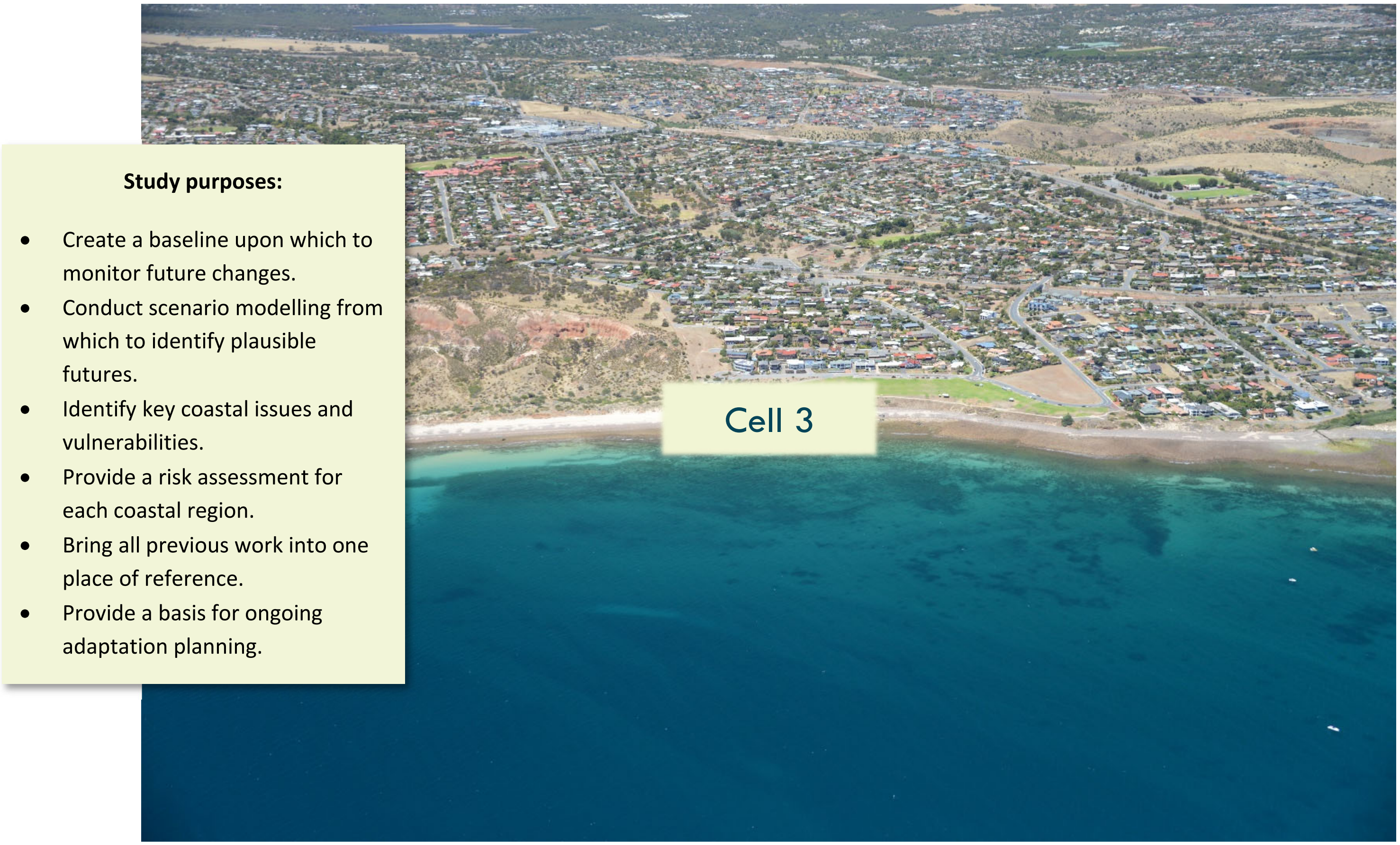
Coastal Adaptation Study

HALLETT COVE BEACH



By Integrated Coasts

Review date 1 December 2022

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Mark Western, Project Leader, Integrated Coasts (2018, 2022).

Joram Downes, Integrated Coasts, (2022).

Dr Graziela Miot da Silva, geology assessment (2018).

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Report reference:

Western, M. et al, 2022, Coastal Adaptation Study, Marino Cliffs, for City of Marion, Adelaide, South Australia.

Front cover:

South Australian Coast Protection Board, oblique photograph, 2014.

Review date:

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1. Introduction

This coastal cell report is a review of the *Coastal Adaptation Study for City of Marion, 2018*. These cell reports are now structured within a template so that future reviews can also build upon this report. The final section, *Summary and Recommendations*, is designed as a standalone section that can be used in other reporting contexts and acts in a similar way to an Executive Summary.

PROJECT SCOPE

Climate Variables

Managing projected climate change impacts involves dealing with 'deep uncertainty'[1]. This uncertainty is primarily related to the nature of long-term projections which are based on climate models. These models are computer-based simulations of the Earth-ocean-atmosphere system. Models are effective at simulating temperature, but their accuracy is much less for the simulation of rainfall[2]. Overall rainfall is expected to decline in our region over the coming century and the intensity of rainfall events is expected to increase, but these projections are not assigned with as much confidence as for temperature or sea level rise. Furthermore, the climate is a complex system and the variables interdependent. For example, on the one hand we might predict that declining rainfall would produce a more arid climate and therefore less vegetation but a recent study by NASA has found that over the last 35 years the planet has been greening, and that increased carbon dioxide in the atmosphere is 70% responsible[3]. As we learn more about the climate system and obtain more data over time, observable trends and projections will also become more certain.

Direct and indirect impacts

Some climate change impacts are more direct than others. Rising sea levels will directly impact the landforms adjacent the coast, either through increasing inundation of lower lying areas, or increasing erosion. Other impacts will be less direct. For example, projections for a drier climate are often associated with less vegetation in dunes, and the increased cracking of cliffs[5]. Increased intensity of rainfall events may increase the erosion and gullying of cliff-tops thereby increasing the potential for increased rates of recession and instability. The impact of rising sea levels can be assessed through sea flood modelling within digital models. The impact of vegetation loss cannot be easily quantified and as noted above, is based upon less certain projections. Attempting to incorporate too many impacts into a coastal study is likely to compound the level of uncertainty and deliver less clear outcomes.

Direct and indirect risks

Direct risks relate to the impact of rising sea level on the fabric of the coast. Different areas of coast will be vulnerable to different risks. Low lying areas will be more likely to be vulnerable to inundation and soft sediment backshores more vulnerable to erosion. In this study we evaluate the direct impact of *inundation* and *erosion* in four main receiving environments:

- Public assets
- Private assets
- Safety of people
- Ecosystem disruption.

Associated with these direct risks are a range of indirect risks. For example, the potential loss of a beach from erosion is a potential social and economic risk (if the beach is related to an activity such as tourism). A political risk may occur when the decision makers act in ways the communities do not support.

Project focus

To increase certainty, this project evaluates the *direct impacts* of inundation and erosion in the context of *rising sea levels*. In a bid to contain focus, this study assesses the *direct risks* to assets, people and ecosystems that are positioned within coastal regions.

[1] https://coastadapt.com.au/pathways-approach
[2] https://coastadapt.com.au/how-to-pages/how-to-understand-climate-change-scenarios

[3] https://www.nasa.gov/feature/goddard/2016/carbon-dioxide-fertilization-greening-earth

[5] Resilient South (2014) Regional Climate Change Adaptation Plan, URPS and Seed Consulting, p.22 (and technical report p.3)

1. Introduction

ASSESSMENT FRAMEWORK

Coastal hazards experienced along a section of a coastline can be 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 coast (how resistant it is to erosion). Coastal geology is assessed 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 which has modified the fabric of the coast from dunes to rock.

[6] Watson, P., 2020, Updated mean sea level analysis: Australia. Outer Harbor 2.5mm (1945 – 2018), satellite 3.5mm since 1990.

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. Coastal exposure is assessed in four main ways:

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

CHANGES IN THE RELATIONSHIP

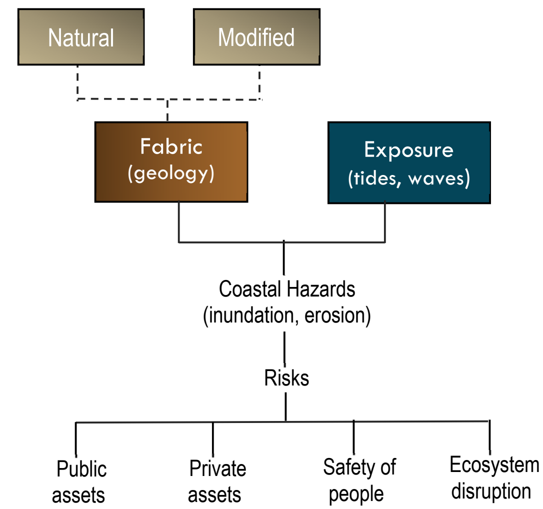
Finally, we are also interested to know how this relationship between ***fabric*** and ***exposure*** may change over time, and what this may mean in the context of our coastal settlements.

Our sea levels have been quite stable for several thousand years after a ~1m drop in sea level ~6000-4000 years ago. However, in recent times, the rate of sea level rise has increased. Last century, sea levels rose on average ~1.7mm per year. Since 1990, seas are rising on average at ~3-4mm per year in our region[6][7]. The consensus is that the rate of sea level rise will escalate towards the end of this century.

[7] See also sealevel.info and calculate rises from 1945 to 1990 (2.09mm) and compare with 1990 to 2022 (3.6mm).

While the projected rate of sea level remains uncertain, what is certain is that if seas rise as projected, then the relationship between fabric and exposure will change significantly in coastal locations.

Figure a: Conceptual framework



The aim of 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 with rising sea levels. We conduct this evaluation within the regional setting of secondary coastal cell **Adelaide Coast** (CoastAdapt) and within tertiary cell, **Hallett Cove Beach, Cell 3.**

1. Introduction

Regional Setting

Cell 3

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Beach

Secondary Cell

Australian regional setting

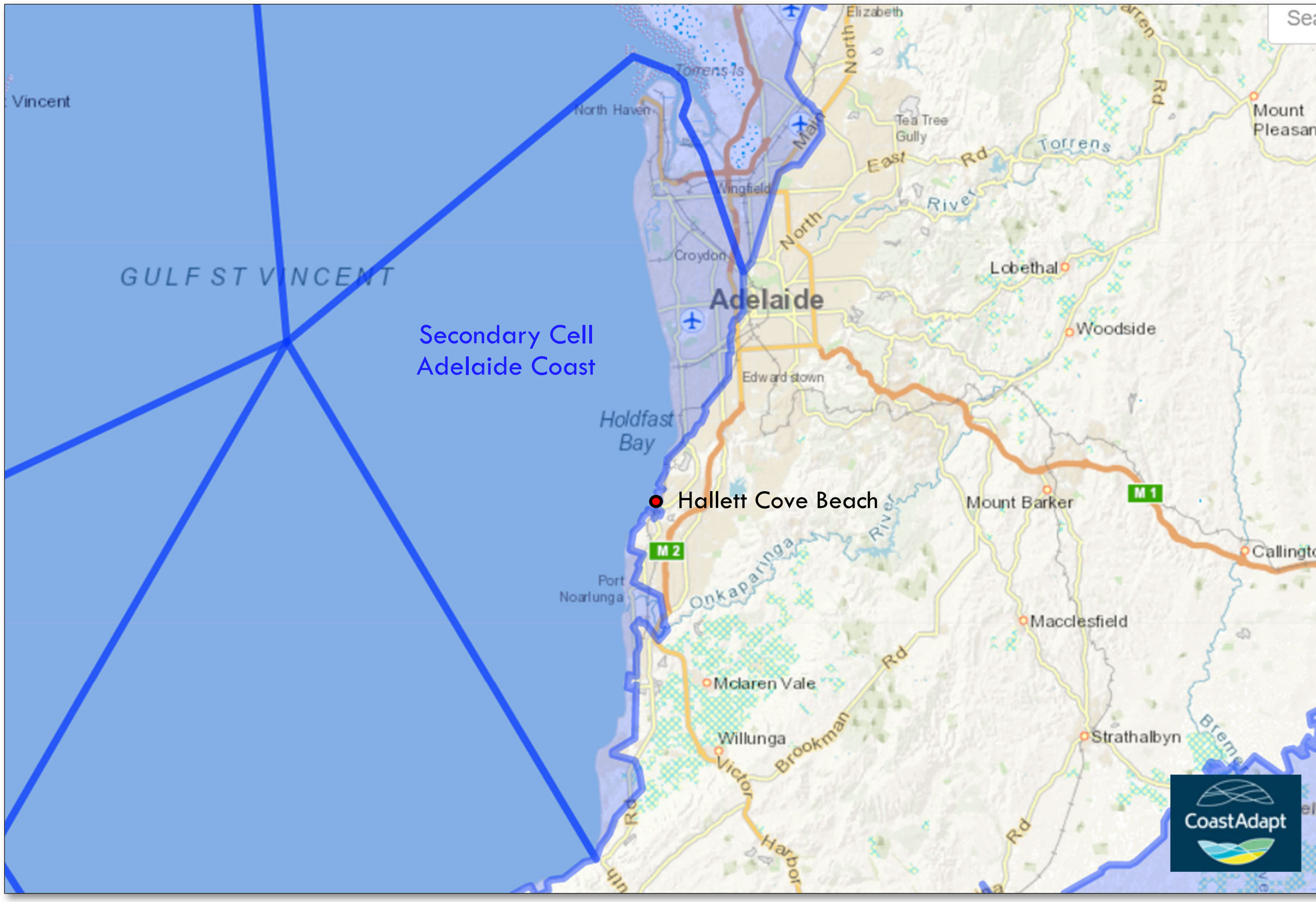
Hallett Cove Beach is situated within the Adelaide Coast secondary cell.

Geomorphology of the cell:

The northern section of this compartment comprises ~30km of Holocene sandy coast.

South of Adelaide, the coast is dominated by a series of arcuate north-easterly trending faults.

This section of the coastline features uplifted zones associated with prominent cliffs and headlands, with sandy embayments occupying fault angle depressions. There is minimal sediment supply, with small creeks and rivers. Littoral drift is to the north and sand supply is expected to decline causing recession to embayed beaches.



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). Much of the Adelaide coast is protected from south-westerly swell waves because of the sheltering effect of Kangaroo Island. The tidal range increases from microtidal to mesotidal towards the head of Gulf St Vincent. **Source: https://coastadapt.com.au/sites/default/files/docs/sediment_compartments/SA02.01.04.pdf**

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1. Introduction

Regional Setting

Cell 3

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Beach

Tertiary Cell

Relative Exposure
Moderate

Wave energy
Low

Shoreline class
Low tide terrace and Rock.

Substrate
Exposed bedrock with both cobble and coarse sand present.

Source: Nature Maps (SA)

Notes:
Minor cells represent in blue are areas where geomorphologic factors are different from neighbouring areas and require independent analysis.

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2. SETTLEMENT HISTORY

A historical review ensures that the circumstances in which the settlement was founded are understood, identifies how actions of the sea have interacted with the settlement, and builds appropriately on previous study. In this section we:

- Give a brief history of the settlement
- Review archives at Coastal Management Branch
- Identify key coastal studies

2. 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 second purpose is to identify key studies and plans so that we build appropriately upon previous work and bring all previous work into one place of reference.

BRIEF HISTORY

This section relies primarily upon the Coastal Management Study by D. Lord completed in 2012 for the City of Marion, unless otherwise indicated[8].

Aboriginal Settlement at Hallett Cove

Aboriginal settlement at Hallett Cove is believed to date back 40,000 making it one of the earliest in Australia. The original inhabitants appear to be the Kartan people whose presence is recorded through large stone implements found near the coast and the Waterfall Creek camp site. More recent settlement of the area was by the Kaurna people and their occupation dates back 2000 years before present.

Early European settlement

Hallett Cove was first explored by Europeans in 1837 when John Hallett visited the area while searching for wandering livestock. Farming was conducted in the area from 1850s.

Copper was discovered upstream of the Field River and the Worthing Mine was established which supported the livelihoods of 100 people by 1850[9].

Field River

Field River was named after Lieutenant W G Field who carried out a survey of the coast for Colonel Light. The mouth of Field River was considered as a suitable site for a harbor to carry produce from the farming and the mine. The construction of a breakwater and deep-water harbor for bigger ships was planned for half a mile (800m) south of the river mouth. However, the mine was closed by 1860 and the project abandoned[7].

In the late 1880s, Hallett Cove was used for naval exercises and rocks were cleared from the southern area to allow landings[10]. [Project note: this provides a feasible explanation for the removal of rocks in front of the dune at Field River].

Residential development

The first subdivision at Hallett Cove was in the 'model estate', which was opened near the railway line in 1913. Mr Allan Sheidow subdivided some land south of Grand Central Avenue. Only six buildings were located on this land by 1963, showing the relatively recent development of the area[11].

Following the end of World War II, holiday shacks were established along the Crown land fronting the present conservation area and Heron Way Reserve.

The surrounding area remained predominantly as farming land through to the 1950s, when the South Australian Housing Trust acquired much of the land for industrial use.

Figure a. Hallett Cove shacks, 1970. Hallett Cove Coastal Management Study, p. 6.

Hallett Cove Coastal Management Study

This study was produced in 2012 by Doug Lord and should be regarded as a prime resource for coastal assessment for the Hallett Cove Beach and Field River region. Additionally, this study provides a geomorphological context for the entire City of Marion coastal region.

[8] Lord, D. 2012, Hallett Cove Coastal Management Study for City of Marion.
[9] Dolling, A. 1981, Marion on the Sturt, p. 260.
[10] The only reference to contain this historical information was https://hallettcoveja.weebly.com/history.html
[11] Department of Lands, 1963, photograph, State Library of SA.

2. Settlement history

Residential Development (continued)

In 1973, approvals were granted for 480 houses on the eastern side of the railway line behind Hallett Cove Beach. In 1974 approvals were given for a subdivision of 300 acres between the railway line and what is now known as the Hallett Cove Conservation Park. Smaller parts on the southern part of the amphitheatre were filled to establish the subdivision and to create Heron Way Reserve (Figure b).

This development activity brought a series of protests from the community who lobbied for the preservation of the site. The State Government purchased land in 1972 and 1975 and established the Hallett Cove Conservation Park in 1976 so that 'its geological and scientific interest could be preserved in perpetuity'[12].

Field River

The residential development of the immediate backshore of Field River occurred later. The houses on River Parade were constructed in the early 1980s and the six houses (including one semi-detached dwelling) backing the dune were constructed in the late 1990s. The allotment in D62237 situated behind the dune on the southern side of Field River has been more recently subdivided into ~15 allotments, but as at the time of writing, only internal accessways have been constructed.

[12] Lord, D. 2012, citing Dolling, Marion Upon Sturt, 1981.

COASTAL STRUCTURES

The purpose of identifying the establishment of coastal structures is to consider what impact these may have on coastal processes. The first two structures have been considered in the context of possible interruption of sand movement up the Gulf.

Port Stanvac Oil Refinery

The Port Stanvac oil refinery opened south of Hallett Cove in 1963. This facility included a jetty (extending 600m from the back beach) and harbour protected by a rock wall (extending 225m from the back beach)[13].

O'Sullivan Beach launching facility

In 1983 a boat launching ramp and rock breakwater were constructed at O'Sullivan Beach, approximately 4.5km south of Hallett Cove. The southern breakwater is approximately 400m in length, extending 250m from the back beach. The shorter northern breakwater is approximately 160m long.

The Hallett Cove Coastal Management Study concluded that these structures are unlikely to have significantly interrupted sand supply and that 'the beach response and condition over the last 40 years is consistent with a sediment-deficient coast and a low rate of sea level rise' (p. 15-16).

[13] A desalination plant was constructed on the site in 2012 but any impact upon coastal environs not reviewed here.

Figure a. Development proposals brought protests from the community, State Library of SA, SRG 847.1.10.

Figure b. Subdivision layout and formation of Heron Way Reserve, ~1975, State Library of SA, SRG 847.1.18

2. Settlement history

Coastal Structures (continued)

Heron Way Reserve embankment

The natural dune system that existed below Heron Way Reserve was removed in the early 1970s and an earthen embankment installed (Figure a). Historical analysis shows that the toe of this embankment was progressively eroded from 1980s, including several erosion scarps in the storm of May 2016[14].

Development Application DA 100/0932/99 to place rock protection on Hallett Cove Beach was declined by Coast Protection Board because 'an assessment of aerial photographs has indicated the area has remained relatively stable for the past five years and the Board does not consider there is a need for heavy protection measures at this time.

Rock revetment at Field River

Erosion of the sand spit on the southern side of Field River was a concern since the 1990s. The fragility of this dune is not abnormal for a sand spit in this location and in this case, the majority of the dune is a sand cap over the underlying clay substrate.

Development Application DA 100/0552/98 for a rip rap sea wall to the south side of Field River was not supported by Coast Protection Board who stated, 'While it is appreciated that the coastline as this location is subject to slow coastal erosion, it is not currently threatening development, and the Branch would appreciate justification for undertaking the work at this time'.

Six years later, rock revetment was placed in front of the dune due to erosion and caving that was occurring at the base of the dune.

Coastal Walkway.

The coastal walkway, installed in the 1990s, traverses across the back of the dunes along Hallett Cove Beach and at the top of the embankment of Heron Way Reserve. In 2021, a board walk was constructed across the dune system north of Field River. On the south side of Field River, the coastal walkway was widened, and rock revetment installed on its seaward edge.

Figures b & c. Rock revetment placed in front of the Field River dune, November 2004, Photograph, City of Marion.

Figure a. The natural dune system removed, earthen embankment installed, 1975, State Library of SA, SRG 847.1.1.31

[14] This is likely to indicate that the toe was located incorrectly.

2. Settlement history

COASTAL STUDIES AND PLANS

The purpose of this section is to bring all previous work into one place of reference for the Hallett Cove Beach (Cell 3). Some of these reports are applicable to the Council as a whole, others are more specifically focused on Hallett Cove Beach.

Hallett Cove Management Study (2012).

Purpose and scope

This study was completed by Doug Lord from Coastal Environment Pty Ltd in 2012. The stated purpose of the study was to 'assess current and potential future coastal management issues…and to identify and evaluate alternative management strategies in response to those issues that could be considered in a coastal management plan for the area' (p.iv). This study preceded and informed the masterplan for Heron Way Reserve which was progressively upgraded from 2012 to 2020.

The area of interest for the study was from Black Point on the northern end of Hallett Cove Beach to the southern border of City of Marion (just north of the desalination plant).

The project based its understanding of coastal processes on information from existing reports, the community, Coast and Marine Branch, historical records, photography, and observations.

A key study reviewed by the Hallett Cove Management Study was the coastal modelling completed in 2004 by Coastal Engineering Solutions which formed the basis for the State Government's Metropolitan Living Beaches strategy in 2005. Hallett Cove was reviewed in the context of sand transport issues.

Contents and subject matter

Regional setting (Section 2).

This section includes an extensive review of the history of settlement (including Aboriginal settlement), geological and geomorphological background, native vegetation, and recorded changes to the beach. Regarding the latter, the report reviewed sand levels on the beach and concludes that the beach has always had minimal sand due to its geology, but it is likely that there was less sand in 2012 than in the 1970s.

Project note: The current study has reviewed aerial and land-based photography back to 1920s and concludes that the beach has always had minimal sand.

Coastal processes (Section 3)

This section of work reviewed sand transport issues, noting that the movement of sand is northward up Gulf St Vincent (pp.17-19), tides and wind (p.20), waves (p.22), storm surge (p 23), and analysed the two Coast Protection Board breach profile lines that have surveyed the beach and ocean floor since the 1970s.

Climate change impacts are reviewed in this section noting that sea level rise projections of 0.30m by 2050 and a further 0.70m by 2100 have been included in South Australian planning schemes since the early 1990s. The report notes the difficulty of estimating erosion at Hallett Cove where changes to the beach profile are constrained by the presence of clay, shingle and rock, and the material behind the beach is unknown, but likely to be a combination of clay and rock with a sand cap. Further the offshore bathymetry is not well defined, and the local wave climate is derived from studies outside of Hallett Cove.

Project note: Integrated Coasts obtained bathymetry for Hallett Cove in 2021 and wave data is to be obtained in 2020 (July to August).

The project concludes that long-term recession of the beach is occurring at very low rates over recent years and estimates future erosion at ~10m by 2050 and ~25m by 2100 based on the projections noted above.

Key coastal study:
Hallett Cove Coastal Management Study, 2012
The Hallett Cove Coastal Management study was produced in 2012 by Doug Lord and should be regarded as a prime resource for coastal assessment for the Hallett Cove Beach and Field River region. Additionally, this study provides a geomorphological context for the entire City of Marion coastal region.

2. Settlement history

Hallett Cove Management Study (2012) cont.

Project site impacts (Section 4)

The Hallett Cove Management Study reviewed the possible impacts of restricted sand supply because of the construction of the breakwater at Port Stanvac and the boat launching facility at O'Sullivan Beach, both of which capture sand on their southern side. Dredging operations at both sites periodically transferred sand to their northern side.

The study concluded that since the closure of Port Stanvac in 2003, it is likely that limited sand has bypassed the Port Stanvac works since 2000. Coast and Marine Branch advised D. Lord in 2012 that recent inspections indicated that the harbour and nearshore areas were filled with sediment and that bypassing should naturally begin meaning that alongshore sand supply from the south to Hallett Cove is not likely to be currently interrupted by the Port Stanvac breakwater.

The remainder of this section is devoted to analysing four management sections in the context of:

- Description of existing beach and backshore,
- Existing coastal issues (if any),
- Impacts upon infrastructure in the context of sea level rise.

Consultation (Section 5)

Section 5 reports on the findings of the consultation with the community, Council, Coast and Marine Branch, and local Aboriginal heritage representatives. The main issues identified were, in order of priority:

- Lack of sand on the beach,
- Additional reserve/ redevelopment facilities,
- Coastal walking trails and linkages,
- Erosion of dunes at Field River entrance,
- Erosion of the dune face along the beach in general (and asbestos management[15]).

Management Options (Section 6)

The study concludes that Hallett Cove is well placed to accommodate the impacts that will arise from climate change, and specifically, rising sea level. Generally, the report noted:

- It is likely that the beach will become rockier for longer periods of time as the meagre sand reserve is transported to the north.
- The natural armouring of the beach and the broad shingle slope provide some protection, and this is evidenced by the minor erosion of the back beach over recent decades.
- Depending on the rate of sea level rise, there will be a gradual increase in erosion. This erosion will need to be increasingly managed and ultimately may require hard protection structures at some places if infrastructure is to be maintained.
- The overarching approach should be to adopt a minimal and non-confrontational approach over time. Current practices of dune management, replanting and minimal use of hard protection should be continued.
- For most of the beach the preferred strategy will to be accommodate erosion in the short term and allow the escarpment to recede. However, along the foreshores fronting Heron Way this will be difficult and the slope of the embankment will increase, along with potential safety issues.
- Around Field River and the southern section of Heron Way Reserve, soft management options may not be sufficient, hard protection items are likely to be required. These areas should be monitored, and appropriate designs developed.
- The small remnant sand dune cap on the south side of Field River will continue to be at risk and is the only section of sand dune remaining in Hallett Cove.

The study analyses management options for each section in more detail (pp 54 to 74).

[15] The reference to asbestos management relates asbestos buried in the backshore. City of Marion engaged Coffey in 2007 who advised the amounts were small, not dangerous to public health and advised management techniques.

2. Settlement history

Hallett Cove Management Study (2012) cont.

Recommendations

1. As a high priority, establish a program to monitor changes to the Hallett Cove beach and backshore over time. This is essential for assessing the impacts of sea level rise and to identify when coastal management strategies are required.

Project note: City of Marion has implemented a monitoring program, currently in its second year.

2. Continue to monitor long term beach profiles maintained by Coast Protection Board and an additional monitoring program to evaluate beach changes every six months.

Project note: This is more effectively captured using drone technology for the whole beach.

3. Obtain baseline a bathymetric survey at Hallett Cove Beach to a depth of greater than 10m. If possible, incorporate seabed/ habitat mapping.

Project note: Integrated Coasts obtained bathymetric data to depth of 15m in 2021.

4. Studies should be conducted to identify suitable sources of sand, shingle, and rock for future repairs to Hallett Cove.

5. Geotechnical advice should be obtained on the appropriate method and slope required to stabilise the currently unstable beach slopes of the toe of Heron Way Reserve.

6. Geotechnical advice should be obtained for the area of back beach between the storm water drain and the Field River to determine the likely substrate and foundation conditions for rock revetment as a basis for considering protection designs (if needed).

7. Adopt a detailed coastal management strategy/plan that identifies the preferred management approaches for each coastal section and identifies triggers for implementation. The plan should be funded and reviewed at least every ten years.

8. Evaluate whether appropriate development controls exist to control development in area at future risk from sea level rise. This is most applicable to the Field River area.

9. Formulate and implement measures to restore or enhance the natural alongshore littoral processes that supply sand to Hallett Cove Beach (p. 79).

10. Incorporate the current understanding of the erosion hazards to the Heron Way Reserve Masterplan and the audit of the walking trail.

11. Construct a detailed schedule of maintenance works with the various volunteer groups to undertake dune stabilisation and revegetation works along the foreshore.

Key coastal study:
Hallett Cove Coastal Management Study, 2012

The Hallett Cove Coastal Management study was produced in 2012 by Doug Lord and should be regarded as a prime resource for coastal assessment for the Hallett Cove Beach and Field River region. Additionally, this study provides a geomorphological context for the entire City of Marion coastal region.

The report recommends adopting a monitoring strategy and the collection of beach and bathymetric data. City of Marion has completed the following:

- Captured 3D coastal model to be used as a comparison with a future capture (2018).
- Initiated a coastal monitoring program in 2021.
- Captured coastal terrain and bathymetry data (2021).

The report analysed sand supply issues in detail and concluded that while there had been some decline of sand on the beach, the beach has always been naturally rocky and sand cover only ever a veneer.

In the context of rising sea levels, the recommendation was to allow dune escarpments to recede. However, it was recognised that the slope of the embankments under Heron Way Reserve would steepen, and a protection strategy is likely to be required. Further, the state of the dune adjacent Field River should be monitored.

2. Settlement history

Hallett Cove Study Report (1977)

The main focus of this study was the conservation park, public access issues, and the possible purchase of further land to consolidate the park. However, one reference does give an insight into the nature of the beach at that time, and reports on a comparative examination of aerial photographs taken in 1949 which 'show there have been no substantial changes to the beach over this period'[53].

Coastal Management Strategy Plan (1997).

This report prepared by Kinhill Engineers provides insight into issues under consideration at the time, including storm water run-off over cliffs, dune erosion, cliff stability issues. One of the main issues under consideration was the forming of the coastal walkway. The report also provides a full inventory of coastal features including storm water outlets, and coastal protection measures. The study stated,

> 'the coastal management strategy for Marion seeks to promote improvements in the management of the coastal strip by developing a coastal management plan which identifies appropriate uses and adjoining buffer areas, access paths, traffic management, car parking, the location of management, car parking, the location of visitor facilities and tourist opportunities'.

In particular, the report recommends to:

- Develop opportunities for stormwater management improvements,
- Augment existing initiatives to protect sand dune areas where necessary to ensure the retention of dunes,
- Develop a revegetation programme for the coastal areas[16].

The Hallett Cove Creeks Stormwater Plan (2012).

This study investigated the storm water system for three catchment areas located in Cell 2 and 3, and a suggested improved management strategy.

The study used a 1 in 10 ARI rainfall event which it considers the standard event to use in evaluating the effectiveness of stormwater infrastructure capacity. Coincidently, such an event did occur within the study period and the effectiveness of the system was evaluated in that context.

The report did note that climate change leads to changes in frequency, intensity, and duration of rainfall patterns. However, because the time frame of the study was limited to 2050, no account was taken of increased rain intensity in the study. The report concluded that stormwater infrastructure was assessed as meeting performance standards in line with current expectations (with a few exceptions).

The key issues flagged for improvement were:

- Erosion of Waterfall Creek channel, along most of its length,
- Lack of stormwater quality improvement measures,
- Lack of stormwater harvesting and reuse,
- Various upgrades and strategies, but none relating to ocean outfalls (apart Heron Reserve).

The report noted that while most of the study area is drained to watercourses or gullies which do ultimately drain to the sea, there are a number of stormwater drainage systems that discharge directly to the Gulf. The concern is that these outlets discharge well above beach level, with little or no erosion control or pollutant interception measures in place. Australian Water Environments (AWE) reviewed these outlets in 2005 and developed concept designs to address the issues identified as outlined in the table below[17].

Location	AWE Ref	AWE Recommendation	Status
Westcliff Ct	11	No work required	-
Nungamoora St	13	Install GPT	Outstanding
Peera St	14	No work required	-
Fryer Street	16	Install GPT	Outstanding
Clifftop Cr	18	Install rock-lined overflow swale	Completed (refer photo below)
Grand Central Ave	21	Install GPT	Outstanding

[16] Kinhill Engineers (1997) Draft Coastal Management Strategy Plan

[17] Southfront (2012), Hallett Cove Creeks Stormwater Plan, Table 4.3

2. Settlement history

Resilient South, 2014.

The Southern Adelaide region (Holdfast Bay, Mitcham, Marion and Onkaparinga Councils) cooperated together to produce the Resilient South Climate Change Adaptation Plan (2014). In relation to coastal adaptation, the plan explains the general impacts of rising sea levels, changes to rainfall patterns, and increased erosion, but does not specifically review the coastal environs of City of Marion. The plan did identify some general options for coastal adaptation but did not identify any preferred coastal adaptation options for City of Marion.

Resilient South has a designated website where all studies and projects can be accessed. Resilient South.

