SPECIALIST COASTAL ENGINEERING REPORT

Site analysis and definition of the development setback line on ERF 134, LUZ DE LUA, Infanta

report by

LAURIE BARWELL

JULY 2026

FINAL

Site analysis and definition of the setback line on ERF 134, Luz de Lua.

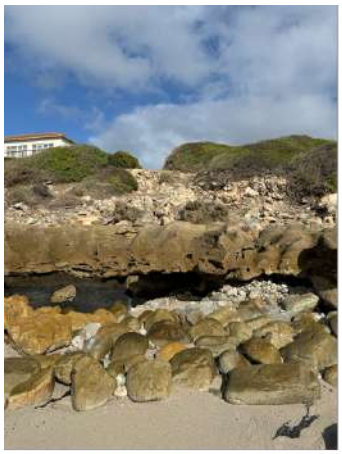
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The rocky coastline at Erf 134, Luz de Lua, Infanta

SPECIALIST DECLARATION

I, **Lauriston Barwell**, declare that -

- I act as an independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to the application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing: (i) any decision to be taken with respect to the application by the competent authority; and (ii) the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in term of regulation 48 and is punishable in terms of section 24F of the Act.



.....
Signature of the Specialist

Date: 13 July 2026

Indemnity and conditions relating to this report

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Limitations of the study

The aerial image and photographic analysis that forms the basis of the shoreline stability assessment, conclusions and recommendations are based on the availability of historical and recent data and information. Due to poor resolution of such historic material it is required to make use of much interpretation of landscapes and features as well as the technical skill to undertake comparative image analysis that is shaped via experiential learning. As such only a broad idea of the relevant dynamics can be reached. However, this approach has proven to be useful in identifying long-term trends that are important when attempting to understand natural processes and their potential impact on and potential response to developmental and / or management actions.

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Frontispiece: Erf 134, Luz de Lua, Luz de Lua
March 2026 at 16:18. (Tide level = +1.77 m CD, +0.84 m MSL)

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Figure 1: **Erf 134, Luz de Lua is located to the south of the mouth of the Breede River Estuary Mouth directly NNW of the coastal village of Infanta**

EXECUTIVE SUMMARY

The Owners of the property Portion of Erf 134, and in particular Luz de Lua, **Westerhelling Investments,** are proposing a housing development on Erf 134, Infanta located behind a designated setback line to allow for the current and future river floods and coastal processes at the site.

Laurie Barwell & Associates (Pty) Ltd (**LB&A**) was appointed on behalf of the Applicant to produce specialist coastal engineering input to demarcate the setback line as required as part of the Basic Assessment process being managed by **PHS Consulting.**

The Client provided information by FRASER Consulting Civil Engineers cc on the demarcation of the 100yr flood line for the small river that crosses Erf134 and spills into the sea across the rocky shoreline east of the property. An ecological corridor is also defined that spans 20 m either side of the centre line of the river/stream as indicated on the development plan provided by the Client.

This assignment is focused on addressing the Coastal Management Lines (CMLs) related information highlighted in the December 2025 comments by the Western Cape: DEA&DP, and in particular to demarcate the setback line.

The report addresses the following:

i. The physical environmental context (Section 3).
ii. The coastline stability over the 39-year period from 1984 to 2023 using available satellite, and Google Earth Pro™ aerial images, and a site survey (Section 4).
iii. The 2030, 2050 and 2100 storm hazard levels including the effects of climate change on the coastline stability and in particular the implications of the projected rise in sea level using defensible current knowledge (Section 5).
iv. Consideration of the WC DEA&DP coastal management lines and beach access audit as published (Section 6).
v. Considering the CMLs and the previous 2010 and 2012 setback lines, studies a development setback line is recommended combining the coastal processes and 100 yr flood line (Section 7).

In addition, the recommended alignment and other design parameters of a possible public wheel-chair friendly boardwalk and access along the eastern edge of the property (Section 8).

It is the author's considered opinion that the development setback line will allow for positioning the proposed infrastructure beyond the reach of the natural processes of floods and the sea including the influence of climate change and in particular Sea Level Rise

1. INTRODUCTION

Laurie Barwell & Associates (Pty) Ltd (**LB&A**) was appointed on behalf of the Applicant, **Westerhelling Investments,** to produce specialist coastal engineering input as required as part of the Basic Assessment process being managed by **PHS Consulting.**

Design input on the position of the coastal setback line and the hazard levels for locating the proposed development beyond the reach of the sea-storm processes.

Full recognition of the WC DEA&DP coastal management lines and beach access audit is provided in recommending design parameters for the development setback line and a wheel-chair friendly walkway within the coastal strip between the proposed development and the high water mark (HWM) at the relevant portion of Erf 134, Luz de Lua.

1.1 Study area

Erf 134, Luz de Lua is located about 1200 m SSE of the western side of the Breede Estuary mouth 50 m NNW of the coastal village of Infanta. The property is located within the Swellendam Local Municipality in the Overberg District Municipality of the Western Cape province in South Africa (Figure 1).

The rocky seaward edge of Erf 134, Luz de Lua is about 200 m long and has a NNW (325°) to SSE (145°) orientation.

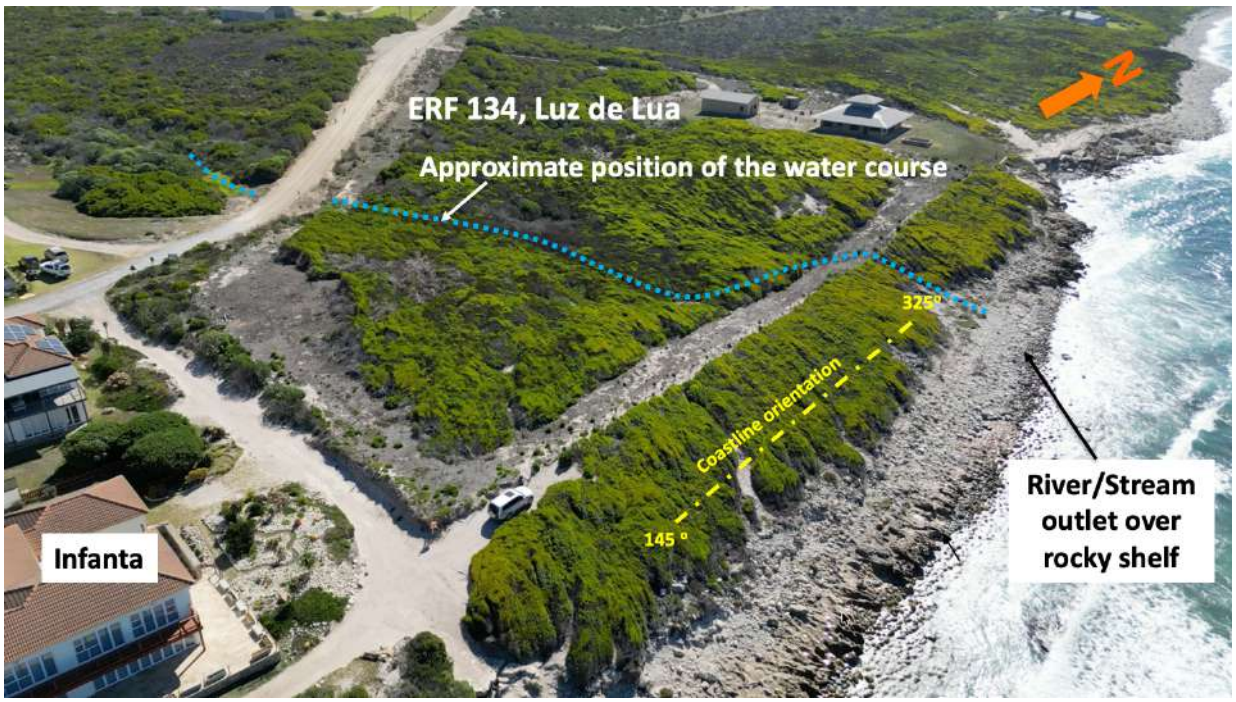


Figure 2: Erf 134, Luz de Lua fronts onto a 200 m long rocky shoreline with a NNW-SSE orientation fronting the Indian Ocean

1.2 Approach and process

In order to understand the coastal processes and in particular the historic stability of the coastline at the site, the available information, including available aerial images and a long-term coastline changes assessment[1], and a recent topographical survey were used to determine the shoreline changes over a period of 39 years (Satellite images from 1984 to 2003, and images from Google Earth Pro™ (2003 to 2023).

The analysis included:

1. Site photographs and a survey, undertaken in early 2026, allowed an assessment of the state of the foreshore and shoreline with reference to the location of Erf 134, Luz de Lua.

2. The use of information from a satellite images analysis by Theron, D. and Theron, A.K. (2025)[1] supplemented by an analysis of Google Earth Pro™ images provided statistics of the historic stability of the shoreline at the site.

3. The calculation of the position of the projected future storm wave runup, erosion and future hazard lines. A comparison of the results to the DEA&DP coastal management line guidelines.[2]

4. The derivation of the likely 2030, 2050 and 2100 sea storm hazard lines and the 1% short-term storm hazard levels to inform design parameters for defining the position of the setback line from a coastal processes point of view.

5. Combining the available 100yr flood line[3] with the 2100 sea storm hazard line to demarcate the Development Setback Line for Erf134.

[1] Theron, D and Theron A.K. (2025). Monitoring and Analysis of South African Shoreline Dynamics Using Satellite Imagery. Estuaries and Coasts (2026) 49:30 https://doi.org/10.1007/s12237-025-01638-6

[2] DEA&DP: Western Cape Government's (WCG) Coastal Management Unit. https://www.arcgis.com/apps/webappviewer/index.html?id=fdfc43db00224a6688cb964b47f713b0

[3] FRASER Consulting Engineers cc. 100 yr Flood line for Erf 134, Infanta. AF134-04 Rev 3. 12 December 2020.

2. RELEVANT LEGISLATION AND POLICIES

The following legislation needs to be taken into account when planning activities within the littoral active zone or within sensitive dune systems. (Note: Ef 134 falls **within** the Urban Edge)

Government Gazette No 38282, 04 December 2014 – NEMA EIA Regulations, GN No. R 985 of Listing Notice 3

Activity 12: The clearance of an area of 300m^2 or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan.

(iii) Within the littoral active zone or 100m inland from the high-water mark of the sea or an estuarine functional zone, whichever is the greater, excluding where such removal will occur behind a development setback line or erven in urban areas.

Activity 14: The development of -

(ii) Infrastructure or structures with a physical footprint of 10m^2 or more.

Where such development occurs-

(a) Within a water course.

(c) If no development setback has been adopted, within 32 meters of a watercourse, measured from the edge of a water course.

Excluding the development of infrastructure or structures within existing ports or harbours that will not increase the development footprint of the port or harbour.

i. Outside urban areas

Government Gazette No 38282, 04 December 2014 – NEMA EIA Regulations, GN No. R 983 of Listing Notice 1

Listed Activity 17: Development –

(iii) within the littoral active zone,

(v) if no development setback exists, within a distance of 100 metres inland of the high-water mark of the sea or an estuary, whichever is greater.

In respect of –

(d) rock revetments or stabilising structures including stabilising walls.

(e) infrastructure or structures with a development footprint of 50 square meters or more.

but excluding-

(aa) the development of infrastructure and structures within existing ports or harbours that will not increase the development footprint of the port or harbour;

(bb) where such development is related to the development of a port or harbour, in which case activity 26 of Listing Notice 2 of 2014 applies;

(cc) the development of temporary infrastructure or structures where such structures will be removed within 6 weeks of the commencement of development and where coral or indigenous vegetation will not be cleared; or

(dd) where such development occurs within an urban area.

Listed Activity 18: The planting of vegetation or placing of any material on dunes or exposed sand surfaces of more than 10 square meters, within the littoral active zone, for the purposes of preventing the free movement of sand, erosion or accretion, excluding where—

(i) the planting of vegetation or placement of material relates to restoration and maintenance of indigenous coastal vegetation undertaken in accordance with a maintenance management plan; or
(ii) such planting of vegetation or placing of material will occur behind a development setback.

Listed Activity 19: The infilling or depositing of any material of more than 10 cubic meters into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 cubic meters from a watercourse but excluding where such infilling, depositing, dredging, excavation, removal or moving—

(a) will occur behind a development setback.
(b) is for maintenance purposes undertaken in accordance with a maintenance management plan; or
(c) falls within the ambit of activity 21 in this notice, in which case that activity applies.
(d) occurs within existing ports or harbours that will not increase the development footprint of the port or harbour; or
(e) where such development is related to the development of a port or harbour, in which case activity 26 in Listing Notice 2 of 2014 applies.

Listing Activity 19A: The infilling or depositing of any material of more than 5 cubic meters into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 5 cubic meters from –

i. the seashore.
ii. the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or an estuary whichever distance is the greater;

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

(a) will occur behind a development setback;
(b) is for maintenance purposes undertaken in accordance with a maintenance management plan;
(c) falls within the ambit of activity 21 in this Notice, in which case that activity applies;
(d) occurs within existing ports or harbours that will not increase the development footprint of the port or harbour, or
(e) where such developments is related to the development of a port or harbour, in which case activity 26 in Listing Notice 2 of 2014 applies.

