Coastline

Developing a management strategy for coastal cliff erosion hazards in South Australia

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An initiative of the Coast Protection Board of South Australia

Government of South Australia

Department of Environment, Water and Natural Resources


Cliffs make up approximately 38% of the South Australian coastline

Overview

Coastal cliff erosion is increasingly posing serious hazards for coastal communities. Cliff erosion processes can cause significant issues for public safety and serious damage to critical infrastructure. There are also environmental, cultural and amenity issues. This is particularly concerning in South Australia as cliffs make up approximately 38 percent of our coastline.

Coastal cliff erosion events have already been notable in locations such as Kingscote, Streaky Bay, Robe, Port Hughes, Ardrossan and southern metropolitan Adelaide. Figure 1 illustrates a recent cliff fall at Ardrossan, tonnes of rock unexpectedly collapsed on a public beach. The fall occurred on a Saturday morning and 3 metres of land was lost at the cliff top. Consequently, a bitumen walking track will need to relocate further back on the cliff top and other development located in close proximity will need to be reviewed. This example highlights the seriousness of the threat posed to public safety and infrastructure by a single erosion event. Taking into consideration anticipated sea level rise and the effects of climate change it is likely that coastal cliff erosion issues will increase in coming years. It is essential that local communities and councils develop management strategies to mitigate adverse impacts on public safety, existing assets and infrastructure and future uses of coastal zones.

Figure 1: *Cliff collapse at Ardrossan 2013*

Management strategy aims;

- To avoid or mitigate the adverse effects of cliff erosion hazards on coastal land use and future development of the coastal environment.
- To substantially raise the awareness of the risk posed by coastal cliff erosion hazards to the public and those responsible for coastal erosion hazard management.
- To identify the vulnerability of people and communities to coastal cliff erosion hazards.
- To foster and raise community resilience to coastal cliff erosion hazards, and increase adaptation.
- To significantly reduce the risk of loss of property, amenity value, economic costs and the actual and potential adverse effects on natural and cultural resources.

Coastal cliff erosion processes

Coastal cliff erosion is a natural process that occurs as a result of atmospheric and marine forces acting on a cliff landform. Cliffs will actively retreat under the influence of these forces depending upon the extent of cliff exposed and how resistant the rock is. Figure 2 illustrates the most dominant factors influencing cliff erosion processes namely, wave action and weathering.