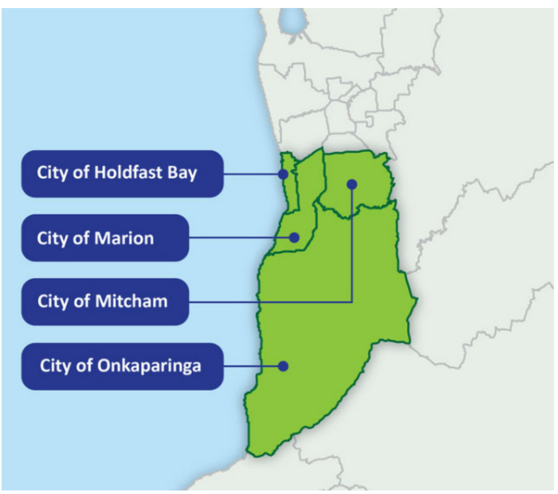

Figure a. Resilient South, a partnership between City of Holdfast Bay, City of Marion, City of Mitcham and City of Onkaparinga.

Climate Change Adaptation Governance Assessment Report for the City of Marion 2019.

This study prepared by Climate Planning and Seed Consulting Services in 2019 assessed how well City of Marion is incorporating climate change adaptation governance into their corporate processes and frameworks.

The Project Team conducted a governance assessment of the City of Marion to explore how climate change was considered in their corporate documents. The City of Marion was assessed against ten quantitative governance indicators, with Figure (b) displaying Council's performance.

The report concluded that City of Marion has considerable inclusion of climate change in its formal governance documents. This meant that not only could staff identify key physical climate risks to the functions of Council, they could also identify clear corporate strategic drivers for decision making. There was also consistent understanding of climate change risks from an officer to senior executive level.

The fact that climate change has been considered in all of the ten key governance indicators sees it placed as a leader in Australia (compared to the 200 councils who have been assessed).

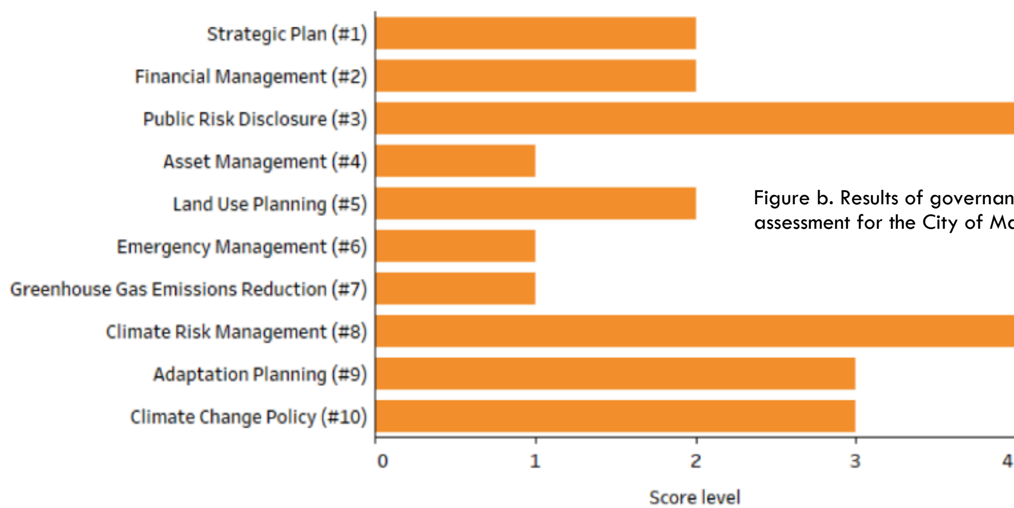

Figure b. Results of governance assessment for the City of Marion, 2019.

2. Settlement history

STRATEGIC PLANS AND POLICIES

City of Marion develops and updates strategic plans and policies on a regular basis and these can be located on the City of Marion website.

Climate Change Policy (2021-2025)

City of Marion Climate Change Policy was adopted on 11 May 2021 and will be reviewed by 11th May 2025. The primary objectives of the policy are:

- To incorporate climate change mitigation and adaptation into strategic and operational activity…,
- To support residents, businesses, and local ecosystems to build resilience and adapt to the impacts of a changing climate.
- To work in collaboration with regional partners and the wider community.

Other strategic plans and policies

- Community Vision: Towards 2040 (adopted 26 July 2016)
- Strategic Plan 2019 – 2029 (endorsed August 2019)
- Business Plan 2019 – 2023 (endorsed June 2019)
- Environmental Policy (endorsed November 2019)
- Carbon Neutral Plan, 2020 – 2030.

Settlement History
Key Points

Hallett Cove Beach was predominantly settled for residential development in the 1970s, at which time coastal shacks were removed. Protests about the ongoing development from the community resulted in the establishment of Hallett Cove Conservation Park in 1976 'its geological and scientific interest could be preserved in perpetuity'.

Human interventions in the coastal area include:

- Removal of rocks in front of Field River (perhaps by the army in 1880s).
- Port Stanvac Oil Refinery in 1963 (including rock wall extending 225 from the back beach) and O'Sullivan Beach launching facility in 1983 (including rock breakwater) may have decreased sand supply to Hallett Cove Beach.
- Heron Way Reserve embankment replaced natural dunes and vegetation in 1970s.
- Rock revetment installed at Field River, 2004.

The Hallett Cove Management Study was conducted in 2012 and provides a comprehensive review of the coastal processes, history, and recommendations for coastal management.

The City of Marion website is a source from which to find updated plans, studies, and policies that relate to coastal regions.

3. GEOMORPHOLOGY

The study of coastal geomorphology analyses how the coast was formed and how the coast has changed over time. The study provides the 'bigger picture' for understanding how sea level rise may interrelate with the coastline in the future.

For a fuller explanation of the coastal geomorphology of the region see Hallett Cove Coastal Management Study by D. Lord completed for City of Marion, 2012.

3. Geomorphological context

GEOLOGICAL SETTING

Structure of the coastline[18]

The basic structure of the Adelaide Metropolitan coast is influenced by a series of prominent arcuate (curved) faults. In particular, the Eden-Burnside Fault, the Clarendon-Ochre Cove Fault and the Willunga Fault have produced major escarpments, which intersect the coastline and run out to sea, where the faults are best exposed. Uplift and back tilting of the fault blocks has produced associated fault angle depressions occupied by the Adelaide Plains Sub-Basin, the Noarlunga Embayment and the Willunga Embayment (Figure a), which have been infilled with sediments over the past 40 million years. More recently in the Holocene period, the sandy beaches and dunes were formed on the low-lying embayments. The City of Marion coastline is entirely positioned within the elevated Eden-Burnside Fault which separates the Noarlunga embayment to the south and the long stretch of low-lying Metropolitan beaches to the north.

Resistant Neoproterozoic rocks extend from the Marino Rocks boat ramp to Hallett Cove Conservation Park (Cell 1,2). Cliff exposures of siltstone, shales and sandstones from this period get progressively younger from north to south. Despite these sedimentary rocks now being metamorphosed into harder rocks, sedimentary layers are still distinguishable and form distinct shore platforms. There is very little sand, and any beaches comprise of shingles (rocks).

Hallett Cove Beach (Cell 3) is an internationally important site geologically because features of the Permian glaciation are preserved here, and numerous large boulders (glacial erratics) occur on the beach. The host sediments to the boulders, deposited during the Permian glaciation, have been more recently exposed by coastal erosion. The only river in this section of coast is the Field River at the southern end of Hallett Cove.

From Hallett Cove to Port Stanvac (Cell 4), ***resistant*** folded Neoproterozoic strata form cliffs up to 20 m high, with the adjacent serrated shore platforms revealing complex folds of the Delamerian Orogeny period (>500 million years).

Sea levels have cycled between 2m above present sea level during the Last Interglacial Maximum (the last time the earth was free of ice, 132-118ka) to 125m below present sea level during the Last Glacial Maximum (the maximum ice extent, 21 ka). These major cyclic fluctuations in sea level meant that the present area of Gulf St Vincent was periodically exposed as dry land, and some higher sea level events such as the Last Interglacial experienced even larger areas of sea coverage. Furthermore, the climate at that time was warmer and wetter than today, with the Leeuwin Current bringing warmer ocean surface waters from Indonesia and the north-eastern Indian Ocean.

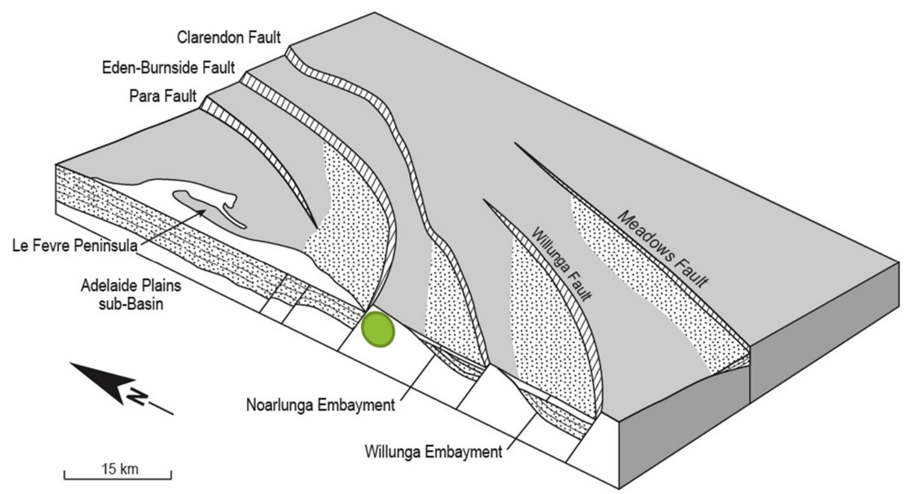

Figure a: The geological setting of the coastline between Sellicks Beach and the metropolitan area. The prominent fault scarps consist of uplifted ancient rocks, resistant to erosion, while the embayments are occupied by younger and more easily eroded rocks and sediments. The City of Marion coastline is positioned within the Eden-Burnside Fault.

[18] Bourman et al, 2016, Coastal Landscapes of SA, University of Adelaide Press.

3. Geomorphological context

GEOLOGICAL SETTING

In simple terms, the geomorphology of coasts is assessed in three main parallel zones: the subtidal, intertidal and backshore. The intertidal zone consists of the area between low and high-water marks. The backshore is typically characterised as up to 500m inland of the intertidal zone[10].

The Marion Coastline has been divided into coastal cells based upon geological layout (Figure a). The Marion coastline is predominantly a combination of *sloping hard-rock shores* and *sloping soft-rock shores*. Sections of *undifferentiated rock shores* refer to locations which are not easily classified as hard or soft rock and can generally be assigned an erosion classification between the two. The Field River area is assigned as 'river mouth'. Hallett Cove Beach is assigned 'sloping soft-rock shores'. The elevated geology of the Marion Council coastline means that the coastline is not subject to inundation. The exceptions are The Esplanade, Marino, and the Field River area, but these are also backed by steeply sloping backshores. The extensive areas of cliff categorised as *sloping hard rock shores and undifferentiated rock shores* suggest that the City of Marion coastline is not subject to rapid erosion. Areas categorised as *sloping soft rock shores* such as Hallett Cove Beach are more likely to be vulnerable to erosion. This assessment is supported by analysis by CoastAdapt which assigns almost the entire coast as *dominantly hard rock shores* with a low erodibility outlook[19].

Dr Miot da Silva and Dr Robert Bourman assess the cliff vulnerability in this region as 'low to moderate' erodibility composed by sedimentary to meta-sedimentary rocks ranging from Pleistocene to Neoproterozoic ages. These rocks are not the very 'low erodibility' type of rock associated with basement rocks such as igneous basalts and granites, nor high erodibility of the unconsolidated sediments of the recent Holocene period, and therefore fall between the two classifications. As such, these rocks are not readily erodible, but the presence of rock platforms indicate that cliffs have eroded and retreated in the past over long time periods.

[10] http://www.ozcoasts.gov.au/coastal/introduction.jsp
[19] https://coastadapt.com.au/coastadapt-interactive-map

Figure a. Geological layout of city of Marion coastline.

3. Geomorphological context

SEDIMENT BALANCE - SAND SUPPLY FOR THE COAST

Gulf St Vincent

Sand deposits along the coast were likely deposited by the wind in the last ice age when seas were up to 120m lower than present. As the ice melted and sea levels rose, these sediments formed the current layout of the beaches. Since sea levels stabilised over the last 7000 years the coast has slowly been losing sand which is unable to be replaced. This lack of sand supply to Gulf St Vincent is compounded because littoral drift (sand movement) is to the north and the Adelaide coastline only has small creeks and rivers that deliver minimal sediment to the coast. Therefore, sand supply is expected to decline causing recession to embayed beaches[20].

Hallett Cove and Marino beaches

The Hallett Cove Coastal Management Study (HCCMS) has thoroughly evaluated the coastal processes in Gulf St Vincent as they impact upon the Marion coastline and should be relied upon in the final coastal adaptation plan[21].

The HCCMS summarises the sediment environment in Hallett Cove Beach region:

> The foreshores of Hallett Cove present as a slowly receding coastline, starved of sediment. The available coastal process modelling indicates the potential for sand transport out of the Hallett Beach compartment (100,000m^3 / year) is an order of magnitude greater than the natural rate of sand supply along the coastline from the south (5000m^3/ year)[22]….
>
> While the community perception that the sand cover has reduced over the past 30 years may be true, the likelihood is that over historical times the volume of sand on the beach has always been small and variable, providing a thin sand veneer from time to time over sections of the exposed shingle [and that] additional sand cover is unlikely to be a practically achievable outcome.

Geomorphology
Key Points

1. The coastal lands of City of Marion are set in the vicinity of the Burnside-Eden fault (area of uplifted land) and therefore generally elevated well-above risk of inundation from current and future storm activity. The exceptions are The Esplanade at Marino and the area around Field River. However, in both these locations the backshores slopes upward.

2. The coastline consists predominantly of hard-rock sloping shores (Coast Adapt) and Bourman et al (2016) characterise the cliffs areas as 'resistant'. Exceptions to this resistant characterisation exist with Hallett Cove Beach and Field River area (Cell 3) which are backed by softer sediments. Pockets of less resistant rocks also exist at Marino (The Esplanade and Marino Rocks carpark).

3. The City of Marion coastline is much older than the Onkaparinga coastline to the south and the Metropolitan beaches to the north (both which were formed in the Holocene Period, 11.7ka) when seas rose to their current level.

4. Generally, the City of Marion coastline has always consisted of rock platforms and pebble beaches. In relation to Hallett Cove Beach, it is likely that sand levels were higher in the past, but sand cover has always been limited to a thin veneer over a rocky beach.

5. Within Gulf St Vincent sand levels are expected to continue to decline due to the inability of the coastal environment to replace sediments that were deposited at the last interglacial period. The movement of sand is northward, and Gulf St Vincent contains only small rivers and creeks that deliver minimal sediment to the coast.

[20] Bourman et al, Coastal Landscapes of SA, p. 66.
[21] D. Lord., Coastal Management Study, Hallett Cove, SA. 2012, pp 17-26.
[22] HCCMS suggests that this calculation is based on modelling at O'Sullivan Beach boat ramp.

4. COASTAL FABRIC

In this section we evaluate coastal fabric in more detail:

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

Viewing instruction:

View the coastal fabric section utilising full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

4.1 Coastal fabric - overview

Introduction

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). In some locations, humans have intervened and changed the nature of the coastal fabric. For example, a construction of a seawall changes the fabric from sand to rock. The construction of an esplanade road too close to the coast can install rigidity in the backshore, which formerly could naturally adapt to erosion and accretion cycles. Some interventions change the way in which the beach operates, and new erosion problems are created.

Why evaluate shoreline change?

Beaches undergo normal cycles of accretion and erosion which may span time measured in decades. These changes can be observed in two main ways. The position of the shoreline changes, and the levels of sand change on the beach. In times of erosion, the shoreline tends to recede, and sand levels become lower. In times of accretion, the opposite is true. If sea level rises as projected, then shorelines are likely to go into longer term recession. The purpose of evaluating the historical changes to the shoreline is to formulate a baseline understanding of how the coast has been operating in the past. In the context of rising sea levels, identifying future shoreline recession trends will assist us to identify when the beach begins to operate outside its normal historical range.

What is the shoreline?

The shoreline is the position of the land-water interface at one instant in time. But in reality, the shoreline position changes continually through time because of the dynamic nature of water levels at the coastal boundary. The best indicator of shoreline position is the location of the vegetation line. In other circumstances the shoreline may be the base of a cliff, an earthen bank at the toe of a slope, or a seawall in locations where humans have intervened.

How will we analyse the shoreline?

The analysis includes:

- Comparisons of aerial photography from 1949 to current day. This requires very fine-grained georeferencing of photography to ensure that comparisons are accurate.
- Comparison of surveyed profile lines which have been conducted by SA Coast Protection Board since the 1970s (if within the cell).
- Evaluation as to how humans may have intervened in the coastal fabric and how this intervention may have changed the natural operation of the coast.

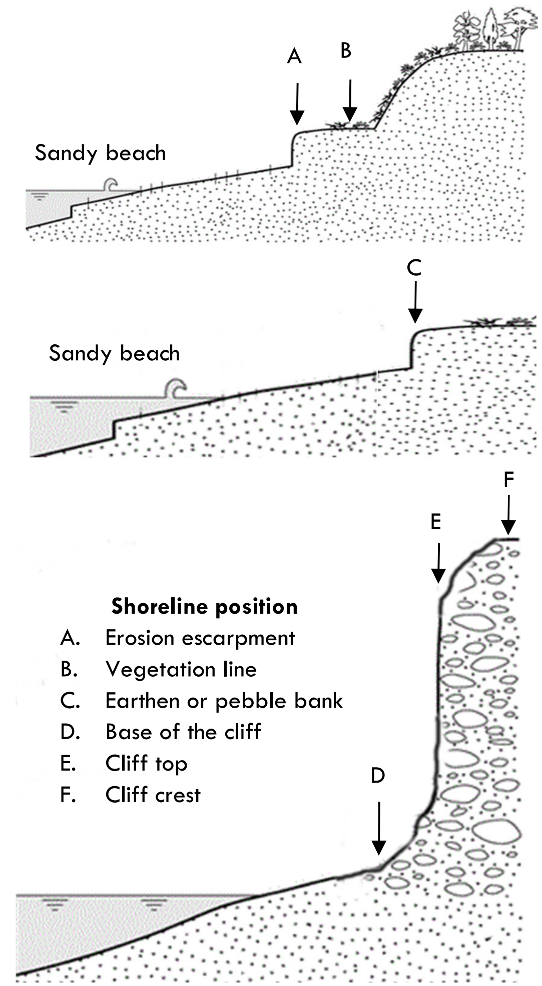

Figure a. Adapted from Boak and Turner (2005), Shoreline definition and detection.

4-1 Coastal fabric - overview

Overview

Marion (Cell 3)
Secondary Cell: Adelaide Coast
Tertiary Cell: Hallett Cove Beach

Form

Beach
The bedrock platform is partially covered by sand at high tide, but it is mainly rock flats with boulders at low tide.

Backshores
Backshore 1 (at beach)
A mixture of 5m high dune (3.1,3.2), man-made clay embankment (3.3, 3.4) and a fluvial system (river mouth) in the south (3.5, 3.6).
Backshore 1 (inland of beach)
Coastal slopes upward to 30m to 60m AHD at ~200m inland of beach.

Bathymetry
Overall slope of ocean floor:
-5m ~390 to 720m from beach
(overall slope ratio ~1:66).

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4-1 Coastal fabric - overview

Overview

Cell 3

Secondary Cell: Adelaide Coast

Tertiary Cell: Hallett Cove Beach

Geology

Geology

Backshore 3.1-2: This section of beach is underlain by glacial clay and till deposits which extend from the back of the beach offshore to below the low tide limit. The dune system in the immediate backshore is also primarily underlain by clay.

Backshore 3.3-4 This section of beach is underlain by glacial clay and till deposits which extend from the back of the beach offshore to below the low tide limit. The beach is backed by steeped sloped sediment escarpment (some imported fill to the embankment).

Backshore 3.5-6 The location is inter-tidal zone is shingle/ sand beach (underlain by clay) and backed by low dunes.

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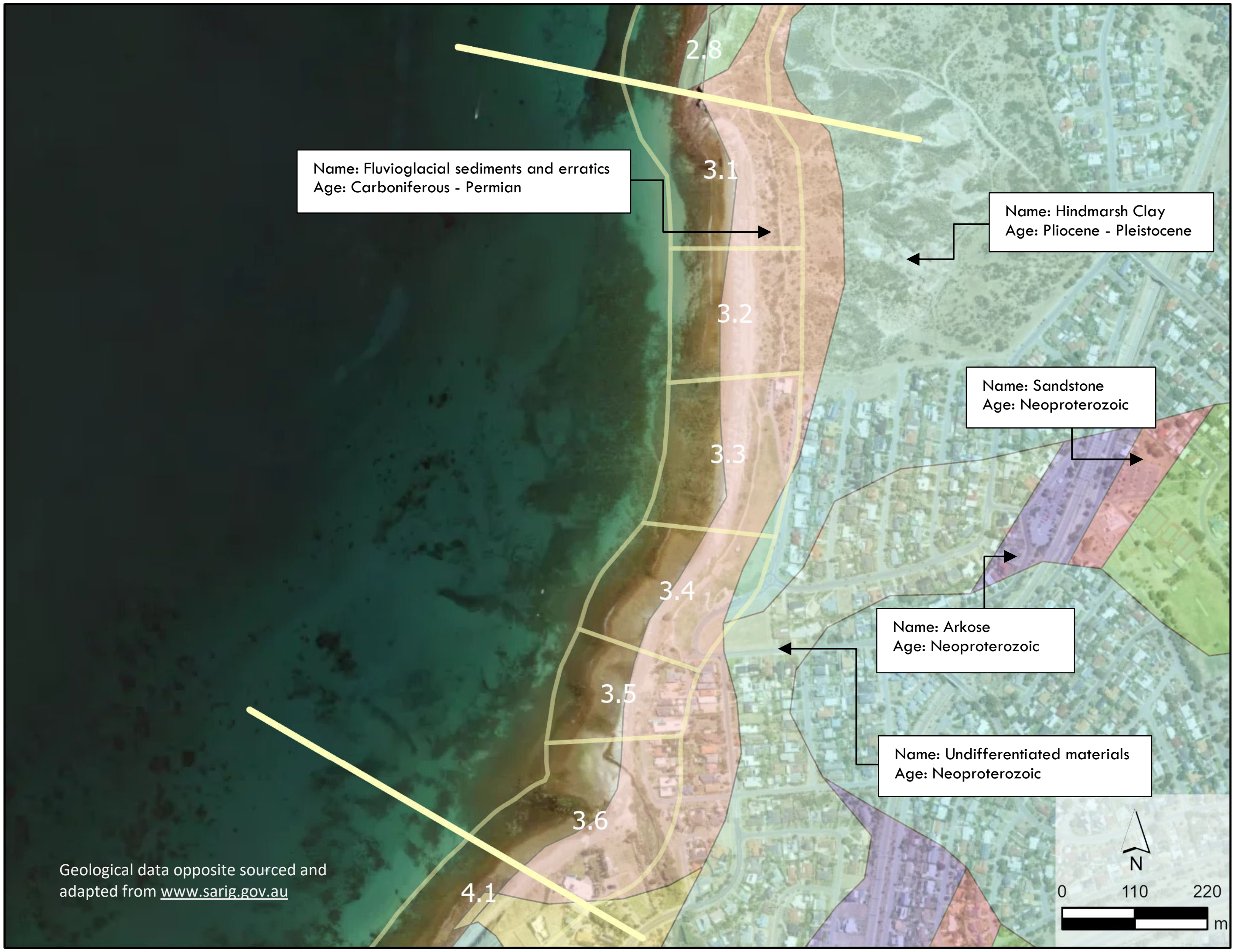


Geological data opposite sourced and adapted from www.sarig.gov.au

4-1 Coastal fabric - overview

Overview

Cell 3

Secondary Cell: Adelaide Coast

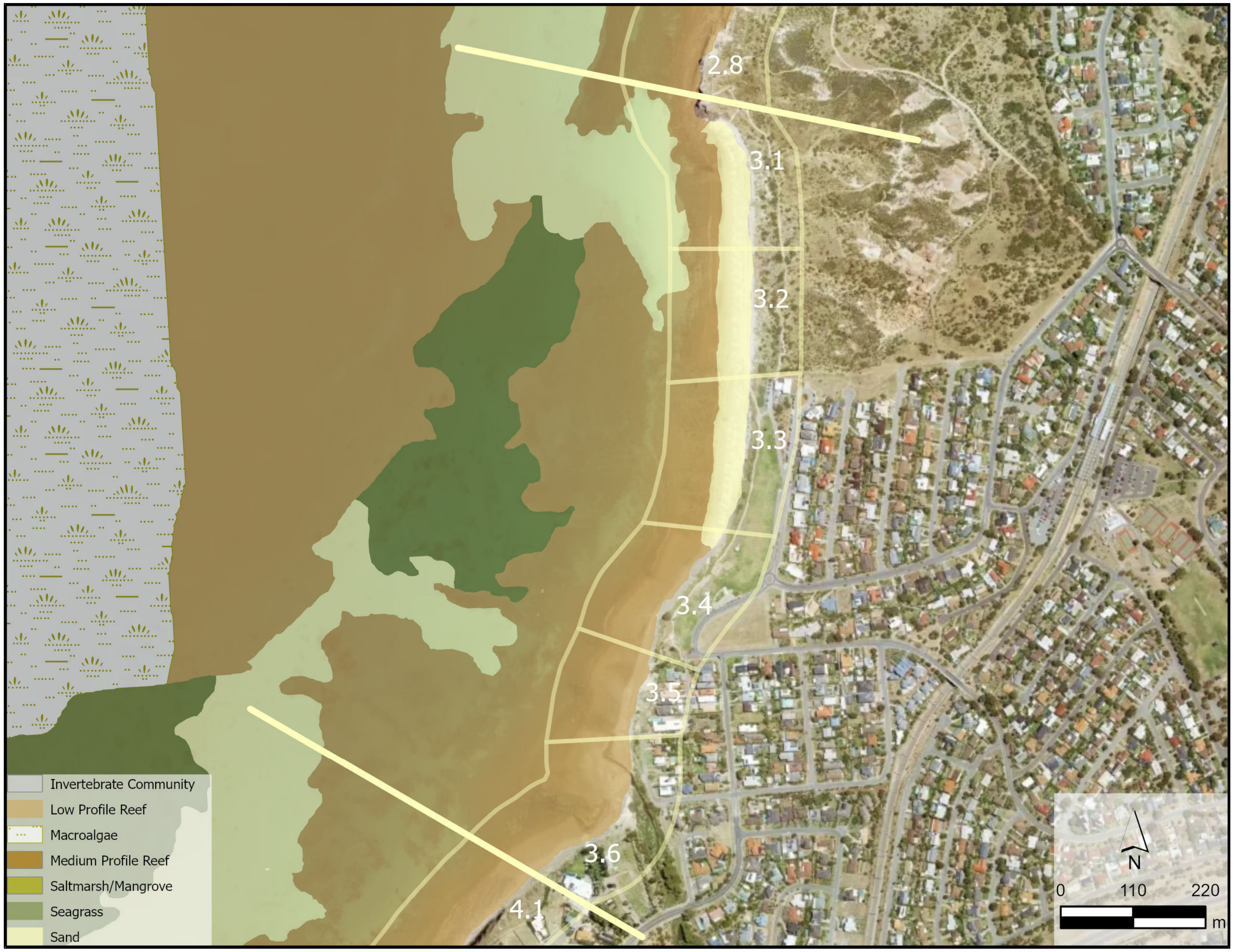
Tertiary Cell: Hallett Cove Beach

Benthic

Benthic

The benthic environment is dominated by low profile reef, and to a lesser extent includes seagrass meadow, bare sand and macroalgae communities.

Benthic data sourced from Nature Maps (SA).



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4-2 Coastal fabric – geology (Cell 3.1-2)

This section of beach is underlain by glacial clay and till deposits which extend from the back of the beach offshore to below the low tide limit. The beach itself comprises a mixture of shingle and sand overlying the clay till layers and the rock shelf. The sand cover varies along the beach from time to time in both composition and quantity (Lord, D, 2012, p. 10-16).

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Notes

At the base of the cliffs to the north and south of Hallett Cove Beach is a narrow wave cut rock platform about 50m wide. This bedrock presumably underlies the beach and the amphitheatre and forms the modern surface of Heron Way Reserve and the subdivisions landward of the beach to the north and south of the Field River. Lord, D, Hallett Cove Coastal Management Study, 2012.

Map

Hallett Cove Beach 3:1,2

Geological assessment

Integrated Coasts. 2019. 2022

4-2 Coastal fabric – geology (Cell 3.3-4)

The natural dune system was replaced by earthen embankment in the 1970s.

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Notes

At the base of the cliffs to the north and south of Hallett Cove Beach is a narrow wave cut rock platform about 50m wide. This bedrock presumably underlies the beach and the amphitheatre and forms the modern surface of Heron Way Reserve and the subdivisions landward of the beach to the north and south of the Field River. Lord, D, Hallett Cove Coastal Management Study, 2012.

Map

Hallett Cove Beach 3:3-4

Geological assessment

Integrated Coasts, 2019, 2022

4-2 Coastal fabric – geology (Cell 3.5-6)

Towards the southern end of the beach (around the Field River mouth and further south) 'again only visible at low tide, is a layer of sediment known as a flow till. This layer was deposited later and overlies the lodgement till, extending shoreward where it is covered by the sand of the beach. It contains a greater number of rocks than the underlying lodgement till and shows convoluted and contorted, interbedded sands, silts and clays with embedded pebbles.' (Lord, D, 2012, p. 10-16).

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Notes

At the base of the cliffs to the north and south of Hallett Cove Beach is a narrow wave cut rock platform about 50m wide. This bedrock presumably underlies the beach and the amphitheatre and forms the modern surface of Heron Way Reserve and the subdivisions landward of the beach to the north and south of the Field River. Lord, D, Hallett Cove Coastal Management Study, 2012.

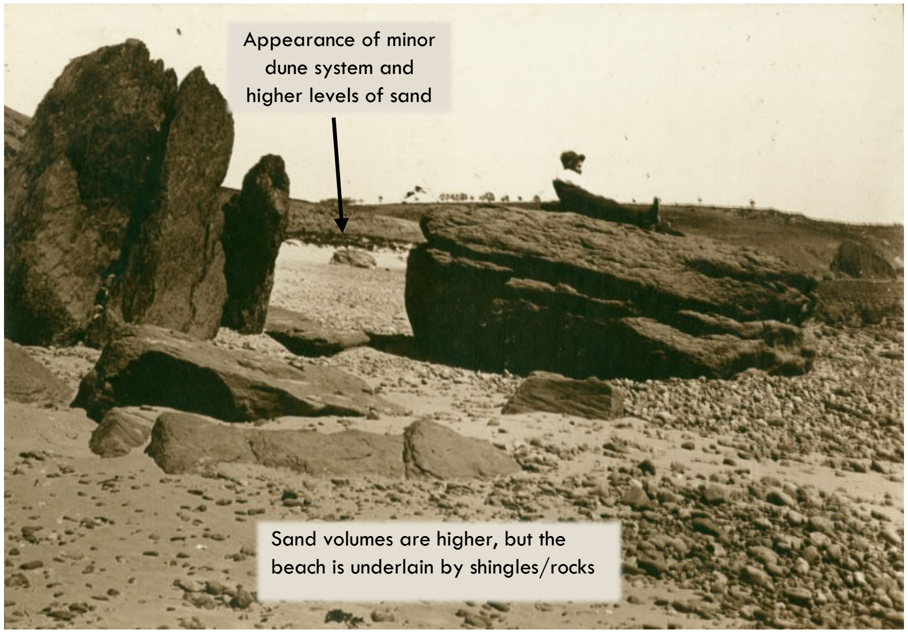
Map

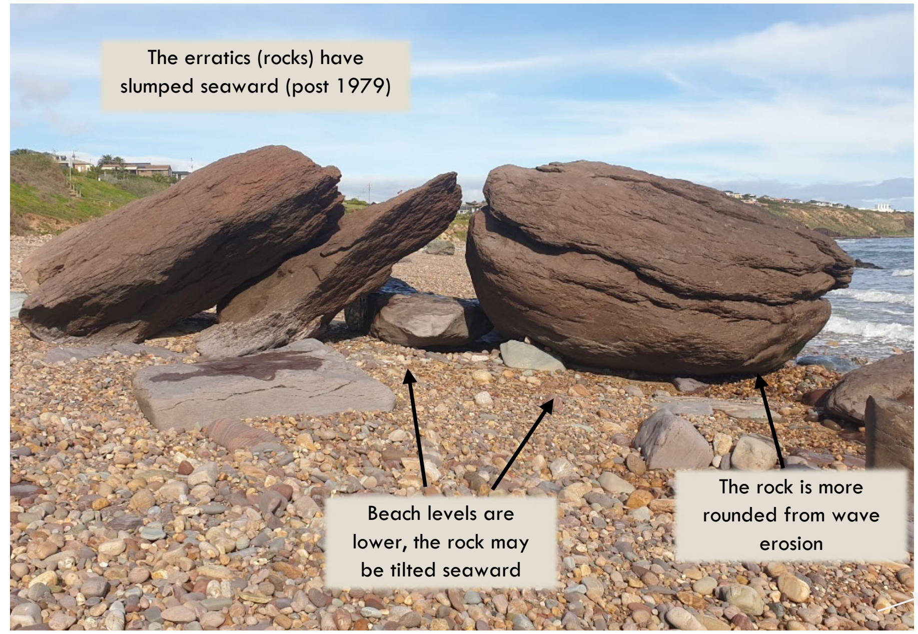
Hallett Cove Beach 3:5-6

Geological assessment

Integrated Coasts, 2019, 2022

4-3 Coastal fabric – beach changes (Cell 3)





Why compare historical photographs?

The purpose of comparing historical photographs is to analyse **coastal change:**

- How do beach levels compare? Over the last 100 years, sea levels have risen 200mm to 250mm. Decreasing beach height may be a result of increasing sea levels (or it may relate to annual or decadal variations).
- How much of the rock has eroded? (this will give us some indication of how susceptible cliffs will be to erosion).
- What changes have occurred in the backshore? (nature, vegetation)
- What human interventions have occurred?

Note: care in interpretation needs to be exercised in relation to the perspective that the cameras from different eras generate.