Furthermore, the following sections of the relevant legislation are considered:

Section 1:	National Environmental Management Act No 107 of 1998
Section 2:	National Environmental Management Act No 107 of 1998
Section 28:	National Environmental Management Act No 107 of 1998
Section 6:	'ORV Regulations' Regulations for the Management of Vehicles in the Coastal Zone, dated 2001
Section 1:	NEM: Integrated Coastal Management Act No 24 of 2008
Section 7:	NEM: Integrated Coastal Management Act (Composition of Coastal Public Property)
Section 13:	NEM: Integrated Coastal Management Act (Access to coastal public property)
Section 16:	NEM: Integrated Coastal Management Act (Composition of the Coastal Protection Zone)
Section 17:	NEM: Integrated Coastal Management Act (Purpose of the Coastal Protection Zone)
Section 18:	NEM: Integrated Coastal Management Act (Coastal Access Land)
Section 20:	NEM: Integrated Coastal Management Act (Responsibilities of Municipalities with respect to Coastal Access Land)
Section 63:	NEM: Integrated Coastal Management Act, 2008 (Act No 24 of 2008) (Environmental Authorisation for coastal activities)
Section 83:	NEM: Integrated Coastal Management Act, 2008 (Act No 24 of 2008) (Control of Use of Vehicles in the Coastal Area)

3. PHYSICAL ENVIRONMENT

3.1 Introduction

In order to ensure that the correct developmental and management decisions are taken and implemented, it is important to have a basic understanding of the physical coastal environment at the study site. In particular, this involves having knowledge of the established biophysical processes and being able to assess the environmental consequences of management or developmental actions.

The coastline system at Infanta is influenced by a complex interaction between several physical and abiotic components. However, it is the tidal reach, the approaching waves and wind- and wave setup and -runup during onshore storm surges, the influence of the rocky nature, the effect of the prevailing wind regime and the associated aeolian sand movement potential, the orientation of the coastline, and the influence of the surface water runoff from the upland across the property and foreshore that are most relevant to determining the development setback line position including the relevant hazard levels. These aspects are discussed below.

The coastline at the site consists of a series of calcrete ridges (The Waenhuiskrans Formation) at an elevation of between +2.0 and +6.0 m MSL overlying Table Mountain Quartzite rounded boulders and pebbles on outcrops the Klein Brak Formation.

Large storm surge runup undercuts the calcrete and pieces of rocks crack and fall seawards of the calcrete platform. The collapsed slabs of limestone form a natural breakwater for a period, limiting landward erosion.

Larger storm waves cause splash over and wave runup in the mouth of the small river/stream and can reach an elevation of +4.0 m MSL in areas that are lower.

Overall, the hard rocky nature of the coastline at Erf 134, Luz de Lua limits the erodibility and poses little threat to infrastructure placed landwards of the setback line and hazard level discussed in this report. (Figure 3).

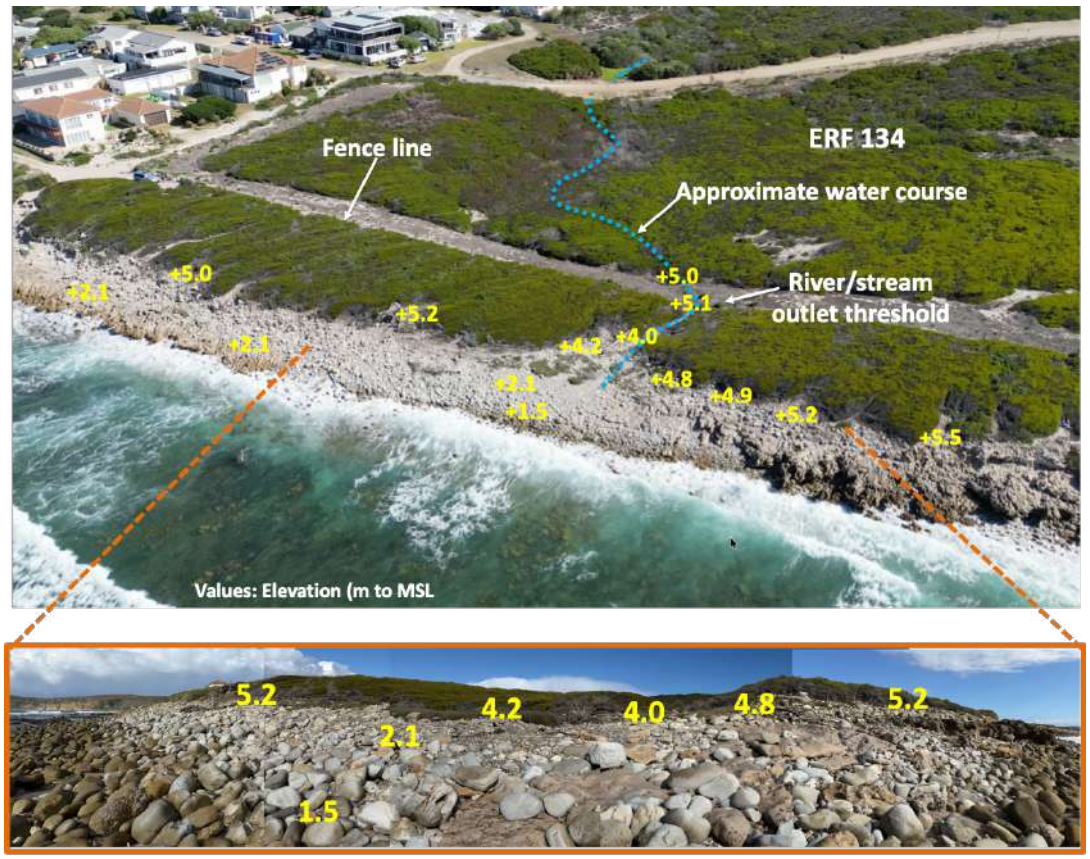


Figure 3: The mouth of the small river/stream flows over a narrow ridge located at +5.1 m MSL

3.2 Coastal processes

The study site is situated at Infanta within the San Sebastian Bay at the southern Southwestern end (1/3 rd) along the logarithmic spiral-shaped (crenulated) embayment. (Figure 1).

The physical processes that have caused the log-spiral equilibrium shape of the bay[4] to be formed are governed by the sea swells reaching the coastline and the resultant longshore and cross-shore currents, the availability of sediment within the dune system along the coastline eastwards of the Breede Estuary mouth as well as those flushed from the Breede river during large floods, the effect of prevailing winds, and the local geology.

[4] Barwell. L (2011). Integrity assessment procedure for buffer dune systems on the Cape South coast, South Africa. MSc Eng Thesis. Stellenbosch University.

The availability of sediment in the nearshore and onshore areas plays a significant role and it is this quantified interaction of the movement of the available sediment by nearshore currents and the wind that is termed the local sediment budget.

Coastal studies[5] have shown that 64% of deep-sea waves on the southern Cape coast of South Africa originate from the SW sector. The Median significant deep sea wave height for this area was 2.4 m and the highest annual wave heights were 7.8 m.

The Cape Infanta promontory shelters the coastline at Erf 134, Luz de Lua from much of the deep-sea waves that typically originate from the SSW sector[5] . Some of the SSW wave energy reaches the study site in the lee of the headland through wave refraction (bending) around the headland. The wave diffraction and refraction processes reduce the wave energy as they approach the shoreline and change the wave approach direction.

Typical of a half-heart bay along this section of the South African coastline[4], there is a westward counter current flowing along the beach along the sandy coast east of the estuary mouth. This alongshore current transports sand within the surfzone. The sand flows into the Breede Estuary and results in a westward growing sand spit on the eastern side of the mouth at Witsand.

The waves at Infanta and Erf134 are generally small relative to the deep-sea waves and approach the coastline from an easterly to southeasterly direction. However, the shoreline at Infanta is directly exposed to infrequent storm wind-waves from the eastern sector. The waves hit the coastline at a large oblique angle, and this results in a strong alongshore current directed to the north towards the estuary mouth. Little nearshore sand is therefore present in the nearshore area at Erf 134, Luz de Lua.

The water depth and strong currents in the permanently open Breede mouth prevent the sand from crossing to the Infanta side of the river and thus little if any 'new' sand reaches the coastline at Erf 134, and in particular Luz de Lua. Only relict dunes thus exist around the site. This reduces the risk of wind-blown sand on the current and any future development as discussed below.

3.3 Wind climate and aeolian sediment movement

Wind blowing onshore from the SE sector dominates all year round. The offshore wind components occur from the S to SSW and from the NNW sectors and is mainly associated with passing low pressure systems during winter.

The coastline orientation at Erf 134, Luz de Lua, luz de Lua is NNW to SSE. During the Spring and Summer months the prevailing winds are mainly alongshore and obliquely onshore.

[5] Carter RA (1983) Report No. 21: Breë (CSW 22). In: Heydorn AEF, Grindley JR (Eds) Estuaries of the Cape. Part II: Synopsis of available information in individual systems. Estuarine and Coastal Research Unit, NRIO (CSIR), Stellenbosch, CSIR Research Report 420

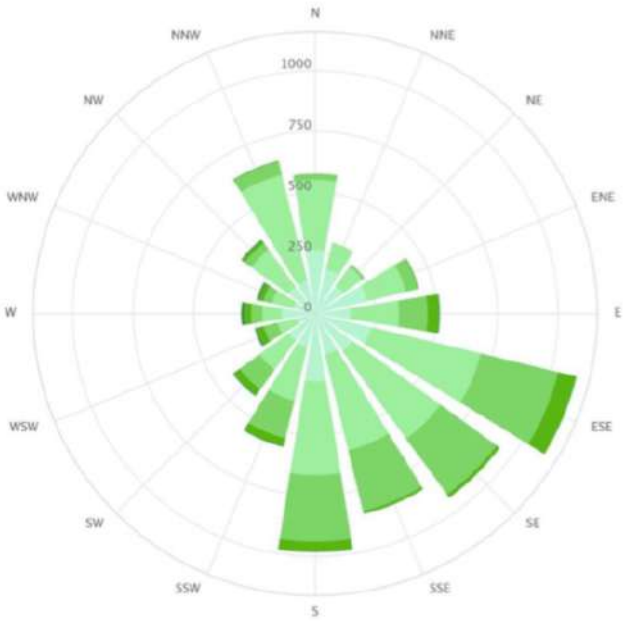


Figure 4: Annual wind rose for the Infanta area (from Metroblue™) wind statistics

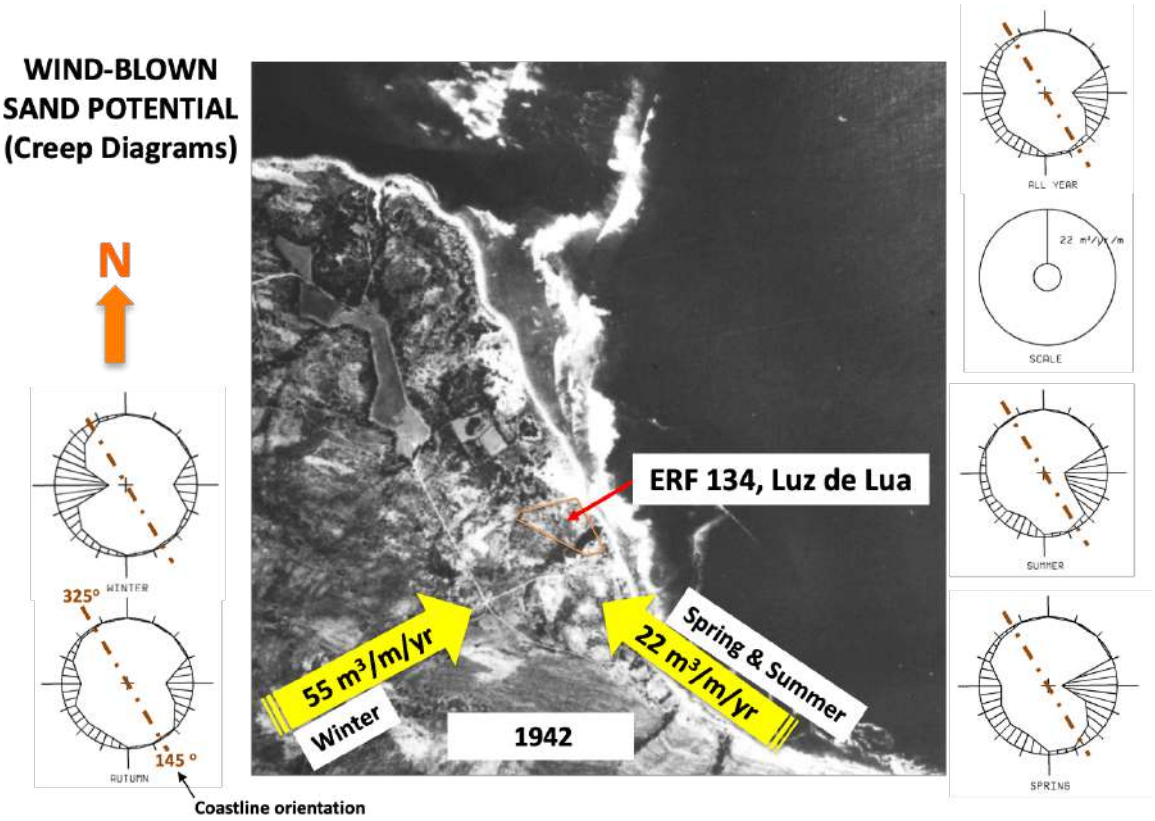


Figure 5: Wind-blown sand potential (Creep Diagrams)[6]

[6] Swart, D.H. 1986. Prediction of wind-blown sediment transport rates. Paper delivered at the 20th International Conference on Coastal Engineering, Taipei.

From Figures 4 and 5 and observations of blow-outs and the orientation vegetation in the area it is deduced that the potential movement of wind-blown sand (when available) at the study site is obliquely onshore from the ESE to SW sectors (WNW to NE-bound), dominantly from the ESE. A potential NW-bound rate of 22 m3/m/yr is calculated. During the dry summer months (November to February) these onshore winds typically blow for an average of 16 days per month. Summer time is also when dry sandy areas can exist in the area which can allow wind-blown sand to move.

