Development of a Methodology for Defining and Adopting Coastal Development Setback Lines.

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GLOSSARY OF TERMS

Accretion: the accumulation of (beach) sediment, deposited by natural fluid flow processes.

Alongshore: parallel to and near the shoreline; same as longshore.

Astronomical tide: the tidal levels and character which would result from gravitational effects, e.g. of the earth, sun and moon, without any atmospheric influences.

Bar: an offshore ridge or mound of sand, gravel, or other unconsolidated material which is submerged (at least at high tide), especially at the mouth of a river or estuary, or lying parallel to, and a short distance from, the beach.

Bathymetry: the measurement of depths of water in oceans, seas and lakes; also the information derived from such measurements.

Bay: a recess or inlet in the shore of a sea or lake between two capes or headlands, not as large as a gulf but larger than a cove.

Beach: (1) a deposit of non-cohesive material (e.g. Sand, gravel) situated on the interface between dry land and the sea (or other large expanse of water) and actively "worked" by present-day hydrodynamics processes (i.e. Waves, tides and currents) and sometimes by winds. (2) the zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation. The seaward limit of a beach – unless otherwise specified – is the mean low water line. A beach includes foreshore and backshore. (3) (smp) the zone of unconsolidated material that is moved by waves, wind and tidal currents, extending landward to the coastline.

Beach erosion: the carrying away of beach materials by wave action, tidal currents, littoral currents or wind.

Beach profile: a cross-section taken perpendicular to a given beach contour; the profile may include the face of a dune or seawall, extend over the backshore, across the foreshore, and seaward underwater into the nearshore zone.

Bed: the bottom of a watercourse, or any body of water.

Benefits: the economic value of a scheme, usually measured in terms of the cost of damages avoided by the scheme, or the valuation of perceived amenity or environmental improvements.

Buffer area: a parcel or strip of land that is designed and designated to permanently remain vegetated in an undisturbed and natural condition to protect an adjacent aquatic or wetland site from upland impacts, to provide habitat for wildlife and to afford limited public access.

Cay: A small, low island composed largely of coral or sand.

Cliff: a high steep face of rock.

Climate change: refers to any long-term trend in mean sea level, wave height, wind speed, drift rate etc.

Coast: a strip of land of indefinite length and width (may be tens of kilometers) that extends from the seashore inland to the first major change in terrain features.

Coastal management: the development of a strategic, long-term and sustainable land use policy, sometimes also called shoreline management.

Coastal processes: collective term covering the action of natural forces on the shoreline, and the nearshore seabed.

Coastal zone: the land-sea-air interface zone around continents and islands extending from the landward edge of a barrier beach or shoreline of coastal bay to the outer extent of the continental shelf.
Coastline: (1) technically, the line that forms the boundary between the coast and the shore. (2) commonly, the line that forms the boundary between land and the water. (3) (smp) the line where terrestrial processes give way to marine processes, tidal currents, wind waves, etc.

Conservation: the protection of an area, or particular element within an area, accepting the dynamic nature of the environment and therefore allowing change.

Continental shelf: the zone bordering a continent extending from the line of permanent immersion to the depth, usually about 100 m to 200 m, where there is a marked or rather steep descent toward the great depths.

Contour line: a line connecting points, on a land surface or sea bottom, which have equal elevation. It is called an isobath when connecting points of equal depth below a datum.

Cross-shore: perpendicular to the shoreline.

Debris line: a line near the limit of storm wave up-rush marking the landward limit of debris deposits.

Deep water: in regard to waves, where depth is greater than one-half the wave length. Deep-water conditions are said to exist when the surf waves are not affected by conditions on the bottom.

Deep water waves: a wave in water the depth of which is greater than one-half the wave length.

Depth: vertical distance from still-water level (or datum as specified) to the bottom.

Design storm: coastal protection structures will often be designed to withstand wave attack by the extreme design storm. The severity of the storm (i.e. Return period) is chosen in view of the acceptable level of risk of damage or failure. A design storm consists of a design wave condition, a design water level and a duration.

Design wave: in the design of harbours, harbour works, etc., the type or types of waves selected as having the characteristics against which protection is desired.

Direction of waves: direction from which waves are coming.

Direction of wind: direction from which wind is blowing.

Dunes: (1) accumulations of windblown sand on the backshore, usually in the form of small hills or ridges, stabilized by vegetation or control structures. (2) a type of bed form indicating significant sediment transport over a sandy seabed.

Duration: in forecasting waves, the length of time the wind blows in essentially the same

Ecosystem: the living organisms and the nonliving environment interacting in a given area.

Erosion: wearing away of the land by natural forces. (1) On a beach, the carrying away of beach material by wave action, tidal currents or by deflation. (2) the wearing away of land by the action of natural forces.

Estuary: (1) a semi-enclosed coastal body of water which has a free connection with the open sea. The seawater is usually measurably diluted with freshwater. (2) the part of the river that is affected by tides.

Event: an occurrence meeting specified conditions, e.g. Damage, a threshold wave height or a threshold water level.

Fetch: the length of unobstructed open sea surface across which the wind can generate waves (generating area).

Fetch length: (1) the horizontal distance (in the direction of the wind) over which a wind generates seas or creates wind setup. (2) the horizontal distance along open water over which the wind blows and generates waves.

Gabion: (1) steel wire-mesh basket to hold stones or crushed rock to protect a bank or bottom from erosion.

Geology: the science which treats of the origin, history and structure of the earth, as recorded in rocks; together with the forces and processes now operating to modify rocks.
Georeferencing: (1) the process of scaling, rotating, translating and de-skewing the image to match a particular size and position (2) establishing the location of an image in terms of map projections or coordinate systems.

High water (HW): maximum height reached by a rising tide. The height may be solely due to the periodic tidal forces or it may have superimposed upon it the effects of prevailing meteorological conditions. Non-technically, also called the high tide.

High water mark: a reference mark on a structure or natural object, indicating the maximum stage of tide or flood.

Mean high water springs (MHWS): the average height of the high water occurring at the time of spring tides.

Mean sea level: the average height of the surface of the sea for all stages of the tide over a 19-year period, usually determined from hourly height readings.

Ocean: the great body of salt water which occupies two-thirds of the surface of the earth, or one of its major subdivisions.

Offshore: (1) in beach terminology, the comparatively flat zone of variable width, extending from the shoreface to the edge of the continental shelf. It is continually submerged. (2) the direction seaward from the shore. (3) the zone beyond the nearshore zone where sediment motion induced by waves alone effectively ceases and where the influence of the sea bed on wave action is small in comparison with the effect of wind. (4) the breaker zone directly seaward of the low tide line.

Offshore wind: a wind blowing seaward from the land in the coastal area.

Outcrop: a surface exposure of bare rock, not covered by soil or vegetation.

Overtopping: water carried over the top of a coastal defence due to wave run-up or surge action exceeding the crest height.

Peak period: the wave period determined by the inverse of the frequency at which the wave energy spectrum reaches its maximum.

Photogrammetry: the science of deducing the physical dimensions of objects from measurements on images (usually photographs) of the objects.

Port: a place where vessels may discharge or receive cargo.

Reach: (1) an arm of the ocean extending into the land. (2) a straight section of restricted waterway of considerable extent; may be similar to a narrows, except much longer in extent.

Recession: (1) a continuing landward movement of the shoreline. (2) a net landward movement of the shoreline over a specified time.

Refraction: the process by which the direction of a wave moving in shallow water at an angle to the bottom contours is changed. The part of the wave moving shoreward in shallower water travels more slowly than that portion in deeper water, causing the wave to turn or bend to become parallel to the contours.

Return period: average period of time between occurrences of a given event.

Revetment: (1) a facing of stone, concrete, etc., to protect an embankment, or shore structure, against erosion by wave action or currents. (2) a retaining wall. (3) (smp) facing of stone, concrete, etc., built to protect a scarp, embankment or shore structure against erosion by waves of currents.

Rocks: an aggregate of one or more minerals rather large in area. The three classes of rocks are the following: (1) igneous rock – crystalline rocks formed from molten material. Examples are granite and basalt. (2) sedimentary rock – a rock resulting from the consolidation of loose sediment that has accumulated in layers. Examples are sandstone, shale and limestone. (3) metamorphic rock – rock that has formed from pre-existing rock as a result of heat or pressure.
Run-up: the rush of water up a structure or beach on the breaking of a wave. The amount of run-up is the vertical height above still-water level that the rush of water reaches.

Sand: an unconsolidated (geologically) mixture of inorganic soil (that may include disintegrated shells and coral) consisting of small but easily distinguishable grains ranging in size from about .062 mm to 2.0 mm.

Scour protection: protection against erosion of the seabed in front of the toe.

Sea defences: works to prevent or alleviate flooding by the sea.

Sea level rise: the long-term trend in mean sea level.

Seawall: (1) a structure built along a portion of a coast primarily to prevent erosion and other damage by wave action. It retains earth against its shoreward face. (2) (smp) a structure separating land and water areas primarily to prevent erosion and other damage by wave action. Generally more massive and capable of resisting greater wave forces than a bulkhead.

Sediment transport: the main agencies by which sedimentary materials are moved are: gravity (gravity transport); running water (rivers and streams); ice (glaciers); wind; the sea (currents and longshore drift). Running water and wind are the most widespread transporting agents. In both cases, three mechanisms operate, although the particle size of the transported material involved is very different, owing to the differences in density and viscosity of air and water. The three processes are: rolling or traction, in which the particle moves along the bed but is too heavy to be lifted from it; saltation; and suspension, in which particles remain permanently above the bed, sustained there by the turbulent flow of the air or water.

Setback: (smp) a required open space, specified in shoreline master programs, measured horizontally upland from a perpendicular to the ordinary high water mark.

Shallow water: water of such depth that surface waves are noticeably affected by bottom topography. Typically this implies a water depth equivalent to less than half the wave length.

Shoal: (1) (noun) a detached area of any material except rock or coral. The depths over it are a danger to surface navigation. Similar continental or insular shelf features of greater depths are usually termed banks. (2) (verb) to become shallow gradually. (3) to cause to become shallow. (4) to proceed from a greater to a lesser depth of water.

Shore: that strip of ground bordering any body of water which is alternately exposed, or covered by tides and/or waves. A shore of unconsolidated material is usually called a beach.

Significant wave height: average height of the highest one-third of the waves for a stated interval of time.

Significant wave period: average period of the highest one-third of the waves for a stated interval of time.

Soft defences: usually refers to beaches (natural or designed) but may also relate to energy-absorbing beach-control structures, including those constructed of rock, where these are used to control or redirect coastal processes rather than opposing or preventing them.

Spring tide: a tide that occurs at or near the time of new or full moon, and which rises highest and falls lowest from the mean sea level (msl).

Stillwater level (SWL): the surface of the water if all wave and wind action were to cease. In deep water this level approximates the midpoint of the wave height. In shallow water it is nearer to the trough than the crest. Also called the undisturbed water level.

Surf zone: the nearshore zone along which the waves become breakers as they approach the shore.

Surf zone: the zone of wave action extending from the water line (which varies with tide, surge, set-up, etc.) Out to the most seaward point of the zone (breaker zone) at which waves approaching the coastline commence breaking, typically in water depths of between 5 m and 10 m. See figure 6.

Surge: (1) long-interval variations in velocity and pressure in fluid flow, not necessarily periodic, perhaps even transient in nature. (2) the name applied to wave motion with a period intermediate between that of an ordinary
wind wave and that of the tide. (3) changes in water level as a result of meteorological forcing (wind, high or low barometric pressure) causing a difference between the recorded water level and that predicted using harmonic analysis, may be positive or negative.

Survey, control: a survey that provides coordinates (horizontal or vertical) of points to which supplementary surveys are adjusted.

Survey, hydrographic: a survey that has as its principal purpose the determination of geometric and dynamic characteristics of bodies of water.

Survey, photogrammetric: a survey in which monuments are placed at points that have been determined photogrammetrically.

Survey, topographic: a survey which has, for its major purpose, the determination of the configuration (relief) of the surface of the land and the location of natural and artificial objects thereon.

Swash zone: the zone of wave action on the beach, which moves as water levels vary, extending from the limit of run-down to the limit of run-up.

Swell: waves that have travelled a long distance from their generating area and have been sorted out by travel into long waves of the same approximate period.

Toe: (1) lowest part of sea- and portside breakwater slope, generally forming the transition to the seabed. (2) the point of break in slope between a dune and a beach face.

Topographic map: a map on which elevations are shown by means of contour lines.

Updrift: the direction to which the predominant longshore movement of beach material approaches.

Wave crest: (1) the highest part of the wave. (2) that part of the wave above still water level.

Wave direction: the direction from which the waves are coming.

Wave height: the vertical distance between the crest (the high point of a wave) and the trough (the low point).

Wave hindcast: the calculation from historic synoptic weather charts of the wave characteristics that probably occurred at some past time.

Wave length: the distance, in meters, between equivalent points (crests or troughs) on waves. Wave period: (1) the time required for two successive wave crests to pass a fixed point. (2) the time, in seconds, required for a wave crest to traverse a distance equal to one wave length.

Wave rose: diagram showing the long-term distribution of wave height and direction.

Wave set-up: elevation of the still-water level due to breaking waves.

Wave steepness: the ratio of wave height to its length. Not the same thing as the slope between a wave crest and its adjacent trough.

Wave train: a series of waves from the same direction.

Wave trough: the lowest part of the wave form between crests. Also that part of a wave below still water level.

Wave variability: (1) the variation of heights and periods between individual waves within a wave train. Wave trains are not composed of waves of equal heights and periods, but rather of heights and periods which vary in a statistical manner. (2) the variability in direction of wave travel when leaving the generating area. (3) the variation in height along the crest.

Wind rose: diagram showing the long-term distribution of wind speed and direction.

Wind setup: (1) the vertical rise in the stillwater level on the leeward side of a body of water caused by wind stresses on the surface of the water. (2) the difference in stillwater levels on the windward and the leeward sides of a body of water caused by wind stresses on the surface of the water. (3) synonymous with wind tide and

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storm surge. Storm surge is usually reserved for use on the ocean and large bodies of water. Wind setup is usually reserved for use on reservoirs and smaller bodies of water.

Wind waves: (1) waves formed and growing in height under the influence of wind. (2) loosely, any wave generated by wind.

World Geodetic System, 1984 (revised 2004): an earth fixed global reference frame used for defining coordinates when surveying and by GPS systems.
1 Introduction

1.1 BACKGROUND

Coastal areas are sensitive, vulnerable, often highly dynamic and stressed ecosystems. Increasingly coastal areas will be subjected to climate change impacts along the coast, 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.

A number of specific motivations exist for the establishment of setback lines (as determined through discussions with various focus groups related to this project (Minutes of meetings, Appendix A) and also from the project terms of reference (Appendix B)). These are as follows.

1.1.1 Facilitation of Development

The terms of reference for this study highlights that at present, an EIA (Environmental Impact Assessment) must be conducted for development of all infrastructure within 100 m of the high water mark, in accordance with the EIA Regulations. According to the project terms of reference (Appendix B) “Unintended consequences” of this act are:

- Home owners situated close to the shoreline 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).

(It should be noted that in some instances impacts occur landward of the 100 m line – such as due to windblown sand – thus impacting on development facilitation as well).

Through the law reform process it is intended to include flexibility in the implementation of certain coastal activities, by introducing the concept of a “setback” (i.e. certain activities will not require environmental authorisation if situated landward of a development setback line). In future, strategic infrastructure planning will be more appropriately informed by strategic environmental assessment with coastal setback lines to be strategically determined, rather than ad hoc project level assessments having to be done for different infrastructure projects. In addition, the determination of coastal development setback lines will enable the refinement of the coarse “within 100 metres of the high-water mark of the sea” threshold used in the EIA listed activities, with the setback resulting in improved protection being given to the coast and resulting in unnecessary EIA being prevented.

1.1.2 Safety of developments

Developments that have historically been situated too close to the sea are in danger of erosion (e.g. Milnerton Golf Club and the adjacent restaurant, and Paradise Beach development near Saldanha are threatened by beach erosion) or of wave attack (e.g. The Beach Club, Hermanus has experienced severe wave damage). Determining affordable protection measures for these developments is a problem. Development on the KwaZulu Natal shoreline have also experienced problems (e.g. Figure 1.1)

Taking into account sea-level rise and the coincident increase in vulnerability to storm waves, it is vital that development setback lines are established so that such problems do not recur.
1.1.3 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 City of Cape Town spends considerable effort and money on the removal of sand, e.g. on Baden Powell Drive, because developments (in this case the road) are situated within the zone of active nearshore processes (windblown sand). Figure 1.2 provides another example of a maintenance headache in False Bay. Removal of debris due to high waves during high waters occasionally depositing on Baden Powell Drive is also a maintenance problem. Establishment of setback lines that take into account such coastal processes will avoid this type of ongoing maintenance problem.

Figure 1.1  Dwelling destroyed during the major storm in KwaZulu Natal in 2007. This could have been avoided with adequate setback

Figure 1.2  This slide will need constant maintenance to keep it clear of wind-blown sand. (from: City of Cape Town)
1.1.4 Estuaries

Unexpected behaviour of estuary mouth channels can result in erosion of the sandy hinterland nearby these channels. Where possible estuary mouth behaviour should be anticipated and development setback lines established to avoid the undermining of developments (e.g. Figure 1.3).