100 years of beach changes

The following changes are observed:

- The larger rocks have slumped seaward.
- Sand/rock levels appear to be ~300mm lower around the rocks in 2022.
- Constant interaction with waves has eroded the larger rock on the right.
- A natural dune in the backshore rather than embankment (see also ‘human intervention’ section below.
- Some larger rocks in foreground appear to have moved.

Figure a. Rock erratics on Hallett Cove Beach, 1920, State Library of SA, B69399/26
Figure b. Rock erratics on Hallett Cove Beach, 2022, M. Western.

4-3 Coastal fabric – beach changes (Cell 3)

80 years of beach changes

The photographs on this page are each separated by ~40 years. Note, the photographs of 1937 and 1977 were both taken in January. The photograph in 2022 was taken in June.

- Sand levels appear similar in 1937 and 1977, but lower in 2022 with significant patches of pebbles showing.
- Almost no vegetation in 1937, increasing over time until 2022.
- The shoreline is completely natural in 1937, but an embankment formed in the southern portion of the pictures by 1977.
- Seaweed strands appear higher on the beach in 2022 (but this may be expected for a photograph in June).

Figure a. Hallett Cove Beach (from Black Cliff), 1977, State Library of SA, PRG/1631104/14
Figure b. Hallett Cove Beach (from Black Cliff), 1937, State Library of SA, PRG/1561/5/1/1
Figure c. Hallett Cove Beach (from Black Cliff), 2022, M. Western.

4-3 Coastal fabric – beach changes (Cell 3)

100 years of beach changes, but the fundamentals are still the same.

While it can be observed that sand levels have declined on Hallett Cove Beach over this time period, the fundamentals of the beach are the same. 'The beach itself comprises a mixture of shingle and sand overlaying the clay till layers and the rock shelf. This sand cover varies along the beach and from time to time in both composition and quantity. The shingle on the beach is derived from the eroded glacial deposits that overlay the Cambrian bedrock and from the ongoing erosion of the exposed cliffs and rock shelfs. This results in a variety of rocks forming the shingle layer and larger stones on the beach' (Hallett Cove Beach Coastal Management Study). (See also 'Human Intervention' section below).

Figure a. Hallett Cove Beach, circa 1920. The backshore to the beach in this time period was a natural dune system. State Library of SA, SRG847.1.1.31

Figure b. Hallett Cove Beach, 4 July 2022 (winter). The location of the vegetation seen in 1920 is likely to have been at the base of this embankment.

4-3 Coastal fabric – location map (Cell 3.1)

Medium Term Changes

Cell 3.1

Hallett Cove Beach
Historical comparison

Location Map

Location:
Conservation Reserve (north)

Aerial photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the dune in the backshore or the vegetation line.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 1949

<u>General observation:</u>

Increased sand cover (see also photograph from 1937 inset).

The erosion escarpment is in a similar position as 2017. In the northern section the low grassed sand platform at the toe of the dune is 2-6m seaward of 2017. Over a period of decades this platform accretes and erodes.

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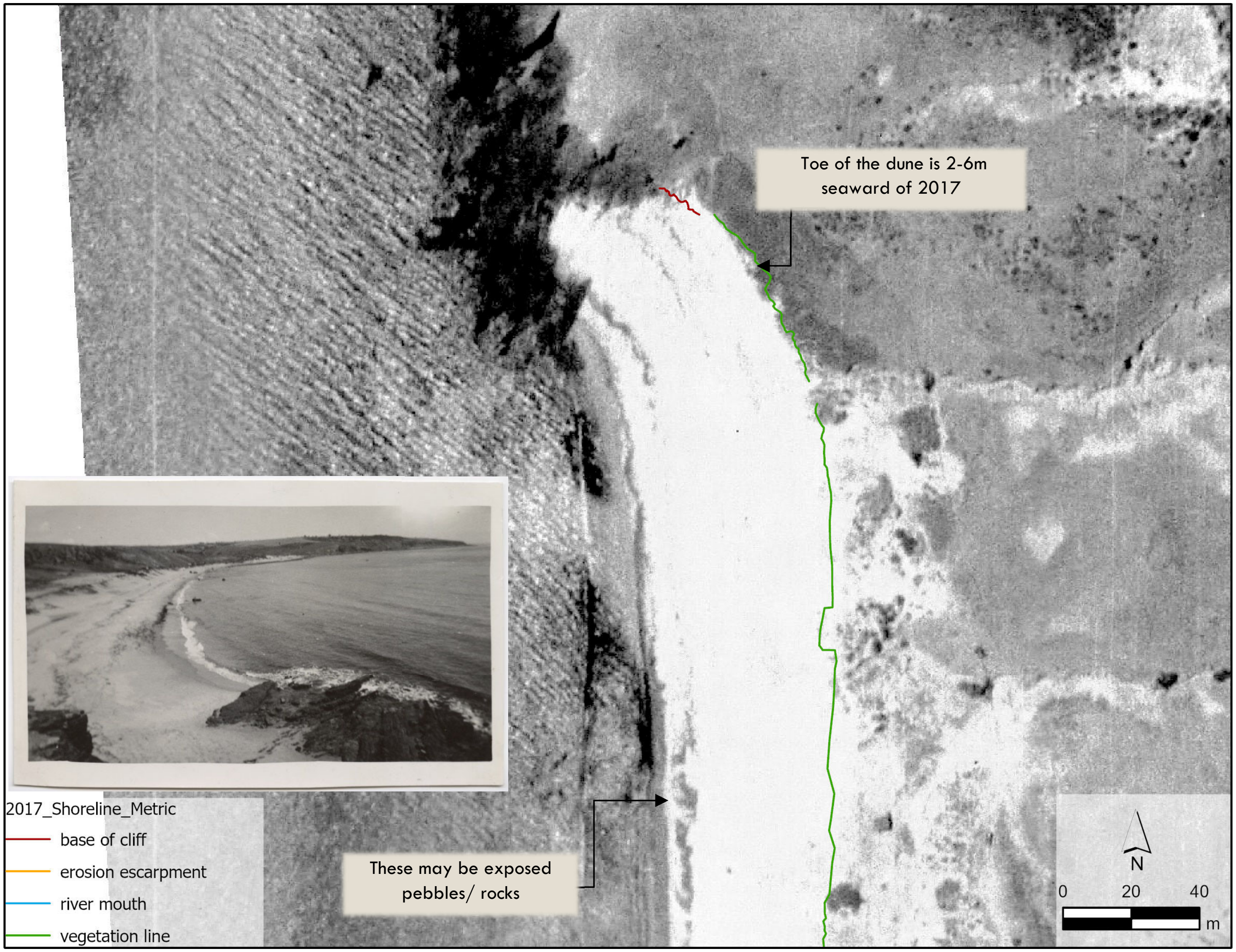

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 1979

Shoreline recession:
Minor. In the northern section the low grassed sand platform at the toe of the dune is 1m inward of 2017. Over a period of decades this platform accretes and erodes.

Gullying
Two storm water gullies (natural) which were there in 1949.

Vegetation
Much less than 2017

Sand cover
More sand cover in 1979 than 1989 (than 2017). Progressively lost sand over a period of 40 years.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 1989

Shoreline recession:
Nil Minor. In the northern section the low grassed sand platform at the toe of the dune is 1m inward of 2017. Over a period of decades this platform accretes and erodes.

Gullying
Two storm water gullies (natural) which were there in 1949.

Vegetation
Much less than 2017.

Sand cover
Declining sand cover from 1979 to 1989.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 2002

Shoreline recession:
Toe of the dune is similar to 1979 but the dune scarp has eroded landward ~2m.

Gullying
Two storm water gullies (natural) which were present in 1949.

Vegetation
Less than 2017

Sand cover
Similar sand cover to 1989, but increased exposed pebbles in backshore in the north.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 2007

Shoreline recession:
Toe of the dune is in similar position to 2017.

Gullying
Two storm water gullies (natural) which were present in 1949.

Vegetation
Similar to 2017

Sand cover
Similar sand cover to 1989 (less exposed pebbles in backshore than 2002).

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.1

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Year 2012

Shoreline recession:
Low grassed platform building seaward since 2007.

Gullying
Two storm water gullies (natural) which were there in 1949.

Vegetation

Similar to 2017

Sand cover
Similar sand cover to 2007.

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4-3 Coastal fabric – shoreline changes (Summary)

Medium Term Changes

Cell 3.1

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (north)
Summary

70 years
The toe of the dune accretes and erodes over time. Recession of the toe and dune escarpment ~2-6m in the north.

40 years
Nil shoreline recession. Changes in vegetation observed at base of dunes likely due varying wave attack. Increasing vegetation in the dunes and backshores. Decreasing sand cover on the beach when comparing 1977 to 2017.

10 years
Less sand compared to 2007, but the remainder of the coast the same.

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4-3 Coastal fabric – location map (Cell 3.2)

Medium Term Changes

Cell 3.2

Hallett Cove Beach
Historical comparison

Location Map

Location:
Conservation Reserve (south)

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the dune scarp or the vegetation line.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach

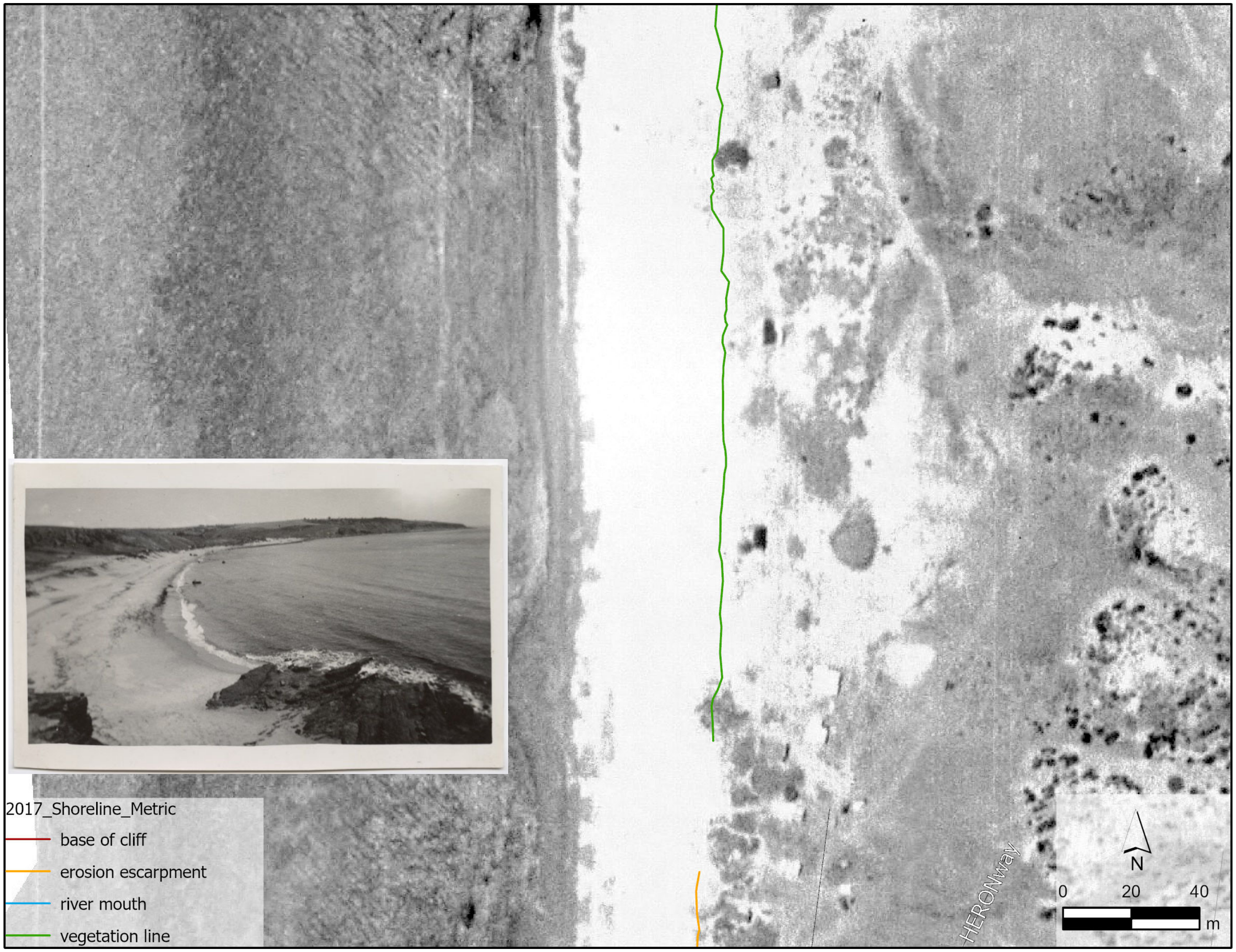
Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 1949

General observations:

More sand on beach than 2017, Less vegetation in the dunes. See also 1937 land-based photograph (inset).



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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 1979

Shoreline recession:

Significant recession of dune and/or grassed platform of ~7m between 1979 and 2017 (where shown).

Gullying

Two storm water gullies (natural) which were present in 1949.

Vegetation

Increasing from 1949, sparser than 2017.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 1989

Shoreline recession:

Recession since 1979 is 3.5m where shown (the shoreline is 3.5 seaward of 2017).

Gullying

One storm water gully just beginning to form at the coast but was present in 1949.

Vegetation
Similar to 1989.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 2002

Shoreline recession:
Between 1989 to 2002 minimal change.

Gullying
Storm water gully growing at shoreline.

Vegetation

Less vegetation in 2002 than 2017 (drought?)

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 2007

Shoreline recession:
Shoreline is seaward (3-4ms) than 2017 (possible the low grassed platform).

Gullying
Storm water gully similar 2012

Vegetation

Similar to 2017 (more vegetation due to May capture).

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.2

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Conservation Reserve (south)
Year 2012

<u>Shoreline recession:</u>
Significant recession of dune/grassed platform (probably as a result of large events 2007, 2009). Shoreline in similar position to 2017.

<u>Gullying</u>
One gullies (natural) which was present in 1949. The gully deepens, and more vertical in the sides (see inset photograph 2017).

<u>Vegetation</u>

Similar to 2017

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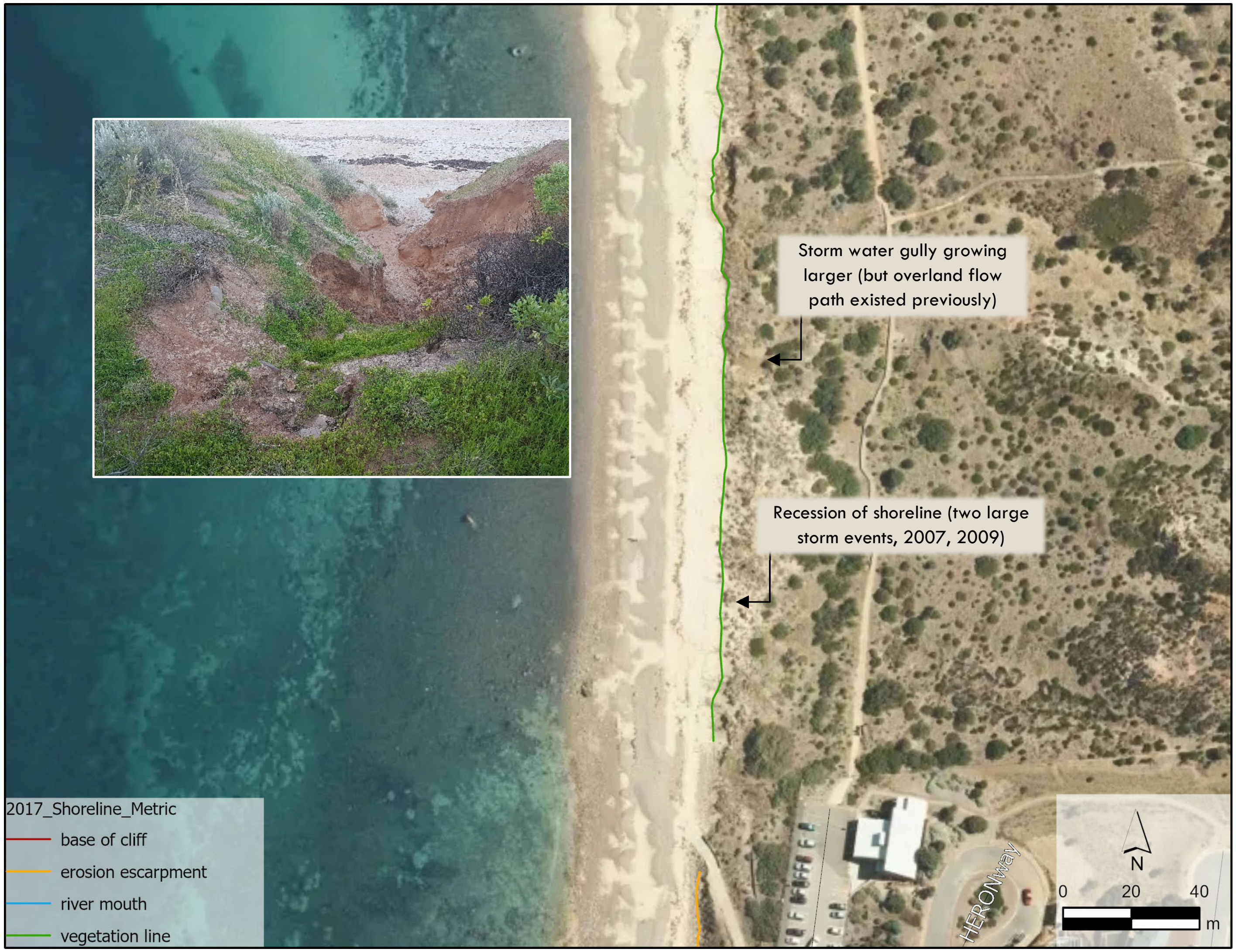


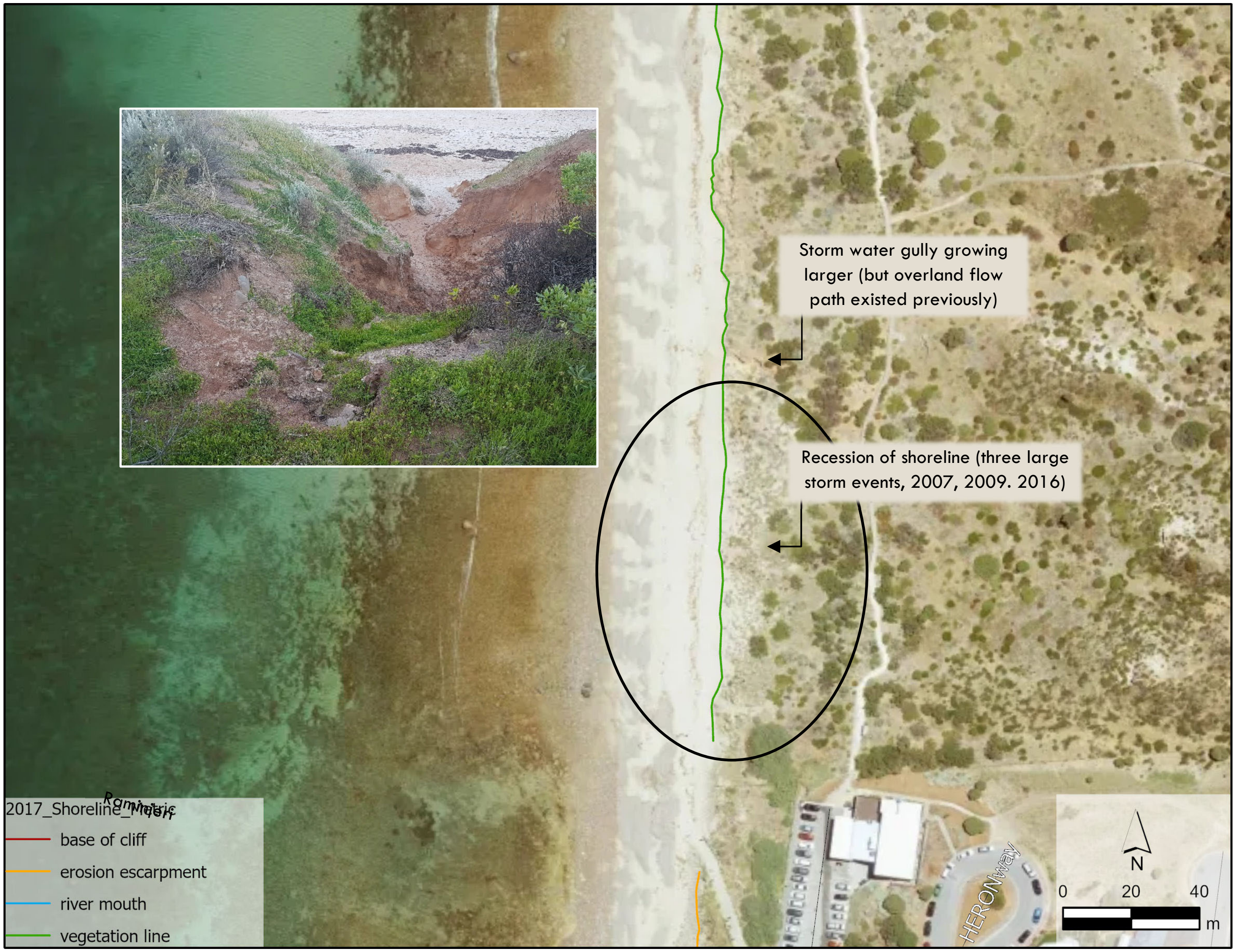
4-3 Coastal fabric – shoreline changes (Summary)

Medium Term Changes

Cell 3.2

Hallett Cove Beach
Historical comparison

Shoreline



Location:
Conservation Reserve (south)
Summary

70 years
Poor quality photograph makes assessment difficult.

40 years
Cycles of accretion and erosion, but overall recession of 4m. Vegetation line (swash line) is 4-5m seaward in 1979. Decreases in 1989, but by 2007 is seaward 2017 line and decreases.

10 years
Vegetation line recedes 5m in southern section (after the 2007 photograph there has been the highest three events on record).

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4-3 Coastal fabric – location map (Cell 3.3)

Medium Term Changes

Cell 3.3

Hallett Cove Beach

Historical comparison

Location Map

Location:
Heron Way Reserve (north)

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the embankment.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 1949

Observations:

Shacks on the foredune.

More sand beach than in the current era, but rock /pebble platform seen in south.

Very low vegetation.

Inset photograph provides example of beach layout in 1937 (twelve years prior to the aerial photograph).

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 1979

Shoreline recession:

The embankment was constructed in the early 1970s. It was constructed 2-3m seaward of current position in 2017 (the position was likely misplaced).

Vegetation

Grassed backshore.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 1989

Shoreline recession:

The embankment was constructed in the early 1970s. It was constructed 2-3m seaward of current position in 2017. Some recession in the middle of the photograph.

Vegetation

Grassed backshore. Minimal vegetation on the embankment.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 2002

Shoreline recession:

Similar position of toe of embankment to 2017 in the north, a little recession from 1989.

Vegetation

Grassed backshore managed by Council.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 2007

Shoreline recession:

Some scarping in north near onramp but much less than 2012.

Shoreline ~1m seaward of 2012 in the south. In the north near the ramp the shoreline is further landward.

Vegetation

Managed by Council since 1979. Vegetation increasing on the embankment.

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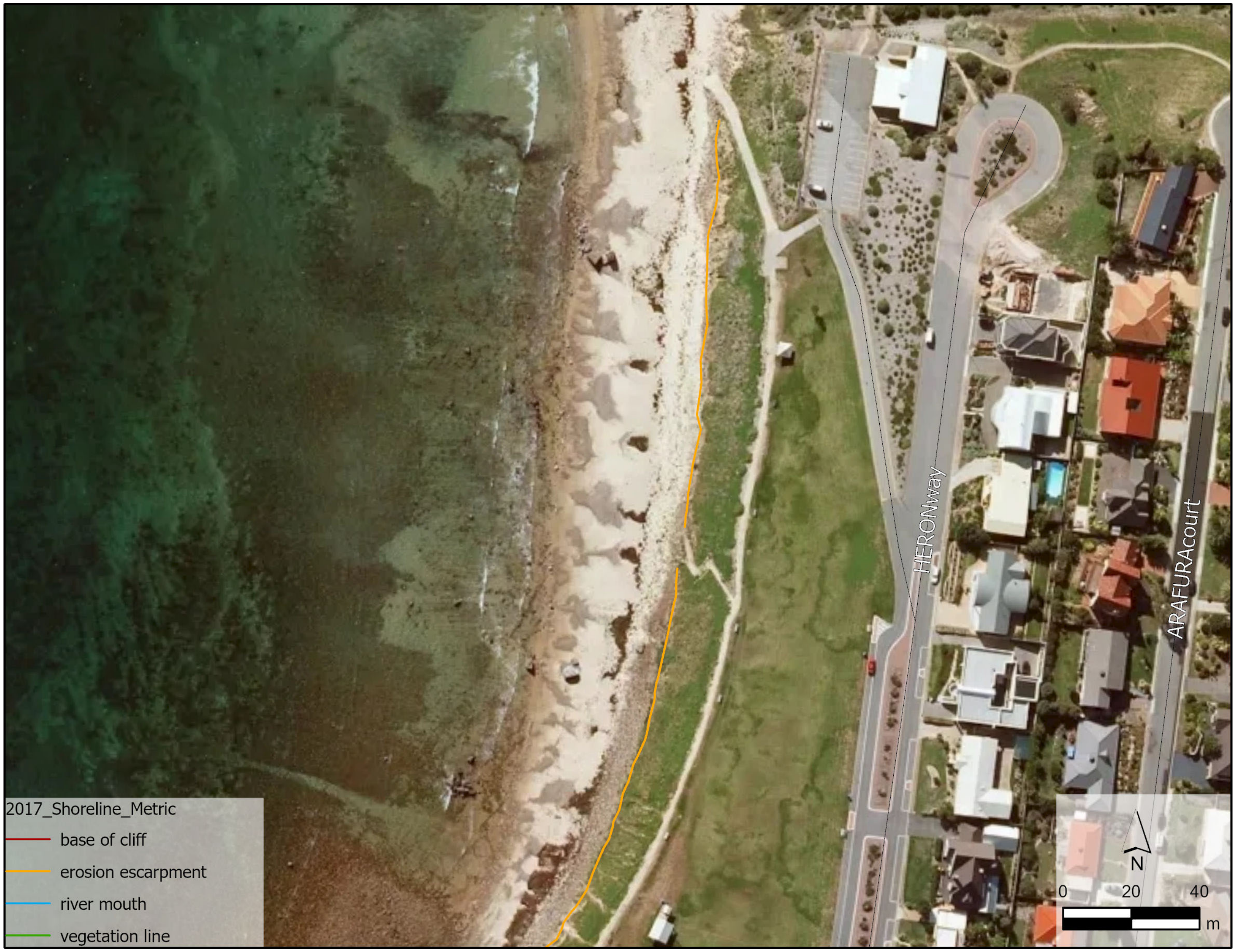

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.3

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Year 2012

Shoreline recession:

From 2007 to 2012, increasing erosion scarps in the embankment likely due to large storm evens on 4 July 2007, 25 April 2009.

Vegetation

Similar to 2017

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4-3 Coastal fabric – shoreline changes (Summary)

Medium Term Changes

Cell 3.3

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (north)
Summary

70 years
Backshore changed to man-made embankment (from dune system).

40 years
Embankment constructed out of imported earth. Constructed ~2-3m seaward in the north of the current position. Storm impact 2007, 2009 and other higher storms scarped the embankment in the north.

10 years
9 May 2016 caused damage to north and south. Rebuilt shortly after. Vegetation managed by council

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4-3 Coastal fabric – location map (Cell 3.4)

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Location Map

Location:
Heron Way Reserve (south)

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the embankment in the backshore or the vegetation line.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach
Historical comparison

Shoreline

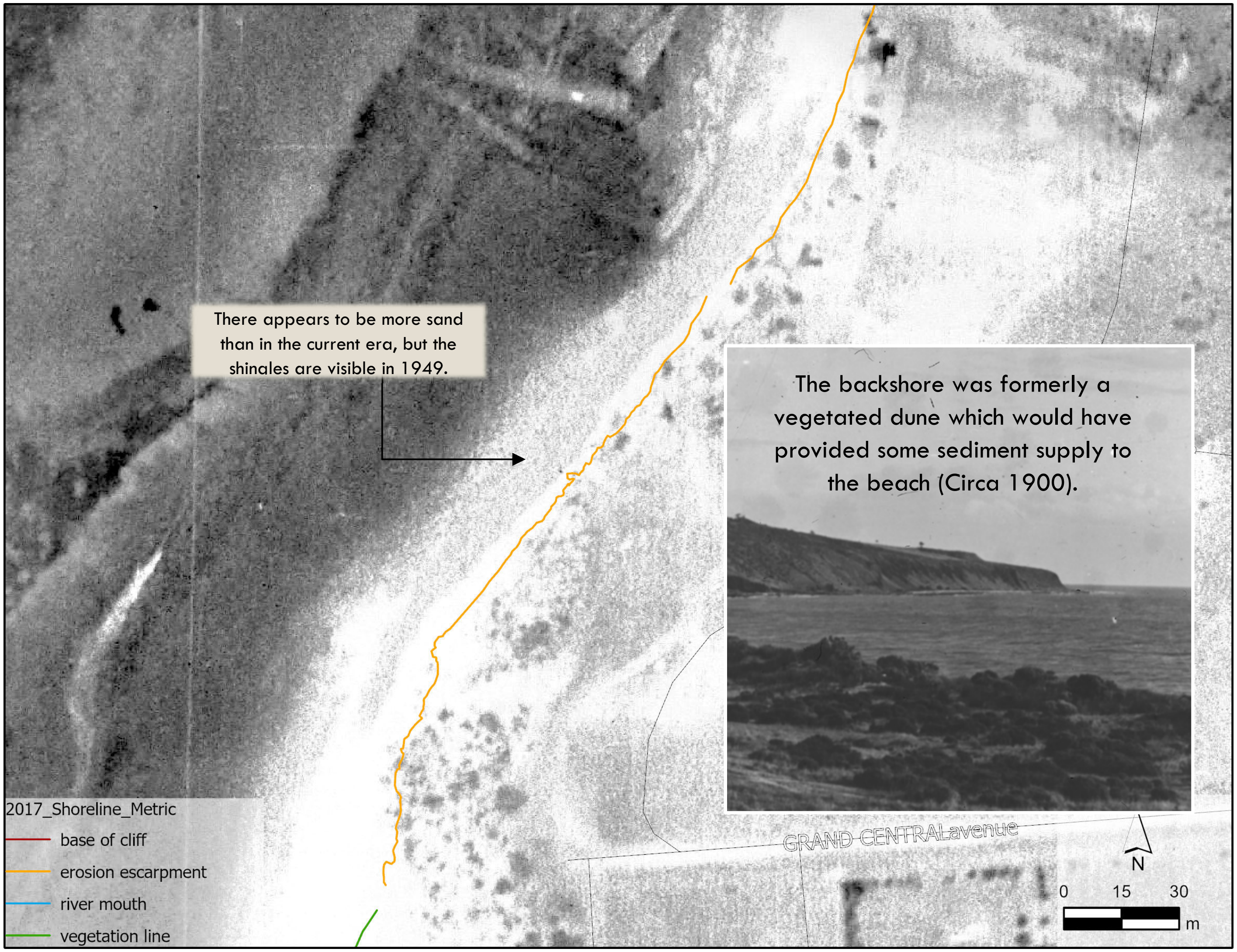
Location:
Heron Way Reserve (south)
Year 1949

Observations:

The backshore of the beach was a natural vegetated dune (see inset photograph from 1900).

There appears to be more sand than in the current era, but the rock shingles are visible on the beach in 1949.

Caution: the photograph is over exposed and resolution poor and therefore the rendering of white does not necessarily indicate sand.



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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Year 1979

Shoreline recession:

Comparison to 1949 not possible. The embankment was formed in the early 1970s (see inset photograph).

Recession of the embankment observed in the south (3-6m) when compared with 2017. This is likely because the location of the base of the embankment was determined by humans in early 1970s.

Vegetation

New vegetation, grassed banks.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Year 1989

Shoreline recession:

The base of the embankment in same location as 1979 which is landward of the location in 2017 by 3-6m.

Vegetation

New vegetation, grassed under council management.