Strong but infrequent winds from the western sector prevail in Winter which has the potential to move exposed sand offshore at a potential rate of 55 m^3/m/yr.

This rate of wind-blown sand is experienced in the dune field east of the estuary mouth where much sand is available. However, a lack of available sand within Erf 134, Luz de Lua and in the immediate vicinity means that little or no wind-blown sand impacts are expected.

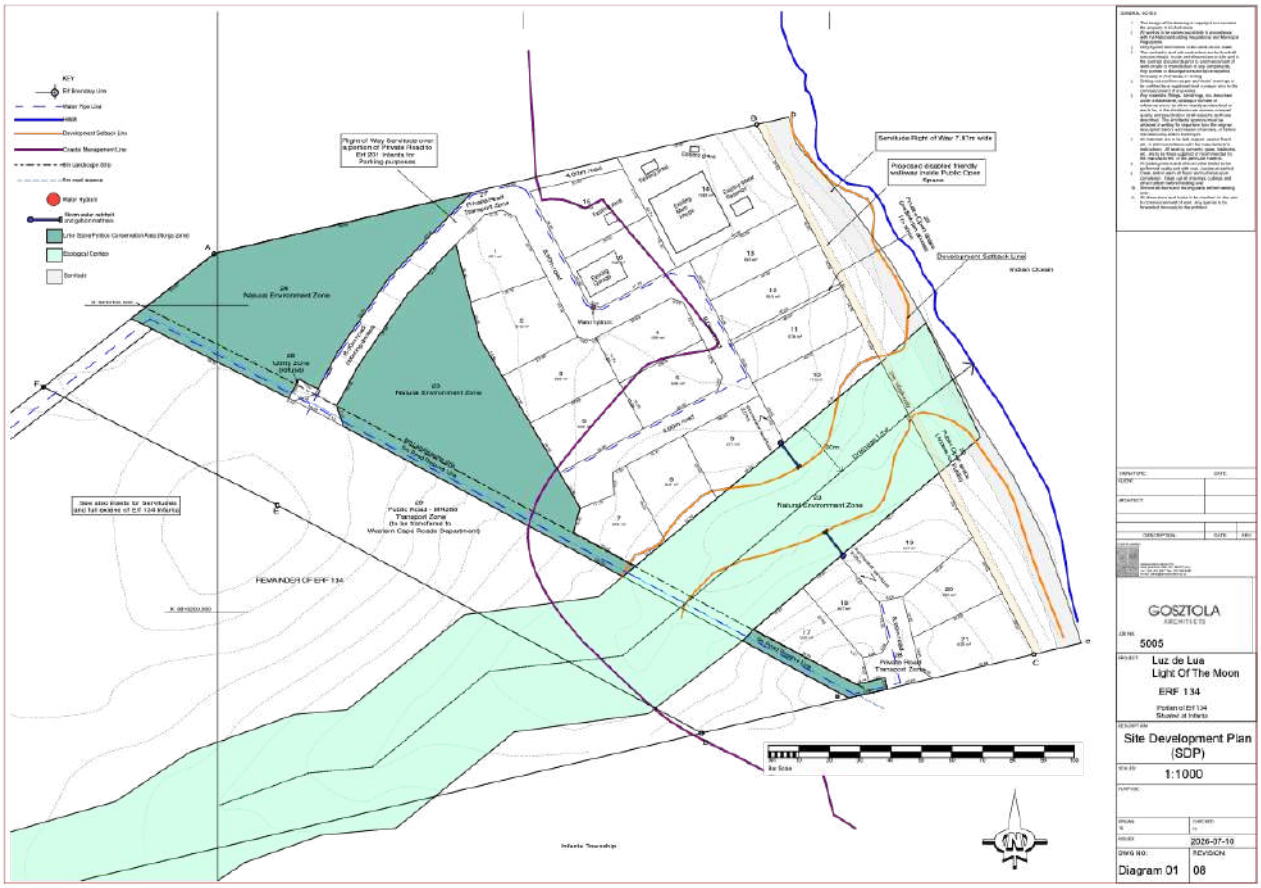


Figure 6: Proposed Site Development Plan and topographic contours.
(The recommended development setback line is included - see Section 7 & Figure 15).

3.4 Topographical survey

A topographical survey of Erf 134, Luz de Lua was provided by the Client (Figure 6) As this survey did not cover all the area of importance (e.g. the mouth area at the river/stream and the foreshore down to the high water mark along the coastline, a supplementary survey was carried out on 27 April 2026 by the author using an accurate DGPS survey instrument.

The profile positions are shown in Figure 7.0, and the cross-sections are shown in Figures 7.1 to 7.3. This information reflects the form, slope, and position of the rocky shoreline and foreshore area at the time of the survey. It is used to determine the landward reach of the various wave energy and climate change induced SLR scenarios.

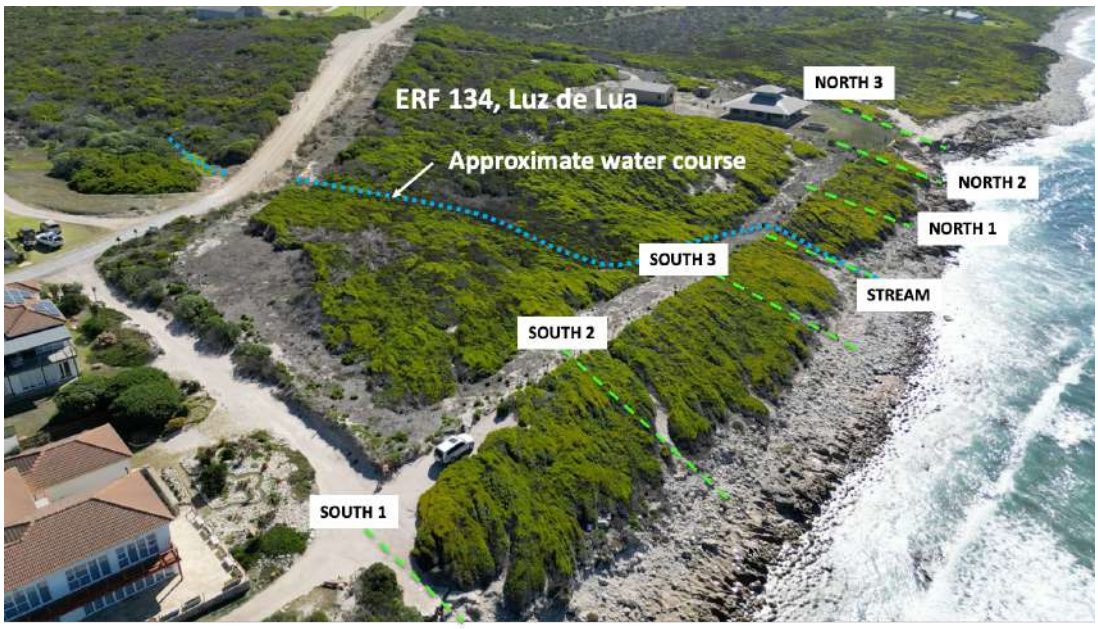


Figure 7: Cross-sections surveyed as surveyed on 27 April 2026

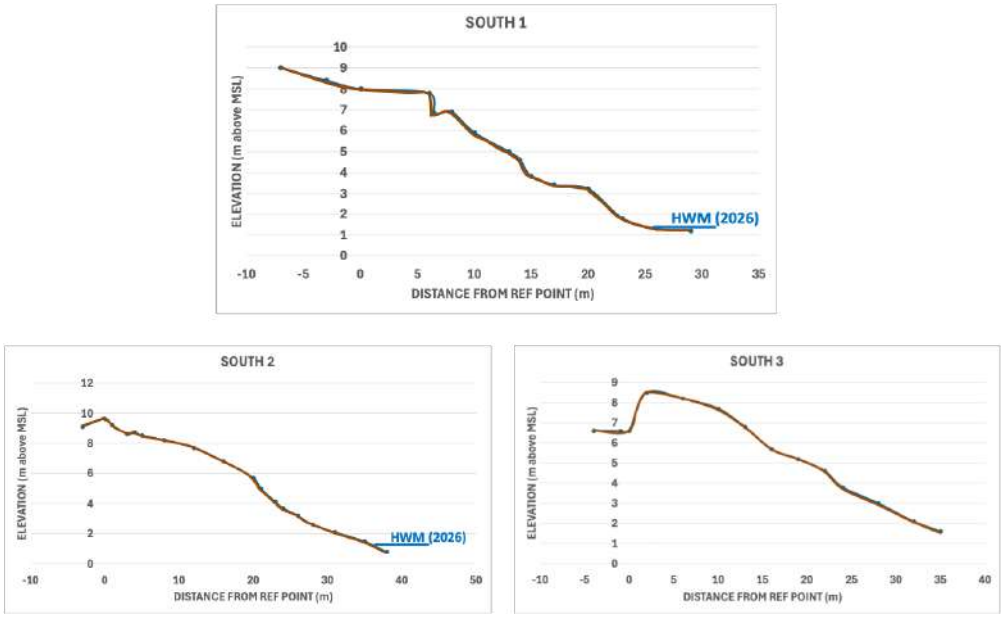


Figure 7.1: Rocky shoreline and foreshore area profiles across the southern side of Erf 134, Luz de Lua as surveyed on 27 April 2026

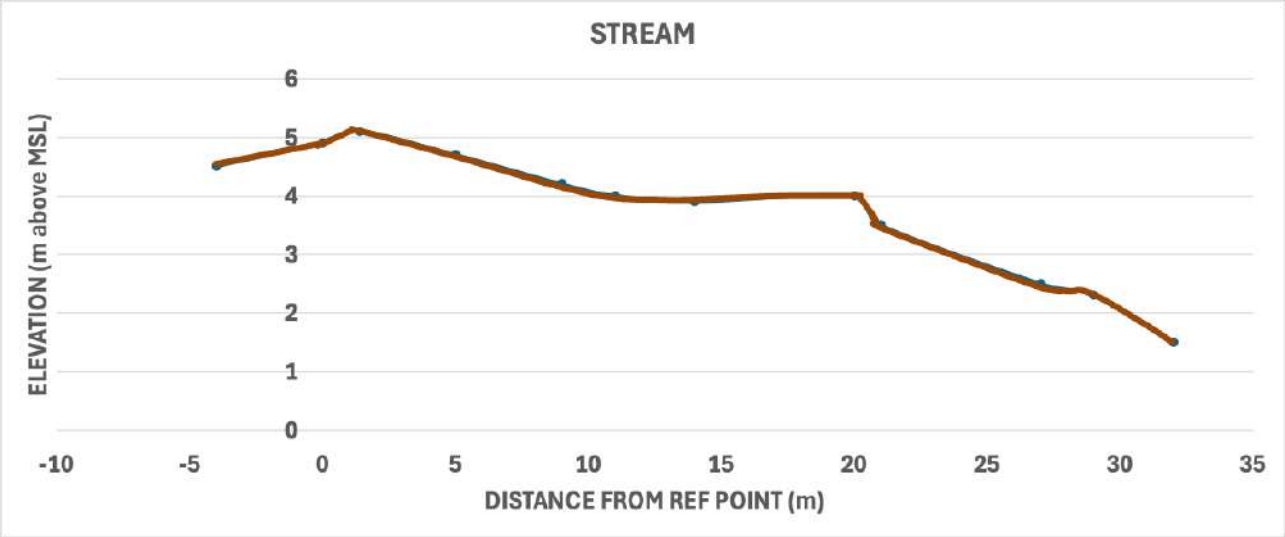


Figure 7.2: Foreshore profile across the central area at Erf 134, Luz de Lua where a natural stormwater course crosses the rocky foreshore as surveyed on 27 April 2026

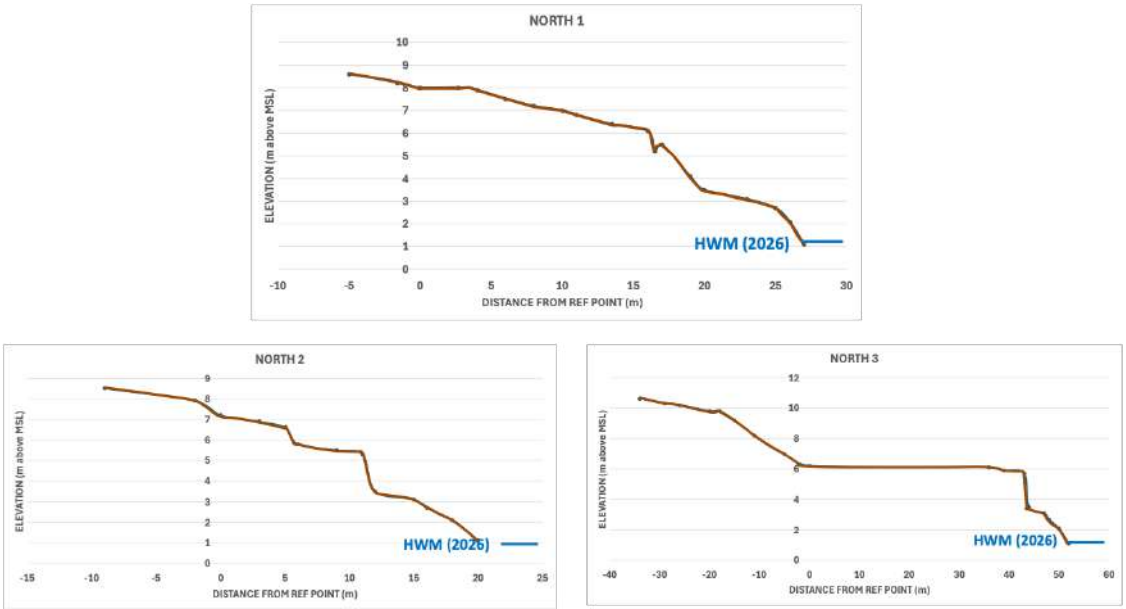


Figure 7.3: Rocky shoreline and foreshore area profiles across the northern side of Erf 134, Luz de Lua as surveyed on 27 April 2026

4. COASTLINE STABILITY

If the natural wave energy buffering foreshore ecosystem is allowed to maintain its natural integrity, the ecosystem service is capable of forming an effective and enduring protection of the back shore area and adjacent infrastructure against the forces of the sea. This is particularly valid when development is located beyond the reach of the coastal processes. The effects of human activities (for example placing development and infrastructure on the shoreline can result in limiting the natural coastline dynamics. This can reduce the natural ability of the foreshore system to effectively buffer against the erosional effect of sea storms, thereby putting infrastructure at risk of being undercut, causing shoreline slumping and resultant damage to infrastructure by the forces of the sea.