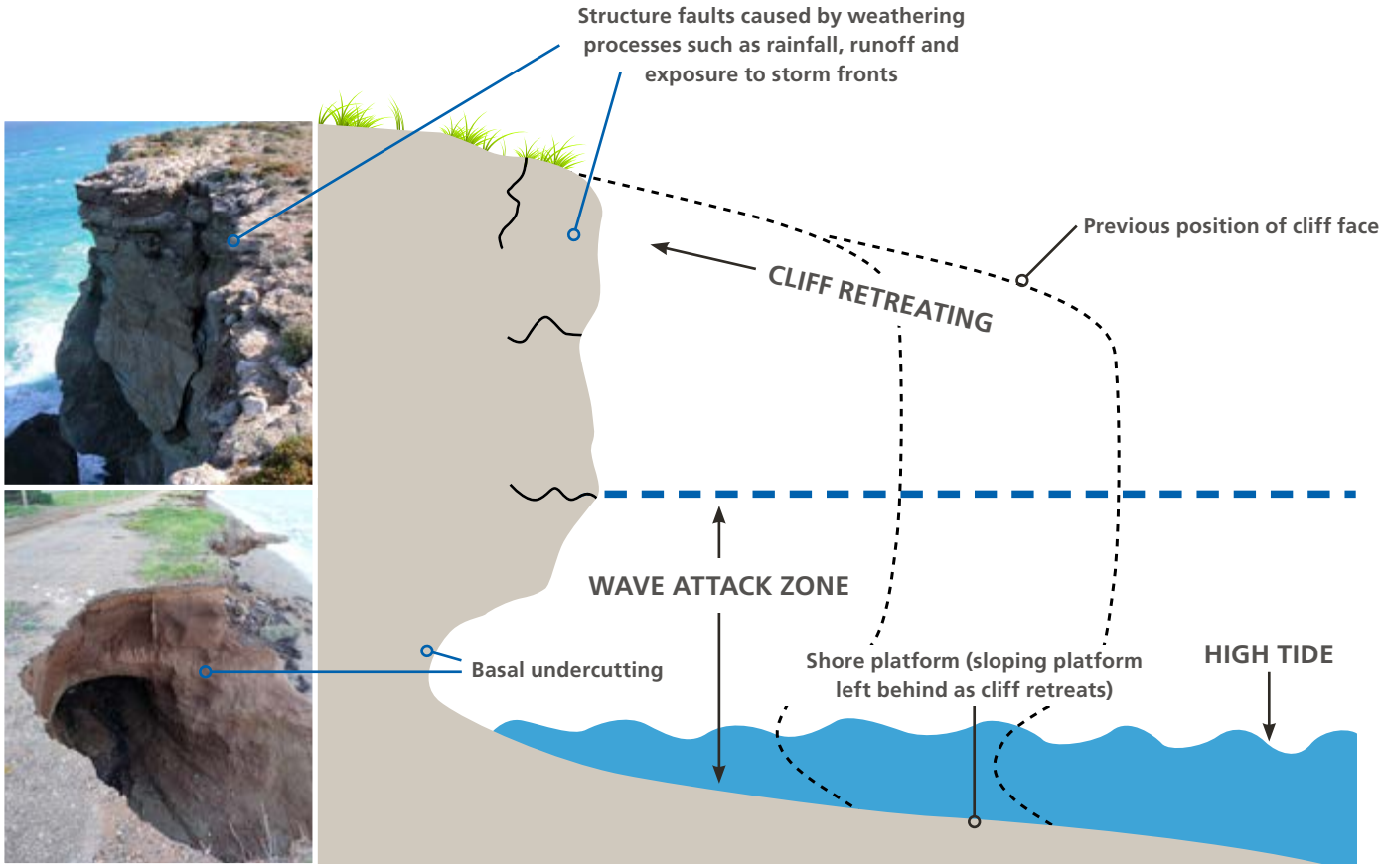


Figure 2: *Dominant factors influencing coastal cliff erosion (Adapted from The British Geographer, 2013)*

Waves play the most critical role in basal erosion and cliff stability. The erosive force of waves highlights the importance of protecting the cliff toe from wave action to avoid destabilising cliffs through notching and undercutting. A beachfront, reef, or the presence of rubble at the cliff toe are all effective defences that force waves to break off shore and limit the wave energy reaching the cliff toe.

Playing an equally important role in cliff stability is rock resistance. A cliffs resistance to erosive forces is shaped by the homogeneity, structure and lithology of the rock. Weathering through rainfall, exposure to storm fronts and runoff for example, actively reduces rock strength through the creation of faults and fractures in the rock face, leaving the cliff more susceptible to erosive forces.

Due to the complex array of influencing factors causing change in coastal cliff landforms, cliff erosion is a highly localised and episodic process. It produces hazards to coastal communities through both annual recession and less frequent,larger scale cliff falls. However, in general a cliff will undergo the following cycle of recession (Figure 3).

Cliffs may exhibit short to medium term stability within this cycle however, cliffs are inherently unstable in the long term. If a cliff in your local area is either severely undercut, fractured or is highly exposed to erosive forces, such as the cliff pictured at stage 3, these are usually indicative signs that the cliff is unstable and there may be a heightened risk of cliff collapse.