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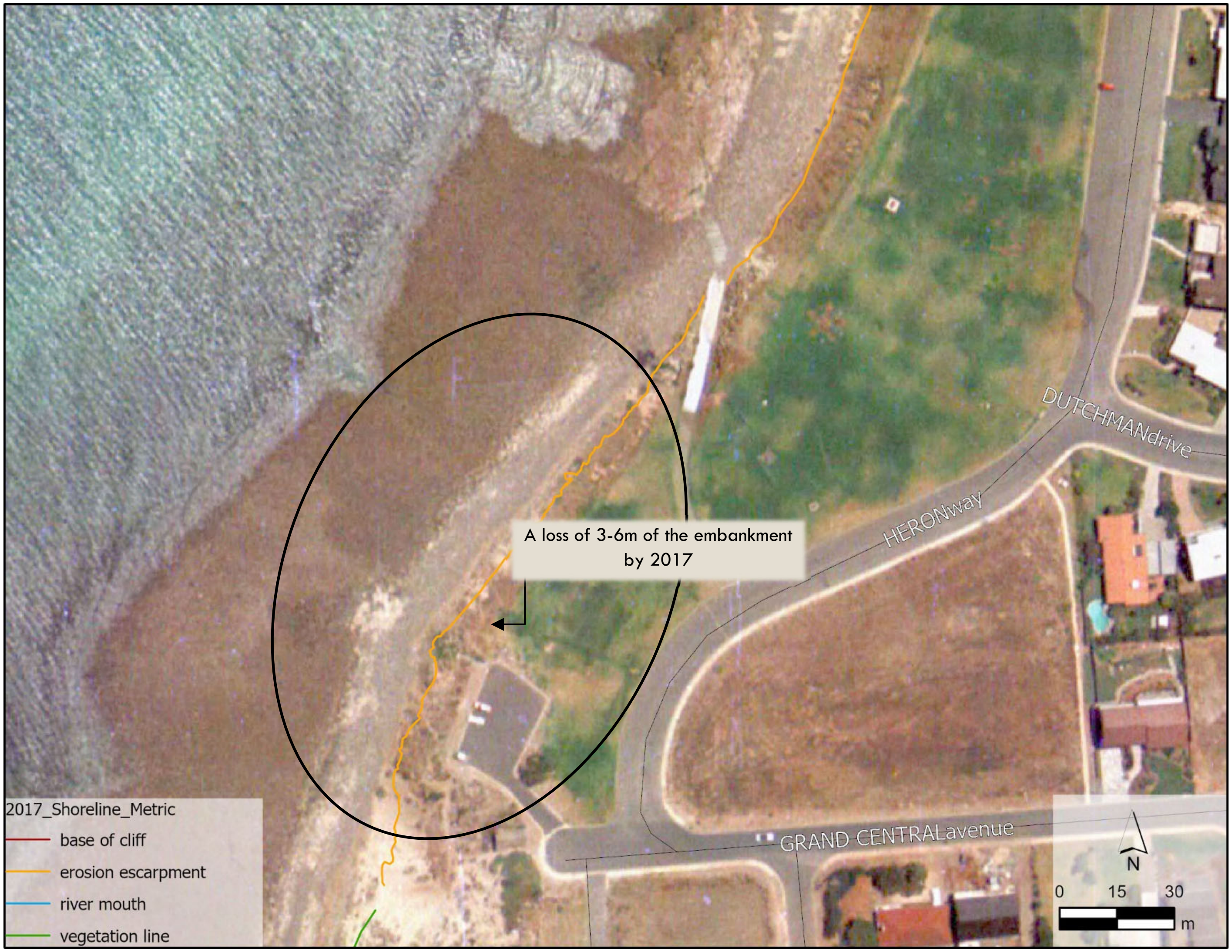

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Year 2002

Shoreline recession:

Shoreline (i.e. the base of the manmade embankment) receded 2m from 1980 to 2002.

Vegetation

Similar to 2017.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Year 2007

Shoreline recession:

Nil change between 2002 and 2007.

Vegetation

Similar to 2017

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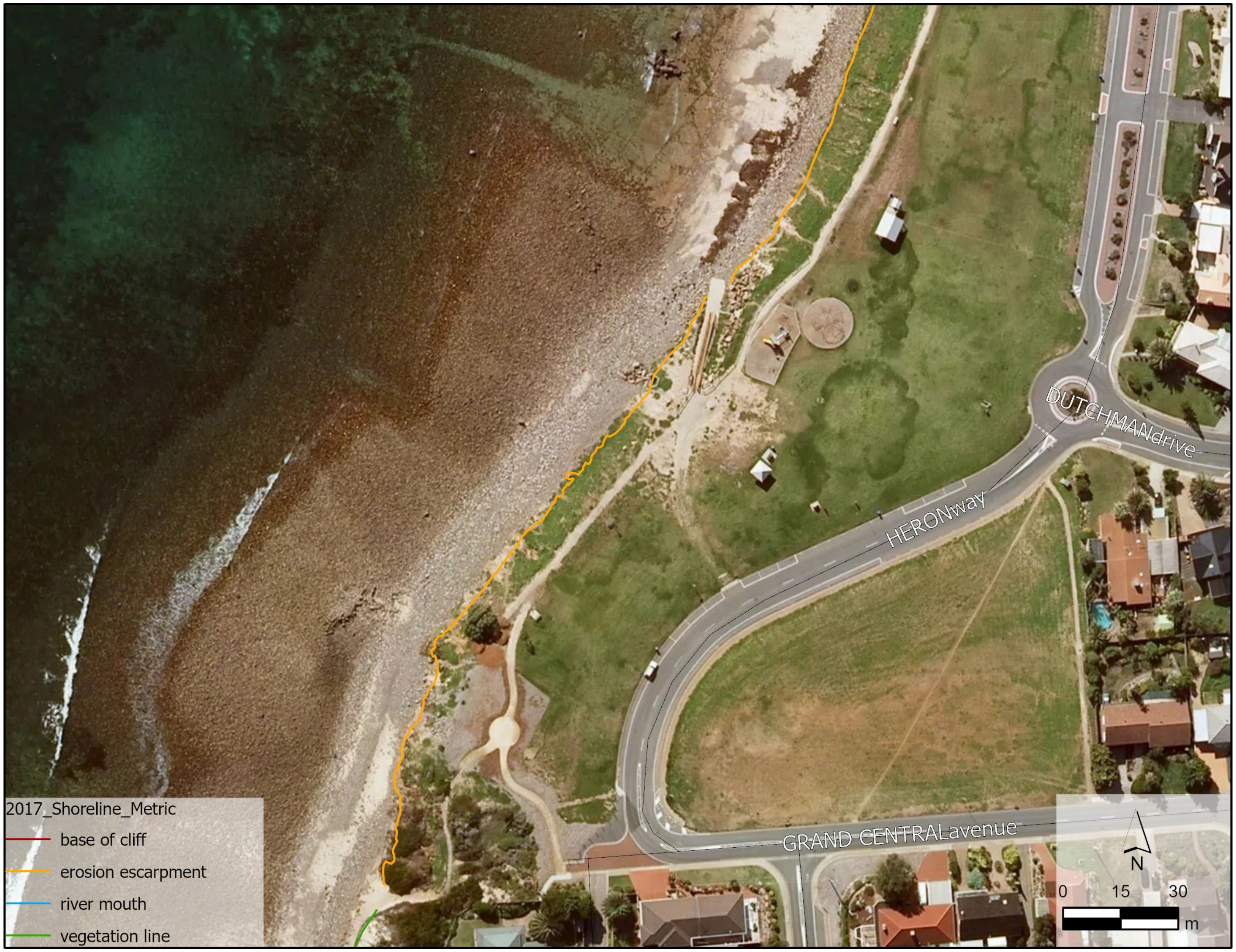

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Year 2012

Shoreline recession:

The base of the embankment receded 2-4m likely due to two large storms of 2007 and 2009.

Vegetation

Similar to 2017

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4-3 Coastal fabric – shoreline changes (summary)

Medium Term Changes

Cell 3.4

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Heron Way Reserve (south)
Summary

70 years
Formerly a natural vegetated dune which would have provided some sediment to the beach. There appears to be more sand in 1949, but rock shingles can be observed.

40 years
Dunes in backshore removed and earthen embankment installed, the base of which has receded 3-6m since installation.

10 years
2-4m recession of the base of the embankment in places due to 3 large storm events (2007, 2009, 2016).

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4-3 Coastal fabric – location map (Cell 3.5)

Medium Term Changes

Cell 3.5

Hallett Cove Beach
Historical comparison

Location Map

Location:
Field River (north)

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the base of the dune or vegetation line.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (north)
Year 1949

Observations:

Formerly a sandy, vegetated dune approximately 70m wide.

The appearance of the backshore would have been similar to the 1900 photograph (see inset photograph).

Caution: The 1949 photograph is over exposed and resolution poor and therefore the rendering of white does not necessarily indicate large volumes of sand.

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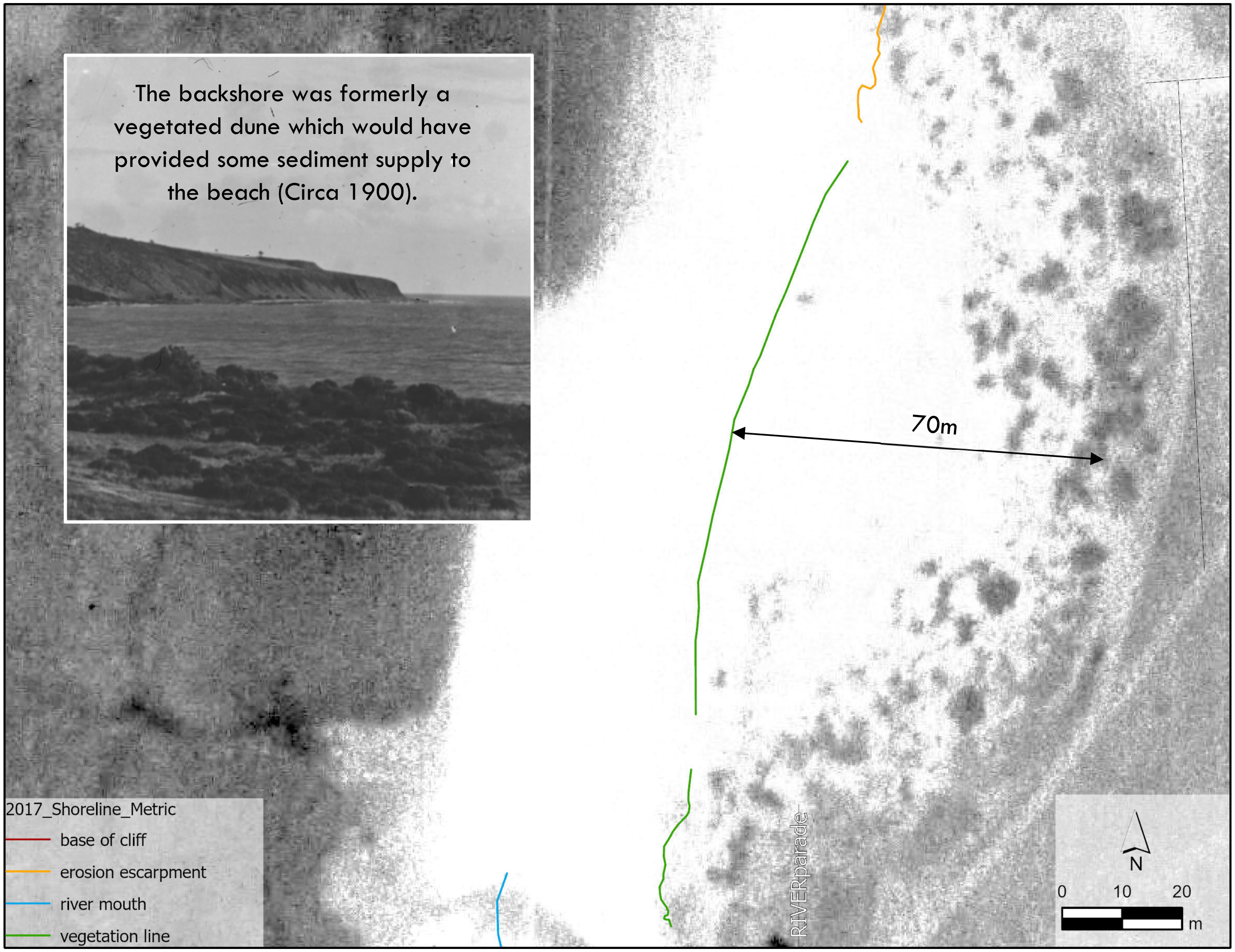

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (north)
Year 1979

Shoreline recession:

There is more sand than in the current era but the rock and shingle platform clearly visible in intertidal zone.

The toe of the dune has receded 5-6m from 1979 to 2017.

Vegetation

Sparse vegetation.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (north)
Year 1989

Shoreline recession:

The toe of the dune may have receded 0.5m between 1979 and 1989.

Vegetation

Similar to 1979 (sparse)

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (north)
Year 2002

Shoreline recession:

Possible recession of the dune toe by 2-3m from 1989.

Sand drift fencing installed was installed in this time period which has maintained the shoreline position.

Vegetation

Increases in vegetation likely a result of Council management.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Field River (north)
Year 2007

Shoreline recession:

Sand drift fencing maintains the shoreline position.

Vegetation

Overall similar to 2002.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.5

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Field River (north)
Year 2012

Shoreline recession:

No change since 2007 (due to netting). Less sand on the beach compared to 2007.

Vegetation

Similar to 2007

Human intervention
Beach access stairs installed (x2); sand drift net fence moved seaward in line with stairs.

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4-3 Coastal fabric – shoreline changes (summary)

Medium Term Changes

Cell 3.5

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Field River (north)
Summary

70 years
Originally a natural dune of 70m – now a 20m wide dune.

40 years
Installation of residential area upon former dune. Sand drift net fencing installed 2002 effectively maintains shoreline position.

10 years
Minimal change. Slightly less sand than 2007. Minor adjustment to sand drift net fence line.

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4-3 Coastal fabric – location map (Cell 3.6)

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Location Map

Location:
Field River (south)

Aerial Photograph from 2017 provides the basis for comparison of coastal change over the last 70 years. Comparisons are made with aerial photography from:

- 1949
- 1976
- 1989
- 2002
- 2007
- 2012
- 2017

In this location the shoreline position is the toe of the embankment in the backshore or the vegetation line.

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
1949

General observations.

Significant sand cover in comparison to 2017.

River mouth shifts consistently.

Very low vegetation cover.

Human intervention:

Rocks removed prior to 1949 (possibly 1880s by the army to create a landing location).

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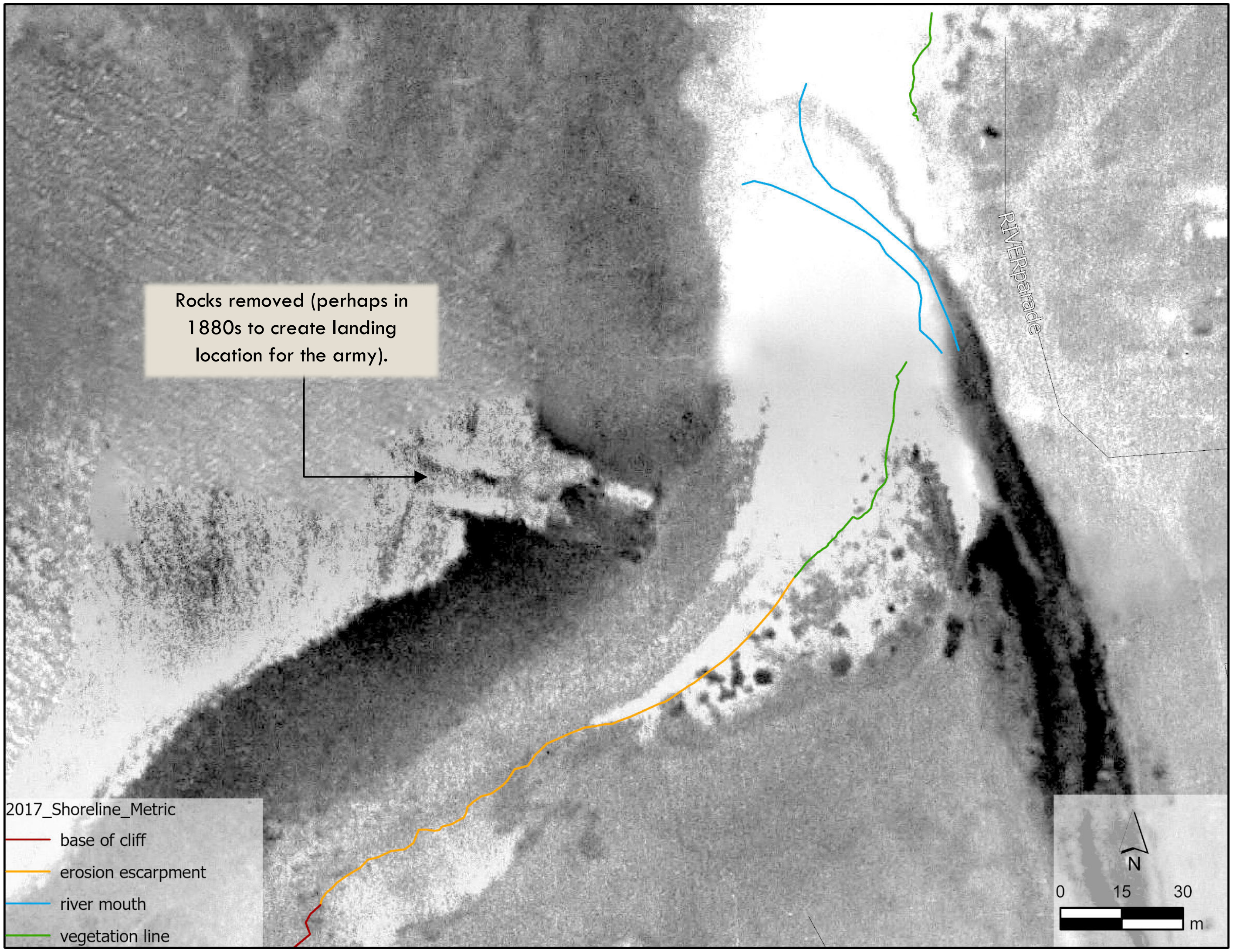

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach
Historical comparison

Shoreline

Location:
Field River (south)
1979

Shoreline recession:

Isolated dune likely formed with sediment from Field River. Was 5m to 15m seaward than current position. The loss of rocks from the seafloor may have increased erosion of the dune.

Vegetation

Sparse vegetation on dune and along riverbanks.

Human intervention:

Rocks removed prior to 1949 (possibly 1880s by the army to create a landing location).

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
1989

Shoreline recession:

Isolated dune likely formed with sediment from Field River. Receded from 1979 ~3m.

Vegetation

Similar to 2017.

Human intervention:

Nil

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
2002

Shoreline recession:
Receded 5m from 1989, now 7m seaward of 2017 position. Inset picture shows significantly more sand than 2017. Doug Lord notes that increasing erosion at Field River first of concern in 1990s (Lord, p.8)

Vegetation

Vegetation increasing – Field River.

Human intervention:

Sand drift fencing installed to front of Field River dune. Caving occurred in the 1990s on southern end of the dune and Council collapsed these (Lord p. 9).

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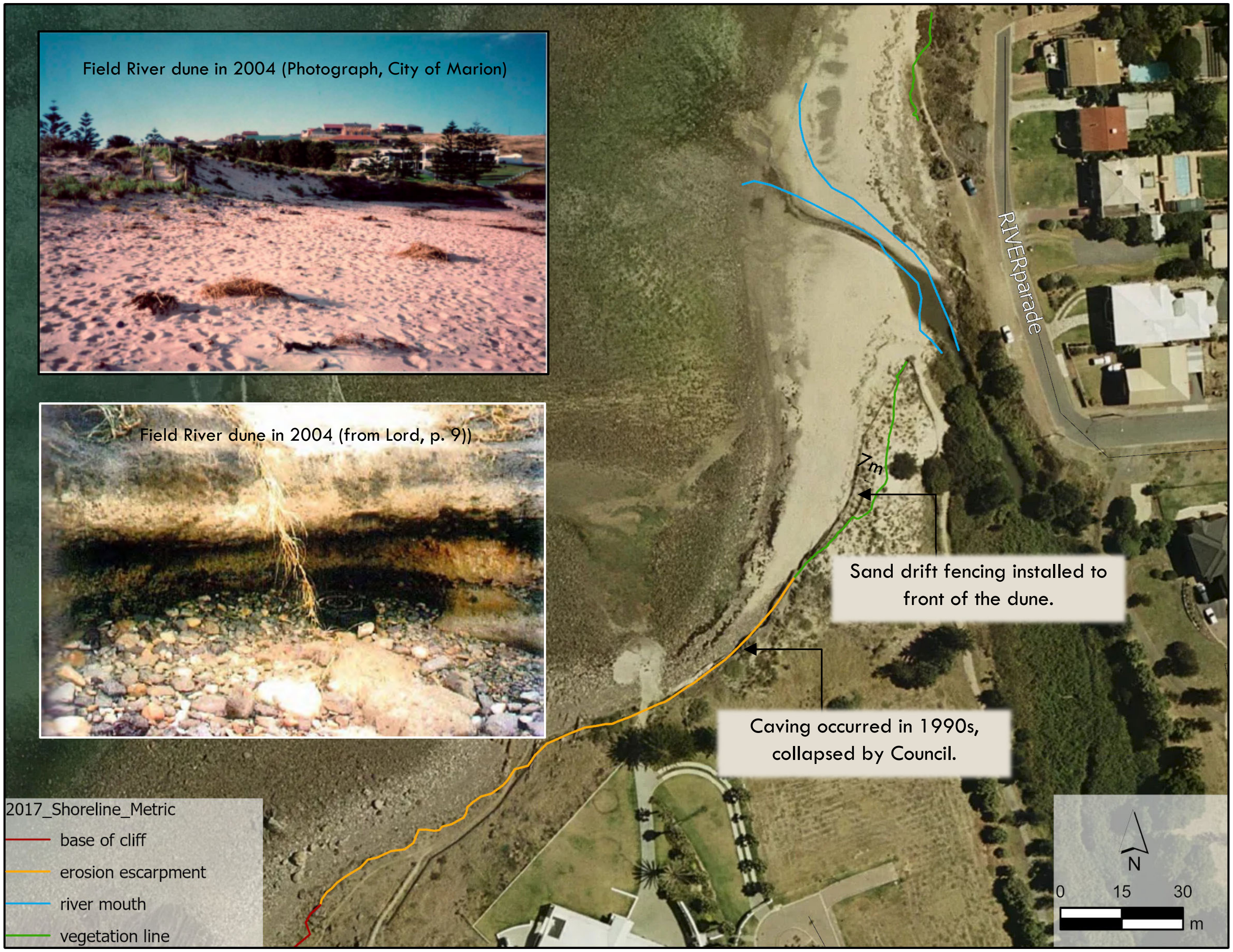

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
2007

Shoreline recession:

Sand drift net fencing is similar position as 2007 and holds shoreline position.

Vegetation

Vegetation increasing along the Field River.

Human intervention:

Imported rock installed to the southern end of the dune and covered with sand. The sand quickly washed away.

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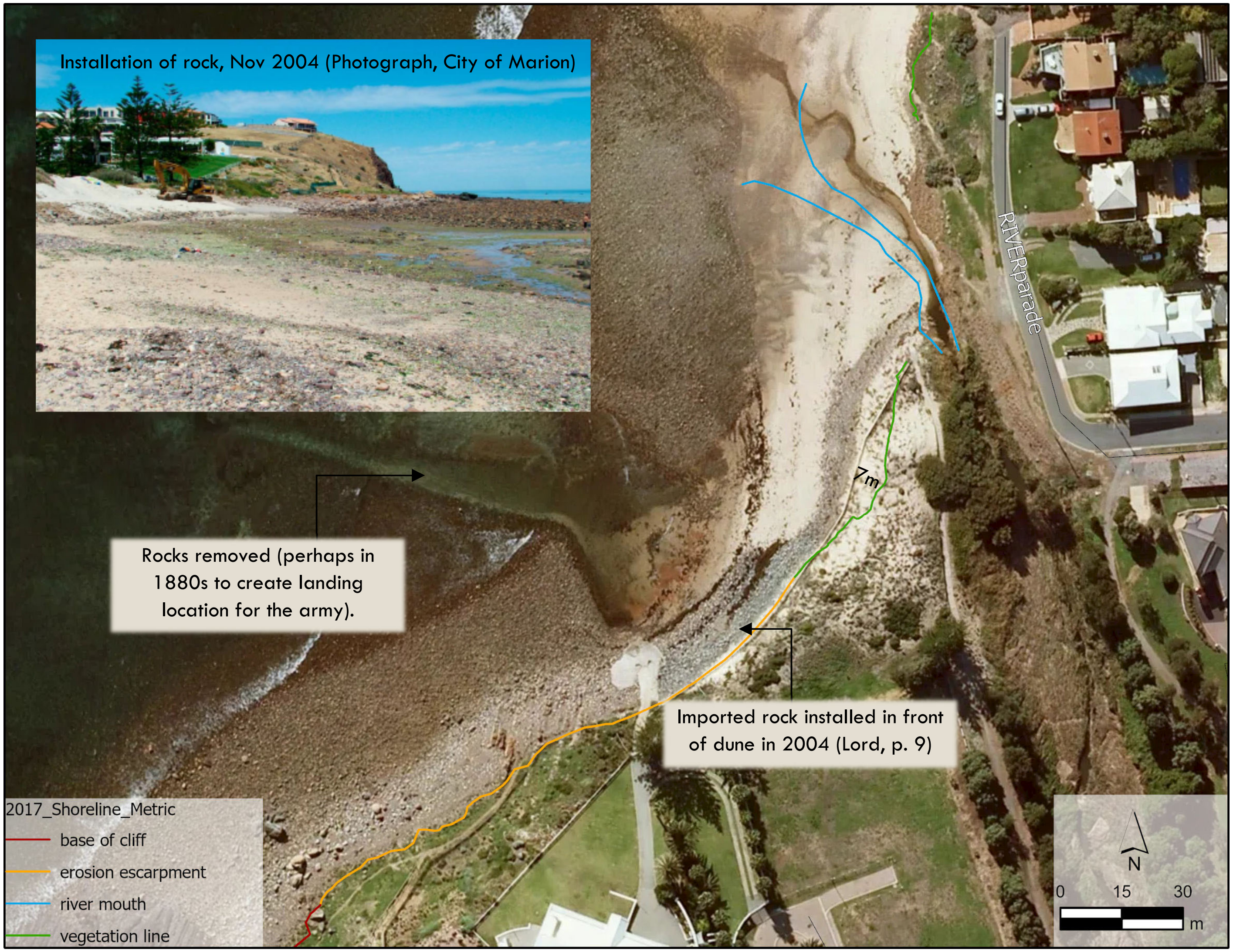

4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
2012

Shoreline recession:

6m seaward of 2017 (drift net fencing holding the shoreline position).

Vegetation

Vegetation increasing along the Field River.

Human intervention:

Nil

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4-3 Coastal fabric – shoreline changes

Medium Term Changes

Cell 3.6

Hallett Cove Beach

Historical comparison

Shoreline

Location:
Field River (south)
Summary

70 years
Significantly more sand around the Field River in 1949. Sediment supply likely from the river and the natural dune system.

40 years
Progressively less sand on the beach, the Field River dune begins to erode more significantly in the 1990s. Various interventions – rock revetment, sand drift fencing. 5-15m recession of dune on northern end.

10 years
Dune eroded 7ms where shown (further erosion has occurred since 2017).

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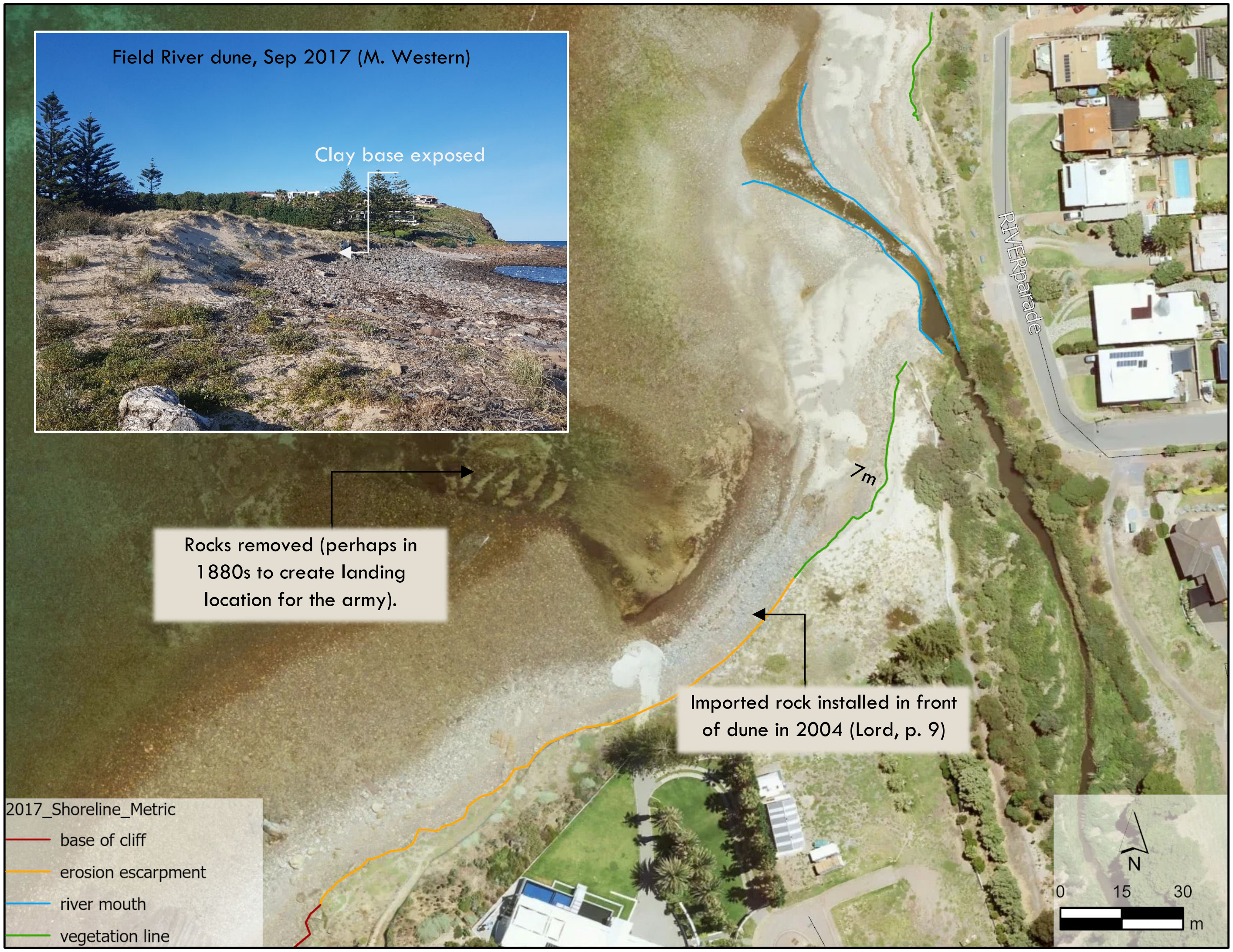

4-4 Coastal fabric – beach profile changes

Medium Term Changes

Cell 3

Hallett Cove Beach

Historical comparison

Profile line

Analysis

The Coast Protection Board has been surveying seafloor and coastal backshores since the 1970s around South Australia.

Profile lines:

- 200040
- 200041

An evaluation of these profile lines provides a context to consider sand movements within Hallett Cove Beach.

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4-3 Coastal fabric – beach profile changes

Medium Term Changes

Cell 3

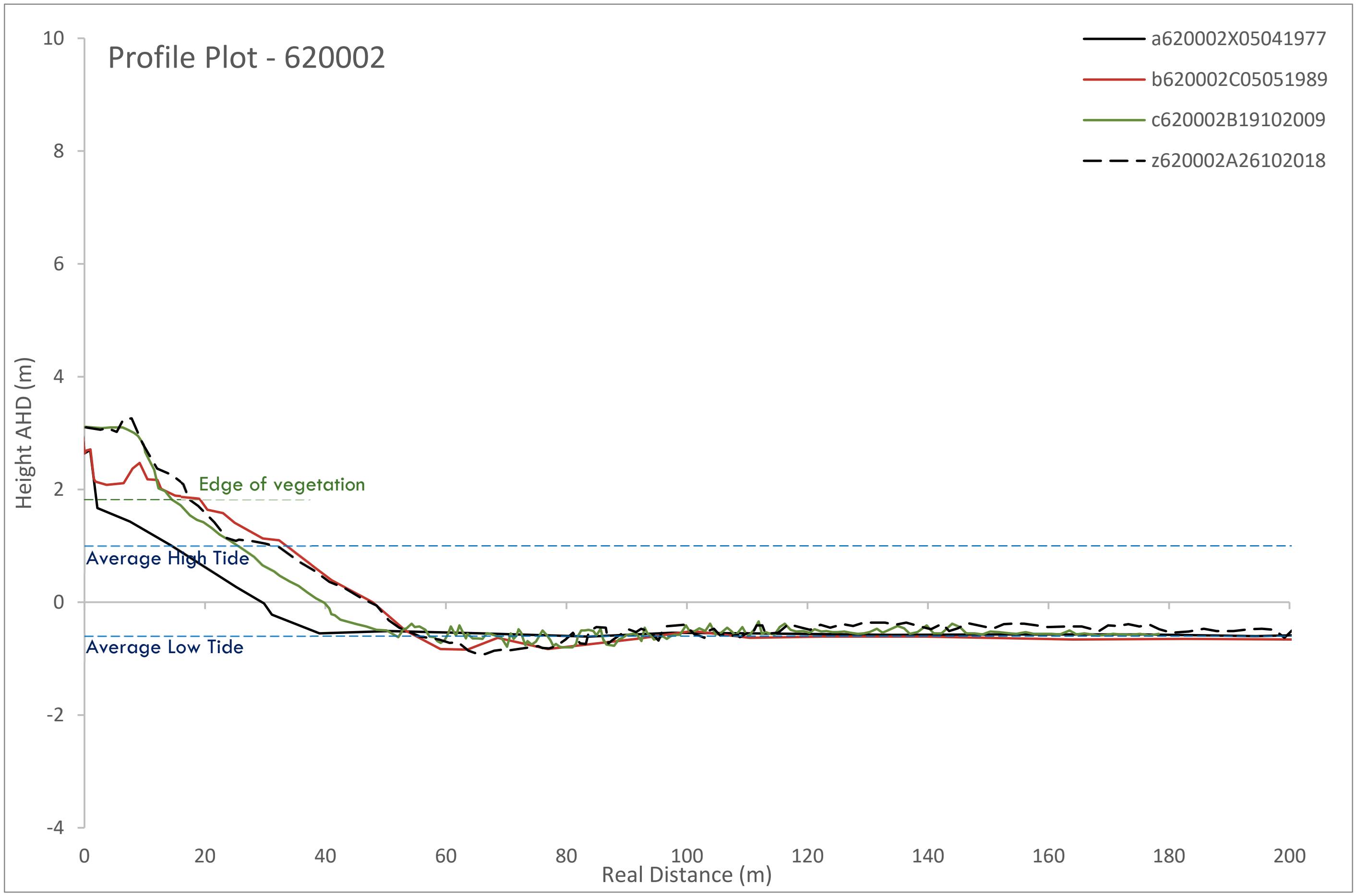
Hallett Cove Beach

Historical comparison

Beach Profile

Analysis:
Profile line 200040
Hallett Cove Beach 1

Yet to be completed. Note, these plots are for Encounter Bay.



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As a general observation, below the low tide line is dominated by a low-profile reef which is reflected in the minimal amount of movement in the profile line offshore. The area below the low tide line close to the shore (where there is no reef) currently shows a lower level of sand than in previous eras, but further offshore, sand is at a slightly higher level.

