

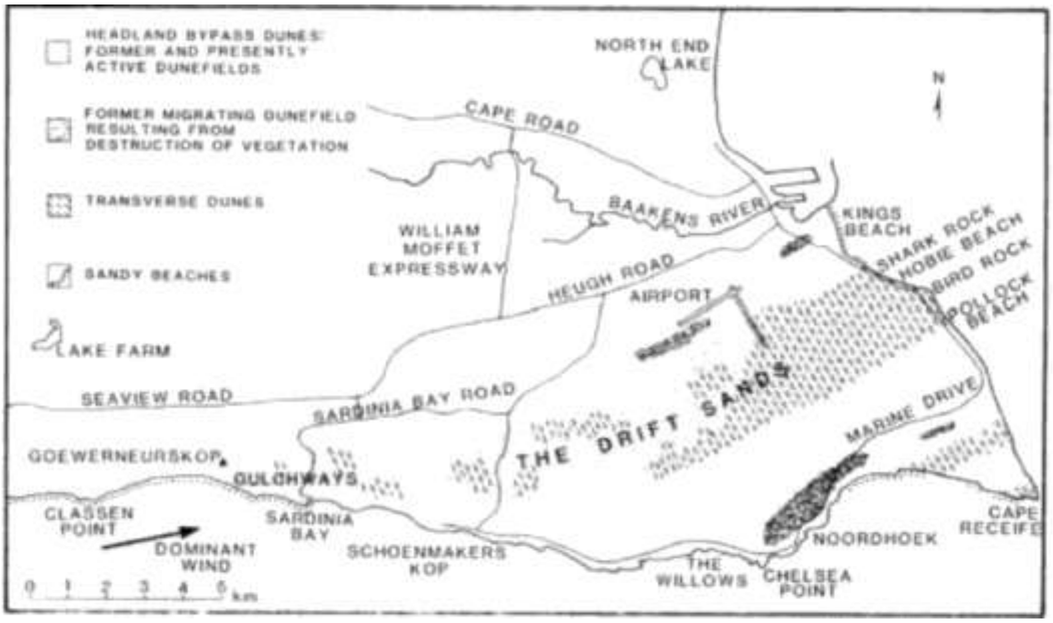

Figure 15: Layout of Cape Recife and Port Elizabeth showing the large headland bypass dunefields which were active prior to development, figure originally from Lord *et al.,* 1985.

In a similar fashion to Cape St Francis, the dune fields on Cape Recife have been stabilized to promote agriculture and provide an environment for human habitation that is free of the bothersome, windblown sands. This stabilization, ongoing in South Africa since the mid 19th century, has resulted in a net reduction of sand available to the beaches on the lee of the headlands (McLachlan *et al.,* 1994). It is likely that a major pulse of sand moved across the Cape Recife Driftsands and reached the eastern side of the cape during the middle of the 19th century, roughly coinciding with the arrival of European settlers. This pulse of sand threatened settlements at Port Elizabeth in the 1860‟s and resulted in efforts to stabilize the dunes.

The final stabilization effort began in 1890 when the Forestry Department began a systematic plan of spreading the town refuse over the dunes then planting vegetation in the refuse. Using this method the dunes along the shore of Algoa Bay were stabilized by 1897 and the entire Driftsands dune field was stabilized by 1909.

Besides the major dunefield known as “The Driftsands”, Cape Recife contains two other smaller headland bypass dune fields. These are the “Noordhoek” and “Cape Recife” dune fields. The leading half of the Noordhoek dunefield was stabilized in the 1960‟s and 70‟s during construction of a sewage treatment facility in the area. The smallest transverse dune system at the tip of Cape Recife has remained active to this day.

Sand enters Algoa Bay by either Aeolian transport across the headland or by wave transport around Cape Recife. Once deposited into the bay, the sand is moved generally to the north and east forced along by wave generated currents. Currently, only the last remaining dunefield at the south-easternmost tip of Cape Recife is active. With a dune width of 350 m, this system probably moves in the order of 12,000 (McLachlan *et al.,* 1994) to 26,000 (Lord *et al.,* 1985) cubic meters per year into the waters of Algoa Bay to the east.

Wave driven transport, which moves sand around the tip of the cape and to the north along the eastern side of the headland, is the other form of sand input to Algoa Bay. The volume of sand moved around Cape Recife can be calculated based on the accretion observed at Kings Beach, located on the southern side of the Port Elizabeth breakwater, which has experienced consistent accretion since the construction of the harbour, after the stabilization of the Driftsands in the late 19th and early 20th centuries (Figure 16).

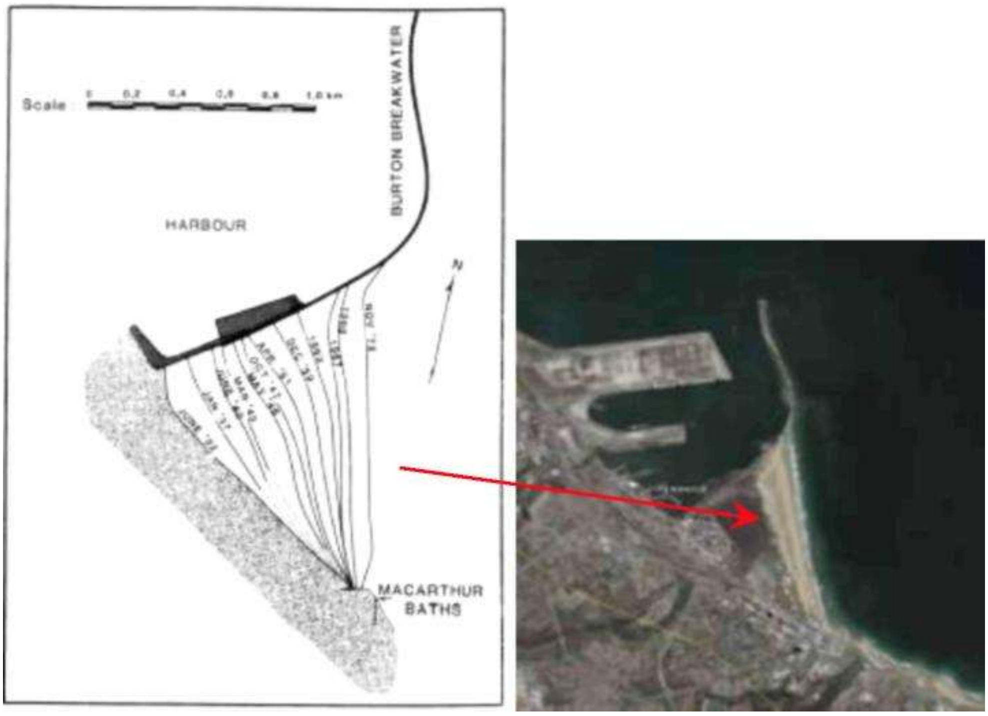

Figure 16: Left: Accretion of sand at King's Beach. From Lord *et al,* (1985). Right: Current aerial photo of King's Beach - the beach is now "over-flowing" and moving around the breakwater and into the approach channel, which requires regular dredging. It is estimated that approximately 1 million cubic meters of beach sand is located off the breakwater.

The first accurate survey of the shoreline in this area was conducted in 1877 and surveys have been conducted consistently since that time. The surveys, as well as casual observations, show that Kings Beach has been steadily accreting, especially since the construction of the harbour breakwater (Figure 16). Between 1933 and 1979, a total of 850 m of beach accumulated in this area, or approximately 18 m/year. Surveys also showed that the depth of the water offshore of the breakwater remained constant over the same time period, meaning that no sand was bypassing the harbour, but rather that it was all being trapped upstream and therefore represents an accurate estimate of the total longshore transport. This figure was estimated to be 130,000 m^3/yr for the period from 1933 – 1969. After 1969, there was evidence of sand bypassing the breakwater and harbour and the rate of accumulation on Kings Beach was estimated to be 100,000 m^3/yr between 1969 and 1979 (Lord *et al.,* 1985). McLachlan *et al.,* (1994), citing Prestedge (1986)[*] revise this number slightly higher and give an average value of 150,000 m^3/yr for the accretion at Kings Beach for the period between 1931 and 1985.

Shortly after construction of the main harbour breakwater in 1903, extensive erosion of the beaches on the northern (down-drift) side of the harbour was observed; this confirmed the assumption of a northward littoral drift in the area and has led to the problems currently experienced north of Port Elizabeth Harbour towards the Swartkops River.

North of the Swartkops River, the sites at Wells Estate and Bluewater Bay Beach do not suffer from beach erosion problems. At both Wells Estate and Bluewater Bay there is ample sand, a wide beach (up to 150 m wide) and coastal developments are set back behind the dune line and do not interfere with the natural coastal processes. This is likely to be because these sites lie to the northeast of the Swartkops River and inside a separate littoral cell from Port Elizabeth proper. The volume of sand transported across this section of beach is estimated at 150 – 200,000 m^3/yr (Illenberger & Associates, 1998). The beach itself is a mixed sand and pebble beach with pebbly storm berm deposits that underlie the sand in the back beach. The beach has a transverse bar system, with rip current cells that are generally spaced some 150 to 300 m apart.

Construction of the deepwater port of Ngqura began in 2003 and was completed in 2007, a sand bypass scheme was installed as part of the port construction and this was operational by 2007. Long term beach profile monitoring is carried out on the beaches either side of the port in order to monitor the effect of the port and the effectiveness of the sand bypass system. The results of this monitoring indicate that over the 3 years before the sand bypass scheme became operational accretion was experienced on the updrift side of the port and erosion on the downdrift side. Fortunately a high percentage of rock and pebble substrate on the downdrift side of the port meant that this side was fairly resilient to erosion and shoreline retreat in this area was not significant. In addition the shoreline has remained fairly stable within a few kilometres either side of the port and the sand bypass system seems to be operating effectively (Afri-Coast, 2010).

2. LEGAL FRAMEWORK

Setback lines should be considered as a planning tool for National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) (herewith referred to as the: “ICMA”) implementation, and their definition should be based on an integrated approach, covering aspects such as physical processes, ecosystem efficiency, coastal safety for economic and recreational activities and landscape protection from a natural and cultural heritage perspective. The objective of this section is (i) to outline the administrative and legal framework at the Provincial and Local Municipal Level, together with some relevant international and national experiences (ii) to provide a common basis for processes, concepts and definitions related with coastal setbacks, and (iii) to recommend an integrated legal approach for the identification of coastal setbacks at the Provincial and Local Municipal level in relation to Nelson Mandela Bay Municipality’s coastline (Celliers et al., 2009)

The proposal and the use of setback lines can be the origin of strong conflict, both at the administrative level, where criteria and implementation rules are discussed, and at the local level, where the interests between different stakeholders groups are confronted. It is therefore necessary to identify set-back lines with a strong scientific approach on one hand, which can give a clear vision of the physical, ecological and socio-economic processes, and with a systematic participatory approach on the other hand, which can give a clear vision of the socio-economic implications at the local level and, at the same time, provide support for their implementation in a legally accepted manner (Celliers et al., 2009).

Relevant administrative, legal and policy requirements, which the Eastern Cape Department of Economic Development and Environmental Affairs and/ or the Nelson Mandela Bay Municipality will be responsible for carrying out during the implementation of the Establishment of Coastal Development Setback Lines for Nelson Mandela Bay Municipality:

2.1 Co-operative governance (Constitution Act 108 of 1996)

The constitution states that:

> '… everyone has the right to an environment that is not harmful to their health or well being: and to have the environment protected for the benefit of present and future generations through reasonable legislative and other measures that 1) prevent pollution and ecological degradation; 2) promote conservation; and 3) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development'

2.2 National Environmental Management Act (No. 107 of 1998)

Any actions taken by the developer must be done in accordance with constitutional principles, the common law, the overarching policy principles set out in section 2 of NEMA and the principles applicable to environmental assessment.

Chapter 1 of NEMA contains the following relevant principles:

2. Environmental management must place people and their needs at the forefront of its concern, and serve their physical, psychological, developmental, cultural and social interests equitably.
3. Development must be socially, environmentally, and economically sustainable.

4. (a) Sustainable development requires the consideration of all relevant factors including:

    (i) that the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

    (vii) that a risk-averse and cautious approach is applied, which takes into account the limits of current knowledge about the consequences of decisions and actions

    (f) The participation of all interested and affected parties in environmental governance must be promoted, and all people must have the opportunity to develop the understanding, skills and capacity necessary for achieving equitable and effective participation, and participation by vulnerable and disadvantaged persons must be ensured.

    (g) Decisions must take into account the interests, needs and values of all interested and affected parties, and this includes recognising all forms of knowledge, including traditional and ordinary knowledge. […]

    (o) The environment is held in public trust for the people, the beneficial use of environmental resources must serve the public interest and the environment must be protected as the people's common heritage."

