Coastal Adaptation Study
for Alexandrina Council

BOOMER-KNIGHT BEACH

By Integrated Coasts: Western, Hesp, and Bourman (2019)

Report to be cited as: Western, M, Bourman, R., Hesp, P (2019) Coastal Adaptation Study for Alexandrina Council (Cell SF9 Boomer-Knight Beach) prepared by Integrated Coasts, South Australia.

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Front cover picture: Coast Protection Board, oblique photograph, 2008

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Introduction

This document is a partial output for the Coastal Adaptation Study for Alexandrina Council (Boomer-Knight Beach Cell SF9). This document also represents an output from the coastal adaptation assessment tool designed by Integrated Coast.

This document should be read in conjunction with the main report, *Coastal Adaptation Strategy for Alexandrina,* that explains more fully the underpinning methodology. Definition of terms within this work are adopted from www.coastadapt.com.au (Glossary).

ASSESSMENT FRAMEWORK

This coastal assessment tool adopts a simple and intuitive framework. Coastal hazards experienced along a section of a coastline can be categorised and assessed in three main ways:

- **Coastal fabric (geology)**

Intuitively we understand that if we are standing on an elevated coastline of granite that the coast is not easily erodible. Conversely, we understand if we are standing on a low sandy dune that erosion may indeed be a factor. It is the geology of the coast upon which our settlements are situated that determines one side of the hazard assessment in terms of elevation (height above sea level), and the nature of the fabric of the coasts (how resistant it is to erosion). This assessment tool categorises coastal geology in four main ways:

(1) Low erodibility
(2) Moderate erodibility
(3) High erodibility
(4) Very high erodibility

- **Coastal modifiers (human intervention)**

In some locations there are additional factors that modify this core relationship between fabric and exposure. For example, an extensive rock revetment has been installed from Brighton to Glenelg along the Adelaide coastline. This installation has modified the fabric of the coast from dunes to rock.

- **Coastal exposure (actions of the sea)**

If we find ourselves on the shore of a protected bay, or in the upper reaches of a gulf, we intuitively know that the impact from the ocean is likely to be limited. On the other hand, if we are standing on a beach on the Southern Ocean and listening to the roar of the waves, we understand that we are far more exposed. This assessment tool categorises coastal exposure in four main ways:

(1) Very sheltered
(2) Moderately sheltered
(3) Moderately exposed
(4) Very exposed

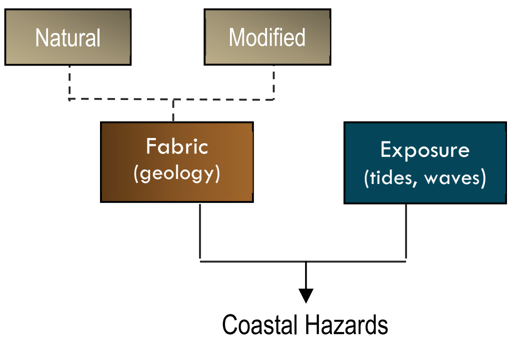
CHANGES IN THE RELATIONSHIP

Finally, in a coastal adaptation study, we are also interested to know how this relationship between ***fabric*** and ***exposure*** may change over time, and what this may mean in the context of our coastal settlements.

Our sea levels have been quite stable for several thousand years. However, in recent times, the rate of sea level rise has escalated. Last century, sea levels rose at ~2-3mm per year. In this century, seas are rising on average at ~4-5mm per year in our region. The general consensus of the scientific community is that the rate of sea level rise will continue to escalate towards the end of this century (~10-15mm per year). These projections are based on sound physics, but the exact rate is uncertain.

What is certain is that if seas rise as projected then the relationship between fabric and exposure will change significantly in some coastal locations.

Figure 1: Conceptual framework



What we aim to do in this project is to evaluate the relationship between the ***fabric*** of the coastline and its current ***exposure*** to actions of the sea and how this relationship may change over time. We conduct this evaluation within the regional setting of secondary coastal cell **Fleurieu southeast coast** (CoastAdapt) and within tertiary cell **Southern Fleurieu 9** (Nature Maps).

These cells are depicted on the following pages.

Introduction

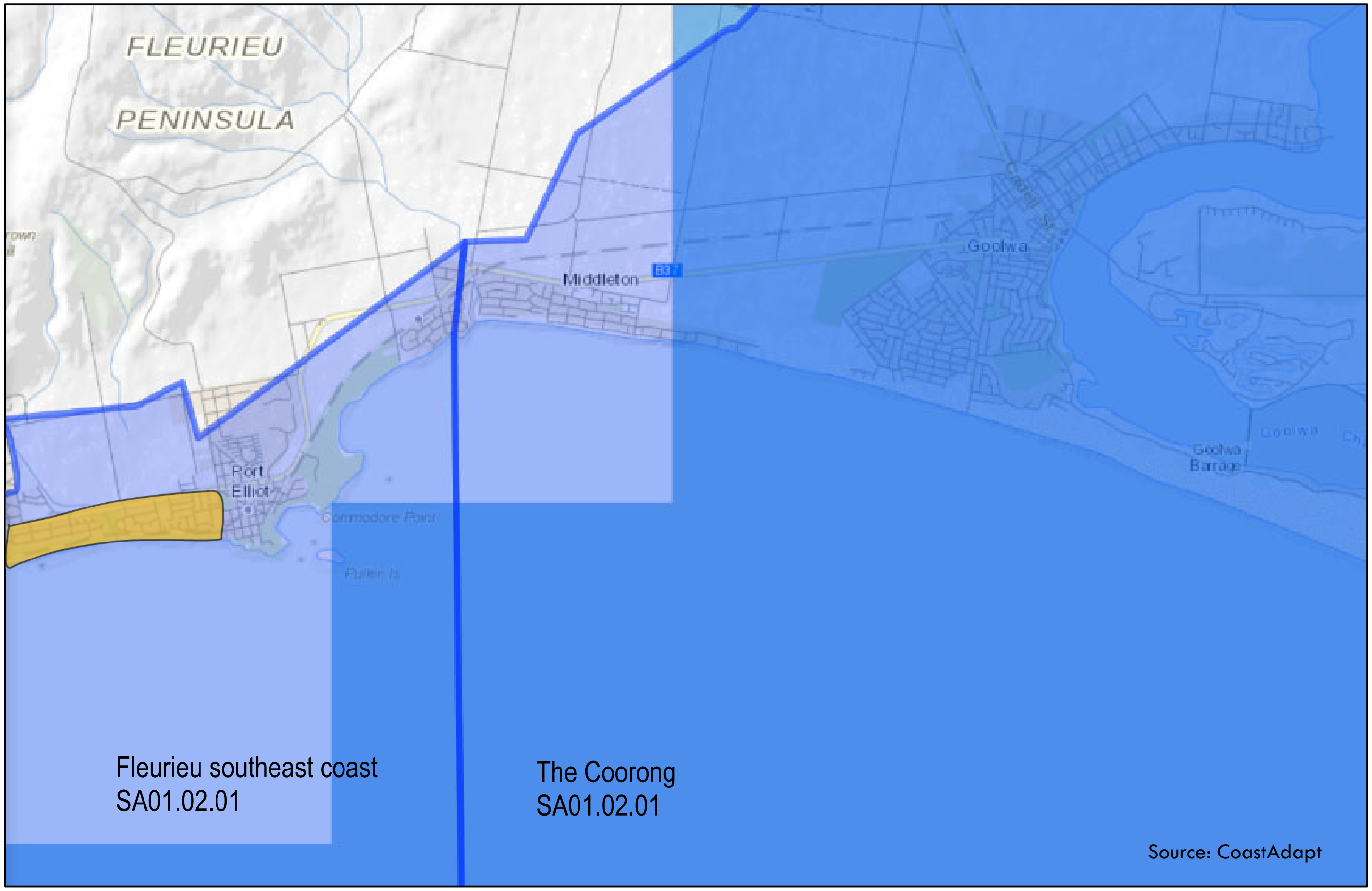
Regional Setting

Map: SF9

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Boomer-Knight

Secondary Cell



Source: CoastAdapt

Nature Maps

CoastAdapt:

Australian regional setting
Cell: Fleurieu - southeast coast.

Geomorphology of the cell:
Exposed, south facing, bedrock dominated, moderate-high energy coast with some embayed wave dominated beaches.

Outcrops of Encounter Bay Granite dominate the Port Elliot cell forming headlands, islands, and rocky reefs. The resistant granite has a strong influence on the orientation of approaching waves, which have moulded sandy bays such as Horseshoe Bay and Crockery Bay.

The dominant regional processes influencing coastal geomorphology in this region are the Mediterranean to humid cool-temperate climate, micro-tides, high energy south-westerly swells, westerly seas, carbonate sediments with interrupted swell driven longshore transport, and the Southern Annular Mode (driving dominant south-westerly swells and storms). Regional hazards or processes driving large scale rapid coastal changes include: mid-latitude cyclones (depressions), storm surges and shelf waves.
Source: https://coastadapt.com.au/sites/default/files/docs/sediment_compartments/SA01.03.01.pdf

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Introduction

Regional Setting

Map: SF9

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Boomer-Knight

Minor cells: Boomer and Knight

Tertiary Cell

Nature Maps

Shoreline class
Longshore bar and trough and low tide terrace.

Sand rating
Fine-medium sandy beach

Exposure:
Moderate

Wave:
Moderate

Form:
Low-moderate 3-10 deg (slope is 1:34 to -10m mark)

Backshore 1:
Cliff 5m to 20m high

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1. SETTLEMENT HISTORY

A historical review ensures that the circumstances in which the settlement was founded are understood and key documents and events are identified and reviewed. In this section we:

- Give a brief history of the settlement
- Review archives at Coastal Management Branch
- Identify key studies and plans (NIL)

1. Settlement history

The first purpose of this section is to identify the key factors of settlement history in the context of the coastal environment. The purpose is not to provide a comprehensive historical account. In particular, we are interested in identifying any key ocean impacts, and past protection and management strategies. A second purpose is to identify key studies and plans so that we build appropriately upon previous work.

BRIEF HISTORY

Goolwa to Victor Harbor trainline

The first urban infrastructure constructed in the Boomer Beach area was the extension of the Goolwa railway line from Port Elliot to Victor Harbor in the 1850s, including a bridge over Watson Gap (See Cell SF10).

The land upon which the trainline is situated is Crown Land owned by the State Government. Currently the railway line is leased to Australian Railways Historical Association until 2026 who operate the Steam Ranger tourist train between Victor Harbor and Goolwa[1].

The trainline effectively divides the backshore of Boomer beach into two sections (Figure 2).

From a coastal adaptation viewpoint, as a first line of defence, the State Government is likely to be responsible to protect the railway line. As long as the State Government protects the line, Council and private infrastructure will be protected behind the line.

[1] Telephone call, Crown Lands, DEW on 1/04/19

Residential expansion

Residential expansion into the Knight Beach area is likely to have occurred in the 1890s as part of the southern expansion of Port Elliot[2]. A survey plan drawn around the turn of the century depicts the original cadastral layout (Figure 3).

The original subdivision for Boomer Beach is likely to have been drawn in the 1950s. A plan drawn before 1975 shows that the coastal area of Boomer Beach was developed by this time, and thus prior to any requirement to take sea level rise into account (see next page 19750424).

A review of recent cadastral plans demonstrates that some urban consolidation has been undertaken in the area in the form of new houses on smaller allotments, row dwellings, and semi-detached dwellings (Figure 5).

The typical coastal planning configuration for the Alexandrina Council has been to construct an esplanade road between the coast and urban development. One exception to this rule is the western end of Barbara St (see figures 4,5).

Key Point

The Goolwa to Victor Harbor railway line is owned by the State Government and dissects the backshore of Boomer Beach. As long as the State Government protects the railway line, public and private infrastructure will also be protected behind the line.

[2] Port Elliot and Goolwa Heritage Study, p. 8,10

Figure 2: The Goolwa to Victor Harbor railway line dissects the backshore of Boomer Beach

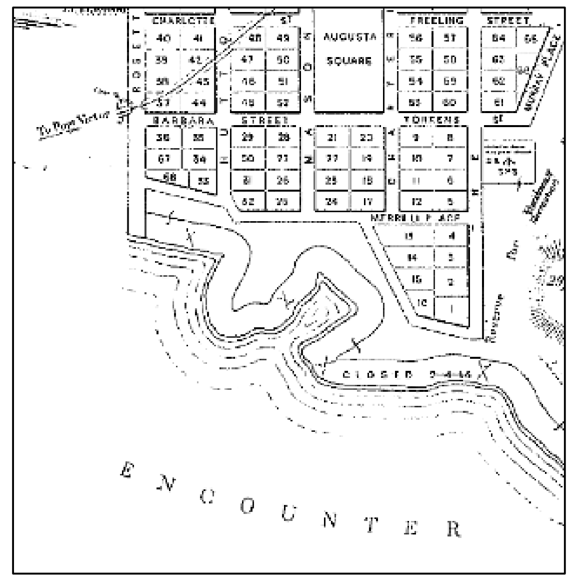

Figure 3: The subdivision behind Knight Beach was completed circa 1890s

1. Settlement history

ARCHIVAL REVIEW

Records exist in hardcopy within the archives of Coastal Management Branch from 1974 to 1983. Scans are referenced within text according to date. Only one item was located relating to Boomer Beach.

Boomer Beach drain

In 1975 'The Railways' installed two pipes under the trainline at the 'end of Barbara Street' (19750424). A report by Coast Protection Branch noted that the two pipes installed by 'The Railways' had caused the dune edge to retreat 25m and was now threatening the stability of the trainline itself (19800225). Cost of repairs was $5272 of which Council paid half (19800326). In 1986 'severe erosion from stormwater outlet' was again raised by the Council but no further entries exist in the file.

Key Points

The residential area behind Knight Beach was established in late 1890s.

Boomer Beach was likely established in the 1950s (but definitely by 1970s). Both of these expansions pre-date the requirement to take the impact of sea level rise into account.

The usual urban coastal configuration within Alexandrina Council is to have a coastal reserve, esplanade road, and then residential development. The exception to this rule is the west end of Barbara Street.

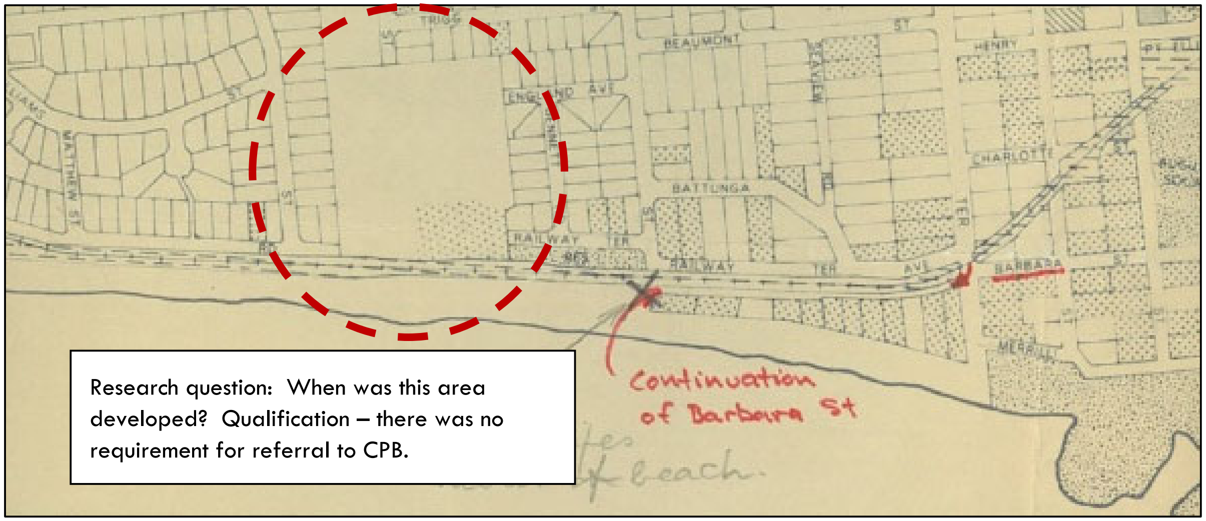

Figure 4: Portion of 1975 cadastral plan showing initial subdivision(s) and location of storm water problems.

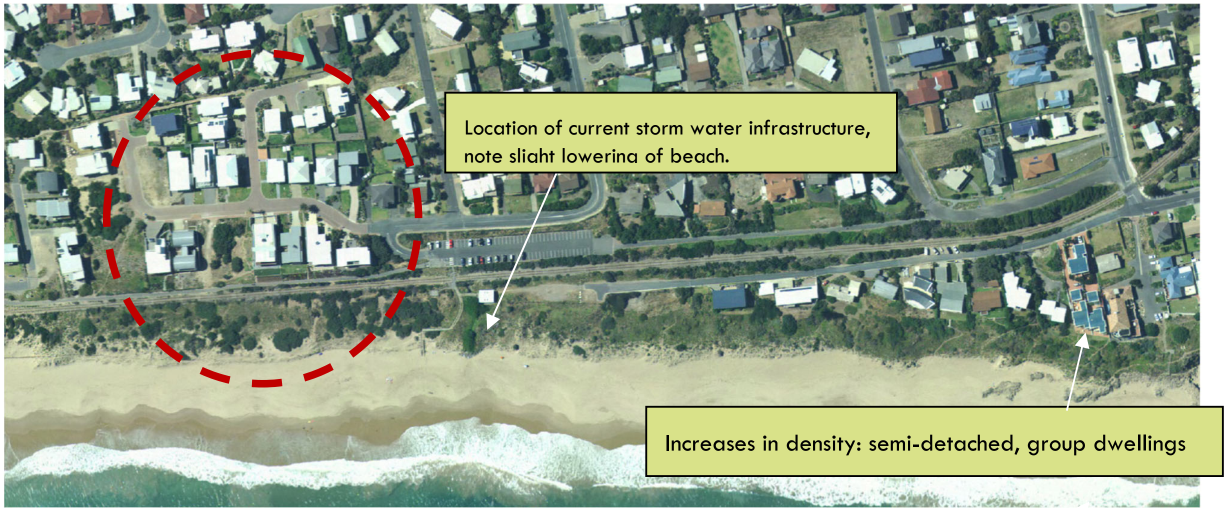

Figure 5: Location of current storm water infrastructure and examples of increased density.

2. GEOMORPHOLOGY

2. Geomorphological context

How the geology (fabric) of the coast has changed over time.

By Dr Robert Bourman
See full version in Part 1 of the report

COASTAL FORMATION

Today we live in an interglacial period, the most equitable time for human beings. The previous time in Earth history was about 125,000 years ago during what is called the Last Interglacial when locally it was warmer and wetter than at present with sea level being 2-5m higher than present.

Tectonic Movement

Relicts of the geological history of the area are preserved in places along the Alexandrina Coastline. Ancient metamorphic and granitic rocks at Middleton and Port Elliot bring stability to the shoreline at those locations. Permian glacial sediments and alluvium of the last interglacial age form the back shore of easily eroded coastlines, while offsets of limestones of various ages record the tectonic behaviour of the area. In particular, offsets of the last interglacial shoreline (125,000 years old), which originally stood at ~2m above present sea level confirm the ongoing tectonic uplift of the Mount Lofty Range and the South East Coastal Plain, with subsidence occurring in the Murray Estuary. Consequently, most of the study area is undergoing subsidence at an approximate rate of 0.02mm/yr.

Modern coastline

The modern coastline developed after sea level rose between 17,000 and 7000 years ago at a rate of ~10mm /year at the end of the Last Glacial Maximum. With sea level rise, large reserves of sand, including the last glacial maximum desert dunes on the exposed continental shelf, were carried landward, providing source material for the modern beaches and dunes. The coastline east of Middleton Creek is very dynamic, changing with variations in sea level, wind, storm waves and tidal conditions. A prominent feature of this section of coastline has been recent coastal erosion, which as been particularly marked in the softer rocks of the Middleton to Goolwa Section of the coastline.

KEY POINTS

- Land areas to the east of Watson Gap are subsiding, but at a very low rate of 0.02mm/ yr.
- The coastline from Middleton to Goolwa is very dynamic and has undergone significant erosion in times before the 1950s.

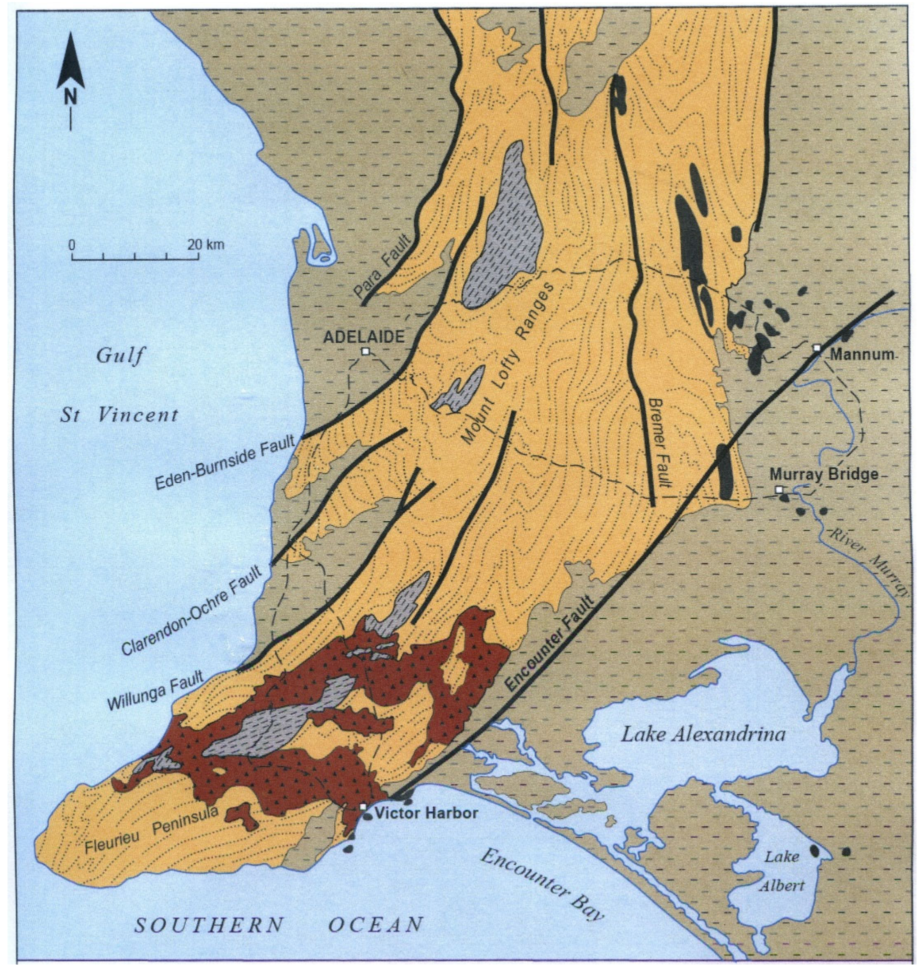

Figure 6: The location of the Encounter Fault, which runs out to sea near Watson Gap. This fault separates the uplifting Mount Lofty Ranges, on which sits the Chiton to Watson Gap coastal sector, from the subsiding Murray Basin, the setting for the remainder of the Alexandrina Coast.

2. Geomorphological context

By Dr Robert Bourman
See full version in Part 1 of the report

Watson Gap to Port Elliot

Watson Gap is marked by a change in the coastal geology from Permian glacial sediments ~300 million years old, to a consolidated Pleistocene coastal sand dune about 250,000 years old. A stream at Watson Gap, which is backed by a low-lying swamp area, breaches the coastline. This is a potential area for oceanic ingress with a rising sea level.