4-3 Coastal fabric – beach profile changes

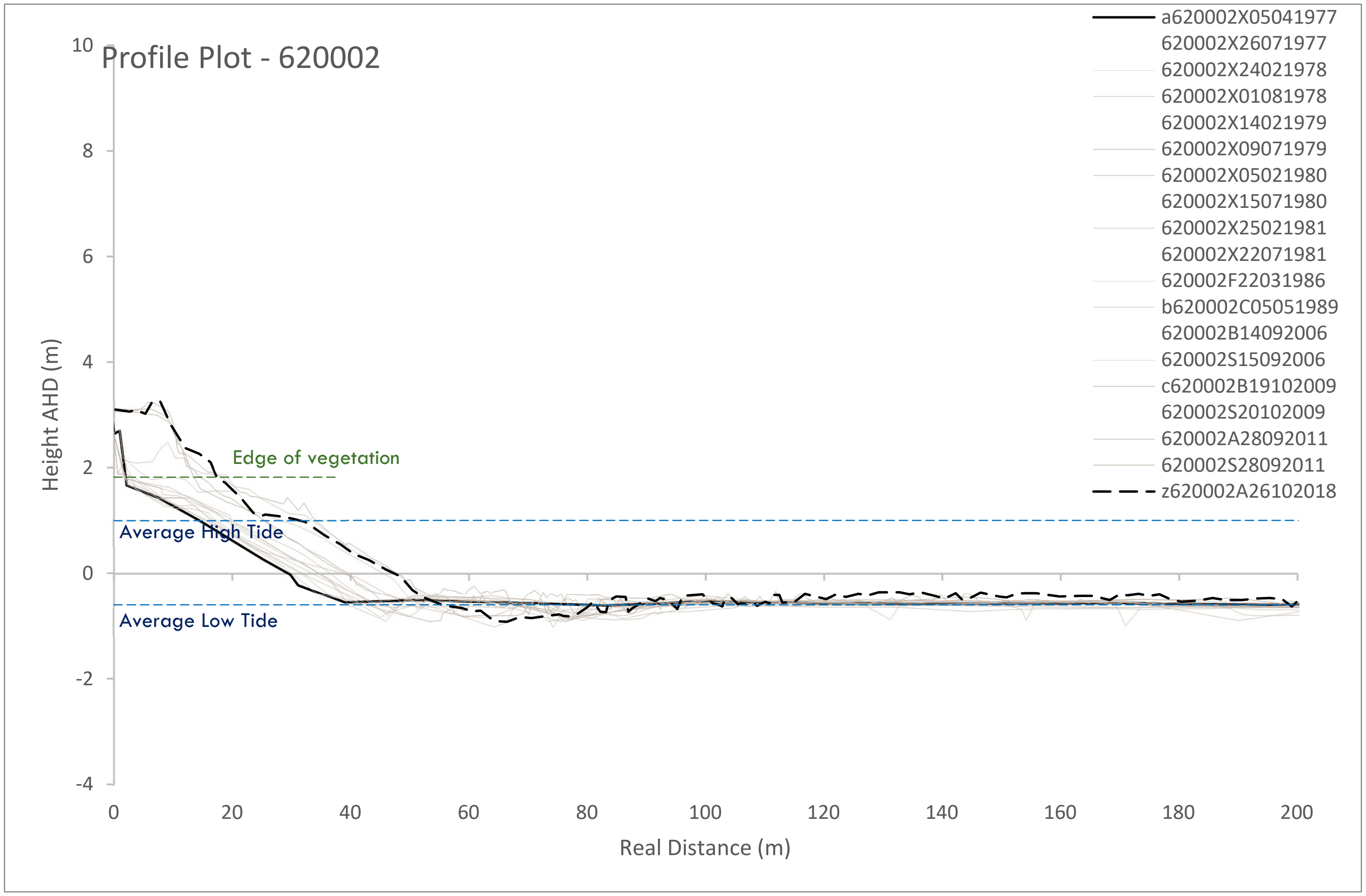
Medium Term Changes

Cell 3

Hallett Cove Beach

Historical comparison

Beach Profile



Analysis:
Profile line 200041
Hallett Cove Beach 2

Yet to be completed. Note, these plots are for Encounter Bay.

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Notes: It is relevant to note that the position of the backshore in 1977 was formed by wave action in that time period (early 1970s were a time of increased storminess). Therefore, it could be anticipated that this section of coast is likely to come under pressure to recede in the context of increased storminess and higher than average high tides when these occur.

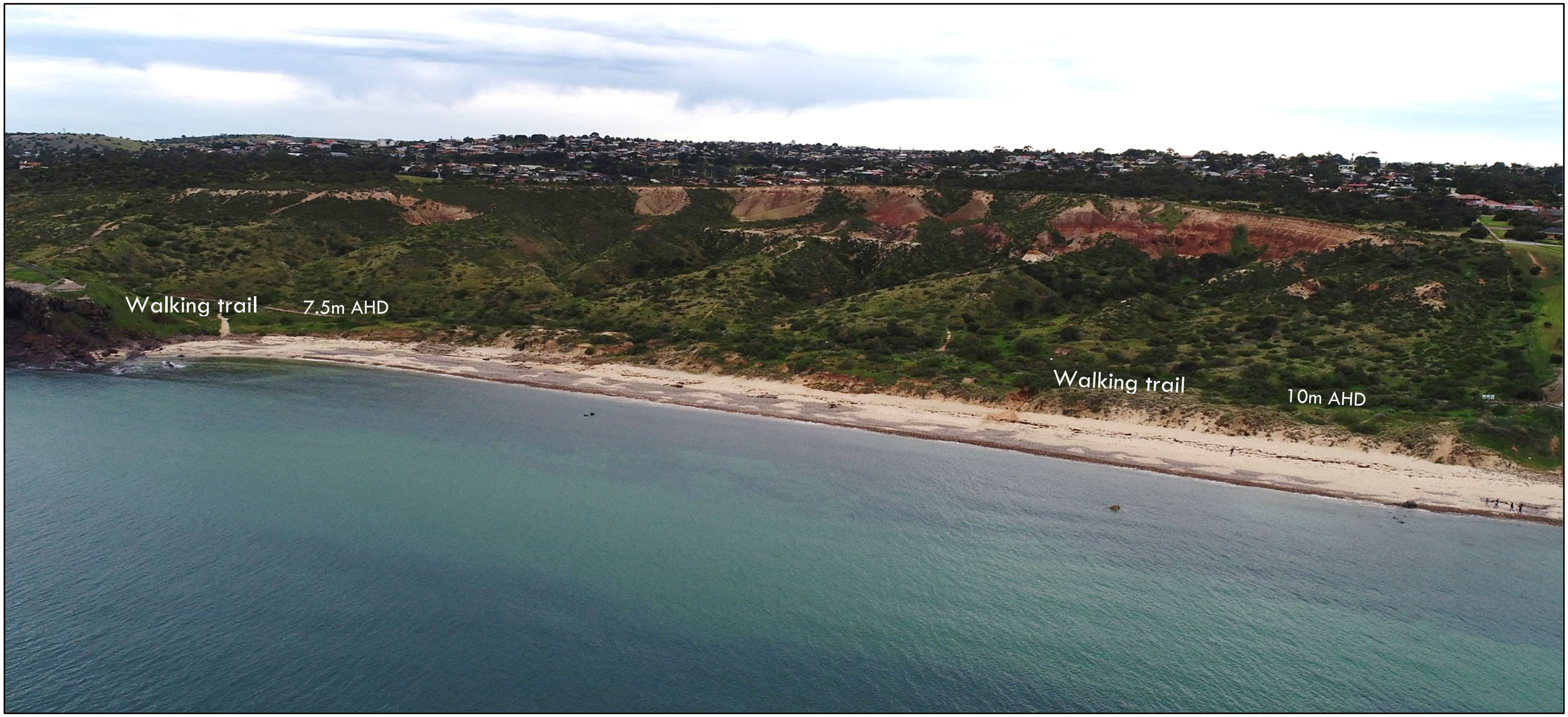
4-5 Coastal fabric – human intervention (Cell 3.1-2)

MODIFIED COASTS

Human intervention has decreased in this section of coast since the 1970s. After World War II, beach shacks and internal dirt roads were constructed here. The shacks were removed in the 1970s and the Hallett Cove Conservation Park declared in 1976 so that 'its geological and scientific interest could be preserved in perpetuity' (Hallett Cove Management Study).

Modifications: Walking trails and signage are the two remaining human interventions in this section of coast.

Protection items: No protection items are installed in this section of coast.



4-5 Coastal fabric – human intervention (Cell 3.3-4)

MODIFIED COASTS

Modifications: The natural dune system was removed in the early 1970s and an earthen embankment installed (inset photograph). As observed in section 4-4, the base of this slope eroded over a period of decades. Two concrete access ramps (one wide enough for a vehicle) and two beach access stairs were installed. Other urban infrastructure has been set well-back from the coast.

Protection items: Rock revetment was installed on both sides of the southern onramp. At the time of construction of the embankment, it appears that rocks were also installed along the coast, some now buried. (See inset photograph). The embankment was damaged on 9 May 2016 and repairs undertaken. (Geotextile fabric still visible in the photograph below).

Installation of earthen embankment and urban infrastructure behind (~1974) State Library of SA, SRG 847.1.17

4-5 Coastal fabric – human intervention (Cell 3.5-6)

MODIFIED COASTS

The area around Field River was formerly a dune system that would have interacted naturally with the ocean environment and more flexible to manage accretion and recession.

Modifications: The dune system has largely been built upon and roads and other infrastructure act as 'hold points' preventing natural recession and accretion. Rocks were removed from the sea floor (possibly as early as 1880s) which is likely to have resulted in increased impact from actions of the sea upon the backshore.

Protection items: Rock revetment was placed on the southern end of the Field River dune in 2004. Before this installation, actions of the sea were creating caves under the dune. Sand drift fencing has been installed in front of the dune to the north of Field River. River Parade and residential area is generally above 6m AHD (well above sea-flood risk).

4-4 Coastal fabric – human intervention (Cell 3)

LAND USE ZONING

The current urban planning controls are briefly reviewed here to ascertain if existing development controls are adequate in the context of coastal areas.

Zoning and policy areas

Hills Neighbourhood

The predominant zoning in this area is Hills Neighbourhood but all residential properties in this zone are set well-back from the coast in Cell 3.

Suburban Neighbourhood

Residential properties adjacent the coast in the Field River area are zoned Suburban Neighbourhood. The desired outcome is for low density housing, but semi-detached are permitted with 9m frontages. A local variation requires minimum site levels at 4m AHD and finished floor levels at 4.25m AHD.

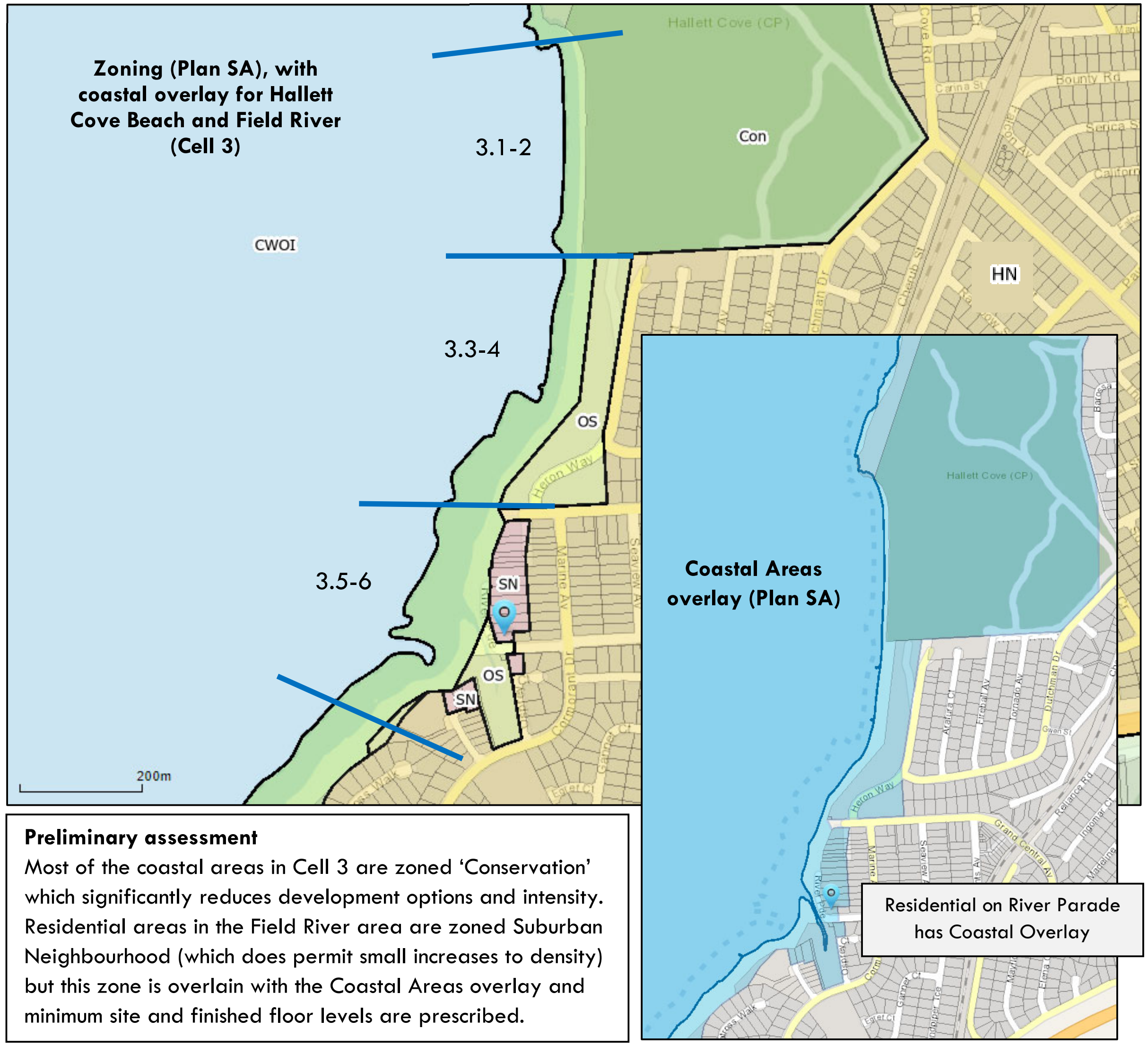
Conservation Zone

Conservation Zone is positioned along the coast and includes Hallett Cove Conservation Park and Heron Reserve. This zone limits development options.

Overlays

Coastal Areas (only one reported here)

This overlay is positioned over the Conservation Zone but also positioned over the residential properties in the Field River area. Development proposals would require a referral to Coast Management Branch (SA).



Preliminary assessment
Most of the coastal areas in Cell 3 are zoned 'Conservation' which significantly reduces development options and intensity. Residential areas in the Field River area are zoned Suburban Neighbourhood (which does permit small increases to density) but this zone is overlain with the Coastal Areas overlay and minimum site and finished floor levels are prescribed.

4. Coastal fabric – summary table (Cell 3)

Hallett Cove Beach

Hallett Cove Beach		Coastal context - natural				Modified	Coastal changes		
Cell	Location	Bathymetry	Benthic	Beach	Backshore	Human	70 years	10 years	Erodibility
3.1-2	Hallett Cove Conservation Park.	Slope at 1:100. Sea floor becomes steeper towards Black Point 1:50.	Low profile reef, seagrass bed and sand patch near Black Point.	Rock and shingle beach covered with thin layer of sand.	5m high vegetated dunes overlaying clay. Sloping backshore in the amphitheatre.	Walking trail and signage.	Erosion of northern dunes 2-6m to current era. Erosion on southern end since 1979 (~7m)	Shoreline accreted and then receded (due to three large storms, 2007, 2009, 2016).	**Moderate erodibility** The beach likely undergoes cycles of accretion and erosion over decades.
3.3-4	Heron Reserve	Slope 1:100 (-4m at 400m offshore).	Low profile reef and seagrass beds.	Rock and shingle beach covered with thin layer of sand.	Manmade earthen embankment, Landward is steeply sloping backshore.	Dunes removed; earthen embankment installed. Rock protection adjacent onramp.	Since 1979, Earthen embankment receded 4-6m in places (earlier in north than south).	The base of the earthen embankment receded 2-4m in the south (but scarped in the north).	**Moderate erodibility**
3:5-6	Field River	Slope 1:100 (-4m at 400m offshore).	Low profile reef.	Shingles and pebbles, minimal sand.	Earthen embankment adjacent road, Landward is steeply sloping backshore.	Rocks removed from ocean floor (1880s), rock revetment installed on southern dune.	Continual decline of sand. Dune began receding in 1990s.	Continual decline of sand. Significant erosion of the dune (2007, 2009, 2016)	**High erodibility**

Hallett Cove Beach: key points

(3:1-4) Soft rock sloping shores (sediments overlaying rock substrate), but predominantly stable. Rated as **moderate erodibility** due to the dunes and earthen embankment in backshores, which are under wave attack in larger events. Human interventions are almost nil in 3.1-2, significant interventions in 3:3-4 with removal of dune system. Rock revetment protects the onramp below Heron Reserve

(3:5-6) Field River is rated as **high erodibility** due to river mouth and rapid recession of the dune. Historical photographic analysis identified recession/impacts which supports these assessments. Human intervention includes River Parade and some houses in the former dune field in 3:5-6. Rock revetment protects part of the dune south of the Field River.

5. COASTAL EXPOSURE

To evaluate how actions of the sea currently impact the coastal fabric and how actions of the sea are projected to impact in the future in this section we complete the following:

- Review impact of storms (if any)
- Apply current 1 in 100 sea-flood risk scenario,
- Analyse routine high-water impact,
- Analyse these scenarios in time frames: 2022, 2050, 2100.

Viewing instruction:
View sea-flood modelling using full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

5. Coastal exposure – overview

COASTAL EXPOSURE EXPLAINED

The concept of coastal exposure is something we tend to understand intuitively. For example, if we find ourselves on the shore of a protected bay, we 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.

In this study we are primarily concerned with the exposure of coastal landscapes to wave energy and ocean swell. However, coastal landforms can also be vulnerable to exposure from rainfall run-off or from the impact of wind. These can also increase the erosion of coastal landscapes, especially in cliff regions of softer constituency.

Due to its location within Gulf Saint Vincent, which is afforded protection by Kangaroo Island from the Southern Ocean, Nature Maps (SA) has assigned the exposure rating for City of Marion coastline as 'moderate' and the wave energy as 'low'[1].

Storm surges

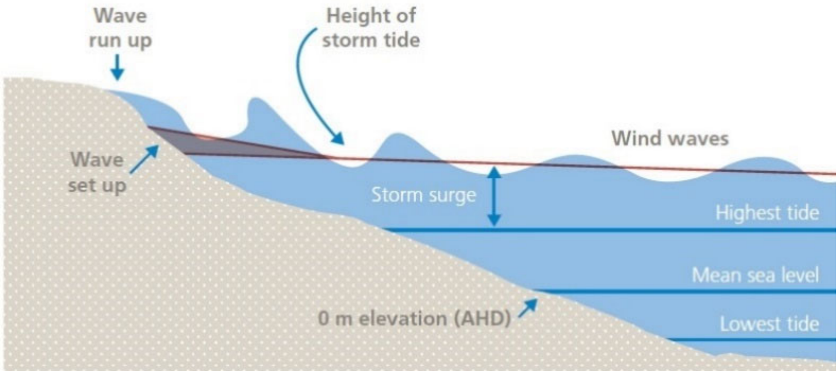
Despite this protection, when several meteorological conditions combine, storm surges can produce water levels up 1-2m higher than the predicted astronomical tide in Gulf St Vincent. To manage the risk of these events upon human infrastructure, SA Coast Protection Board has set storm surge policy risk levels for the 1 in 100-year event. In terms of probability, this event is predicted to occur once every hundred years. However, 'nature' does not read our probability charts and there is no reason why these large events could not occur closer together, albeit less likely. While storm surges may have significant impact on the coast, these by their very nature are rare events. Over time beaches may rebuild and we can repair the damage.

[1] https://data.environment.sa.gov.au/NatureMaps
[2] CD stands for Chart Datum and relates to tide heights recorded in the local tide charts.
[3] Australian Height Datum (AHD) is the same measurement system that a surveyor would utilise and generally relates to mean sea level (the middle height of water between high and low water).

The event of 9 May 2016 was the highest event recorded at the Outer Harbor tide gauge and was recorded at 3.80m CD[2] or 2.35 AHD[3]. This event came close to the *1 in 100-year event* set by South Australian Coast Protection Board at 2.50m AHD. *Wave setup* of 0.30 has been adopted for the entire City of Marion coastline[4]. *Wave runup* allocations have been made for each cell based upon surveys conducted of seaward strands from four storms in 2021-2022 (Figure a).

Routine high water

While storm surges can have a significant impact on the coast, these are rare events. If seas rise as projected, routine tidal action is likely to have a greater impact on beaches and backshores over time. In the context of a cliff coast, areas that are currently receiving intermittent wave impact will receive constant wave impact and this is likely to increase the rate of erosion. To calculate the height of this tide, the average monthly high tide from March to September from the tidal record at Port Stanvac was calculated at 1.40m AHD[5]. It is likely that this tidal regime would occur on average one to three times per month.



[4] Set by SA Coast Protection Board. In the context of a storm surge, the water from wave action cannot flow back to the sea and water levels rise against the coast. This is known as 'wave setup'.
[5] Port Stanvac gauge operated from 1992 to 2010. Actual height was calculated at 1.42m AHD which represents 90% of the height at Outer Harbor for the same period at 1.59m AHD.

5. Coastal exposure – overview

COASTAL PROCESSES

Wave action on the Marion Council coastline

The degree of susceptibility of a coastline to wave erosion is related to the degree of exposure of the coast to wind, current and wave attack. There are two main types of waves which fashion beaches: storm (forced waves); and swell (constructional waves). Forced waves scour the beach, erode sand from beach faces and form offshore bars. When storms subside, constructional waves tend to push sand back onto the beach.

The alignment of Marion's coastline tends more to the north-east/ south-west in contrast to Onkaparinga and Adelaide metropolitan coastline which tends to orientate north-south. Swell waves are generated in the Southern Ocean, but after passing through Investigator Strait, and having 'refracted, diffracted and attenuated due to bottom friction', wave heights are much reduced as they approach the Marion coastline. Swell waves that propagate to the Marion coastline region have 12-16 second periods, heights below 1m, and directions close to 260˚. Sea waves within the Gulf St Vincent are generally of short-wave period and quite steep, frequently with white caps and approach the shore from the direction of the wind, mostly west-south-west winds, but can roll in at range 250˚ - 310˚. Combine with south-west swells, the net wind-wave direction is northward. Wind waves are generally lower than swell waves but have been recorded at 2.6m in Gulf St Vincent[6] (Figure a).

Storm action on the Marion Council coastline

The conditions that produce the highest levels of water in Gulf St Vincent have been documented by Flinders Ports[7]. With the passage of a deep depression across the Southern Ocean, the winds are from the North which then swings to the North-West. A strong gusty north-westerly wind, with a depression in the Southern Ocean, backing to the south-west at about the time of low water, will cause a storm surge of maximum amplitude from the Southern Ocean, and heights may be expected from 1m to 2m

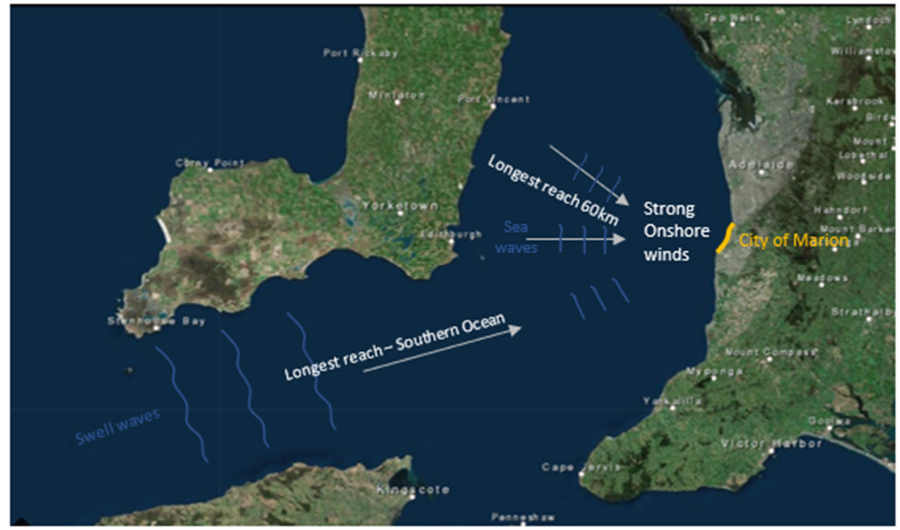


Figure a. The orientation of the City of Marion coastline to wave energy (M. Western, 2018)

Tidal Range on the Marion City Council coastline

The effect of tides pushing up through a narrowing Gulf increases the tidal range in the northern parts of the Gulf. In the Marion region, the categorisation is borderline in the upper ranges of micro-tidal as assessed by Doug Lord 2012.

Level	**Chart Datum (m)**	**AHD (m)**
Lowest astronomical tide	0.00	-1.45
Mean sea level	1.30	-0.15
Australian Height Datum	1.45	0.00
Mean high water neaps	1.30	-0.15
Mean high water springs	2.40	0.95

Figure b. The tidal range at City of Marion is characterized as micro-tidal (upper range).

[6] D. Lord., Coastal Management Study, Hallett Cove, SA. 2012

[7] Flinders Ports (ND) Port User Guide – General Information

5. Coastal exposure – overview

SEA LEVEL RISE

Climate change occurs over long timescales in response to solar variations, changes in the Earth's orbit around the Sun, volcanic eruptions, and natural variability. Sea levels reflect the state of the climate system. During ice ages a large volume of water is stored on land in the form of ice sheets and glaciers, leading to lower sea levels, while during warm interglacial periods, glaciers and ice sheets are reduced and more water is stored in the oceans[8]. Over the last few thousand years sea levels have stabilised, and also within this time frame, urban settlements have been established near the coast all over the world.

Global mean sea levels

The average level of the ocean is known as *global mean sea level* (GMSL). Long term tide gauges show that seas began to rise in the 19th century and this trend has continued throughout the 20th century at on average rate of 1.7mm per year. However, this average rate of rise was not constant. Rates of sea level rise were higher in the period 1920s to1940s[9] (in the context of higher temperatures and melting of the Greenland ice sheets[10]). In the 1990s sea levels again rose at a faster rate, comparable to that of the 1920s to 1940s. Since 1990, satellites have been tracking mean sea level rise at 3-4mm per year in our region[3]. However, this shorter-term record is likely to contain an element of natural variability and the current rate of rise not unusual in the context of natural variability and the data record from last century[11]

Regional sea levels

Regional changes occur in sea level, but these do not change the overall mass of the ocean. For example, regional sea levels change in accordance with the climate variability associated with El Nino and La Nina cycles. During El Nino years sea level rises in the eastern Pacific and falls in the western Pacific, whereas in La Nina years the opposite is true. Longer term changes are also associated with changes in the Trade Winds which bring increases in sea levels in the Western Tropical Pacific region[2]. Sea levels can also change in relationship to the vertical movement of land. If an area of land is falling, then in relative terms, sea levels will rise, and vice versa.

Projected sea level rise

Projections of future climate change are carried out using climate models that use various greenhouse gas emissions scenarios. These models are computer-based simulations of the earth-ocean-atmosphere system that identify plausible futures as to how the climate will respond over the coming century[4]. Sea level rise projections are based upon these various scenarios. In 1993, South Australian Coast Protection Board (CPB) adopted sea level rise allowances into planning policy of 0.3m rise by 2050 and 1.0m rise by 2100. These sea level rise projections are similar to the high emissions scenario shown in Figure a.

Scenario modelling

In this project we take the current storm surge risk levels and current routine high-water data and model the impact of these in a digital model captured in 2018. We then take the sea level allowances set by CPB at 0.3m by 2050 and 1.0m by 2100 and model the projected impact of sea level rise upon the coast.

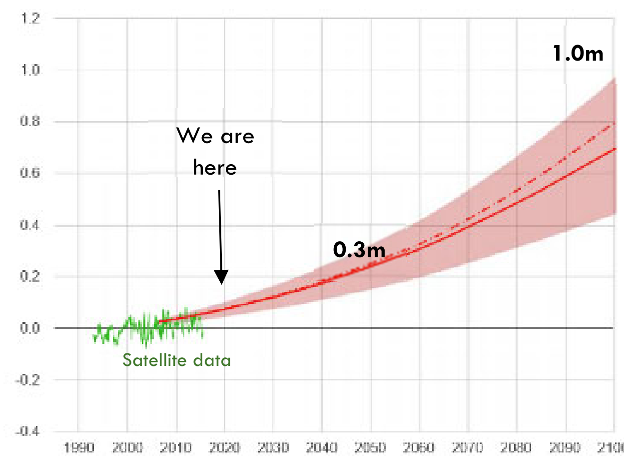


Figure a: Sea level rise high emissions scenario (Coast Adapt, 2017). Coast Protection Board sea-level rise policy added.

[8] Coast Adapt, 2017.
[9] IPCC, WG1AR5, Sea level change, 2014, Watson, P, 2020.
[10] Curry, J., Sea level and climate change, 2019.
[11] CSIRO, 2020, Sea level, waves and coastal extremes.

5.1 Coastal exposure – previous storm impact

HISTORICAL STORMS

The analysis of previous storms provides a window into the past to assist us to identify where the coast is most vulnerable. This analysis also provides a window into the future because it provides a context from which to consider how storms will impact the coast if seas rise as projected. In some ways, storms are 'natures' vulnerability assessment of how resilient our coast currently is, and how it may respond in the future.

Storm event – 9 May 2016

The three highest storm surges on record at Outer Harbor tide gauge occurred:

- 9 May 2016 – 2.35m AHD (3.80 CD)
- 3 July 2007 – 2.27m AHD (3.71 CD)
- 25 April 2009 – 2.22m AHD (3.65 CD)

There is no record in the archives of any impact of the lower two events and this may imply that the event of 9 May 2016 was the first time that storms impacted the backshores in any significant manner.

Field River

Photographs and videos of the storm are only available for the Field River area that show waves impacting the base of banks and the dunes (example, Figure a). Water in Field River was also elevated (Figure b). The sand dune at Field River, which began receding in the 1990s suffered further erosion (Figure c).

Figure a. Photograph taken at 17.20, 9 May 2016 by Bill and Glenys Summersides, residents on The Esplanade at Marino (used with permission).

Figure b. Elevated water in Field River, but not with rainwater. (Photo: Bill and Glenys Summersides, residents on The Esplanade at Marino, used with permission).

Figures c. Field River dune suffered its first major erosion event (Photograph: unknown, 14 May 2016)

<u>Comparison of Port Stanvac and Outer Harbor tidal data</u>

A comparison of all monthly high tides showed Port Stanvac was on average 87% lower than Outer Harbor. A comparison of monthly high tides (April to September) revealed that Port Stanvac was 90% lower. A comparison of storm events demonstrated a congruence at 90%:

- 3 July 2007 (2.07 PS, 90% of 2.27OH is 2.04m)
- 25 April 2009 (1.95 PS, 90% of 2.22m is 2.00m)

Therefore, 9 May 2016 was likely to have been in vicinity of 2.12 at Port Stanvac and is adopted for this event.

5.1 Coastal exposure – previous storm impact

HISTORICAL STORMS (CONT)

Hallett Cove Beach

No photographs exist of the storm within Hallett Cove Beach, but photographs were taken of the damage to the backshores. There were three areas of damage to the slope below Heron Reserve:

1. Adjacent the vehicular down ramp (Figure a)
2. Adjacent the pedestrian down ramp (Figure b).
3. At the headland between Hallett Cove Beach and the Field River area (not pictured).

All three areas were repaired by importing clay, remaking the slope, covering with geotextile matting and revegetating (Figures c, d).

<u>History revealed</u>

The scars in the embankment reveal some of the history of Hallett Cove Beach. The former dune can be seen under the earth that was imported when Heron Reserve was formed (Figure a). The imported fill and buried debris were revealed in the area adjacent the pedestrian ramp (Figure b). See also photograph from 1975 in the Settlement History that shows how Hallett Cove Beach backshore was formed. The key point here is that a flexible dune system was removed that probably provided some sediment to the beach.

Figure a. The slope under Heron Reserve was scarped in the storm (Photograph, City of Marion, 14 June 2016).

Figure b. The slope under Heron Reserve was scarped in the storm (Photograph, City of Marion, 14 June 2016).

Figure c. The same location as Figure (a) taken in September 2022 (Integrated Coasts, drone video, 17 September 2022.

Figure d. The same location as Figure (b) taken in September 2022 (Integrated Coasts, drone video, 17 September 2022.

5.2 Coastal exposure – location map (Cell 3.1)

Location

Cell 3.1

Hallett Cove Beach

Location Map

Conservation Park (North)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:
Low

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Viewing instruction:
View the coastal exposure section utilising full screen mode within your PDF software (Control L). Then use arrow keys to navigate.

5.2 Coastal exposure – routine high water (2020)

Routine high water

Cell 3.1

Hallett Cove Beach

2020 scenario

Event: Routine high water

Conservation Park (North)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling of wave runup appears to be higher than observations by approximately 2m.

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5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.1

Hallett Cove Beach

2050 scenario

Event: Routine high water

Conservation Park (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine monthly tide	1.60m AHD
Sea level rise	0.30m
Wave setup	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Routine actions of the sea at 0.30m higher than present can be expected to erode the base of the dunes (measured in metres).

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5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.1

Hallett Cove Beach

2100 scenario

Event: Routine high water

Conservation Park (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

<u>The event modelled:</u>

Routine highwater	1.60m AHD
Sea level rise	1.00m
Wave setup	<u>0.30m</u>
Total risk	2.90m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Actions of the sea at 1.00m higher than present can be expected to cause significant recession (measured in decametres, perhaps 2).

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5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.1

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Conservation Park (North)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would have similar impact as storm event 9th May 2016. As a rare event, the dunes would most likely recover.