Establishing a sustainable and durable coastal buffering system is dependent on meeting two broad management objectives: (1) managing the system to maintain the functionality of the prevailing coastal processes including the integrity of the foreshore ecosystem; and (2) protecting the interests of property owners (private and public) against the impact from the natural processes as well as to enhance the recreational and aesthetic qualities of the area.

Key to understanding the functioning of the prevailing coastal system at the site as well as determining the risk to public infrastructure and private property is gaining an understanding of any erosion or accreting trends in the short (seasonal) and long-term (decadal) shoreline stability at the site.

By undertaking an analysis of available historic aerial photographic and satellite imagery complemented by periodic topographic surveys if these are based on a common survey datum, effectively carries out the trend analysis as discussed in the following section.

4.1 Aerial and satellite images analysis

The wave run-up is typical of the landward reach of seastorms and is relatively easy to observe on aerial images as the boundary between the dark areas (debris) and the light area (dry, upper shoreline). This is often seen as the seaward edge-of-vegetation line. It means that seawater, typically during storms, regularly reaches a point up the shoreline slope and prevents vegetation growth. On an unrestricted shoreline, the non-storm related wave run-up line is also seen as a proxy for the position of the normal (non-storm related) High-Water Mark (HWM).

On rocky shorelines such as at Infanta and Erf 134, Luz de Lua, storm waves splash up and over the frontal rocks during storms and very high tides the wave runup reaches the edge-of-veg line as is clearly seen on site (Figure 8). Tracking this line at Erf 134, Luz de Lua as the observable edge-of-vegetation line over time provides a useful indicator of coastline stability as discussed in the next section.

Whereas on sandy shorelines this data also provides a baseline for a statistically approach to determining the storm erosion and future storm runup lines using a modified method developed by Theron A.K., (2016) and

recently refined by Theron, D. and Theron, A.K. (2025)[7] on rocky shores the erosion component is negligible, but the storm wave runup is still possible where the rocky shelf is low and flat enough. The wave runup will be somewhat dampened by the presence of rocks that break the energy.

Here the post SLR hazard elevation becomes the key factor for demarcating the coastal processes setback line.

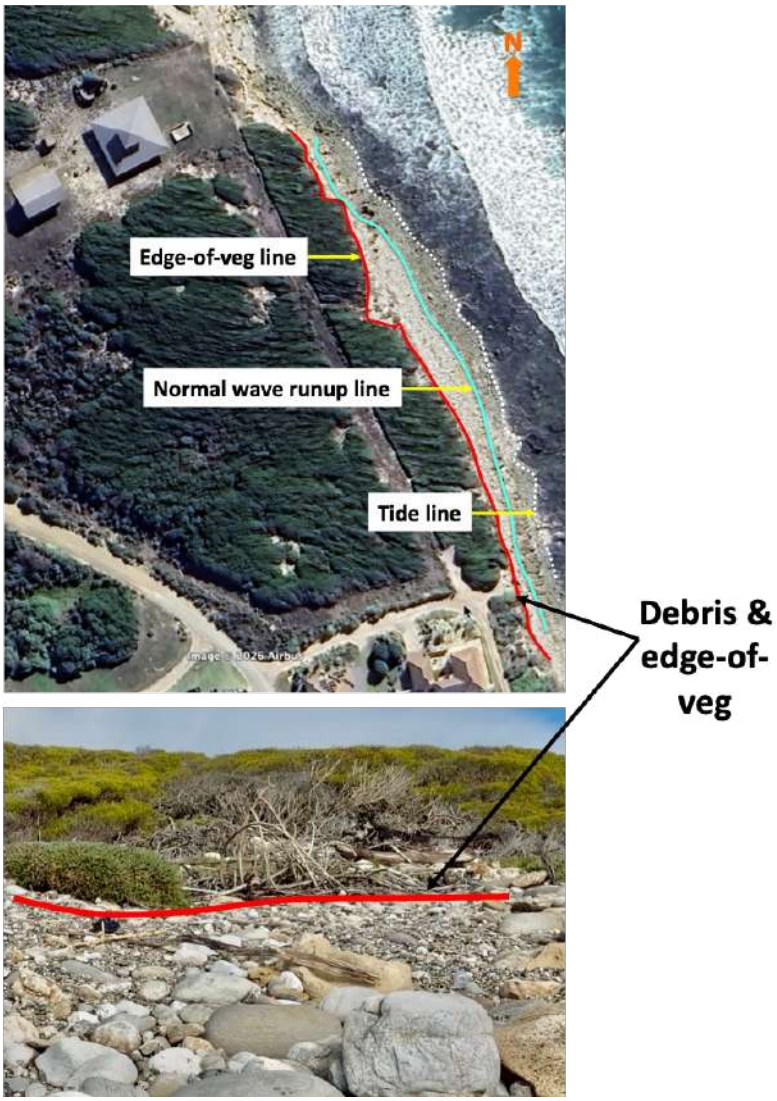


Figure 8: Definition of the 'edge of the vegetation' and normal wave run-up lines

A comparative analysis of the seaward edge of the vegetation and normal wave run-up lines on the available images for the 39 years (1984 to 2023) was done. The analysis reference lines are shown on Figure 9. The results are shown in table in Figure 9 and reflect the position of the long-term average wave runup (non-storm) line as determined by Theron D. (2025)[6]. As noted above, shoreline erosion is not a factor here due to the hard rocky nature of the shoreline.

[7] Theron, D and Theron A.K. (2025). Monitoring and Analysis of South African Shoreline Dynamics Using Satellite Imagery. Estuaries and Coasts (2026) 49:30 https://doi.org/10.1007/s12237-025-01638-6

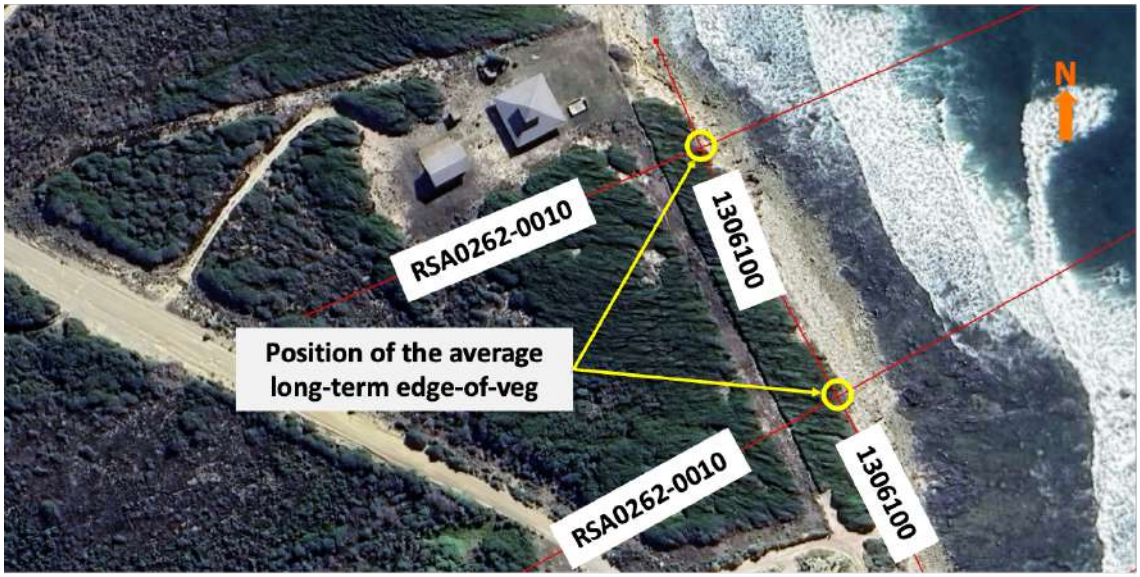


Figure 9: The reference lines as used by Theron, D and Theron A.K (2025) to determine the variability of the position of the normal run-up

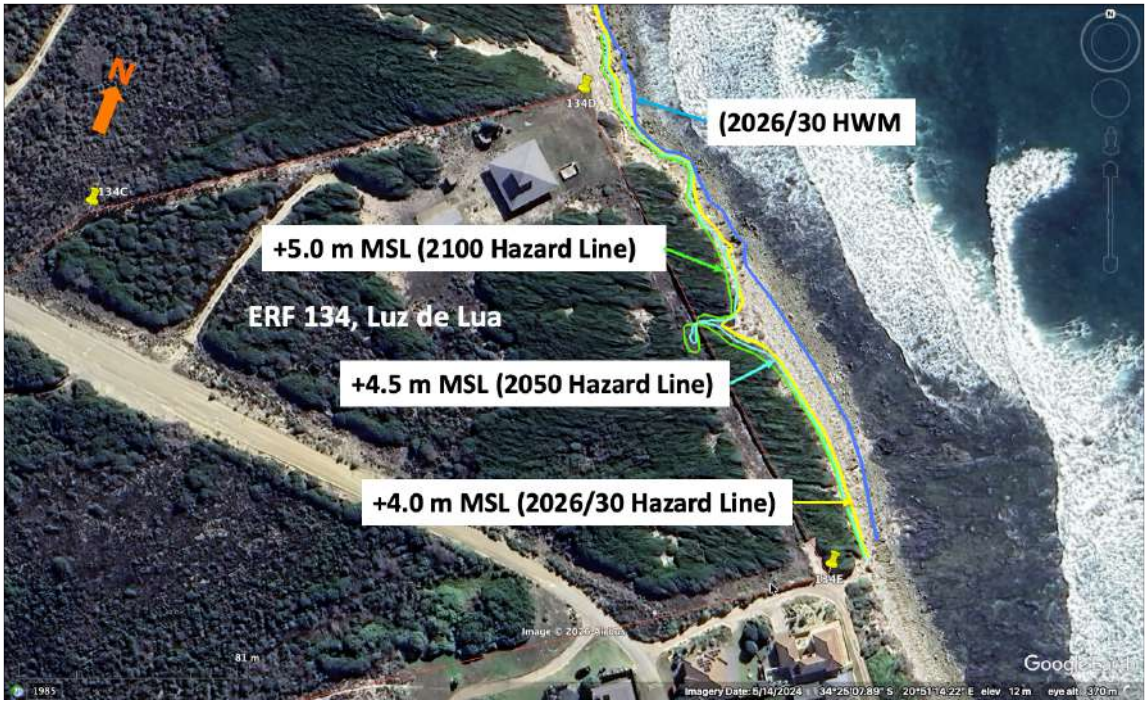


Figure 10: The statistical method defined by Theron, A.K. (2016) allows the calculation of the 2050 and 2100 future hazard line based on the level and assuming no if any erosion. Runup amount adapted for a rocky shoreline by Author (Figure 11).

The results of the 39-year image analysis summarised show that the horizontal position of the normal wave runup line varied within an average range of 5 m and had a calculated standard deviation of 2 m from the average runup position, the edge-of-veg line. This means that the principal factor is the change in water levels in time as discussed below.

This means that the coastline at the study site showed little to no erosional or accretional trend over the analysis period, and it is thus concluded as being in a state of equilibrium which is expected of a rocky shoreline even with naturally collapsing calcrete layers.

5. CLIMATE CHANGE AND SEA LEVEL RISE

5.1 Introduction

As was noted in IPCC (2001), climate change is expected to have a number of consequences that will detrimentally affect coastal resources. These are, amongst others: higher sea levels; higher sea temperatures; changes in precipitation patterns and sediment fluxes from rivers; changed oceanic conditions; and changes in storm tracks, frequencies and intensities. The apparent increase in storm activity and severity will be the most visible impact and the first to be noticed, since higher sea levels will require smaller storm events to overtop existing storm protection measures and be seen as e.g. coastal erosion.

5.2 Climate change scenarios

As discussed in Appendix 1, which is a direct extract from a CSIR report (CSIR, 2012), it is concluded that the best estimate ('mid scenario') of sea level rise (SLR) by 2100 is around 1 m, with a plausible worst-case scenario of 2 m, and a best case scenario of 0.5 m. The corresponding best estimate ('mid scenario') projection for 2050 is 0.3 m to 0.5 m off the 2010 baseline. For this study a projected SLR of +0.17 m by 2030, +0.35 m by 2050 and +1.0 m by 2100 off the 2011 basis level is considered.

5.3 Sea storms and climate change

As discussed above, the coastline at Erf 134, Luz de Lua consists of a hard, rocky nature with little risk of rapid erosional events impacting on it as is the case along soft, sandy coastlines. However the foreshore elevation is low enough to experience significant storm wave runup and surges into the river/stream outlet which is located at a lower elevation by nature.