The establishment of coastal development setback lines will be addressed in terms of Sections 24(2) (a) and 24 d of the National Environmental Management Act, 1998, namely, the Environmental Impact Assessment ("EIA") Regulations 2010 (Government Notice No. R. 543, R. 544, R. 545, R. 546 and R. 547 in Government Gazette No. 33306 of 18 June 2010). The EIA regulations 2010 replace the EIA regulations that were promulgated in 2006. The following regulations refer but not limited to:

(14) The construction of structures in the coastal public property where the development footprint is bigger than 50 square metres, excluding:

(i) the construction of structures within existing ports or harbours that will not increase the development footprint or throughput capacity of the port or harbour;

(ii) the construction of a port or harbour, in which case activity 24 of Notice 545 of 2010 applies;

(iii) the construction of temporary structures within the beach zone where such structures will be demolished or disassembled after a period not exceeding 6 weeks.

(15) The construction of facilities for the desalination of sea water with a design capacity to produce more than 100 cubic metres of treated water per day.

(16) Construction or earth moving activities in the sea, an estuary, or within the littoral active zone or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever is the greater, in respect of:

(i) fixed or floating jetties and slipways;

(ii) tidal pools;

(iii) embankments;

(iv) rock revetments or stabilising structures including stabilising walls;

(v) buildings of 50 square metres or more; or

(vi) infrastructure covering 50 square metres or more

but excluding:

(a) if such construction or earth moving activities will occur behind a **development setback line**; or

(b) where such construction or earth moving activities will occur within existing ports or harbours and the construction or earth moving activities will not increase the development footprint or throughput capacity of the port or harbour;

(c) where such construction or earth moving activities is undertaken for purposes of maintenance of the facilities mentioned in (i)-(vi) above; or

(d) where such construction or earth moving activities is related to the construction of a port or harbour, in which case activity 24 of Notice 545 of 2010 applies.

(17) The planting of vegetation or placing of any material on dunes and exposed sand surfaces, within the littoral active zone for the purpose of preventing the free movement of sand, erosion or accretion, excluding where the planting of vegetation or placement of material relates to restoration and maintenance of indigenous coastal vegetation or where such planting of vegetation or placing of material will occur behind a development setback line.

(18) The infilling or depositing of any material of more than 5 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock from

(i) a watercourse;

(ii) the sea;

(iii) the seashore;

(iv) the littoral active zone, an estuary or a distance of 100 metres inland of the high~water mark of the sea or an estuary, whichever distance is the greater

but excluding where such infilling, depositing, dredging, excavation, removal or moving

(i) is for maintenance purposes undertaken in accordance with a management plan agreed to by the relevant environmental authority; or

(ii) occurs behind the **development setback line**.

(24) Construction or earth moving activities in the sea, an estuary, or within the littoral active zone or a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever distance is the greater, in respect of:

(i) facilities associated with the arrival and departure of vessels and the handling of cargo;

(ii) piers;

(iii) inter- and sub-tidal structures for entrapment of sand;

(iv) breakwater structures;

(v) coastal marinas;

(vi) coastal harbours or ports;

(vii) structures for reclaiming parts of the sea;

(viii) tunnels; or

(ix) underwater channels;

but excluding -

(a) activities listed in activity 16 in Notice 544 of 2010,

(b) construction or earth moving activities if such construction or earth moving activities will occur behind a development setback line;

(c) where such construction or earth moving activities will occur in existing ports or harbours where there will be no increase of the development footprint or throughput capacity of the port or harbour; or

(d) where such construction or earth moving activities takes place for maintenance purposes.

(39) The expansion of

(i) canals;

(ii) channels

(iii) bridges;

(iv) weirs;

(v) bulk storm water outlet structures;

(vi) marinas;

within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, where such expansion will result in an increased development footprint but excluding where such expansion will occur behind the development setback line.

(40) The expansion of

(i) jetties by more than 50 square metres;

(ii) slipways by more than 50 square metres; or

(iii) buildings by more than 50 square metres

within a watercourse or within 32 metres of a watercourse, measured from the edge of a watercourse, but excluding where such expansion will occur behind the development setback line.

(43) The expansion of structures in the coastal public property where the development footprint will be increased by more than 50 square metres, excluding such expansions within existing ports or harbours where there would be no increase in the development footprint or throughput capacity of the port or harbour.

(44) The expansion of facilities for the desalination of sea water where the design capacity will be expanded to produce an additional 100 cubic metres or more of treated water per day.

(45) The expansion of facilities in the sea, an estuary, or within the Iittoral active zone or a distance of 100 metres inland of high-water mark of the sea or an estuary whichever is the greater, for-

(i) fixed or floating jetty and slipways

(ii) tidal pools;

(iii) embankments;

(iv) rock revetments or stabilising structures including stabilising walls;

(v) buildings by more than 50 square metres;

(vi) infrastructure by more than 50 square metres;

(vii) facilities associated with the arrival and departure of vessels and the handling of cargo;

(viii) piers;

(ix) inter- and sub-tidal structures for entrapment of sand;

(x) breakwater structures;

(xi) coastal marinas;

(xii) coastal harbours or ports;

(xiii) structures for draining parts of the sea or estuary; (XI

(xiv) tunnels; or

(xv) underwater channels -

where such expansion will result in an increase in the development footprint of such facilities but excluding where such expansion occurs:

(a) behind a **development setback line**; or

(b) within existing ports or harbours where there will be no increase in development footprint or throughput capacity of the port or harbour.

(52) The expansion of facilities or infrastructure for marine telecommunication where there will be an increased development footprint.

(54) The expansion of an island, anchored platform or any other permanent structure on or along the sea bed, where the expansion will constitute an increased development footprint.

2.3 National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) ("ICMA")

Principal to this study, it will be critical to give cognisance to other pieces of legislations, policies and guidelines as they relate to the proposed project. In terms of National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) ("ICMA") which was promulgated on 11 February 2009.

The objectives of the ICMA are:

- to determine the coastal zone of the Republic;
- to provide, within the framework of the National Environmental Management Act, for the co-ordinated and integrated management of the coastal zone by all spheres of government in accordance with the principles of co-operative governance;
- to preserve, protect, extend and enhance the status of coastal public property as being held in trust by the State on behalf of all South Africans, including future generations;

- to secure equitable access to the opportunities and benefits of coastal public properly; and
- to give effect to the Republic's obligations in terms of international law regarding coastal management and the marine environment.

2.3.1. The coastal protection zone (section **16**) (from Celliers *et al*., 2009)

In essence, the coastal protection zone consists of a continuous strip of land, starting from the HWM and extending 100 metres inland in developed urban areas zoned as residential, commercial, or public open space, or 1000 metres inland in areas that remain undeveloped or that are commonly referred to as rural areas. A detailed description of the areas included in the coastal protection zone can be found at the end of this section. There are however some provisions in order to justify certain adjustments to this zone.

The coastal protection zone is established to manage, regulate and restrict the use of land that is adjacent to coastal public property, or that plays a significant role in the coastal ecosystem. The coastal protection zone consists of:

- Sensitive coastal areas, as defined by the Environment Conservation Act (Act No. 73 of 1989, section 21 [1]);
- Any part of the littoral active zone that is not coastal public property;
- Any coastal protected area, or part of such an area, which is not coastal public property;
- Any rural land unit that is situated within one kilometre (1000 metres) of the HWM which is zoned as agricultural or undetermined;
- Any urban land unit that is situated completely or partly within 100 metres of the HWM;
- Any coastal wetland, lake, lagoon or dam which is situated completely or partially within a land unit situated within 1000 metres of the HWM that was zoned for agricultural or undetermined use, or is within 100 metres of the HWM in urban areas
- Any part of the seashore which is not coastal public property (including all privately owned land below the HWM);
- Any Admiralty Reserve which is not coastal public property; and
- Any land that would be inundated (submerged or covered) by a 1:50 year flood or storm event (this includes flooding caused by both rain storms and rough seas).

2.3.2. The purpose of the coastal protection zone (section **17**) (from Celliers et al., 2009)

The coastal protection zone is established to manage, regulate and restrict the use of land that is adjacent to coastal public property, or that plays a significant role in the coastal ecosystem. More specifically, the coastal protection zone aims:

- To protect the ecological integrity, natural character, and the economic, social and aesthetic value of the neighbouring coastal public property;
- To avoid increasing the effect or severity of natural hazards;
- To protect people, property and economic activities from the risks and threats which may arise from dynamic coastal processes such as wave and wind erosion, coastal storm surges, flooding and sea-level rise;
- To maintain the natural functioning of the littoral active zone;
- To maintain the productivity of the coastal zone; and
- To allow authorities to perform rescue and clean-up operations.

2.3.3. Part 7 in Chapter 2 of the ICMA also provides for the establishment of coastal set-back lines and defines “coastal set-back line” as “a line determined by an MEC in accordance with section 25 in order to demarcate an area within which development will be prohibited or controlled in order to achieve the objectives of this Act or coastal management objectives”. The procedures for establishing coastal set-back lines are set out in section 25 which states that:

An MEC must in regulations published in the Gazette—

(a) establish or change coastal set-back lines—

(i) to protect coastal public property, private property and public safety;

(ii) to protect the coastal protection zone;

(iii) to preserve the aesthetic values of the coastal zone; or

(iv) for any other reason consistent with the objectives of this Act; and

(b) prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of that coastal set-back line.

Before making or amending the regulations referred to in subsection (1), the MEC must—

(a) consult with any local municipality within whose area of jurisdiction the coastal set-back line is, or will be, situated: and

(b) give interested and affected parties an opportunity to make representations in accordance with Part 5 of Chapter 6.

A local municipality within whose area of jurisdiction a coastal set-back line has been established must delineate the coastal set-back line on a map or maps that form part of its zoning scheme in order to enable the public to determine the position of the set-back line in relation to existing cadastral boundaries.

A coastal set-back line may be situated wholly or partially outside the coastal zone.

The ICMA highlights in sections 27 and 28 that in determining or adjusting the boundaries of coastal areas the following must, inter alia, be taken into account:

-the dynamic nature of the shoreline;

-the need to make appropriate allowance for the periodic natural movements in the high-water mark; and the erosion and accretion of the seashore;

-the importance of ensuring the natural functioning of dynamic coastal processes and of extending the coastal boundaries to include the littoral active zone and sensitive coastal ecosystems, including coastal wetlands;

-the potential effects of projected rises in sea-level;

-the purpose for which a coastal area is to be established;

-the importance for coastal management to incorporate land inland of the high-water mark that should be maintained in, or restored to, a natural or semi-natural state;

-the need to avoid risks posed by natural hazards to people, biodiversity, coastal public property and private property;

-the potential for the number and severity of natural disasters to increase due to the effects of global climate change and other impacts on the environment, and the importance of taking preventive measures to address these threats; and

-the importance of allowing for the movement of the position of the high water mark over time and of protecting the inland coastal boundary by demarcating a continuous strip of land adjacent to it.

2.3.4. Part 5 of Chapter 6 of the ICMA specifies the requirements for consultation and public participation for determination or adjustment of coastal boundaries and states:

53. (1) Before exercising a power, which this 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, MECs 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.

2.3.5. While both the amended NEMA EIA Regulations and the ICMA allows for the pro-active determination of coastal development setback lines, coastal development setback lines must also at times be re-actively determined when considering development applications in terms of the NEMA EIA Regulations.

2.4 Marine Living Resources Act, 1998

Chapter 4 of Marine Resources Living Act provides for the Minister to declare an area to be a marine protected area under section 43 in order to protect marine living resources and coastal zones from further deterioration.

43(1) The Minister may, by notice published in the Gazette, declare an area to be a marine protected area—

(a) for the protection of fauna and flora or a particular species of fauna or flora and the physical features on which they depend;

(b) to facilitate fishery management by protecting spawning stock, allowing stock recovery, enhancing stock abundance in adjacent areas, and providing pristine communities for research; or

(c) (c) to diminish any conflict that may arise from competing uses in that area.

43(2) No person shall in any marine protected area, without permission in terms of subsection (3)—

(a) fish or attempt to fish;

(b) take or destroy any fauna and flora other than fish;

(c) dredge, extract sand or gravel, discharge or deposit waste or any other polluting matter, or in any way disturb, alter or destroy the natural environment;

(d) construct or erect any building or other structure on or over any land or water within such a marine protected area; or

(e) (e) carry on any activity which may adversely impact on the ecosystems of that area.

43(3) The Minister may, after consultation with the Forum, give permission in writing that any activity prohibited in terms of this section may be undertaken, where such activity is required for the proper management of the marine protected area.

2.5 Biodiversity Act

In terms of the National Environmental Management Biodiversity Act (NEMBA, 2004) the developer has a responsibility for:

- The conservation of endangered ecosystems and restriction of activities according to the categorization of the area (not just by listed activity as specified in the EIA regulations).
- Promote the application of appropriate environmental management tools in order to ensure integrated environmental management of activities

thereby ensuring that all development within the area are in line with ecological sustainable development and protection of biodiversity.