Figure 1.3. Erosion of the car park and the threat of erosion of the building could have been avoided by assessing historical records of estuary channel behaviour at Plettenberg Bay

1.1.5 Heritage

The South African Heritage Resources Agency (SAHRA) and Heritage Western Cape (HWC) highlight that most coastal heritage sites (particularly shell middens, wrecks, fish traps, and lighthouses) are concentrated at and near the existing high water mark. In certain instances, the determination of an appropriate setback can significantly contribute to the protection of such sites.

1.1.6 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.

1.1.7 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 Nature’s Valley where the houses are well set back 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.
1.2 LEGAL REQUIREMENT

In reaction to the clear need for setback lines as outlined above, the National Environmental Management Act and the Environmental Impact Assessment Regulations, as well as the Integrated Coastal Management Act (ICMA) now call for coastal development setback lines to be determined. Specifically, section 25 of the ICMA indicates the priority for setback lines to be established (or changed from existing locations), as follows:

1. 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.

The establishment of setback lines is to follow a participatory approach:

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.

The setback line is to be plotted on maps as part of zoning and made available to public, as indicated in the ICMA:

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.

It is relevant to note that a development setback line may extend some distance inland, as indicated in the ICMA:

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

1.3 STUDY OBJECTIVES

In response to the above motivation and legal requirements, the Terms of Reference of this study (Appendix B) are expressed as follows:

- Develop a methodology for defining and adopting coastal development setback lines; and
- Test the methodology in the Cape Town Metropolitan area and in the Saldanha Bay Municipal area in consultation with the City of Cape Town and the Saldanha Bay Municipalities.
From steering committee meetings (Appendix A) and comments received, it was evident that the development setback line methodology should ideally comply with various requirements:

1. The methodology should be applicable in all 4 coastal provinces. Although the methodology study is for the Western Cape, it is likely that the methodology or parts of the methodology will be applied in other provinces. Therefore the methodology should consider conditions prevalent in all provinces.

2. The methodology should be generally conservative in considering the accuracy of data, methods and climate change. The need for a risk averse and precautionary approach under conditions of uncertainty is clearly indicated in (Dept. Environmental Affairs and SSI, 2009).

3. The methodology should not rely on excessively expensive and time-consuming data collection and should minimise costly specialist expertise, over and above the essential coastal processes expertise required.

4. The methodology must represent international best practice.

5. The methodology must be legally defensible and must withstand legal scrutiny.

6. The methodology must ideally be reproducible, i.e. if conducted by another professional a similar result should be obtained.

It was agreed that the setback methodology developed within this study would not deal with Estuaries per se. Estuarine systems are complicated by river flows (and floods) and tidal currents. The latter currents are largely responsible for shoreline erosion at Langebaan, for example. However, the development setback necessary to take account of meandering estuary channels on the open coast on either side of existing estuary mouths is to be accommodated.

1.4 STUDY APPROACH

A key requirement of this study is to document how the setback methodology was developed. In this study the methodology was as developed:

- By assessing the practices currently applied on setback studies in house (Staff of WSP Africa Coastal Engineers have been involved in over 30 setback and shoreline studies - the latter involving assessment of present and future state of the shoreline). The methods employed were referred to extensively in the development of the setback line methodology.
- By assessing the current practices applied by others. A detailed literature review was conducted to assess the best practice methodologies employed both locally (e.g. by the CSIR) and internationally.
- By applying “feedback” information from execution of the case studies. A true test of a methodology is in its application to the case studies. In the process of application shortcomings and/or insights for improvement are obtained.
- Through incorporation of information obtained from consultation. The proposed methodology was described in steering committee meetings, focus group meetings and public forums. Comments and discussions were recorded and where scientifically sound were incorporated in the methodology.

In developing the methodology an attempt was made (a) to simplify the approach and (b) to classify coasts such that standard setback distances could be applied, even as a “rapid assessment” initial setback. However, it was found that no simple formula or approach exists. This is primarily due to the large spatial variation in coastal processes along the shoreline. Wave heights can vary by as much as an order of magnitude within only a few
hundred metres, due to wave focussing or wave sheltering effects of offshore feature. Similarly sand transport, affecting storm erosion and long-term trends, changes rapidly alongshore. These variations in conditions and processes cannot be assessed by means of any simplified approach.

1.5 FORM OF THE REPORT

In Section 2 of this report, a discussion of local and international best practice relating to the establishment of development setback lines follows. Assumptions and principles associated with the setback methodology are indicated in Section 3. An overview of the proposed methodology is provided in Section 4, while Sections 5 to 10 provide further detail. Section 11 provides deals with issues relating to implementation of the methodology. Finally, Section 12 provides conclusions and recommendations.

In this study, reference is made to additional reports which are an integral part of this project:

- Development of a Methodology for Defining and Adopting Coastal Development Setback Lines: Milnerton Case Study (Error! Reference source not found.).
- Development of a Methodology for Defining and Adopting Coastal Development Setback Lines: Langebaan Case Study (Error! Reference source not found.).
- Stakeholder engagement Report: Western Cape Coastal Setback Line Methodology (Error! Reference source not found.).

Specific information is provided in information “boxes”. This includes minimum requirements to execute the setback line methodology.

Minimum requirements are provided in yellow boxes such as this one

Technical detail on the methodology (aimed at the experienced coastal process practitioner) is also provided within boxes. This information is aimed at ensuring reproducibility of the methodology if applied by different practitioners.

Important technical detail is provided in blue boxes such as this one
2 National and International Practice

2.1 INTRODUCTION

Information on both local and international approaches to the establishment of setback lines (and associated issues) was sourced as a guide to the methodology development.

In the available literature, erosion setback is frequently referred to. The erosion setback line is the maximum erosion line on the existing surface of the earth (at the time of establishment) that can reasonably be expected (as a result of elevated water-levels and storms) in the time period applicable (e.g. typically 50 or 100 years). It should be noted that erosion setback is a major component of the total setback required for development. Other factors besides coastal erosion require consideration.

A review of South African practice below is followed by information on international practice. These reviews are followed by a summary of key findings.

2.2 SOUTH AFRICAN PRACTICE

2.2.1 Coastal zone management

Recent studies regarding coastal development management in South Africa incorporate aspects other than pure physical coastal processes, and stress the importance of an integrated approach to managing development along the shoreline. These studies include considerations of existing land-use, historic and archaeological features, aesthetic and ecological value of the coastal zone. This is well in line with the existing Integrated Coastal Management Act (2008) of South Africa which aims for socially, economically and ecologically sustainable development and use of natural resources of the coastal zone.

2.2.2 Coastal erosion setback studies

Setback lines have been conducted for almost 30 years in South Africa. Numerous coastal erosion setback studies have been conducted in South Africa; some on a small, local scale (limited to a few kilometres) for private developers and others on a larger municipal scale spanning several tens of kilometres. To our knowledge, up to date, WSP and CSIR have been the primary authorities on development of erosion setback lines (e.g. WSP, 2006; WSP, 2007; WSP, 2008a; WSP,2008b; Theron, 2000; CSIR, 2000b; CSIR, 2003a & CSIR, 2004). The primary focus of these setback studies was to obtain relative safety of development from the prominent coastal processes (generally focussing on erosion setback).

These erosion setback studies in the past have taken into account:

- long-term shoreline variation;
- short-term shoreline variation (the use of the SBEACH storm erosion model as a tool to assess erosion of beaches is specifically indicated in Theron, 2000);
- shoreline response to sea level rise;
- oceanographic characteristics;
- beach characteristics;
- sediment characteristics;
- sediment transport (cross-shore and longshore);
- wind-blown sand;
- the presence of and nature of vegetation.
Furthermore, CSIR studies discuss guidelines of development at the site taking local physical features (e.g. river mouths, coastal protection features, rock outcrops) into account once the erosion setback distance is determined.

Of the setback studies consulted, detailed consideration was not given to ecological, socio-economic, cultural or archaeological aspects of the study site because the purpose of the erosion setback distance at the time was solely for safety from physical coastal processes.

2.2.3 Coastal development setback concept

Within the realm of the ICMA, the concept of coastal development setback lines has become significant. The development setback differs from the erosion setback line in that the latter is inherently incorporated within the former. Roets & Duffell-Canham (2009) discussed the requirement for delineating the development setback line, with acceptable buffer zones, to reduce the effects of likely increasing coastal erosion and flooding due to climate change. The authors describe adopting a sustainable approach to determining the development setback line based on the existence of environments vulnerable to climate change (with specific reference to sea level rise, and predictions of storm frequency and intensity changes) to preserve the economic and ecological integrity of the local ecosystems.

Roets & Duffell-Canham (2009) indicated that formally establishing a development setback line will avoid potential uncertainties associated with definitions of ‘no development’ areas and will promote ecological integrity. Case studies were presented illustrating how encroaching on specific areas has resulted in undesirable effects and damage to property and the natural environment. Three main areas undesirable for development were defined:

1. Below the 1 in 100 year flood line
2. Below the 5 m contour (with reference to estuarine systems)
3. Primary and secondary dunes

The rationales of each of these areas were described. The rationale for the areas defined by points 1 and 3 are readily defendable; however Point 2 is vulnerable to debate. Table 2.1, copied with modification from Theron and Rossouw (2008), was provided to explain how the 5 m contour, based on components of extreme inshore sea water levels, was derived from an approximate (rounded up) addition of various parameters affecting water-level rise.

Table 2.1: Parameters and estimated maximum effects on still-water levels for SA coast.

<table>
<thead>
<tr>
<th>Parameters and effects</th>
<th>Elevation [m to Mean Sea Level] or Setup [+m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean High Water Spring</td>
<td>1</td>
</tr>
<tr>
<td>Highest Astronomical Tide</td>
<td>1.4</td>
</tr>
<tr>
<td>Severe Wind Setup (*)</td>
<td>+ 0.5</td>
</tr>
<tr>
<td>Maximum Hydrostatic Setup (*)</td>
<td>+ 0.35</td>
</tr>
<tr>
<td>Wave Setup (*)</td>
<td>+ 1</td>
</tr>
<tr>
<td>100 Year Sea Level Rise (**)</td>
<td>+ 0.2 to + 0.6</td>
</tr>
<tr>
<td></td>
<td>Mean = 0.0031 +/- 0.0007 m/yr</td>
</tr>
</tbody>
</table>

* Does not include effects of climate change (e.g. increased extremes of events)

** Base on Bindoff et al. (2007) and Solomon et al. (2007) (IPCC)
Note that the above table does not account for wave run-up which is the maximum reach of water up the beach profile due to individual waves. Wave run-up is not a long-term phenomenon and varies according to the elevations and setups listed in Table 2.1. Wave run-up may cause penetration of waves up to several metres higher than the 5 m contour suggested by Roets & Duffell-Canham (2009), indicating that a greater elevation will be required at times.

Roets & Duffell-Canham (2009) did not describe how to incorporate aspects such as socio-economic issues, existing land-use regulations or cultural, religious or archaeological considerations.

eThekweni Municipality has been proactive in integrated management of the coastal zone incorporating coastal setback. The Municipality initiated a programme to determine a coastal erosion line based on shoreline variation since 1935 and a 1 in 50 year event. The development setback line, landward of the coastal erosion line, provides a buffer zone for the re-establishment of vegetation. Studies such as CSIR (2000b) and CSIR (2003) contributed toward this programme.

Initiatives by region within the municipal district have developed official management plans which authorities can consult for guidelines on development in coastal areas, amongst others. One example is the Ohlange-Tongati Local Area Plan and Coastal Management Plan: Land Use Management Guidelines (2007). This document refers to the development setback line determined by the municipality as a major tool to guide development management in the region. Additionally, information and requirements of other management tools are provided such as, amongst others, EIA regulations, beach shadow line policies, floodlines and protection of specific types of ecosystems.

Michel (2009) discusses the concept of Shoreline Management Plans (SMP's) which aim to identify, assess and manage potential impacts between the physical and human environments, and look toward management policies which provide for sustainable development in the coastal zone. (Such SMP's are in place in North America and the United Kingdom.)

### 2.3 INTERNATIONAL PRACTICE

While in South Africa laws and regulations are being implemented, it is beneficial to look at practices of other countries for guidance. In general three approaches to managing development along the coastline have been adopted:

1. **Accommodate:** this approach relies on the society’s ability to cope and adapt with natural hazards with no interference on natural processes
2. **Protect:** this approach involves a range of (costly) methods, hard and soft, to protect coastal development
3. **Retreat:** manage and restrict land-use to avoid hazardous situations, and where development has taken place close to the shoreline aim to relocate development (if practical)

In the context of this study the final approach, as defined, is likely to apply to future developments, while relocation of existing development is deemed unlikely (would involve complex and expensive legal issues). However, in time, relocation may in practice become unavoidable in some instances due to expected climate change effects. Systems/plans/regulations from a select few countries are discussed below to illustrate various methods of the determination of the development setback line.
2.3.1 Australia

South Australia has a dedicated institution, the “Coastal Protection Board”, which was formed with the proclamation of their official Coastal Protection Act of 1972, which is the primary authority on managing coast protection, advising on coastal development and administering the Coastal Protection Act. The Board works closely with regional natural resources management whose focus on sustaining natural resources including protecting the natural environment from development pressures. Certain development applications are referred to the Board by the relevant planning authorities, upon which the Board responds after consulting specialist studies. Of particular concern to the Board is land and development likely to be affected by coastal processes (Department for Environment and Heritage, Government of South Australia: Coasts and Marine http://www.environment.sa.gov.au/coasts/about-us/coast-protection-board.html)

The Coastal Protection Board has published a policy document, endorsed in 2002, which outlines the aims and objectives of the board in terms of policies grouped into 8 areas:

1. Development
2. Hazards
3. Protection works
4. Conservation
5. Heritage
6. Access and amenity
7. Partnerships, integration and capacity building
8. Research, reporting, monitoring and assessment

The Hazard policy of the Board (Coastal Protection Board, 2004) with regards to coastal hazards and development setback distance from the waterline is divided into two components: sea level rise and erosion. Sea level rise component (informing flood levels) takes the following into account:

- 0.3 m rise in sea level by 2050 (allowing for a further 0.7 m in the following 50 years)
- Allowance for land subsidence

The erosion component includes allowance for 100 years of erosion together with 0.3 m of sea level rise.

The Development policy includes statements against development in sand dunes, wetlands, coastal estuaries and marine vegetation. The Conservation policy seeks to promote conservation of diversity of plant and animal species as well as supporting investigations into identifying, protecting and managing areas of high conservation value as well as investigations into impacts of development on the environment.

In terms of the Heritage and Landscape policy the board is in support of identifying and protecting coastal areas with:

- Significant landscape value
- Marine archaeological heritage
- Cultural significance
- Scientific significance

Within this policy the rights and needs of the aboriginal people have been incorporated through consultation regarding decisions which affect sites of aboriginal significance and native title.

Western Australia, in the State Coastal Planning Policy issued by the Western Australian Planning Commission (WAPC), provided factors to be considered in delineating the setback distance (WAPC, 2003). The factors are as follows:
1. Distance for absorbing extreme erosion (S1): this requires modelling the impact of a 1 in 100 year storm sequence on the shore. The storm sequence is made up of 3 successive runs of a recorded storm, agreed upon by WAPC and the Department for Planning and Infrastructure (DPI). S1 is then the total recession of the mean sea level. If no modelling or survey data is available then a default of 40 m is used.

2. Distance for historic trend (S2): the long-term shoreline erosion rate is determined from a minimum period of 40 years of shoreline data. S2 is then taken to be 100 times the resulting annual erosion rate and where the coast is deemed to be relatively stable a minimum safety allowance of 20 m is used. Where accretion is evident and will result in more than 20 m of accretion in 100 years, S2 will be zero.

3. Distance to allow for sea level rise (S3): vertical rise assumed (at the time of issue) is 0.38 m. Using the Bruun rule this value multiplied by 100 to obtain an S3 value of 38 m.

To determine the total setback distance S1, S2, and S3 are added.

2.3.2 United States of America

In the United States, 23 of 29 coastal states and territories have setback regulations (Fenster, 2006). Coastal authorities in the USA adopt 2 different approaches to setback distances (Houlahan, 1989) floating setback or fixed setback distances. Of the 23 US coastal states with setback regulations, 15 use the fixed setback method, and 5 use the floating setback method and 4 use a combination of both (Fenster, 2006).

**Floating setback** distance is determined by the multiplication of the annual long-term erosion rate of the area by the anticipated life-span of the development (Houlahan, 1989).

**Fixed setback** distance is a fixed distance, from (usually) the edge of permanent vegetation, determined to allow the natural variability of the shore. This line has been determined in a number of ways (Houlahan, 1989):

- Set a distance from a set marker to allow a protective buffer between coastal process and development based on aerial photographs - Delaware and Hawaii.
- Consideration of the vulnerability to storms, alignment of existing structures, buildable property and maintenance of structures to determine a set distance marking the Coastal Construction Control Line (CCCL) (Alabama)
- Develop a CCCL based on shoreline erosional trends, short-term shoreline fluctuations (seasonal and storm) as well as storm surges with associated waves (Beaches and Shores Resource Center, 2007, Chiu & Dean, 2002, Komar et. al., 1999)

Healy and Dean (2000) described a methodology to delineate the CCCL (termed the development setback in their work) incorporating a Coastal Hazard Zone (CHZ). The description was based on previous works, particularly methods of coastal zone hazard identification in New Zealand. The following formula, based on conceptualisation of the beach profile, was provided:

\[
CHZ = R + 2 F_{(max)} + \Delta y + D
\]

where CHZ is a horizontal distance inland measured from a fixed reference point, R is the long-term dune movement, \(F_{(max)}\) is the maximum short-term duneline fluctuation, \(\Delta y\) is the horizontal distance of retreat of the dune in response to sea level rise and D is the dune stability factor. Each term is briefly described below.