The waves approaching the coast are affected by, inter alia, the bottom topography and rocky reefs and outcrops. Whether on a sandy shore or rocky, such as at the site, as the sea level rises, existing topographic features such as nearshore reefs and rocks will be located in deeper water (when compared to the present) and will have a different effect on waves approaching the coast. The natural energy breaking features in the breaker zone will be in deeper water with sea level rise and will either have an amplified or dampening effect on the wave energy compared to the present.

Water over deep-water features (such as submerged reefs) may deepen to the degree that their effect on the wave climate is significantly reduced. The points of wave energy convergence and divergence will change. The new locations of wave energy convergence could be expected to experience an increase in erosion while those locations currently subject to energy convergence could accrete if they are exposed to less energy in future. Changes in wave approach direction will change alongshore currents and alongshore sediment transport.

Low, rocky ledges, such as at Erf 134, Luz de Lua, will therefore experience higher wave energy with higher splash-over thereby enabling a higher runup level reflected as a future Hazard Level as discussed below.

In conclusion, the primary hazards to physical (abiotic) coastal infrastructure related to sea storms and climate change are:

- Extreme inshore sea water levels resulting in flooding and inundation of low-lying areas.
- Changes in storm system characteristics, winds and local wave regime resulting in direct wave impacts.
- Coastal erosion on sandy shorelines and a higher reach of wave energy on rocky shorelines, removal of beaches and dunes on sandy coasts and subsequent under-scouring of, for example, foundations and revetment structures located too close to the high water mark, or at a low elevation on both types of shorelines.
- A combination of extreme events, such as sea storms during high tides plus sea level rise, will have the greatest impacts and will increasingly overwhelm existing and future incorrect placed infrastructure as climate change related factors set in in time.

The main metocean drivers related to the above are thus waves and sea water levels (and to a lesser extent winds and currents). The landward drivers include flash floods that create higher storm water levels along lower beach levels when rivers, storm water drains and canals flow out onto beaches, often at the same time as high energy sea storm waves and surges respond to the same atmospheric conditions (i.e. high waves and high rainfall). This combination often occurs along the southern Cape coastline when a so-called 'cut-off' low pressure system prevails.

5.4 Landward retreat of the shoreline due to sea level rise (SLR)

Due to the hard rocky nature of the foreshore at Erf 134, Luz de Lua, landward retreat (rapid erosion) due to sea level rise is highly unlikely. Some increased collapse of the calcrete rock layers, especially along the northern side of the site (Sections North 2 &3) will occur but with an insignificant risk to the proposed development on Erf 134, Luz de Lua.

5.5 Extreme inshore sea water levels due to climate change

Commissioned by the then national Department of Environmental Affairs (DEA) in 2014, the CSIR produced a research report that summarised the state of knowledge on coastal processes for the SA coastline (in 2014[8].). The report still forms the basis of coastal hazard and vulnerability assessments of the South African coastal region. However, some refinement has taken place and regional information now exists and has been included in demarcating guidelines showing coastal management lines[9] as discussed later.

[8] CSIR (Council for Scientific and Industrial Research). 2014. *Determination of the inshore wave climate along the South African coast – Phase 1 for coastal hazard and vulnerability assessment*. CSIR Report CSIR/NRE/ECOS/ER/2014/0037/A, Stellenbosch.

[9] DEA&DP: Western Cape Government's (WCG) Coastal Management Unit. https://www.arcgis.com/apps/webappviewer/index.html?id=fdfc43db00224a6688cb964b47f713b0

The CSIR report produced estimates of extreme values for realistic combinations of the inshore seawater elevation components as applicable to each SA coastal region. Based on these calculations and the wave conditions, robust first-order (coarse) storm surge levels estimates are provided of the regional storm surge levels around the South African coast for the offshore wave regime.

Stated clearly, therefore, is the reality that although it is at present not possible to reliably estimate climate change related changes in storm patterns, windiness, wave energy or direction, the increase in storm activity and severity will probably be the most visible impact as a risk to vulnerable properties.

The analysis method described in detail in CSIR (2014) was used to determine the storm hazard elevation (m to MSL) along the exposed coastline at Infanta as illustrated in Figure 12.

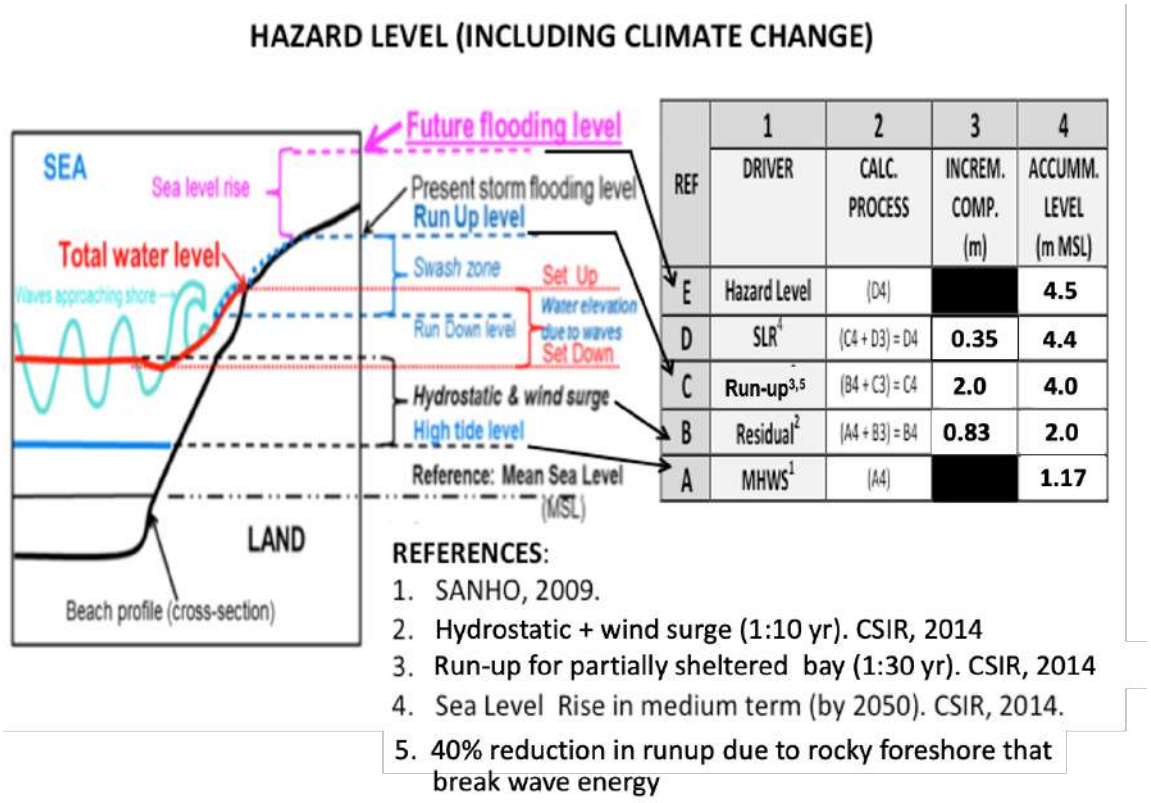


Figure 11: 2050 extreme still water level & wave run-up along the partially sheltered rocky coastline at Infanta for 2050

Figure 11 shows the extreme inshore sea water levels calculated for the study site (using the tidal information available for Mossel Bay (http://www.sanho.co.za), being the closest water level recording station, due to the combination of the various contributing components. The figure shows the increasing water levels all relative to Mean Sea Level (MSL) which is at 0 m elevation. Table 5.1 summarises the calculation of the hazard level.

Table 5.1: Calculation of the storm hazard level

Ref.	Description	Notes	Water level
1	Mean High Water Spring tide (MHWS)	Cell A4 in Figure 11	+ 1.17 m MSL
2	Storm surge as estimated for a 1:10 year return period (Note 1)	Cell B3.	Add 0.83 m (=+2.0 m MSL). [Cell B4]
3	Wave run-up (Notes 2 &3)	Cell C3	Add 2.0 m (=+4.0 m MSL) [Cell C4]
4	Sea Level Rise by 2050 (Note 4)	Cell D3	Add 0.35 m (=+4.4 m MSL) [Cell D4]
5	Storm Hazard level by 2050 (Note 5)	Cell D4 and E4	Add a small safety factor and round up to +4.5 m MSL [Cell E4]

Notes:

1. The storm surge amount includes the effect of a low-pressure weather system ('cold front') passing the coast that results in a local set-up (increase) of the sea water level due to strong onshore winds and low barometric pressure, known as the residual component – Cell B3. Thus, at present, a coastal low pressure system passing the coast during spring tides (which occur every 2 weeks) could result in sea water levels of about +2.0 m above MSL along the coast at Infanta.

2. The above elevations all relate to the still-water level at the shoreline. This should not be confused with the additional effect of wave run-up, which can reach higher elevations. (Wave run-up is the rush of water in the swash zone up the shoreline slope (and a sloping natural rocky shelf) above the still-water level).

3. A 40% reduction in the vertical runup amount is assumed due to the hard and relatively high rocky shelf along the foreshore. This breaks the wave energy effectively.

4. Interpolating for 2050 off the 2011 baseline, the mid scenario (best estimate) for Sea level Rise (SLR) due to Climate Change) is +0.35 m by 2050[10].

[10] Theron, A.K., Rossouw, M., Barwell, L., Maherry, A., Diedericks, G., De Wet, P. (2010). Quantification of risks to coastal areas and development: wave run-up and erosion. CSIR 3rd Biennial Conference 2010. Science Real and Relevant, CSIR International Convention Centre, Pretoria 30 August – 01 September 2010, South Africa. http://hdl.handle.net/10204/4261.

5. The projected SLR by 2100 is 1.0 m thus the 2100 storm hazard level is +5.0 m MSL at Erf 134, Luz de Lua.

The background discussion to extreme inshore sea water levels is provided in Appendix 1.

The example shown in Figure 12 indicates the effect of run-up during a large sea storm. Note that the return period for that particular storm is estimated to be in the region of 1:20 years. Noteworthy is that in South Africa the 1:50 year return period event is normally specified for the location and design of houses and infrastructure. It is important to realise that South Africa has not yet experienced a 1:50 year magnitude sea storm since wave recordings began some 50 years ago.



Figure 12: Example of the effect of a large storm coinciding with a high tide level (Photo: Ethekwini Municipality)

As calculated above, the projected storm hazard level by 2050 is thus at +4.5 m MSL. At Erf 134, Luz de Lua the rocky nature of the shoreline will break some of the wave energy and only wave splash up will occur along most of the southern and northern sections. However at the river/stream outlet the natural elevation is lower and the seafront consists of smaller loose rocks and pebbles. (Figure 7.2). Here the storm surge can reach a level of + 4.5 m MSL by 2050 which includes SLR and a level of +5.0 m MSL by 2100. This will allow seastorm surges to penetrate into the ecological corridor on Erf 134, Luz de Lua on occasion.

5.6 Projected future position of the storm wave runup lines due to coastal processes

The total projected landward retreat of the long-term wave run-up position and the position of the average long term HWM lines at the site due to coastal processes are shown in Figure 13.1 to 13.7 for the profiles

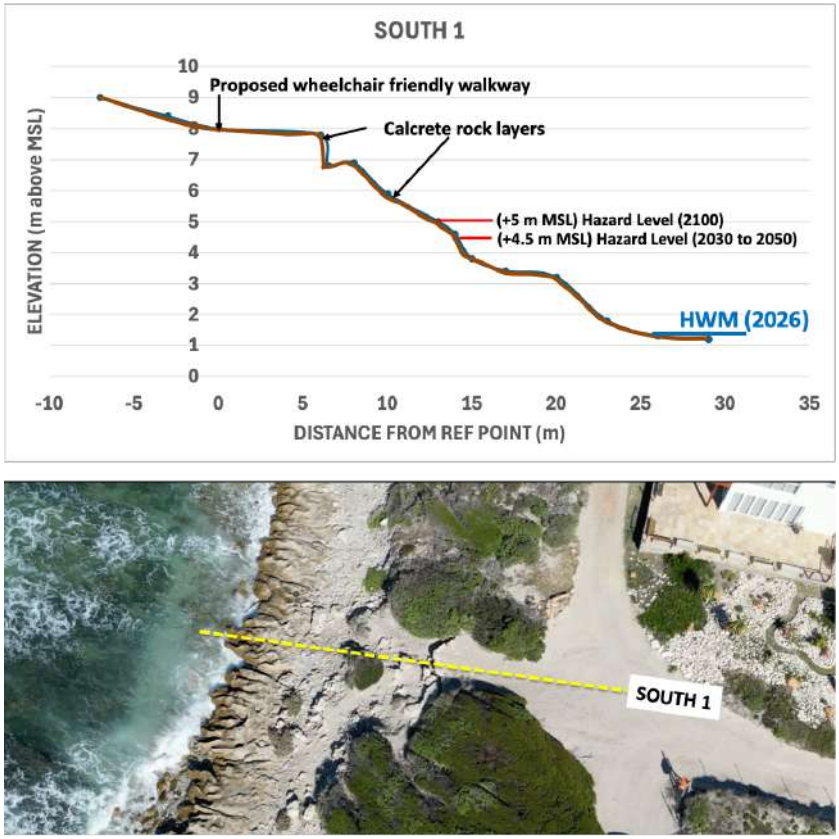


Figure 13.1: Projected hazard levels included SLR at South 1.