- Limit further loss of biodiversity and conserve endangered ecosystems.

2.6 Environment Conservation Act and Regulations GN154

- Development must be environmentally, socially and economically sustainable. Sustainable development requires the consideration of inter alia the following factors:
    - that pollution and degradation of the environment is avoided, or, where they cannot be altogether avoided, are minimised and remedied;
    - that waste is avoided, or where it cannot be altogether avoided, minimised and re-used or recycled where possible and otherwise disposed of in a responsible manner;
    - that the use and exploitation of non-renewable natural resources is responsible and equitable, and takes into account the consequences of the depletion of the resource;
    - that the development, use and exploitation of renewable resources and the eco-systems of which they are part do not exceed the level beyond which their integrity is jeopardised; and
    - that negative impacts on the environment and on peoples' environmental rights be anticipated and prevented, and where they cannot be altogether prevented are minimised and remedied.
- Environmental management must place people and their needs at the forefront of its concern, therefore any environmental impacts resulting from the development activities are not distributed in such a manner as to unfairly discriminate against any persons, particularly vulnerable and disadvantaged persons.
- In terms of section 20, the developer is required to obtain a permit from DWAF in order to establish, provide or operate any waste disposal site within the boundaries of the property.
- The developer is required to undertake Environmental Impact Assessments (EIA) for all projects listed as a Schedule 1 activity in the

EIA regulations in order to control activities that might have a detrimental effect on the environment. Such activities will only be permitted with written authorisation from a competent authority.

2.7 Conservation of Agricultural Resources Act 43 of 1983 and Conservation of Agricultural Resources Regulations.

In terms of section 6 of the Act, the Minister may prescribe control measures with which all land users have to comply. The control measure may relate to the following:

- the regulating of the flow pattern of run-off water;
- the control of weeds and invader plants;
- the restoration or reclamation of eroded land or land which is otherwise disturbed or denuded.

2.8 Forest Act 122 of 1984

Protected trees

The Forest Act provided for the protection of trees on private land by providing that ‘no person may cut, damage, destroy, disturb or remove any protected tree from the land in question, or collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any part or produce thereof’.

The Minister was authorised, in respect of any land not forming part of a State forest, to declare a particular tree, a particular group of trees, or trees belonging to a particular species occurring on that land, to be a protected tree or trees. Regulations published under the Act list 58 species of protected trees to which these prohibitions apply. Although the NFA has repealed the old Forest Act, the majority or regulations promulgated under the Act still remain in force until such time they are replaced by new regulations under the NFA.

2.9 National Forests Act 84 of 1998

Protected trees

The Minister may declare a tree, group of trees, woodland or a species of trees as protected. The Minister is required to publish a list of all species protected under this Act, an appropriate warning of the prohibitions set out and the consequences of its infringements, annually in the Government Gazette. The prohibitions provide that ‘ no person may cut, damage, disturb, destroy or remove any protected tree, or collect, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any protected tree, except under a licence granted by the Minister’.

2.10 National Heritage Resources Act 25 of 1999

- No person may alter or demolish any structure or part of a structure, which is older than 60 years without a permit issued by the relevant provincial heritage resources authority.
- No person may, without a permit issued by the responsible heritage resources authority destroy, damage, excavate, alter, deface or otherwise disturb any archaeological or paleontological site.
- The protection of archaeological and paleontological sites and material is the responsibility of a provincial heritage resources authority and all archaeological objects, paleontological material and meteorites are the property of the state. Any person who discovers archaeological or paleontological objects or material or a meteorite in the course of development must immediately report the find to the responsible heritage resources authority, or to the nearest local authority offices or museum, which must immediately notify such heritage resources authority.
- No person may, without a permit issued by SAHRA or a provincial heritage resources authority destroy, damage, alter, exhume, remove from its original position or otherwise disturb any grave or burial ground older than 60 years which is situated outside a formal cemetery administered by a local authority. “Grave” is widely defined in the Act to

include the contents, headstone or other marker of such a place, and any other structure on or associated with such place.

- A permit will only be granted if SAHRA is satisfied that the applicant has made satisfactory arrangements for the exhumation and re-interment of the contents and reached agreement with the affected communities regarding the future of such grave or burial ground.

2.11 Eastern Cape Environmental Conservation Bill, 2003

To provide for the consolidation and the repeal of certain laws relating to environmental conservation applicable in the Province, including the Sea-shore Act, 1935, Mountain Catchment Areas Act, 1970, and the Environmental Conservation Act, 1989; to provide for the declaration of Provincial protected areas; to provide for the management of biodiversity in the Province; to provide for Provincial coastal management; to regulate air quality and waste management in the Province; and to provide for matters connected therewith.

This bill provides a number of schedules which protect endangered flora and for which a permit is required. According to Chapter 12 ‘Miscellaneous provisions relating to endangered flora’ 112. (1) Subject to the provisions of this Act, no person may – in respect of flora listed in Schedule 4, without a possession permit (iii) pick, uproot, damage or destroy any endangered flora.

2.12 Provincial Nature Conservation Ordinance (PCNO)

Protected indigenous plants in general are controlled under the relevant provincial Ordinances or Acts dealing with nature conservation. In the Eastern Cape the relevant statute is the 1974 Provincial Nature Conservation Ordinance. In terms of this Ordinance, a permit must be obtained from Department of Economic Affairs Environment and Tourism (DEAET) to remove or destroy any plants listed in the Ordinance.

2.13 Nelson Mandela Bay Municipality's Metropolitan Open Space System (MOSS)

The boundary of the Metropolitan Open Space (MOSS) system has been defined for the metropolitan area. Understandable, MOSS has been considered as the blueprint while determining the environmental buffer and it is therefore necessary to determine synergy between this study, MOSS and all other strategic development plans of the NMBM. The NMBM's Metropolitan Open Space System plan also indicates the major portion of the coastline as an important component of the Metropolitan Open Space System, including Nature Reserve areas at UPE, Cape Recife and Sardinia Bay as well as an indication of a very important public open space along Marine Drive. The MOSS plan also indicates a corridor along the coastal area linking the Sardinia Bay Nature Reserve, Cape Recife and the UPE Nature Reserve.

2.14 Metropolitan Spatial Development Framework, 2009

Consistent with the critical components of the NMBM's Metropolitan Spatial Development Framework (MSDF) (NMBM, 2009), coastal setback lines determination, as part of sector plans, has identified areas where the Municipality should make decisions and hence trade offs during allocation of its resources by adopting four main elements of the MSDF which include:

- Core economic areas.
- Infill priority areas.
- Strategic development areas.
- Service upgrading priority areas.

3. METHODOLOGY

An integrated approach

In order to identify coastal set-back lines for the coastal zone as a policy option, an analysis of the whole system should be carried out, through the calculation of coastal set-backs based on physical processes and the incorporation of ecological and landscape protection criteria. This preliminary analysis identifies a buffer zone as a base for further analysis of the already existing socio-economic factors, i.e. the legal and administrative framework, the presence of building and human activities and the local perception of coastal protection and the use of set-backs. In any case a clear formulation of the problem and of the objectives of setback lines should be identified in the beginning of the process, in the framework of a broader coastal management plan (NMBM, 2009).

Based on the previous reflections on coastal types, physical ecological and socioeconomic processes, an integrated approach should cover two parts (i) a technical analysis and (ii) the analysis of the implication of policy implementation at the local level.

Table 1: Steps of the proposed integrated approach, for the identification of coastal setbacks

Phase	Processes	Activity
Technical analysis	Physical	1. Identification of geomorphologic features (type of coast) together with elevation models
		2. Calculation of physical risk lines
	Ecological	3. Identification of ecological and landscape values, buffers and corridors
	Socio-economic	4. Identification of cultural and human landscape values
		5. Identification of public coastal uses
		6. Analysis of transit and accessibility issues
Policy analysis	Socio-economic	7. Analysis and proposal of legal and administrative provisions
		8. Public involvement and discussion on the proposed setbacks
Policy implementation	9. Final Setbacks	

Given that the approach in the National Environmental Management: Integrated Coastal Management Act, 2008 (Act No. 24 of 2008) is based around human use and activities along the coast, the balance between the opposing risk extremes of asset loss and the usage of the coast for human purposes must be achieved. If one then reviews the philosophy of coastal set-back lines it is clear that one single set-back line is impractical. There are two real issues which need to inform the development of set-back lines. The first issue which needs to be defined is the extent of the hazard zone (this is an area where the coastal processes are able to play themselves out) and secondly the appropriateness of infrastructure and how close this can be placed to the hazard zone.

The use of setback lines should be based on a trade-off between environmental and human safety and public use, and also between a short term and a long term perspective. Local populations could be willing to accept the risks of flood, erosion and environmental degradation, in a short term perspective. However it is the responsibility of National, Provincial and Local Government Departments to maintain a broader perspective of the issue, including the long term consequences and ecological values, under the principles of sustainability.

GIS Working Procedures & Data Needs for Determining Coastal Set-back Line for Nelson Mandela Bay Metropolitan

The following steps were undertaken in determining the 'coastal set back line' for NMBM:

Step 1 - Determine the 1:10 year storm wave height and period for the NMBM coastline using the available wave statistics.

Step 2 - In order to ascertain the most suitable sandy shoreline wave run up model in this region a selection of models were assessed for suitability. The three models that were tested and variables required are shown in Table 2 below:

Table 2: Wave run up models and variables required.

Model	**Variables required**
Nielsen and Hanslow 1991	Wave height Beach shore face slope
Stockdon *et al*. 2006	Wave height Wave period Beach shore face slope

Mather *et al.,* 2009 (as used in the Durban SLR study 2009)	Wave height Bathymetric profile

These models were run at three locations identified by the NMBM. At each location, cross-sections were analysed using the above models. The results from the three models were compared and the most suitable model determined by three criteria, namely: the accuracy of wave run up prediction, the most efficient and cost effective and the model giving 100% coverage of the coastline without the need for additional data.

Step 3 – Determine the inland maximum scour envelope using aerial and or cross section data. This was then used in later steps to buffer the High Water Mark (HWM).

Step 4 – Determine the current theoretical High Water Mark in terms of the ICMA using the 1:10 year wave data and the chosen model for the sandy portion of the NMBM coastline.

Step 5 – Determine the current theoretical High Water Mark (HWM) in terms of the ICMA using the 1:10 year wave data and the Eurotop manual for the rocky portion of the NMBM coastline.

Step 6 – Determine the predicted future High Water Mark (HWM) for the sandy coastline using three sea level rise scenarios, 300mm, 600mm and 1000mm. The Bruun rule coastal regression model was used. Simulate SLR for the rocky shoreline areas.

Step 7 – Determine the Environment buffers required inland from the HWM to maintain a functional coastal ecosystem under future sea level rise scenarios. A specialist coastal ecologist provided this input.

Step 8 – Determine of social buffers required along the coast. For example allowance for public beach access through and along the coastal frontage or for areas which have cultural significance and will need to be preserved from development.

Step 9 – Determine any economic requirements for the coast. For example, allowance for new beach facilities that will need to be placed closer than normal development to serve the public. Economic demands often require a trade off against environmental aspects at a particular site. Therefore an acceptable methodology to deal with the possible conflicts between the desire for environmental protection and the need for economic activities is provided.

Step 10 – Determine the ‘coastal set-back line’ and ‘coastal protection zone’ taking into account the information and requirements of the above steps.

4. RESULTS

Step 1: Determine 1:10 year storm wave height and period for NMBM coastline

The 1:10 year storm wave height and period for NMBM coastline was determined using available wave statistics. Extreme wave analysis statistics from recent coastal engineering and oceanographic studies were reviewed. The results of several available studies are presented in Table 3 below:

Table 3: Extreme wave analysis 1:10 and 1:100 year return period wave height, period, statistical methods and source.

1:10 H_0 (m)	1:10 Tp (sec)	1:100 H_0 (m)	1:100 Tp (sec)	Method	Report
8		9.4		Weibull Distribution	(ASR, 2008)
8.4	17.7	9.8	19.2	Weibull Distribution The 95% confidence level to the best estimate is calculated using the Monte Carlo method.	(PRDW, 2009)
9.8	19.2	11.5	20.8	Weibull Distribution as above including increased wave heights due to climate change, which is assumed to increase the heights by 17%	(PRDW, 2009)

From evaluation of the results of extreme wave statistics presented in Table 3 above, it was decided that due to the conservative approach of this study the effects of climate change should be incorporated and thus the extreme 1:10 year return wave conditions to be used are H_o = 9.8 m as calculated for a

position at 30m water depth off Thyspunt roughly 100 km southwest of Cape Recife shown in
Figure 17 below.

Step 2: Evaluation of the run up model comparisons

The only assumption, which could make a material difference to the results of the comparisons, is the offshore wave heights. Port Elizabeth does not have a wave height recorder and so data for wave height and period, which is used in all the models, was sourced from NOAA Wave Watch 3 (NWW3) global wave model hindcast data.