**The long-term dune movement (R),** which may be the equivalent to the shoreline trend, is determined through historical surveys and/or aerial photographs. The reference point, or feature, identified in every survey and photograph is to be consistent. A unit rate of m/100 years is obtained which may be a positive or negative value in the case of eroding or accreting coasts respectively.

**The maximum short-term duneline fluctuation** \(F_{(max)}\) relates to the “cut and fill” of the dune due to episodic erosive events or decadal trends. This may be determined through survey data or through model predictions using relevant statistical storm and surge information. To \(F_{(max)}\) a safety factor may be applied to account for error, uncertainty and lack of data. The default is 2.
The horizontal effect of sea level rise ($\Delta y$) comprises of two components: Determining the sea level rise to apply and the effect of the rise on the coast. Determining sea level rise should take the following into account: the effect of local tectonics, local sea surface geodynamic effects, steric effects and human-induced effects. The rise determined for any one section of coast is specific to that section.

Historically the Bruun rule, a two-dimensional model first introduced by P. Bruun in 1962 (Bruun, 1962), was used to determine the response of the coast to sea level rise. The model predicts the shoreline retreat ($\Delta y$) due to erosion induced by sea level rise. The original form is:

$$\Delta y = \frac{\Delta s \cdot l^*}{h^*}$$

where $\Delta s$ is the relative sea level rise, $l^*$ is the beach profile length and $h^*$ is the depth of the limit of sediment exchange between the beach and the offshore.

The parameters of Bruun rule (and subsequent modifications thereof) are open to interpretation. For example, how does one determine the limit of sediment exchange between the beach and the offshore, or the appropriate length of the beach profile. In addition, the Bruun rule assumes the hinterland to be erodable (sandy) material. This may not be the case.

Various modifications of the Bruun rule were provided by Healy & Dean (2000), only two of which are described below. Dubois (1977) developed a simplification of the Bruun rule:

$$\Delta y = \Delta s \cdot \tan \beta$$

where, in addition to the existing parameters already defined, $\tan \beta$ if the slope of the offshore bar. Dune dimensions are not explicitly accounted for in the original Bruun model and so Weggel (1979) included the dune height:

$$\Delta y = \frac{\Delta s \cdot l^*}{h^* \cdot E}$$

Where, in addition to the existing parameters already defined, $E$ is the height of the dune.

The most recent model to predict shoreline response to sea level rise, according to Healy & Dean (2000), was proposed by Dean (1994):

$$\Delta y = \frac{1}{(h^* + E)} (\Delta s \cdot l^* + \Delta V)$$

where $\Delta V$ is the volume of sediment added to the beach profile to achieve the Bruun rule, assuming an equilibrium beach profile proposed by Dean in earlier works.

The dune stability factor ($D$), the last term of the delineation of the CHZ, relates to the stability angle, or angle of repose, of the dune face. This factor predicts the horizontal distance to be allowed in terms of dune stability for every unit of dune height eroded. To this effect the following calculation is proposed:

$$D = \frac{E}{\tan \alpha}$$

where, in addition to the existing parameters already defined, $\tan \alpha$ is the natural angle of repose of the dune.

Healy and Dean (2000) provide 3 methods to test the determined CHZ:

1. **Episodic storm cut and sand reservoir considerations**: this test involves checking whether sufficient dune volume remains within the CHZ after the worst known storm. This may be done relatively easily by analysing historical surveys, particularly those shortly after a storm event. However, such critical surveys are often not available in which case the Dutch standard is applied. Approximately 400 m$^3$/m of dune volume should still remain above sea level within the CHZ after the worst known storm assuming a storm surge and wave run-up of 5 m. If not, the CHZ is revised.
2. Storm surge washover and flooding: a design storm surge and run-up calculation is made and applied to the beach profile. If resulting level exceeds the dune height, then the CHZ needs to be revised. Total storm wave run-up is determined by adding the following components:

Table 2.2: Components of design storm surge and wave run-up.

<table>
<thead>
<tr>
<th>Component</th>
<th>Formula and Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal level</td>
<td>( h_T = \text{(highest predicted tide)} - \text{(datum)} )</td>
</tr>
<tr>
<td>Barometric set-up</td>
<td>( h_{AB} = 0.010 \times (1014 - \text{storm barometric pressure}) )</td>
</tr>
<tr>
<td>Wind set-up</td>
<td>( h_w = \frac{K h_1 u^2 W}{g h_2^2 (1 - \frac{h_1}{h_2})} \ln \frac{h_1}{h_2} )</td>
</tr>
<tr>
<td>Wave set-up</td>
<td>( h_w = 0.19 \times [1 - 2.82(H_b/gT^2)^0.5]H_b ) where ( H_b = 0.563 H_0/(H_0/L_0)^{0.2} )</td>
</tr>
<tr>
<td>Wave run-up</td>
<td>( h_r = (H_bL_0)^{0.5} \tan \beta )</td>
</tr>
</tbody>
</table>

Notations:

- \( K \) = constant \((3 \times 10^{-6})\)
- \( h_1 \) = water depth at shelf break
- \( h_2 \) = depth at the shore or point of interest \((must be non-zero)\)
- \( u \) = wind speed
- \( W \) = width of the continental shelf
- \( g \) = gravitational acceleration
- \( H_b \) = wave height at wave breaking
- \( T \) = deep water wave period
- \( H_0 \) = deep water wave height
- \( L_0 \) = deep water wave length

Possible tsunami hazard: where information regarding maximum water level of tsunami events is available, this level is checked against the height of the dune. If the dune is lower than the tsunami water level, the CHZ will be revised.

A further definition of setback distance available in the literature pertaining to the USA, specific to only certain states like North Caroline, is relative to development size and purpose. The bigger the development footprint the further landward of the high water mark the development is to be situated. The purpose, i.e. commercial or residential, has an associated life-span which is to be incorporated in determining the distance from the high water mark. Finally, the purpose of the development also dictates the ability of the development to be relocated which is considered a viable option in literature consulted.

2.3.3 Eastern Caribbean

In 1985 UNESCO established a project on “Coast and beach stability in the Lesser Antilles” (COSALC) which was refocused in 1996 in the context of the Coastal Regions and Small Islands (CSI) endeavour. General public is informed of existing coastal problems and their causes and educated on the need for cautious human interaction with the natural coastal system.

Previous guidelines identified a setback distance from the high water mark for particular coast slopes. These guidelines do not allow for natural variability of the coastal zone and may be variably interpreted based on season or state of the coast line relative to the most recent event.
To help protect coastal installations, new guidelines for construction setbacks in the Eastern Caribbean islands were developed in 1997 (Cambers, 1997). The guidelines are aimed at coastal planners, managers and at concerned stakeholders. In these guidelines the coastal environment was divided into four geomorphological zones:

1. Cliffs
2. Low rocky shores
3. Small sandy offshore cays
4. Sand and stone beaches

For the first three zones a general description is first provided briefly describing the dynamics of these zones after which fixed distances, from set benchmarks (e.g. the permanent vegetation line), are provided beyond which development may occur. The setback of the fourth zone is not as simplistic. The following is taken into account:

- Historical change in the coastline using aerial photographs
- Recent beach changes using a monitoring database
- Changes in dune or coast line in response to a storm event
- Offshore features or changes
- Coastal geomorphological features (e.g. exposed beach rock) or anthropogenic features (e.g. sand mining)
- Planning considerations such as lot size or nature of development

Consideration is given to smaller establishments such as bars or restaurants, the success of which depend on proximity to the ocean. However such developments are subject to building materials (i.e. wood) and are to include no permanent foundations.

The above setback methodology was improved by Daniel and Abkowitz (2005) who proposed a more quantitative assessment using the following combination of long and short term erosion, within a GIS-based ‘Beach Analysis and Management’ system:

\[
\text{Horizontal short-term variation} + \text{Horizontal long-term variation} + \text{Safety factor}
\]

Maximum dune or beach retreat during an extreme storm event
Dune stability factor indicative of dune erosion and slumping
Beach or dune retreat due to sea level rise
Existing beach or dune retreat/advance trend

Safety factor Value between 1.0 and 2.0 representative of the level of certainty

Techniques for determining each component of the above calculation were provided.

2.3.4 India

In 1991 the Government of India developed the Coastal Regulation Zone (CRZ). This area consisted of the land between 500 m landward of the high tide mark and the low tide mark (Nayak, 2004). Restrictions were imposed on setting up of or expanding industries, operations and processes to manage development in the coastal area. GIS database topographical contouring was developed (CRZ) and included databases of ecologically sensitive zones (CRZ I), developed areas (CRZ II), undeveloped areas (CRZ III) and islands (CRZ IV).

This plan has now been superseded due to ineffective implementation with a proposed Coastal Zone Management plan (Venugopal, P.N. (2010)). The details of this plan have not yet been investigated.
2.4 KEY FINDINGS

Key findings are distilled from the literature review above. These findings relating to the general approach to the setback lines as well as to specific methods/tools to be employed in setback line analyses.

2.4.1 General Approach

The following information represents common themes which were evident from the review on local and international practice. This information on the general approach to setback lines is pertinent to the development of the setback line methodology:

1. Assessment of the coastal erosion setback line (i.e. coastal erosion setback line is the landward boundary of the natural coastline variation that occurs in the coastal zone) should include separate assessments of (a) long-term erosion trend, (b) short term erosion (by storms) and (c) erosion (and/or setback) due to sea-level rise. Distances of the shoreline retreat for each of these three items are added together;

2. The erosion trend is generally assessed from aerial photographs and also historical topographical surveys, when available,

3. The assessment of erosion setback requires an understanding of sediment transport (both alongshore and cross-shore);

4. Consideration should be given to wind-blown sand;

5. Consideration must be given to coastal protection features, such as rock outcrops;

6. Consideration must be given to unique conditions encountered at estuary mouths;

7. Development setback should consider the following issues:
   a. Coastal hazards (very high water levels and co-incident storms);
   b. Conservation/biodiversity;
   c. Heritage;
   d. Public access and amenity;
   e. Landscape value (sense of place).

8. Modelling is indicated as a tool to assess storm erosion;

9. The Bruun formula is applied (with caution and associated judgement) as well as similar approaches to assess setback required for sea-level rise;

10. In assessment of the setback line the type/lifespan of development is considered in some cases;

11. Coast type (sandy/rocky) and slope are important parameters when assessing setback.

All of the above items are incorporated in the proposed methodology for the establishment of development setback lines, noting that coast type (item 10 above) is implicitly incorporated (i.e. erosion setback is excluded in the case of non-sandy shorelines).
2.4.2 Specifics

The following information on specific methods/analysis tools obtained from the literature review is pertinent to the development of the setback line methodology:

1. Assessments of storm erosion and/or flooding (determination of the extent of wave penetration) should consider:
   a. Maximum tides
   b. Wind setup
   c. Water-level increase due to low atmospheric pressures prevalent during storms
   d. Sea-level rise
   e. Wave set-up and wave run-up

2. The long-term erosion rate (if applicable) should be determined considering data covering a period of at least 40 years (applied in West Australia) and the allowance for this erosion should cover a period of 100 years.

3. If no storm erosion modelling is done and/or no survey data is available, a default setback contribution for storms of 40 m is applied in West Australia.

4. At time of publishing (2003), Western Australia employed sea-level rise of 0.38 m and a setback allowance of 38 m for sea-level rise.

Most of the findings above, relating to specific best practice methods/tools, are applied in the proposed development setback line methodology. Exceptions are items 3 and 4, which are considered, but the exact numbers are not explicitly applied (It is not advocated that such values indicated in points 3 and 4 be used, since each region or site must be analysed individually, but points 3 and 4 provide a useful indication of the order of magnitude of setback allowance for sea level rise in a wave climate roughly similar to that of South Africa)
3 Setback Line Study Assumptions and Principles

It was necessary to make a number of assumptions and to adopt certain principles before developing the setback line methodology. Key issues are:

- The number of setback lines (having different purposes);
- The time period associated with setback lines;
- When setback lines should be revised;
- How setback lines should be indicated if they are found to be landward of an existing development.

3.1 NUMBER OF SETBACK LINES

It is clearly indicated in the guide to the ICMA (Dept. Environmental Affairs and SSI, 2009) that there may be more than one setback line for any given area. The guide indicates “For example, one setback line may be an anticipated erosion setback line, while another may relate to aesthetics…”

Throughout the discussions and stakeholder engagement process (minutes, Appendix A), various arguments were presented for keeping the development setback to one single line or for having more than one line. The appeal of a single line is simplicity. However, more than one line may be needed to demarcate “non negotiable” areas for development, versus areas which are negotiable for limited or controlled development. For this reason, two setback lines are defined, as follows:

1. A coastal processes (or “no development”) setback line. This line will demarcate setback required to allow for coastal erosion, wave penetration during storms (i.e. the limit of the wave hazard zone), and wind-blown sand transport. In other words this line will incorporate erosion setback as well as wave penetration (wave runup) and wind-blown sand. Development seaward of this line is considered to be non-negotiable since it will potentially result in damage to developments, impacts (erosion) on neighbouring shorelines, or high maintenance costs; hence the term “no development”. It is proposed that even with an EIA, the region seaward of this line should be “no go” area. The exception would be implementation of measures to protect the coastal environment, such as wooden walkways across sensitive dunes.

2. A limited or controlled development setback line. This line will demarcate the setback required for issues such as aesthetics, buffer zones required for biodiversity and/or setback to allow for heritage (e.g. shipwreck sites, shell middens). Such issues may allow for limited development seaward of this setback line while still retaining the priorities of heritage/aesthetics/biodiversity. The limitation on development or control of development would be defined by the requirements relating to heritage/aesthetics/biodiversity. An example of a limited development may be a development that must avoid proximity to demarcated shell middens. An example of a controlled development may be one for which only log cabins (with minimal foundations) are allowed. Note that the limited/controlled development setback line will either be on the same as the coastal processes/no development line, or will be situated landward of it.

It is important to note that this line is established in combination with the development limitation or control conditions. These conditions may in fact require that no development occurs (as for the coastal processes line). In such a situation, it is important that the two lines are established – a distinction between a setback line for coastal processes should be distinguishable from a setback line for other reasons.

In the assessment of the above setback lines, a number of interim setback lines should be developed (e.g. setback for aesthetics only, setback for biodiversity only, setback for heritage only). It is vital that on these individual “component” setback lines be recorded and made available at the stage when an EIA for a development is carried out.
3.2 TIME PERIOD

With the coastal region constantly changing, it is important that a time period is associated with a setback line. It is assumed with in this study that if a time period of X years is indicated then a 1:X year storm erosion should be considered and a X year period should be considered with regard to an erosion trend and to sea-level rise. Until recently a reasonable approach was to consider a period of X=50 years for housing developments, since:

- Building structures and other common structures have an indicative design working life of 50 years (SANS 10160) (more economical to maintain than design for 1:100 years)
- Flood lines for rivers were commonly 1:50 years
- The setback line employed at Ethekwini is based on shoreline variation since 1935 and a 1 in 50 year storm event.
- One of the criteria defining the Coastal Protection Zone in the ICMA (Section 16) is: “Any land that would be inundated by a 1:50 year flood or storm event.

In assessing the period associated with setback, Table 3.1, could be useful. The approach indicted in this table implies having different setback periods for different infrastructure.

Although a period of 50 years has been applied to date for residential housing, it is assumed that a longer period of 100 years should be employed, since:

- This is the maximum period indicated in the above Table 3.1 for high value infrastructure (which includes residential homes);
- CapeNature recommend a 1:100 year period (for flood lines);
- Event statistics are likely to change with climate change and sea level rise (Theron and Rossouw, 2008) such that more severe storms will occur more often;
- The need for a risk averse and precautionary approach under conditions of uncertainty is clearly indicated in the guide to the ICMA (Dept. Environmental Affairs and SSI, 2009);
- In South Australia, which experiences a similar wave climate to South Africa, development setback lines consider 100 years of erosion;
- Statistically, within a period of 50 years, there is a 63% probability of the 1 in 50 year storm erosion occurring one or more times. Considering this, it is considered prudent that a longer period than 50 years (and thus a larger storm) be considered;
- Predictions of sea-level rise for 100 years are available. However predictions further into the future are not generally available and are likely to be inaccurate;
- The City of Cape Town setback for inland rivers for residential development is the 50-year floodline. However, it is recognised that the destructive forces associated with waves and coastal erosion are more severe than the inundation by the inland floodwaters and thus the setback is more comparable with the inland “high hazard zone” which is defined for the 100-year flood and within which all development is excluded. (Details: City’s Floodplain and River Corridor Management Policy, 2009).