Between Watson Gap, Boomer Beach and Knight Beach the coastline is backed by Pleistocene aeolianite or calcarenite. The age of this former coastal dune now hardened (lithified) and its upper surface protected by resistant white limestone (calcrete), has been established as 266±34 ka (thousand years), formed during the high sea level of an isotopic stage 7e, or penultimate last interglacial age. The nearest equivalent dune forms the Point Sturt Peninsula. Even though the dune formed during an interglacial, sea level then was not quite as high as now, probably only coming up to 6 m below present sea level. Furthermore, this locality is in the Murray Basin, which has subsided since the dune originally formed. This explains why there are shore platforms and small cliffs in the intertidal zone, formed by coastal erosion of the ancient lithified dune, which extends well below sea level.

Figure 7: 1949 aerial photograph of the coast between Watson Gap and Port Elliot. This coastal sector is backed by a fossil, consolidated (lithified) sand dune ~250,000 years old with a hard limestone (calcrete)

Erosion of the aeolianite produces an ongoing supply of beach sand to the area. This sand at Knight Beach and Boomer Beach is stripped from the beach during storm conditions, exposing greater areas of shore platforms, and forms offshore sand bars from which the sand is returned to the beach during calmer conditions.

The coast from Chiton to Knight Beach is essentially a self-contained beach compartment, although under extreme conditions storm waves can entrain beach sediment and bypass the granite headlands into the bays to the east.

Figure 8: View to the west from granite mass at Knight Beach. Towards Boomer Beach. Note the consolidated former sand dune in the intertidal zone, which helps to protect the shore from erosion.

BOOMER BEACH

COASTAL FABRIC

In this section we evaluate coastal fabric in more detail:

- Overview of the current coastal fabric
- Changes to shoreline over seventy years
- Changes to seafloor since 1977
- Human intervention (coastal modifiers)

3. Coastal Fabric - natural

Overview

Map: SF9-1

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Boomer Beach

Form

Beach

Fine-medium sandy beach

Backshores

Backshore 1: Sand dune (10-16m high)

Backshore 2: Steeply sloping soft rock shore rising above 27m AHD at 300m inland.

Bathymetry

Overall slope of ocean floor: -10m ~1km from beach (overall slope ratio 1:100) or <5 deg.

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3. Coastal Fabric - natural

Overview

Map: SF9-1

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Boomer Beach

Geology

Geology

Dr Bourman

The coastline is backed by Pleistocene aeolianite or calcarenite. A former coastal dune now hardened (lithified) and its upper surface protected by resistant white limestone (calcrete) Pleistocene aeolianite or calcarenite.

Figure opposite sourced from www.sarig.gov.au

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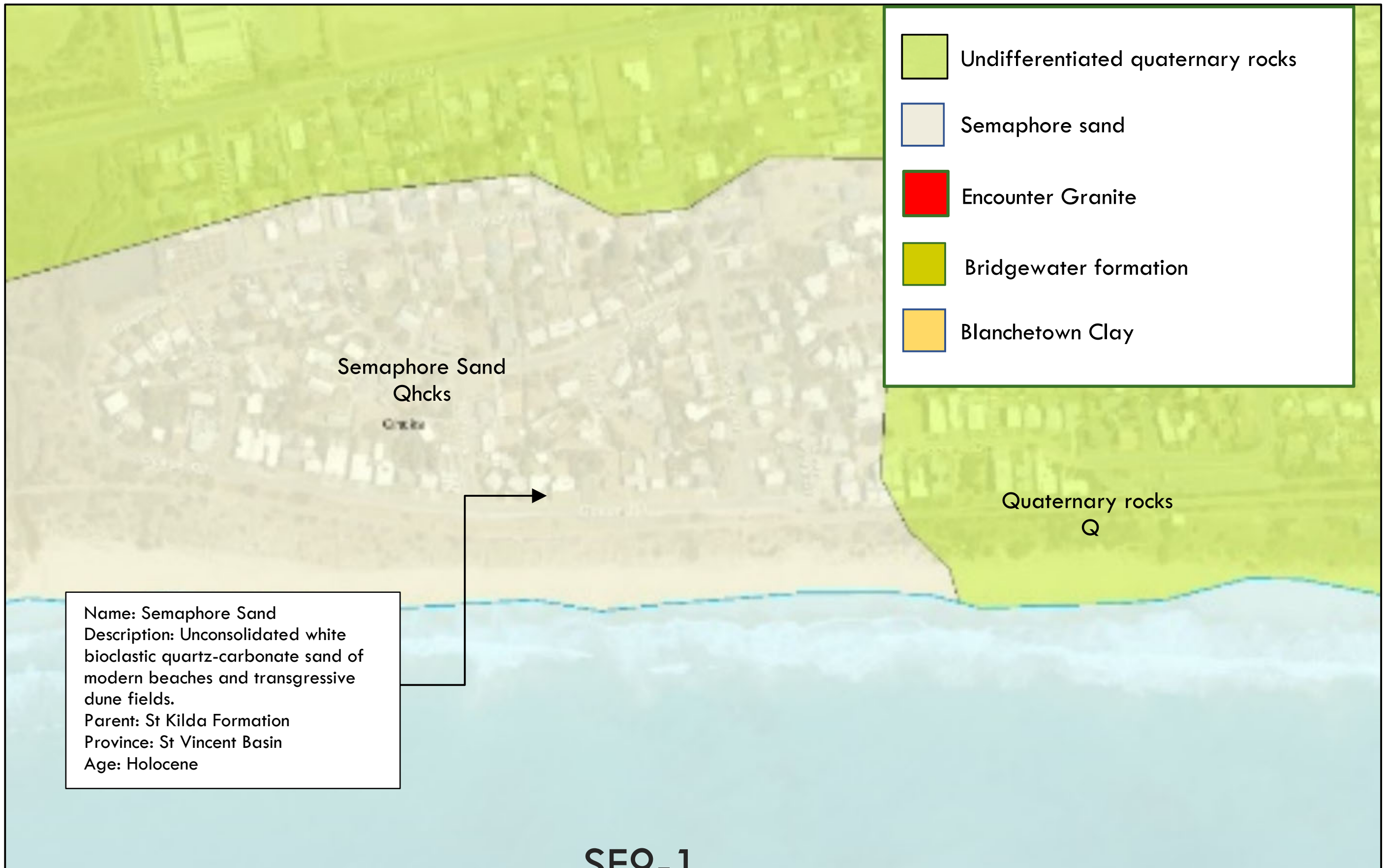

Between Watson Gap, Boomer Beach and Knight Beach the coastline is backed by Pleistocene aeolianite or calcarenite. The age of this former coastal dune now hardened (lithified) and its upper surface protected by resistant white limestone (calcrete), has been established as 266$\pm$34 ka (thousand years), formed during the high sea level of an isotopic stage 7e, or penultimate last interglacial age. Even though the dune formed during an interglacial, sea level then was not quite as high as now, probably only coming up to 6 m below present sea level. Furthermore, this locality is in the Murray Basin, which has subsided since the dune originally formed. This explains why there are shore platforms and small cliffs in the intertidal zone, formed by coastal erosion of the ancient lithified dune, which extends well below sea level (Dr. Bob Bourman)

3. Coastal Fabric - natural

Overview

Map: SF9-1

Secondary Cell: Fleurieu SA Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Boomer Beach

Benthic

Benthic

A low-profile reef of varying constituency (continuous, or patchy) dominates the surf zone.

The intertidal zone is dominated by sand.

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3. Coastal Fabric - natural

Overview

Map: SF9-1

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Boomer Beach

Nature Maps

Shoreline class
TBR + LTT+ Rock (reflective?)

Sand rating
Fine-medium sandy beach

Exposure:
Moderate

Wave:
Moderate

Form:
Low-moderate 3-10 deg (slope is 1:34 to -10m mark)

Backshore 1:
Cliff 5m to 20m high

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3. Coastal Fabric - natural

How the geology (fabric) of the coast has changed over time.

MEDIUM TERM CHANGES

Map SF9-1
Boomer Beach

Historical comparison

Event: 1949

Risk: Shoreline regression

Assessment

Aerial photograph from 1949.

<u>Georeferencing</u>

The 1949 aerial photograph has been checked against 2018 aerial photograph at Middleton Hotel, and several houses in this region. The two photographs are highly congruent, and the 1949 photograph can be relied upon for comparison purposes.

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3. Coastal Fabric - natural

MEDIUM TERM CHANGES

Map SF9-1
Boomer Beach

Historical comparison

Event: 1949

Risk: Shoreline regression

Assessment

Aerial photograph from 1949.

The baseline escarpment position in 1949 is depicted as a dotted line.

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How the geology (fabric) of the coast has changed over time.

Georeferencing

The 1949 aerial photograph has been checked against 2018 aerial photograph at Middleton Hotel, and several houses in this region. The two photographs are highly congruent, and the 1949 photograph can be relied upon for comparison purposes.

3. Coastal Fabric - natural

How the geology (fabric) of the coast has changed over time.

MEDIUM TERM CHANGES

Map SF9-1
Boomer Beach

Historical comparison

Event: 1949 - 2006

Risk: Shoreline regression

Assessment

Aerial photograph from 2006.

The baseline escarpment position in 1949 is depicted as a dotted line.

Minor accretion is observed on western end. This accretion may relate to less outflows of storm water (due to drought, or improved retention of storm water as a result of the new development on Port Elliot Road).

Some erosion is observed within the red rectangle (see inset on p. 22)

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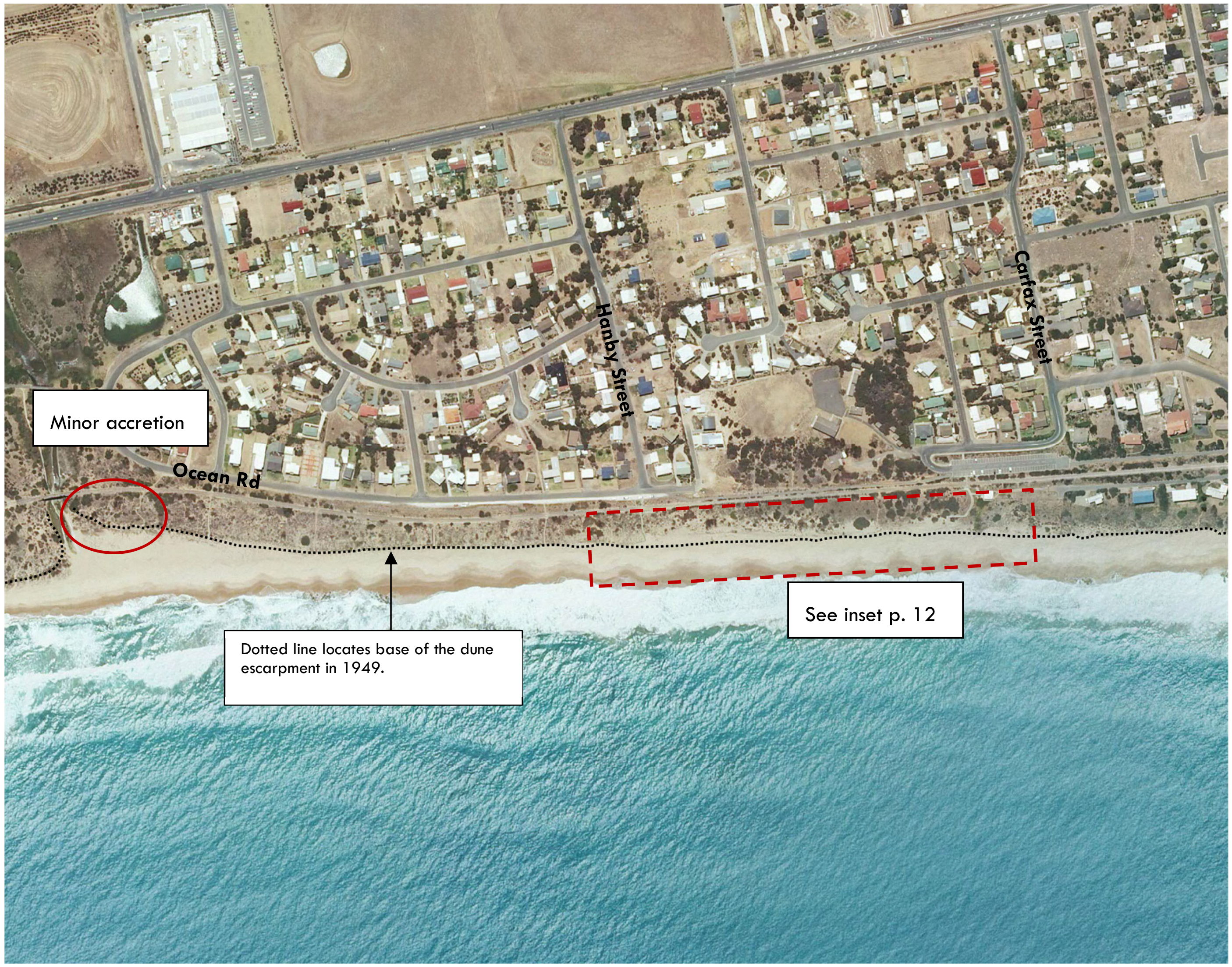

3. Coastal Fabric - natural

MEDIUM TERM CHANGES

Map SF9-1
Boomer Beach

Historical comparison

Event: 2006- 2016

Risk: Shoreline regression

Assessment

Aerial photograph from 2016. The baseline escarpment position in 1949 is depicted as a dotted line.

The base of the dune appears in the same position as 2006.

Areas of erosion and accretion are observed in comparison to 1949.

Some erosion is observed within the red rectangle (see inset on p. 22)

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3. Coastal Fabric - natural

MEDIUM TERM CHANGES

Map SF9-1
Boomer Beach

Historical comparison

Event: 1949- 2016

Risk: Shoreline regression

Assessment

Aerial photograph from 2016. The baseline escarpment position in 1949 is depicted as a dotted line.

The section of beach from Hanby Street to Boomer Beach carpark has undergone some erosion (recession).

Most of these areas appear to be caused by wave-run up. Dune fencing was installed to the major erosion at end of Hanby Street but has been undermined.

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4. Coastal fabric - modified

HUMAN INTERVENTION

Protection and/ or infrastructure:

Currently no hard protection strategies are utilised in this cell.

A dune fence has been installed to ensure that pedestrians utilise the designated beach access points.

The Goolwa to Victor Harbor trainline is situated on Crown land owned by the State Government. The line is leased to Steam Ranger to operate the tourist train.

For most of this cell, the trainline runs in front of the esplanade road, walking trail and private dwellings.

The train line sits atop of dune system, dissecting the backshore. This means that the dune system cannot retreat as the trainline acts as a 'hold point'.

Figure 9: Knight and Boomer Beaches (M. Western, 2018)

4. Coastal fabric - modified

HUMAN INTERVENTION

The zone map on this page depicts the main zoning characteristics for Boomer Beach and Knight Beach (Knight Beach is reviewed as a minor cell in section 2).

Zoning:

<u>Coastal Conservation</u>

Principles of Development Control are standard South Australian policy apart from:

- Buildings and structures should not be located within sand dunes or on land subject to erosion.
- Development should not impede the safe movement and maneuvering of boats and other waterborne craft.

<u>Residential</u>

Relevant development controls are contained within policy and precinct zoning.

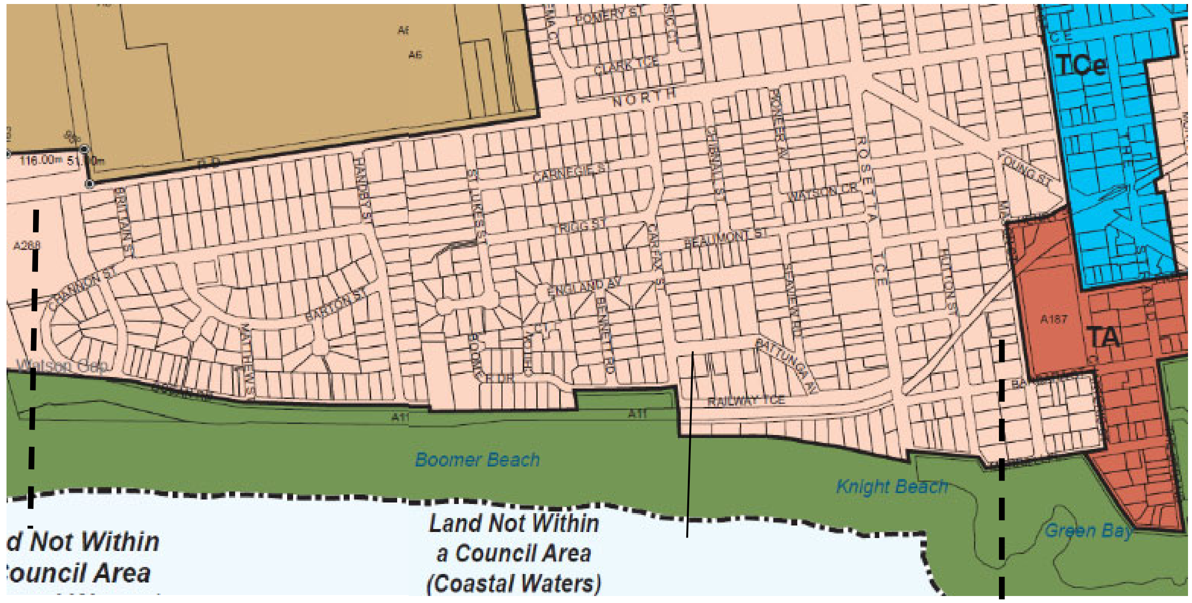
Policy area:

Southern Policy Area

Precinct area:

Boomer Beach

Key density control: minimum site area is $450m_2$ with 12m frontage where development is connected to community wastewater management



Coastal Areas policy

Coastal Areas policy is standard South Australian policy apart from the inclusion of matters relating to public access:

11 Private or public access to coastal areas should not result in ecological harm, including but not limited to:

(a) vehicular and pedestrian access to sensitive or vulnerable areas being limited and controlled to minimise adverse impacts

(b) structures such as jetties being restricted and constructed only for public or shared use.

Comments:

Residential zoning is set behind Coastal Conservation zoning and therefore no referrals to Coast Protection Board are required within the Residential Zone.

Residential areas are set behind the State-owned railway line and therefore set well back from the shore.

Minimum site area is $450m^2$.

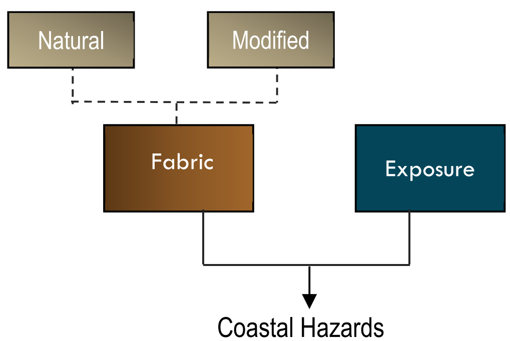
(See also comments for Knight Beach below)

COASTAL FABRIC

Summary and conclusions

Progress report:

So far, we have completed a preliminary assessment, a review of settlement history and completed an assessment of the fabric of the cell. In the next section we will deal with the 'exposure' of the cell.



Summary:

Boomer Beach is situated within cell SF9.

Beach

The beach compartment is classified as a 'sandy beach'. Dr Bob Bourman notes the following in relation to this Cell.

'Erosion of the aeolianite produces an ongoing supply of beach sand to the area. This sand at Knight Beach and Boomer Beach is stripped from the beach during storm conditions, exposing greater areas of shore platforms, and forms offshore sand bars from which the sand is returned to the beach during calmer conditions.

The coast from Chiton to Knight Beach is essentially a self-contained beach compartment, although under extreme conditions storm waves can entrain beach sediment and bypass the granite headlands into the bays to the east".

Benthic

Mapping from Department of Environment and Water shows low profile reef in sub-tidal zone and sand in the surf-zone

Backshore 1:

Sand dune at heights 10m to 16m at Boomer Beach and a low height cliff at Knight Beach.

Backshore 2:

Soft rock sloping shore rising to 28m AHD 500m inland.

Geology

Between Watson Gap, Boomer Beach and Knight Beach the coastline is backed by Pleistocene aeolianite or calcarenite. The age of this former coastal dune now hardened (lithified) and its upper surface protected by resistant white limestone (calcrete), has been established as 266±34 ka (thousand years), formed during the high sea level of an isotopic stage 7e, or penultimate last interglacial age. Even though the dune formed during an interglacial, sea level then was not quite as high as now, probably only coming up to 6 m below present sea level. Furthermore, this locality is in the Murray Basin, which has subsided since the dune originally formed. This explains why there are shore platforms and small cliffs in the intertidal zone, formed by coastal erosion of the ancient lithified dune, which extends well below sea level.

Recent geomorphology

For the most part the base of the escarpment appears in similar position to 1949. However, the area between Hanby Street and the Boomer Beach carpark shows areas of recession/ erosion. Dune fencing installed to the beach access point at Hanby Street has been undermined.

Human intervention

No protection works have been installed in the Boomer Cell.

Erodibility rating:

Backshore 1: High erodibility (3)

Backshore 2: Moderate erodibility (2)

CURRENT EXPOSURE

Evaluating how actions of sea and other weather events currently impact the coastal fabric by:

- Analysing a current storm event
- Applying current 1 in 100 sea-flood risk scenario
- Analysing monthly high-water impact.
- Analysing storm water runoff

5. Current exposure – overview

Overview

Map SF9-1

Boomer Beach

Overview

SA Classification (Department of Environment and Water)

Shoreline class
Longshore bar and trough + Low tide terrace + Rock

Sand rating
Fine medium sandy beach

Exposure:
Moderate relative exposure

Wave:
Moderate (narrow beach break)

Backshore 1:
Dune unstable – bare or partially vegetated

Backshore 2:
Lithified dune.