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5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.1

Hallett Cove Beach

2050 scenario

Event: 1 in 100 sea-flood risk

Conservation Park (North)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave setup	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would be significant on the dunes. Combined with higher routine events, the dunes would recede (measured in metres).

D. Lord, 2012, estimated 10m recession by 2050 but as yet, rates of sea level rise have not escalated.

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5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.1

Hallett Cove Beach

2100 scenario

Event: 1 in 100-year event

Conservation Park (North)

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

Storm surge	2.30m AHD.
Sea level rise	1.00m
Wave setup	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would be significant on the dunes. Combined with higher routine events, the dunes would recede (measured in metres).

D. Lord, 2012, estimated 25m recession by 2100.

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5.2 Coastal exposure – summary (Cell 3.1)

Summary

Cell 3.1

Hallett Cove Beach

Summary

Conservation Park (North)

2020-2050

Current impact of routine actions of the sea are low on the dunes. Sea levels 0.3m higher than present can be expected to recede the dunes by several metres (D. Lord, 2012) estimated 10 m.

2050-2100

If sea levels rise as projected, in the latter half of the century the combination of storm events and routine highwater at 1m higher would cause significant recession of the dunes, measured in decametres.
D. Lord, 2012, estimated 25m by 2100.

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5.2 Coastal exposure – location map (Cell 3.2)

Location

Cell 3.2

Hallett Cove Beach

Location Map

Conservation Park (South)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:
Low

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5.2 Coastal exposure – routine high water (2020)

Routine high water

Cell 3.2

Hallett Cove Beach

2020 scenario

Event: Routine high water

Conservation Park (South)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling appears to be congruent with observations of routine highwater events.

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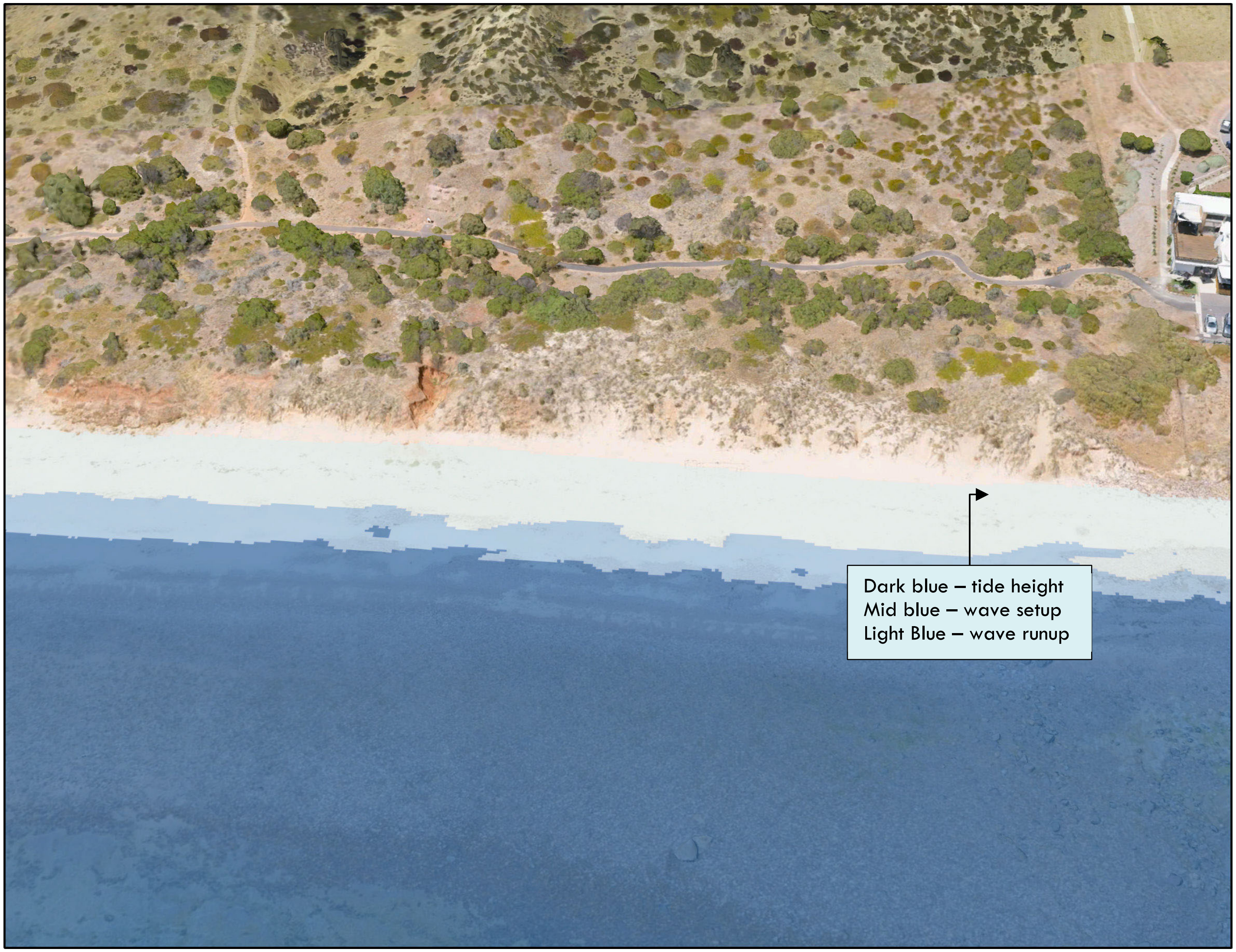

5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.2

Hallett Cove Beach

2050 scenario

Event: Routine high water

Conservation Park (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:	
Routine highwater	1.60m AHD
Sea level rise	0.30m
Wave set-up	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Actions of the sea at 0.30m higher than present can be expected to erode the base of the dunes (measured in metres).

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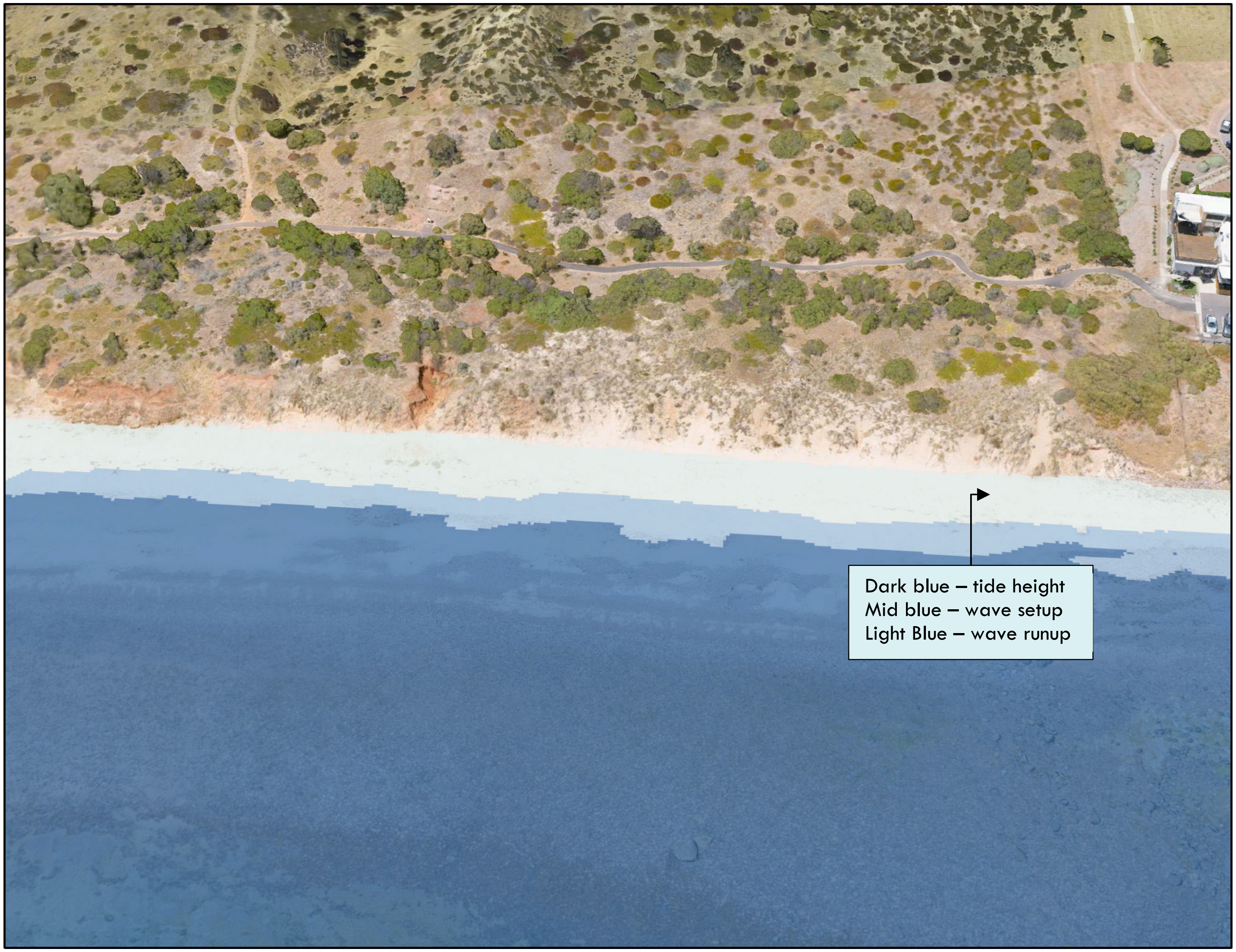

5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.2

Hallett Cove Beach

2100 risk:

Event: Routine high water

Conservation Park (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	1.00m
Wave set-up	0.30m
Total risk	2.90m

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: Actions of the sea at 1.00m higher than present can be expected to cause significant recession (measured in decametres, perhaps 2).

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5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.2

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Conservation Park (South)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would have similar impact as storm event 9th May 2016. As a rare event, the dunes would most likely recover.

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5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.2

Hallett Cove Beach

2050 scenario

Event: 1 in 100 sea-flood risk

Conservation Park (South)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave set-up	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would be significant on the dunes. Combined with higher routine events, the dunes would recede (measured in metres).

D. Lord, 2012, estimated 10m recession by 2050 but as yet, rates of sea level rise have not escalated.

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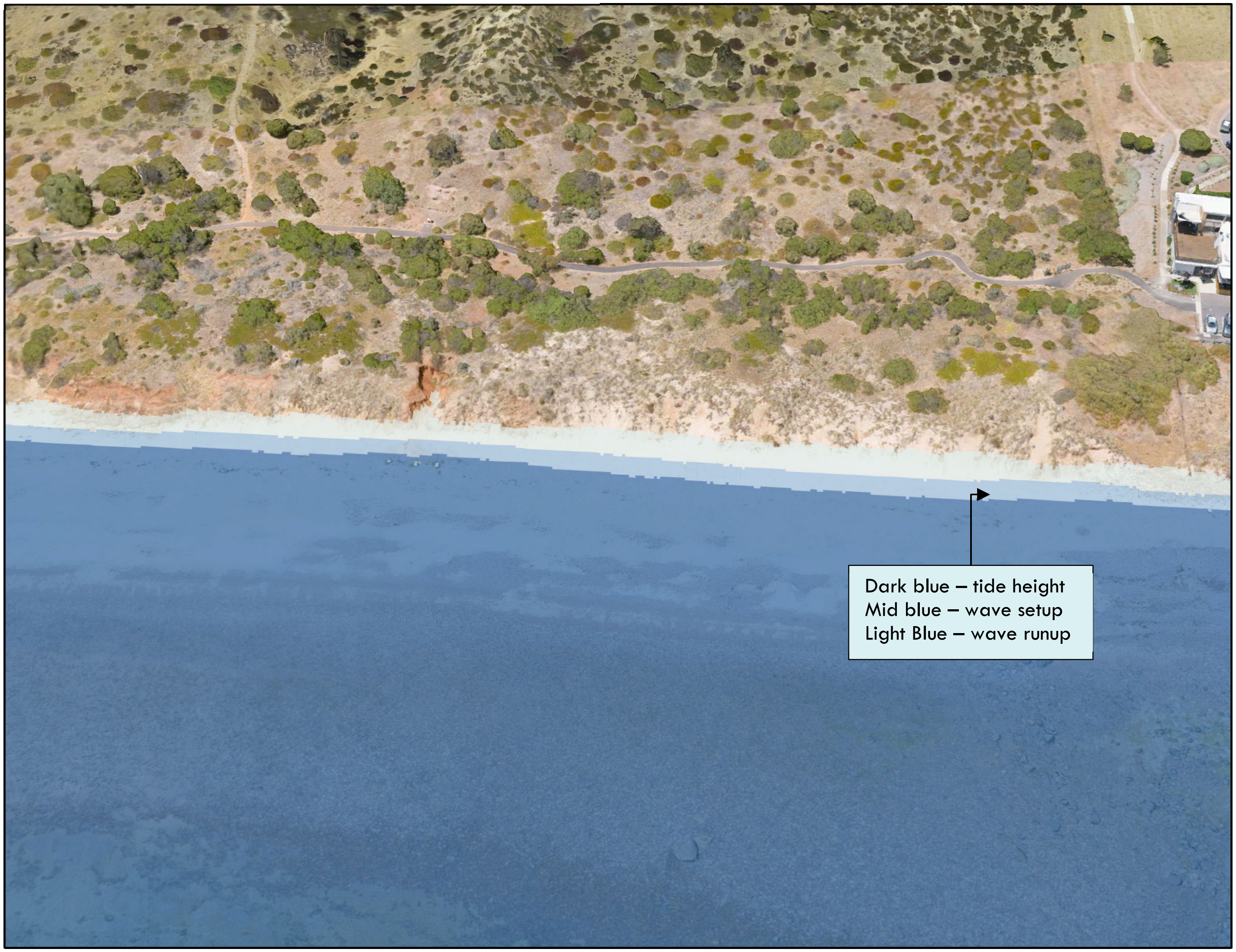

5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.2

Hallett Cove Beach

2100 scenario

Event: 1 in 100-year event

Conservation Park (South)

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

Storm surge	2.30m AHD.
Sea level rise	1.00m
Wave set-up	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would be significant on the dunes. Combined with higher routine events, the dunes would recede (measured in metres).

D. Lord, 2012, estimated 25m recession by 2100.

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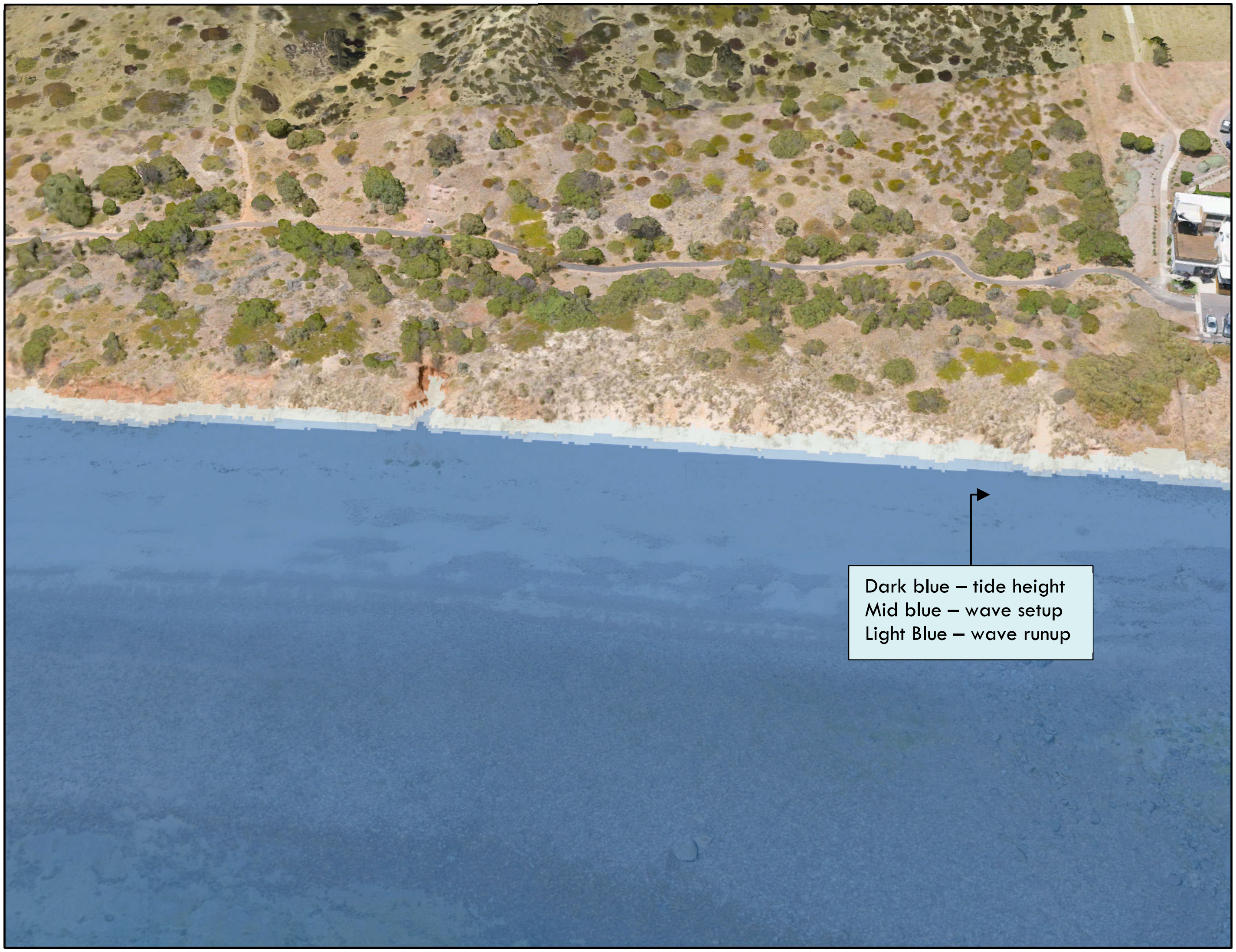

5.2 Coastal exposure – summary (Cell 3.2)

Summary

Cell 3.2

Hallett Cove Beach

Summary

Conservation Park (South)

2020-2050

Current impact of routine actions of the sea are low on the dunes. Sea levels 0.3m higher than present can be expected to recede the dunes by several metres (D. Lord, 2012) estimated 10 m.

2050-2100

If sea levels rise as projected, in the latter half of the century the combination of storm events and routine highwater at 1m higher would cause significant recession of the dunes, measured in decametres.
D. Lord, 2012, estimated 25m by 2100.

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5.2 Coastal exposure – location map (Cell 3.3)

Location

Cell 3.3

Hallett Cove Beach

Location Map

Heron Way Reserve (North)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:

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5.2 Current exposure – routine high water (2020)

Routine high water

Cell 3.3

Hallett Cove Beach

2020 scenario

Event: Routine high water

Heron Way Reserve (North)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment: The modelling of wave runup may be 1-2m higher than observations of routine highwater events.

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5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.3

Hallett Cove Beach

2050 scenario

Event: Routine high water

Heron Way Reserve (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	0.30m
Wave set-up	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Routine highwater events at 0.30m higher than present would likely scour and scarp the base of the embankment on a regular basis.

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5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.3

Hallett Cove Beach

2100 scenario

Event: Routine high water

Heron Way Reserve (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	1.00m
Wave set-up	0.30m
Total risk	2.90m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Routine high-water events at 1.00m higher than present would cause significant recession and collapse of the embankment.

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5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.3

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (North)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Assessment:
The impact of this storm event would have a similar impact as storm event 9th May 2016 and therefore some scouring and collapse of the embankment would be expected.

See storm analysis above for examples of damage to the embankment.

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5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.3

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (North)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave set-up	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Combined with routine highwater events at 0.30m higher than present, the base of the embankment can be expected to be scarped and some collapsing occur.

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5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.3

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (North)

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

Storm surge	2.30m AHD.
Sea level rise	1.00m
Wave set-up	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.20m and depicted in light blue.

Combined with routine highwater events at 1.00m higher than present, the base of the embankment would recede and the slope become more vertical, and collapsing of the bank would occur.

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5.2 Coastal exposure – summary (Cell 3.3)

Summary

Cell 3.3

Hallett Cove Beach

Summary

Heron Way Reserve (North)

2020-2050

Large storm events (perhaps 1 in 20-year events) are likely to scour the base of the embankment. Increases in sea levels by 0.30 will result in more frequent scouring and collapses.

2050-2100

If sea levels rise as projected, the base of the embankment will recede, the slope become more vertical and the eventual collapse of the embankment.

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5.2 Coastal exposure – location map (Cell 3.4)

Location

Cell 3.4

Hallett Cove Beach

Location Map

Heron Way Reserve (South)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:
Low

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5.2 Coastal exposure – routine high water (2020)

Routine high water

Cell 3.4

Hallett Cove Beach

2020 scenario

Event: Routine high water

Heron Way Reserve (South)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.4

Hallett Cove Beach

2050 scenario

Event: Routine high water

Heron Way Reserve (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Sea level rise	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

The modelling suggests that impacts on the backshore from this event would be low.

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5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.4

Hallett Cove Beach

2100 scenario

Event: Routine high water

Heron Way Reserve (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Sea level rise	1.00m
Total risk	2.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Routine highwater events at 1m higher than present would cause significant undercutting of the embankment resulting in collapses.

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5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.4

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (South)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
The impact of this storm event would have similar impact as storm event 9th May 2016. There were no impacts on the embankment from that event.

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5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.4

Hallett Cove Beach

2050 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (South)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave setup	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
The impact of this storm event, combined with routine highwater events at 0.30m higher would have significant impact on the base of the embankment causing scouring and some collapses.

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5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.4

Hallett Cove Beach

2100 scenario

Event: 1 in 100 sea-flood risk

Heron Way Reserve (South)

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

Storm surge	2.30m AHD
Sea level rise	1.00m
Wave setup	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
Combined with routine highwater events at 1.00m higher than present, the base of the embankment would recede and the slope become more vertical, and collapsing of the bank would occur.

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5.2 Coastal exposure – summary (Cell 3.4)

Summary

Cell 3.4

Hallett Cove Beach

Summary

Heron Way Reserve (South)

2020-2050

This section of the embankment is more sheltered than others due its oblique profile. Impacts would be less, but some scouring and collapses could be expected with sea levels 0.30 higher than present.

2050-2100

If sea levels rise as projected, then routine high-water events combined with storm events will cause significant recession of the escarpment. The slope would steepen and the bank eventually collapse.

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5.2 Coastal exposure – location map (Cell 3.5)

Location

Cell 3.5

Hallett Cove Beach

Location Map

Field River (North)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:
Low

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5.2 Coastal exposure – routine high water (2020)

Routine high water

Cell 3.5

Hallett Cove Beach

2020 scenario

Event: Routine high water

Field River (North)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.5

Hallett Cove Beach

2050 scenario

Event: Routine high water

Field River (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	0.30m
Wave set-up	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Routine highwater events 0.30m higher than present appear to have limited impact on backshores.

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5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.5

Hallett Cove Beach

2100 scenario

Event: Routine high water

Field River (North)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

<u>The event modelled:</u>

Routine highwater	1.60m AHD
Sea level rise	1.00m
Wave set-up	0.30m
Total risk	2.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Routine highwater events 1.00m higher than present would cause significant recession of the dunes (perhaps 10m).

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5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.5
Hallett Cove Beach
2020 scenario
Event: 1 in 100 sea-flood risk

Field River (North)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
The impact of this storm event would have a similar impact as storm event 9th May 2016 which scoured the base of the dunes and embankments in a minor way. The Field River dune could be expected to erode further.

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5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.5

Hallett Cove Beach

2050 scenario

Event: 1 in 100 sea-flood risk

Field River (North)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave set-up	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
Combined with routine high-water events at 0.30m higher than present recession of the dune is likely to occur (but noting that routine highwater events have lesser impact in this section of coast).

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5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.5

Hallett Cove Beach

2100 scenario

Event: 1 in 100 sea-flood risk

Field River (North)

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

Storm surge	2.30m AHD.
Sea level rise	1.00m
Wave set-up	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue.

Assessment:
Combined with routine high-water events at 1.00m recession of the dune is likely to occur (perhaps 10m to 15m).

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5.2 Coastal exposure – summary (Cell 3.5)

Summary

Cell 3.5

Hallett Cove Beach

Summary

Field River (North)

2020-2050

Current routine events do not impact the backshores apart from the Field River dune. Increases in sea level by up to 0.30 would see increased impact to the dunes and some recession (measured in metres).

2050-2100

If sea levels rise as projected, then routine high-water events combined with storm events will cause significant recession of the dunes and the Field River dune (perhaps 10m to 15m).

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5.2 Coastal exposure – location map (Cell 3.6)

Location

Cell 3.6

Hallett Cove Beach

Location Map

Field River (South)

The scenarios modelled are:

- Routine tidal action is likely to have greater impact on the backshore over time. Routine high-water events are expected to occur a few times per month from April to September.
- 1 in 100-year ARI storm surge event (CPB)

The timing of the scenarios:

- Current
- 2050
- 2100

Nature Maps (SA) assigns:

Relative exposure:
Moderate

Wave energy:
Low

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5.2 Coastal exposure – routine high water (2020)

Routine high water

Cell 3.6

Hallett Cove Beach

2020 scenario

Event: Routine high water

Field River (South)

Routine high-water events are expected to occur a few times per month from April to September.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Wave set-up	0.30m
Total risk	1.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Assessment: The modelling is congruent with observations and the current impact on beach and backshore is low.

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5.2 Coastal exposure – routine high water (2050)

Routine high water

Cell 3.6

Hallett Cove Beach

2050 scenario

Event: Routine high water

Field River (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	0.30m
Wave set-up	0.30m
Total risk	2.20m AHD

Wave run-up is an additional 0.80m and depicted in light blue

Routine highwater events 0.30m higher than present would have significant impact on the dune (with recession measured in metres).

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5.2 Coastal exposure – routine high water (2100)

Routine high water

Cell 3.6

Hallett Cove Beach

2100 scenario

Event: Routine high water

Field River (South)

Sea level rise will increase the frequency of routine interactions between the sea and coastal fabric so that the impact on backshore will become greater over time.

Inputs are based on analysis on data from Outer Harbor and analysis of five storms (2021, 2022).

The event modelled:

Routine highwater	1.60m AHD
Sea level rise	1.00m
Wave set-up	0.30m
Total risk	2.90m AHD

Wave run-up is an additional 0.80m and depicted in light blue.

Routine highwater events 1.00m higher than present would likely erode the dune completely, and under cut the embankments.

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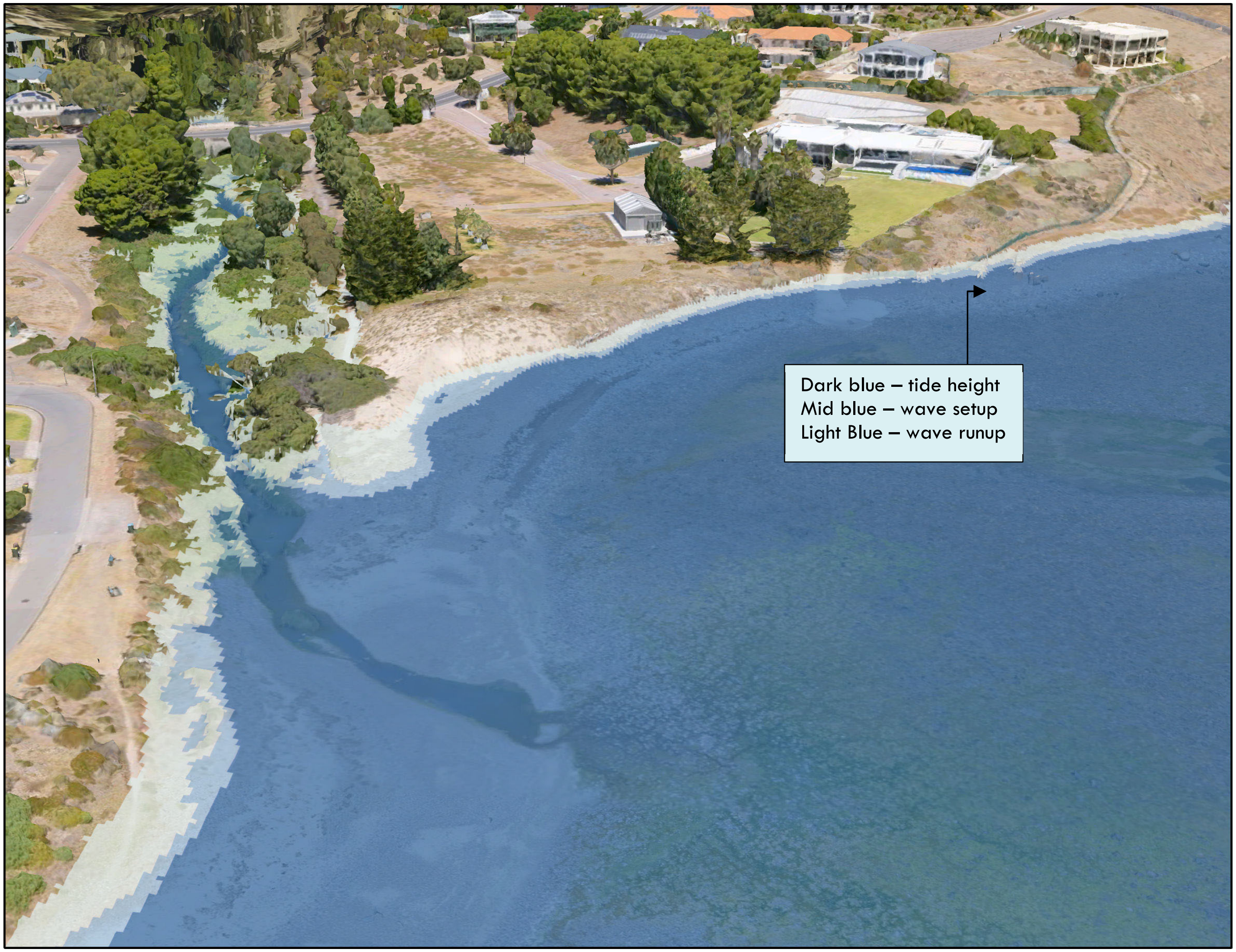

5.2 Coastal exposure – storm surge (2020)

Storm surge

Cell 3.6

Hallett Cove Beach

2020 scenario

Event: 1 in 100 sea-flood risk

Field River (South)

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

Storm surge	2.30m AHD.
Wave set-up	0.40m
Risk	2.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue

Assessment:
The impact of this storm event would have a similar impact as storm event 9th May 2016 which scoured the base of the embankments along River Parade and caused recession in the dune.

The walking trail would be significantly overtopped.

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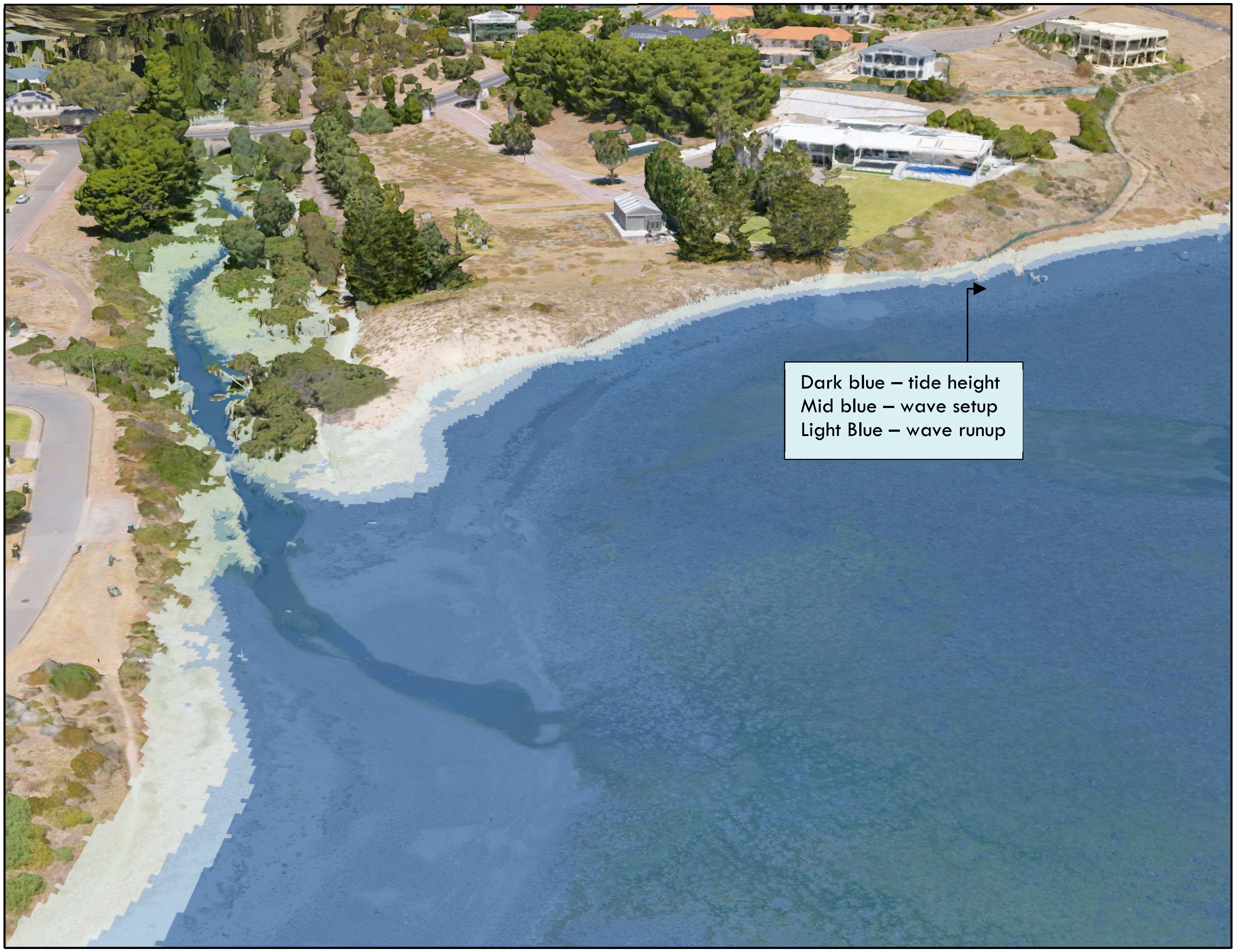

5.2 Coastal exposure – storm surge (2050)

Storm surge

Cell 3.6

Hallett Cove Beach

2050 scenario

Event: 1 in 100 sea-flood risk

Field River (South)

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

Storm surge	2.30m AHD.
Sea level rise	0.30m
Wave set-up	0.40m
Risk	3.00m AHD

Wave run-up is an additional 1.00m and depicted in light blue

Assessment:
Combined with routine highwater events 0.30m higher than present would cause significant recession of the dune and undercutting of the embankments along River Parade.