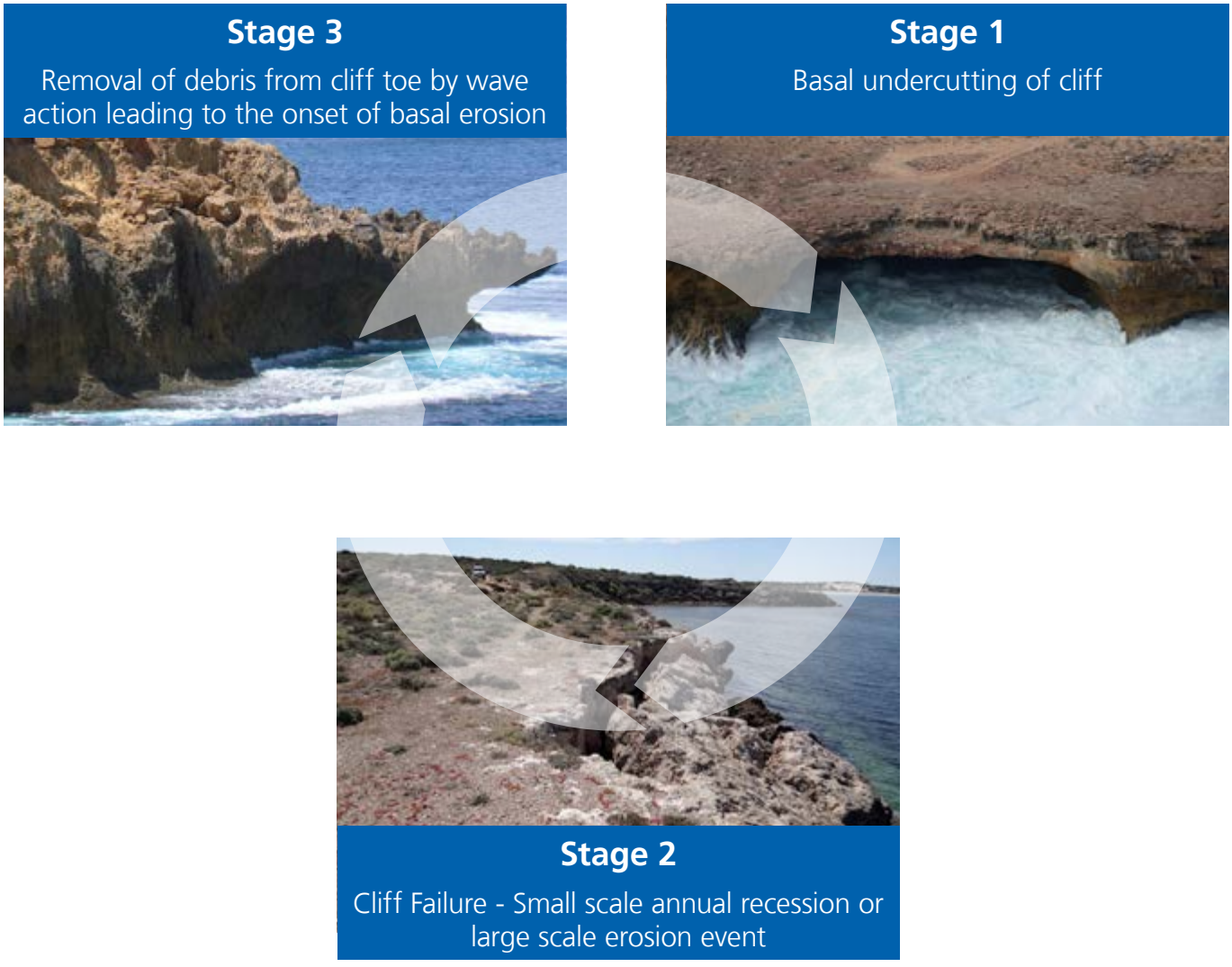


Figure 3: *Generalised recession cycle*

Primary factors influencing cliff stability in South Australia

For South Australian cliff landforms, the principal processes influencing coastal cliff change can be summarised as follows;

- Severe gullying of cliffs as a result of untrained storm water or drains being located in and around the cliff face.
- Wave attack at the cliff toe due to an absence of protection features such as rubble.
- Weathering, in particular during summer storm events. Slumping often occurs after heavy rains reduce rock strength.
- Loss of protective beaches as a result of the landwards migration of beach profiles as a response to sea level rise and anthropogenic features such as groynes that block sand transportation.
- Along the beach. A wide beach is often the best natural defence but a reduction in volume of beach sediment decreases beach width and lowers beach level, allowing storm waves to readily reach cliff base.
- Rising sea levels will produce higher tides that more readily erode talus and other protective features allowing for more intensive basal attack.
- Climate Change - Increase in aridity will affect the survival of cliff top vegetation which helps to stabilise cliffs.
- Climate Change may also increase the frequency and magnitude of storm erosion events.

Figure 4: *Basal undercutting (left) and cliff collapse in close proximity to informal car park, Nullarbor cliffs 2013*

Figure 5: *Storm water overflowing cliff tops (left) & removal of protective rocks at cliff base (right) at Simms Cove December 2011, (Robyn Sambell)*

Key vulnerabilities and potential impacts

Coastal cliff erosion poses a serious threat to public safety, existing infrastructure and assets, future coastal use and environmental and cultural values.

The following chart outlines key vulnerabilities to coastal cliff erosion and the potential impacts that an erosion event would likely inflict.