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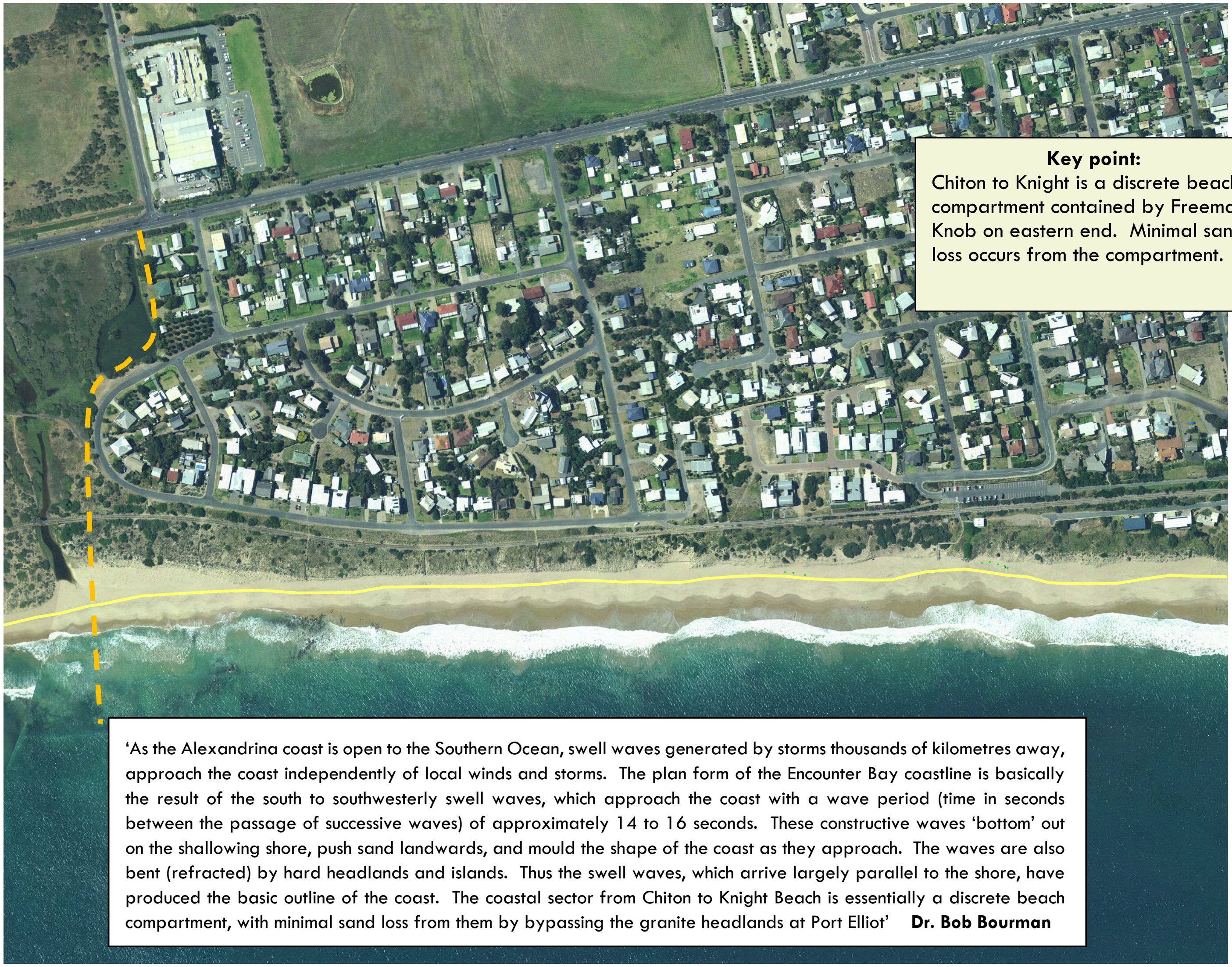

Key point:
Chiton to Knight is a discrete beach compartment contained by Freeman Knob on eastern end. Minimal sand loss occurs from the compartment.

'As the Alexandrina coast is open to the Southern Ocean, swell waves generated by storms thousands of kilometres away, approach the coast independently of local winds and storms. The plan form of the Encounter Bay coastline is basically the result of the south to southwesterly swell waves, which approach the coast with a wave period (time in seconds between the passage of successive waves) of approximately 14 to 16 seconds. These constructive waves 'bottom' out on the shallowing shore, push sand landwards, and mould the shape of the coast as they approach. The waves are also bent (refracted) by hard headlands and islands. Thus the swell waves, which arrive largely parallel to the shore, have produced the basic outline of the coast. The coastal sector from Chiton to Knight Beach is essentially a discrete beach compartment, with minimal sand loss from them by bypassing the granite headlands at Port Elliot' **Dr. Bob Bourman**

5. Current exposure- storm event

Storm event

Map SF9-1

Boomer Beach

Event: 21-22 November 2018

Assessment

A storm event on 21-22 Nov 2018 provides the basis for establishing wave effect parameters.

The event was recorded at Victor Harbor gauge at 11.45pm at a height of 1.99 (Chart Datum) or 1.41m (AHD).

Evidence within SF9-1 was sparse (and based upon two seaweed strands that were 0.40m variation).

Based on this evidence wave effects were set at 0.5m wave setup and 1.20m wave run-up.

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5. Current exposure – storm surge

Storm surge

Map SF9-1

Boomer Beach

Current risk: storm surge

1 in 100-year sea flood risk

Assessment

The current 1 in 100-year event risk set by Coast Protection Board is:

Storm surge	1.75m AHD.
Wave set-up	0.50m
Risk	2.25m AHD

Wave run-up is 1.2m and depicted in light blue.

In this event wave run-up would flow up the beach but the modelling does not show that it would impact the base of the dunes.

Note: wave effects in this region were based upon only two seaweed strands. A future storm should be analysed.

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5. Current exposure – monthly high water

Monthly high water

Map SF9-1

Boomer Beach

Current risk:

Event: monthly high water

Assessment

Extreme events are very rare and can have a significant impact. Routine tidal action may also have an impact on the stability of a dune system over time.

Monthly tidal data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal event. The event pictured here is expected to occur every one or two months.

The event modelled:

Average high tide	1.50m
Wave effects	0.30m
Total risk	1.80m

Wave run-up of 0.80m is included.

The current impact on beach and backshore is low.

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5. Current exposure – storm water

Storm water

Map SF9-1

Boomer Beach

Current risk:
storm water

Assessment

Storm water in SF9-1

An inspection of the outlet at the base of the Boomer Beach carpark was conducted on 22 April 2019. (See photographs on next page).

In regard to other outlets, more information is required as the plans are not clear where storm water is being drained.

It appears as if storm water is being drained to the area adjacent the trainline (perhaps acting as a detention system). In the context of a coastal adaptation study, there appears to be no impact upon the coast from these outlets.

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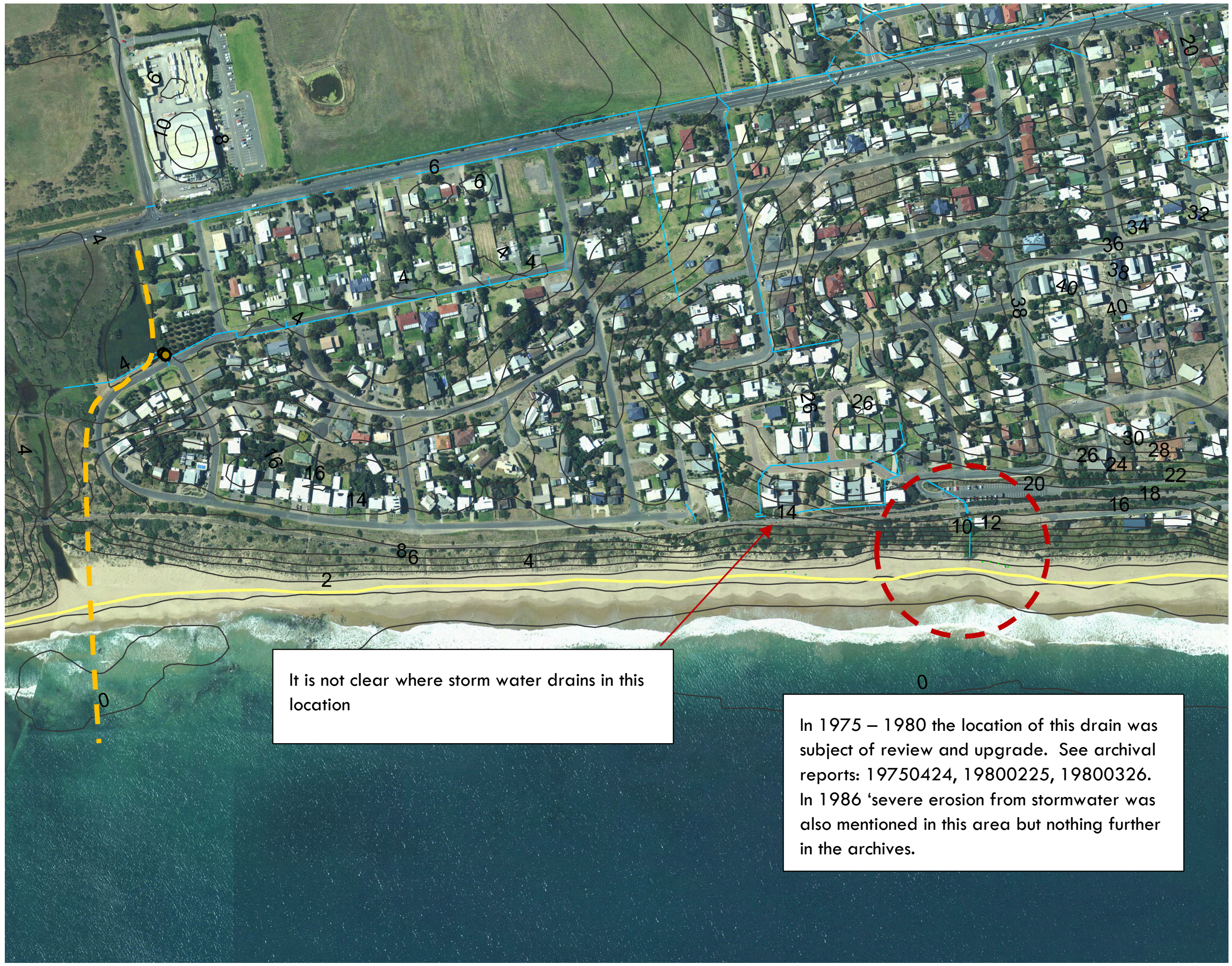

5. Current exposure – storm water

Storm water

Map SF9-1

Boomer Beach

Current risk:
storm water

Assessment

Storm water in SF9-1

Storm water drains down a long dissipation surface. The area is well vegetated, and no scouring is observed.

There appears to be no scouring of the beach and sand levels are high in proximity of the exit point. However, we are in a very dry period.

The beach closer to the run-up zone appears to be lower than surrounding beach levels. The inset pic also suggests that storm water is lowering the beach in this location.

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Note erosion escarpment in this location.

Figure 10 and 11: Boomer Beach (M. Western, 2018)

5. Current exposure - erosion

Erosion

Map SF9-1

Boomer Beach

Current risk:
Erosion outlook

Assessment

A comparison of historical aerial photographs supports the view that the base of the dune escarpment has largely been in the same location since 1949 apart from section between Hansby and the Boomer Beach carpark.

Flood modelling demonstrates that routine high tides are not reaching the back of the beach.

The limited survey from 18 November 2018 showed wave action near the back of the beach (note green survey points in middle of photograph on this page).

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Flood modelling indicates minimal impact at the back of the beach, but the photograph demonstrates that tidal action is reaching the back of the beach in some locations.

FUTURE EXPOSURE

Evaluating how future actions of sea and other weather events may impact the coastal fabric by:

- Reviewing 1 in 100-year scenarios for 2050 and 2100
- Reviewing monthly high-water scenarios for 2050 and 2100
- Analysing erosion risk to 2100

6. Future exposure – storm surge (2050)

Storm-surge

Map SF9-1
Boomer Beach
2050 sea-flood risk
1 in 100-year sea flood risk

Assessment
The 1 in 100-year event risk set by Coast Protection Board for 2050 includes an allowance of 0.3m sea level rise:

Storm surge	1.75m AHD
Sea level rise	<u>0.30</u>
	2.05m AHD
Wave set-up	<u>0.50</u>
Risk	2.55m AHD

Wave run-up of 1.20m has been depicted in light blue.

Scenario modelling demonstrates that wave-runup would impact the rear of the beach in places.

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6. Future exposure – storm surge (2100)

Storm-surge

Map SF9-1

Boomer Beach

2100 Sea-flood risk

1 in 100-year sea flood risk

Assessment

The 1 in 100-year event risk set by Coast Protection Board for 2100 includes an allowance of 1.0m sea level rise:

Storm surge	1.75m AHD
Sea level rise	1.00
	2.75m AHD
Wave set-up	0.50
Risk	3.25m AHD

Wave run-up of 1.2m is indicated by the lighter blue shading.

The modelling shows that if an event of this magnitude occurred that the impact at the base of the dune escarpment would be significant.

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6. Future exposure – monthly high water (2050)

Monthly high water

Map SF9-1

Boomer Beach

2050 risk

Monthly high water

Assessment

Monthly high tidal data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal event. This modelled event is expected to occur every one or two months.

Routine tidal action may have a larger impact on the stability of a dune system over time.
The event modelled:

Average high tide	1.50m
Plus sea level rise	0.30
	1.80m
Wave set up	0.80m
Total risk	2.60m

Wave run-up of 0.8m has been included.

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6. Future exposure – monthly high water (2100)

Monthly high water

Map SF9-1

Boomer Beach

2100 risk

Monthly high water

Assessment

Monthly high tide data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal event. This modelled event is expected to occur every one or two months.

Routine tidal action may have a larger impact on the stability of a dune system over time.

The event modelled:

Average high tide	1.50m
Plus sea level rise	1.00
	2.50m
Wave set up	0.30m
Total risk	2.80m

Wave run-up of 0.8m has been included.

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6. Future exposure - erosion

By Dr Patrick Hesp
See full version in Part 1 of the report

Shoreline recession due to sea level rise

In the following, we attempt to estimate shoreline retreat at Boomer Beach due to sea level rise. This is achieved by two methods, one, utilising the Bruun Rule, which is the standard method to estimate shoreline retreat, but which has several implicit assumptions, and ignores the possibility of dune translation. The second is a method which assumes the beach and dune system can translate upwards and landwards as sea level rises, and estimates shoreline change based on assumptions that the coastal system can actually do this, and that there is sufficient sediment in the system for this to occur.

Shoreline Change indicated by the Bruun Rule

The Bruun Rule is an equation developed by Per Bruun (1962). While it has subsequently been modified (e.g. Dean and Houston, 2016), the modified equations require more data than available for this coast. The original equation is the most widely used method for determining shoreline response to sea level rise.

$$S = - S p \, (W / dc + B) \qquad (1)$$

Where

- *S* is Erosion due to sea level rise
- *Sp* is Sea level rise projection
- *W* is Width of the beach profile
- *dc* is Depth of closure
- *B* is Foreshore/Dune crest height

The depth of closure is estimated from equation *(2)* where *h* is the closure depth in the inner portion of the surfzone-nearshore, and *Hs* is mean annual significant wave height following Hallermeier (1981) as modified by Houston (1995):

$$h = 8.9\overline{Hs} \qquad (2)$$

Equation (1) applies to the upper shoreface (Cowell et al., 2003a). It assumes that the upper shoreface keeps the same profile and translates seaward or landward depending on the sediment budget, and ignoring alongshore and across-shore changes in sediment supply (Le Cozannet et al. (2016). Obviously this is a huge assumption in the case of many coastal tracts in South Australia. This is particularly so for Bashams Beach, since the surfzone-nearshore is characterised by significant areas of subtidal reef which may restrict sand movement, and alter the ability of the nearshore-surfzone profile to translate landwards. In addition, the small foredune and dune system present at Bashams Beach indicates it has never had more than a small sediment supply in the past.

Boomers Beach

There is extremely limited information available at Boomers Beach to determine alongshore and acrosshore sediment exchanges These are the contributions of other processes causing losses or gains of sediments in the active beach profile. However, as Le Cozannet et al. (2016), note, there is currently no better model or "rule" to use. Recent results regarding the global impact of sea-level rise on shoreline change are largely based on the Bruun rule and it is commonly utilised to provide a rough estimate of shoreline migration in relation to sea level rise. Alternative approaches exist, but they are more complex and they require more data. Thus, for the purposes of obtaining some estimate of shoreline change driven by sea level rise, the Bruun Rule is first utilised.

An estimate of shoreline retreat due to a sea level rise of 1m by 2100 has been carried out for one topographic profile in the middle of the bay at Boomers Beach (Figure 3).

Note that seawards of ~-5m there is reef present in places, and the slope past that depth is likely controlled by the presence of the reefs so the estimate of shoreline recession here must be treated with caution.

For a sea level rise of 1.0 metre, depth of closure (*dc*) of 8.9 (assumes a significant wave height [$\overline{Hs}$]of 1.0m), and beach profile widths (*W in eqn 1*) of 350m, the Bruun Rule indicates a shoreline recession of 18.5m by 2100.

Key point

Applying the Bruun Rule to Boomer Beach indicates a shoreline recession of **18.5m** by 2100, but this must be treated with caution as onshore/ offshore sediment transport are not operating in a straightforward manner.

6. Future exposure - erosion

By Dr Patrick Hesp
See full version in Part 1 of the report

Continued

This number essentially indicates recession resulting in a cliff. The vertical face or scarp of this cliff is inherently unstable, and will collapse and slide to a more stable angle resulting in a zone of slope adjustment. This will produce further landward retreat of the dune crest in addition to that estimated by the Bruun Rule erosion.

The 'closure depth' is the depth where most sediment transport due to waves and wave induced currents terminates (Hesp and Hilton, 1996). This closure depth cannot easily be determined at Boomer Beach due to the fact that the nearshore region is dominated by complex three-dimensional geomorphology and includes sand, possible bedrock or calcarenite outcrop, and reef. Onshore/offshore sediment transport processes are therefore not operating in a straightforward manner, and application of the Bruun Rule is likely not easily applicable here.

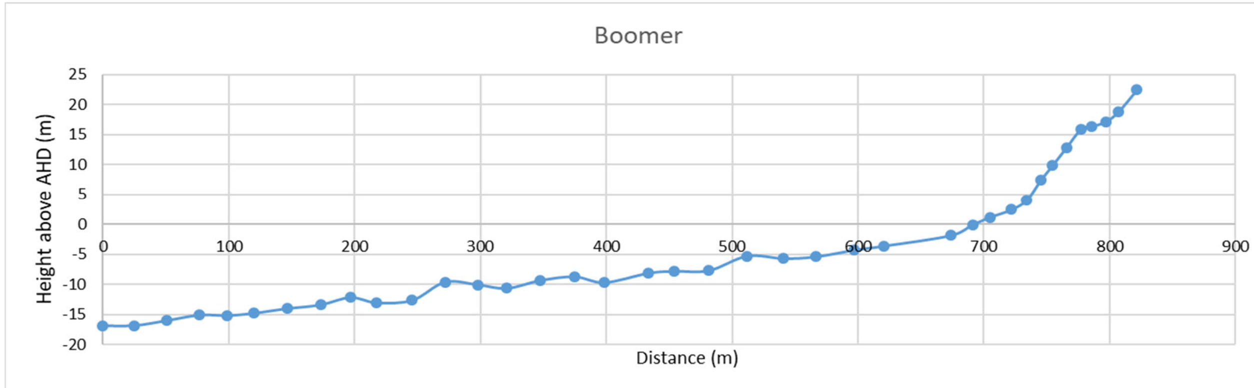


Figure 12. Topographical survey conducted November, 2018 (Inset photograph depicts location of survey).

Shoreface-Beach and Dune Translation Model

The utility of the Bruun Rule has been the subject of debate over the last decades, because the "rule" takes no account of longshore sediment transport, the possibility that the foredune or dunes existing behind the beach can translate upwards and landwards with sea level rise, and it is not supposed to be utilised where surfzone-nearshore reefs exist.

It is now a known fact that beaches and dunes can easily translate upwards and landwards as either shoreline erosion occurs or sea level rises (Davidson-Arnott, 2005). Therefore, another way to estimate the degree of shoreline retreat due to a given sea level rise is to take the latest topographic profile of the nearshore-beach-dune system and merely translate it entirely upwards and landwards by a given amount of sea level rise (in this case 1.0 m by 2100).

The distance that the profile is translated horizontally is determined by maintaining the distance between two topographic points (i.e. the slope of the beach-backshore) on the original profile in the projected future translated profile. For example, if the distance between zero m or AHD on the current profile (Figure 12) and the foredune toe is, say, 15m, then that distance between those two points is maintained in the translated 2100 profile.

6. Future exposure - erosion

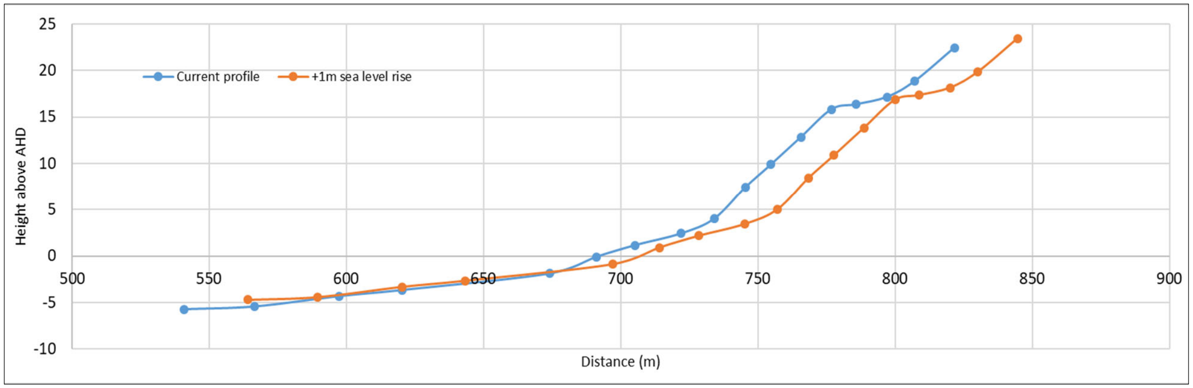
Continued

Figure 13 indicates detail of the beach-dune system segment of the latest available topographic profile from a 2018 survey, and the estimated translated topographic profile for 2100. Past -5m water depth there is considerable shallow reef, and it is difficult to impossible to translate this material. It is also virtually impossible to determine what will happen to this reef (and surrounding reefs) as sea level rises.

It may be seen that the beach-foredune system will translate approximately **23 metres by 2100.** Note that this assumes there is enough sediment in the system to allow this to occur (a large assumption), and that the nearshore profile can translate adequately given all the reefs present. It also assumes that the foredune is maintained as the shoreline retreats and sea level rises and has not been destroyed, in part or fully, due to increased storminess and/or significant jumps in sea level due to meltwater pulses (very rapid rises in sea level due to massive ice retreat or ice shelf collapse) occurring in the next ~80 years.

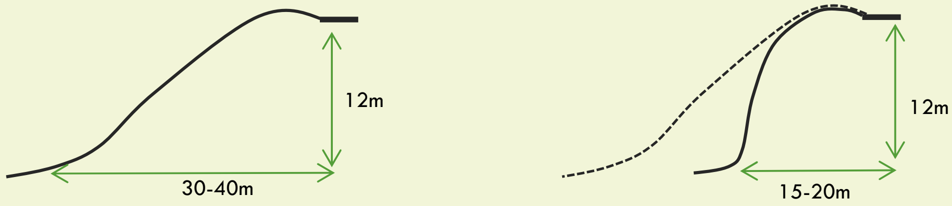
Note that as future sea level rises over the reef dominated nearshore region, wave energy will increase due to the fact that there will be less dissipation of waves over the reefs as the water depths increase. This will increase wave energy at the beach face and impact several of the factors considered above (storm wave heights and runup, significant wave heights).

Figure 13. Topographic profile surveyed in November 2018 at Boomer Beach and translated profile for a sea level rise of 1m by 2100 (Source: Integrated Coasts)



The trainline is a fixed hold line on top of escarpment

The erosion modelling indicates 18m to 23m recession of the shoreline by 2100. The trainline dissects the dune system at the top of the escarpment. As this is a fixed line, it will not be possible for the dune to translate landwards, and therefore the slope of the dune must increase. This slope will become increasingly unstable, and successive collapses will tend to make the escarpment increasingly vertical, and increasingly more unstable.