Table 3.1: Infrastructure value, lifespan, impact of failure, planned sea-level rise (Courtesy Andrew Mather, Ethekwini Municipality)
<table>
<thead>
<tr>
<th><strong>Low</strong></th>
<th><strong>Short term</strong></th>
<th><strong>Medium to Long Term</strong></th>
<th><strong>Very High</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>i.e. Recreational facilities, car parks, board walks, temp beach facilities</td>
<td>Less than 20 years</td>
<td>Between 50 and 100 years</td>
<td>In excess of 100 years</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td><strong>Short to Medium Term</strong></td>
<td><strong>High</strong></td>
<td><strong>Long term</strong></td>
</tr>
<tr>
<td>Tidal pools, piers, recreational facilities, sewerage pump stations.</td>
<td>Between 20 and 50 years</td>
<td>Between 50 and 100 years</td>
<td>In excess of 100 years</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td><strong>Medium to Long Term</strong></td>
<td><strong>High</strong></td>
<td><strong>Very High</strong></td>
</tr>
<tr>
<td>Beachfronts, small craft harbours, Residential homes, sewerage treatment works.</td>
<td>Between 50 and 100 years</td>
<td>Between 50 and 100 years</td>
<td>In excess of 100 years</td>
</tr>
<tr>
<td><strong>Very High</strong></td>
<td><strong>Long term</strong></td>
<td><strong>Very High</strong></td>
<td><strong>Long term</strong></td>
</tr>
<tr>
<td>Ports, desalination plants, nuclear power stations</td>
<td>In excess of 100 years</td>
<td>Major disruption to the regional and national economy, failure of key national infrastructure</td>
<td>In excess of 100 years</td>
</tr>
</tbody>
</table>

* i.e. the amount of sea-level rise catered for in planning such structures.

For relatively low to medium value infrastructure (e.g. those items defined as low value in Table 3.1) it is assumed that a period of 50 years would be appropriate. However, this would only apply for a continuous region of such infrastructure since it will be impractical to have adjacent and alternating 50 and 100 year setback lines.

For both very high value infrastructure (Ports, desalination plants, nuclear power stations) a 200 year setback should be considered. As for the above, this would only apply for a continuous region of such infrastructure since it will be impractical to have adjacent and alternating 200 and 100 year setback lines.

Finally, infrastructure such as hospitals, clinics, nursing homes, old age homes, police stations, fire stations, educational facilities, public halls, etc., are critical facilities during any major flooding disaster situation. A 200 year setback should be considered for such infrastructure.
3.3 **SETBACK LINE REVISION**

It is assumed that setback lines should only require revision:

- With significant change in global conditions (published, consensus sea-level rise predictions, and a published or clearly evident indication of storm wave intensity increase);
- With significant *unforeseen* local and regional changes (e.g. a significant change in sediment transport budget such as a curtailed river sand discharge);
- After considerable time has passed. It is considered that a 1:100 year setback line should be revised after 50 years;
- If there is a change in policy on hold/advance/retreat of an established setback line.

It is recognised that anthropogenic changes, e.g. harbour construction, dredging, etc., can alter coastal processes to the extent that re-assessment of an established setback line may be required.

3.4 **SETBACK LINES AND EXISTING DEVELOPMENT**

It is intended that the scientifically determined setback line will be reflected regardless of the existing development. This was decided within steering committee meetings (Minutes, Appendix A).

3.5 **SETBACK LINES AND MINING**

Just as development may impact on coastal processes (e.g. by increasing turbulence, reducing sand supply) so mining (particularly sand mining) can impact on coastal processes. The primary influence is likely to be a reduction in sand supply. The latter may not be problematic if the mining is adequately setback from the shoreline. Thus, it is recommended that mining operations be treated the same as developments with regard to setback.

3.6 **BUDGETARY CONSTRAINTS**

As practitioners familiar with the complexity of coastal processes, we believe that very accurate setback is only attainable by means of accurate modelling (with accurate input data) and analysis. This would require the items such as those indicated in Table 3.2 in which an indication of cost (to cover the Western Cape region) is included.
Table 3.2. Required data and studies for highly accurate assessment of setback

<table>
<thead>
<tr>
<th>Item</th>
<th>Reason required</th>
<th>Rough Cost Indication (to cover Western Cape Province) in ZAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathymetry survey</td>
<td>For accurate modelling of nearshore waves, long-term shoreline change and storm erosion.</td>
<td>Tens of million</td>
</tr>
<tr>
<td>Nearshore wave measurements</td>
<td>To calibrate wave transformation modelling.</td>
<td>Several million</td>
</tr>
<tr>
<td>Repeated topographical surveys</td>
<td>To accurately assess short-term and long-term on/offshore shoreline trends</td>
<td>2-3 million per survey</td>
</tr>
<tr>
<td>Wave modelling (calibrated)</td>
<td>Calibration of wave models and simulation of a range of conditions provides all the detailed information required for long-term shoreline modelling, short-term storm erosion modelling and wave runup calculations.</td>
<td>At least 1 million</td>
</tr>
<tr>
<td>Shoreline modelling (calibrated)</td>
<td>To understand and quantify shoreline change and to predict future shoreline change in response to sea-level rise and anthropogenic influences</td>
<td>At least 2-3 million for selected sites</td>
</tr>
<tr>
<td>Storm erosion modelling (calibrated)</td>
<td>To accurately quantify storm erosion</td>
<td>~ ½ to 1 million</td>
</tr>
</tbody>
</table>

Without any budgetary constraint it would be recommended that measurements and studies of this nature be conducted in order to determine very accurate erosion setback lines.

However, it is recognised that budgetary constraints may limit the extent to which such studies can be done. Therefore, the assumed approach to determining setback lines is to conduct a minimum of measurements, limited modelling studies and application of sound judgement by coastal processes professionals.
4 Overview of Proposed Setback Line Methodology

Reference is made to Figure 4.1 which illustrates an outline of the proposed setback methodology, as submitted to the steering committee for comment. There are four main sections of this flowchart:

1. Preliminary work
2. Setback assessment
3. Stakeholder engagement
4. Finalisation (of setback)

The key component of preliminary work is entitled “enabling studies”. This involves work (such as aerial surveys) which is done once-off on a regional basis. The results of such studies will feed into the setback line studies within that region to facilitate easier execution and more accurate results. The enabling studies are discussed in Section 5. Preliminary work also includes a visit to the site/area in question, data collection relevant to that area, and a review of existing boundaries (e.g. of property ownership, proposed coastal protection zones, etc.). These preliminary items are discussed in Section 6. The setback assessment involves the technical assessment of various components of (or contributing to) setback, i.e. items A to F in Figure 4.1. From consideration of the maximum setback derived each of the items A to C, which relate to coastal processes (such as erosion, wave runup and overtopping, and wind-blown sand) the coastal processes/no development setback line can be established (described in Section 7). From consideration of the maximum setback derived from each of the items D to E, which relate to biodiversity, heritage and miscellaneous other issues, the limited/controlled development setback line can be established (Described in Section 8). Finalisation of the setback line submission is dealt with in Section 9. Simultaneous to the preliminary work and setback assessment work, a stakeholder engagement process is executed. This is described in Section 10. In Section 11, issues relating to implementation of the methodology are discussed. Finally, in Section 11, conclusions are drawn and recommendations made.
5 Preliminary Work: Enabling Studies

The large scale of a setback line study on a provincial (or even national) scale will allow for economisation as a result of this large scale. For example, essential topographical data for a single coastal site (say a few kilometres in length) would cost some R5000-00 to R10 000-00 per kilometre employing traditional surveyor services. However, making use of aerial laser technology, the same information can be obtained for about R1600-00 per kilometre. A number of studies/surveys have been identified which will benefit from the economy of scale and which need only be conducted once (and not for every setback line study commissioned). These are as follows:

1. Aerial topography survey (employing laser or photogrammetry);
2. Establishment of a Wave Atlas in order to assess conditions at each site.
3. Establishment of regional storm surge.

These are discussed in detail below.

5.1 AERIAL TOPOGRAPHY SURVEY

5.1.1 Motivation

The setback required for sea-level rise, wave erosion and wave runup is strongly dependent on the topography of the shore. For example, steep shorelines generally require less setback than flat shorelines. Therefore, good quality topography survey data is absolutely essential in the assessment of setback.

The commonly employed land-based survey techniques are very time consuming and thus expensive (estimated to be between R5000-00 and R10 000-00 per kilometre - Table 4.1). Furthermore, while the time to survey an extended area of shoreline can be reduced by employing a number of surveyors, cost cannot be reduced in the same fashion.

An appealing alternative to traditional survey methods is airborne survey techniques. Costing approximately R1600-00 per kilometre, this alternative is far less expensive. The approach is also appropriate considering the time constraint (four years from the date of the ICMA) and scale of a study to establish setback lines in an entire province.

5.1.2 Topography data requirements

Ideal requirements for topographical data are as follows:

- Vertical accuracy of data points should be ±0.1 m (±0.3 m at most).
- Horizontal accuracy should be ±0.5 to ±1.0 m.
- A corridor of 200 m to 500 m inland of the spring low waterline should be measured.
5.1.3 Survey methodology

Two common airborne survey techniques have been assessed, namely:

- LiDAR (Light Detecting And Ranging); and
- Aerial Photogrammetry.

A preliminary comparison of the two techniques indicates:

- The costs to be similar, to achieve required accuracies;
- Higher accuracies can be achieved via LiDAR if required;
- LiDAR will deliver more data (which may have alternative uses) than photogrammetry;
- Limited bathymetry can be derived from photogrammetry. This is possible with LiDAR but only with specialised equipment (expensive);
- Both methodologies depend on good weather, but LiDAR has the advantage of surveying day and night.
- Both methodologies result in aerial images but the photogrammetry images are more accurate.
- LiDAR (and to some extent photogrammetry) is able to penetrate coastal forest and bush to determine ground level.

5.1.4 Budget

A budget of R2 800 000-00 has been estimated for a LiDAR survey of the entire Western Cape Province (approximately 1600 km of shoreline, extending 500 m inland). Indications from investigations are that photogrammetry costs would be similar. This budget translates to a cost of roughly R1600 per kilometre of shoreline.

5.1.5 The way forward

The topographical survey of the Western Cape should be put out to tender to photogrammetry and LiDAR companies. Tenders should be evaluated in terms of:

- Accuracy of results (within the required accuracy band)
- Cost
- Additional uses/benefits of data delivered.
- Form of data provided (digital terrain models, contour charts, beach profiles/cross sections)

Minimum requirement:

- Topographical survey of Western Cape coastal region – put out to Tender
5.2 WAVE ATLAS

5.2.1 Motivation

Poor estimates of storm wave conditions result in poor estimates of storm erosion and wave runup. This in turn results in developments not being adequately setback and consequent storm damage (e.g. Figure 5.1) from erosion and wave runup (as revealed by the KZN 2007 storm, potentially costing millions). Setting of computer models of large regions to predict storm wave conditions along the shoreline will allow for sufficient accurate estimates of wave conditions and consequent erosion and/or wave runup.

![Figure 5.1: Storm damage (in 2003) at Hermanus Beach Club due to inadequate setback. Subsequent storms have also caused damage.](image)

5.2.2 Study requirements

Ideally, modelling should be conducted with suitable measured wave data (offshore waves are measured by Transnet National Ports Authority (TNPA). A good alternative is high quality hindcast wave data. The hindcast WAVEWATCH III wave data is freely available, but requires specialised processing to convert ‘raw’ data to useful parameters. Hindcast data from OCEANOR or Oceanweather has to be purchased, but is presented in a useable format with all relevant wave parameters. The grid resolution of the Oceanweather as well as OCEANOR wave models is better than that of WAVEWATCH III and can thus provide more site specific information. However, experience has shown that WAVEWATCH III data is of good quality and will be adequate for the purpose of setback line assessments.

A reputable wave model should be employed (ideally the SWAN model (Deltas, 2009), or equivalent). Accuracies in the order of 5-10% should be achieved through calibration using existing data.
Model outputs should include (a) plots showing wave fields (wave heights and directions) along the coastline and – e.g Figure 5.2, and (b) time series (at least 10 years, every 3-6 hours) of wave heights, periods and directions at specific point alongshore (spacing of points depending on alongshore wave condition variability – but on average about every 500 m).

### 5.2.3 Budget

Based on work done on the case studies for this project, and assuming that spectral wave data will need to be purchased to optimise accuracy, it is estimated that a Wave Atlas study for the Western Cape would cost in the order of R400 000-00. This will translate to roughly R220 per kilometre of shoreline.

![Figure 4.2: Predicted wave field (showing wave heights and directions) at Saldanha. The red line shows the region of modelling grid refinement. The red dots indicate where wave time series were calculated.](image)

**Figure 4.2:** Predicted wave field (showing wave heights and directions) at Saldanha. The red line shows the region of modelling grid refinement. The red dots indicate where wave time series were calculated.

### 5.2.4 The Way Forward

Establishment of a Wave Atlas for the Western Cape should be put out to tender to relevant universities and coastal consultants. Tenders should be evaluated in terms of:

- Methodology (model/s employed, calibration approach, means of calculating wave data time series)
- Accuracy of wave results
- Cost
- Form of data to be provided
5.3 WATER LEVEL AND STORM SURGE ANALYSIS

5.3.1 Motivation

During storms, high winds and low atmospheric pressure generally result in an increase in average water-level – this is termed storm surge. Under extreme conditions, the rise in water level from storm surge can be in the order of 0.5 m. The increased water-level allows waves to penetrate further inland, particularly the surge occurs during high tides (as for the KZN storm of 2007).

Thus, it is important that existing information be analysed to assess the extent of storm surge and to include this in calculations of wave runup and storm erosion in the assessment of setback. A wealth of information exists in the form of measured tides and atmospheric pressure which can be employed to provide estimates of storm surge under extreme and average conditions. It is possible to apply this information to a region – for example storm surge data determined for Simonstown can be applied to a large area of the Cape Metropolitan region.

5.3.2 Study requirements

The following would be required:

- Access all available water-level measurements and associated atmospheric pressure data;
- Determine a relationship between storm surge (independent of tidal water variations) and atmospheric pressure;
- Assess the role of wind and extent to which this is included in surge measurements and adjust as necessary;
- Apply the pressure vs storm surge relationship, together with predicted tides to fill gaps in measured tide data. Thus produce continuous water-level time series for application in setback studies;
- Applying extreme value statistics to surge data only, determine extreme storm surge that can be expected (e.g. 1 in 100 year storm surge).

5.3.3 Budget

It is expected that such a study should cost between R75 000-00 and R150 000-00 (translating to a cost of no more than R85-00 per kilometre of coastline.

5.3.4 The Way Forward

A storm surge study for the Western Cape should be put out to tender to relevant universities and coastal consultants. Tenders should be evaluated in terms of:

---

Minimum requirements:

- Wave Atlas for Western Cape coastal region – put out to Tender
5.4 STORM EROSION MODEL PRELIMINARY STUDY

5.4.1 Motivation
Experience with aerial photographs indicates that at some sites only a few aerial photographs and often no beach profile data are available. For example, in the Langebaan setback case study (Error! Reference source not found.) only six aerial photographs were available for use. Applying the assumption that the on/offshore movement of shorelines from these photographs are normally distributed the storm erosion may be estimated. However, statistical analysis (i.e. application of the Chi-square test) proves that the normal distribution is not achieved with such a small group of photographs. As a result the predicted 1:100 storm erosion from this approach is not likely to be accurate. Therefore, an integral part of the setback line methodology is the additional computational modelling of storm erosion.

However, experience (particularly from the Milnerton and Langebaan case studies) indicated that supplementary preliminary work is needed to establish storm erosion modelling with integrity. An enabling study to conduct this preliminary work should focus on the modelling approach and on the calibration of the storm erosion model employed.

5.4.2 Study requirements
The following would be required:

- Collect data on measured beach profiles from various sites and extract wave data relevant to those sites (this assumes that the Wave Atlas enabling study has been conducted);
- Calibrate the storm erosion model (SBEACH is recommended) for an array of different beach conditions. This will provide a set of model coefficients to be used in storm erosion modelling;
- Develop an automated modelling approach to conduct the following efficiently
  - Selection of several nearshore storms per year (from the Wave Atlas data);
  - Simulation of erosion and consequent shoreline retreat due to all the storms;
  - The simulations should be conducted with water-level which include tide effects as well as storm surge (wind and atmospheric pressure effects) as obtained from the above water-level and storm surge analysis;
  - Statistical analysis of the modelled shoreline retreat from all storms to estimate extreme erosion (e.g. the 1:100 year erosion).

This modelling approach can then be employed efficiently in setback line assessments.

Minimum requirement:

- Storm Surge Study for Western Cape coastal region – put out to Tender
5.4.3 Budget

It is expected that such a study should cost between R75 000-00 and R150 000-00 (translating to a cost of no more than R85-00 per kilometre of coastline.

5.4.4 The Way Forward

A storm erosion model preliminary study should be put out to tender to relevant universities and coastal consultants. Tenders should be evaluated in terms of:

- Methodology
- Cost
- Form of data to be provided

**Minimum requirement:**

- Storm Erosion Model Preliminary Study - put out to Tender
6 Preliminary Work: Other

Preliminary work includes the collection of data and a site visit (during which some data is collected). In addition, the context of the shoreline under investigation can be determined through an assessment of existing boundaries.

6.1 DATA COLLECTION

6.1.1 Essential data

The following information is essential for defining a setback line with the proposed methodology:

- Aerial photographs and/or satellite images
- Hydrographical charts
- Zoning – considering current and future land use activities
- Sediment grain size distributions
- Wind data
- Wave data
- Water levels
- Beach topography data
- Biodiversity maps
- Heritage maps and reports
- Socio-cultural characteristics of the area

Details of each are as follows.

- **Aerial photographs**
  
  A set of aerial photographs is essential for determining the set back line. A set of these images provides an indication of trends of coastline movement (erosion, accretion or dynamic stability) and an estimate of short-term (storm) erosion.

  Aerial photographs should span a long period if possible, ideally with reasonably regularly spaced time intervals. Best practice in Western Australia dictates images should cover a period of at least 40 years in order to determine reliable long-term shoreline trends. As earliest aerial images in South Africa are generally dated circa 1940 this requirement can generally be addressed.