The NWW3 wave model is the world standard, it is a third generation ocean wave propagation model. NWW3 solves the spectral action density balance equation for wave number-direction spectra. The model domain is the entire globe between 78°N and 78°S with grid points spaced at 1° latitude and 1.25° longitude. The wind fields used to drive the NWW3 wave generation forecast come from the NOAA Global Forecast System (GFS), which combines data assimilation and a forecasting model. The NWW3 hindcast are run with the archived (historical) wind fields, which provide higher accuracy wave data than the forecast data.

Hindcast wave data extracted from a position directly offshore of Cape Recife (34.25°S, 25.75°E), shown in

Figure 17 below, was then used to evaluate the 3 wave run-up models.

Figure 17: Wave data extraction locations for Step 1 and Step 2, PRDW refraction modelling extraction in approximately 30m water depth offshore Thyspunt and WW3 hindcast data extracted for a position directly offshore of Cape Recife respectively.

The comparison are based on the three proposed models of

- Nielsen and Hanslow, 1991;
- Stockdon et al., 2006; and
- Mather et al., 2010.

The models have been tested for applicability in the NMBM region by applying data gathered from the region at the following sites: Maitlands Beach, Pollok Beach, Bluewater Bay Beach and Wells Estate (Figure 18) below. All oceanographic data used in the model evaluation exercise is shown in Table 4 below.

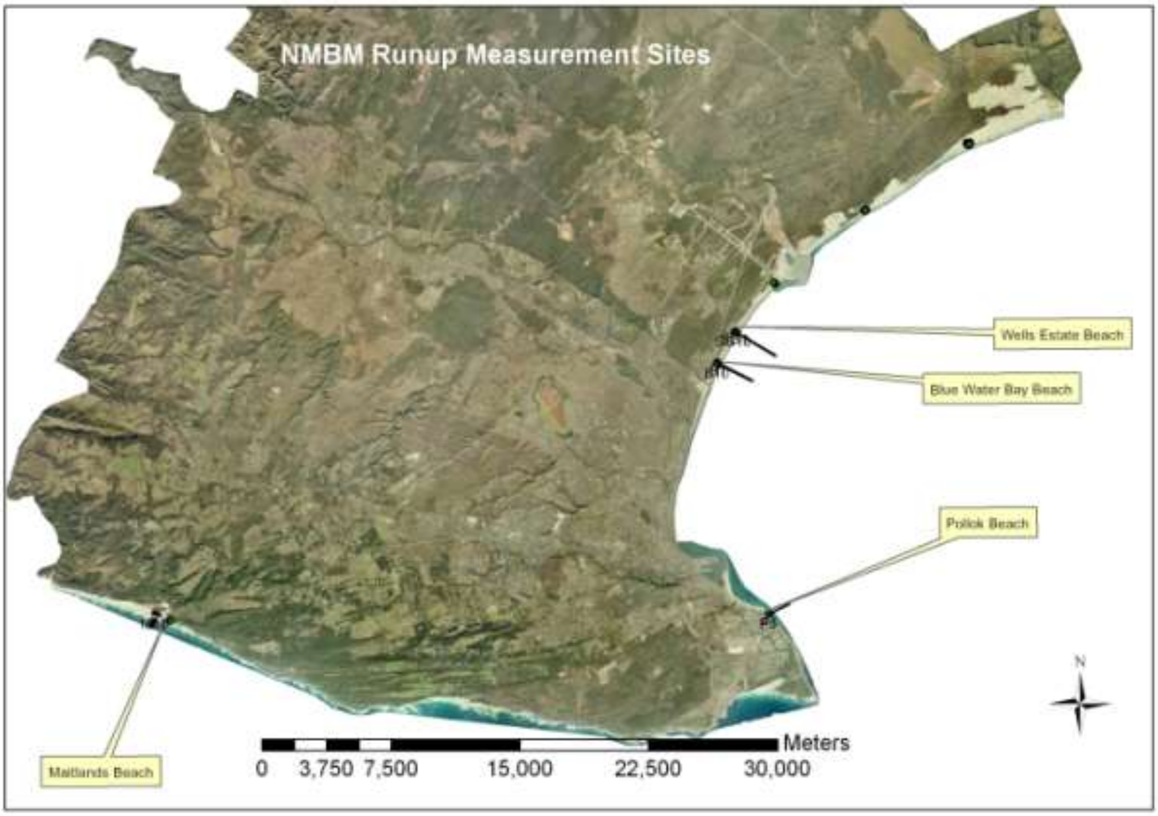

Figure 18: Map of NMBM coastline and run-up measurement sites

Table 4: Oceanographic data used in the model evaluation exercise.

Parameter	**Value**	**Source**
SWL, (m)	2.45m	SANHO, measured data PE Harbour

Ho, (m)	6.5 m	NWW3, Hindcast
T, (sec)	15 sec	NWW3 ,Hindcast

Bathymetric data (SAN 125) and beach survey data were utilized to produce all other data for input into the three models. 10 shore normal transects were measured at Maitlands Beach, Blue Water Bay Beach and Wells Estate, only 5 shore normal transects were measured at Pollok beach due to limited data coverage at this site. Along each transect the following measurements were made: measured run-up level, lower beach level, distance between 0 MSL and -15m depth contour. From the measured run-up level and lower beach level the beach face slope could be calculated. A schematic representation of this method is shown in Figure 19 below and transects, beach survey data and contours for Pollok Beach are shown in Figure 20 below.

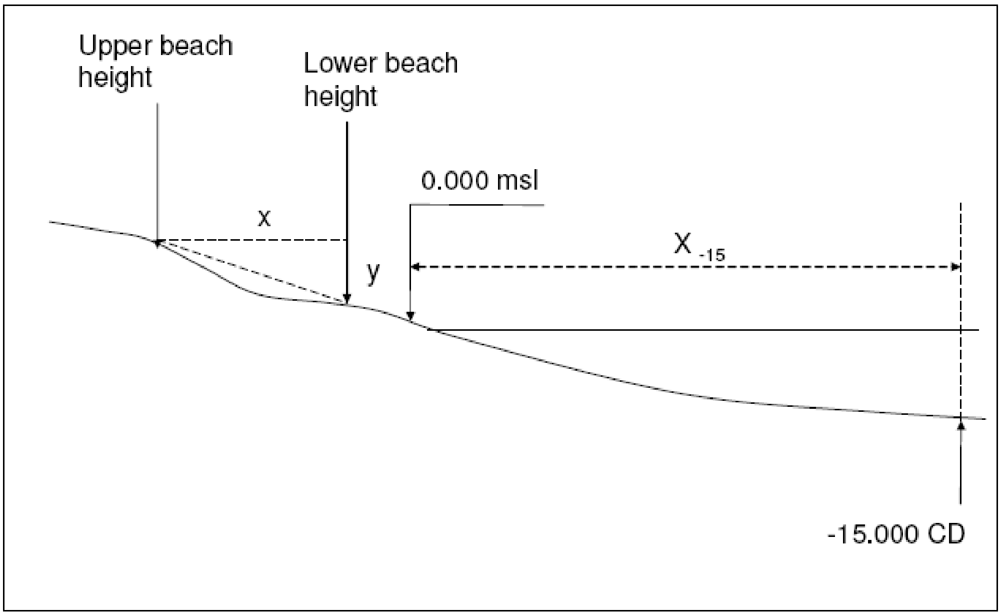

Figure 19: Schematic of beach transect measurements for the model evaluation

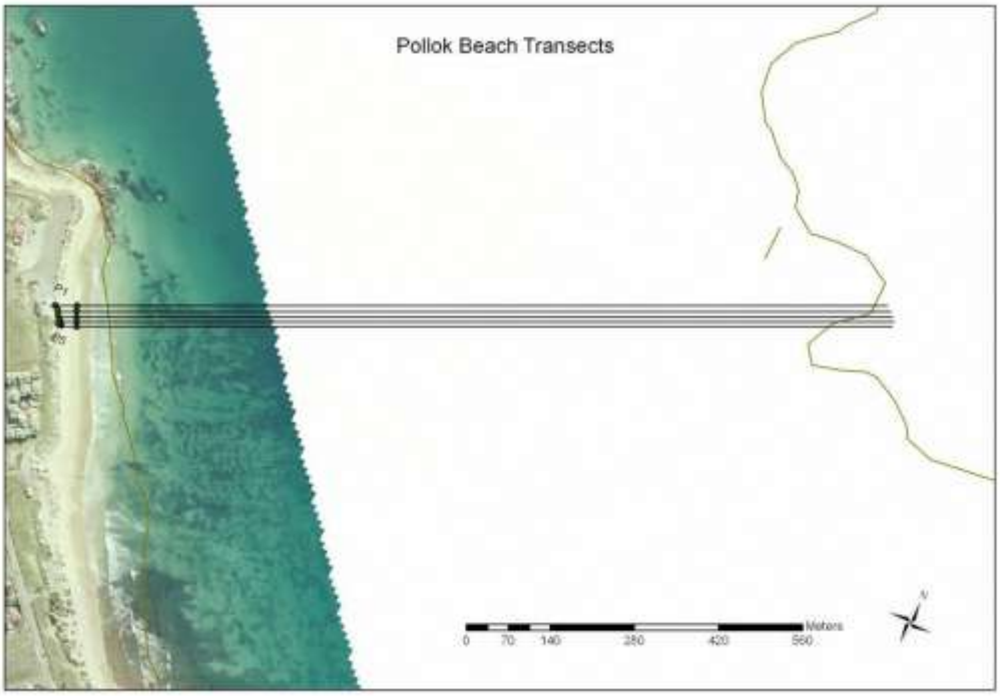

Figure 20: Beach transects at Pollok Beach, beach survey measurements in green, 0m msl and -15m depth contour shown in brown.

The first model is that of Nielsen and Hanslow 1991. This model is a two part model and as the slopes in all the study sites are less then 0.1 the Nielsen and Hanslow formulae reduces to a simple formulae which is not dependent on beach slope. The result of this is that when the results are plotted, the model returns the same value for predicted wave run up at all sites (4.814m above MSL) as shown in Figure 21 below.

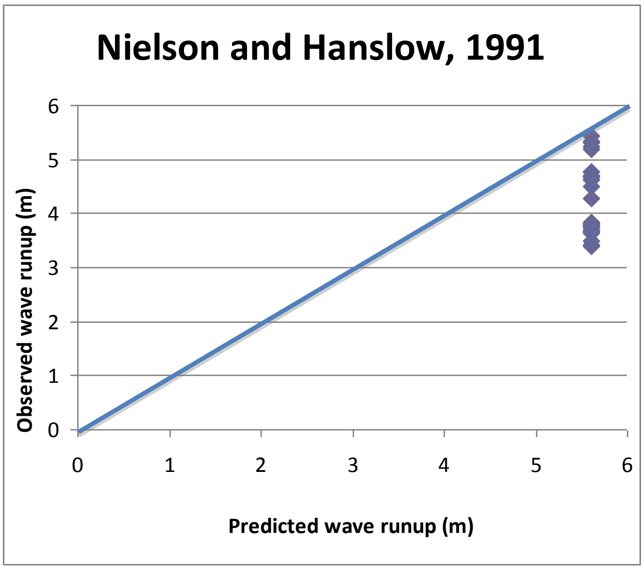

Figure 21: Wave run-up results for Nielsen and Hanslow model.

The next model evaluated is that of Stockdon et al. 2006. This model performed well as can be seen in Figure 22 below.

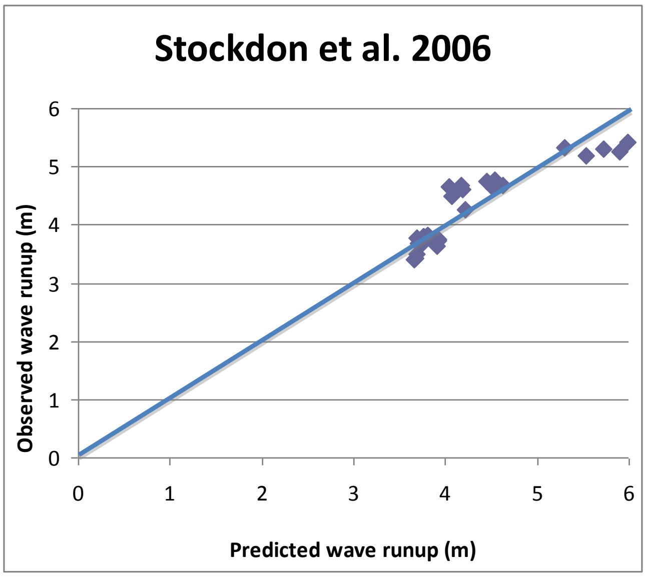

Figure 22 Wave run-up results for Stockdon et al. 2006.