6. Future exposure – erosion (2100)

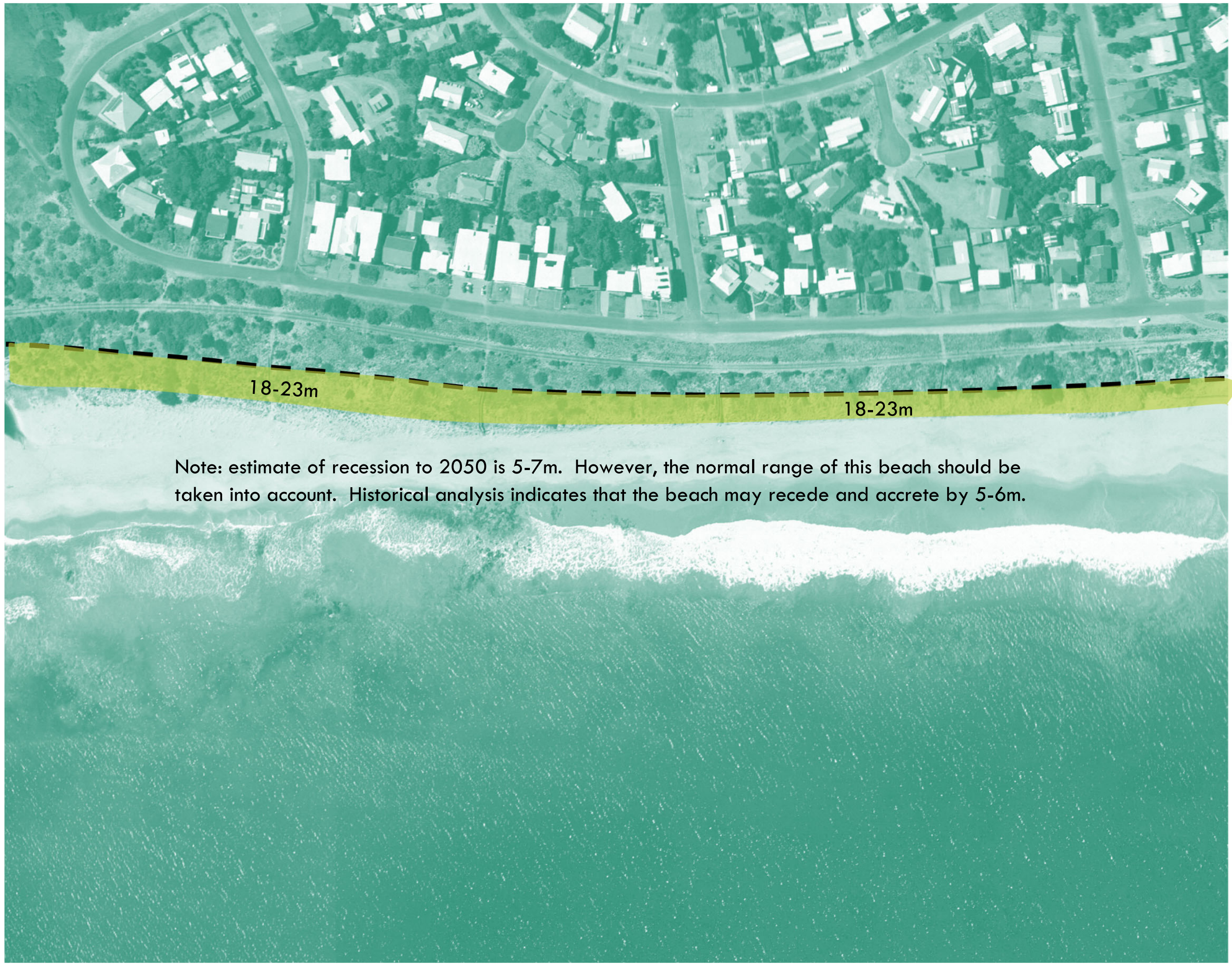
By Dr Patrick Hesp
See full version in Part 1 of the report

Erosion

Map SF9-1

Boomer Beach

2100 Erosion outlook



Assessment

Two evaluation methods have been utilised to provide the basis for an estimate of shoreline recession.

Sea-flood and routine high tide modelling also indicate increased impact on dunes.

Erosion assessment is made difficult by the presence of a reef at -5m.

Estimates of shoreline recession range between **18m** and **23m** by 2100.

Estimate of shoreline recession by 2050 range between 5m and 7m.

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6. Future exposure – erosion (2100)

Erosion

Map SF9-1

Boomer Beach

2100 Erosion outlook

Assessment

Two evaluation methods have been utilised to provide the basis for an estimate of shoreline recession.

Sea-flood and routine high tide modelling also indicate increased impact on dunes.

Erosion assessment is made difficult by the presence of a reef at -5m.

Estimates of shoreline recession range between **18m** and **23m** by 2100.

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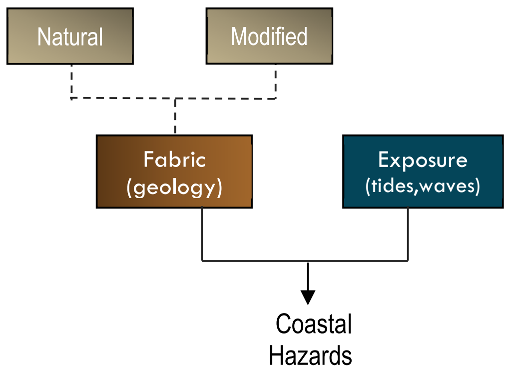
COASTAL EXPOSURE

Summary and Conclusions

Progress report:

So far, we have completed a preliminary assessment, a review of settlement history and completed an assessment of the 'geology' or 'fabric' of the cell. In the last section we also analysed current and future exposure.



Current exposure

Baseline storm event

The event of 21-22 November 2018 provided a baseline event from which to quantify wave effects at Boomer Beach. (It is recommended that one or two more events are analysed in the future). Total wave effects in SF9 totalled 1.70m.

However, while this storm produced significant wave effects the tide at the gauge was not exceptionally high (less ~0.20m than record of 9 May 2016).

Storm surge

Coast Protection Board has set 1 in 100-year risk event at 1.75m AHD (ie at the tide Victor Harbor tide gauge).

If this event was to occur, mapping shows that wave run-up would impact the base of the dune escarpment. However, the nature of this beach is such that the dunes would reform.

Monthly high water

Extreme events such as a 1 in 100-year risk event can cause considerable damage but these are rare events. Routine tidal action is more likely to break down the dune system over time. Routine high tides are unlikely to be causing any significant erosion in this current era.

Future exposure (indicatively by 2050)

Storm surge

A 1 in 100-year risk storm surge event would significantly impact the dunes. However, the nature of this beach is such that the dunes would be likely to reform. With higher sea level, the incursion would increase.

Monthly high water

Mapping indicates that routine tidal action will not have a significant impact. However, it is likely that the higher tides will cause more permanent recession of the dune escarpment (by 5-7m).

Future exposure (indicatively by 2100)

Storm surge and high tides

The 1 in 100-year risk storm event would significantly impact the beach and base of the dune. High tides 1m greater than today would also routinely impact the base of the dune and cause recession by 18-23m (estimated).

As the trainline forms a fixed point at the top the dunes, landward translation will not be possible. Therefore, the slope of the dune will tend to increase over time, going through episodes of collapse. If left unchecked the dune slope will become increasingly vertical and undermine the integrity of the trainline.

Exposure ratings

Moderate exposure

Moderate wave energy

Contextual note

Mapping of 2050 and 2100 scenarios is super-imposed over the current beach and dune system. It is understood that the layout of the beach and dune system will have changed, especially by 2100. However, this mapping does give an indication of the likely extent of recession, and where impacts will be 'felt' the most.

7. Inherent hazard risk assessment

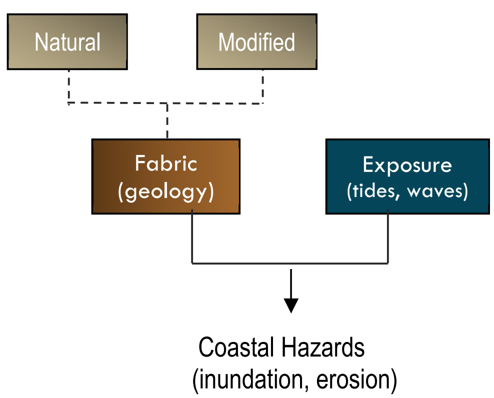
CoastAdapt identifies two main coastal hazards:

- Inundation
- Erosion

It is the combination of the characteristics of the coastal fabric and the nature of the exposure that determines the degree of hazard risk.

This reality is most simply understood when considering inundation risk. Whether a coast is at risk from inundation depends entirely on the topography of the coast. If we explain this another way, a low-lying coast is *inherently* more at risk from flooding whereas an elevated coast is inherently not at risk from flooding.

The assessment of the erosion hazard is far more complex, but it is still the relationship of *fabric* to *exposure* that determines whether a coast is *inherently* more at risk from erosion or less at risk.



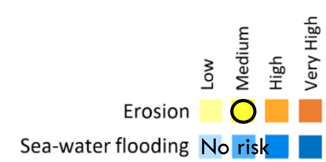
Inundation hazard risk

Due to the slope and elevation of backshore 1, there is no inundation hazard risk for Boomer Beach.

Erosion hazard risk

Evaluation steps	Assessment factors	Inherent hazard risk
Allocate initial erosion hazard rating from geological layout table (Main report)	Sandy beach, backshore 1: dune backshore , backshore 2: soft rock rising to 27m 300m inland	Medium
Should this rating be amended due to human intervention such as a protection item? If so, how?	No, human intervention is limited to dune fencing.	Medium
Apply an exposure rating (Nature Maps)	Nature Maps assigns an exposure rating of 'moderate'.	Medium
Assess any impact on backshore 1	Due to the nature of this beach, the location of the dune escarpment relates to the routine actions of wave run-up (monthly high water). Most of the escarpment has not been undercut apart from the area at base of Boomer Beach carpark (Hanby Street).	Medium
Assess any influence from Benthic	Offshore reefs: with increasing depths of water exposure may increase but this is expected to be more.	Medium
Assess the sediment balance	Boomer-Knight Beach is essentially a closed cell with limited amount of sand moving to the east.	Medium
Assess any other factors that may warrant a change of inherent hazard risk.	Nil	Medium

Inherent Hazard Risk – Boomer Beach



HAZARD IMPACTS

In this section we identify and describe the potential hazard impacts within four main receiving environments:

- Public assets
- Private assets
- Safety of people
- Eco-system

8. Assets at risk (public)

Hazard impacts

Map SF9-1
Boomer Beach
Assets at risk
Public

The Goolwa to Victor Harbor trainline dissects the top of the dune.

The trainline is situated on Crown Land and is owned by the State Government. It is leased until 2026 to Steam Ranger (Goolwa) to operate tourist train services.

It is likely that the responsibility to protect this line will fall to the State Government. Council and private assets are afforded default protection as long as the State Government protects its asset.

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The trainline is a fixed 'hold' line on top of escarpment

The erosion modelling indicates 18m to 23m recession of the shoreline by 2100. The trainline dissects the dune system at the top of the escarpment. As this is a fixed line, it will not be possible for the dune to translate landwards, and therefore the slope of the dune must increase. This slope will become increasingly unstable, and successive collapses will tend to make the escarpment increasingly vertical, and increasingly more unstable.

8a. Assets at risk (public)

Hazard Impacts

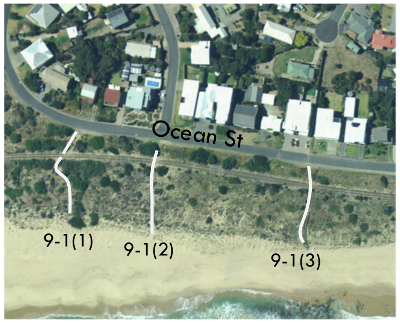
Map SF9-1
Boomer Beach

Assets at risk

Public

Council has a responsibility to maintain the beach access points along the coastline.

In this section we identify each beach access point and provide brief risk outlook.



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General comment: 9-1(1) and 9-1(2) are positioned very close to each other. Is there a need for two access points? On upgrade, recommend only one access point.

9-1(1)

Beach access set well from beach and currently situated behind a small frontal dune. Currently, no risk from impacts of the sea.

9-1(2)

Beach access set well back from swash (wave run-up) zone. Currently, no risk from impacts of the sea.

9-1(3)

Beach access set well back from swash (wave run-up) zone. Currently, no risk from impacts of the sea.

8a. Assets at risk (public)

Hazard Impacts

Map SF9-1

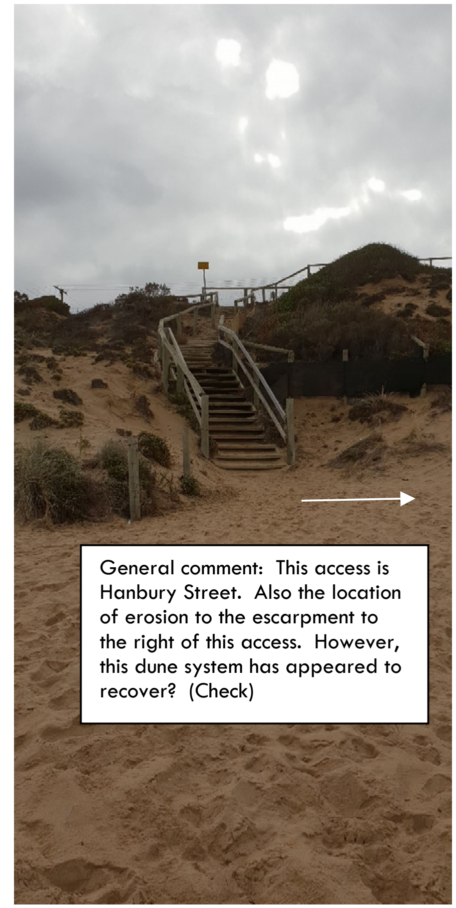
Boomer Beach

Assets at risk

Public

Council has a responsibility to maintain the beach access points along the coastline.

In this section we identify each beach access point and provide brief risk outlook.



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9-1(4)

Beach access is likely to be impacted by wave-runup in storm events. (note seaweed strands). Sand volume appears 300-400mm above base of front posts.

9-1(5)

Beach access is likely to be impacted by wave run-up in storm events. Sand volume appears 500-600mm above base of front posts.

9-1(6)

Beach access is set further back within dune. This is Hanbury St which has been location for increased erosion of the escarpment

8a. Assets at risk (public)

Hazard Impacts

Map SF9-1
Boomer Beach
Assets at risk
Public

Council has a responsibility to maintain the beach access points along the coastline.

In this section we identify each beach access point and provide brief risk outlook.

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9-1(7)

Significant sand accretion has occurred in this location since installation of stair way.

Key points – beach access

Beach access ways demonstrated the level of accretion that Boomer Beach has undergone with increased heights of sand in vicinity of 400- 600mm. As long as the accretion cycle continues, or at least current sand levels maintained, beach access points are likely to be less at risk. Should these require upgrading it will be important to take into account the erosion/ accretion cycle of this beach so that new access ways are not left stranded when the erosion cycle takes hold again in the future.

8c. Safety of people

The assessment conducted within this project is only related to how impacts of the sea may increase the risk to people accessing the area. It is not related to any risks that the beach and backshore currently pose to the safety of people. This assessment remains with Council in its normal operation of risk.

In the current era there appear to be no additional risks above those normally associated with a beach/ foreshore environment.

Should beach access ways require upgrade, care needs to be taken that these are positioned to cater for the normal accretion and erosion cycle of this beach. If they are wrongly positioned in an accretion cycle (ie current), then they may be stranded in an erosion cycle leaving a gap between the bottom stair and the beach.

In the longer term, if seas rise as projected, then erosion of the dune escarpment seems most likely. The position of the trainline at the top will prevent the dune from translating landwards, and the slope of the dune will increasingly become steep and unstable, and subject to collapse. This may pose a safety risk in the future.

8d. Ecology at risk

The assessment of ecology of risk in the context of this project is confined to that which may be described as 'ecosystem disruption' with the intent that this disruption would occur on a wide scale. For example, sea water flooding through the dunes at Ratalang Basham will irreversibly change the nature of the ecosystem on a large scale.

The geological layout of Boomer Beach indicates that major ecosystem disruption is not a risk.

Site inspection: Magryn & Associates
Personnel: Will Souter
Date: 26 June 2019

Magryn concluded:

> Minimal erosion is present at the base of the cliff. The stormwater from the street and carpark to the north discharges to the beach. The pipe outlet was not visible due to dense vegetation surrounding it. Existing stormwater erosion protection appears to be effective on the beach adjacent the outlet; however the overall beach level has dropped as a result of stormwater outflow across the beach.
>
> Recommendation : Monitor

RISK ASSESSMENT

In this section we conduct a formal risk assessment of hazard impacts upon the four receiving environments:

- Public assets
- Private assets
- Safety of people
- Eco-system

This risk assessment utilises the risk framework of Alexandrina Council.

9. RISK ASSESSMENT

Inherent hazard rating

Integrated Coasts has developed a risk classification system to operate over the State of South Australia that categorises the risk to a coastal cell in relation to two main hazards:

- Sea-water flooding
- Erosion

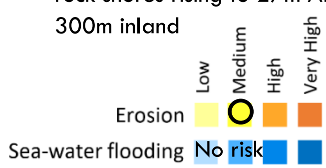
The application of an inherent risk rating does not suggest that areas rated as low are entirely free from vulnerability, nor conversely that areas rated more highly are necessarily vulnerable now. The aim is to assess the underlying inherent vulnerability of the fabric of the coastal location using a process that will also benchmark the locality in the context of all of South Australia.

The visual output from the inherent risk assessment process is purposefully designed so that it is immediately accessible and meaningful to a wide range of personnel involved in managing the coastal environs.

The inherent hazard risk rating for Boomer Beach is:

Inherent Hazard Rating

Sandy beach backed by soft rock shores rising to 27m AHD 300m inland



Specific Risk Assessment

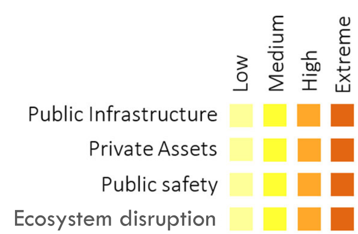
Each of the cells are assessed more specifically for risk in the context of four receiving environments:

- Public infrastructure
- Private assets
- Public safety
- Ecosystem disruption

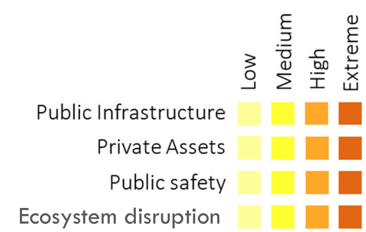
The term eco-system disruption is used to describe the situation where changes in a coastal region might bring about larger scale changes that may threaten to disrupt the entire ecological system, for example seawater flooding into freshwater ecologies.

This assessment utilises the Councils risk assessment framework and is provided for two eras: the current era, and the 'future outlook'. In this study, future outlook means the end of this current century. The risk assessment is conducted within either the inundation or erosion risk assessment template (see next page).

Erosion Hazard Rating
(Current outlook -2020)



Erosion Hazard Rating
(Future outlook - 2100)



Yet to be assigned

9. Risk Assessment

Erosion assessment

Boomer Beach (SF9-1)

Risk identification: Erosion is currently, or may in the future, threaten the backshore of Boomer Beach

Coastal processes	Boomer Beach is categorised as a reflective medium sandy beach, tends to be a closed cell as it is bordered by granite headlands on the east. The beach is backed by sand dunes varying in height from 10m AHD (in west) to 18m AHD (in east). Exposure is categorised as 'moderate', and wave energy moderate at ~1m. Historical analysis suggests that the back-shore of the beach undergoes periodic accretion and recession over periods of decades. Currently the beach has been in an accretion cycle for ~10 years. Analysis of future regimes suggests that this may change.

Are any strategies employed to mitigate the risk? Nil

Receiving environment	Coastal Context	Time	Likelihood	Consequence	Risk
Public infrastructure	The risk to major public infrastructure relates to the proximity of the State Government owned railway line. (See in text for risk to beach access points)	current	*No risk*	*No risk*	low
		2100	*Likely*	*Catastrophic*	Extreme
Private assets	Private assets are situated behind the trainline (apart from three dwellings on end of Torrens Street).	current	*Rare*	*Minor*	low
		2100	*Rare*	*Significant*	moderate
Safety of people	This assessment does not relate to general beach safety of pedestrians or swimmers. It relates only to how the safety of people may be exacerbated due to increased sea level (and associated impacts)	current	*Rare*	*Insignificant*	low
		2100	*Rare*	*Insignificant*	low
Ecosystem disruption	This assessment relates to large scale disruption to ecological systems. The geology of the area contains the risk and therefore there is no perceived risk.	current	*No risk*	*No risk*	No risk
		2100	*No risk*	*No risk*	No risk

Inherent Hazard Rating

Sandy beach back by lithified dune >24m at 500m

	Low	Medium	High	Very High
Erosion		X		
Inundation	No risk			

Erosion Hazard Rating (current outlook - 2020)

	Low	Moderate	High	Extreme
Public Infrastructure	X			
Private Assets	X			
Public safety	X			
Eco-system disruption	No risk			

Erosion Hazard Rating (future outlook- 2100)

	Low	Moderate	High	Extreme
Public Infrastructure				X
Private Assets		X		
Public safety	X			
Eco-system disruption	No risk			

Note: the assignment of future risk assumes that no action is taken to mitigate the risk apart from normal safety procedures.

Rain intensity and storm water impacts not assessed in this risk assessment

Summary	Boomer Beach cycles through stages of erosion and accretion. Over the last 10 years, the beach has been accreting. Scenario modelling suggests that only extreme events may reach the backshore with current sand conditions. The main threat that sea level rise will bring is the permanent recession of the dune at the base, coupled with the inability of the dune to translate landwards due to the trainline positioned on top of the dune system. The key to decision making for Boomer Beach will be ongoing monitoring to ascertain what is the normal parameters of the beach, and what is being influenced by rising sea levels.

10. ADAPTATION PROPOSALS

Adaptation proposals

ADAPTATION OPTIONS

CoastAdapt notes that there are generally six categories of adaptation responses to climate change in the coastal zone:

- Avoidance
- Hold the line (protect)
- Accommodation (or limited intervention)
- Managed retreat
- Monitor and respond
- Loss acceptance

Within each of the four response categories there is a range of potential adaptation options in the areas of[1]:

- Planning
- Engineering
- Environmental management

Planning

These are options that use planning legislation and regulations to reduce vulnerability and increase resilience to climate change and sea-level rise. Thus, land that Is projected to become more prone to flooding in future can be scheduled as suitable only for development such as light industry or warehouses, and unsuitable for housing or critical infrastructure.

Engineering

In the context of climate change adaptation 'engineering' has come to describe adaptation options that make use of capital works strategies such as seawalls and levees. Such projects are 'engineered' to solve a particular challenge such as to protect coastal infrastructure from erosion and inundation damage. These approaches differ from other types of approaches in that they require significant commitments of financial resources and create a physical asset.

Environmental management

Environmental management includes habitat restoration and enhancement through activities such as revegetation of coastal dunes or building structures to support continued growth of habitat such as seagrasses or reefs.

It may also include developing artificial reefs to reduce wave erosion of shorelines or engineered solutions to prevent encroachment of saltwater into freshwater systems.

ADAPTATION APPROACHES

There are two broad ways in which adaptation can occur in relation to timing:

- Incremental approach

A series of relatively small actions and adjustments aimed at continuing to meet the existing goals and expectations of the community in the face of the impacts of climate change.