Public saftey
• A number of tragic incidents over previous years have highlighted the importance of increasing public safety around cliff landforms. Injury has resulted from both the collapse of cliff overhangs on people underneath and people walking on unstable cliff tops that have collapsed.
Private infrastructure and assets
• Structural damage to privately owned dwellings or businesses is costly and can have detrimental impacts on livelihoods. • Reduction in property value can occur as the loss of land migrates hazards closer to existing development.
Public infrastructure
• Damage or destruction to critical infrastructure such as water, sewerage or gas pipes and communications and transport infrastructure such as roads and powerlines is extremely costly to repair. • Significant costs involved in removal of damaged infrastructure or relocation • Significant costs involved in the construction and maintenance of protection structures.
Public assets
• Foreshore parkland and public access to the foreshore is often the first to be lost in long term recession and erosion events.
Scenic value
• Loss of amenity value impacting coastal recreation, tourism attractions and accommodation • Loss of amenity values through the construction of protective structures such as sea walls.
Environmental and cultural values
• Loss of habitat and vegetation • Reduction in areas of ecological significance • Loss of cliffs of geological significance • Adverse impacts on Aboriginal Lands • Adverse impacts on Heritage Sites.
Coastal land use
• Impacts for current and future use of coastal areas • Current coastal land uses may need to change due to the risk of cliff failure. ie. recreational uses • Certain uses may be restricted by cliff hazards.

Management strategies

Coastal cliff erosion processes are highly variable in both magnitude and across the coastal landscape which creates challenges for coastal management strategies. Nevertheless, recognising the high values of the coast, many local governments across Australia and internationally have been implementing strategies in an attempt to reduce the hazards that surround coastal landscapes. These strategies focus on minimising the erosion hazard to reduce the risk to people and property while aiming to protect and conserve coastal landscapes. Some of the preventative and remedial approaches to coastal erosion hazards are outlined below.

Education and awareness raising

Increasing public safety should be a priority for management strategies. One of the most effective methods is through raising awareness of erosion hazards and engaging those at risk. This could be achieved through the construction of warning and information signs in high risk areas, education programs in schools or at community meetings, or pamphlets and posters located in strategic places within coastal towns such as tourism centres and caravan parks. Educating and raising awareness of the hazards to those at risk will likely encourage people to manage the risk to their property or business.

Figure 6: *Examples of Warning Signs. (R. Raymond, 2013).*

Controlling access

Controlling both foot and vehicle access is an effective means of promoting public safety. It also has beneficial results for the environment such as decreasing erosion, reducing the spread of weeds and disease and avoiding the disturbance of wildlife. The use of fences, trail markers, lookouts, designated paths and access points can help keep the public away from hazardous coastal areas while avoiding heightening the hazard. Pathways should be clearly visible to the public and where inappropriate tracks already exist, these should be removed through revegetation or barring access.

This strategy will limit the ad hoc nature of coastal access that degrades the landscape and facilitates erosion processes through vegetation loss, topsoil capping and gullying. Reducing pressures from sensitive, degraded coastal areas will enable them to rehabilitate naturally.

Figure 7: *Ad hoc access facilitating erosion, Copper Coast Simms Cove, 2007*

Development control

Coastal cliff hazards can be managed by effective land use planning that limits the exposure of people and property to erosion hazards. This is best achieved by establishing cliff setbacks and rezoning vulnerable areas as coastal.

Prevention is often the most cost effective means of management as developing sites that are later found to be under threat from erosion can be very costly to landholders or the public. Establishing cliff setbacks that take into account annual cliff recession and larger scale cliff collapses for at least the next

100 years will provide a buffer between coastal hazards and future developments. It will also allow for the natural migration of the coast landward taking into consideration both annual recession rates of centimetres a year and larger scale cliff falls that can take out metres of land in a single event. Additionally, this will reduce the need for unsightly and costly stabilisation and protection efforts. It is important to note that since erosion processes are highly localised, each situation will need to be assessed individually and distances for coastal setbacks should be defined based on advice from geotechnical experts that accommodate for local conditions. Setback distances should also safeguard against the effect of a 1 metre sea level rise by 2100 on erosion processes.