The banks of Field River appear to overtop (but this may not occur as the modelling includes wave runup).
The walking trail would be significantly overtopped.

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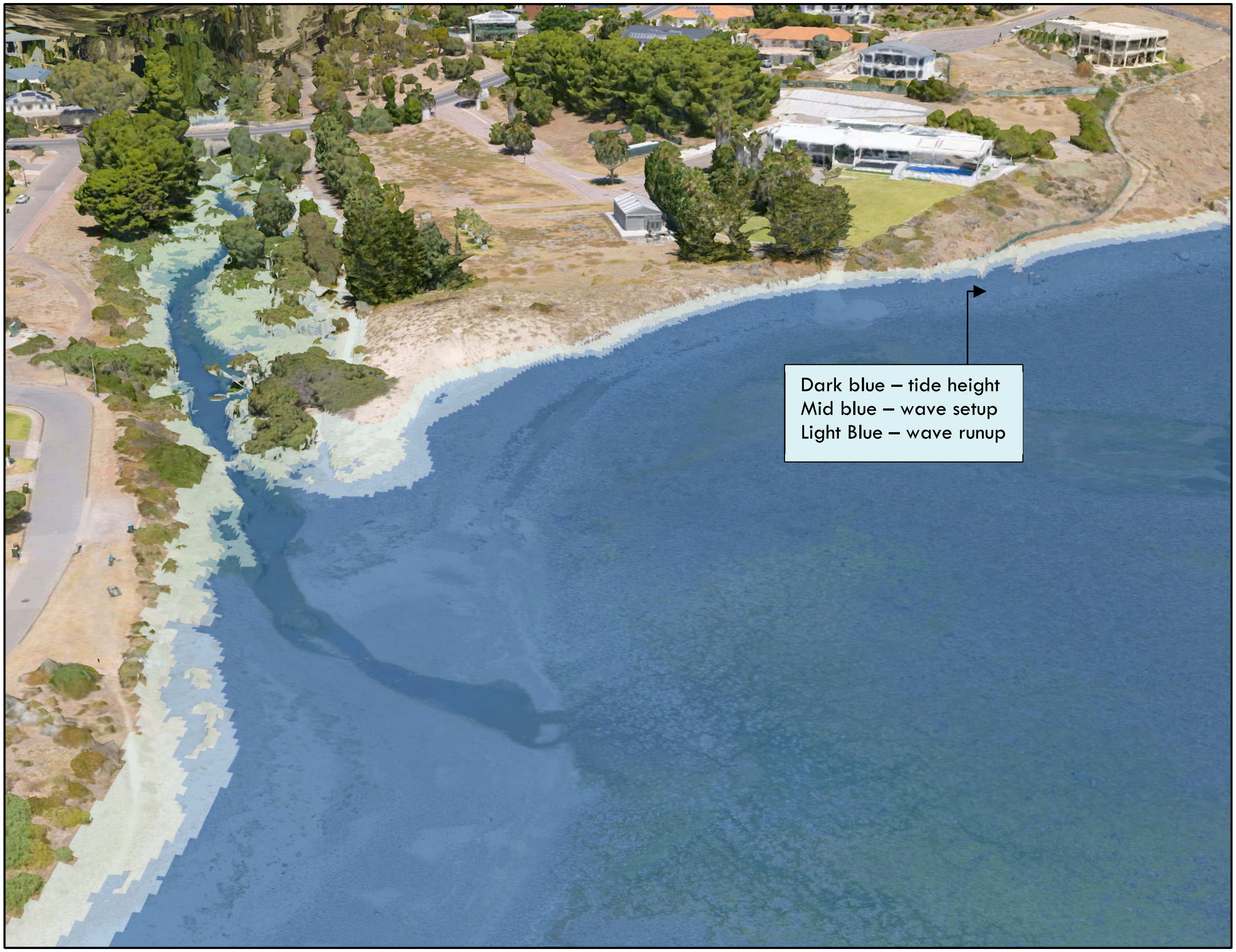

5.2 Coastal exposure – storm surge (2100)

Storm surge

Cell 3.6

Hallett Cove Beach

2100 scenario

Event: 1 in 100 sea-flood risk

Field River (South)

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

Storm surge	2.30m AHD.
Sea level rise	1.00m
Wave set-up	0.40m
Risk	3.70m AHD

Wave run-up is an additional 1.00m and depicted in light blue

Assessment:
Combined with routine highwater events 1.00m higher than present would likely remove the dune and undercut/ collapse embankments along River Parade.

The event would be contained within Field River basin (but with overtopping of the banks).

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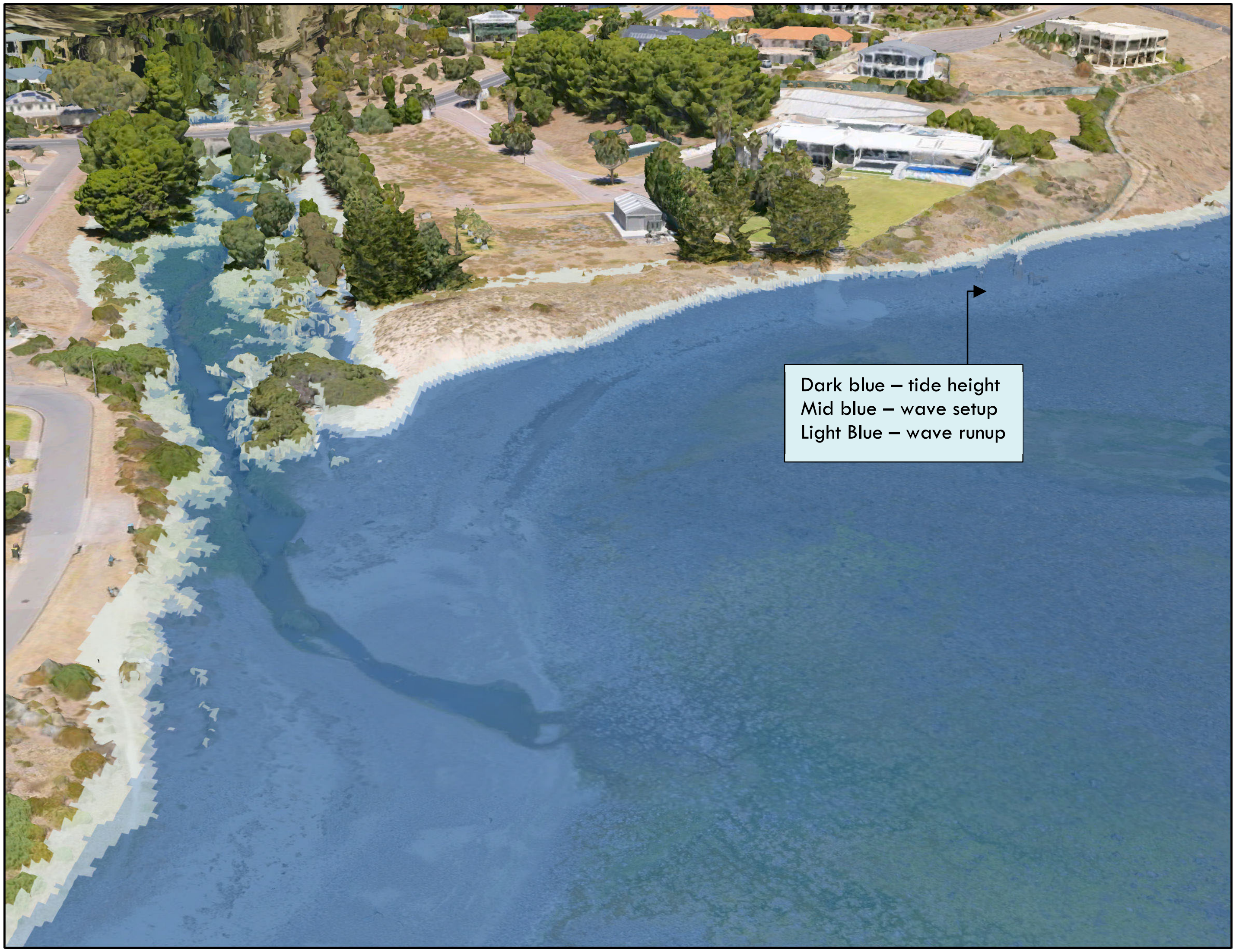

5.2 Coastal exposure – summary (Cell 3.6)

Summary

Cell 3.6

Hallett Cove Beach

Summary

Field River (South)

2020-2050

Routine highwater events have an impact on the base of the dune but is limited elsewhere. Events 0.30m higher than present would cause significant recession of the dune and undercutting of the embankments. The current 1 in 100-year event is likely to overtop the walking trail.

2050-2100

If sea levels rise as projected, then routine high-water events combined with storm events will cause significant recession of the dune (perhaps removing it), and the embankments along River Parade would be undercut/ collapsed. The walking trail would be continually overtopped.

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COASTAL EXPOSURE – Summary table

Hallett Cove Beach (Cell 3)

Hallett Cove Beach		Coastal context - natural				Modified	Exposure*	Scenario Modelling	
Cell	Location	Bathymetry	Benthic	Beach	Backshore	Human	Waves	2020 - 2050	2050-2100
3.1-2	Conservation Park	Slope at 1:100. Sea floor becomes steeper towards Black Point 1:50.	Low profile reef, seagrass bed and sand patch near Black Point.	Rock and shingle beach covered with thin layer of sand.	5m high vegetated dunes overlaying clay. Sloping backshore.	Walking trail and signage.	Moderate exposure Low wave energy	Current impact of routine actions is low. Sea levels 0.3m higher than present can be expected to recede the dunes by several metres.	Sea levels 1.00m higher than present would cause significant recession of the dunes, measured in decametres (2). D. Lord (2012) estimated 25m.
3.3-4	Heron Reserve	Slope 1:100 (-4m at 400m offshore).	Low profile reef and seagrass beds.	Rock and shingle beach covered with thin layer of sand.	Manmade earthen embankment, steeply sloping backshore.	Dunes removed; earthen embankment installed. Rock protection adjacent onramp.	Moderate exposure Low wave energy	Very large events impact the embankment. Sea levels 0.30 than present can be expected to undercut the base of the embankment.	Actions of the sea 1.00m higher than present would cause the embankment to recede, the slope become steeper, finally, collapse.
3.5-6	Field River	Slope 1:70 (-4m at 250m offshore).	Low profile reef to 100mthen medium seagrass bed	Shingles and pebbles, minimal sand.	Embankment next to road. Landward is steeply sloping backshore.	Rocks removed from ocean floor (1880s?), rock revetment installed on southern dune.	Moderate exposure Low wave energy	Current impacts are low (dune excepted). Sea levels 0.30m higher than present will cause significant recession of the dune, erode banks.	Actions of the sea 1.00m higher than present would like remove the dune, undercut/collapse embankments along River Parade.

***Exposure Rating:** assigned by SA Nature Maps.

Hallett Cove and Field River – Key Points

Hallett Cove Beach. Current impacts are low. Seas 0.30 higher than present will cause some recession of the dunes (measured in metres). Seas 1.00m higher, significant recession (20m). **Heron Reserve.** Very large storm events impact the base of the embankment. Seas 0.30m higher than present will scour/ scarp the base regularly. Seas 1.00m higher than present will cause collapse of the embankment. **Field River.** Current impact is low (apart from on the dune). Seas 0.30m higher than present will cause significant recession of the dune, undercutting of banks. The walking trail would be frequently overtopped. Seas 1.00m higher than present will cause significant recession of dunes (10 to 15m).

6. Storm water runoff from urban settlement

6. Storm water runoff from urban settlement

Purpose of the study

The purpose of this study is to evaluate the impact of storm water that flows from urban areas to the coast. Large volumes of rainwater can quickly accumulate and flow from the impervious surfaces of urban settlements. Storm water flowing over softer embankments can cause gullying and instability and scouring of dunes and beaches. Over time cliffs, embankments and dunes break down and sand levels are likely to drop on the beach. In the context of sea level rise, the locations where storm water is impacting beaches and backshores may be locations where incursions of seawater occur first. Finally, in some locations the potential exists for a confluence of events where storm water and sea storms combine and produce greater levels of flooding.

Four questions are assessed in this project:

(1) Does Council manage storm water from urban settlement so that it does not flow uncontrolled over backshores and beaches?

(2) What impact is occurring on the backshores and beach due to storm water runoff?

(3) Is there any potential for increased flooding due to confluence of rain events with sea storm events?

(4) Do any storm water outlets require review[12]?

Methodology

A drone was utilised to capture photography of the City of Marion coastline after rain events to check for scouring of backshores and beaches, or debris deposits on beaches. Two captures were achieved, one in 2021 and one in 2022.

Storm water monitoring (2021)

In the last two weeks of July, rain fell on 11 out of 14 days. The rain fall for July was ~50% above the 20-year mean. Specifically, 14mm of rain fell on 31st July. No evidence of scouring or slides within cliff escarpments, nor sediment transfer to the beach was observed apart from some moderate mud staining on the beach at Hallett Cove from storm water runoff from the Conservation Park[13].

Storm water monitoring (2022)

Significant rain events occurred in early June 2022, but these have not been evaluated at the time of writing this report[14]. For example, 52mm rain fell on 5 June 2022 and 15.4mm on 6th June (Happy Valley gauge). The drone photographic capture of the whole coast was undertaken on 9th June 2022. The findings were similar to those of 2021 (see above).

Storm water outlet review

On 9 and 10 June 2022 (after significant rain events), every storm water outlet that could be located was reviewed, photographed, and assessed within the GIS environment. In particular, the following items were catalogued and assessed:

1. Location of outlet (e.g. top of cliff)
2. Outlet type (e.g. 300mm pipe)
3. End control (e.g. Headwall)
4. Condition of infrastructure
5. Vegetation cover (e.g. overgrown)
6. Nature of backshore (e.g. cliff, embankment)
7. Nature of beach (e.g. rocky, sandy)
8. Impact on backshore (e.g. scouring, gullying)
9. Impact on beach (e.g. scouring, gullying)
10. Comments and recommendations.

Outputs from the study

Two main outputs are generated from this study:

- A digital file (GIS) with locations, photographs, and an attribute table for each of the storm water outlets.
- This report which provides a summary of the findings on the following pages.

[12] In this cell, Question 4 was not relevant due to the elevated nature of backshores.

[13] See Cells 1-4, Coastal Monitoring program for City of Marion, year 2021.

[14] See Cells 1-4, Coastal Monitoring Program for City of Marion, year 2022 (not completed at date of writing).

6. Storm water runoff from urban settlement

Previous studies and plans

Hallett Cove Creeks Storm Water Management Plan, Southfront, 2012.

Overview of the study

The Hallett Cove Creeks Stormwater Management Plan (2012) produced by Southfront is a thorough investigation of the current storm water system for three catchment areas located in Cell 2 and 3, and a suggested improved management strategy.

The report concluded that stormwater infrastructure was assessed as meeting performance standards in line with current day expectations (with a few exceptions). The study used a 1 in 10 ARI rainfall event which it considers the standard to use in evaluating the effectiveness of stormwater infrastructure capacity. Coincidently, such an event did occur within the study period and the effectiveness of the system was evaluated in that context.

The key issues flagged for improvement were:

- Erosion of Waterfall Creek channel, along most of its length,
- Lack of stormwater quality improvement measures,
- Lack of stormwater harvesting and reuse.

Coastal Outlets

The report lists numerous recommended upgrades and strategies, but none of these appear to relate to ocean outfalls (apart for GPT at Heron Reserve). However, the study did review coastal outlets and concluded the following.

While the significant majority of the study area is drained to water courses or gullies that ultimately discharge into the Gulf, there are a number of underground stormwater drainage systems that also discharge directly to the Gulf…. There had previously been concern regarding the erosion of cliffs and beaches due to many of these outfalls discharging well above beach level, with little or no erosion control, or pollutant interception measures in place. AWE reviewed these outfalls in 2005 and developed concept designs to address the issues identified. Six outfalls were identified in the study area (Cell 2 and 3) and summarised in the table on this page.

It is understood that some of these upgrades have been completed (e.g. Grand Central Ave) but this has not been reviewed as part of this project.

In the context of coastal adaptation

In some coastal locations there is the potential for a confluence of a rain event with a sea storm event which may increase the likelihood of flooding of urban settlement. However, in the City of Marion coastal area which is predominantly cliff area, storm water is usually discharged well above high water levels of the ocean. However, as noted in the Southfront report, the issue within City of Marion relates to potential erosion of backshores (cliffs and slopes) and the containment of pollution and debris in the storm water runoff.

Location	AWE Ref	AWE Recommendation	Status
Westcliff Ct	11	No work required	-
Nungamoora St	13	Install GPT	Outstanding
Peera St	14	No work required	-
Fryer Street	16	Install GPT	Outstanding
Clifftop Cr	18	Install rock-lined overflow swale	Completed (refer photo below)
Grand Central Ave	21	Install GPT	Outstanding

Table: 4.3 from Southfront Report

6. Storm water runoff from urban settlement

Storm water

Cell 3.1
Hallett Cove Beach
Storm Water
2022

Storm water outlet assessment Conservation Park (North)

1. Is storm water managed appropriately?

Storm water from the amphitheatre does drain through gullies to the beach. This area is under the control of Department of Environment and Water.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

Some gullying on backshores.

3. Outlets requiring review.

Department of Environment and Water notified about gullying.

Integrated Coasts
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www.integratedcoasts.com

6. Storm water runoff from urban settlement

Storm water

Cell 3.2
Hallett Cove Beach
Storm Water
2022

Storm water outlet assessment
Conservation Park (South)

1. Is storm water managed appropriately?

Storm water from the amphitheatre does drain through gullies to the beach. This area is under the control of Department of Environment and Water.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

Some gullying through the dunes (see inset photograph).

3. Outlets requiring review.
Nil.

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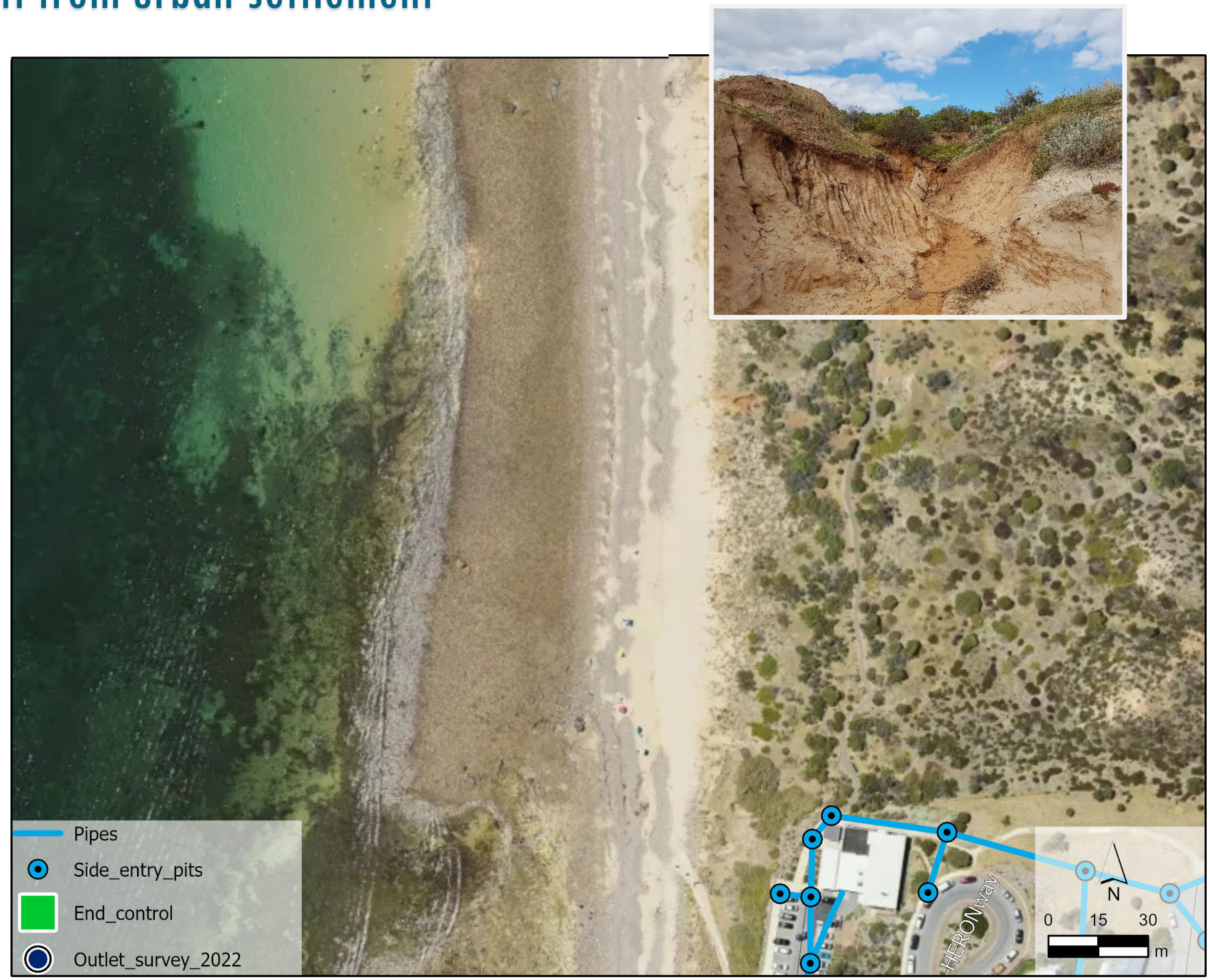

6. Storm water runoff from urban settlement

Storm water

Cell 3.3

Hallett Cove Beach

Storm Water

2022

Storm water outlet assessment
Heron Way Reserve (North)

1. Is storm water managed appropriately?

Stormwater is collected and piped into Cell 3.4.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

No runoff from urban environments are flowing to the beach.

3. Outlets requiring review.

Nil.

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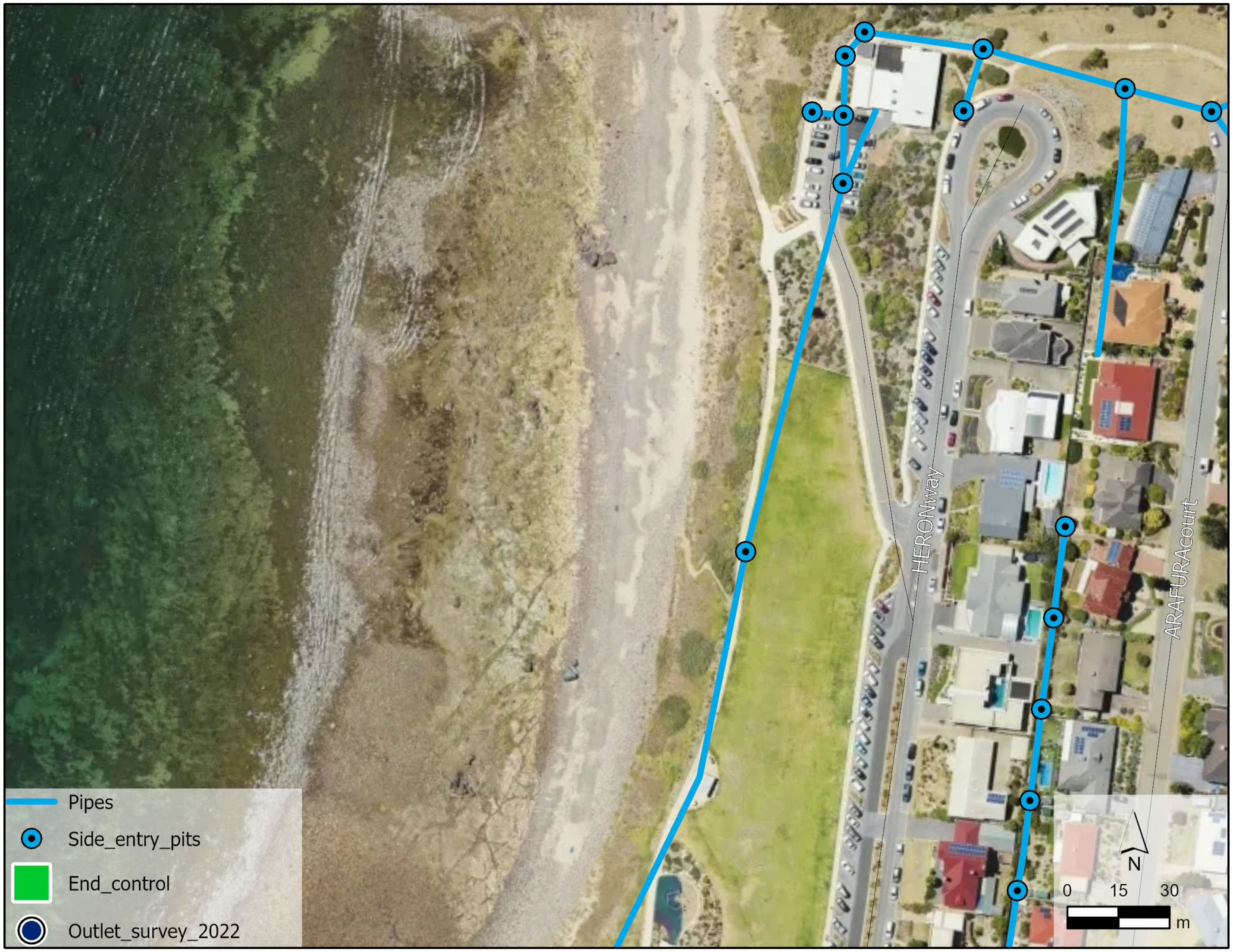

6. Storm water runoff from urban settlement

Storm water

Cell 3.4

Hallett Cove Beach

Storm Water

Current design

Storm water outlet assessment
Heron Way Reserve (South)

1. Is storm water managed appropriately?

Storm water is collected and piped to the beach (3.1) and halfway down the embankment (3.2).

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

No impact observed on beach or backshores.

3. Outlets requiring review.
3.1 The concrete is undercut and requires fill.
3.2 Monitor to ensure that the embankment is not gullied.

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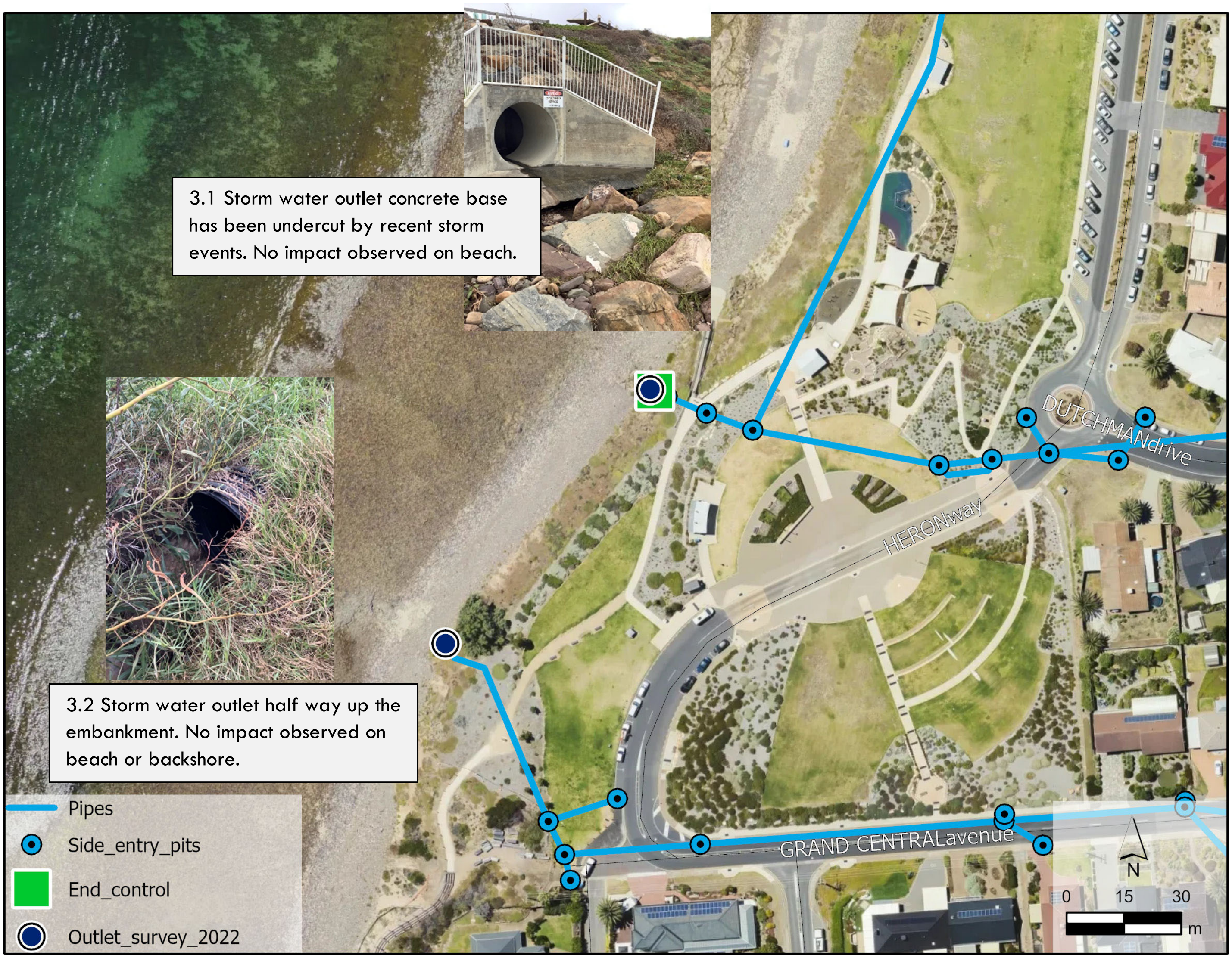

6. Storm water runoff from urban settlement

Storm water

Cell 3.5

Hallett Cove Beach

Storm Water

Current design

Storm water outlet assessment
Field River (North)

1. Is storm water managed appropriately?

No storm water outlets.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

No storm water outlets.

3. Outlets requiring review.

Nil.

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www.integratedcoasts.com

6. Storm water runoff from urban settlement

Storm water

Cell 3.6

Hallett Cove Beach

Storm Water

Current design

Storm water outlet assessment
Field River (South)

1. Is storm water managed appropriately?

Storm water River Parade drain into Field River or to the beach.

2. What impact is occurring on the backshores and beach due to storm water runoff (if any)?

We were unable to locate outlets in this area due to vegetation.

3. Outlets requiring review.

Recommend that outlets be located and surveyed to ensure confluence of events is unlikely to occur.

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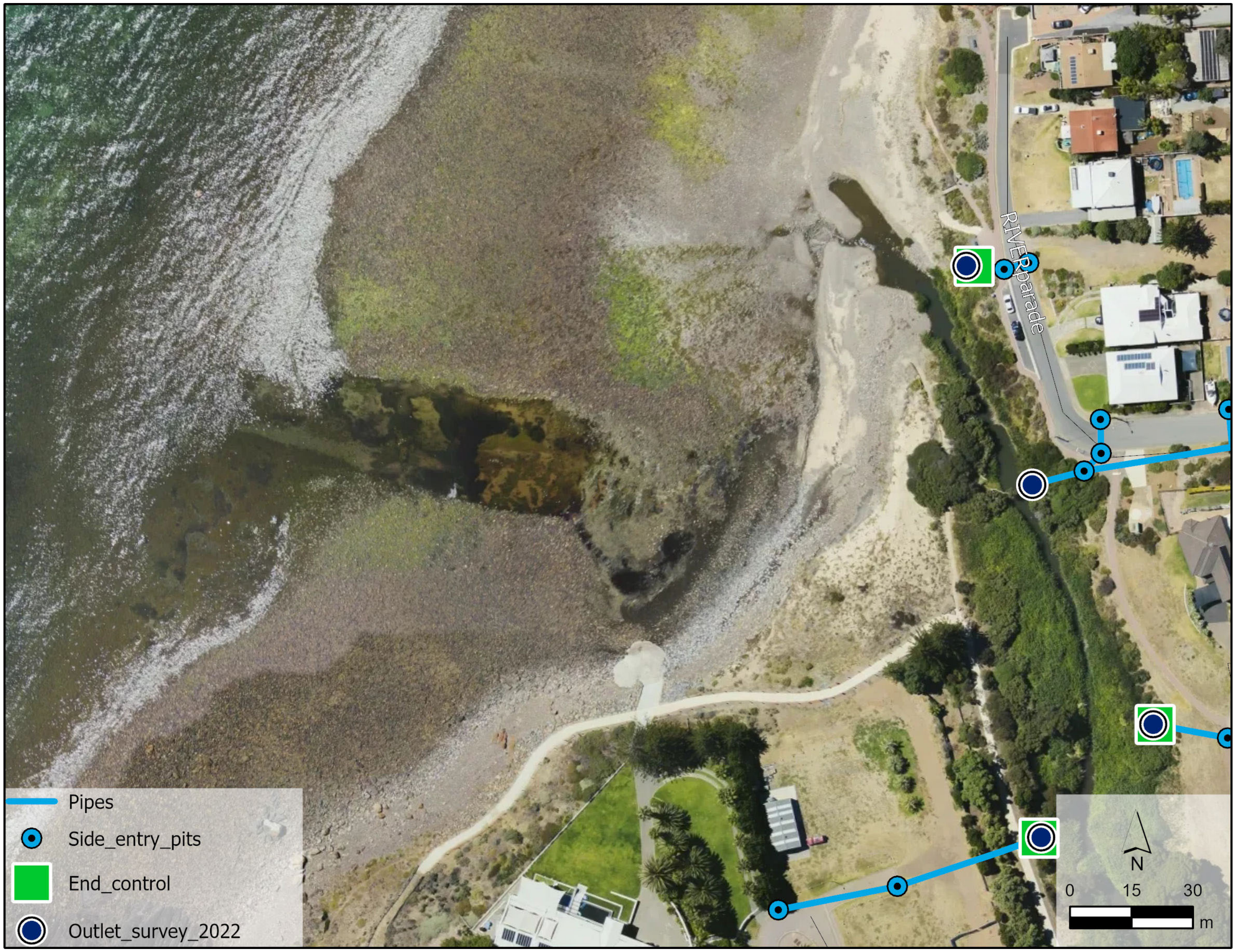


6. Storm water runoff from urban settlement

Summary of findings[15]:

1. Does Council manage the flow of storm water from urban settlement so that it does not flow uncontrolled over coastal backshores and dunes?