- Transformative approach

In some locations, incremental changes will not be sufficient. The risks created by climate change may be so significant tat they can only be addressed through more dramatic action. Transformational adaptation involves a paradigm shift: a system-wide change with a focus on the longer term. A transformative approach may be triggered by an extreme event or a political window when it is recognised the significant change could occur.

BOOMER BEACH

The modelling and assessment indicate that Boomer Beach undergoes normal periods of accretion and recession over time periods likely to be measured in decades.

The main adaptation issue is the location of the Stage Government owned railway line. As long as the State Government continues to protect its asset, Council and private owners will be afforded protection by default.

An incremental adaptation approach is recommended.

To protect this public infrastructure over time, an initial **hold the line** methodology is recommended.

Because there is unlikely to be any immediate threat, the approach should be to **monitor** this beach over time, with special attention to changes/impacts to the back shore.

Further reading and resources

This section of work adopts the framework and understanding of adaptation options from CoastAdapt. Further reading at:

https://coastadapt.com.au/understand-adaptation
https://coastadapt.com.au/adaptation options

[1] CoastAdapt also includes 'community education'.

Adaptation proposals

Monitor and respond

Map SF9-1

Boomer Beach

Adaptation proposal

For more information on monitoring strategies refer to the main report.

Monitor and respond

The key to managing Boomer Beach over time is to understand what the normal parameters of the beach are, and what impacts may be attributed to sea level rise.

Monitor

The beach and base of the escarpment should be regularly monitored. The purpose of the monitoring is to understand how the beach operates over time. The second purpose is to monitor the impact of storm events.

Monitoring over time will give the Council and State Government the appropriate basis to determine which coastal impacts are part of the normal cycle of the beach, and when sea level rise is changing that normal cycle.

Respond – in the first place, hold the line, then consider retreat.

Should increase impact to the base of the escarpment occur, then low cost protection options could be considered. However, if impact to the base of the dune is significant then the cost of protection will be astronomical, unlikely to succeed, and in the context of a tourist train likely to be unsupported.

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Monitoring overview

Introduction

The purpose here is not to provide a design for a detailed monitoring program as this will be completed as a separate project. The purpose here is to provide a context for understanding why monitoring is necessary and broadly, what type of monitoring actions are likely to be adopted.

In most areas of Alexandrina coastline, this study has recommended an 'incremental approach' to adaptation (see page above). The main reason to adopt this approach is that most of the coastline is not currently at risk from erosion or inundation. In fact, large sections of the coastline have shown to be accreting over the last ten years.

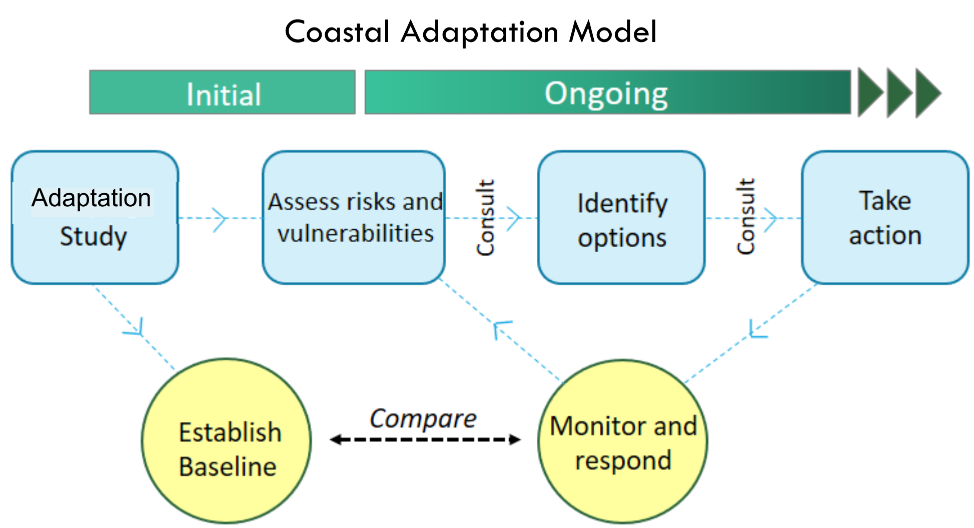
Prime response – 'monitor and respond'

Therefore, the prime adaptation response will be to 'monitor and respond'. Data will be collected on an ongoing basis and compared to the baseline we have established in this study.

We have established a baseline in two ways: First, the capturing of the digital elevation model in 2018 provides a point in time baseline of the current form of the coast. In 5- or 10-years' time (depending whether the coast is accreting or eroding), another digital elevation model could be captured and comparisons made between the two digital models (Figure).

The second way in which this study has formed a baseline is by analysing coastal change over time. We have compared the position of the shoreline from 1949 to 2018 and identified areas of erosion and accretion. Overall, the coastline in most places appears to have been stable for 70 years. In some places it has eroded. This understanding of how a coast operates over time also forms part of the baseline understanding. In the future, we can use newly acquired aerial photographs to compare shoreline position in the future, and use other techniques to monitor sand volumes (see also Main Report).

Figure: In a digital environment, software tools can be utilised to compare coastal change (Source: Aerometrex)



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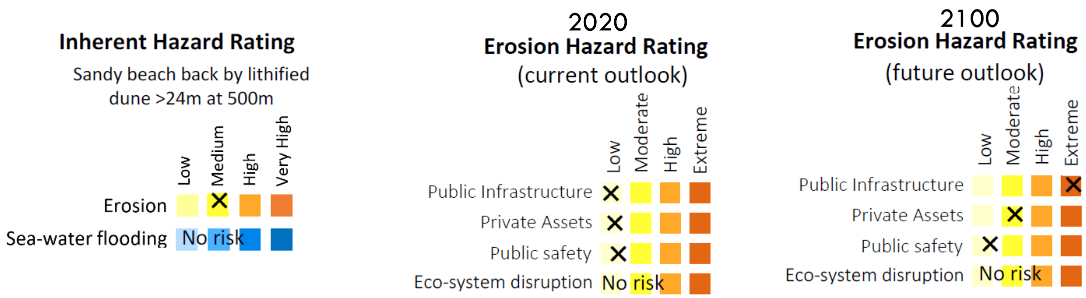
Adaptation Proposals: Boomer Beach (Cell SF9-1)

Coastal processes	Boomer Beach is categorised as a reflective medium sandy beach, tends to be a closed cell as it is bordered by granite headlands on the east. The beach is backed by sand dunes varying in height from 10m AHD (in west) to 18m AHD (in east). Exposure is categorised as 'moderate', and wave energy moderate at ~1m. Historical analysis suggests that the backshore of the beach undergoes periodic accretion and recession over periods of decades. Currently the beach has been in an accretion cycle for ~10 years. Analysis of future regimes suggests that this may change.

Risk outlook



Adaptation overview:

If seas rise as projected, then it is unlikely that the base of the dune at Boomer Beach can be protected. The dune may recede by 18-23m and the slope become increasingly unstable. This is likely to place the trainline at risk in the latter part of the century. It is less likely that private property will be at risk. The overall strategy is to monitor the beach, initially hold the line utilising soft options, and then consider retreat.

Adaptation proposals:

	Approach	Short term strategy 2020	Mid-term strategy 2050	Long term strategy 2100	Adaptation Type	Monitoring strategy
Boomer Beach Cell 9-1	Incremental [monitor and respond]	Monitor [no immediate works are likely to be required]	Monitor [hold the line using soft-protection options]	Managed retreat [Recession of dune projected at 18-23m by 2100 will destabilise the dune and position of trainline at top]	Environmental: Use soft options to hold the line as long as possible.	Shoreline position Storm impacts on backshore Sand volumes – identify the normal range of the beach.

KNIGHT BEACH

Minor Cell: Knight Beach SF9-2

COASTAL FABRIC

In this section we evaluate coastal fabric in more detail:

- Overview of the fabric of the cell
- Changes to shoreline over seventy years
- Changes to seafloor since 1977
- Human intervention

3. Coastal Fabric - natural

Overview

Map: SF9-2

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Knight Beach

Classification

SA Classification

Shoreline class
TBR + LTT+ Rock (more likely a reflective beach)

Sand rating
Fine-medium sandy beach

Exposure:
Moderate

Wave:
Moderate 1m

Form:
Low-moderate 3-10 deg (slope is 1:34 to -10m mark)

Backshore 1:
Cliff 5m to 20m high

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3. Coastal Fabric - natural

Overview

Map: SF9-2

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Knight Beach

Form

Beach

Sandy Beach

Backshores

Backshore 1: Cliff (Pleistocene aeolianite or calcarenite)

Backshore 2: Soft rock/ hard rock shores rising to 27m AHD at 300m inland.

Bathymetry

Overall slope of ocean floor: -10m ~1km from beach (overall slope ratio 1:100) or <5 deg.

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3. Coastal Fabric -natural

Overview

Map: SF9-2

Secondary Cell: Fleurieu SE Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Knight Beach

Geology

Beach and backshore 1:

Quaternary Rocks:

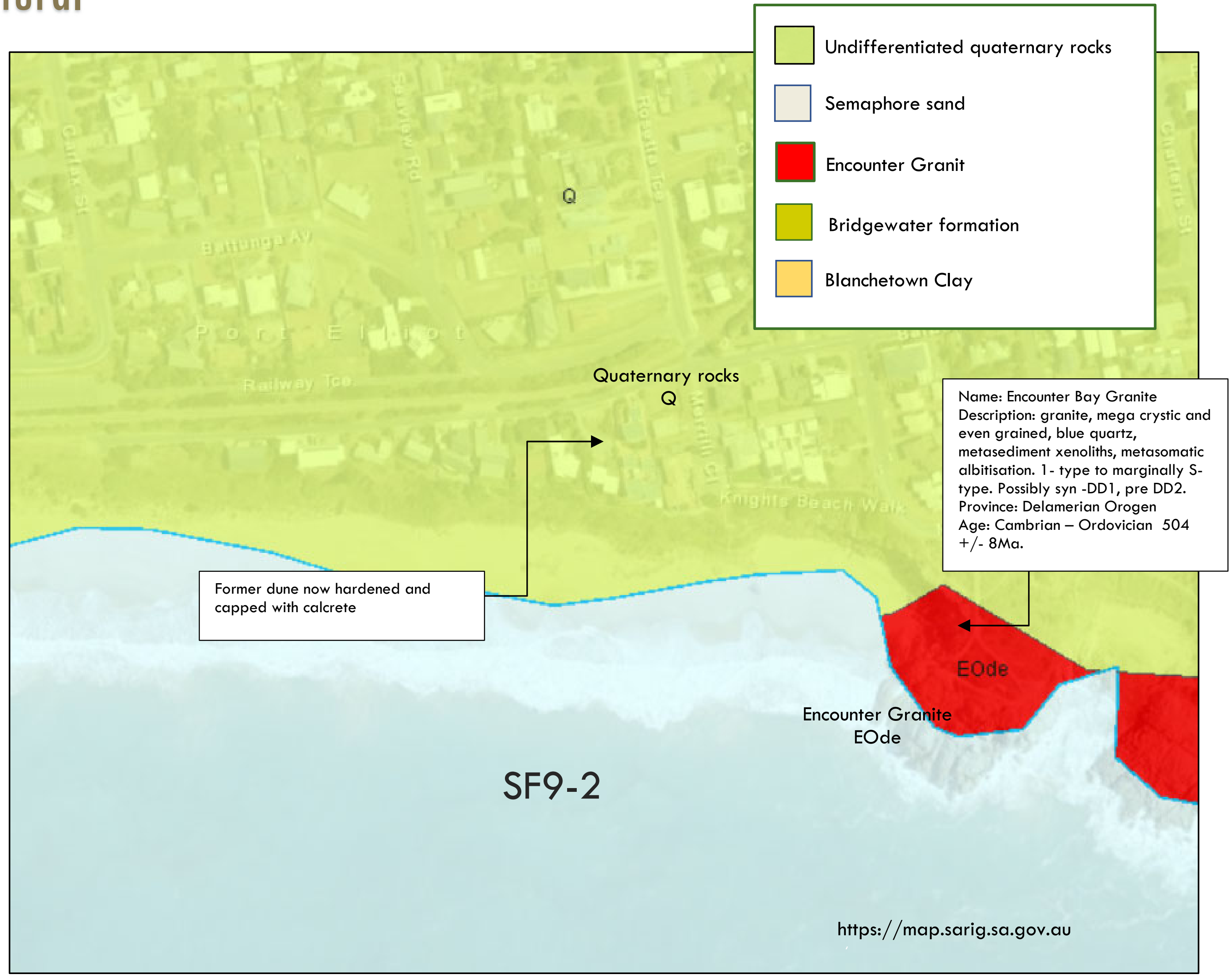
Age: Pleistocene

Backshore 2

Quaternary Rocks:

Rising above 27m AHD at 300m inland

Age: Pleistocene



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3. Coastal Fabric - natural

Overview

Map: SF9-2

Secondary Cell: Fleurieu SA Coast

Tertiary Cell: Port Elliot (West)

Minor cell: Knight Beach

Benthic

Benthic:

A low-profile reef (patchy) dominates Knight Beach which gives some protection to the base of the escarpment in the eastern section of the cell.

Outcrops of the reef are visible above the sand in places.

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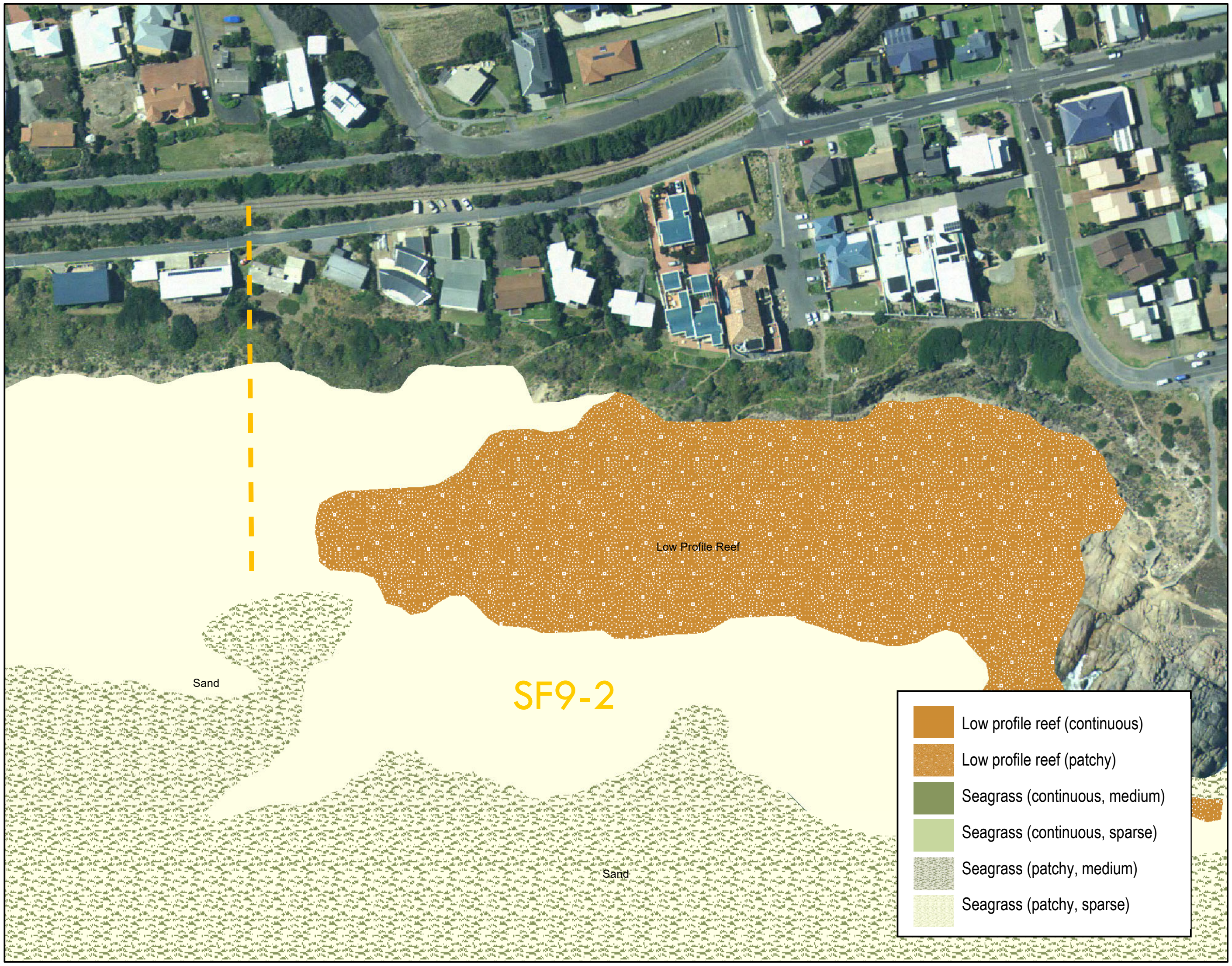
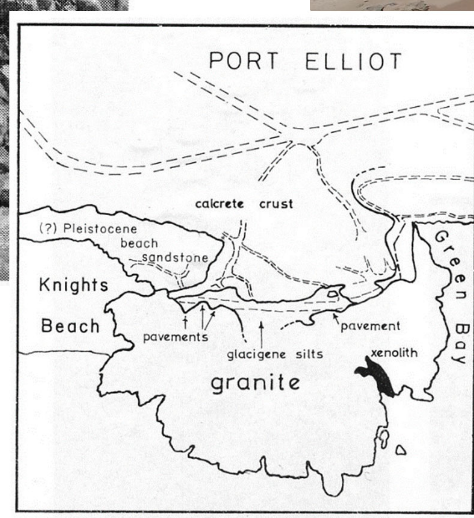


3. Coastal Fabric - natural

Figure: Oblique aerial view of granite headland with Knight Beach on the left and Green Bay on the right (1947)

Figure: Oblique aerial view of granite headland with Knight Beach on the left and Green Bay on the right (2018)

No evidence of erosion in the backshore of Knight Beach



Sketch of previous aerial photographs highlighting the basic geology of the site (R. Bourman, 2016).

3. Coastal Fabric - natural

How the geology (fabric) of the coast has changed over time.

MEDIUM TERM CHANGES

Map SF9-2
Knight Beach

Historical comparison

Event: 1949

Risk: Shoreline regression

Assessment

Aerial photograph from 1949.

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Georeferencing

The 1949 aerial photograph has been checked against 2018 aerial photograph at Middleton Hotel, and several houses in this region. The two photographs are highly congruent, and the 1949 photograph can be relied upon for comparison purposes.

3. Coastal Fabric - natural

MEDIUM TERM CHANGES

How the geology (fabric) of the coast has changed over time.

Map SF9-2
Knight Beach

Historical comparison

Event: 1949

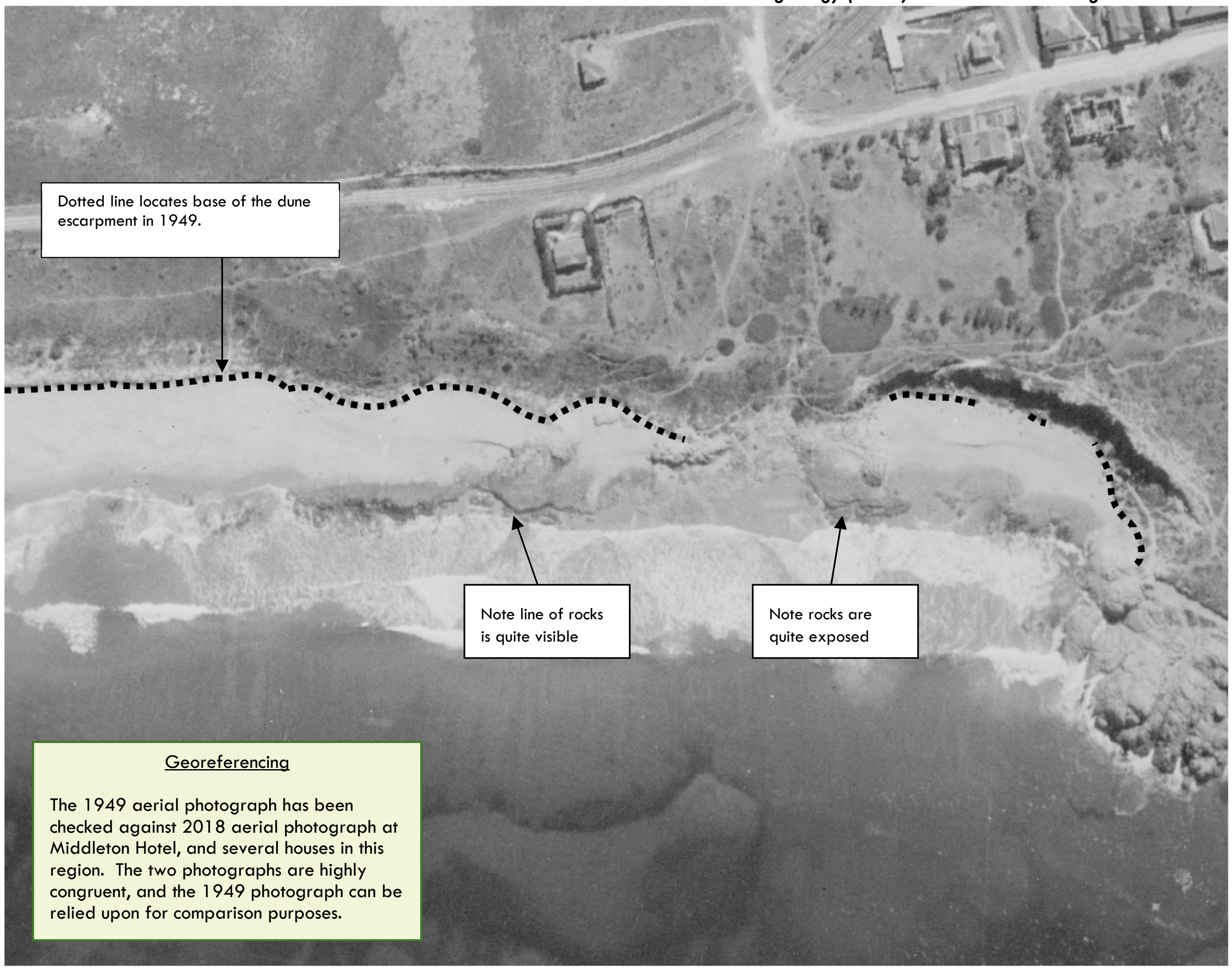
Risk: Shoreline regression

Assessment

Aerial photograph from 1949.

The baseline escarpment position is depicted as a dotted line.

Note also the exposed nature of the rocks in the wave runup zone.



Georeferencing

The 1949 aerial photograph has been checked against 2018 aerial photograph at Middleton Hotel, and several houses in this region. The two photographs are highly congruent, and the 1949 photograph can be relied upon for comparison purposes.

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3. Coastal Fabric - natural

How the geology (fabric) of the coast has changed over time.