  Photographs must be of high resolution and should not be over-exposed, so as to identify coastal features (particularly the high-water mark) clearly. Ortho-rectification (to ensure it fits a survey system) of aerial photographs is required, as well as the geo-referencing (effectively applying reference coordinates) of images. All images are of such quality that these processes can be conducted on them.

  Orthophoto maps are also useful if available, since they include the aerial image as well as a co-ordinate grid, contours and spot heights.
Both aerial photographs and orthophoto maps can be obtained from the Chief Directorate of Surveys and Mapping, Department of Land Affairs (website: http://www.cds.gov.za). They also provide topographical maps (with a vertical contour interval of 5 m).

Supplementary to aerial images, high resolution satellite images can also be useful in the assessment of shoreline trends. Experience to date indicates these to be excessively expensive. However this situation may change in future.

It has been found that use of Google Earth will provide supplementary information on shoreline movements. Typically an additional 2 to 10 images are available. It is recommended that use be made of this data, under legal licence. The Google Earth software licence costs approximately R3000-00.

- **Hydrographical charts**

  The South African Navy Hydrographic Office (website: http://www.sanho.co.za ) is the national supplier of charts of coastal areas of South Africa & Namibia. These charts (SAN charts) contain bathymetrical data that can be used in assessing any seabed features that may be relevant, and as input for storm erosion modelling.

- **Zoning and future plans**

  The Spatial Development Framework (SDF) available from the local municipality must be consulted to determine existing developed zones and the proposed development limits for future development. The Rural Land Use Planning & Management Guidelines should be consulted where relevant. Other strategic planning documents such as Strategic Environmental Assessments (SEA’s) can also be used.

- **Sediment grain size distributions (from samples)**

  The grain size distributions emanating from the sediment samples are essential for the calculation of wind-blown sediment transport potential and for the computational modelling of storm erosion.

  The grain size distribution of a beach is determined by analysing sediment samples obtained at the site (refer to Section 6.2). Typically, sediment samples are collected along survey profile-lines that run perpendicular to the shoreline, and should include the intertidal zone (for assessment of storm erosion) and areas of wind-blown sand (generally the dune – for assessment of wind-blown sand transport). In general, beach/dune systems having a narrow range of grain-sizes will require fewer samples to characterize them than will systems with a wide range of grain-sizes. Samples should be taken at several locations along the shoreline of the site.

- **Wave data**

  Reference is made to section 5.2 which describes the Wave Atlas to be established for the setback line study. Reference will be made to this Wave Atlas to determine the typical storm and average conditions at the site. From the Wave Atlas, plots of storm wave will illustrate the alongshore variability of wave conditions and highlight dangerous areas of wave focussing. From the Wave Atlas, time series of wave data (height, period and direction) will also be available that are relevant to the site where setback is being assessed.

- **Wind data**

  Local wind data is essential in calculating windblown sand transport. Hourly wind data consisting of wind speed and direction are available at the South African Weather Service for a number or stations. A ten year data set from one of the Automatic Weather Stations (AWS) costs approximately R1050. Purchase of larger volumes of data results in savings.
An alternative which will provide a reasonable assessment of local wind data can be obtained from offshore wind forecast models such as WAVEWATCH III free of charge (however requiring considerable processing to produce a useable form). Alternatively more user-friendly data can be purchased from OCEANOR or Oceanweather. The greater speed of wind over water must be considered.

- **Water levels**
  Time series of measured water levels should be employed in the analysis. These will be obtained from the water level and storm surge analysis (as outlined in Section 5.3).

- **Beach topography data**
  Beach topography data will be obtained from the *enabling* aerial topography survey (described in 5.1). Where available, historical beach topographical survey data must be used in the assessment of shoreline and beach profile changes. Experience has shown that a database of beach profiles extending for several years to decades allows for more accurate setback line assessments. For example, a set of surveys in the Saldanha region showed that the shoreline movements are normally distributed (from the Chi-square goodness-of-fit test) while the same was not evident from aerial photographs.

- **Biodiversity maps**
  These can be obtained from CapeNature or the South African National Biodiversity Institute (SANBI), free of charge.

- **Heritage reports and maps**
  These can be obtained from Heritage Western Cape, free of charge.

- **Socio-cultural characteristics of the area**
  The stakeholder engagement process will provide information on the specific socio-cultural characteristics of the area under consideration. For example, in some cultures the beach may is used for religious rites.

A summary of essential data, with sources of the data and an indication of cost, is provided in the following Table 5.1. Note that all of these data can be readily measured and/or accessed in South Africa.

### Minimum requirement for data collection:

- Aerial photographs (from surveys and mapping)
- Hydrographical charts (from SA Navy Hydrographic office)
- Relevant Spatial Development Frameworks (from Municipalities)
- Sediment grain size distributions (sampled on site and sieved/settling tube)
- Wind data (from Weather Bureau)
- Wave data (from Wave Atlas – Section 4.2)
- Water level data (from Water Level and Storm Surge Study – Section 4.3)
- Beach topography data (from Aerial Topographical Survey – Section 4.1)
- Biodiversity maps (from SANBI)
- Heritage maps and reports (from Heritage Western Cape)
### Table 5.1: Essential data items, sources, costs.

<table>
<thead>
<tr>
<th>Data</th>
<th>Source</th>
<th>Approximate cost</th>
<th>Approx cost per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical Aerial photography</td>
<td>Dept. Surveys and Mapping</td>
<td>Contact prints: R 7/print; Enlargements: R 75/print</td>
<td>R450-00 (assume 6 photos)</td>
</tr>
<tr>
<td>Georeferencing of historical aerial photos</td>
<td>Spatial analysis/GIS specialist companies</td>
<td>± R 400/photo</td>
<td>R 2400-00 (assume 6 photos to correct)</td>
</tr>
<tr>
<td>SA Navy Bathymetry Charts</td>
<td>South African Navy Hydrographic Office (website: <a href="http://www.sanho.co.za">http://www.sanho.co.za</a>)</td>
<td>R 300 per chart</td>
<td>R30-00 (assume chart covers 10 km)</td>
</tr>
<tr>
<td>Spatial development Framework</td>
<td>Municipality</td>
<td>No Cost</td>
<td>No cost</td>
</tr>
<tr>
<td>Sediment grain size distribution</td>
<td>Analysis by accredited soils laboratory</td>
<td>R 1200/km (R 300 per sample and about 4 samples per km of beach). Cost of Reduction to R50 will be possible for large quantities.</td>
<td>R900 (assume 3 samples per km)</td>
</tr>
<tr>
<td>Offshore waves and wind data time series</td>
<td>ftp://polar.ncep.noaa.gov/pub/history/waves</td>
<td>No cost</td>
<td>No cost</td>
</tr>
<tr>
<td>Water level data</td>
<td>Access from the water level and storm surge analysis (Section 4.3)</td>
<td>No cost</td>
<td>No cost</td>
</tr>
<tr>
<td>Beach Topography Data: 1. Conventional land survey with coastal experience</td>
<td>Specialist aerial survey companies</td>
<td>1. R 5000 to R 10 000 per km</td>
<td>R 5000 to R 10 000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Aerial topography survey: R 2.8 million for 1800 km by 500 m strip (~R1600/km)</td>
<td>R1600</td>
</tr>
<tr>
<td>Bio-diversity maps (GIS)</td>
<td>CapeNature / SANBI</td>
<td>No cost</td>
<td>No cost</td>
</tr>
<tr>
<td>Heritage maps</td>
<td>Heritage Western Cape, 3rd floor, Protea Assurance building, Green Market Square (contact: Nick Wiltshire 021 483 9685)</td>
<td>No cost</td>
<td>No cost</td>
</tr>
</tbody>
</table>
6.1.2 Useful data

The following information is not essential to the proposed setback line methodology, but will certainly aid in improving the accuracy and quality of the setback line that is established.

- **Literature**
  Where possible previous studies, reports, articles or any other historical information on the site should be obtained and examined.

- **Satellite images**
  Satellite images can be used in addition to aerial photographs. A drawback is that satellite photos of sufficient resolution are expensive. Satellite images can be obtained through Digital Globe, a provider of commercial, high-resolution, imagery products and services (http://www.digitalglobe.com).

- **Geological information**
  Information on the geology of the site will be useful, particularly where the stability of cliffs or of dunes will influence the required setback.

6.2 SITE VISIT

During the site visit, the investigator must conduct a visual assessment of the area.

All major geological features and signs of dynamic instability must be observed. Features such as clear signs of erosion, cliffs, rocky outcrops and dune stability (gradual sloping dunes with vegetation versus steep sloped dunes showing clear signs of erosion) should be noted by the investigator.

Signs indicating the seaward extent of wave penetration (e.g. significant seaweed/kelp deposits on the shoreline) should be recorded via GPS. Note that such signs must be distinguished from windblown materials (seaweed) and human interference.

The extent and nature of permanent vegetation should be noted.

The location of breaking waves, variations in wave action and signs of wave action on the coastline must be noted. Current patterns should be noted.

Variations in wind speed and direction along the shore (e.g. sheltered zones) and the possible cause for these variations should be noted. This would be achieved by observing wind conditions and identifying windblown sand features along the beach.

Most importantly, sediment samples are collected during the site visit (described in Section 6.1.1).

Photographs should be taken of all general features of the coastal zone, e.g. beach at various locations (looking inland, seaward and alongshore), dunes, rock outcrops, and any existing developments. Specifically, a detailed
digital photographic record should be taken in both directions in line with the beach and in both directions across the beach, at intervals of 10 to 30 meters, using high quality digital cameras to provide overlapping views, for a historical record and also for later viewing and reviewing.

Ideally the site visit should take place during spring low water (spring low tide) in order to observe the condition of the entire intertidal beach.

### Minimum requirement for the site visit:
- Note and photograph condition of the shoreline
- Record the location of signs indicating the maximum extent of wave penetration
- Note and photograph coastal processes

### 6.3 ASSESSMENT OF BOUNDARIES

A review of any existing boundaries (and their associated background) may provide valuable background information, in particular:

- **Previous setback lines** will be useful if information on their origin is available (e.g. what they incorporate (storms, sea-level rise) and what period they represent (e.g. 50 years);
- **Coastal public property** boundaries will be useful in defining usage of the coastal area when this extends well landward of the high water mark;
- **Coastal protection zones** and available information on their origin will provide a useful guideline and may “red flag” areas, for example, that may flood in future or that have high biodiversity value;
- **Municipal/Town planning zones** are useful for defining the extent of existing and proposed future development;
- **Military or other special use areas** may be useful in “reserving” land, e.g. for biodiversity or heritage;
- **Cadastral boundaries** will be useful in defining property limits and land ownership (the latter is important when defining stakeholders that may be affected by updated setback lines);
- Development setback lines as determined by development approvals (e.g. conditions of rezoning or governmental authorisation).

Most of this information will be available from the Spatial Development Framework which is produced by municipalities every 5 years. Previous reports and the Rural Land Use Planning & Management Guidelines will also provide information.

### The minimum requirement for assessing boundaries is to consult the Spatial Development Framework
7 Coastal Process (No Development) Setback Line Assessment

7.1 INTRODUCTION

Setback is required for a number of reasons. Most critical is the setback required to allow the functioning of natural coastal processes without impacting on development or being impacted upon by development. Thus, setback allowance for coastal erosion (described in Section 7.2), for flooding (Section 7.3), and for wind-blown sand and geotechnical stability (Section 7.4) are important to consider. Consideration of these aspects will result in the coastal processes (no development) setback line as defined in Section 3.1

7.2 EROSION SETBACK

7.2.1 Introduction

The erosion setback line is the maximum erosion line on the existing surface of the earth (at the time of establishment) that can reasonably be expected (as a result of elevated water-levels and storms) in the time period applicable (a 100 year time period was selected as per Section 3.2).

It is important that the erosion setback line be applied to the elevation of the earth’s surface at the time of its establishment because erosion setback is dependent on elevation (For example, low-lying shores require greater erosion setback since landward penetration of waves can be greater during storms).

A two-pronged approach should be applied to estimate erosion setback, incorporating:

1. Statistical analysis of shoreline information (from aerial images and historical beach survey data when available); and
2. Computer model simulations.

Statistical analysis has been routinely used in past setback studies. However, this generally relies on limited numbers of aerial photographs. The results are therefore not likely to be statistically significant. For this reason, supplementary computational modelling is incorporated as part of the setback line methodology. Although not financially viable when assessing individual sites in the order of up to a few kilometres, modelling becomes economically viable when addressing large sections of coastline, such as is required for an entire province or large subsection thereof. Furthermore, the local and international practice review (Section 2) recommends use of computational modelling as a tool to assess storm erosion.

As was also indicated by the local and international practice review, erosion setback should consider the distance of shoreline retreat for sea-level rise, a distance of shoreline retreat to accommodate long-term shoreline trends (erosion), a distance to accommodate short-term shoreline excursions (particularly landward retreat of the shoreline due to storm erosion) and a distance to accommodate dune or cliff collapse, if relevant. These distances can be added to get the total erosion setback. Figure 7.1 is a flow chart indicating the steps required in the process of determining erosion setback. The details are provided below.
Figure 7.1: Flow chart indicating the steps required to estimate erosion setback.

7.2.2 Sea-level rise

- **2007 predictions:**

  The Intergovernmental Panel on Climate Change (IPCC - home web page: [http://www.ipcc.ch](http://www.ipcc.ch)) was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear, global scientific view on the current state of climate change and its potential environmental and socio-economic consequences. During 2007 the IPCC reviewed their estimates of sea-level rise and found (Bindoff et al., 2007; and Solomon et al., 2007):

  - Accurate measurements by satellite altimetry during the period 1993 to 2003 indicate a global average rate of sea-level rise of 3.1 mm/year. This results in a rise of 0.16 m in 50 years. Furthermore, the average global sea level was predicted to rise between 0.18 m and 0.59 m by the year 2100. However, these predictions were based on thermal expansion due to ocean heating and ice melting but excluded ice sheet dynamics (calving).

  - From 1961 to 2003, the average rise in sea level was 1.8 mm/year based on tide gauge data. The tide gauges on the South African East Coast were not included in this analysis.

  - The rate at which the sea level rises varies from location to location on the globe. Processes such as the variability in ocean circulation cause these differences in sea-level rise. In some areas the sea level actually dropped.
After correcting the tidal record between 1970 and 2003 for Durban, Mather (2007) analysed the tide data and concluded that the rate of sea-level rise for Durban is 2.7 mm/year or 2.4 mm/year depending on whether the monthly mean sea levels or the yearly mean sea levels are considered respectively. These rates, that are just less than the global average rate of 3.1 mm/year, refer to a linear rise of sea-level over time.

- **Latest predictions**

Pheffer et al. (2008) added the effect of ice sheet dynamics (calving) to the IPCC estimates in 2007 and found, for plausible but still accelerated conditions, a sea-level rise of approximately 0.8 m by 2100. Furthermore they found that kinematic constraints on glacier contributions limit the maximum probable rise in sea level to about 2 m by 2100.

Since the IPCC estimates of 2007, scientists are in agreement that sea-level rise has accelerated (ISCCC, 2009; Fletcher, 2009), although they differ in the extent of the rise (the extrapolation). Measurements show, apart from a general exponential trend in sea-level rise from 1880 to 2000, also a probable secondary trend, namely: significant variation over each 10 year to 15 year period.

During the International Scientific Congress on Climate Change in Copenhagen in May 2009 (ISCCC, 2009) it was stated that: (1) the upper range of sea-level rise by 2100 could be in the range of about one meter, or possibly more; and (2) it looks increasingly unlikely that sea-level rise will be much less than 0.5 m by 2100. In investigating the effect of climate change on maritime operations around the Southern African coast, Rossouw and Theron (2009) assessed the latest sea-level rise estimates and decided to use 0.5 m to 2.0 m by 2100.

In a recent review paper, Fletcher (2009) concludes that: (1) global average sea-level rise may reach 1 m by 2100; and (2) the sea level is highly variable. This agrees with estimates employed in South Australia (Section 2) where sea-level rise of 0.3 m is employed to 2050, with a further 0.7 m of sea-level rise in the following 50 years.

More recent work by Mather et al (2009) investigated all tide gauge sites along the southern African coastline. Based on available data and a linear analysis of monthly data, local sea-level rise (i.e. including the effects of crustal movements and atmospheric pressure) was found to range from -0.4 mm/year (Mossel Bay) to 2.7 mm/year (Durban). This study suggested local sea-level rise in the Western Cape to be slightly less than that further east (Eastern Cape, KZN) and north (Northern Cape).

- **Sea-level rise prediction to be applied in the methodology**

Based on the above research, it is suggested to use the conservative 1 m global average rise in sea level for South Africa in the next 100 years. This estimate may be too conservative for the Western Cape, based on Mather (2009). However, as a reliable analysis would ideally require 50 years of data (Woodworth 1990, Douglas, 1991), this estimate of 1 m in 100 years should be applied (reasonably conservatively) to the entire coastline of South Africa until further data becomes available.

---

**Important Technical Detail:**

**Sea-level rise should consider:**

- Vertical crustal movements along the shoreline
- Local changes in barometric pressure

However, based on the data presented in Mather et al (2009) these influences are unlikely to affect the sea-level rise estimate for 100 years (i.e. 1m) by more than some 10%.
Application of sea-level predictions

The most commonly known (and applied) formula for estimating recession due to sea-level rise is that proposed by Bruun (1988). This formula, frequently referred to as the “Bruun Rule”, has been applied internationally (Section 2) and is appealing because of its simplicity. However, direct application of the Bruun formula without considering all relevant factors can result in erroneous prediction of shoreline recession. For example, Theron and Rossouw (CSIR website: http://www.csir.co.za/nre/coupled_land_water_and_marine_ecosystems/pdfs/CPO-0029_standard.pdf) indicate that “there are many types of coastal conditions where application of the Bruun rule is inappropriate”. Limitations of the Bruun Rule are also highlighted in Cooper and Pilkey (2004). Thus application of the formula requires experience and caution.