Figure 8: *Cliff recession, North Shields, (left) 2009; (right) 2013*

Land use regulation

Rezoning areas as coastal will ensure that any future planning or development of coastal areas will be referred to the Coast Protection Board for comment. The Board will review any future development within a designated coastal area, against its coastal protection policies and the developments potential impacts on coastal qualities such as vegetation, reserves or beaches. The Board will provide advice on the impacts of development on coastal processes and also inform developers of any coastal hazards. Coastal zoning provides a platform on which coastal managers will be better facilitated to closely monitor hazards and help ensure that future development is based on expert knowledge that promotes the sustainable use of the coast.

Figure 9: *Structure under threat from coastal cliff erosion, Clare Bay, 2007*

Regardless of current zoning or setbacks, future development and use of coastal areas need to consider potential coastal cliff hazards in the region. Erosion hazards are often difficult to measure in magnitude, frequency and/or impacts, so a precautionary approach to future planning should be adopted. This means shifting away from coastal trends of developing rigid and permanent coastal structures and infrastructure towards lightweight, temporary structures that can readily be moved to accommodate for the inevitable natural migration of the shoreline. Councils and individuals should seek professional advice on the design of future development and infrastructure to ensure that it doesn't exacerbate erosion or contribute to further degradation of coastal areas.

Figure 10: *Cliff erosion hazard, Port Gibbon 2013*

Stabilisation

There are a variety of stabilisation methods available for increasing cliff stability ranging from less invasive, relatively low cost action such as revegetation of cliff slopes and maintaining rubble at the cliff base to more permanent fixed structures, such as seawalls and drainage systems.

Management of the cliff base and cliff top is the simplest way to promote cliff stability. Natural defences such as beaches and rubble at the cliff toe can dramatically reduce the frequency and energy of waves reaching the cliff toe. For this reason, it is essential that beach levels are maintained and rubble at the cliff toe is not removed. Maintaining or revegetating cliff tops is another relatively simple method for reinforcing cliff stability. The root networks of plants can help reduce soil loss and capture rainfall, avoiding the saturation of cliff tops that leads to instability.

Figure 11: *Untrained storm water Simms Cove, December 2011 (Robyn Sambell)*

Where gullying has been identified as a key driving factor in cliff instability, it is important to ensure that storm water delivery is minimised at cliff tops by redirecting storm water flows. This will decrease the impact of soil saturation and gullying on cliff stability. Storm water systems should be reviewed to ensure that water is being disposed of appropriately and away from cliff tops.

Safety around unstable cliffs can be increased through the use of rock netting, catch fences and ditches that prevent loose rocks falling onto roads and paths.

The use of more rigid protective structures such as groynes and seawalls should be used with caution and thoroughly investigated before implementation. It is essential to assess the impacts that these structures will have on neighbouring coastal landscapes. Protective structures can often have a destabilising effect on cliffs in nearby localities as they alter the transfer of sediment and simply push the erosion issues further down the coast.

Figure 12: *Rocks protecting base of cliff from wave attack, Happisburgh, Norfolk, UK (www.halcrow.com*

Figure 13: *Rock netting used to revegetate cliff slope enhancing stability (www.halcrow.com)*

Monitoring, research and modelling

The key to managing coastal cliff hazards effectively is to understand the processes that drive coastal cliff erosion in a locality more comprehensively through monitoring and research. Monitoring cliff profiles and their environmental setting through regular site inspections is vital for the collection and documentation of data on cliff erosion hazards. This data can be used to assess the extent of cliff hazards and provide a basis for establishing a coastal cliff hazard directory that will be useful for following cliff erosion trends and processes.

Visual surveys and audits, aerial photographs, and beach and cliff profiling are all useful management tools that will help acquire the data needed to fill the information deficit on cliff erosion. Data can also be used for developing hazard maps that identify areas according to their susceptibility to erosion. Recently, the Coast Protection Board have undertaken a hazard assessment of coastal cliff landforms along the South Australian coast which flags potential hazard areas for priority management according to how susceptible they are to erosion. The hazard map will be a valuable tool for identifying areas that pose a particularly high hazard and highlight these for further investigation. It should be noted that although the assessment took into account many variables influencing cliff erosion, cliff erosion will ultimately be dependent on local processes. Consequently, an on ground assessment of each hazard site should be undertaken by the relevant coastal and geotechnical experts to evaluate the hazards dimensions and explore the most appropriate management strategy for the specific locality.