MEDIUM TERM CHANGES

Map SF9-2
Knight Beach

Historical comparison

Event: 1949- 2006

Risk: Shoreline regression

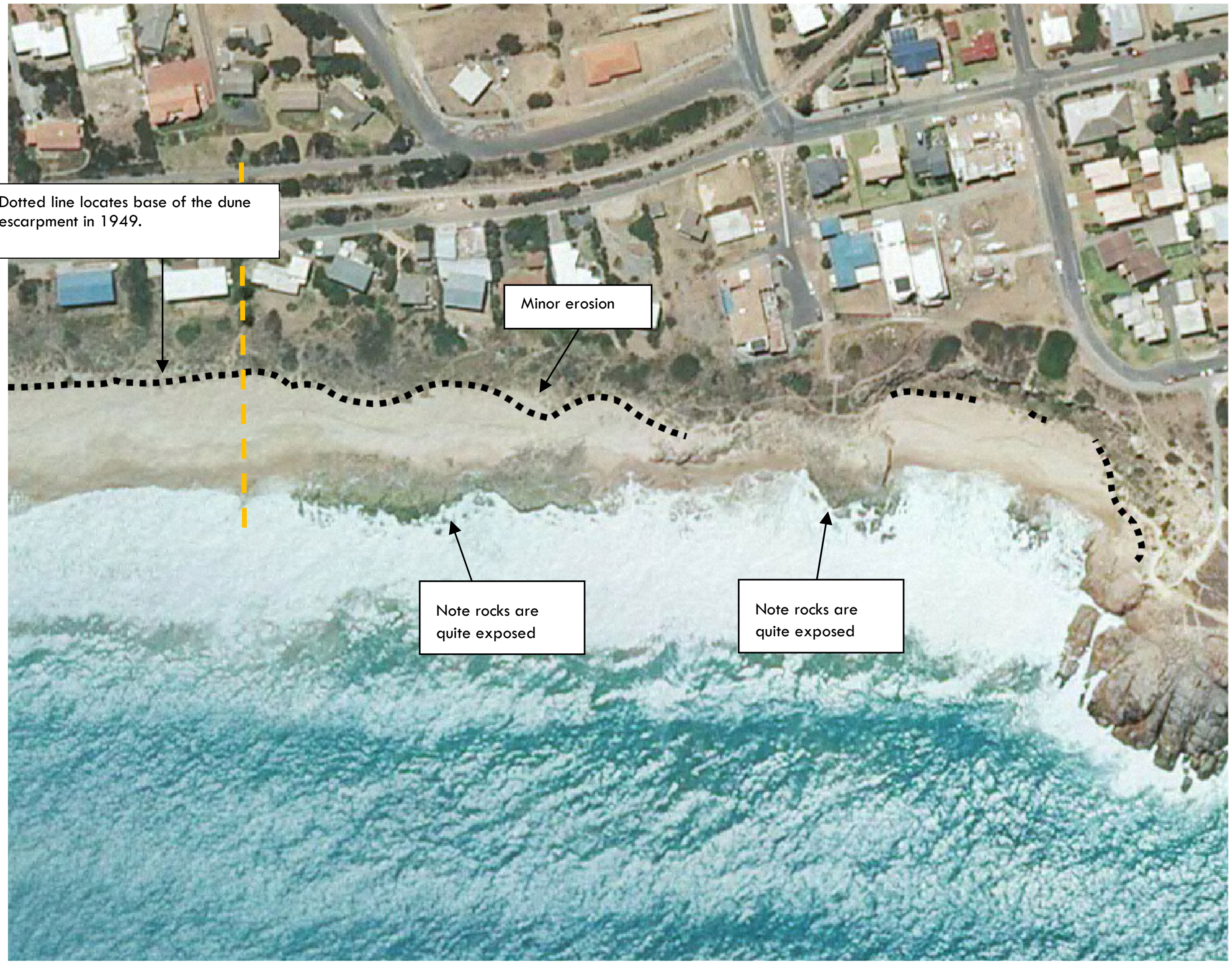
Assessment

Aerial photograph from 2006.

The baseline escarpment position is depicted as a dotted line.

Note also the exposed nature of the rocks in the wave runup zone.

The base of the dune and cliff escarpments are essentially in the same position in 1949. Minor erosion where shown.



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3. Coastal Fabric - natural

MEDIUM TERM CHANGES

Map SF9-2
Knight Beach

Historical comparison

Event: 2006- 2016

Risk: Shoreline regression

Assessment

Aerial photograph from 2018. The baseline escarpment position is depicted as a dotted line.

Note that the rocks in surf zone are now mostly covered with sand. This suggests accretion/ sand accumulation in this region (as observed in Middleton – Goolwa)

The base of the dune and cliff escarpments are essentially in the same position in 1949.

Direct comparisons were made with the top of the cliff line in Knight Beach and it appears in the same position as 1949.

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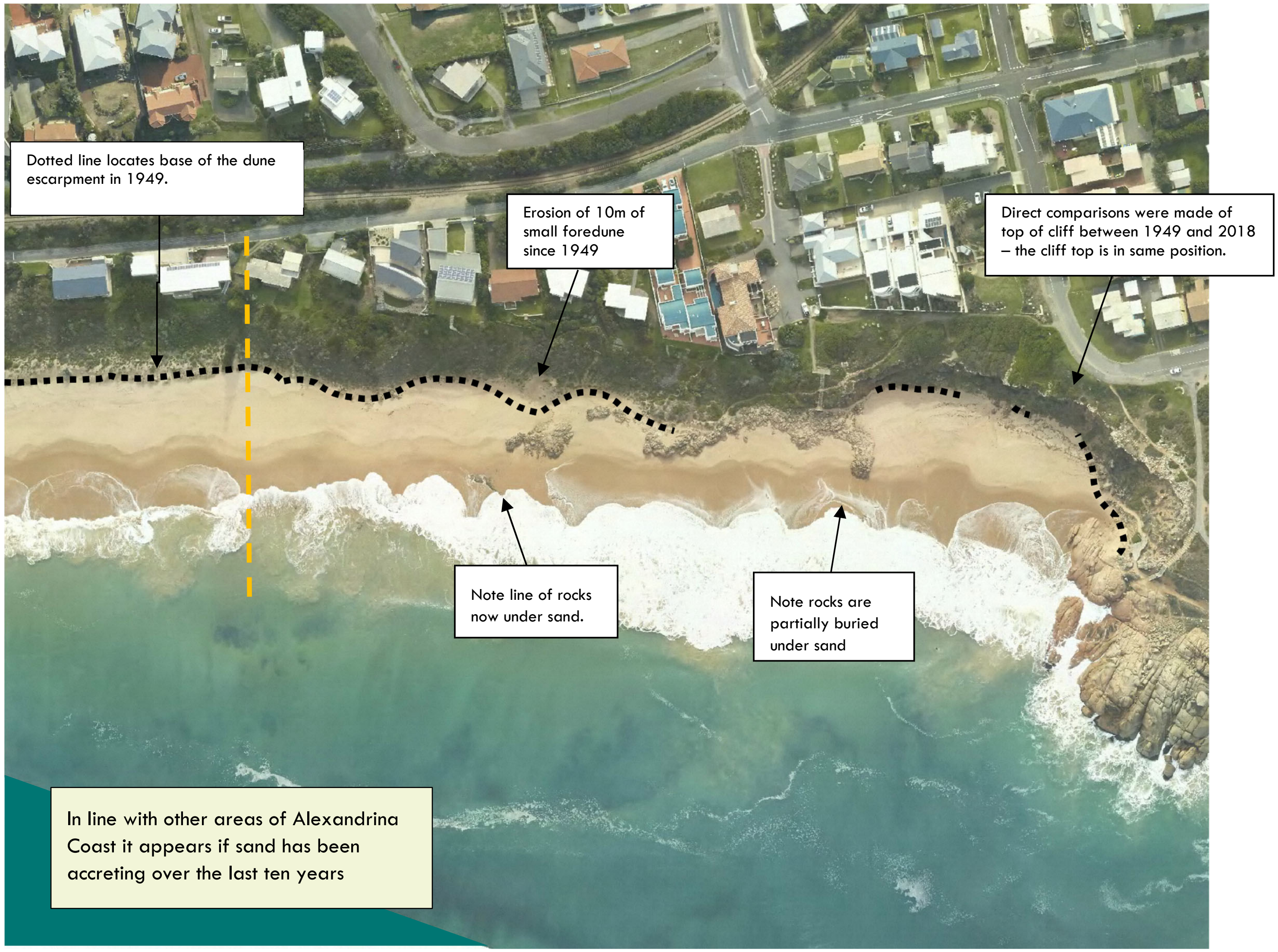

3. Coastal Fabric - - natural

MEDIUM TERM CHANGES

Map SF9-2
Knight Beach

Historical comparison

Event: 2006- 2016

Risk: Shoreline regression

Assessment

The oblique aerial photograph taken by Coastal Management Branch in 2006 depicts sand levels at much lower levels in the swash zone.

The sand levels are much higher at the rear of the beach. This is either as a result of a large storm that has removed sand from the beach, or the beach is in rebuilding mode (P. Hesp).

The remainder of Alexandrina coastline appears to have undergone a slight accretion stage over the last ten years.

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4. Coastal fabric - modified

HUMAN INTERVENTION

Protection and/ or infrastructure:

Currently no hard protection strategies are utilised in this cell. Nor soft protection options. Walking trails have minimal impact on the beach (stairs to the beach).

Urban settlement:

The zone map on this page depicts the main zoning characteristics for Boomer Beach and Knight Beach (Knight Beach is reviewed as a minor cell in section 2).

Zoning:

Coastal Conservation

Principles of Development Control are standard South Australian policy apart from:

- Buildings and structures should not be located within sand dunes or on land subject to erosion.

Residential

Relevant development controls are contained within policy and precinct zoning.

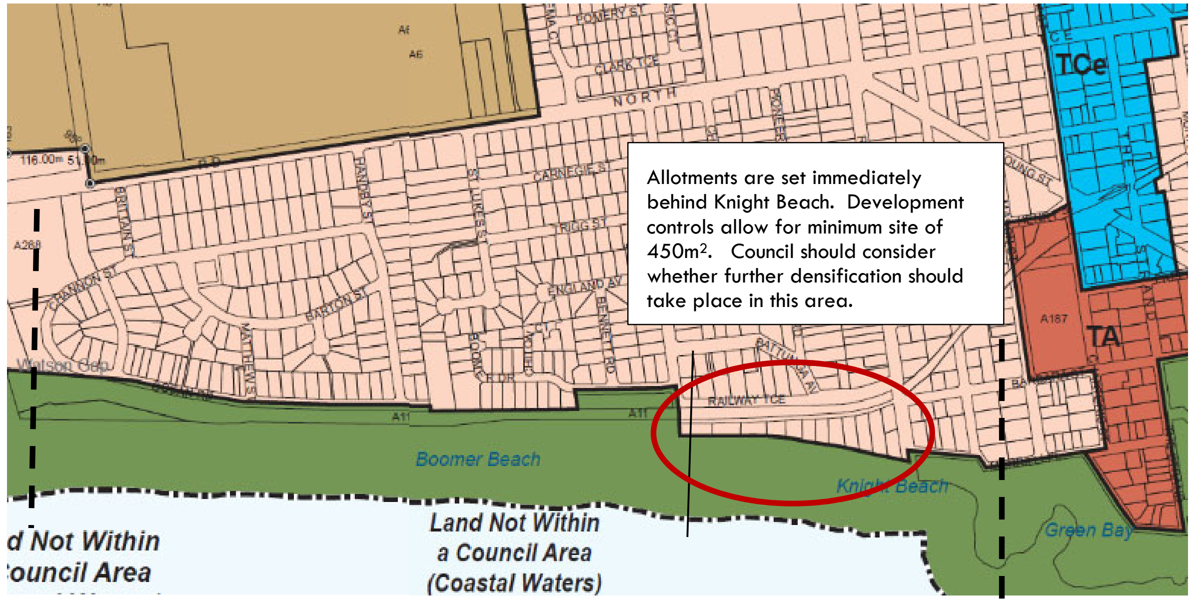
Policy area:

Southern Policy Area

Precinct area:

Boomer Beach

Key density control: minimum site area is 450m² with 12m frontage where development is connected to community wastewater management.



Coastal Areas policy

Coastal Areas policy is standard South Australian policy apart from the inclusion of matters relating to public access:

11 Private or public access to coastal areas should not result in ecological harm, including but not limited to:

(a) vehicular and pedestrian access to sensitive or vulnerable areas being limited and controlled to minimise adverse impacts

(b) structures such as jetties being restricted and constructed only for public or shared use.

Comments:

Residential zoning is set behind Coastal Conservation zoning and therefore no referrals to Coast Protection Board are required within the Residential Zone.

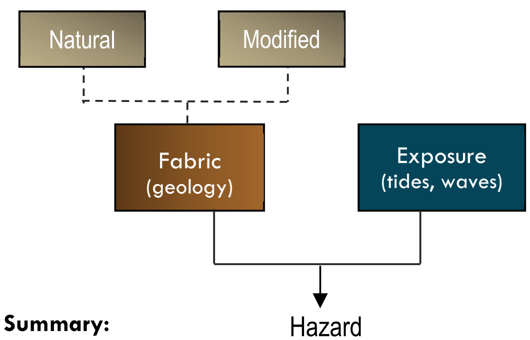
Residential sites are set adjacent the cliff top at the rear of Knight Beach on Torrens Street. Minimum site area is 450m² with 12m minimum frontage. These controls suggest that further subdivision could take place on undeveloped allotments

COASTAL FABRIC

Summary and conclusions

Progress report:

So far, we have completed a review of settlement history, completed an assessment of the 'geology' or 'fabric' of the cell. In the next section we will deal with the 'exposure' of the cell.



Summary:

Knights is situated within the Boomer Beach cell SF9.

Beach

The beach compartment is classified as a 'sandy beach'. Dr Bob Bourmann notes that it is a closed compartment with Freeman Knob on eastern end and that the 'erosion of the aeolianite produces an ongoing supply of beach sand to the area'

'Erosion of the aeolianite produces an ongoing supply of beach sand to the area. This sand at Knight Beach and Boomer Beach is stripped from the beach during storm conditions, exposing greater areas of shore platforms, and forms offshore sand bars from which the sand is returned to the beach during calmer conditions.

The coast from Chiton to Knight Beach is essentially a self-contained beach compartment, although under extreme conditions storm waves can entrain beach sediment and bypass the granite headlands into the bays to the east".

Benthic

DEW mapping depicts a low profile reef in Knights Beach section, and several outcrops are visible above the level of sand, these tending to protect the base of the escarpment behind. The area in the western side of this cell is more sand dominated with less protection at the base of the escarpment.

Backshores 1:

Between Watson Gap, Boomer Beach and Knight Beach the coastline is backed by Pleistocene aeolianite or calcarenite. Even though the dune formed during an interglacial, sea level then was not quite as high as now, probably only coming up to 6 m below present sea level. Furthermore, this locality is in the Murray Basin, which has subsided since the dune originally formed. This explains why there are shore platforms and small cliffs in the intertidal zone, formed by coastal erosion of the ancient lithified dune, which extends well below sea level.

Backshores 2:

This same lithified dune rises to 28m AHD 500m inland.

Recent geomorphology

A comparison of cliff top shows no recession since 1949. A comparison of aerial and oblique photographs shows no impact to the base of the escarpment since 1949.

Erodibility rating

Beach – highly erodible

Backshore 1 – moderately erodible

Backshore 2 – moderately resistant

CURRENT EXPOSURE

Evaluating how actions of sea and other weather events currently impact the coastal fabric by:

- Analysing a current storm event
- Applying current 1 in 100 sea-flood risk scenario
- Analysing monthly high-water impact.
- Analysing storm water runoff

5. Current exposure – overview

Overview

Map SF9-2

Knight Beach

Overview

SA Classification

Shoreline class
Reflective+ Low tide terrace + Rock

Sand rating
Fine medium sandy beach

Exposure:
Moderate relative exposure

Wave:
Moderate (narrow beach break)

Backshore 1:
Cliff 5m to 20m high

Backshore 2:

Rising about 28m AHD at 500m inland (old consolidated dune)

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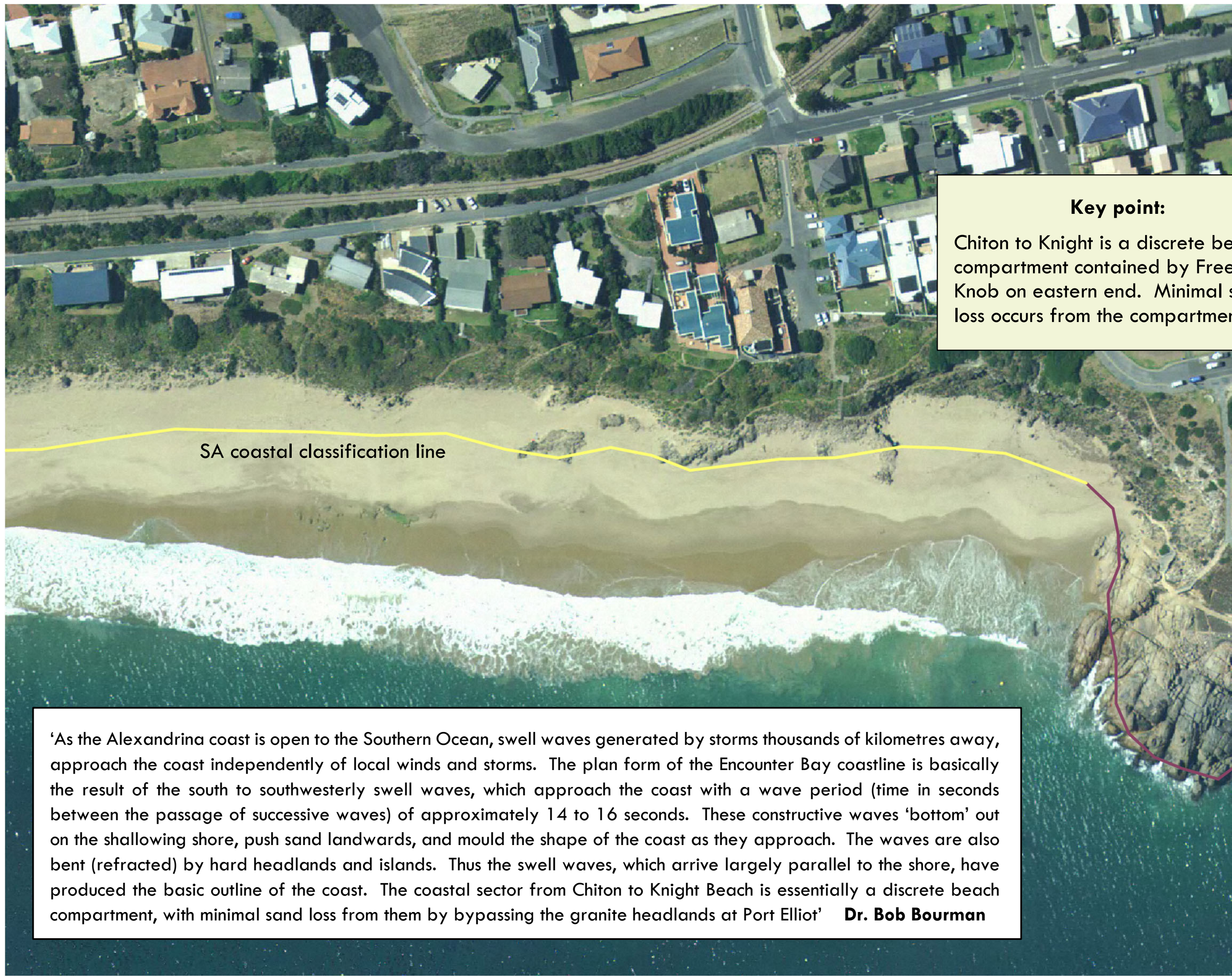

Key point:

Chiton to Knight is a discrete beach compartment contained by Freeman Knob on eastern end. Minimal sand loss occurs from the compartment.

'As the Alexandrina coast is open to the Southern Ocean, swell waves generated by storms thousands of kilometres away, approach the coast independently of local winds and storms. The plan form of the Encounter Bay coastline is basically the result of the south to southwesterly swell waves, which approach the coast with a wave period (time in seconds between the passage of successive waves) of approximately 14 to 16 seconds. These constructive waves 'bottom' out on the shallowing shore, push sand landwards, and mould the shape of the coast as they approach. The waves are also bent (refracted) by hard headlands and islands. Thus the swell waves, which arrive largely parallel to the shore, have produced the basic outline of the coast. The coastal sector from Chiton to Knight Beach is essentially a discrete beach compartment, with minimal sand loss from them by bypassing the granite headlands at Port Elliot' **Dr. Bob Bourman**

5. Current exposure- storm event

Storm event

Map SF9-2

Knight Beach

Event: 21-22 November 18

Assessment

A storm event on 21-22 Nov 2018 provides the basis for establishing wave effect parameters.

The event was recorded at Victor Harbor gauge at 11.45pm at a height of 1.99 (CD) or 1.41m (AHD).

Analysis within SF9:2 of seaweed strands and other markers after the event demonstrated wave effects were ~1.80m above tidal gauge height. Wave set-up 0.5m and 1.3m wave runup.

Wave effects were very large, but this event occurred at a lower tide and had very little impact on beach and backshore.

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5. Current exposure – storm surge

Storm surge

Map SF9-2

Knight Beach

Current risk: storm surge

1 in 100-year sea flood risk

Assessment

The 1 in 100-year ARI event current risk set by Coast Protection Board is:

Storm surge	1.75m AHD.
Wave set-up	0.50m
Risk	2.25m AHD

Wave run-up is 1.3m and depicted in light blue.

In this event wave run-up would flow up the beach but the modelling does not show that it would impact the base of the dunes/ cliffs apart from on the eastern end of the cell.

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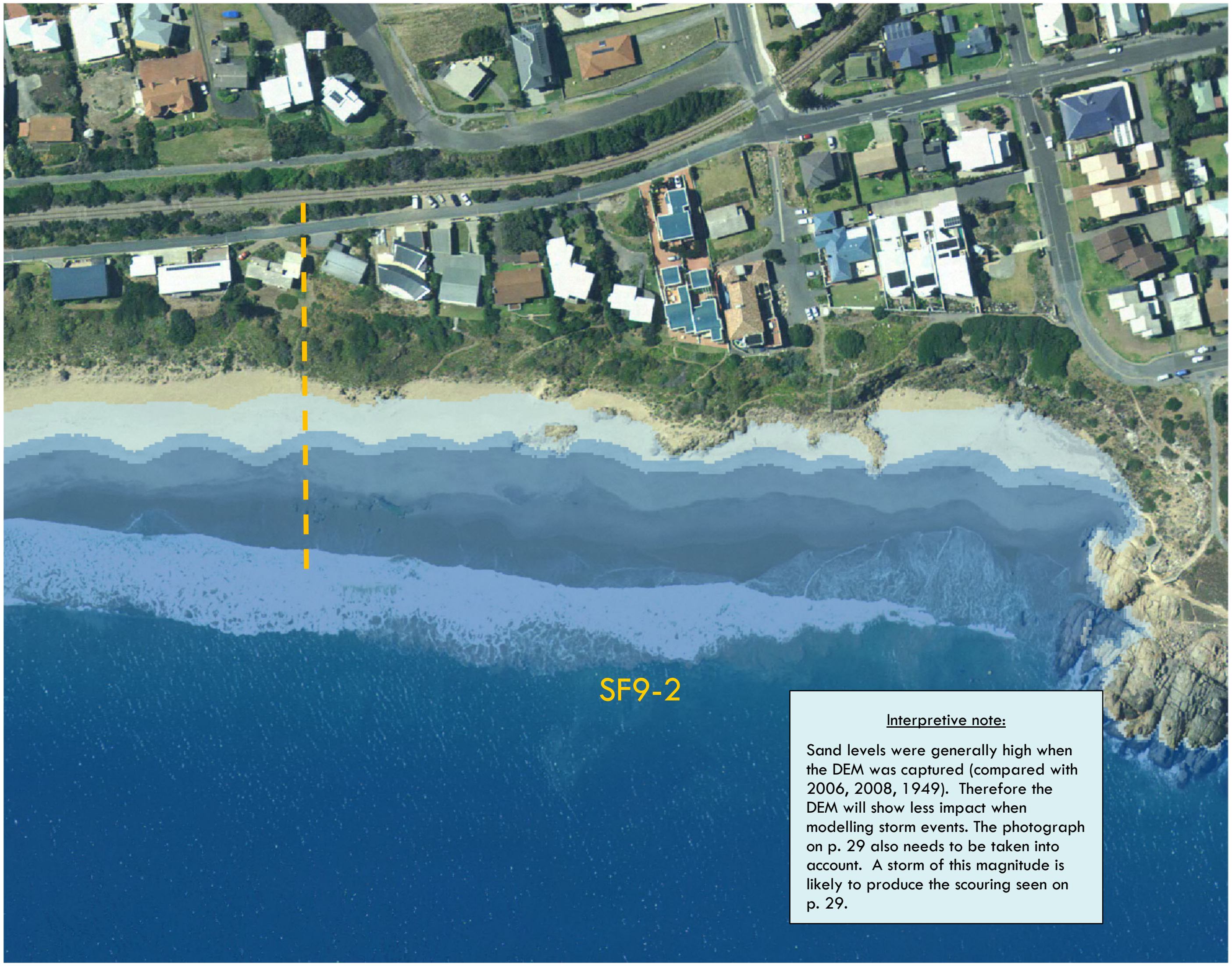

Interpretive note:

Sand levels were generally high when the DEM was captured (compared with 2006, 2008, 1949). Therefore the DEM will show less impact when modelling storm events. The photograph on p. 29 also needs to be taken into account. A storm of this magnitude is likely to produce the scouring seen on p. 29.