It is proposed that, in addition to the use of the Bruun formula, the effect of 1 m sea-level rise on the measured beach profile be estimated by calculating the direct horizontal translation of the waterline due to the vertical shift of the water level. By way of example, if the present beach slope is 1-in-10, then a 1 m rise in water level would result in a 10 m landward shift in the waterline. This simple “slope-based” approach should provide a lower end of the “bracket” for horizontal shoreline change due to sea level rise, while the Bruun formula inevitably provides the upper end of the “bracket”. By applying careful coastal process judgement, taking into account the nature and geology of the shoreline (particularly considering signs that the hinterland is resistant to erosion), and the time that the measurement is taken (slopes vary seasonally) the appropriate setback within these upper and lower values must be estimated.

Important Technical Detail:

When applying the Bruun Rule the following guidelines apply:

- The maximum the depth of the limit of sediment exchange between the beach and the offshore is well defined by closure depth formulae – the formula of Birkemeier (1985) is recommended.
- The erodability of the hinterland must be considered. The conservative assumption is that this is erodable beach sand. However, there may be clear signs that more resistant layers (rock or compact soil) occur.

Minimum requirement for determining an allowance for sea-level rise:

1. Determine setback required for a 1 m sea-level rise, assuming no erosion on the slope in question (this provides the minimum retreat);
2. Apply the Bruun Rule judiciously, taking into account the guidelines above (this provides the maximum retreat);
3. Taking into account the local geology, estimate the retreat due to sea-level rise, between the two limits indicated above.

7.2.3 Long-term shoreline trend
While rapid on/offshore changes to the shoreline occur throughout the year, a long-term trend, on the time scale of several years to decades, often also occurs. This should be assessed considering the Sand transport budget as well as an analysis of aerial images and (if available) beach topography survey data. Reference is made to Figure 7.1 which outlines the steps required to determine the long-term shoreline trend. Details follow.

**Sand transport budget**

Long term shoreline change can be affected by the sand transport budget (i.e. the sources, sinks and prevailing transport of sand). An assessment of the sand budget should be conducted to assess sand sources (e.g. river sand supply, artificial sand supply/nourishment), sand sinks (e.g. sand mining, sand tied up in dune vegetation) and transports (e.g. alongshore sand transport by waves/wind-blown sand transport onto or off beaches – this can be altered by coastal structures). This sand transport budget will aid in the assessment and understanding of long-term shoreline accretion or erosion as determined from the shoreline trend analysis which follows. If it is determined that

1. influences (generally anthropogenic – such as harbour developments/dredging) have occurred in recent years which may affect the sediment transport budget and cause long-term erosion or accretion; and
2. these influences may not be manifested by the shoreline trend analysis (described below);

then a detailed shoreline modelling study should be applied.

**Minimum requirement – sand transport budget**

1. Estimate the longshore transport regime employing wave input from the Wave Atlas, and available bathymetry
2. Estimate sand sources (e.g. from rivers) and sand sinks (e.g. wind-blown sand into dune fields).
3. Conduct a shoreline modelling study if:
   a. significant anthropogenic influences on the sand transport budget have occurred and
   b. these influences will not be manifested in the shoreline trend analysis.

**Shoreline modelling study**

If needed, this study would incorporate:

- Calibration of a shoreline model (e.g. UNIBEST-CL – WLDelft, 2005 - or equivalent), demonstrating that with input of the local wave climate (obtained from the Wave Atlas), local beach profiles, local sediment grain sizes and local sand sources/sinks, the model represents shoreline changes as measured (e.g. by means of aerial photographs and/or historical topographical surveys);
- Model scenarios, to investigate future evolution of the shoreline, considering any changes in sediment budget or wave climate.

**Shoreline trend analysis**

It is vital that the ongoing long-term shoreline trend be identified and assessed. If this is not identified and allowed for, erosion will persist until structures are threatened, such as is the case at Paradise Beach (Figure 7.2) and Milnerton (Figure 7.3) where temporary emergency protection measures have been installed.
As was indicated in the review of local and international practice, historical surveys (if available) and aerial photographs should be used for such an analysis. A set of aerial and satellite images should include at least one undistorted, coordinated photo to scale – which can be used as a reference to determine distances and to allow for geo-correction of other photographs. The analysis of aerial images covering a wide time span provides a good indication of any long-term trend (erosion/accretion) or of the stability of the shoreline. In Western Australia a minimum period of 40 years is recommended to determine a long-term shoreline trend. As conditions are not dissimilar in South Africa, a similar period should be applied locally.

The limitations of assessing shoreline variation and stability using aerial photographic analysis include the following:
• Rectification and geo-correction errors can be up to a few metres;
• The level of accuracy when establishing the position of the high-water (run-up) mark. This is typically taken to be accurate to within some 10 m and is affected mainly by the tide and wave conditions at the time the photograph was taken;
• A limited number of aerial photographs of adequate quality.

Another approach is to use the vegetation line (i.e. the line demarcating sand and vegetation along the coast) instead of the water-line. This potentially resolves difficulties relating to the tidal level at the time of the photography are eliminated. However, this should be conducted supplementary to the high water mark analysis, which represents the most relevant approach. Caution is required since the vegetation line can be altered due to trampling, drought and vehicles. In addition, the water line is typically much more dynamic than the vegetation line. Therefore, if the vegetation line is used, care must be taken to ensure sufficiently conservative results.

The proposed approach is to select a number of cross-sections along the site. At least some of these should correspond to the location of topographical surveyed cross-sections/beach profiles, if these are available. On each aerial image and at each cross section the position of the high water mark should be measured relative to a fixed point on land (defined by a reference coordinate). If these distances are plotted against time at each cross section, the variation of these distances over time is obtained. An example is shown in Figure 7.4. A positive trend line (determined by linear regression) indicates accretion because the beach becomes wider; that is, the distance increases over time. Similarly, a trend line having a negative slope depicts erosion (as in Figure 7.4). If the distances fluctuate around a mean value (the trend is horizontal), it indicates that the beach is dynamically stable.

At limited sites, historical topographical surveys of the beach will be available. This data can be used in a similar way by plotting the distance of the +2 m MSL contour (deemed to be a representative of the shoreline at high water for most sites) from a beacon against time.

![Figure 7.4: Shoreline trend analysis (in this case the shoreline was represented by the 2m contour determined from a number of beach profile surveys)](image)

The geology of the shoreline being eroded is a key factor in assessing future erosion (e.g. resistant layers often occur once frontal dunes are eroded away). An assessment of whether the rate of erosion or accretion will taper off, increase, or remain the same will be essential and should be based on experience of the typical time scales at which these coastal processes occur.
7.2.4 Short-term erosion (due to storms)

In addition to any long term trend of shoreline behaviour, a vital component of a setback line study is the storm erosion which can reasonably be expected in the time period considered (100 years). The 1 in 100 year storm erosion should be employed for this purpose (discussed in Section 3.2). Reference is made to Figure 7.1 which summarises the methodology to determine short-term erosion. Details are as below.

**Statistical Analysis approach**

In studies assessing beach profile surveys, it has been found that (CSIR, 1990, 2003) for dynamically stable beach profiles in Durban and Saldanha (for which a large database exists), the variation in the location of the high-water mark is normally distributed. Assuming the normal distribution to apply to all shorelines, and evaluating the extremities of this normal distribution, less frequent and therefore more severe shoreline changes can be determined. Thus, the likely storm erosion for a return period of 1:100 years can be estimated.

The method of Theron (2000) should be included where relevant to account for dune effects. This method reduces the erosion retreat due to the effect of dunes having large volumes of sand which assist in arresting erosion. The method considers three possible scenarios (Theron, 2000):

1. If a dune is located within a region of recorded shoreline variations, then its effects are already accounted for in the long-term shoreline trend analysis. No adjustment is made to the setback line to account for further dune effects;
2. If the dune is located landward of the long-term erosion line, then it will not significantly affect the expected erosion. The dune is located too far landward to have any protective effect and no adjustment of the setback distance is justified;
3. If the dune is located landward of the region of recorded shoreline variations, but seaward of the long-term erosion line, then is can be assumed that such a dune will provide some measure of additional protection in the future. In order to take the effect of the dune into account the Volume Ratio (VR) first needs to be calculated by dividing the area under the profile, above the +2m MSL contour and seaward of the point 50m inland of the +2m MSL contour by this same area excluding the dune. The Setback Line Methodology
Ratio (SBR) can then be calculated using the equation below. This ratio is then applied to the erosion distance to allow for the dune.

\[ VR = 5 \cdot SBR^2 - 15 \cdot SBR + 11 \]

Note that this equation was developed from a limited number of sites. Thus the results produced from this approach should serve as a guideline only, and will require careful judgement.

**Storm Modelling approach**

Applicability of the normal distribution can be tested by applying of the Chi-square Goodness-of-fit test (Walpole and Myers, 1978). Application of this test (e.g. at the Langebaan test case site (Error! Reference source not found.)) indicates that the number of data points (based on the number of aerial photographs) will generally not be sufficient to confirm the normal distribution. Since the statistical reliability of the normal distribution is not confirmed, it a modelling approach should therefore be applied together with the statistical approach in order to obtain more certainty on the storm erosion.

In order to determine the 1:100 year storm erosion, a key question is which water-levels, wave heights, wave periods and storm duration to apply. This question is not easily resolved via statistical approaches. For example, Callaghan et al (2008) are only able to represent extreme storm erosion volume up to the 10 year recurrence period, employing a statistically simulated wave climate and storm erosion model. The following approach should be applied in which storm erosion for a number of actual storms is calculated after which the extreme analysis of the erosion (e.g. of the 1:100 year shoreline retreat) is calculated:

- Referring to the Wave Atlas, obtain the relevant nearshore wave data time (at least 10 years long) series just beyond the storm surf zone at the site;
- Simulation of erosion and consequent shoreline retreat due to all storms (ideally some 12 storms per year) as defined from the nearshore wave data time series employing a peak over threshold approach with the actual predicted water level time series included. The simulations make use of measured beach topography, bathymetry from SA Navy charts and inferred from wave breaking patterns if necessary, and sand grain sizes from sampled sand (i.e. parts of the data as outlined in Section 6.1);
- If possible, verification of model results against recorded erosion, to allow calibration of model parameters;
- The simulations should include estimated water-level rise as a result of storm surge (wind and atmospheric pressure effects);
- Statistical analysis of the shoreline retreat from all storms to estimate the 1:100 year erosion (e.g. Figure 7.5).
Figure 7.5: A typical result showing the statistical distribution of modelled shoreline retreat (SA West Coast). Even though based on only 12 model result data points a reasonable distribution fit is found. The graph indicates a 1:100 year erosion of some 28 m which complied with estimates (based on experience) of expected extreme erosion from measurements.

The above modelling approach resulted in a predicted 1:100 year shoreline retreat due to storm erosion in the Milnerton Case Study (Error! Reference source not found.) of 33m. This value agrees well with an average storm erosion of 20m with a maximum of 31m for a 1 in 43 year event which occurred in May 1984 reported in CSIR (1988). This serves to validate the modelling approach (despite the fact that this modelling was not calibrated).

The predicted erosion line should be compared to that predicted with the normal distribution. Considering the accuracy of model input and the accuracy of the modelling per se versus the accuracy and amount of shoreline data (aerial images/surveys), the erosion setback must be estimated from this information, employing careful judgement of the dominant coastal processes and of the composition of the hinterland (sand or harder more resistant material).

**Minimum requirement for determining short-term variation (storm erosion):**

1. Assess standard deviation of short term variations about the mean long-term trend assessed above;
2. Apply the normal distribution to estimate the variation equivalent to a 1:100 year occurrence (approximating the 1:100 year storm erosion);
3. Using at least 10 years of the relevant nearshore wave data (from the Wave Atlas), identify ~12 most severe storms per year;
4. Applying a reliable cross-shore storm erosion model, predict erosion due to each storm;
5. Extreme analysis of the erosion results to estimate the 1:100 year storm erosion;
6. Compare with the modelled result with the result form point 2 above, and apply coastal processes judgement to estimate the 1:100 year erosion from these two results.
7.2.5 Geotechnical stability

It should be noted that geotechnical stability differs from the periodic erosion and accretion of the dune. Geotechnical stability implies that failure of the slope will result in naturally irreversible erosion of the dune. Figure 7.6 shows an example of slope failure on the Richards Bay coast. The geotechnical stability of the frontal dune slopes must be considered since their collapse may require shifting the setback line landward. Failure of dunes or cliffs can have detrimental effects, such as infrastructure collapsing into the sea (Kwazulu-Natal coastline during 2007 storm) or wave run-up reaching infrastructure. There are four main factors affecting the stability of the dune slope:

- Material of the slope
- Angle of the slope
- Local physical features which will control the likelihood of significant rises in the phreatic surface particularly in the neighbourhood of the slope toe
- Degree of undercutting of the slope by wave/current action

For the case of conventional and relatively low dunes, simple calculations can be made to allow additional setback for dune collapse. However in cases where dunes or cliffs show a tendency to collapse, a geotechnical engineer should be consulted to determine the geotechnical stability of the dune or cliff. With this specialist input allowance of a distance for potential collapse can be made.

It should be highlighted that dune conventional collapse along the angle of repose is already incorporated within the SBEACH model and “double counting” of this collapse must be avoided.

Figure 7.6. Geotechnical collapse of the coastal dunes at Richards Bay
7.2.6 Estuaries

An additional item to be considered in the assessment of erosion setback is the potential meandering of estuary mouth channels, where such features occur. Breaching of river mouths in “new” locations due to river floods should also be considered (e.g. this has historically occurred at the Keurbooms Estuary). Mouth meandering is best anticipated from an assessment of historical aerial photographs (Figure 7.7 illustrates how the tendency for possible mouth migration may have been anticipated). “Rogue” or unexpected migration of the estuary mouth channel can be detected from a historical assessment of the estuary concerned as well as considering the historical behaviour of similar estuaries. The following should be done:

- Assess historical aerial photographs and available records to determine previous tendencies of estuary mouth channel to migrate;
- Supplement this study with a review of nearby and similar estuaries.
- Considering the potential flood flows, beach and dune topography and geological constraints (such as rock outcrops) estimate the potential estuary mouth channel location/s.
- Ensure that the combination of channels, storm surge and storm wave activity are considered.

Minimum requirement for determining allowance dune/cliff collapse:

1. Assess the tendency for dune or cliff collapse.
2. For relatively low conventional sandy dunes, calculate potential dune slip.
3. For high dunes and cliffs obtain geotechnical specialist input to assess the allowance for potential collapse.

Minimum requirement to assess setback required for estuary channels:

- Assess historical aerial photographs and available records to determine previous tendencies of estuary mouth channel to migrate. Supplement this study with a review of nearby and similar estuaries.
- If migration tendencies occur, allowance for mouth channel meandering must be allowed for, considering historical trends, geological constraints and beach and dune topography.
7.2.7 Synthesis

The total Erosion Setback distance will be the sum of elements discussed above, as detailed in Table 7.1 below. The simple summation of components, particularly short-term erosion, long-term erosion and shoreline retreat due to sea-level rise is applied locally and internationally (as described Section 2). This should be applied relative to the average high water mark if the shoreline is found to be dynamically stable. If the shoreline is eroding, the setback distance can be applied to the point on the erosion trend line corresponding to the date of the assessment, taking into consideration the statistical significance of the trend line. The red arrow in Figure 7.3 indicates the high water mark position to be applied for an eroding shoreline case, assuming an assessment date of 1 July 2007 (mid-2007). If the shoreline is accreting, the erosion setback distance can be applied to the point of the accretion trend line corresponding to the date of the assessment, taking into consideration the statistical significance of the trend line.

Table 7.1: Erosion Setback components

<table>
<thead>
<tr>
<th>Component</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Setback distance for sea-level rise</td>
<td>Derived with Bruun theory and profile slope method</td>
</tr>
<tr>
<td>2. Long-term erosion (100 years) distance</td>
<td>From historical aerial photograph (or survey data) analysis. Not applicable for dynamically stable or accreting shores</td>
</tr>
<tr>
<td>3. Storm erosion distance</td>
<td>Determined statistically and with computational modelling</td>
</tr>
<tr>
<td>4. Setback to allow for estuary mouth meander, where applicable</td>
<td>From historical aerial photograph assessment. Consider flood effects, topography and geological constraints</td>
</tr>
<tr>
<td>5. Allowance for dune/cliff collapse if applicable</td>
<td>From geotechnical calculations (may require specialist)</td>
</tr>
<tr>
<td>Total Erosion Setback (Sum of 1. + 2. + 3. + 4. + 5.)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7.7: The tendency for the estuary to migrate northwards is indicated in the from the 2003 image (left). Migration to the north has now occurred as shown from the image from 2010 (right), resulting in erosion of the property with blue-roofed buildings.
7.3 SETBACK FOR WIND-BLOWN SAND

Consideration of setback for wind-blown sand was found to be considered in the review of local and international practice. The consequence of not anticipating wind-blown sand transport is endless years of maintenance work, such as is conducted to clear Baden Powell Drive of sand along the margin of False Bay (Figure 7.8 below).