The last model evaluated was that of Mather *et al.* 2010. This model takes a different approach to the two previous models in that it uses the bathymetric profile of the nearshore as opposed to the beach face slope between low and high water marks. The results for c=10 are shown in Figure 23 below.

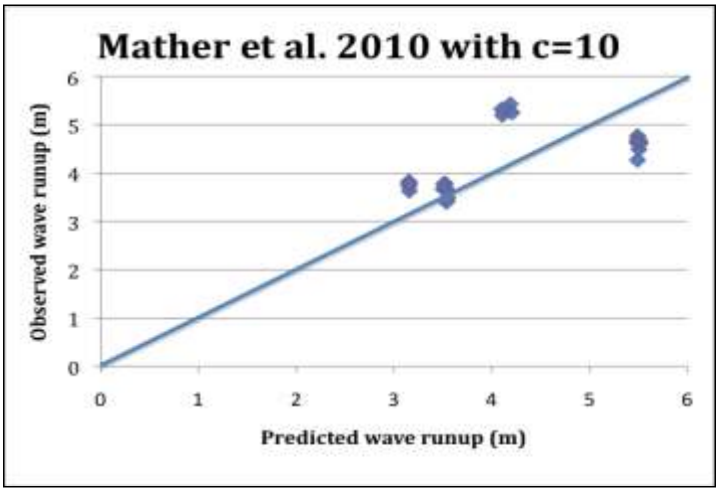

Figure 23: Wave run-up results for Mather et al. 2010.

The results show that each beach can be identified as a tight cluster of data points. The results are scattered either side of the trend line which passes through the centre of the data. This model produced good predictions at Blue Water Bay, under predictions at Wells Estate and Pollock and over predictions at Maitlands.

As the coastline in question is very different east and west of Cape Recife it was decided to modify the Mather *et al.* 2010 model to deal with the two different types of coastline as opposed to the approach shown on figure 6 above which deals with all the sites examined.

The Maitland site was analysed on its own and the coefficient c calibrated by a best fit as c=6. The observed versus predicted results are shown in Figure 24 below.

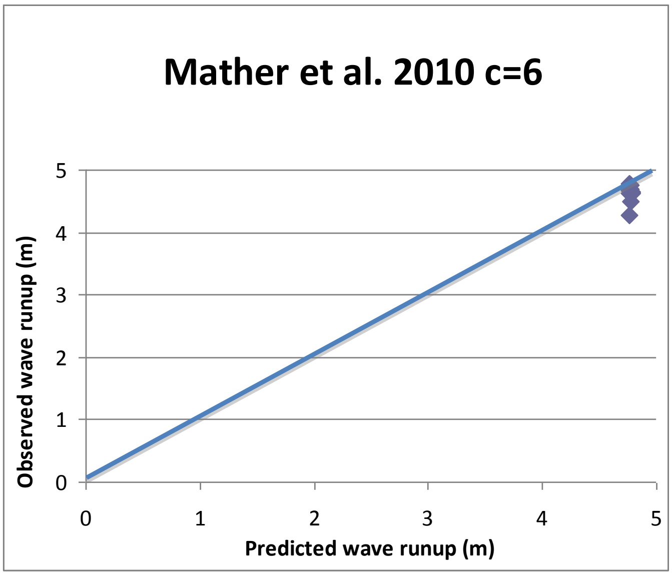

Figure 24: Wave run-up results for Maitlands Beach with c=6.

Likewise the Pollok, Blue Water Bay and Wells Estate where similarly analysed and the results of the coefficient c determined by a best fit as c=11. The observed verse predicted results are shown in Figure 25 below.

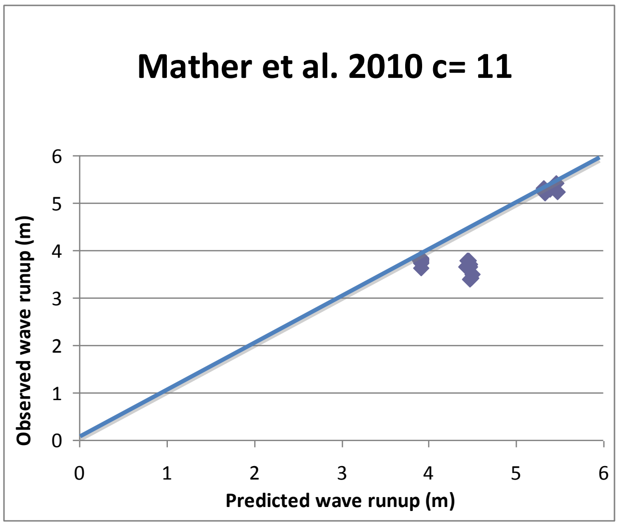

Figure 25: Wave run-up results for Pollok, Blue Water Bay and Wells Estate with c= 11.

From this evaluation it can be seen that the worse performing model for this area is the Nielsen and Hanslow 1991 model. The best performing model was that of Stockdon *et al.* 2006 which while under predicting did give a tighter distribution of results at all four locations. However, this model requires a significant amount of data, which needs to be provided to populate their equation shown below:

$$R_{\max} = 1.1\left[0.35\beta_f\sqrt{H_0L_0} + 0.5\sqrt{H_0L_0\left(0.563\beta_f^2 + 0.004\right)}\,\right]$$

In order to provide the input data for this model a survey would be required along the entire 102 km of coastline to establish the beach face slope βf. This would entail significant additional costs beyond the scope of the current appointment and therefore while the model provides good results the additional costs involved appear to be excessive in terms of the improved prediction of wave run up.

This leaves the Mather et al. 2010 model that uses readily available data and the simple formulae as follows:

$$R_{\max} = CH_0S^{2/3}$$

In this study C=6 for the coastline west for Cape Recife, while C=11 for the coastline east of Cape Recife was used. The wave run up position has been buffered by additional environmental and social requirements and so the position of the set back line will in all cases be inland of this line and therefore it was recommended that the Mather *et al*. 2010 model be used given the constraints to data availability.

Step 3: Determination of inland maximum scour envelope

Shoreline Features

Many shoreline features are distinguishable from aerial photographs on sandy coastlines these include: the seaward vegetation line, high tide wrack line, berm crest, wet/dry interface (wet-line), and beach step. While on rocky inter-tidal areas the algal line can be used as a proxy for the shoreline. The wet-line and algal line give a good approximation of the shoreline at the time of the aerial photograph on sandy and rocky inter-tidal areas respectively (O'Connel, 2003). The wet-line was digitized along sandy sections of beach and the algal line was digitized along rocky sections of coast for aerial photograph from 2004 and 2007. The above mentioned shoreline features could not be distinguished clearly on the lower resolution 1996 aerial photographs therefore these were excluded from this exercise. All wet-line data and algal line data was then used to create a composite wet-line by combining the most landward sections along the entire NMBM coastline.

Shoreline Trends

According to the methodology being developed in the Western Cape: aerials spanning a minimum period of at least 40 years are recommended to determine a long term shoreline trend (WSP, 2010). Due to the fact that only two aerials of suitable quality were available for this study spanning only 3 years it was not possible to calculate regression trends, therefore regression trends could not be included in this study at this stage.

The vegetation line was digitized for 1996, 2004 and 2007 aerials and these data were assessed for suitability for regression trend analysis. Several limitations were encountered with this data:

- Limited record of 11 years between 1996 and 2004
- Large tracts of mobile coastal dunefields along the NMBM coastline, where the vegetation line is controlled by aeolian processes rather than wave processes.
- Uncontrolled access across foredunes has destabilized vegetation in many areas and in some instances leading to blow-outs, affecting the position of the vegetation line.

Cross section data was available for 12 sites within the bay; this data was compared with the composite wet-line data to verify the maximum scour envelope. The data was also evaluated for possible use in identifying and quantifying trends. However the longest data set was only 19 years old and the other data sets were of much shorter duration.

Step 4 - Determination of current HWM in terms of the ICMA for sandy portion of coastline

Before work could begin on Step 4, 5 and 6 the photogrammetric data from aerial photography conducted in July 2004 for the NMBM had to be processed and interpolated to create a Digital Terrain Model (DTM) for the coastline. In addition the -15m depth contour was digitized from the navy chart "SAN125" and added to the DTM data.

According to the ICMA the theoretical High Water Mark is the level reached by storm waves occurring at 1:10 year return period, wave conditions selected in step 1 were modelled using Mather *et al.* 2010. Data points were produced at 20m intervals along the coastline. Overlaying the outputs of the aerial HWM modelling over the DTM and aerial photographs allowed for model data and DTM verification.

Figure 26 below shows the full extent of the NMBM coastline divided at Cape Recife as defined in Step 2 and the input parameters and formula used for this exercise. Examples of HWM modelling output are shown in Figure 27 and Figure 28.

Figure 26 Map of the NMBM coastline divided at Cape Recife and the input parameters for the Mather *et al.* 2010 formula used to model the HWM

Figure 27: Modelled HWM at Sardinia Bay west of Cape Recife, the results are verified by the insert in the lower right hand corner showing extreme wave run up during the September 2008 storm event, note the position of run up in relation to the two structures.

Figure 28: HWM modelling at Wells Estate, north of the Swartkops Estuary mouth

Step 5 - Determination of current theoretical High Water Mark in terms of the ICMA for rocky portion of coastline

For the rocky portions of coast the wave runup was calculated using the 1:10 year wave data from step 1 and the Eurotop manual[1].

Wave run up is described by the formula given by the Eurotop manual (2007) on page 75.

$$\underline{u2\%} - 1.75 - 7b' \, Yf \, Yp^{m} \, 4_{m}\text{-}10 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{Eq. 1}$$

with a maximum of

$$\frac{R_{u2\%}}{m0} \_100 \quad ,\text{-} . \quad 43 \quad 1.6 \quad \backslash \quad 'y_b m \quad m\text{-}1, 0 J \qquad \text{Eq. 2}$$

Where

$R_{u2\%}$ = wave runup height exceeded by 2% of the incomimg waves [m]

y_b = influence factor for a berm

y_f = influence factor for roughness elements on a slope

y_p = influence factor for obilque wave attack

b_m-1 0= breaker parameter = tanay (s 1 0**1**

[1] Eurotop 2007. Wave overtopping of sea defenses and related Structures: Assessment Manual. Archive for research and technology on the North Sea and Baltic Coast.

Rearranging Eq. 1 and substituting ^=1.0 yields

$$R_u2\% = 175\text{-} H_{m0}\text{-} y_f\text{-} y_p\text{-} £_{m\_10} \text{.......................................} \text{Eq 3.}$$

The deepwater 1:10 year wave height was modeled to an inshore wave at the 15m bathy contour using the SWAN model[2]. The roughness factor y_f was applied using the influence factors determined by the previous on site wave run up measurements and on site observations as shown in Table 5 below.

Table 5 Slope friction coefficients used to calculate wave runup

Type of coastline	Eurotop friction factor y_f
Predominately sandy with ± 10% rock	1.0 (calculated)
Sandy with ± 50% rock	0.9 (calculated)
Rocky with ± 20% sandy	0.8 (calculated)
Long continuous rocky shoreline	0.45

This can be shown to plot as a a curve of two parts, covering breaking and non breaking waves, for a particular range of slopes (Figure 29 below).

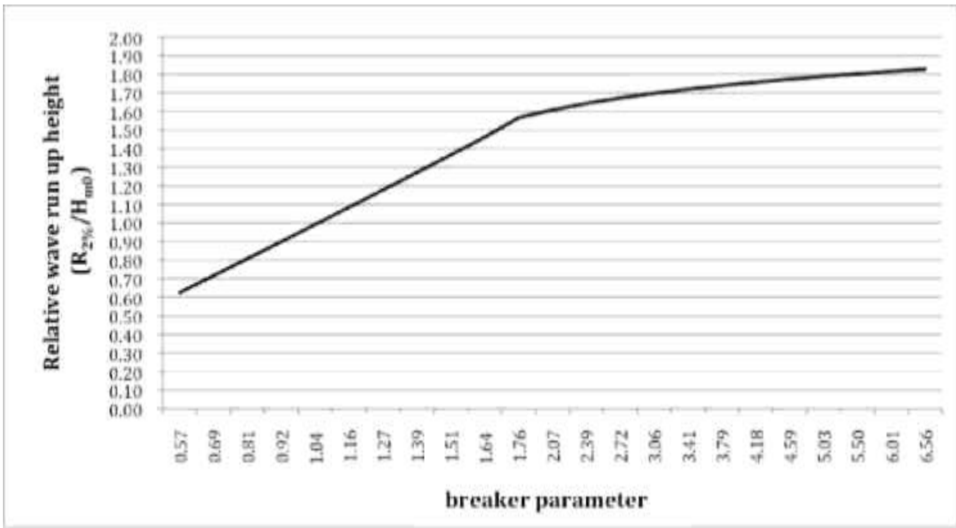

Figure 29 Wave runup curve for rocky shoreline at Port Elizabeth (lambda f = 0.45)

[2] SWAN is a third-generation wave model that computes random, short-crested wind-generated waves in coastal regions and inland waters. See www.swan.tudelft.nl

The modeling was undertaken along the selected sections of rocky shoreline. The results were supplied as a GIS shapefile. Figure 30 below shows modelled runup along a rocky portion of coast west of Cape Recife.