5. Current exposure – monthly high water

Monthly high water

Map SF9-2

Knight Beach

Current Risk:

Monthly high water

Assessment

Extreme events are very rare and can have a significant impact. Routine tidal action may also have an impact on the stability of a dune system over time.

Monthly high tide data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal event. The event pictured here is expected to occur every one or two months.

The event modelled:

Average high tide	1.50m
Wave effects	0.30m
Total risk	1.80m

Wave run-up of 0.90m is included.

The current impact on beach and backshore is low.

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5. Current exposure – storm water

Storm water

Map SF9-2

Knight Beach

Current risk:

Storm water

Assessment

Storm water in SF9-2

Storm water drains to various locations. The GIS plans are not entirely clear.

Storm water does flow into Knight Beach from the settlement to the east. The lowering of the beach in the middle can be observed in the photograph to the right.

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5. Current exposure – storm water

Storm water

Map SF9-2

Knight Beach

Current risk:

Storm water

Assessment

Storm water in SF9-2

Storm water flows into a stormwater culvert on Merrilli Place, is piped under the road and empties on to the cliff escarpment where shown (see inset).

Storm water flows into a storm water pit on Merrilli Close, is piped to the foreshore and empties on to the rocky outcrop at the back of the beach.

See also next page.

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Note storm water scouring through centre of beach (also visible in aerial view)

Water is piped under Merrilli Place and dissipates through vegetation before flowing over the cliff to the beach.

Storm water from the end of Merrilli Close (different location) is piped to the beach, and dissipates over the rocky outcrop at the back of the beach.

5. Current exposure – storm water

Storm water

Map SF9-2

Knight Beach

Current risk:

Storm water

Assessment

Storm water flows into a stormwater culvert at the street which is piped under the road, and flows on to the top of the escarpment. The water appears to be dissipated down the slope through the vegetation and rocks. There is no evidence of scouring at the top of the cliff (but note that we are in a dry period).

The scouring of the beach was not evident on inspection of 22 April, 2019, but is evident in other photographs.

It appears as if this storm water drainage strategy is appropriate, but further checks should be conducted after rain.

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5. Current exposure – storm water

Storm water

Map SF9-2

Knight Beach

Current risk:

Storm water

Assessment

Storm water drains from Merrilli Close to a box culvert. It is pipe from there to the base of the cliff. The intention is that storm water would dissipate over the rocky outcrop at the base of the beach.

This appears to be a sound strategy.

However, the end of the pipe is currently blocked by sand and requires cleaning.

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5. Current exposure - erosion

Erosion

Map SF9-2

Knight Beach

Current risk

Erosion outlook

Assessment

A comparison of historical aerial photographs supports the view that the base of the dune escarpment has largely been in the same location since 1949.

A comparison of historical aerial photographs demonstrates that the top of the cliff has not receded.

Flood modelling demonstrates that routine tidal action is not reaching the back of the beach.

The event of November 2018 did reach back of the beach on north-western side.

Current erosion outlook: The modelling suggests that the rear of the beach is not currently impacted by routine tidal action or large storm events. The backshore shows no evidence of impact from actions of the sea. The event of 18 November 2018 occurred at high tide and was accompanied by a significant storm surge and high wave effects. However, the event occurred on the low side of the tide cycle. Hypothetically, the event could occur on the peak of the cycle, and such an event is likely to reach the back of the beach.

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5. Current exposure - erosion

Erosion

Map SF9-2

Knight Beach

Current risk

Compare 2008

Assessment

In 2008, DEW conducted oblique aerial photograph capture.

The photograph captured to the right demonstrates the possible variation in sand levels on the beach.

In this case, it appears that the beach is being rebuilt. This may have been occurring after a significant storm event were sand was removed from the beach, or sand levels were already low, and the beach is undergoing accretion.

A slight accretion of the beaches of the whole coast is observed in the time period 2006 to 2016.

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FUTURE EXPOSURE

Evaluating how future actions of sea and other weather events may impact the coastal fabric by:

- Reviewing 1 in 100 scenarios for 2050 and 2100
- Reviewing monthly high-water scenarios for 2050 and 2100
- Analysing erosion risk to 2100

6. Future exposure – storm surge (2050)

Storm surge

Map SF9-2

Knight Beach

2050 risk:

1 in 100-year sea flood risk

Assessment

The 1 in 100-year ARI event risk set by Coastal Protection Board for 2050 includes an allowance of 0.3m sea level rise:

Storm surge	1.75m AHD
Sea level rise	<u>0.30</u>
	2.05m AHD
Wave set-up	<u>0.50</u>
Risk	2.55m AHD

Wave run-up of 1.30m has been depicted in light blue.

Scenario modelling demonstrates that wave-runup would impact the rear of the beach on eastern side but not impact the northern side of the base of the escarpment.

Base of the dunes appear not to be impacted on the western side.

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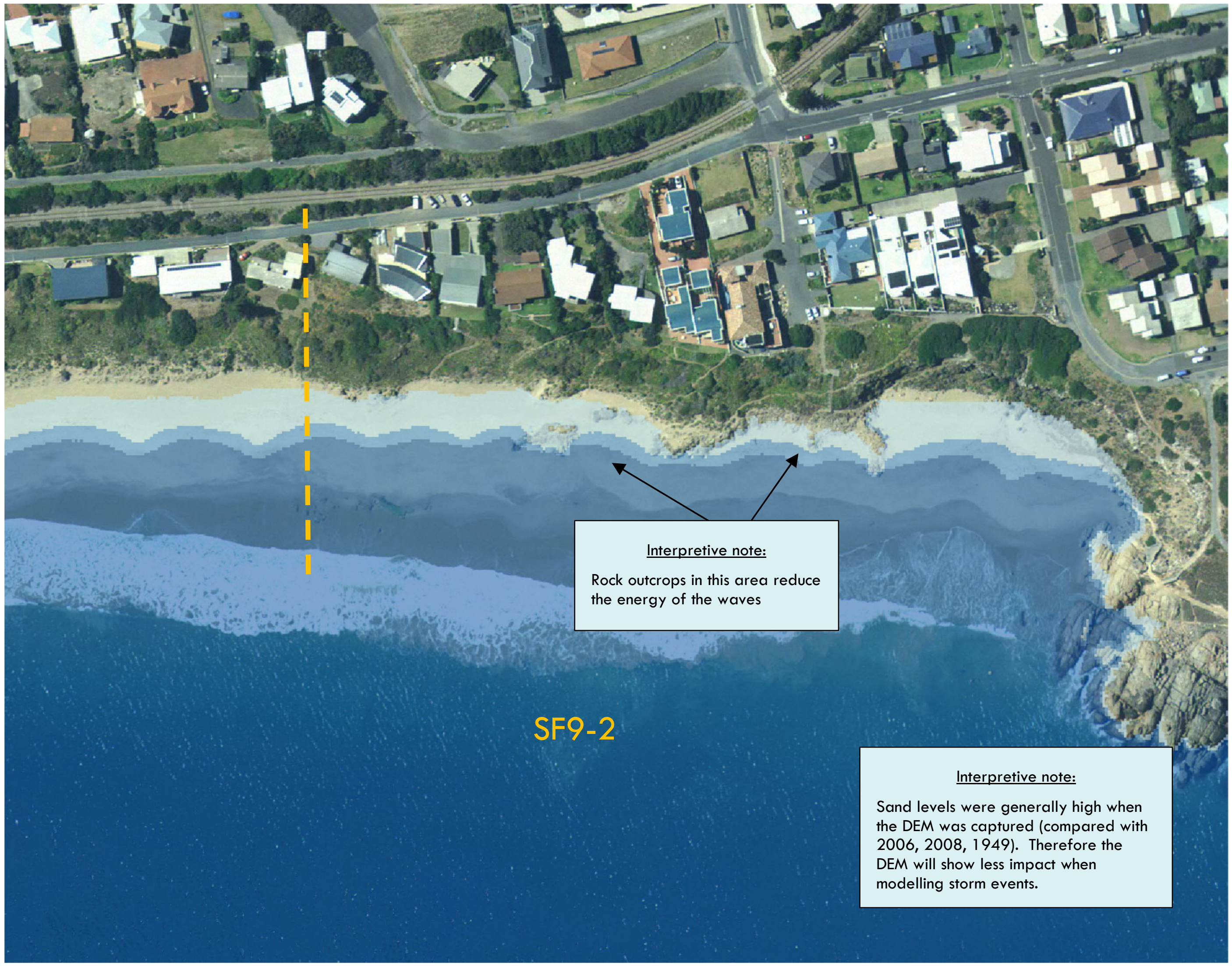

6. Future exposure – storm surge (2100)

With sea level rise

Map SF9-2

Knight Beach

2100 risk:

1 in 100-year sea flood risk

Assessment

The 1 in 100-year ARI event risk set by Coast Protection Board for 2100 includes an allowance of 1.0m sea level rise:

Storm surge	1.75m AHD
Sea level rise	1.00
	2.75m AHD
Wave set-up	0.50
Risk	3.25m AHD

Wave run-up of 1.3m is indicated by the lighter blue shading.

The modelling shows that if an event of this magnitude occurred that the impact at the base of the cliff escarpment would be significant (especially on the eastern side). Dunes to the west may be impacted by wave run up.

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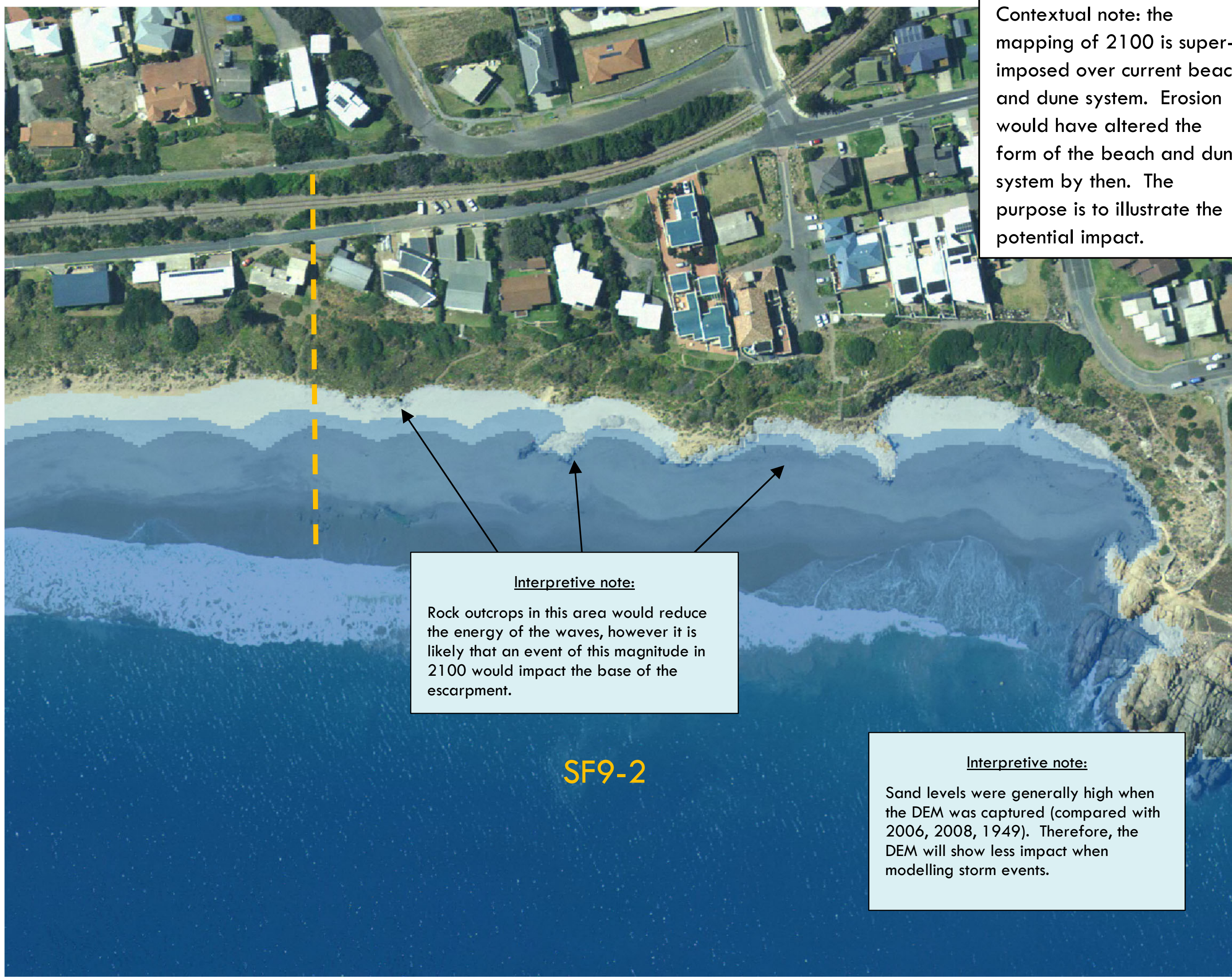

Contextual note: the mapping of 2100 is super-imposed over current beach and dune system. Erosion would have altered the form of the beach and dune system by then. The purpose is to illustrate the potential impact.

6. Future exposure – monthly high water (2050)

Monthly high water

Map SF9-2

Knight Beach

2050 risk:

Monthly high water

Assessment

Monthly high tide data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal action. This modelled event is expected to occur every one or two months.

Routine tidal action may have a larger impact on the stability of a dune system over time.

The event modelled:

Average high tide	1.50m
Plus sea level rise	0.30
	1.80m
Wave set up	0.30m
Total risk	2.10m

Wave run-up of 0.9m has been included.

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6. Future exposure – monthly high water (2100)

Monthly high water

Map SF9-2

Knight Beach

2100 risk:

Monthly high water

Assessment

Monthly high tide data from 1965 to 2016 was averaged to provide a perspective of the more routine tidal event. This modelled event is expected to occur every one or two months.

Routine tidal action may have a larger impact on the stability of a dune system over time.

The event modelled:

Average high tide	1.50m
Plus sea level rise	1.00
	2.50m
Wave set up	0.30m
Total risk	2.80m

Wave run-up of 0.9m has been included.

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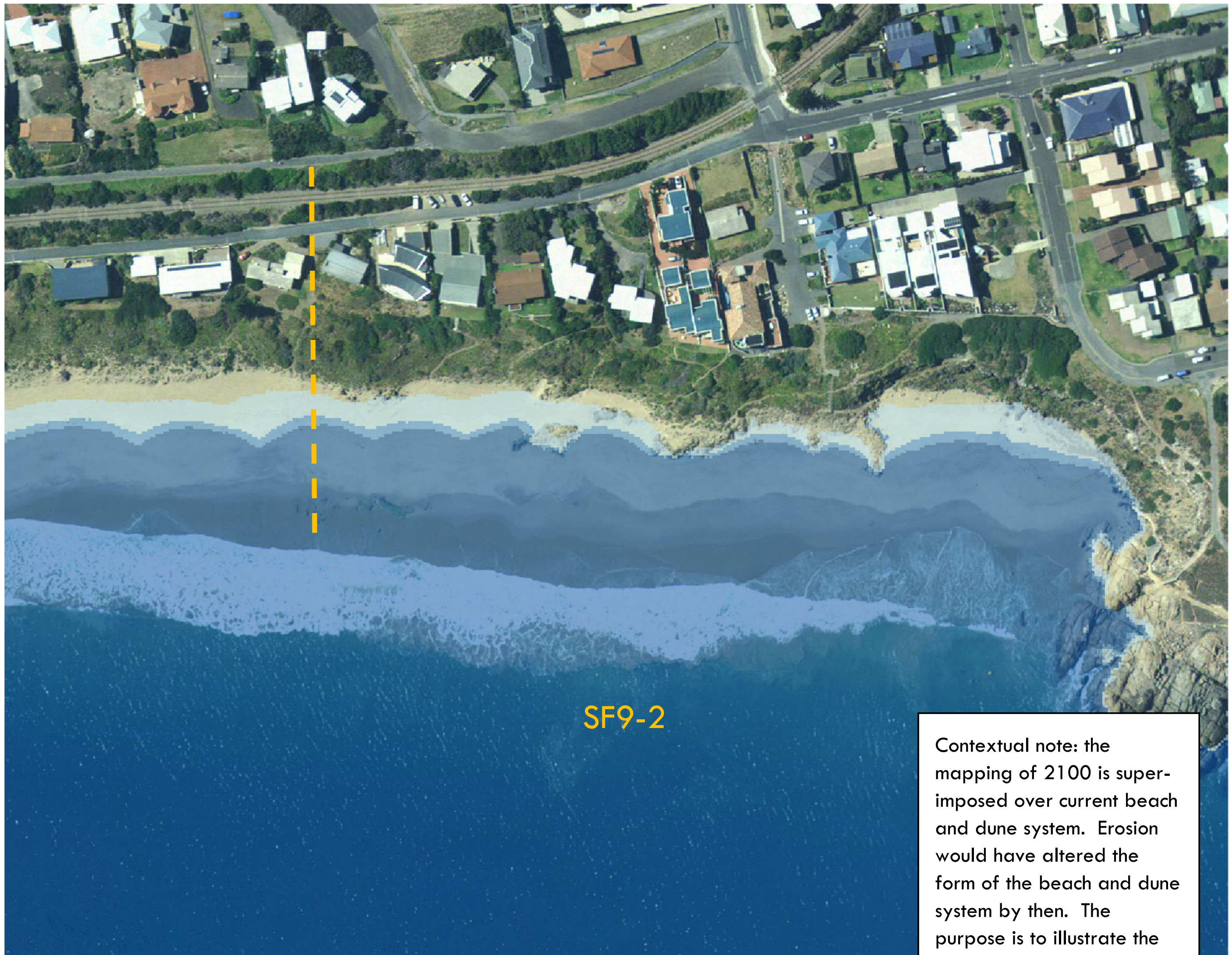

Contextual note: the mapping of 2100 is super-imposed over current beach and dune system. Erosion would have altered the form of the beach and dune system by then. The purpose is to illustrate the potential impact.

6. Future exposure – erosion (2100)

Future Exposure

Map SF9-2

Knight Beach

2100 risk:

Erosion outlook

Assessment

The modelling shows that the backshore would be more significantly impacted by 2100 by storm events but appears less significant with routine tidal action.

However, it is important to note that modelling is conducted on current sand levels, and it isn't possible to establish the likely sand environment in 2100.

The modelling demonstrates that the impact would be higher on the eastern side of the bay.

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The modelling shows that the backshore would be more significantly impacted by 2100 by storm events, but appears less significant with routine tidal action. However, it is important to note that modelling is conducted on current sand levels, and it isn't possible to establish the likely sand environment in 2100.

The modelling demonstrates that the impact would be higher on the eastern side of the bay.

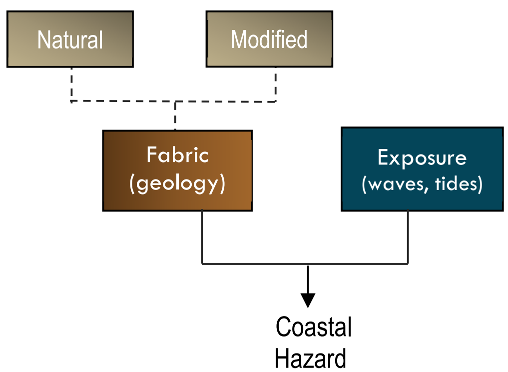
Erosion assessment tools such as the Bruun Rule are not applicable in a location such as Knight Beach where the backshore is a cliff, but rather ongoing monitoring of the behaviour of the bay, and impact on the backshore will be key elements to deal with this beach over time.

COASTAL EXPOSURE

Summary and Conclusions

Progress report:

So far, we have completed a preliminary assessment, a review of settlement history and completed an assessment of the 'geology' or 'fabric' of the cell. In the last section we also analysed current and future exposure.



Current exposure

<u>Baseline storm event</u>

The event of 21-22 November 2018 provided a baseline event from which to quantify wave effects within Knight Beach. (It is recommended that one or two more events are analysed in the future). Total wave effects in SF9-2 totalled 1.80m.

However, while this storm produced significant wave effects, the tide at the gauge was not exceptionally high (less ~0.20m than record of 9 May 2016).

<u>Storm surge</u>

Coast Protection Board has set 1 in 100 ARI event at 1.75m AHD (ie at the tide Victor Harbor tide gauge).

If this event was to occur, mapping shows that wave runup would impact the eastern side of the escarpment.

<u>High tides (every 1 or 2 months)</u>

Extreme events such as a 1 in 100 ARI event can cause considerable damage but these are rare events. Routine tidal action is more likely to break down the dune system over time. Routine highwater is unlikely to be causing any significant erosion in this current era.

However, the mapping is predicated on current sand levels, and it appears as if sand levels are generally higher in 2018 than they were in 2006/ 2008.

Future exposure (indicatively by 2050)

<u>Storm surge</u>

Storm surges at 2050 would have some impact on the back shore (especially on the eastern side), but the beach is likely to reform after these rare events occurred.

<u>High tides (every 1 or 2 months)</u>

Routine tidal action does not appear to have a significant impact upon the back shore.

Future exposure (indicatively by 2100)

<u>Storm surge and high tides</u>

Routine tidal action is modelled in the same location as current 1 in 100 ARI events, but these events are not necessarily accompanied by significant wave action.

Extreme storm events would impact the backshore and erosion of the escarpment is to be expected.