Figure 7.8: Severe windblown sand transport across Baden Powell Drive, False Bay, Cape Town.

If the wind speed gradually increases as the wind blows over a flat expanse of sand, then at the point of incipient motion, a significant number of sand grains will be transported by the wind. As the wind speed increases further, more and more sand will be transported. Sand grains move in a variety of modes: by rolling (or creep), saltation, and suspension (Bagnold, 1954). Saltation is the most important mode in which sand grains are transported (Horikawa, 1988). Most of the sand is transported close to the ground.

Optimum conditions for wind-blown sand transport are the availability of dry, loose sand, strong winds, no vegetation, and a long wind fetch, that is, a long expanse of sand over which the wind can blow. Fluctuations in the wind speed over time also affect the transport rate (Horikawa, 1988).

Calculation of wind-blown sand transport potential must be carried out in the setback study. This is a useful tool to assess the approximate magnitude and direction of wind-blown sand transport. Typical wind-blown sand transport rates range from 20 m$^3$/m per year to 80 m$^3$/m per year (see, for example Swart, 1986). For example, 20 m$^3$/m per year means that, for each 1 m wide section (on the ground) perpendicular to the wind direction, 20
m³ is transported in the direction of the prevailing wind in a year. A number of formulae exist (Fryberger and Dean, 1979; Swart, 1986; and Horikawa, 1988) with which to predict wind-blown sand transport rates. These formulae predict the potential sand transport rates because, in reality, the sand is wet at times, or protected by dunes and/or vegetation, or there is simply not enough sand to be transported.

From the calculations a wind-blown sand transport rose must be produced from the wind direction and speed time series. Figure 7.9 provides an example wind rose. Ideally this should be calculated employing local wind measurements (and the local sand grain size). However, even though offshore hindcast wind time series exclude local diurnal wind effects, they are generally adequate for assessment of general transport trends indicated in the wind transport rose. Typically, these sand transport calculations provide the potential transport rates. Actual transport rates will be lower due to vegetation and wet beach sand, amongst other effects.

Having considered transport rates and directions, the following would be considered in establishing a buffer width for wind blown sand:

- Vegetation
- Dune height
- Direction of transport
- Historical dune widths and movement (aerial photographs)

![Figure 7.9. Example of a windblown sand transport rose at Milnerton, showing potential sand transport of up to almost 60 m³/year per metre width of beach.](image)

From aerial photographs, areas of dune/beach sand exchange and of sand transport corridors can generally be seen. Historical aerial images generally reveal the location of transient wind-blown sand corridors (e.g. which get mobilised after fires have destabilised the dunes) which are important to maintain if not already interrupted by development.
Consideration should be given to the possibility of dunes, which were formerly stabilised with alien vegetation, being denuded. Through the eradication of alien invasive vegetation, such dunes can be re-mobilised. This should either be managed appropriately, or setback allowance must be made for the remobilised sand.

Some specific guidelines relating to establishment of setback for wind-blown sand and dunes are as follows (Based on Tinley (1985):

- Where bush-covered coast dunes form a distinct series of ridges and troughs parallel to the beach, the setback line should be well landward of the third trough and ridge.
- Where multiple small dune barrier ridges occur on shorelines which are growing seawards (accreting) the setback line should be established where the oldest landward ridges are already covered in bush (younger ridges are colonized by dune pioneer plant species and are still in an unstable state).
- The setback line should be situated landward of bare mobile dune areas, unless approved and acceptable stabilisation is to be conducted.
- Where relatively small vegetated dunes occur as a single or double ridge only, the setback line should be confined to the landward base of the dunes.
- In high, steep and broad vegetated dune cordons (e.g. as in Wilderness Area) the setback line should be confined to the landward base of the dunes.

These are not hard-and-fast rules and every site should be assessed individually. The option of applying the limited/controlled development line to allow low key development (e.g. allowing camping/limited log cabins within dune areas) can still be applied if appropriate.

Minimum requirement to assess setback required for windblown sand:

1. Calculate the wind transport rose.
2. Assess historical aerial photographs to identify wind-blown sand corridors and dunes which have since been vegetated.
3. Estimate setback where required, taking into account the guidelines above (Tinley, 1985)

7.4 SETBACK FOR FLOODING

7.4.1 Introduction

In terms of this study, the setback for flooding is defined as the distance landward of the high water mark required to:

1. Prevent damage by wave action (wave runup), or
2. To prevent severe flooding from waves overtopping coastal dunes, rocky shores or man-made revetments.

Calculation of extreme wave run-up with coincident high water is vital to prevent development occurring too close to the shore, where repeated problems are likely to occur, even on rocky shores (e.g. Figure 7.10).
7.4.2 Wave run-up

The following procedure should be followed to assess wave run-up:

- Referring to the Wave Atlas (Section 5.2), obtain the relevant nearshore wave data time series (at least 10 years long) just beyond the storm surf zone at the site;
- Referring to the Water Level and Storm Surge Analysis (Section 5.3), extract measured (and calculated) water levels corresponding to the above time series (i.e. at the same times as the wave data points);
- Employing an appropriate formula which takes into account the wave run-up surface (rocky or sandy), calculate the wave runup and, adding the water level, the maximum extent of wave penetration. This must be conducted for every wave and water-level measurement.

**Important Technical Detail – Wave Runup**

- Experience from the Case Studies and other sites indicated the equation of Nielsen and Hanslow (1991) to provide good results for runup calculation on the beach. However, as this equation requires the offshore significant wave height, it is recommended to determine the nearshore significant wave height converted to the shore-normal offshore equivalent. This prevents overestimation of wave runup.
- For wave runup on rocky shores or headlands, the van der Meer formula (in Pullen et al, 2007) which is normally applied to breakwaters, was found to be appropriate in the Case Studies. The significant wave height input for this formula is applied at the base (or toe) of the rocky slope.
On erodible shorelines, the runup calculation must be made for the worst case, i.e. assuming that erosion due to 100 years sea-level rise, due to 100 years of long-term erosion and due to a 1:100 year storm has occurred. The beach profile resulting from these influences must be used for the wave runup calculation. “Weak points” in dune barriers, i.e. locations where dune protection is the least, must be considered.

Conduct a statistical extreme value analysis of the runup values from the full time series of results and estimate the 1:100 year wave runup.

Note that the calculation of wave run-up should account for the condition of any long-term erosion, storm erosion and sea-level rise.

Minimum requirement to assess setback required for wave runup:

1. Obtain appropriate nearshore wave data time series (at least 10 years) from the Wave Atlas (Section 5.2)
2. Obtain corresponding water levels from the Water Levels Water Level and Storm Surge Analysis (Section 5.3)
3. Calculate maximum wave runup for every time step in the time series.
4. Conduct a statistical extreme value analysis of the runup values from the time series of results and thus estimate the 1:100 year wave runup.
Figure 7.11 illustrates the result of the methodology above as applied to Lynch Point at Saldanha. The correlation coefficient ($r^2 = 0.976$) indicates a good fit to the data and validity of the method.

![Graph showing extreme value distribution](image)

**Figure 7.11: Predictions of extreme wave runup.**

### 7.4.3 Wave overtopping

Overtopping of a sand dune or rocky barrier can impact areas behind the dune or barrier, particularly if such terrain is relatively low-lying. If runup, as determined in the previous section, is found to exceed the dune elevation, then overtopping rates should be determined. Several formulae exits, e.g. the Overtopping Manual (Pullen *et al.*, 2007). Generally these have been developed for coastal defence structures, and should therefore be applied to beaches with caution.

It will be necessary to assess whether the calculated overtopping will be acceptable on infrequent occasions and/or will be manageable through provision of appropriate drainage. If this is not the case, then judgement of the prevailing coastal processes must be applied to consider whether setback further inland must be established in order to avoid overtopping.

**Minimum requirement to assess setback required for wave overtopping:**

1. Determine if waves significantly overtop the coastal barrier (natural or man-made barrier) from the wave run-up analysis

2. Estimate wave overtopping during storm and elevated water-level conditions, applying the appropriate formula (e.g. formulae in Pullen *et al.*, 2007)

3. Apply judgement as to whether drainage systems will be adequate to deal with the volume of water, or whether additional setback (to higher ground) is required.
### 7.5 TOTAL COASTAL PROCESS/NO DEVELOPMENT SETBACK

The coastal processes/no development setback line is determined from the maximum of the following:

- Setback for coastal erosion;
- Setback for windblown sand;
- Setback for flooding (wave runup, overtopping if applicable)

However before finalising this line, it is essential that consultation with the local municipality be conducted, to draw on local expertise and knowledge.

**Minimum requirement to assess establish the no development/coastal processes setback line:**

1. **Determine the setback line from the maximum of**
   - Setback for coastal erosion;
   - Setback for windblown sand;
   - Setback for flooding (wave runup, overtopping if applicable)

2. **Consult with the local municipality before finalisation.**
8 Limited/Controlled Development Line Assessment

The coastal process/no development setback line will define a line seaward of which development would be at risk or would result in expensive maintenance. However, setback is also required to:

- Maintain biodiversity of the coastal region (Section 8.1);
- Allow for heritage issues (Section 8.2);
- Or in some cases to address other issues (Section 8.3), such as shading by buildings, and public access/amenity.

Considering the above, a line landward of which development may be limited or controlled can be defined, i.e. the limited/controlled development setback line. Limited development may be allowed in, for example, a critical biodiversity or reserve area, where a bungalow would allow for public amenity. Controlled development may apply where parts of an area must be protected. For example, known heritage sites such as shell middens may preclude development at particular positions.

8.1 SETBACK FOR BIODIVERSITY, CONSERVATION

The proposed procedure is as follows:

1. Consult the CapeNature/SANBI biodiversity maps on Critical Biodiversity Areas (CBA’s). The details of how to use the maps are provided in Appendix C.

2. These identify:
   - Protected Areas;
   - Critical Biodiversity Areas (CBA’s), where development is limited or controlled in order to achieve biodiversity targets;
   - Ecological Support Areas - areas adjacent to CBA’s, where essential natural services such as rivers or ground water from these areas feed into the CBA’s.

3. Refer to the biodiversity map data indicating:
   - The reasons for the biodiversity status indicated on the map;
   - The proposed management actions in the area concerned.

4. Conduct a site visit with a biodiversity specialist to validate the biodiversity map content (the maps have scale limitations and may be slightly outdated);

5. From the above actions, assign appropriate setback/buffer area where development is to be limited/controlled.

It is essential that this process involves a biodiversity specialist in collaboration with the coastal processes expert (details on expertise are provided in Section 11.2) for the following reasons:

1. The biodiversity maps do not necessarily deal with biodiversity on a local scale. Local important biodiversity issues must be identified by the specialist;

2. The biodiversity maps must be verified or groundtruthed – a mismatch between the maps and the condition on the ground is possible (as indicated in Appendix C);

3. The biodiversity maps focus on terrestrial and aquatic biodiversity – setback allowances for marine biodiversity are not included and must be identified by the specialist.
The setback for biodiversity is not just about critical biodiversity areas. The vegetation, regardless of the threatened status, plays an important role in terms of ecological integrity, stability and aesthetics. An adequate strip of coastal vegetation should therefore be protected along the coast to allow for the maintenance of ecological integrity, stability and aesthetics. It must be ensured that the setback line is not situated landward of the line of permanent (long-term) natural vegetation along the shoreline.

Furthermore, consideration should be given to provision of a buffer zone between, for example, cultivated land and biodiversity protection areas, where nutrification or other pollution of the coastal zone may occur to the detriment of biodiversity.

The setback line for biodiversity must be recorded as this will be useful in later assessments or in response to queries relating to the *limited/controlled development setback line*.

### Minimum requirement to assess setback required for biodiversity:

1. Consult the CapeNature/SANBI biodiversity maps on Critical Biodiversity Areas (CBA’s).
2. Refer to the biodiversity map data indicating:
   a. The reasons for the biodiversity status indicated on the map;
   b. The proposed management actions in the area concerned.
3. Conduct a site visit with a biodiversity specialist to validate the biodiversity map content (the maps have scale limitations and may be slightly outdated);
4. From the above actions, assign appropriate setback/buffer area where development is to be limited/controlled.
5. Ensure the biodiversity specialist reviews and concurs with the result.
6. Applying the judgement of the biodiversity specialist, it is proposed that the setback line not be situated landward of the line of permanent vegetation along the shore.
7. The setback line for biodiversity must be recorded.

### 8.2 SETBACK FOR HERITAGE ISSUES

Coastal heritage items include buildings over 60 years old, burials, shell middens, wrecks, fish traps, cultural landscapes, and lighthouses. Coastal heritage sites are most likely to occur at the shoreline, becoming increasingly less likely proceeding landward. SAHRA and HWC indicate a priority zone for heritage extending to some 200 m shoreward of the high water mark.

Reports and maps indicating heritage sites can be provided by Heritage Western Cape. It is proposed that these maps be considered in the assessment of the setback line for limited/controlled development.

Experience from the case studies revealed that map information is not in a user-friendly or accurate form. Sites or areas with high heritage priority are not provided as coordinates or on coordinated maps - it is recommended that this information be provided.

The setback line for heritage must be recorded as this will be useful in later assessments or in response to queries relating to the *limited/controlled development setback line*.
8.3 SETBACK FOR OTHER ISSUES

The following must also be considered in establishment of the setback line for limited/controlled development:

- **Public access.** Areas earmarked for public access and amenity will be indicated in the Spatial Development Framework. Where public access is along the shoreline (e.g. seaward of developments, setback allowance in addition to the coastal processes setback must be made. The allowance should incorporate sufficient space for the pathway (or track) in addition to the surroundings of the track (e.g. coastal fynbos essential for the experience of the track). Figure 8.1 illustrates how a development in Port Elizabeth has resulted in a coastal boardwalk and cycleway being situated excessively close to the high water mark. This could be avoided in future by providing an allowance for both the coastal processes setback and limited/controlled development setback for public access. The required setback line for this issue must be recorded.

- **Aesthetic features, such as unique rock formations (e.g. Figure 8.2).** Setback may be required for such features, making allowance for viewing them from different angles (i.e. a zone around the feature is required). The required setback line for this issue must be recorded.

- **Shading by structures.** Tall buildings located close to the beach can potentially cast a shadow across the beach at certain times of the day (e.g. Figure 8.3). Some interaction with property zoning restrictions may be required in order to prevent this. Ethekwin i Municipality has instituted a policy by which the height and orientation of buildings along the beachfront are restricted to minimise the shadows which they cast on the beach. The image below shows the shadow of a tall building being cast over a beach. The required setback line for this issue must be recorded.

- **Significant landscapes which define sense of place (such as scenic routes e.g Figure 8.4).** The required setback line for this issue must be recorded.

Minimum requirement to assess setback required for heritage:

1. Access reports and maps indicating heritage sites from Heritage Western Cape (or the appropriate provincial authority).
2. Take into account the heritage sites indicated in the assessment of the setback line for limited/controlled development.
3. The setback line for heritage must be recorded.
Figure 8.1  Public access boardwalk initially resisted by the coastal development resulting in an initially truncated boardwalk (left). The boardwalk and coastal cycleway have now been included, but the setback of the cycleway (and probably the boardwalk) is not adequate (only about 20 m in parts) and is certainly seaward of the coastal process setback line. The limited development line would in future allow for the boardwalk and cycleway between a coastal processes setback and a limited/controlled development setback situated seaward of the development.

**Minimum requirement to assess setback required for other issues:**

1. Ensure that the following are considered in the establishment of setback for limited/controlled development:
   a. Public access
   b. Aesthetic features
   c. Shading by structures
   d. Significant landscapes

2. Setback lines determined for any of the above must be recorded as this will be useful in later assessments or in response to queries relating to the *limited/controlled development setback line*. 
Figure 8.2 Camel Rock, Scarborough, Western Cape. Setback allowance is sometimes needed for unique features such as this.

Figure 8.3 A tall building casting a shadow over the beach such as this can impact on the amenity of the beach.
Figure 8.4. Chapmans Peak drive has a unique sense of place. Adequate setback must be allowed to protect this unique view.

8.4 LIMITED/CONTROLLED DEVELOPMENT SETBACK LINE

The limited/controlled development setback line is determined from the maximum of the following:

- Setback for biodiversity;
- Setback for heritage;
- Setback for other issues.

However before finalising this line, it is essential that consultation with the local municipality be conducted, to draw on local expertise and knowledge.

In addition, it must be ensured that the setback for each of the above issues be clearly recorded.

Minimum requirement to assess establish the limited/controlled development setback line:

1. Determine the setback line from the maximum of
   - Setback for biodiversity;
   - Setback for heritage;
   - Setback for other issues (aesthetics, shading, public access))

2. Consult with the local municipality.

3. Record the component setback lines for each issue (biodiversity, heritage, shading, public access, aesthetics, etc.) that is applicable.
9 Setback Line Study Finalisation

Analyses and modelling to determine the no development/coastal processes setback and the limited/controlled development lines will be described in detail in a draft Setback Line Study Report. This report will be reviewed, commented on and discussed by stakeholder focus groups (Stakeholder engagement is described in Section 10). In addition, the draft report will be peer reviewed by a suitable coastal processes practitioner (expertise requirements – Chapter 11).

Taking into account and addressing comments from the peer reviewer and from stakeholder focus groups, a second draft will be compiled for public consultation (details, Chapter 10). Following the addressing of final comments from the public, the final Setback Line Study Report will be submitted to the authorities.