Figure 30: High Water Mark modelling using Eurotop manual for rocky coastline at Schoenmakerskop, west of Cape Recife

Step 6 – Determine the predicted future High Water Mark (HWM) for the entire NMBM coastline due to Sea Level Rise.

The regression due to predicted sea level rise associated with global warming was simulated differently for sandy and rocky coastline. For sandy coastline vulnerable to erosion, where greater regression is expected, the Bruun rule was used. This was conducted using the DTM data and three sea level rise scenarios, 300mm, 600mm and 1000mm. The Bruun rule was set up in the Auto Cad environment and the regression calculation process was calculated for the whole coastline with outputs at 20m intervals. In order to incorporate the maximum scour envelope all data was 'lifted' and the 0m contour was placed on the composite wet line (from step 3). This process effectively added the distance between the DTM 0m contour to the composite wet line to all the output HWM and regression lines. The wet-line may be slightly higher than the 0m contour in reality and this exercise described above may result in conservative results, this is considered favourable due to the conservative and precautionary nature of this study. Examples of Bruun regression shoreline modelling are shown in Figure 31 and Figure 32 below.

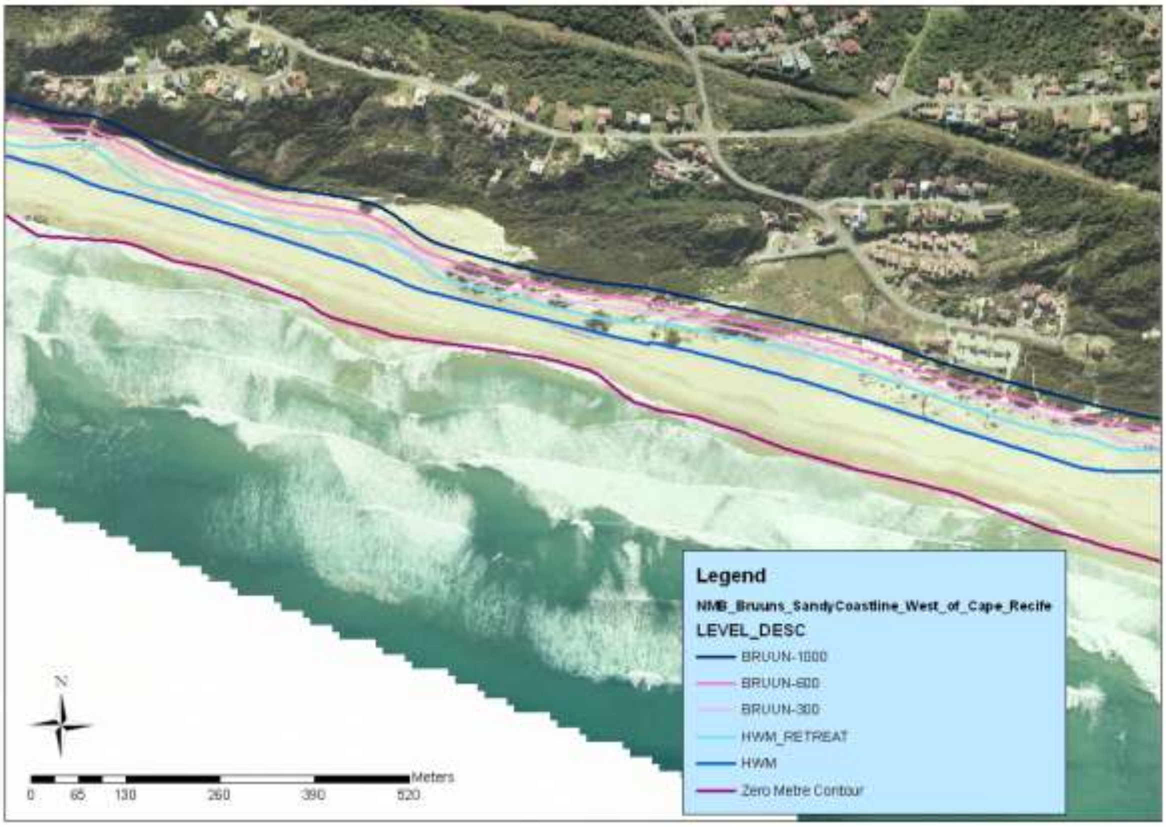

Figure 31 Bruun regression modelling for sandy coastline at Blue Horizon Bay.

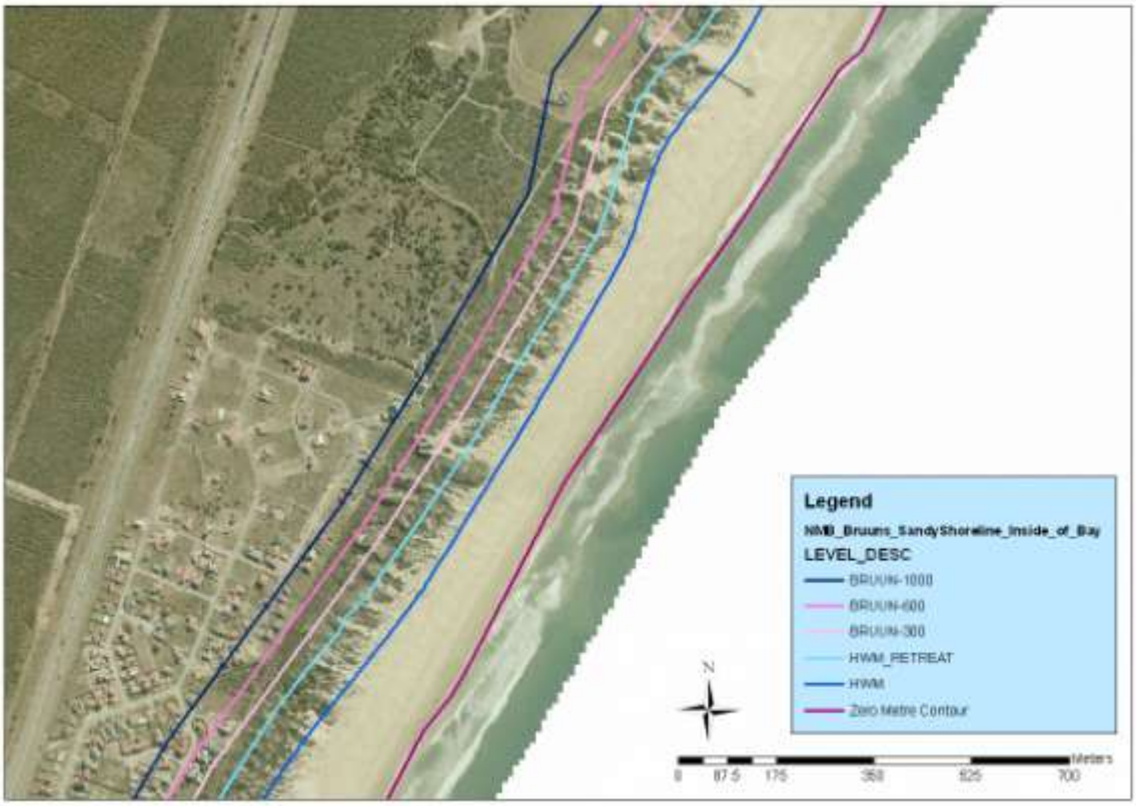

Figure 32 Bruun regression modelling for sandy coastline between Blue Water Bay and Wells Estate

The coastal process setback line (**CPSLs**) for the sandy coastline was determined by:

CPSLs= A*+B+C

Where, **A*** is the difference between the composite wet-line and the DTM 0m contour (only used for sandy coastline), **B** is the HWM modelled using Mather et al., **C** is the regression due to SLR. An example of CPSLs output is presented in Figure 33 below.

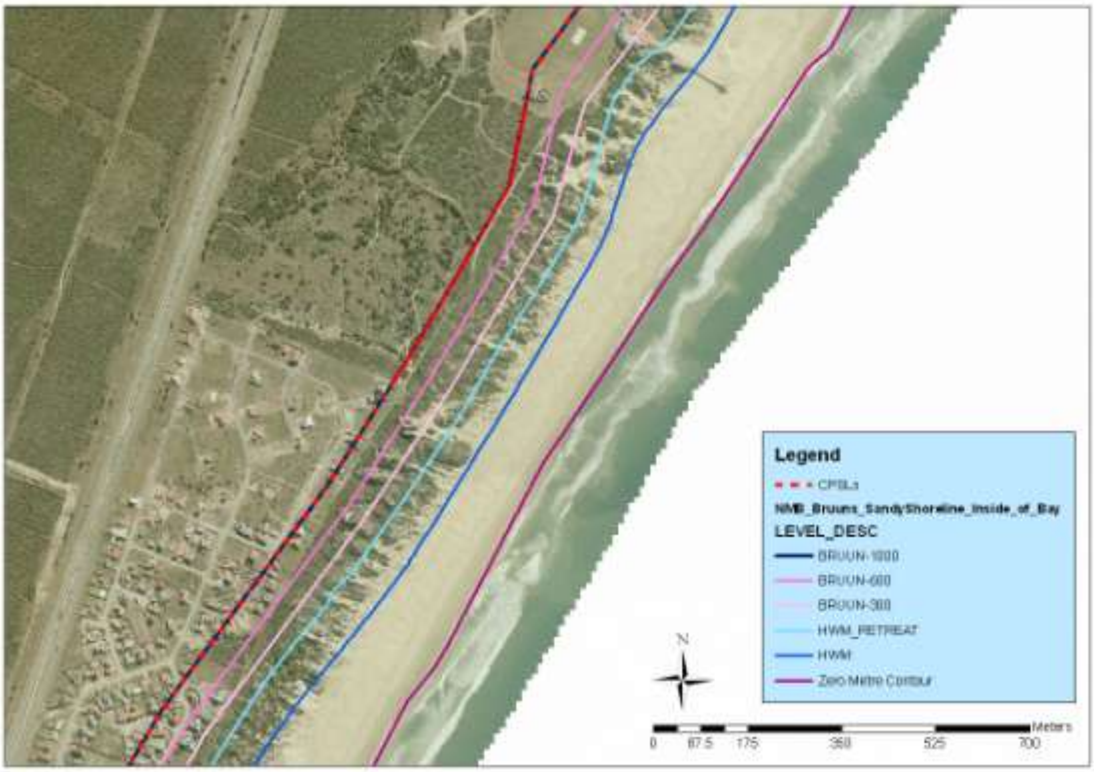

Figure 33 Coastal process set-back line (CPSLs) for sandy coastline.

For rocky coastline resilient to erosion, the Eurotop wave runup modelling output surface was shifted vertically by 1000mm and the intersection with the DTM data was calculated in the Auto Cad environment. An example of sea level rise for rocky shoreline is presented in Figure 34 below.

Figure 34 Sea level rise (1000mm) for rocky shoreline area west of Cape Resife.

The coastal process setback line (**CPSLr**) for rocky coastline was determined by:

CPSLr = D+E

Where, **D** is the HWM modelled using the Eurotop Manual and **E** is the horizontal intersection of the HWM surface lifted vertically by 1000 mm with the DTM.

An example of CPSLr output is presented in Figure 35 below.

Figure 35 Coastal process set-back line (CPSLr) for rocky shoreline are west of Cape Recife.

Step 7 - Environmental Buffers, Step 8 - Social Buffers, Step 9 - Economic Requirements

Upon the resolution taken during the Project Steering Committee meeting held on the 29th July 2010 it was agreed that the project team should consolidate the following steps into a workshop with relevant stakeholders:

Step 7 – Determine the Environment buffers required inland from the HWM to maintain a functional coastal ecosystem under future sea level rise scenarios.

Step 8 – Determine of social buffers required along the coast. For example allowance for public beach access through and along the coastal frontage or for areas which have cultural significance and will need to be preserved from development.

Step 9 – Determine any economic requirements for the coast. For example, allowance for new beach facilities that will need to be placed closer than normal development to serve the public. Economic demands often require a trade off against environmental aspects at a particular site. Therefore the project team will provide an acceptable methodology to deal with the possible conflicts between the desire for environmental protection and the need for economic activities.

In preparation for the workshop, broad steps of the process were followed and provided for to all the participants prior to and during the workshop. Geographic Information Systems imagery and shape files determined in the earlier stages of this project (steps 1-6) were used to facilitate and record the decisions taken at each location. Analysis of data through a live GIS application was also undertaken. The data that was used for the workshop included:-

- Current High Water Mark
- Maximum scour High Water Mark
- Position of the High Water Mark under 300, 600 and 1000mm of sea level rise
- The Nelson Mandela Municipal Open Space System (NMB MOSS) coverage

Process of determination of Coastal Set-back Line and Coastal Protection Zone Limit

Step1

At each stretch of beach examination of the High Water Mark under the various sea level rise scenarios and determination of the hazard zone was done. This was the first line of importance in determining the active hazard zone in which any development placed sea ward of this line is likely to experience direct wave attack. As an aide memoire the table below was provided in order to assist in the discussion of which scenario was appropriate to the development in place/proposed.