7. Inherent hazard risk assessment

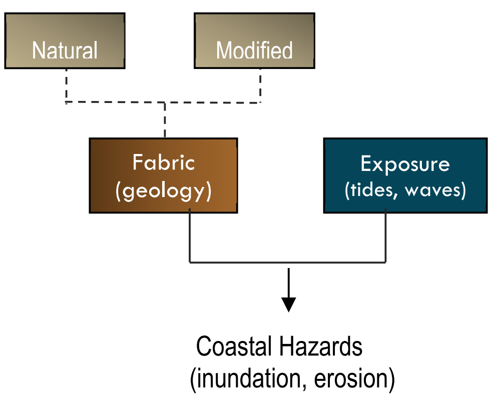
CoastAdapt identifies two main coastal hazards:

- Inundation
- Erosion

It is the combination of the characteristics of the coastal fabric and the nature of the exposure that determines the degree of hazard risk.

This reality is most simply understood when considering inundation risk. Whether a coast is at risk from inundation depends entirely on the topography of the coast. If we explain this another way, a low-lying coast is *inherently* more at risk from flooding whereas an elevated coast is inherently not at risk from flooding.

The assessment of the erosion hazard is far more complex, but it is still the relationship of fabric to exposure that determines whether a coast is *inherently* more at risk from erosion or less at risk.



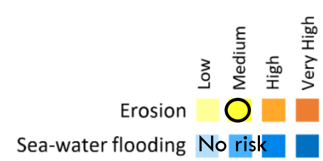
Inundation hazard risk

Due to the slope and elevation of backshore 1, there is no inundation hazard risk for Knight Beach.

Erosion hazard risk

Evaluation steps	Assessment factors	Inherent hazard risk
Allocate initial erosion hazard rating from geological layout table	Sandy beach, backshore 1: Cliff (Pleistocene aeolianite or calcarenite), backshore 2: backed by bedrock rising to 28m inland.	Medium
Should this rating be amended due to human intervention such as a protection item? If so, how?	No, human intervention is limited to dune fencing.	Medium
Apply an exposure rating (DEW)	DEW assigns an exposure rating of 'moderate'.	Medium
Assess any impact on backshore 1	Comparison of photographs from 1940s with present reveals no impact or change to the backshore.	Medium
Assess any influence from Benthic	Offshore reefs: with increasing depths of water exposure may increase but this is expected to be more.	Medium
Assess the sediment balance	Boomer-Knight Beach is essentially a closed cell with limited amount of sand moving to the east.	Medium
Assess any other factors that may warrant a change of inherent hazard risk.	Nil	Medium

Inherent Hazard Risk – Knight Beach



HAZARD IMPACTS

In this section we identify and describe the potential hazard impacts within four main receiving environments:

- Public assets
- Private assets
- Safety of people
- Eco-system

8a. Assets at risk (public)

Public

Map SF9-2
Knight Beach
Assets at risk
Public

Notes

Public assets at risk at Knight Beach are limited to the bend in the road of Merrilli Place.

The assessment and modelling indicate that the backshore of Knight Beach has been stable since 1949, and based on this assessment, Merrlilli Place is unlikely to be at any immediate risk.

Impacts of the sea later in the future are likely to impact the base of the eastern side of Knight Beach which is also in the same proximity as the road above.

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8a. Assets at risk (public)

Public

Map SF9-2

Knight Beach

Assets at risk

Public

Beach access

Knight Beach has two pedestrian access points:

1. Merrilli Place (and also connected to Green Bay)

Access is well designed and protected from erosion by rocky outcrops.

2. Merrilli Close

Access stairs culminate on top of a rocky outcrop and therefore free from any impacts from the sea.

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8b. Assets at risk (private)

Private

Map SF9-2

Knight Beach

Assets at risk

Private

Notes

Twelve private dwellings and allotments are situated on top of the cliff behind Knight Beach.

The long-standing State Government policy has been to not provide funding for private assets. Based on research such as that conducted by Baker McKenzie and Coast Adapt, the prevailing view is that Council is unlikely to be liable to protect these assets.

However, the exception is likely where Council has approved new development in locations at risk.

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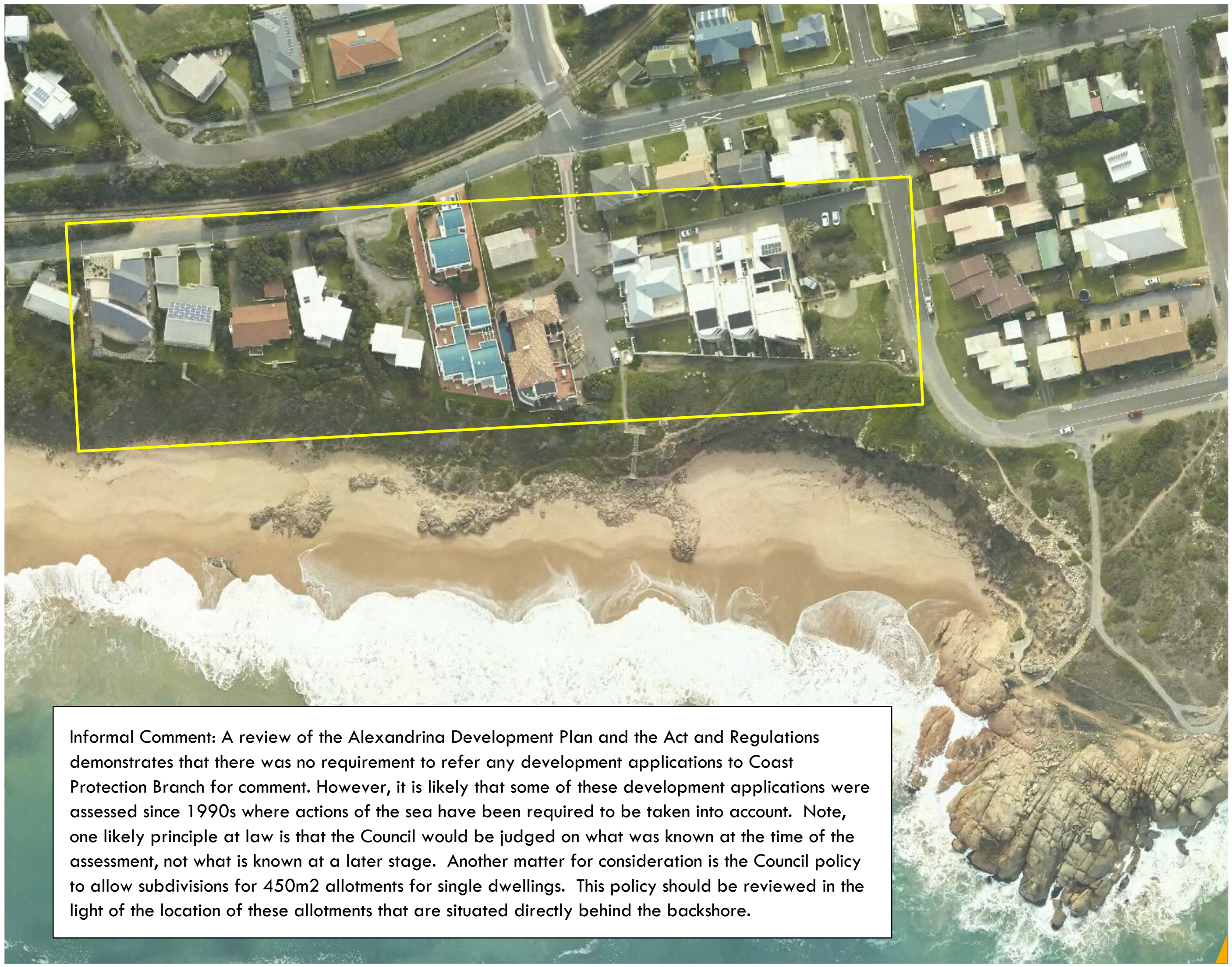


Informal Comment: A review of the Alexandrina Development Plan and the Act and Regulations demonstrates that there was no requirement to refer any development applications to Coast Protection Branch for comment. However, it is likely that some of these development applications were assessed since 1990s where actions of the sea have been required to be taken into account. Note, one likely principle at law is that the Council would be judged on what was known at the time of the assessment, not what is known at a later stage. Another matter for consideration is the Council policy to allow subdivisions for 450m2 allotments for single dwellings. This policy should be reviewed in the light of the location of these allotments that are situated directly behind the backshore.

8c. Safety of people

The assessment conducted within this project is only related to how impacts of the sea may increase the risk to people accessing the area. It is not related to any risks that the beach and backshore currently pose to the safety of people. This assessment remains with Council in its normal operation of risk.

Some potential risks include but should not be regarded as exhaustive:

- If the cliff at the backshore became eroded at the base, then the upper levels of the cliff may be more prone to collapse. The research has shown that no impact is currently evident at the base of the cliff.

- Increased wave action is likely within the bay over time (especially post 2050), but this risk can be offset with warning signs, and if necessary, the reorientation of walk ways and access points.

8d. Ecology at risk

The assessment of ecology of risk in the context of this project is confined to that which may be described as 'ecosystem disruption' with the intent that this disruption would occur on a wide scale. For example, sea water flooding through the dunes at Ratalang Basham will irreversibly change the nature of the ecosystem on a large scale.

The geological layout of Knight Beach with cliff backshore means that no larger scale ecology is at risk.

RISK ASSESSMENT

In this section we conduct a formal risk assessment of hazard impacts upon the four receiving environments:

- Public assets
- Private assets
- Safety of people
- Eco-system

This risk assessment utilises the risk framework of Alexandrina Council.

9. RISK ASSESSMENT

Inherent hazard rating

Integrated Coasts has developed a risk classification system to operate over the State of South Australia that categorises the risk to a coastal cell in relation to two main hazards:

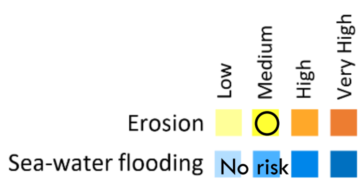
- Sea-water flooding
- Erosion

The application of an inherent risk rating does not suggest that areas rated as low are entirely free from vulnerability, nor conversely that areas rated more highly are necessarily vulnerable now. The aim is to assess the underlying inherent vulnerability of the fabric of the coastal location using a process that will also benchmark the locality in the context of all of South Australia.

The visual output from the inherent risk assessment process is purposefully designed so that it is immediately accessible and meaningful to a wide range of personnel involved in managing the coastal environs.

The inherent hazard risk rating for Knight Beach is:

Inherent Hazard Rating



Specific Risk Assessment

Each of the cells are assessed more specifically for risk in the context of four receiving environments:

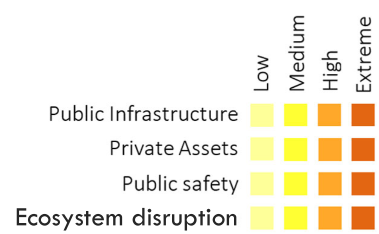
- Public infrastructure
- Private assets
- Public safety
- Eco-system disruption

The term eco-system disruption is used to describe the situation where changes in a coastal region might bring about larger scale changes that may threaten to disrupt the entire ecological system, for example seawater flooding into freshwater ecologies.

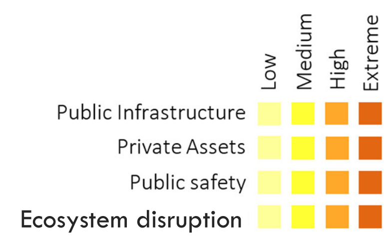
This risk assessment utilises the risk assessment of Alexandrina Council and is reported within standardised templates for the relevant hazard: seawater flooding or erosion (see next page).

The specific risk assessment is provided for two eras: the current era, and the 'future outlook'. In this study, future outlook means the end of this current century.

Erosion Hazard Rating
(Current outlook - 2020)



Erosion Hazard Rating
(Future outlook- 2100)



Yet to be completed

9. Risk Assessment

Erosion assessment

Knight Beach (SF9-2)

Risk identification: Erosion is currently, or may in the future, threaten the backshore of Knight Beach

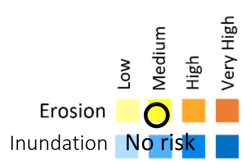
Coastal processes	Knight Beach is categorised as a reflective medium sandy beach, tends to be a closed cell as it is bordered by granite headlands on the east. The beach is backed by cliffs 5-10m high of Pleistocene aeolianite or calcarenite. The bay is bedrock backed, a former sand dune now hardened, rising above 30m at 500m inland. Exposure is categorised as 'moderate', and wave energy moderate at ~1m. Historical analysis suggests that the back-shore of the beach has not, and is currently not being impacted by actions of the sea. Analysis of future regimes suggests that this may change.

Are any strategies employed to mitigate the risk? Nil

Receiving environment	Coastal Context	Time	Likelihood	Consequence	Risk
Public infrastructure	The risk to public infrastructure is contained to the road and associated infrastructure of a section of Merilli Place. Note, current risk rating could be- no risk	current	*Rare*	*Moderate*	low
		2100	*Possible*	*Significant*	high
Private assets	The risk to private assets is contained to 12 allotments and associated dwellings. Note based on assessment, these could be assigned no risk (current).	current	*Rare*	*Moderate*	low
		2100	*Possible*	*Significant*	high
Safety of people	This assessment does not relate to general beach safety of pedestrians or swimmers. It relates only to how the safety of people may be exacerbated due to increased sea level (and associated impacts)	current	*Rare*	*Insignificant*	low
		2100	*Rare*	*Insignificant*	low
Ecosystem disruption	This assessment relates to large scale disruption to ecological systems. The geology of the area contains the risk and therefore there is no perceived risk.	current	*No risk*	*No risk*	No risk
		2100	*No risk*	*No risk*	No risk

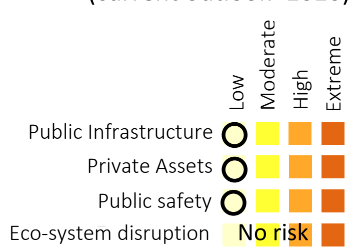
Inherent Hazard Rating

Sandy beach back by soft rock cliff >8m



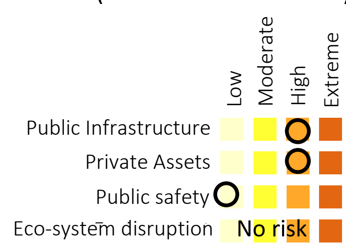
Erosion Hazard Rating

(current outlook- 2020)



Erosion Hazard Rating

(future outlook - 2100)



Note: the assignment of future risk assumes that no action is taken to mitigate the risk apart from normal safety procedures.

Rain intensity and storm water impacts not assessed in this risk assessment

Summary	Knight Beach has shown no evidence of erosion to the backshore since 1949. Scenario modelling suggests that only extreme events may reach the backshore. Even if these do occur, Knight Beach is likely to be a contained cell, and the beach will rebuild over time. Sea level rise is likely to bring increased impact to the rear of the beach and this may undermine the base of the cliffs.

ADAPTATION PROPOSALS

Adaptation options

ADAPTATION OPTIONS

CoastAdapt notes that there are generally six categories of adaptation responses to climate change in the coastal zone:

- Avoidance
- Hold the line (protect)
- Accommodation (or limited intervention)
- Managed retreat
- Defer and monitor
- Loss acceptance

Within each of the four response categories there is a range of potential adaptation options in the areas of[1]:

- Planning
- Engineering
- Environmental management

Planning

These are options that use planning legislation and regulations to reduce vulnerability and increase resilience to climate change and sea-level rise. Thus, land that Is projected to become more prone to flooding in future can be scheduled as suitable only for development such as light industry or warehouses, and unsuitable for housing or critical infrastructure.

Engineering

In the context of climate change adaptation 'engineering' has come to describe adaptation options that make use of capital works strategies such as seawalls and levees. Such projects are 'engineered' to solve a particular challenge such as to protect coastal infrastructure from erosion and inundation damage. These approaches differ from other types of approaches in that they require significant commitments of financial and social resources and create a physical asset.

Environmental management

Environmental management includes habitat restoration and enhancement through activities such as revegetation of coastal dunes or building structures to support continued growth of habitat such as seagrasses or reefs.

It may also include developing artificial reefs to reduce wave erosion of shorelines or engineered solutions to prevent encroachment of saltwater into freshwater systems.

ADAPTATION APPROACHES

There are two broad ways in which adaptation can occur in relation to timing:

- Incremental approach

A series of relatively small actions and adjustments aimed at continuing to meet the existing goals and expectations of the community in the face of the impacts of climate change.

- Transformative approach

In some locations, incremental changes will not be sufficient. The risks created by climate change may be so significant tat they can only be addressed through more dramatic action. Transformational adaptation involves a paradigm shift: a system-wide change with a focus on the longer term. A transformative approach may be triggered by an extreme event or a political window when it is recognised the significant change could occur.

KNIGHT BEACH

The modelling and assessment indicate that the backshore of Knight Beach is currently not under threat from actions of the sea.

An **incremental adaptation** approach is recommended.

To protect private and public infrastructure over time, a **hold the line** methodology is recommended. The cost of holding the line is likely to be borne by Council and private landowners.

Because there is unlikely to be any immediate threat, the approach should be to **monitor** this beach over time, with special attention to changes/impacts to the back shore.

Consider amending **planning controls** to prevent any further densification of sites on Torrens Street adjacent the cliff escarpment.

Further reading and resources

This section of work adopts the framework and understanding of adaptation options from CoastAdapt. Further reading at:

https://coastadapt.com.au/understand-adaptation
https://coastadapt.com.au/adaptation options

[1] CoastAdapt also includes 'community education'.

Adaptation proposals

Monitor and Respond

Map SF9-2

Knight Beach

Adaptation proposal

Monitor and Respond

Monitor

The base of the escarpment should be regularly monitored, especially after storm events (see explanation at end of this report)

Respond – hold the line

Should increase impact to the base of the escarpment occur, then protection options should be considered – rock revetment, sandbags (or similar).

Planning

Consider changing Development Plan controls for sites on Torrens St to prevent further densification of sites adjacent the escarpment.

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Monitoring overview

The purpose here is not to provide a design for a detailed monitoring program as this will be completed as a separate project. The purpose here is to provide a context for understanding why monitoring is necessary and broadly, what type of monitoring actions are likely to be adopted.

In most areas of Alexandrina coastline, this study has recommended an 'incremental approach' to adaptation (see page above). The main reason to adopt this approach is that most of the coastline is not currently at risk from erosion or inundation. In fact, large sections of the coastline have shown to be accreting over the last ten years.

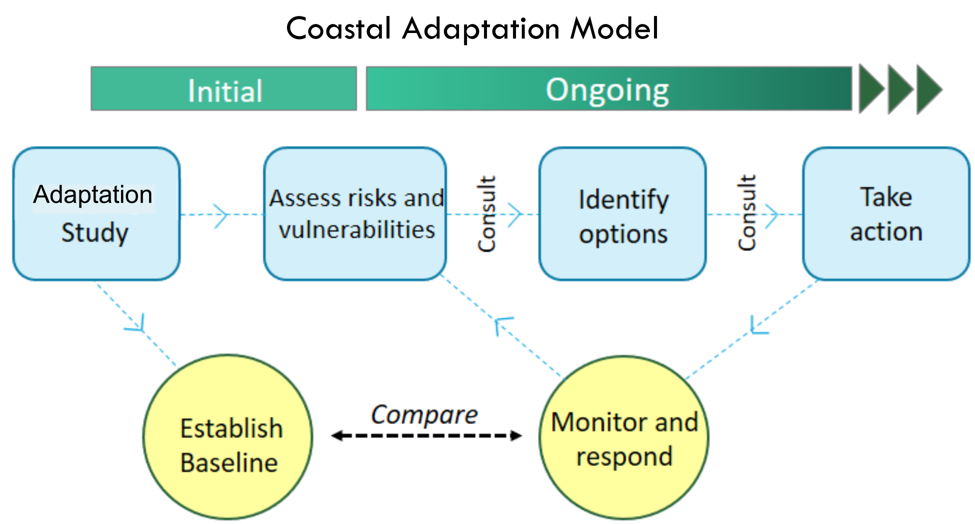
Prime response – 'monitor and respond'

Therefore, the prime adaptation response will be to 'monitor and respond'. Data will be collected on an ongoing basis and compared to the baseline we have established in this study.

We have established a baseline in two ways: First, the capturing of the digital elevation model in 2018 provides a point in time baseline of the current form of the coast. In 5- or 10-years' time (depending whether the coast is accreting or eroding), another digital elevation model could be captured and comparisons made between the two digital models (Figure).

The second way in which this study has formed a baseline is by analysing coastal change over time. We have compared the position of the shoreline from 1949 to 2018 and identified areas of erosion and accretion. Overall, the coastline in most places appears to have been stable for 70 years. In some places it has eroded. This understanding of how a coast operates over time also forms part of the baseline understanding. In the future, we can use newly acquired aerial photographs to compare shoreline position in the future or other sand monitoring techniques (See also Main Report).

Figure: In a digital environment, software tools can be utilised to compare coastal change (Source: Aerometrex)

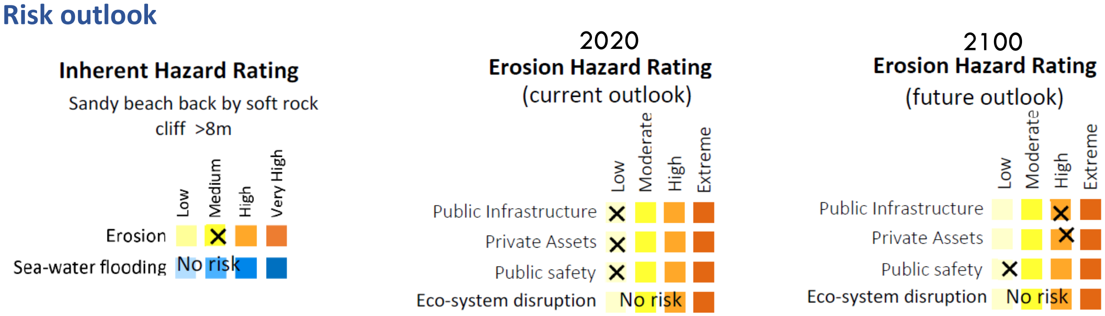


Integrated Coasts (2017)

Adaptation Proposals: Knight Beach (Cell SF9-2)

Coastal processes	Knight Beach is categorised as a reflective medium sandy beach, tends to be a closed cell as it is bordered by granite headlands on the east. The beach is backed by cliffs 5-10m high of Pleistocene aeolianite or calcarenite. The bay is bedrock backed, a former sand dune now hardened, rising above 30m at 500m inland. Exposure is categorised as 'moderate', and wave energy moderate at ~1m. Historical analysis suggests that the backshore of the beach has not and is currently not being impacted by actions of the sea. Analysis of future regimes suggests that this may change.

Risk outlook



Adaptation overview:

The long-term strategy for Knight Beach is to protect the base of the cliff. This strategy is likely to be effective in the geological setting in which Knight Beach is located. An incremental approach to adaptation is recommended. Monitoring of beach processes, sand volumes, and impact to backshore will provide the decision-making context for when protection is required. Review of planning policy for private allotments on Barbara Street is recommended.

Adaptation proposals:

	Approach	Short term strategy 2020	Mid-term strategy 2050	Long term strategy 2100	Adaptation Type	Monitoring strategy
Knight Beach Cell SF9-2	Incremental (monitor and respond)	Monitor [no immediate works are likely to be required]	Monitor [protection may be required by 2050]	Protect backshore [Private and public infrastructure is positioned behind Knight Beach]	Engineering: rock revetment or similar at base of cliff Planning: review and amend planning policy for allotments on Barbara St.	Shoreline position Storm impacts on backshore Sand volumes – identify the normal range of the beach