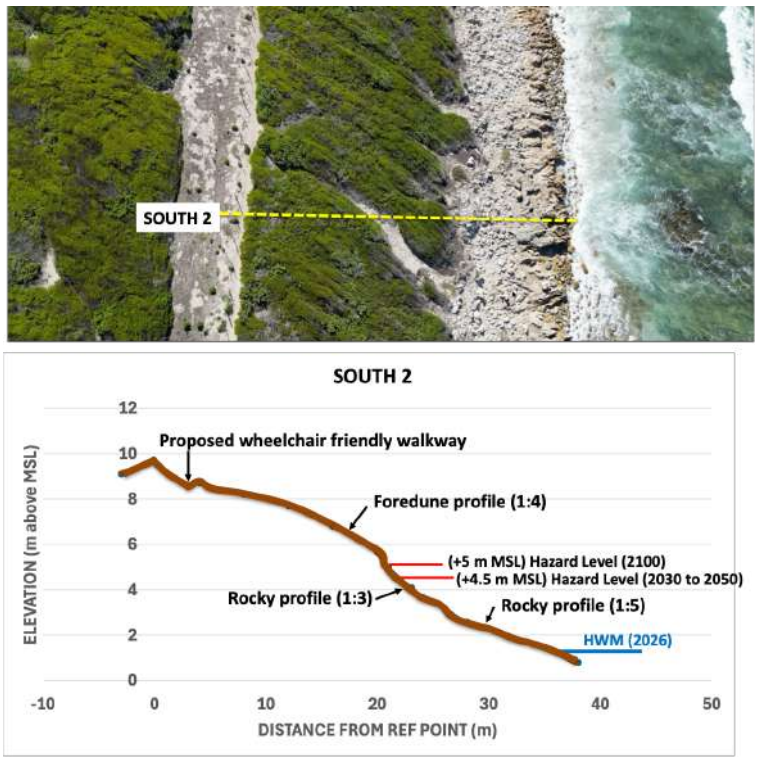


Figure 13.2: Projected hazard levels included SLR at South 2.

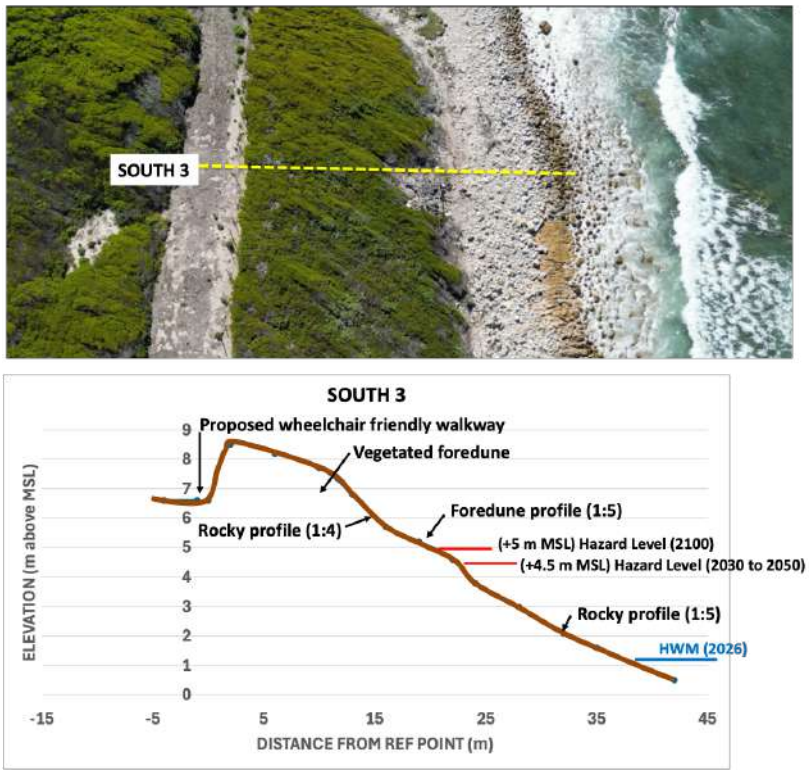


Figure 13.3: Projected hazard levels included SLR at South 3.

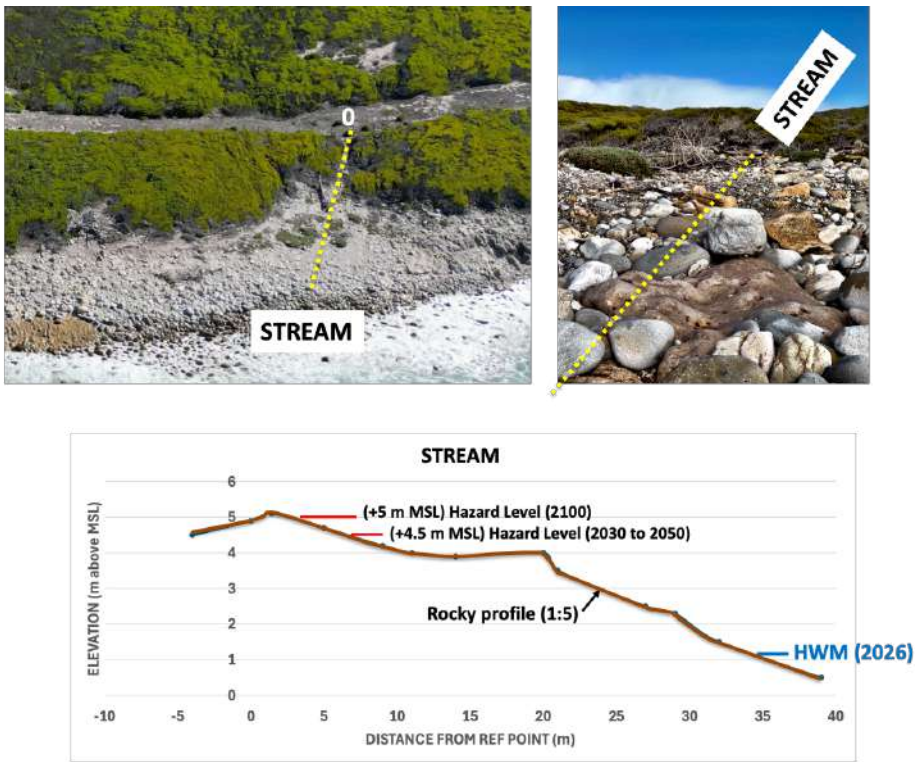


Figure 13.4: Projected hazard levels included SLR at the STREAM outlet.

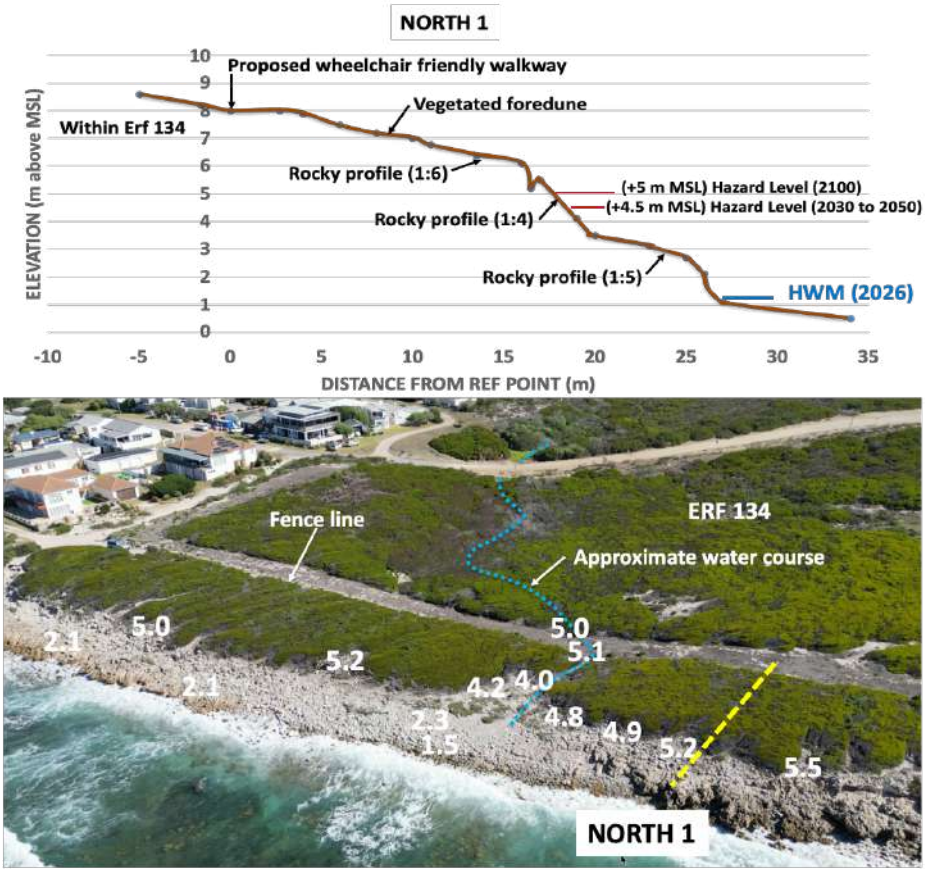


Figure 13.5: Projected hazard levels included SLR at North 1.

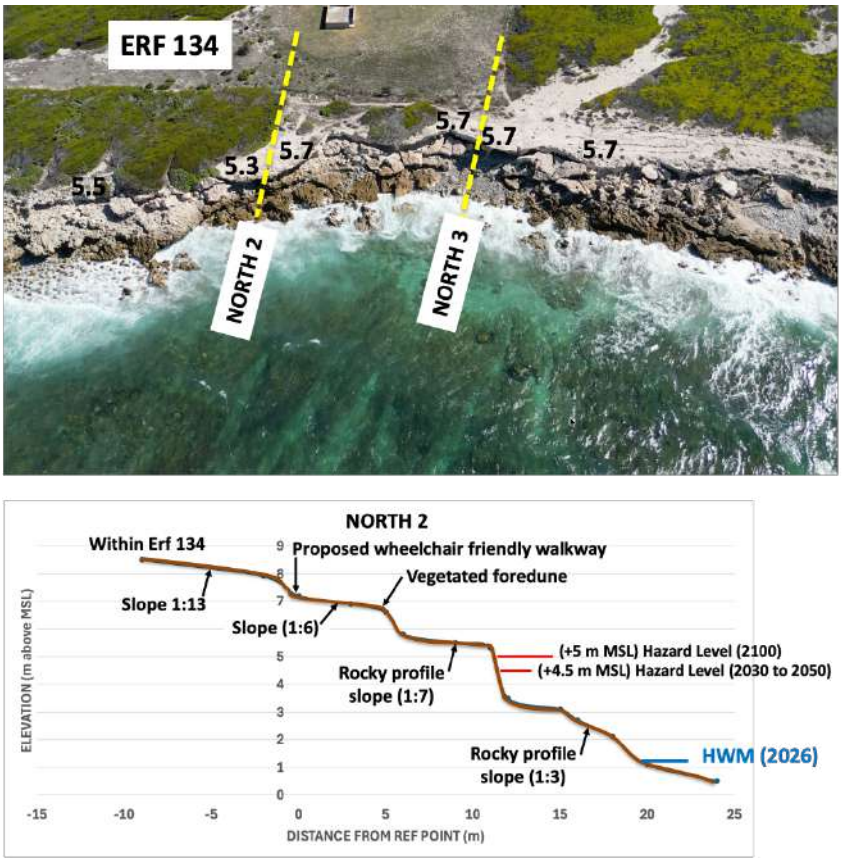


Figure 13.6: Projected hazard levels included SLR at North 2

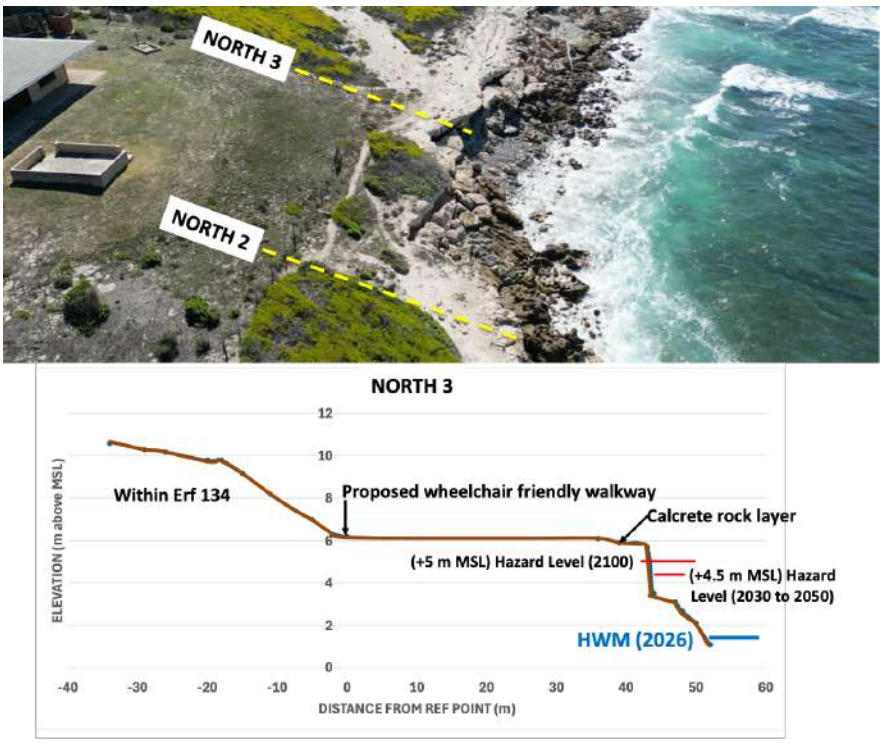


Figure 13.7: Projected hazard levels included SLR at North 3.