In a location such as Hallett Cove and Field River it is inevitable that storm water will need to drain to the coast. Storm water has been effectively captured and piped to the outlet on the beach at Grand Central.

2. What impact is occurring on the beach or backshore due to storm water runoff?

No impacts were observed on beaches or backshores. Inspected after significant rain events in June 2022.

3. Do any storm water outlets require review?

3.1 Underneath the concrete base has been eroded away in recent storm events. Suggest filling.

3.4, 3.5, 3.6 Outlets in Field River were not located due to vegetation. It is recommended that these outlets are surveyed for height to ensure that a confluence of storm water and seawater events can not occur. However, generally, storm water flows will overcome actions of the sea, especially in a steeper location such as Field River.

Figure (a) Outlet 3.1. Under the concrete base has been eroded away in recent storm events. Suggest fill.

[15] In some coastal locations whether a confluence of rain events and sea storm events could create potential for increased flooding would be considered. This cell is elevated above any risk of confluence of events.

7. HAZARD IMPACTS AND RISKS

The purpose of this section of work is to consider the inputs from the first part of the study and undertake an assessment of hazard impacts and risks within this cell. We undertake this in two steps:

1. Assign an inherent hazard rating,
2. Conduct a risk assessment utilising the risk framework of City of Marion.

7. Hazard impacts and risks

Methodology

South Australian Coast Protection Board considers three main coastal hazards: inundation, erosion, and sand drift. Only the first two are under consideration in this project as there are no assets at risk from sand drift. The assessment of hazard impacts and risks is undertaken in two main steps.

1. Assign an inherent hazard rating

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 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. A coastal fabric of granite is less at risk from erosion than a coast backed by sand dunes. In some locations the natural fabric of the coast has been altered by human intervention. For example, the Adelaide metropolitan beaches were once backed by sand dunes, but installation of rock revetment has changed the nature of the fabric to rock.

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. This assessment takes into consideration the following elements and has meaning (context) in relation to all South Australian coasts:

- The geological layout
- Sediment supply/ balance
- The erodibility of beach and backshores
- The historical analysis as to how the coastline has performed over time
- The exposure (set by Nature Maps)
- Whether any human intervention has altered the nature of the coastline.

The risk assignments range from 'low' to 'very high' and may include a 'no risk' category. For example, coastal land that is elevated above any inundation risk will be assigned 'no risk'. A dotted circle to the right of the main assignment indicates that the risk assignment requires intensifying due to unique factors, or to indicate a higher risk that does not qualify for an overall higher rating (Example, Figure a).

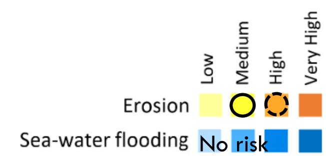


Figure a. Example of inherent risk output

7. Hazard impacts and risks

2. Conduct a risk assessment using the risk framework of City of Marion.

In this study we are primarily concerned with the way that coastal hazards may impact urban settlements over the coming century. How inundation and erosion impact human settlement will vary according to location. For example, at Hallett Cove Beach public assets are positioned in the immediate backshore, whereas at Field River some private assets directly adjoin the beach. Additionally, if seas rise as projected then seawater may flow further inland in low-lying areas and change the ecology. To evaluate public safety, how easily people may be able to retreat to a safe place is considered.

Direct risks

In summary, while the impact of sea level rise may be somewhat uniform on a coastal region, the impact will be felt differently in the context of human experience. To bring appropriate focus, hazard impacts are described within four main receiving environments:

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

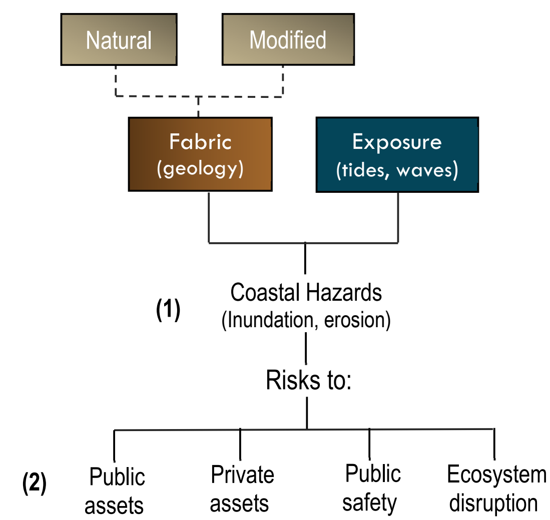
Note, the term ecosystem disruption is used to describe the situation where changes in a coastal region might bring about larger scale changes that may threaten to disrupt the entire ecological system, for example seawater flooding into freshwater ecologies.

Indirect risks

To provide focus and contain variables, this risk assessment is confined to direct impacts upon physical receiving environments. Indirect impacts may arise because of these direct impacts. For example, the loss of a beach in some coastal locations may cause indirect impacts – loss of tourism resulting in a declining economy, and may also diminish social well-being and community pride.

This assessment utilises the Council's risk assessment framework and 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. This is a long-term frame, but infrastructure such as houses and roads, have long lifespans.

The overall risk assessment strategy is summarised in the diagram below (Figure a).



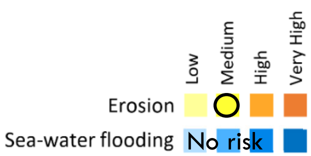
7-1 Inherent hazard risk assessment (SA)

Inherent risk assessment:

Inherent risk assessments are established using set criteria outlined above that apply to the whole State of South Australia[1].

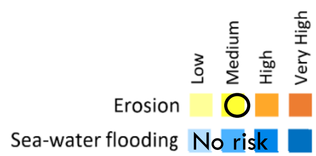
Conservation Park (Cell 3.1-2)

Sandy/ shingle beach with dunes to 5m AHD in backshore. Behind the dunes the height of the slope increases to above 8m AHD at 300m inland. Current impact from moderate storm events is low. Offshore is low profile reef interspersed with sand patches and seagrass.



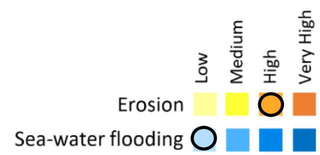
Heron Way Reserve (Cell 3.3-4)

Sandy/ shingle beach backed by sloping earthen escarpment. Above the escarpment the terrain slopes steeply up to Heron Way. Offshore is low profile reef interspersed with sand patches and seagrass.



Field River (Cell 3.5-6)

Predominantly shingle beach with minor sand covering. Dunes are situated either side of Field River. The dune on the south side continues to recede with moderate storm events. The Field River basin rises quite steeply and backshores on both sides of the rive rise to above 8m AHD at 300m inland.



[1] Worksheets that underpin the evaluation are available from Integrated Coasts.

7-2 Risk assessment using Council's risk framework

Risk assessment on receiving environments:

The following pages contain the risk assessments for Hallett Cove Beach and Field River:

- Conservation Park (Cell 3.1-2)
- Heron Way Reserve (Cell 3.3-4)
- Field River (Cell 3.5-6)

The risk assessment template draws on City of Marion risk framework, Policy RM-PRO-1.01 (v8.0) dated 25/02/2020.

Location: Conservation Park (3.1-2) — Erosion — **Risk assessment using Council's risk framework**

Coastal setting Conservation Park	Conservation Park. Low profile reef, seagrass bed and sand patches. Rock and shingle beach covered with a thin layer of sand backed by 5m high vegetated dunes overlying clay. Behind the dunes the land slopes upward into the amphitheatre. Shoreline undergoes cycles of erosion and accretion over decades. Since 1979, sections of the coast undergone net recession of 2m to 6m. Exposure is moderate, and wave energy low. Current impact of routine actions of the sea is low. Sea levels 0.30m higher than present will cause recession of the dunes (measured in metres) and if seas rise as projected in the latter part of this century, then recession can be expected 20-25m.

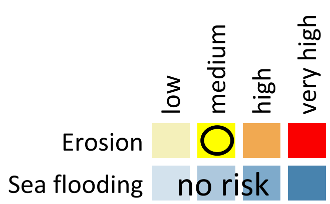
Risk identification: Increasing sea levels will increase impact on the dunes causing them to recede.

Current risk mitigation: Nil

Receiving environment	Risk description	Time	Likelihood	Consequence	Risk
Public infrastructure	Walking trail, signage. Not at risk.	2020	*no risk*	*no risk*	no risk
		2100	*rare*	*minor*	low
Private assets*	No private asets.	2020	*no risk*	*no risk*	no risk
		2100	*no risk*	*no risk*	no risk
Public safety	There is unlikely to be any increase risk to people due to increased erosion (assuming Council follows normal procedures and maintains the walking trail).	2020	*rare*	*insignifcant*	Low
		2100	*unlikely*	*minor*	low
Ecosystem disruption	No broad scale ecosystem disruption due to saltwater flows. Recession of the dunes will result in loss of some vegetation but this is should be viewed as a natural process and no intervention is required.	2020	*no risk*	*no risk*	no risk
		2100	*possible*	*minor*	low

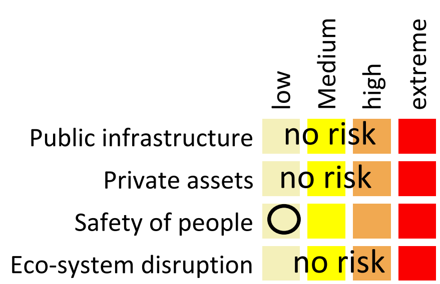
Inherent hazard rating

Inherent vulnerability



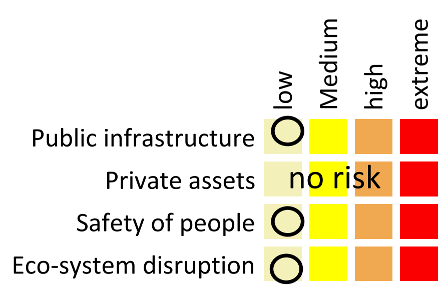
Erosion hazard rating

Current Outlook 2022



Erosion hazard rating

Future Outlook 2100



Assumptions

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

Location: Heron Way Reserve (3.3-4) — Erosion — **Risk assessment using Council's risk framework**

Coastal setting Heron Way Reserve	Heron Way Reserve. Low profile reef, seagrass bed offshore. Rock and shingle beach covered with a thin layer of sand backed by manmade earthen embankment (dunes removed or covered in 1970s). Landward of the embankment the reserve slopes up steeply to Heron Way. Since 1979, the earthen embankment receded 2-6m in places (earlier in north than south). This may be a result of the embankment being built too far seaward. Moderate exposure, low wave energy. Very large storm events impact the base of the embankment (9 May 2016). Seas 0.30m higher than present will scour/ scarp the base regularly. Seas 1.00m higher than present will cause collapse of the embankment.

Risk identification: Large storm events impact the base of the embankment. Sea level rise will increase the impact and cause undercutting and collapse.

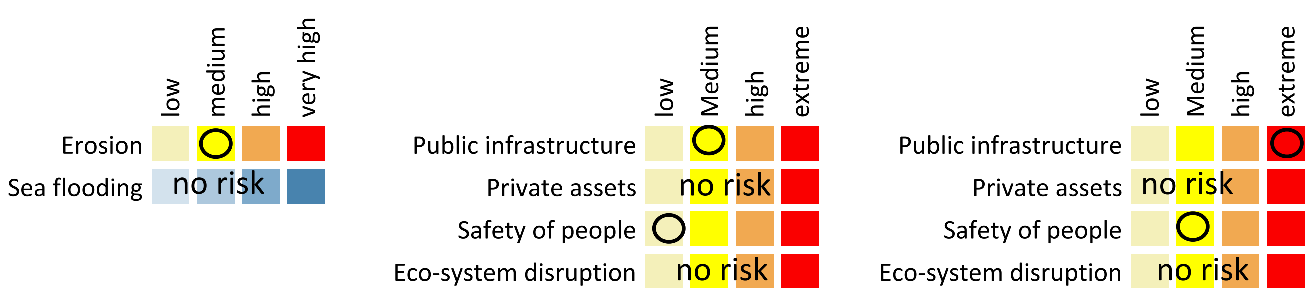
Current risk mitigation: Rock revetment adjacent the pedestrian onramp (south).

Receiving environment	Risk description	Time	Likelihood	Consequence	Risk
Public infrastructure	The embankment, concrete onramps and pedestrian trails, picnic furniture, playground, carpark (boatshed café). Storm water outlet at beach level (with minor undercutting). Concrete paths adjacent the beach are impacted by actions of the sea.	2020	*unlikely*	*moderate*	medium
		2100	*likely*	*severe*	extreme
Private assets*	Nil	2020	*no risk*	*no risk*	no risk
		2100	*no risk*	*no risk*	no risk
Public safety	The public use the footpaths, roads and walking trails. This assessment assumes that people remain on these surfaces. This assessment relates to erosion risk and does not relate to general safety issues common to beaches.	2020	*rare*	*insignifcant*	low
		2100	*unlikely*	*moderate*	medium
Ecosystem disruption	Nil	2020	*no risk*	*no risk*	no risk
		2100	*no risk*	*no risk*	no risk

Inherent hazard rating
Inherent vulnerability

Erosion hazard rating
Current Outlook 2022

Erosion hazard rating
Future Outlook 2100



Assumptions

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

Location: Field River (3.5-6) — Erosion — **Risk assessment using Council's risk framework**

Coastal setting Field River	Beach of shingles and pebbles. Offshore low profile reef. Steeply sloping backshore through which Field River flows to the coast. A dune on the southern side of the river, earthen embankment on north side. Interventions include rock revetment to southern dune, below walking trail. Rocks removed from intertidal zone. Erosion of the dune starting in 1990s, impacted by large events 2007, 2009, 2016. Moderate exposure, low wave energy. Current impact is low (apart from on the dune). Seas 0.30m higher than present will cause significant recession of the dune, some undercutting of banks. Seas 1.00m higher than present will remove dunes (recession 10-15m).

Risk identification: Erosion currently impacts the southern dune. Increasing sea level will increase rates of erosion on both sides of the river.

Current risk mitigation: Rock revetment to southern dune (parts are broken or/or dislodged rock).

Receiving environment	Risk description	Time	Likelihood	Consequence	Risk
Public infrastructure	Walking trail. On north side of river, elevated board walk. On south side of the river, compressed sand/rubble and protected by rock revetment. River Parade. Seas 1.00m higher than present will significantly recede dunes, impact walkways.	2020	*rare*	*minor*	low
		2100	*likely*	*major*	high
Private assets*	Private dwellings set behind River Parade or behind the dunes. Recession of these dunes may be in excess of 15m later in the century and private property impacted.	2020	*no risk*	*no risk*	no risk
		2100	*possible*	*major*	high
Public safety	This assessment assumes that people remain on official walking surfaces. This assessment relates to increased risk from erosion, not normal beach safety issues.	2020	*rare*	*moderate*	low
		2100	*unlikely*	*moderate*	medium
Ecosystem disruption	Increasing sea levels will mean that seawater will enter Field River more frequently. However, the slope of Field River bed is steep, and water 1m higher than present would not flow much further inland.	2020	*no risk*	*no risk*	no risk
		2100	*unlikely*	*minor*	low

Inherent hazard rating
Inherent vulnerability

	low	medium	high	very high
Erosion			○	
Sea flooding	○			

Erosion hazard rating
Current Outlook 2022

	low	Medium	high	extreme
Public infrastructure	○			
Private assets		no risk		
Safety of people	○			
Eco-system disruption		no risk		

Erosion hazard rating
Future Outlook 2100

	low	Medium	high	extreme
Public infrastructure			○	
Private assets			○	
Safety of people		○		
Eco-system disruption	○			

Assumptions

Rain water events have not been assessed in this project.

The assignment of future risks assumes that seas rise as projected and that no adaptation responses are employed.

*Governments are not necessarily liable for private assets.

8. Cell summary and recommendations

This cell report is designed to be reviewed and updated over time so that the baseline data is continually brought forward and modified to reflect any changes in the coastal system. This part of the report contains three main parts:

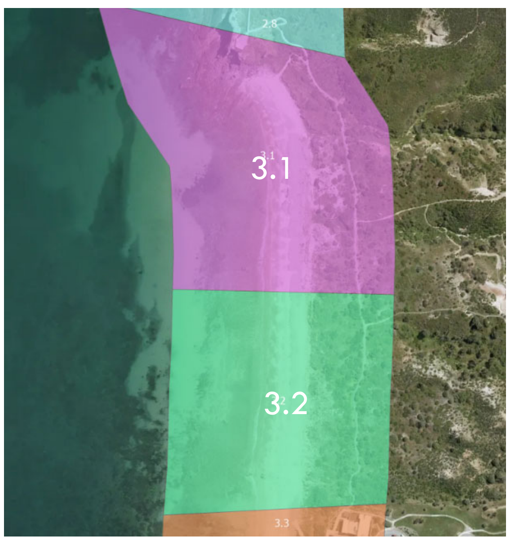
- Summary – a snapshot of the state of the coastal system at the date of writing.
- Overview of adaptation options and strategies.
- Recommendations – a review of recommendations from the prior study and a list of amended recommendations for the future.

8.1 Summary – Hallett Cove Beach (Cell 3.1-2)

Conservation Park

Coastal setting

Rock and shingle beach covered with a thin layer of sand, backed by 5m high vegetated dunes overlying clay. Offshore are a low-profile reef, seagrass beds and sand patches near Black Point. Behind the dunes the land slopes upward into the amphitheatre. The coastal walking trail is situated 30m to 45m inland from the foredune. Exposure is rated as moderate and wave energy low. The Conservation Park is under the control of Department of Environment and Water.



Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that shoreline undergoes cycles of erosion and accretion over decades, most likely due to storm activity. Since 1979, sections of the coast have undergone net recession of 2m to 6m and sand levels declined, but the beach has always been rocky underneath the thin layer of sand.

Coastal exposure – sea level rise, storms, and projections.

The rate of sea level rise remains relatively low at 3-4mm in this region. Current larger storms impact the base of the dunes, but these rebuild where sand, or scarp where clay. Seas 0.30m higher than present will cause recession of the dunes (a few metres), and seas 1.00m higher than present likely to cause recession 20-25m.

Storm water runoff – impacts in the coastal zone

Stormwater flows down from the amphitheatre over natural ground, flows under the walking trail in gullies or pipes, and through gullies to the coast. Larger gullies are being created by the storm water from natural terrain.

Overview of Impacts and risk assessment

Current impact on the coast by actions of the sea is relatively low, but cyclical. Large storm events interact with the base of the dunes, but these can rebuild if sand. The walking trail is set well-back from the fore dune and there are no other assets in this minor cell. The safety of people is unlikely to be adversely impacted by erosion and ecosystems will naturally recede.

Inherent hazard rating
Inherent vulnerability

	low	medium	high	very high
Erosion		O		
Sea flooding	no risk			

Erosion hazard rating
Current Outlook 2022

	low	Medium	high	extreme
Public infrastructure	no risk			
Private assets	no risk			
Safety of people	O			
Eco-system disruption	no risk			

Erosion hazard rating
Future Outlook 2100

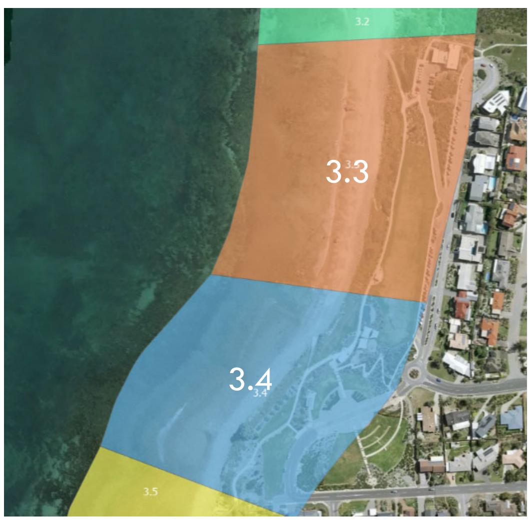
	low	Medium	high	extreme
Public infrastructure	O			
Private assets	no risk			
Safety of people	O			
Eco-system disruption	O			

8.1 Summary – Hallett Cove Beach (Cell 3.3-4)

Heron Way Reserve

Coastal setting

Rock and shingle beach covered with a thin layer of sand backed by manmade earthen embankment (dunes removed or covered in 1970s). Offshore are low profile reef and seagrass beds. Landward of the embankment the reserve slopes up steeply to Heron Way. Public infrastructure in the backshore includes walking path, picnic facilities, and cafe car park. Two concrete ramps and one set of stairs provide access to the beach. Rock revetment is positioned adjacent the southern access ramp.



Coastal fabric – changes to beaches and backshores

Land based and aerial photography indicate that 4-6m recession of the base of the embankment has occurred since 1979. In the north, this occurred early after installation of the embankment which may indicate that it was installed too far seaward. Sand levels appear lower than 1970s, but this was always a thin layer over shingles.

Coastal exposure – sea level rise, storms, and projections.

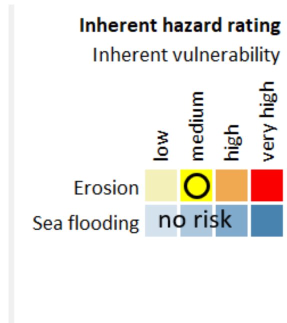
The rate of sea level rise remains relatively low at 3-4mm in this region. The event of 9 May 2016 significantly scarped the embankment in three places. Sea levels 0.3m higher than present are likely to scarp the base of the embankment more regularly. Sea levels 1.00m higher than present would cause large recession and collapse.

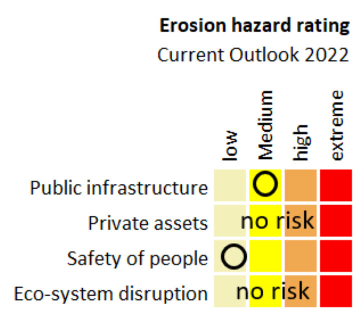
Storm water runoff – impacts in the coastal zone

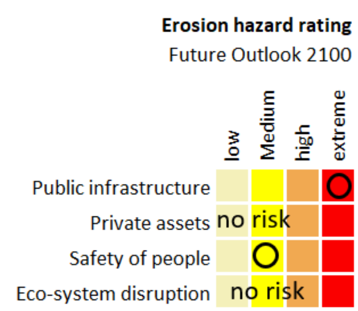
Stormwater is collected and piped long distances to a storm water scheme installed at end of Grand Central Avenue which appears to effectively manage storm water flows with minimal impacts to the beach.

Overview of Impacts and risk assessment

Moderate storms monitored over the last 2 years do not impact the base of the embankment. It is likely that larger storms such as 9 May 2016 will again cause significant scarping, but these will be rarer events. Seas 0.30m higher than present projected for 2050, would increase these scarping events. Seas 1.00m higher than present would cause significant recession, steepening of the slope, and likely collapse of the embankment.



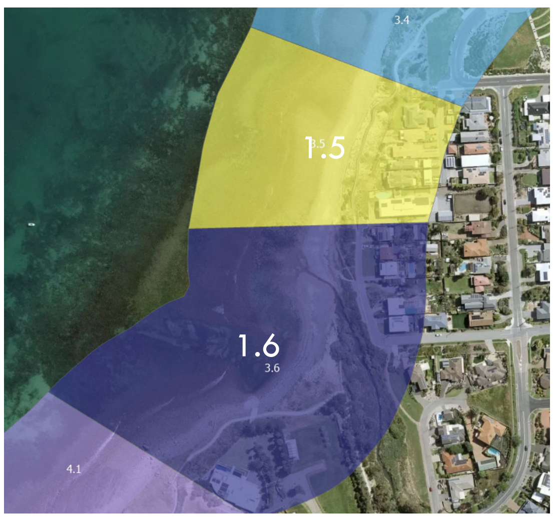




8.1 Summary – Field River (Cell 3.5-6)

Field River
Coastal Setting

Beach of shingles and pebbles backed by a dune on the southern side of Field River and embankment on the northern side. Field River flows to the coast through the steeply sloping backshore. Rock revetment is positioned against the southern dune and underneath the walking trail to the south. Rocks were removed from the intertidal zone in front of the southern dune (prior to 1940s). Positioned immediately behind the embankment on the norther side of the river is River Parade or private dwellings, the latter constructed over a former dune.



Coastal fabric – changes to beaches and backshores

Rocks removed from intertidal zone. Land based and aerial photography show that erosion of the dune started in 1990s, and was further impacted by large events 2007, 2009, 2016.

Coastal exposure – sea level rise, storms, and projections.

The rate of sea level rise remains relatively low at 3-4mm in this region. Storm monitoring Moderate exposure, low wave energy. Current impact is low (apart from on the dune). Seas 0.30m higher than present will cause significant recession of the dune, some undercutting of Seas 1.00m higher than present will remove dunes (recession 10-15m).

Storm water runoff – impacts in the coastal zone

All storm water schemes flow into the Field River apart from one at the bend of River Road. Most outlets were not located at the time of inspection due to vegetation. Field River acts as a catchment for many storm water schemes higher up the valley but there appears to be no adverse impact on the beach.

Overview of Impacts and risk assessment

Moderate storms impact the dune south of the river and this continues to recede. More significant events impact the base of embankments and will threaten to overtop the walking trail to the south. Seas 0.30m higher than present projected for 2050 will undercut embankments and recede the dune. Seas 1.00m higher than present (2100) are likely to remove the southern dune and erode northern dunes back to private properties.

Inherent hazard rating
Inherent vulnerability

	low	medium	high	very high
Erosion			○	
Sea flooding	○			

Erosion hazard rating
Current Outlook 2022

	low	Medium	high	extreme
Public infrastructure	○			
Private assets	no risk			
Safety of people	○			
Eco-system disruption	no risk			

Erosion hazard rating
Future Outlook 2100

	low	Medium	high	extreme
Public infrastructure			○	
Private assets			○	
Safety of people		○		
Eco-system disruption	○			

8-2 Overview of adaptation options and strategies

Adaptation options and strategies

An overview of adaptation approaches is provided on this page to provide context to the recommendations. There are generally six categories of adaptation options:

1. **Avoidance** – Avoid the impacts of coastal hazards by ensuring that assets are not placed in vulnerable locations.
2. **Hold the line** – Install protection infrastructure that reduces the impact of coastal hazards or use environmental practices to strengthen natural protective forms such as dunes.
3. **Accommodate** – Accept some degree of hazard and conduct limited intervention to manage the hazard (for example, in areas that may be subject to inundation, raise houses on poles).
4. **Managed retreat** – Progressively move assets or services away from areas that could be impacted by coastal hazards now or in the future.
5. **Monitor** – monitor the coast and use the data to form future strategies.
6. **Loss acceptance** - Accept that coastal hazards will cause negative impacts on assets and services and when this occurs, they will not be replaced.

Adaptation responses

Within the adaptation options there are a range of potential adaptation responses.

Planning

Planning responses are options that use planning legislation and regulations to reduce vulnerability and increase resilience to climate change and sea-level rise. For example, dwellings and sites required to be positioned at higher elevation or set back from the coastline.

Engineering

In the context of climate change adaptation 'engineering' has come to describe adaptation options that make use of capital works such as seawalls and levees. Such projects are 'engineered' to solve a particular challenge such as to protect coastal infrastructure from erosion and inundation.

Environmental management

Environmental management includes habitat restoration and enhancement through activities such as revegetation of coastal dunes or building structures to support growth of habitat such as seagrasses. It may also include sand nourishment to replace sand that has been lost from the beach system.

Adaptation timing

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 that 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.

Adaptation strategy (Cell 4)

Due to the elevated and rocky nature of this section of coastline, the adaptation strategy will fall into options ***(1) Avoid*** and ***(5) Monitor*** with an incremental approach over time.

8-3 Recommendations – Hallett Cove Beach

Recommended actions from 2018 and review

The recommendations from the Coastal Adaptation Study of 2018 are listed below with reviews in the right-hand column.

	Action	Comments	Time Frame	Review 2022
1	Consult with DEW re storm water gullying in dunes.	Consult with DEW who are responsible of storm water flows noting that if sea water enters these locations the dune system will break down quite quickly.	1-2 years	Unknown if DEW were informed. This may be viewed as natural processes and allowed to proceed, although monitoring should ensure that the walking trail is not impacted.
2	Quantify more accurately the nature of routine and storm surge interaction with dunes (Conservation Park and Field River).	Monitor tidal regime for period of three months (winter). Monitor the impact of storm surge events (if, and when they occur)	1-2 years	The 2-year monitoring program (2021-2022) monitored 5 storm events. At time of writing assessment is underway for year 2022. The conclusion from the monitoring is that moderate storm events are not having an adverse impact but larger events will. Recession of the Field River dune continues.
3	Quantify more accurately the nature of routine and storm surge interaction with escarpment (Heron Way Reserve)	Monitor tidal regime for period of three months (winter). Monitor the impact of storm surge events (if, and when they occur)	1-2 years	The 2 year monitoring program (2021-2022) found that moderate events do not adversely impact the base of the escarpment. Larger events, such as 9 May 2016 will have impact on the escarpment.
4	Review nature of storm water outflows and monitor impacts	Routine inspections are taken of the outfall areas. Recommend that staff incorporate review of scouring impacts (use photography)	1-2 years	In 2022, we undertook inspection of all storm water outlets after significant rain events in June. Overall, the findings were that storm water events did not appear to have significant impact on backshores and beaches (rocky environment).
5	Recapture digital model as basis for comparison.	Use appropriate software to quantify changes in the coastal environment.	3-5 years	This action is recommended for 2023.
6	Solutions are required for to cater for the steep and unstable slope (Heron Way Reserve) that is expected to come under increasing pressure from current and future storm events.	CoM is currently reviewing Hallett Cove Beach foreshore in preparation for a master plan for this region. It is recommended that CoM considers the flood modelling over the century so as to ensure that designs cope with projected sea level rises.	1-2 years	The two year monitoring program suggests that allocating large capital outlays to protect this embankment may be premature. It may be more cost effective to repair the embankment after rare larger events occur such as 9 May 2016.

8-3 Recommendations – Hallett Cove Beach

Recommended actions from 2018 and review (cont)

7	Investigate options for protection for River Pde area and dune system to south.	There is unlikely to be a requirement to protect private property. The Council will have interest in protecting River Parade. Shared costs should be canvassed where private and public interests coincide	1-2 years	The site has been monitored for 2 years (2021-2022) and inspected by DEW. No conclusions were reached about the dune. In light of the findings of the monitoring program it is not likely that private properties will be impacted for a significant amount of time (likely decades).

Recommended actions 2022 to 2027 (five years)

This review and upgrade to the Coastal Adaptation Study (2018) and the City of Marion Coastal Monitoring Project provide the basis for the following recommendations in Cell 1. The summary at 8.1 above provides the immediate context for the recommendations.

	Action	Rationale / Methodology	Time Frame
1	Incorporate the findings of the CoM coastal monitoring program (2021-2022) into this report.	This report represents an upgrade from the Coastal Adaptation Study (2018) by including tasks that were not included in the 2018 project and an upgrade to the format. This has coincided with the conclusion of the first two years of the CoM coastal monitoring project. Some of the findings from the monitoring project inform this upgrade, but they have not been formally integrated with this report.	2023
2	Recapture the digital model as a basis for comparison with 2018 capture.	Use appropriate software to quantify changes in the coastal environment. This is likely to be the most effective way to assess changes in cliff environments.	2023
3	Assess adaptation options and costs for protection of the embankment (Heron Way Reserve).	This item is brought forward from 2018. Recommended that an options analysis be undertaken which can include, monitor, and any further actions could be deferred. The monitoring program (2021-2022) demonstrated that the base of the embankment is not under routine attack (apart from minor locations). It may be valid to defer protection.	2023

4	Monitor changes in beaches and backshores.	Use aerial photography obtained every three months by City of Marion to assess changes to beaches and backshores. This could be done as an annual operation using 4 captures. In particular, identify locations of any new rock falls, slumps or landslides.	Annual (ongoing) (2023-2027)
5	Monitor the impact of moderate storm events, either rain or sea storm (2-3 per year).	Use the Coast Snap photo point to photograph storm events at the base of the Marino Rocks carpark. Use drone photography after storm events. For sea-storm events, monitor the location of seaweed strands in relation to the base of cliffs and any impacts to backshores. For rain events, monitor for any scouring of the backshores and beaches. For both events monitor for slumps, slides and falls in cliff environments. (Note, no survey).	Annual (ongoing) (2023-2027)
6	Assess the impact of any major sea storm.	Identify a suitable tidal benchmark at Outer Harbor to qualify as a major sea storm (for example, 1 in 2 year event). Inspect and survey the seaweed strands and update modelling parameters if required. Note, the proposals for task (4) and (5) simplify some of the current storm monitoring and therefore reduce cost, but still maintains the ability to track more significant storms which will be required in the context of rising sea levels.	As required (likely 3-5 in a five-year period).
7	Monitor the rate of sea level rise in Gulf St Vincent.	It is recognised that this action is not within the direct scope of City of Marion. However, periodic reviews are being done by others (e.g. Watson, 2020) and simple tools now exist at www.sealevel.info. It is recommended that when opportunities exist, City of Marion lobby for improved sea level monitoring in Gulf St Vincent (e.g. additional gauges, tracking vertical land movement). The reason for this action is that currently the rate of sea level rise is relatively low (3-4mm per year) whereas projections for the latter half of the century are high (10-15mm per year). An escalation in the rate at tide gauges will provide an early warning that these projections are being realised.	2023-2027