Table 6: Decision matrix for risk selection to sea level rise for coastal developments including: infrastructure value, lifespan, impact of failure, planned sea-level rise (Courtesy Andrew Mather, Ethekwini Municipality)

Value of infrastructure	**Life of infrastructure**	**Impacts of failure of the infrastructure**	**Planned amount of sea level rise**
Low (up to R2 million) i.e. Recreational facilities, car parks, board walks, temp beach facilities	**Short term** Less then 20 years	**Low** Minor inconvenience, Alternative facilities in close proximity, short rebuild times	**0.3m**
Medium (R2 million to R20 million) Tidal pools, piers, recreational facilities, sewerage pump stations.	**Short to Medium Term** Between 20 and 50 years	**Medium** Local impacts, loss of infrastructure and property	**0.6m**

High (R20 million to R200 million) Beachfronts, small craft harbours, Residential homes, sewerage treatment works.	**Medium to Long Term** Between 50 and 100 years	**High** Regional impacts, loss of significant infrastructure and property	**1.0m**
Very High (greater then R200 million) Ports, desalination plants, nuclear power stations	**Long term** In excess of 100 years	**Very High** Major disruption to the regional and national economy, failure of key national infrastructure	**2.0m**

Step 2

The next issue was to determine the extent of any environmental buffers that may be required in addition to the active hazard zone. Allowance was made for dune systems, coastal forest, etc. to ensure that the coastal zone can remain a functional system. It was important to at least provide a vegetation edge so that re-colonisation of the primary dune vegetation can occur after severe erosion events. NMB MOSS GIS data layer was used as the principle determinant of the environmental buffer and CPZL. The process of determining the CPZL is shown diagrammatically in Figure 36 below.

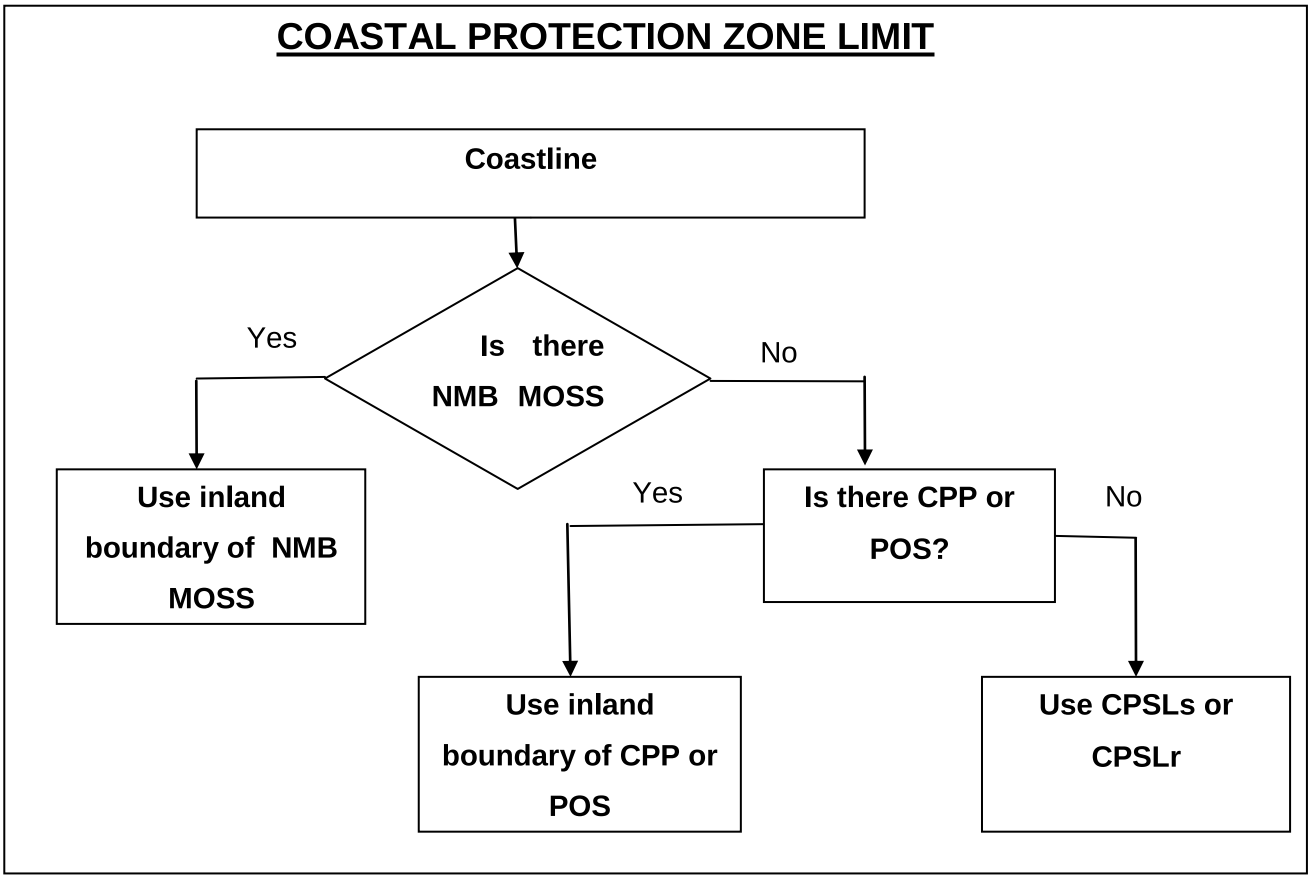

Figure 36 Decision tree for placement of coastal protection zone limit

Step 3

Once the two steps above were completed two lines were determined:

- Coastal Protection Zone Limit
- Coastal Set-back Line

Results

Given that the approach in the ICMA is based around human use and activities along the coast, the balance between the opposing risk extremes of asset loss and the usage of the coast for human purposes, as has been considered. The CPSL with maximum sea level rise of 1000 mm in 100 years was chosen as a principal determinant for both the coastal set-back line (CSL) and coastal protection zone limit (CPZL).

During the workshop, the implications of coastal set-back line and coastal protection zone limit were considered in detail with reference to the specifications contained in the ICMA, 2008. In addition outcomes of similar projects to establish coastal set-back lines in the Western Cape Province were presented and considered when deciding on an approach for NMBM.

The representatives of NMBM proposed that the coastal set-back line should be situated along the CPSLs and CPSLr, regardless of ownership, zoning or socio-economic issues. The rationale being that the NMBM has an obligation to inform all property owners and property developers of likely future risk to properties through coastal processes, especially the impacts of sea level rise associated with global warming.

It was also agreed that the “coastal protection zone limit” would be situated at the landward limit of the NMB MOSS layer where NMB MOSS was present along the coastline and concurrent with the “Coastal Set-back Line” where NMB MOSS was not present. An example of the CSL and CPZL are shown in the Figure 37, Figure 38 and Figure 39 below.

Figure 37: CSL and CPZL for rocky coastal area west of Cape Recife.

Figure 38 CSL and CPZL for hobie beach to pollok beach inside Algoa Bay.

Figure 39 CSL and CPZL for Blue Water Bay to Wells Estate inside of Algoa Bay.

Sediment Pathways

In certain instances the existing coastal processes such as Aeolian sand transport need to be considered in more detail and the CPSL needs to be adjusted to accommodate features like headland bypass dune fields such as the Noordhoek dunefield at Cape Recife. As discussed in the introduction section, several prominent headland bypass dunefields were actively supplying sediment to the bay prior to development in the area. These features were seen as a nuisance by the residents at the time and the authorities went about actively stabilising the largest “Driftsands” dunefield as early as 1870. The leading portion of the smaller “Noordhoek” dunefield was stabilised when a treatment works and maturation ponds were constructed in the 1960’s. The smaller dunefield at the extremity of Cape Recife is still active. It has been calculated that +/- 26 000 $m^3.yr^{-1}$ of sand was transported into the bay via the Noordhoek dunefield prior to stabilisation (McLachlan *et al.,* 1994) (Figure 40 below). Several studies have motivated for the reactivation of this supply in order to provide more sand to the beaches of Algoa Bay (Lord D. A., 1985, Klages *et al.,* 2010). Considering these environmental issues it was agreed that the CSL should be situated on the northern landward margin of the bypass dunefield (Figure 41) in order to allow for this bypass dunefield to become active again in order to once again provide this “ecosystem service” in the supply of sand to the popular tourist beaches along the southern coastline within the bay (Klages *et al.,* 2010).

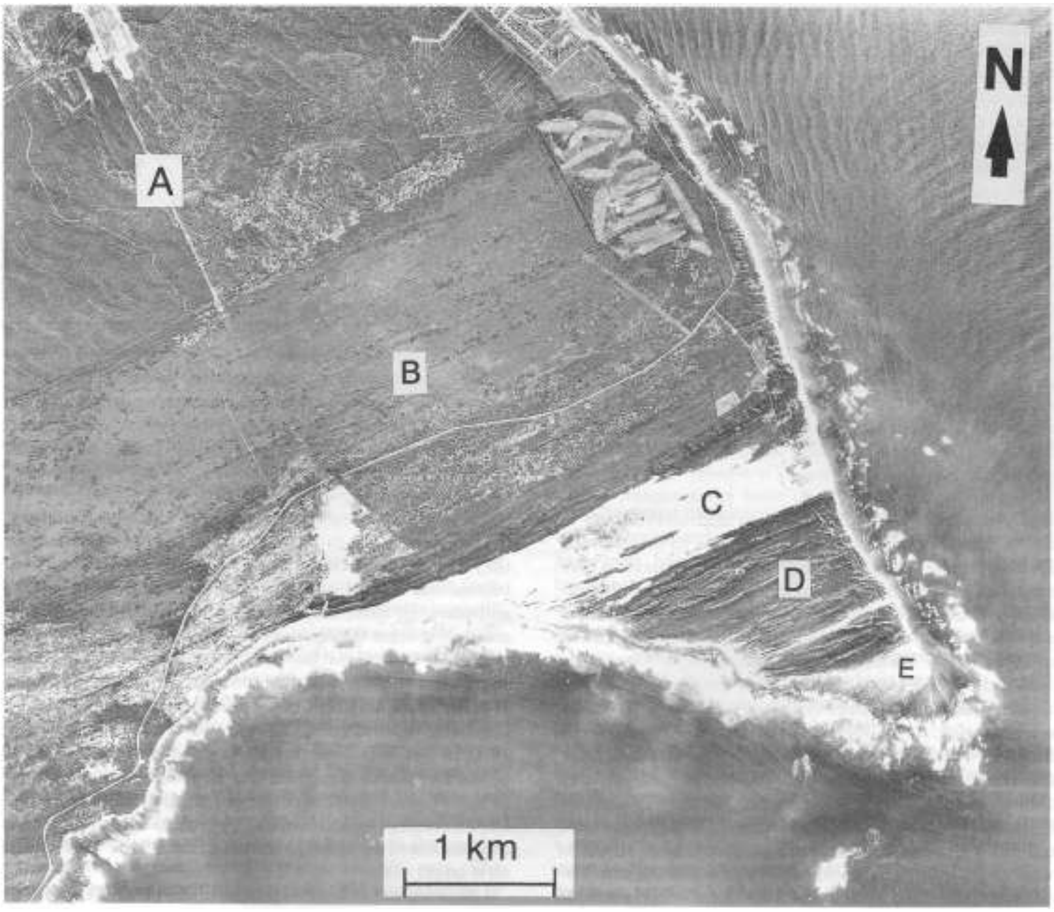

Figure 40: Vertical aerial photograph of Cape Recife taken in 1958, showing artificially vegetated transgressive dunes in the Driftsands dunefield (A), naturally vegetated longitudinal dunes (B), the Noordhoek dunefield (C), active hairpin parabolic dunes (D), and active dunes at Cape Recife (E).from Mclahlan *et al*., 1994.