6. WC DE&DP COASTAL MANAGEMENT LINES

6.1 Introduction and Guidelines

The Western Cape Department of Environment Affairs and Development Planning (DEA&DP)[11] makes available their Coastal Management viewer to enable guidance on the co-called Coastal Management Lines. The Overberg District Coastal Management lines for the coastline at Erf 134, Luz de Lua are shown in Figure 14. Here the 20yr, 50yr and 100yr risk lines as well as the high water mark are shown.

The projected runup lines are seen to all converge a short distance landwards of the high water mark. This is realistic considering the high rocky foreshore along this stretch of coastline.



Figure 14: Low, Medium and High risk lines: DEA&DP Coastal Management App - Annotations added

[11] DEA&DP: Western Cape Government's (WCG) Coastal Management Unit. https://www.arcgis.com/apps/webappviewer/index.html?id=fdfc43db00224a6688cb964b47f713b0

6.2 Conclusion

Due to the rocky nature and relative high elevation of most of the shoreline and a large area within Erf 134, Luz de Lua, the storm wave hazard lines up to 2100 (with a projected 1.0 m SLR) are well within a manageable area.

7.DEVELOPMENT SETBACK LINE AT ERF 134, LUZ DE LUA

7.1 Introduction

Three natural drivers of change that separately and collectively guide the spatial placing and elevation of the development at Erf 134, Luz de Lua. These are:

i The ecological 'wetland' buffer corridor defined as 20 m on either side of the river centreline (Figure 6);

ii the river flood line within the property before the floodwater reaches the sea. A report by FRASER Consulting Civil Engineers[12] shows the 100yr flood line for the property. The results are included in this report; and

iii sea storm surge due to coastal processes. This line includes sea level rise due to climate change and is called the 2100 Hazard Line (Section 5).

This report addresses the integration of (ii) and (iii) and defines it as the 'Development Setback Line' (Figures 15 and 6.).

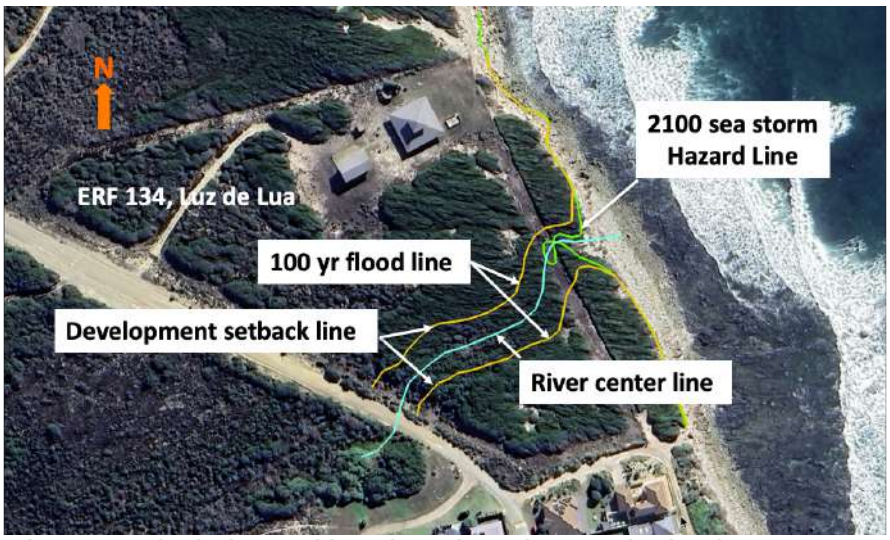


Figure 15: Development Setback Line combines the estimated 100 yr Flood and 2100 Sea Storm Hazard Lines

[12] FRASER Consulting Engineers cc. 100 yr Flood line for Erf 134, Luz de Lua. AF134-04 Rev 3. 12 December 2020.

8.WHEEL-CHAIR FRIENDLY COASTAL WALKWAY

8.1 Introduction

As specified in the NEM: Integrated Coastal Management Act (Responsibilities of Municipalities with respect to Coastal Access Land), safe and effective public access to the coastline is required.

The Coastal Access Audit report[13] for the Overberg (Figure 16) concludes that the coastline at Erf 134, Luz de Lua allows for vehicular access. This may be an error although unrestricted pedestrian access is possible. Vehicles can only park informally at the southern end of Erf 134, Luz de Lua where there is a treacherous informal pedestrian path across the rocks to the shoreline (see Figures 13.1 and 17).

Figure 16 is a screenshot taken from the report and shows the audit results.

The topography along the shoreline at Erf 134, Luz de Lua allows for the positioning of a formal wheel-chair friendly boardwalk as discussed as a conceptual design. below.

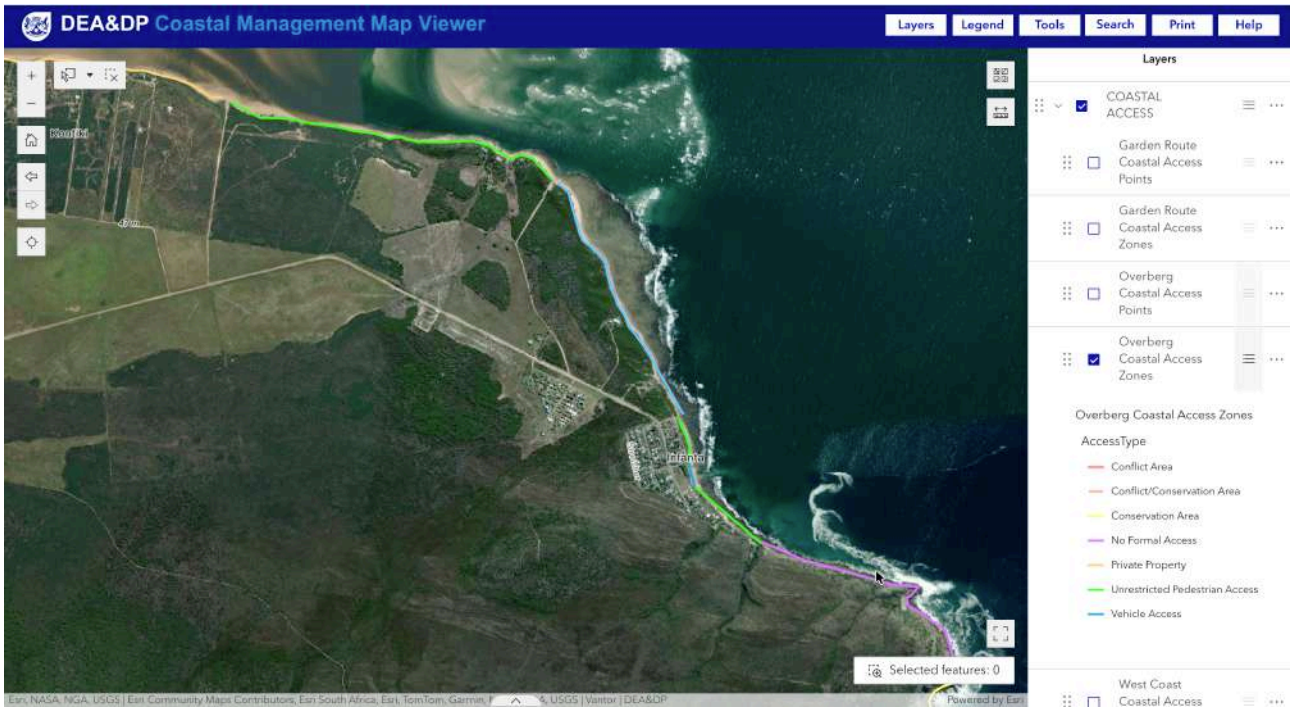


Figure 16: DEA&DP Access Audit

[13] DEA&DP (2019) WCPCASP: Garden Route Coastal Access Audit – Main Report. Western Cape Department of Environmental Affairs and Development Planning, Cape Town. Western Cape Department of Environmental Affairs and Development Planning, Cape Town.

The current coastal access at the site consists of an informal footpath as shown on Figures 17 and 18.

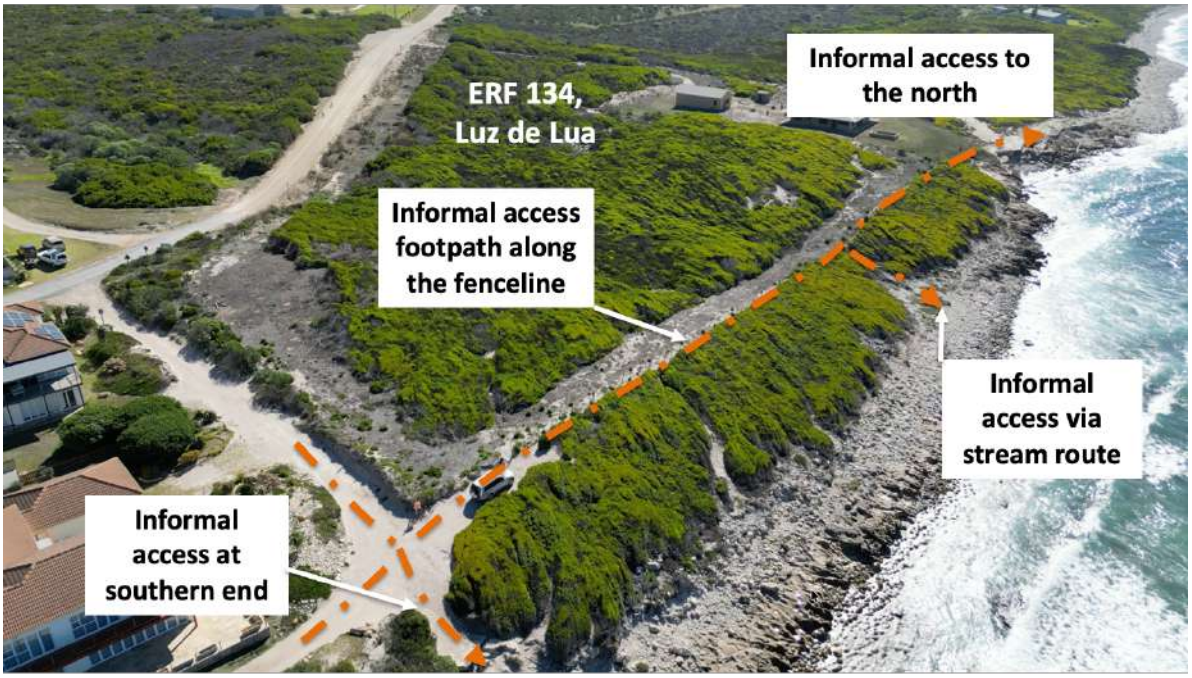


Figure 17: Current informal access routes

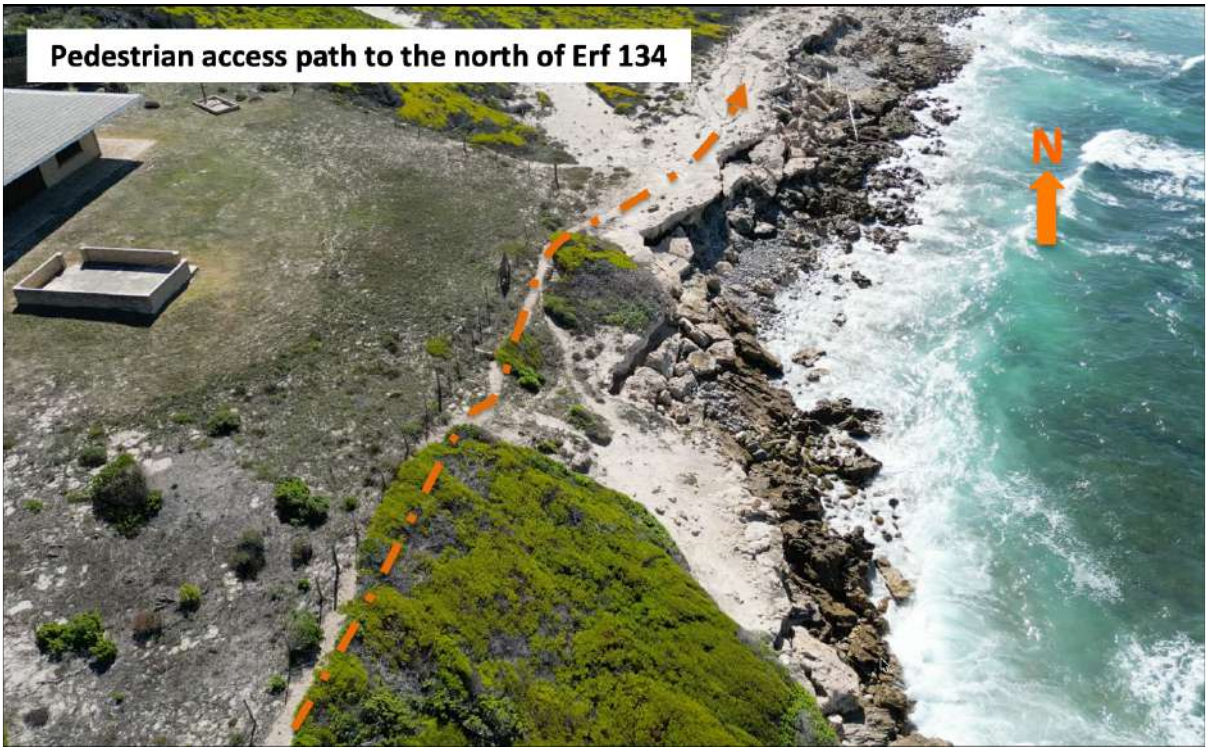


Figure 18: Current coastline access at Erf 134, Luz de Lua

It is possible to install a wheel-chair friendly boardwalk along the same alignment of the current informal footpath. Clear design parameters are required for wheel chairs which include a minimum width (usually 2 m to allow safe passing), mild slopes (1:20 to allow for self-propelled movement) and resting areas every 30 m. It is also possible to provide access steps to the coastline at the river/stream outlet for the general public to reach (and exit) the relatively more comfortable rocky coastline safely. This access should be designed to allow for the storm runup surges at (infrequent) times. Wheel-chairs could then proceed northwards along the cliff if this route is formalised, which is easily done.