Minimum requirement to finalise the Setback Line Study Report:

1. Submit and present 1st draft Setback Line Study Report to Stakeholder Focus Groups for comment.
2. Simultaneously, peer review of the study will be conducted.
3. Incorporate comments from peer review and stakeholder focus groups into a 2nd draft Setback Line Study Report for public consultation.
4. Incorporate subsequent comments, finalise and submit to local and provincial authorities.
10 Stakeholder Engagement Process

10.1 INTRODUCTION

The stakeholder engagement process component of the methodology provides an opportunity to communicate the process and objectives of developing coastal setback lines to a wide range of stakeholders. This process will allow individuals, groups and organisations to provide valuable input into the available options and critical issues to be addressed at each stage of the process.

A phased approach is presented below as the method to ensure the legal requirements and best practice for stakeholder engagement are met. The full stakeholder engagement report has been included in Appendix F of this report. This report provides a detailed methodology development and testing for stakeholder engagement component of developing coastal setback lines.

10.2 LEGAL CONTEXT

The National Environmental Management: Integrated Coastal Management Act (Act 24 of 2008) (ICMA) provides for a basic informative approach to stakeholder engagement within Section 53 (1) of ICMA. This includes:

(a) Consultation with all Ministers, the MECs or local municipalities whose area of responsibilities will be affected by the exercising the powers (within ICMA) in accordance with the principles of co-operative governance as set out in Chapter 3 of the Constitution

(b) Publishing or broadcasting the intention to do so in a manner that is reasonable likely to bring it to the attention of the public; and

(c) By notice in the Government 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

In addition, the responsible practitioner must ensure that the principles of co-operative governance are followed. In terms of Chapter 3 (section 41) of the South African constitution, these principles require that all spheres of government, and all organs of state within each sphere, must co-operate with one another in mutual trust and good faith. ICMA reiterates this notion in terms of the National Environmental Management Act (107 of 1998) (NEMA), which states that:

2(4)(l) - There must be intergovernmental co-ordination and harmonisation of policies, legislation and actions relating to the environment.

In addition, transparency is highlighted as a key principle of NEMA. Section 2 (4) (k) states that:

“Decisions must be taken in an open and transparent manner, and access to information must be provided in accordance with the law.”

Transparency is a key aspect of stakeholder engagement which should be carried throughout the process.

10.3 PHASE 1: PROCESS INITIATION

Given that the development of coastal setback lines is likely to affect large areas of the coastline, and a wide range of stakeholders, it is recommended that a comprehensive engagement process is undertaken. This approach is begins with the process initiation phase.
A.) **Client Steering Committee**

A client steering committee comprising the proponent of the project, key local coastal, environmental and planning authorities, as well as other elected or identified stakeholders, must be established at the outset of the project. This committee will provide high level stakeholder input and strategic guidance for the development of the setback line. The committee should be engaged throughout the project and the establishment and implementation of the setback line.

The development and implementation of coastal setback lines must be integrated with the institutional arrangements outlined in the ICMA. These include national, provincial and municipal Coastal Committees. These committees, their representatives and associated organisations need to be considered as part of the PPP and made use of as representatives of the key coastal stakeholders within the study area. These coastal committees, however, have not regulated, and therefore may not be established in time for the implementation this methodology. Relevant individuals and representatives must be considered and included where possible on the steering committee.

B.) **Authority Consultation**

All relevant authorities and government department are to be notified of the process and representatives registered as stakeholders for the duration of the process. This must include all spheres of government relevant to the study area, including provincial government departments and agencies, local municipalities and non-governmental organisations. Government departments include provincial, district and local departments of:

- Environmental
- Tourism
- Water Affairs
- Agriculture, Forestry & Fisheries
- Heritage
- Planning and development
- Coastal engineering
- Minerals & Energy (where appropriate)
- Trade & Industry (where appropriate)
- Transport (where appropriate)

C.) **Advertising**

Authorities and the general public must be notified of the initiation of the stakeholder engagement process by means of the publishing of 1) a public advertisement and 2) notice in the relevant Government Gazette.

Advertisements must be published in at least one regional, local and/or community publications relevant to the area. This advertisement must include:

- A notice of the intention to develop a coastal setback line for a specific area or region;
- A description of the study area boundaries;
- The key aspects to be considered in the study; and
- An invitation for stakeholders to register as an Interested and Affected Party (I&AP).

The notice in the Government Gazette should be carried out by the competent provincial environmental authority prior or in parallel to the public advertisement of the process (providing a minimum of 30 days for registration of I&APs). The notice in the Government Gazette must provide sufficient information potential Interested and Affected Parties (I&APs) to submit representations or objections to the proposed project.

Both the notice in the Gazette and advertisement should be published in at least two relevant local languages, so as to ensure the widest range of stakeholders are informed of the process.
D.) Development of Stakeholder Database

The stakeholder engagement facilitator must compile a comprehensive database of all registered I&APs, including, but not limited to, the following stakeholders:

- Local and provincial government departments
- Local community-based organisations
- Non-governmental organisations
- Ward councillors
- Local ratepayers associations

The database should be continually updated to accommodate new stakeholders as the project progresses. The stakeholder database provided the means for the distribution of information and continued communications (including registrations, invitation, minutes of meetings, and availability of information for review).

10.4 PHASE 2: FOCUS GROUP MEETINGS

Following the initiation phase key stakeholder groups will be identified. Stakeholders will be grouped according to their sectors or areas of interest (e.g. authorities, environmental, business, residents, community based organisations, etc.). Sector-based stakeholder meetings are proposed in order to capture the relevant issues of each group. These issues should be recorded and used to inform the development of the draft coastal setback line.

10.5 PHASE 3: PUBLIC MEETING

Once a draft report and setback line has been compiled, at least one public meeting must be held within the study area (depending on the size), to provide feedback on the draft setback line to the public. Meeting must be well advertised using the most appropriate means.

The draft report must be made available to all registered I&APs, for a comment period of at least 21 days. All comments must be compiled into the “Issues and Response table” for the final report. Responses must be provided to all comments by the steering committee where appropriate.

10.6 PHASE 4: STAKEHOLDER FEEDBACK

The final phase comprises of the dissemination of the final report (coastal setback line and associated documentation) to registered stakeholders for a minimum of 21 days for comment. This will allow stakeholders the opportunity to view responses tot their comments and the final setback line. Any additional comments must be included into the final PPP in the form of a comments and response table, and integrated (where appropriate) into the final methodology report.

10.7 CONCLUSION

The approach to stakeholder engagement is summarised in the below diagram.
11 Implementation of the Setback Line Methodology

11.1 INTRODUCTION

While it is not specifically within the terms of reference of this study, considerable insight on how the methodology should be implemented has been gained through the process of developing the methodology. It must be emphasised that establishment of setback lines throughout the province and ultimately the country is vastly different in nature to establishing setback lines at a single property. Thus, application to a large area allows for “economy of scale” in terms of data acquisition, data analysis and computational modelling. This has resulted in the inclusion of the enabling studies within the methodology.

Taking this into account, this section deals with some key issues relevant to implementation of the methodology:

• Expertise required;
• Budget cost of setback study;
• Should the setback study be funded and conducted independently, the criteria for independent study;
• Priority areas for establishment of setback lines;
• Proposed interim measures (until setback study is fully completed)

11.2 EXPERTISE REQUIRED

The methodology for the assessment of setback lines requires specialised expertise, including expertise in:

• Coastal processes;
• Stakeholder engagement process;
• Biodiversity;
• Legal issues;
• Other issues.

11.2.1 Coastal process expertise

Coastal processes expertise and experience is required in order to assess the relevant processes and to make the correct judgements in assessment of the setback required. The same level of expertise and experience is required to peer review a setback line study. It is evident from past setback line studies that even experts make mistakes or do not consider all factors. For this reason it is imperative that each setback line study be reviewed. This review has been incorporated at the end of completion of the draft report. However, it is recommended that review ideally be conducted at an earlier stage of the study (i.e. a review of the specific methods to be implemented).

To ensure that the correct expertise is employed in executing the setback line methodology or to review a setback line study, it the party conducting the study and/or the party reviewing the study must have coastal process experience in all of the following:

• Previous development setback line studies;
• Assessment of shoreline trends (short and long-term) from aerial photographs;
• An understanding of ocean waves and wave transformation from offshore to nearshore;
• Computational modelling of storm erosion;
• An understanding of sea-level rise shoreline recession calculation methods;
• Calculation of wave run-up and overtopping.

11.2.2 Stakeholder engagement
Numerous contentious issues are raised in the process of establishing setback lines. It is essential that a practitioner experienced in the stakeholder engagement process be involved.

11.2.3 Biodiversity
It is essential that an expert be involved that understands and can motivate for setback required to ensure that development is limited/controlled to protect areas of high conservation value.

11.2.4 Legal
Expertise in the legal requirements governing the determination of setback lines is required. For example, the legal implications of establishing setback lines through existing developed areas must be established.

11.2.5 Other capacity
It is deemed that only limited components of the methodology could be undertaken by personnel with limited coastal experience. Appropriate guidance and review by an experienced practitioner would be required.

11.3 BUDGET FOR SETBACK LINE STUDY

In response to several comments from the steering committee, costs have been estimated. These costs are expressed per kilometre.

11.3.1 Enabling studies
The cost of enabling studies (as described in Section 5) to obtain recent topographical data, detailed wave information and water-level information will be about R2000-00 per kilometre of shoreline.

11.3.2 Running costs for setback studies
Running costs (aerial photographs and treatment of these, sediment size analyses) would be in the region of R2500-00 to R3000-00 per kilometre of shoreline.

11.3.3 Fees for conducting setback studies
It is estimated that cost for conducting setback studies could range from R15 000-00 to R30 000-00 per kilometre, depending on the size of the area to be covered.

11.4 INDEPENDENT STUDY CRITERIA
If a developer is prepared to finance a setback line study in order to accelerate the establishment of a development setback line it is recommended that this be permitted, as long as:
A section of coastline 1 km long either side of the site is assessed, in addition to the development site. The proposed extent of the assessment is to be approved by the authorities, since it may be required to determine setback for a larger area corresponding to a coastal “unit” e.g. a small bay;

Such a study follows the methodology (and at least the specified minimum requirements) in this document to estimate the no development/coastal processes setback line and limited/controlled development setback lines.

A logical linking with the setback line/s of adjacent areas (if these have been established) must be achieved.

The study should be peer-reviewed by a coastal processes practitioner.

These measures will prevent the problem of several potentially conflicting setback distances along a number of small properties.

It is furthermore recommended that public consultation be managed by an environmental practitioner funded by the developer.

While private funding will assist in the establishment of the setback lines, piecemeal assessment of the shoreline could be problematic if setback lines of adjacent properties are not contiguous. It is therefore recommended that for large areas of shoreline that are likely to be developed within the next 10-30 years, the setback for these large areas be determined by coastal process practitioners to avoid the piecemeal approach.

11.5 PRIORITY AREAS FOR SETBACK LINES

It is proposed that areas earmarked for development and areas of existing development be given priority for the development of setback lines. Setback lines in areas of existing will highlight the potential dangers to such areas and will limit re-development.

11.6 PROPOSED INTERIM MEASURES – RAPID ASSESSMENT

It is appreciated that considerable funding and time will be needed to execute the setback line study in accordance with the methodology outlined in this report. For this reason, the following interim measures are proposed:

Default line:

- Prior to establishment of the no development/coastal process setback line, a default setback distance of the greater of (1) 100 m from the high water mark or (2) the distance from the high water mark to the +10 m MSL contour.
- The interim limited/controlled development line should be situated at the same location as the no development/coastal process line.
- A coastal process practitioner (coastal engineer/scientist) should validate this line and may recommend situating the line further shorewards or seawards in isolated cases.

Rapid assessment:

- For the purpose of planning and/or spatial development frameworks. A conservative rapid assessment no development/coastal processes line may be estimated by a coastal process practitioner. The assessment must allow for the following:
o Shoreline retreat for 1 m sea-level rise;

o Shoreline retreat for long-term shoreline erosion if applicable (this must as a minimum incorporate some form of analysis of a set of at least 5 aerial photographs, their dates spanning at least 40 years);

o Shoreline retreat for short-term/storm erosion;

o Shoreline retreat for dune collapse

o Setback for estuary channel migration.

o Setback to allow for wind-blown sand.

o Setback to allow for wave runup, where relevant.

• The interim limited/controlled development line should be situated at the same location as the no development/coastal process line, until a full setback line assessment is conducted, or unless an obvious setback should be implemented for this (e.g. defined by a coastal protection zone or reserve).

• The components of setback must be justified in terms of previous examples, experience or calculations. It is not anticipated that computational modelling will be essential for the rapid assessment. However, it is recommended that the enabling studies (Section 5) be completed forthwith so that they are available to practitioners to aid in the rapid assessment.

• The study must be conducted by a coastal process professional with experience as specified in Section 11.2.1.

• A review of the proposed rapid assessment setback line must be conducted by a coastal processes professional with experience as indicated in Section 9.2.1.

Full assessment:

• It is recommended that a full scale setback line assessment (of the coastal processes/no development line and of the limited/controlled development line) employing the methodology as outlined within this study, be conducted prior to any future development.

• It is recommended that this be conducted by a coastal process practitioner with experience as defined above in 11.2.1.

An advantage of conducting the full setback assessment just prior to development is that up-to-date information and data (e.g. on sea-level rise, shoreline location) can be used.

It is recommended that the above-mentioned interim and final setback lines become valid immediately and would therefore apply to developments currently under assessment (i.e. currently conducting Environmental Impact Assessments).
12 Conclusions and Recommendations

12.1 THE METHODOLOGY

12.1.1 The Study Approach

A methodology for the establishment of development setback lines has been established through:

- Application of previous experience;
- Reference to local and international best practice;
- Testing the methodology in two case studies;
- Incorporation of relevant comments obtained during consultation.

It is believed that very accurate setback distances are only attainable by means of accurate, validated computational modelling of coastal processes (with accurate input data) and associated analyses. However, such studies are assumed to be excessively costly. Therefore, the proposed approach to determining setback lines is to conduct a minimum of measurements and some limited modelling studies and data analysis. Together with the application of sound judgement by coastal processes professionals, it is believed that suitably accurate setback lines can be determined with this approach.

In developing the methodology an attempt was made (a) to determine a simple methodology and (b) to classify coasts such that standard setback distances could be applied, even as a "rapid assessment" initial setback. However, it was found that no simple formula or approach exists. This is primarily due to the large spatial variation in coastal processes along the shoreline.

12.1.2 The Outcome

The methodology developed within this study is specified in Sections 4 to 10 of this report. Minimum requirements to be fulfilled are indicated (within the yellow boxes). The methodology incorporates two development setback lines:

1. A no development / coastal process setback line. This line would define the limit of the coastal area seaward of which any development is likely to experience unacceptable risk of erosion, flooding by wave action and/or unacceptable maintenance of wind-blown sand accumulations.

2. A limited / controlled development setback line. This line would define areas where some limited and/or controlled development may occur that accommodates requirements of biodiversity, heritage and other aspects not related directly to coastal processes. This line is situated on or landward of the no development / coastal processes setback line.

Peer review of the details of establishing the setback line is an integral part of the methodology. Both the practitioner/s executing the study and peer reviewer must suitable experience (details - Section 11.2)
12.2 INTERIM MEASURES

Accepting that it will take some time to establish setback lines along the entire Western Cape shoreline, interim measures have been provided. These measures include employment of the 100 m setback from the highwater mark (or 10 m MSL elevation) as a default, and a rapid assessment of setback (for planning purposes only). The full setback methodology must ultimately be executed before execution of any future development or re-development. The interim measures are detailed in Section 11.6.

12.3 RECOMMENDATIONS

The following is recommended with regard to the setback line methodology and execution thereof:

- It is recommended that the methodology for the establishment of setback lines as outlined in Sections 4 to 10 of this report be employed. Essential to this methodology is that it is executed by practitioners having the appropriate experience (Section 11.2) and that review by similarly experienced practitioners is carried out.

- Cost estimates have been provided for setback line studies. It is recommended that the distribution of costs between government authorities (DEA&DP and local municipalities) be agreed upon and that the necessary funding be sourced in order to expedite the establishment setback lines required within some 3.5 years from now (according to the ICMA).

- Recognising the time constraint to establish setback lines (in 3.5 years time), it is recommended that the proposed enabling studies which are an essential part of the setback line methodology be executed as soon as is possible. These enabling studies will facilitate interim rapid assessment of setback lines, as well as the setback lines established with the proposed methodology.

In addition, the following specific recommendations are made

- It is recommended that mining operations be treated the same as any other development with regard to setback. Thus only the minister will have the authority to permit the mining activity, and only if specific conditions are fulfilled such that the mining is found to be overwhelmingly in the public interest.

- Experience from the case studies revealed that map information from Heritage Western Cape (HWC) is not provided in a user-friendly or accurate form. Sites or areas with high heritage priority are not provided as coordinates or on coordinated maps - it is recommended that this information be made available by HWC.

- Experience has shown that a database of beach profiles extending for several years to decades allows for more accurate setback line assessments. It is strongly recommended that areas of high risk (particularly sedimentary shorelines where erosion is evident and threatens property) be identified and monitored by repeated beach profile measurements.
13 References


• Floodplain and River Corridor Management Policy (2009). Version 2.1 Approved by Council 27 May 2007 C58/05/09


• WL|Delft Hydraulics (2005), UNIBEST CL+6.0 User and Theoretical Manual, Delft, The Netherlands (copy at CSIR, Stellenbosch