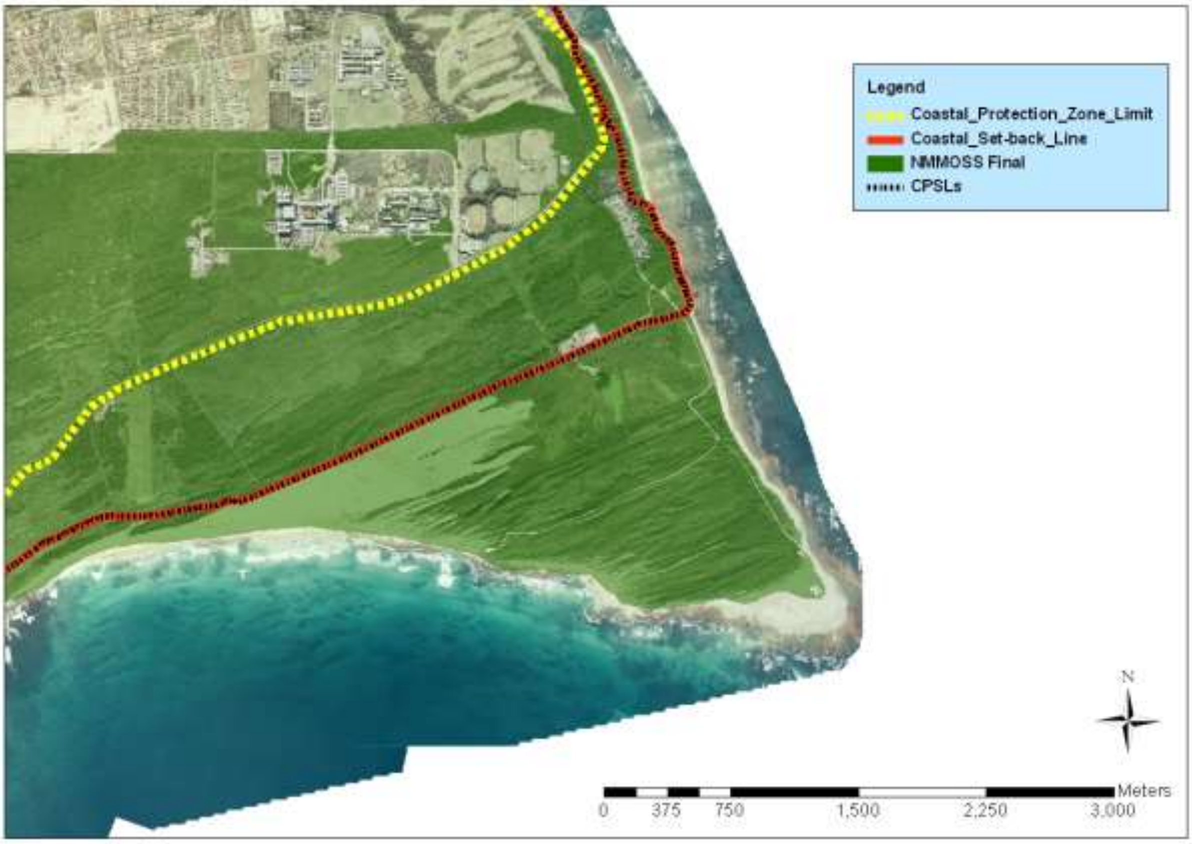

Figure 41: CSL and CPZL in the vicinity of Cape Recife, CSL line situated landward of the Noordhoek dunefield.

Port Limits

The Department of Environmental Affairs and Tourism presented for consideration the request from the Minister of Environmental Affairs and Tourism that certain land be excluded from coastal public property in terms of Section 27(4) of the National Environmental Management: Integrated Coastal Management Act. When the Act was still a Bill in Parliament, the Portfolio Committee on Environmental Affairs had been opposed to the Lexshell/Transnet proposal calling for the exclusion of the V&A Waterfront and all ports from the Act. Since each of these ports were extensive with larger reserved areas, the Portfolio Committee had felt this proposal could not be permitted.

The Portfolio Committee had felt that there had to be certainty as to what would be excluded. The Portfolio Committee thus introduced Section 27(2) -27(4) which allowed exceptions by ministerial proclamation and ratification by Parliament. There was thus agreement for the exclusion of confined port areas, namely the footprint of ports where the actual work was being done. The exclusion did not include the extended areas.

Since the ICMA had been enacted, Transnet had submitted a formal application for the exclusion of nine ports with co-ordinates that covered only the footprint of ports where the actual work was being done. The request did not include the extended areas of each port. For example the V&A Waterfront did not form part of the footprint of the area to be excluded. DEAT concluded that the V&A Waterfront would have to come back to Parliament if it wished to be excluded. The excluded areas were to allow for the development of port operations. Transnet needed to lease its property out for more than twenty years in order to make it financially viable. (PMG,2009).

The operational port areas defined for the port of Ngqura and Port Elizabeth are shown in Figure 42 below. Because these port operational areas submitted by Transnet have been approved by parliament these areas are excluded from the ICMA and therefore coastal setback lines falling within the port limits or concurrent to the port limits have been removed, examples of these edits for the Port of Ngqura and Port Elizabeth are shown in Figure 43 and Figure 44 respectively.

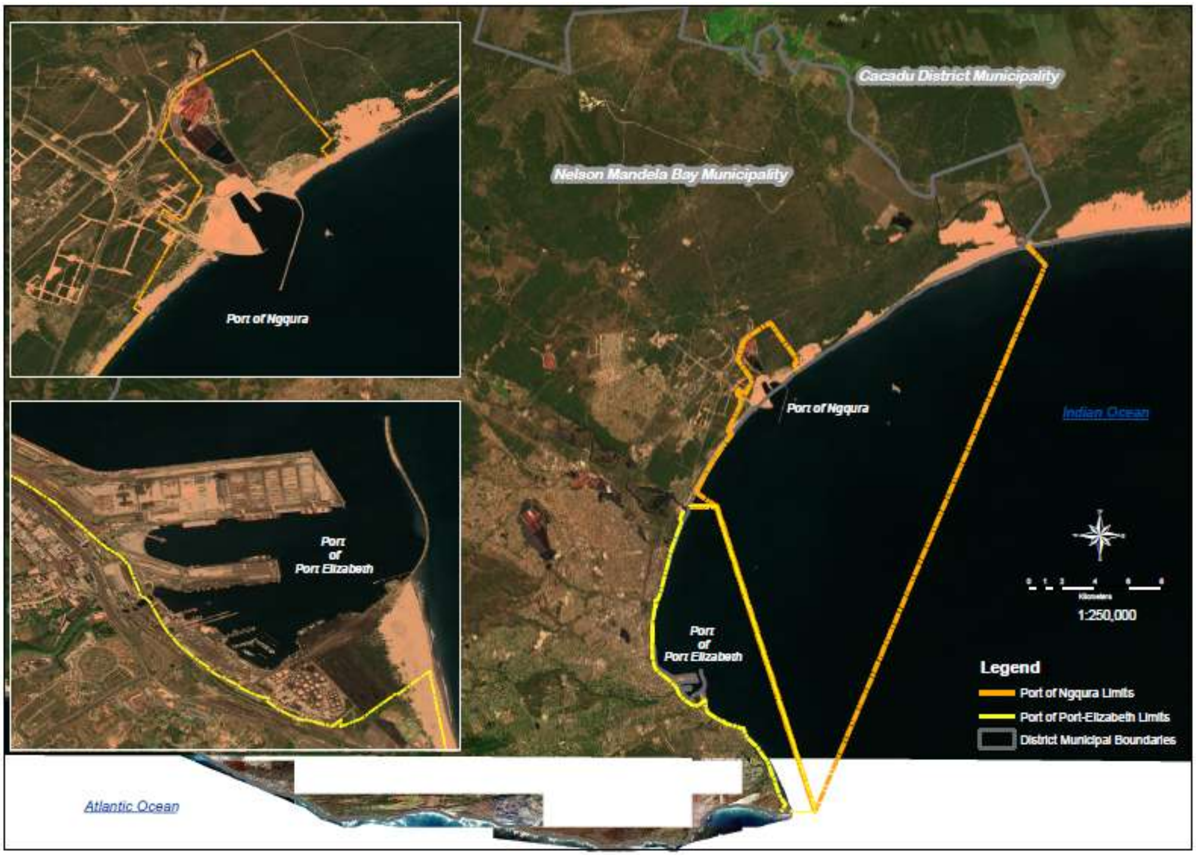

Figure 42: Port Limits for the Port of Ngqura and the Port of Port Elizabeth.

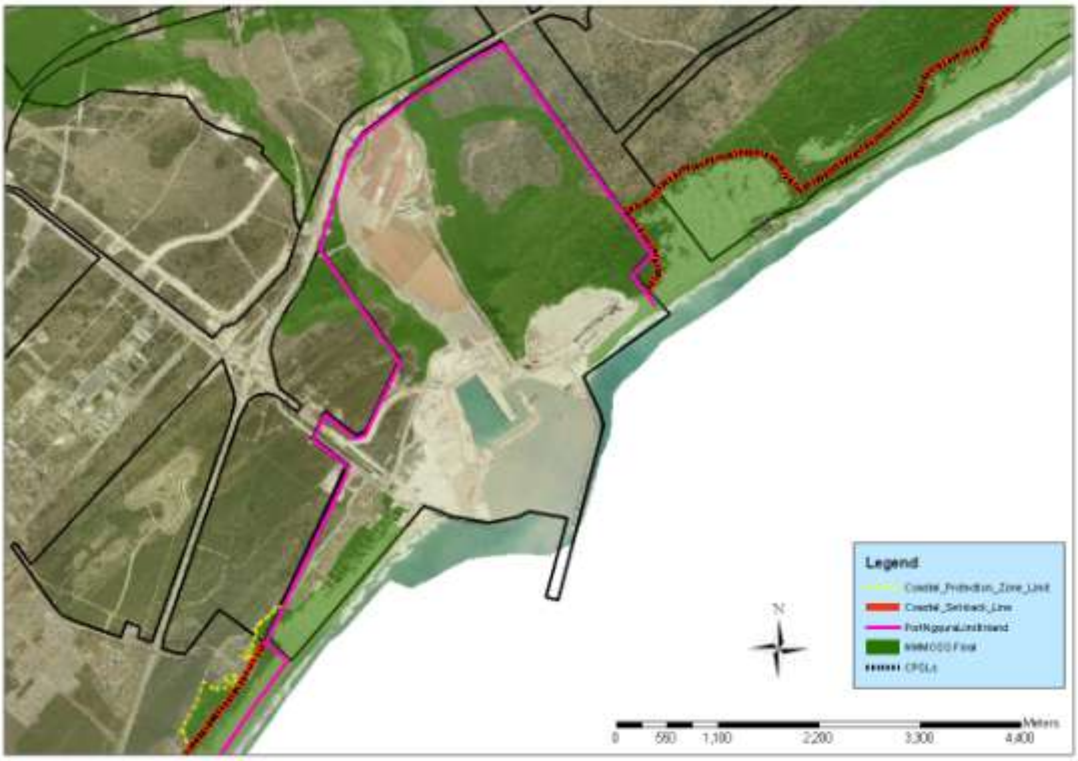

Figure 43: Final setback lines in the vicinity of the Port of Ngqura.

Figure 44 Final set-back lines in the vicinity of the Port Elizabeth harbour

5. RECOMMENDATIONS

The preliminary analysis of the legal frameworks and policies of the coastal management objectives and of the national government shows a lack of a common methodology for coastal set-backs at the provincial and/ local level, even though the procedure on coastal zone determination through the ICMA had been promulgated with a clear reference to coastal set-backs.

The results of the preliminary study carried out shows that setback lines cannot be based on physical processes alone. Furthermore, the generic application of an arbitrary distance from the coastline (e.g. 100 m from high water mark) ignores the diversity of coastal characteristics and physical processes and should be only applied when more specific information is not yet available. However, it could be the starting point for the definition of a more appropriate set-back line, based on scientific understanding and local knowledge, taking into consideration natural processes, landscape values, public use and accessibility.

The ICMA requires that the following process be followed in order to finalise the coastal set-back lines and coastal protection zone and prepare them for official adoption:

Part 7, Coastal Set-back lines, Establishment of coastal set-back lines, section 25:

> (2) Before making or amending the regulations referred to in subsection (1), the MEC must—
>
> > (a) consult with any local municipality within whose area of jurisdiction the coastal set-back line is, or will be, situated: and
> >
> > (b) give interested and affected parties an opportunity to make representations in accordance with Part 5 of Chapter 6.
>
> (3) A local municipality within whose area of jurisdiction a coastal set-back line has been established must delineate the coastal set-back line on a map or maps that form part of its zoning scheme in order to enable the public to determine the position of the set-back line in relation to existing cadastral boundaries.

Part 5 of Chapter 6 of the ICMA specifies the requirements for consultation and public participation for determination or adjustment of coastal boundaries (CSL and CPZL) and states:

> 53:(1) Before exercising a power, which this 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, MECs 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.

While both the amended NEMA EIA Regulations and the ICMA allows for the pro-active determination of coastal set-back lines, coastal setback lines must also at times be re-actively determined when considering development applications in terms of the NEMA EIA Regulations. Due to the uncertainties surrounding the exact impacts of global warming, in terms of sea level rise and increased frequency and intensity of storm events, it is recommended that the whole exercise be repeated using updated input data every 10 years.

Finally as and when funding becomes available the set-back lines for estuaries within the NMBM should be determined and combined with the coastal setback lines established during this study.

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