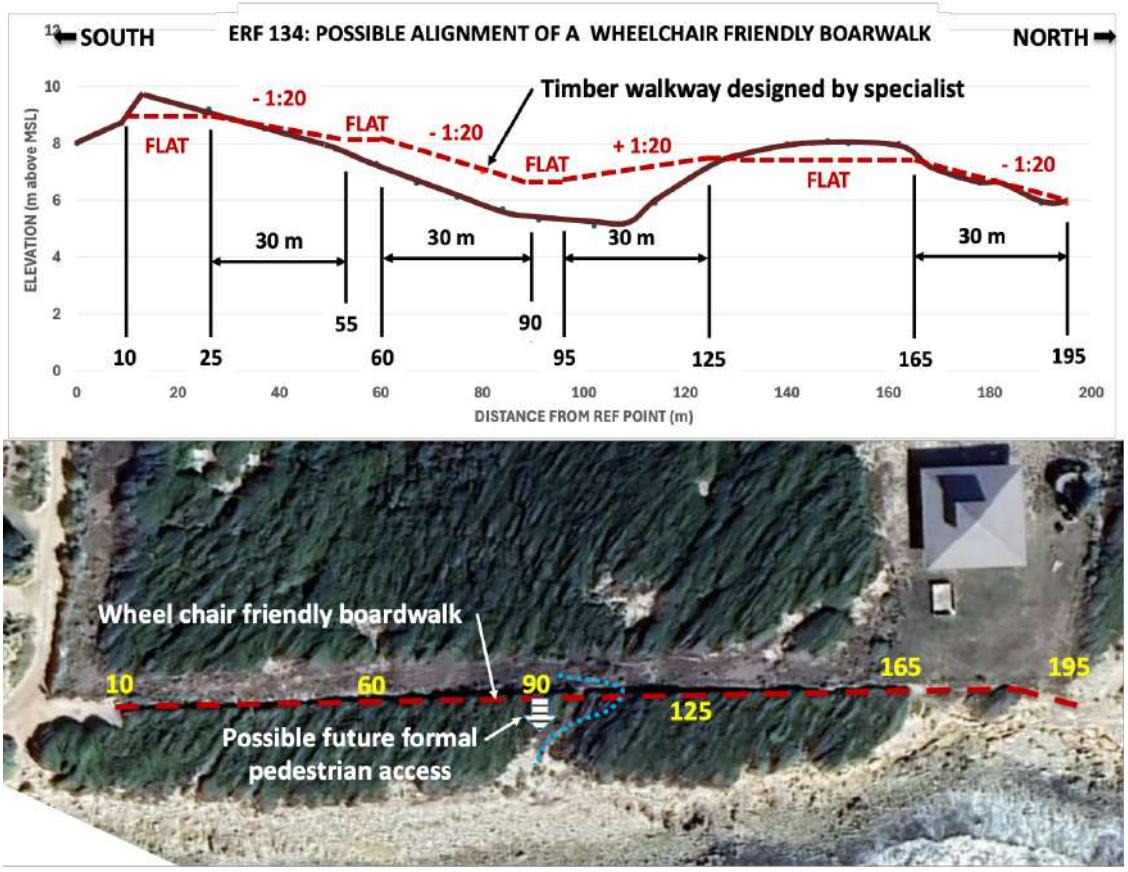


Figure 19: Proposed wheel-chair friendly boardwalk.
Position of possible (future) formalised pedestrian access steps also shown

9. CONSIDERED OPINION WITH REASONING

It is the author's considered opinion that the development setback line will allow for positioning the proposed infrastructure beyond the reach of the natural processes of floods and the sea including the influence of climate change and in particular Sea Level Rise

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APPENDIX 1: Extreme inshore sea water levels

(Extract from CSIR, 2012, written by Theron, A.K. (PhD))

Significant drivers of high inshore sea water levels are tides, wind set-up, hydrostatics set-up, wave set-up and, in future, sea-level rise due to climate change (Theron, *et al* 2010). These drivers all affect the still-water level at the shoreline.

The drivers/components of extreme inshore sea water levels most significant to the Southern African context are the tides (South African spring tides are about 1 m above mean sea level (MSL)), potential SLR, and wave run-up. Theron (2007) has estimated that in the South Africa (SA) setting during extreme events, these components could each contribute additional amounts (heights) of between about 0.35 m to 1.4 m to the inshore sea water level. Note that potential additional impacts of climate change (e.g. more extreme weather events) on wind-, hydrostatic- and wave set-up are not included in the above range of increase.

Recent observations from satellites, very carefully calibrated, are that global sea level rise over the last decade has been 3.3 +/- 0.4 mm/y (Rahmstorf *et al*. 2007)). The IPCC AR4 Report (IPCC 2007) concludes that anthropogenic warming and sea level rise would continue for centuries due to the timescales associated with climate processes and feedbacks, even if greenhouse gas concentrations were to be stabilised. Comparisons between about 30 years of South African tide gauge records and the longer term records elsewhere, show substantial agreement. A recent analysis of sea water levels recorded at Durban confirms that the local rate of sea level rise falls within the range of global trends (Mather 2008). Present SA SLR rates are: west coast +1.87 mm/y, south coast +1.47 mm/y, and east coast +2.74 mm/y (Mather *et al*. 2009).

The probability of sudden large rises in sea level (possibly several metres) due to catastrophic failure of large ice-shelves (e.g. Church and White 2006) is still considered unlikely this century, but events in Greenland (e.g. Gregory 2004, Overland, 2011) and Antarctica (e.g. Bentley 1997; Thomas *et al*. 2004) may soon force a re-evaluation of that assessment. In the longer term the large-scale melting of large ice masses is inevitable. Recent literature (since IPCC 2007) gives a wide range of SLR scenarios, as indicated in Figure A6.1.

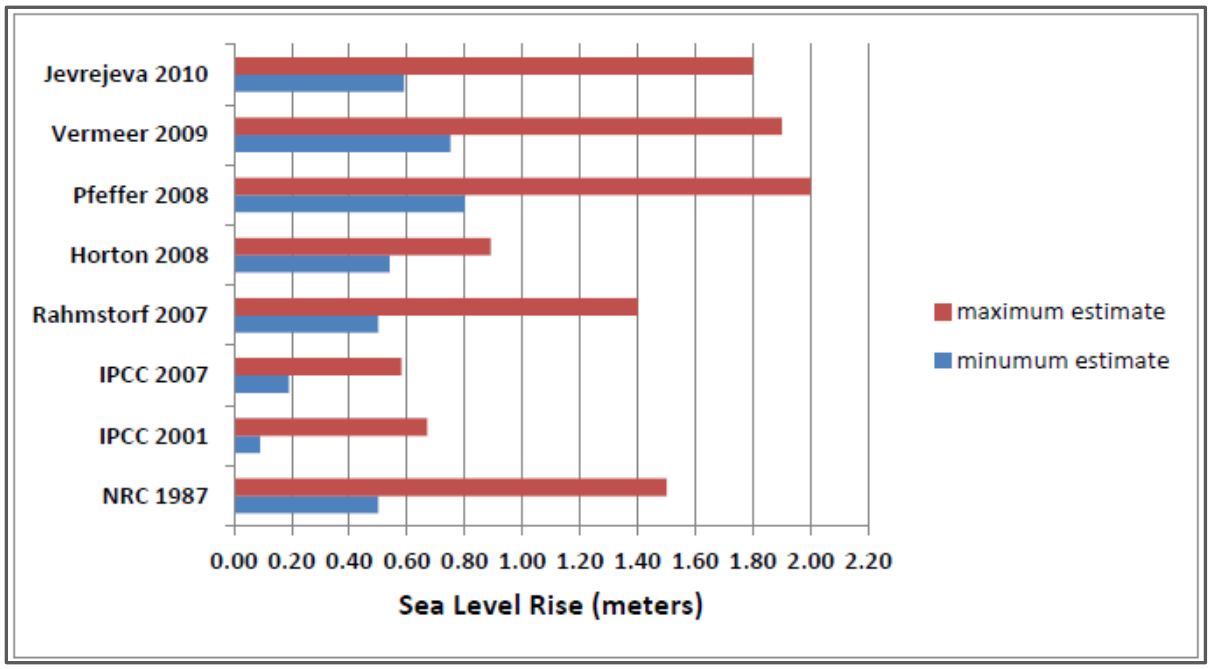


Figure A6.1: Comparison of minimum and maximum estimates of global SLR by year 2100 (USACE, 2011)

Some projections and scenarios are even higher, but most "physics/process based" projections (e.g. Nicholls and Cazenave 2010; Pfeffer *et al* 2008; Milne *et al* 2009; SWIPA 2011) for 2100 are in the 0.5 m to 2 m range, (Fig A6.2) as is also concluded in various reviews (e.g. Theron and Rossouw 2009; Fletcher 2009). It is concluded that the best estimate ("mid scenario") of SLR by 2100 is around 1m, with a plausible worst case scenario of 2m, and a best case scenario of 0.5 m. The corresponding best estimate ("mid scenario") projection for 2050 is 0.3 m to 0.5 m.

The drivers of inshore water levels should not be confused with the added effect of wave run-up, which can reach even higher elevations. Wave run-up is the rush of water up the beach slope beyond the still-water level in the swash zone. According to surveyed elevations (Smith *et al*. 2010), maximum run-up levels on the open Kwazulu-Natal (KZN) coast near Durban during the March 2007 storm (which coincided with highest astronomical tide) reached up to about +10.5 m MSL. Note that wave set-up and run-up are both accounted for in these levels. The maximum wave run-up alone during the 2007 KZN storm is estimated to have been up to about 7 m (vertical), resulting from significant nearshore wave heights of about 8.5 m.

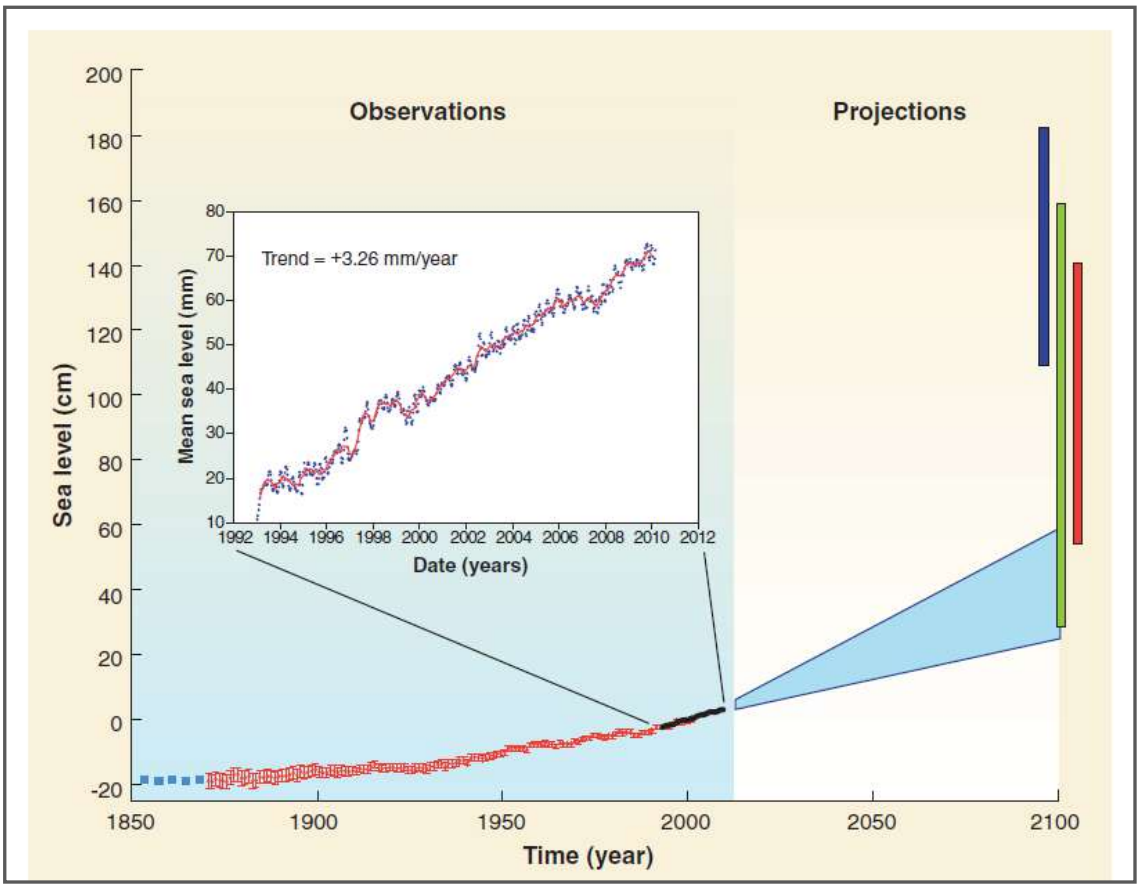


Figure A6.2: Measured and project sea level rise (Nicholls and Cazenave 2010). (The blue, green and red bars are projections from different Author.)

Around southern Africa wave run-up is thus an important factor, which may be considerably exacerbated by tides and future SLR (Theron, *et al* 2010).

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