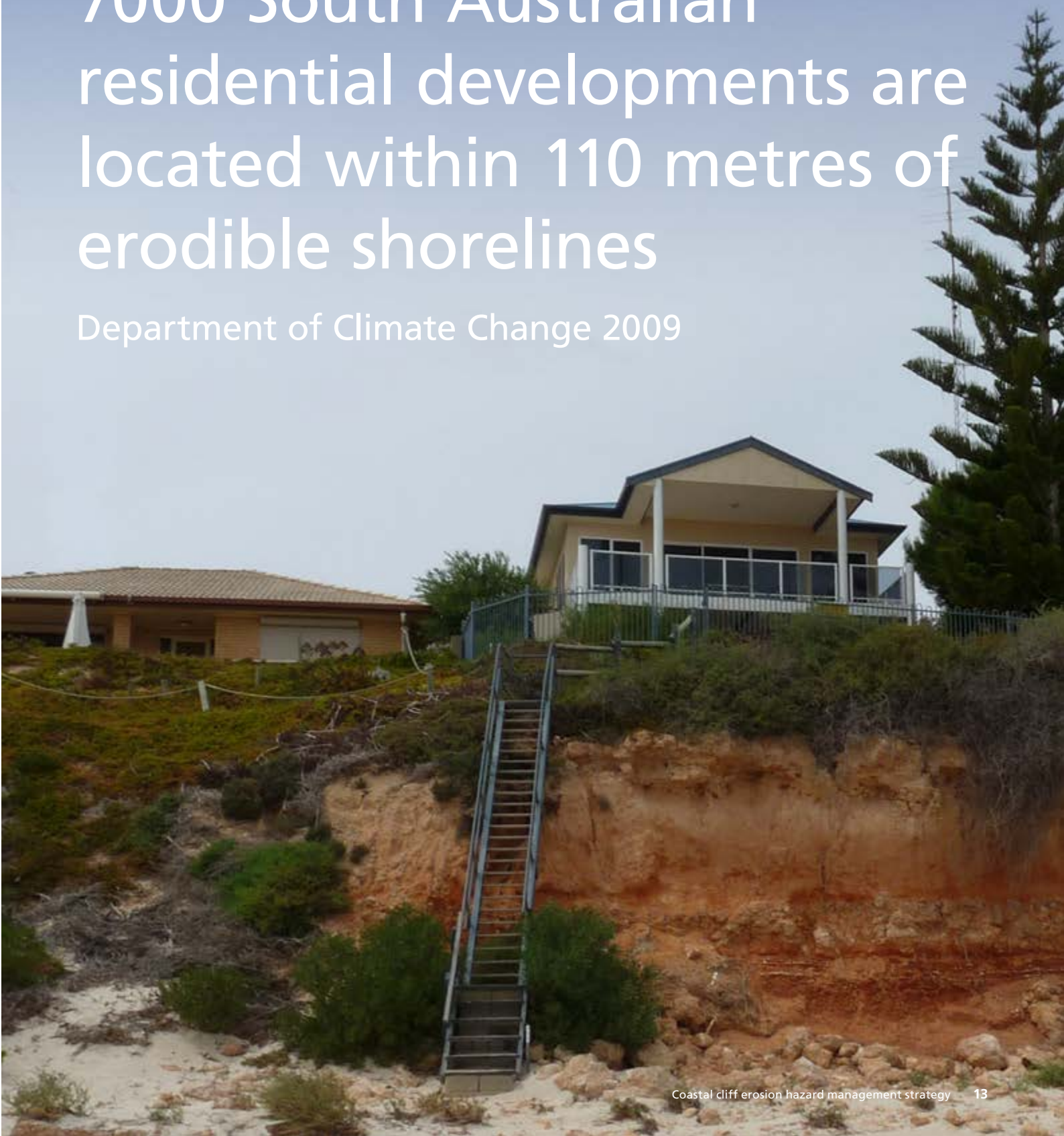
Continual research and data analysis of coastal cliff erosion will facilitate a better understanding of cliff behaviours and will be paramount to effectively managing cliff hazards and driving the most appropriate management tool.

Figure 14: *Cliff erosion, Nullabor Plain 2013*

Cliff erosion at Rossiters Point, Copper Coast 2012

7000 South Australian residential developments are located within 110 metres of erodible shorelines

Department of Climate Change 2009



Conclusions

> In the end, of course, the sea cliffs belong to the ocean, and the ocean will eventually reclaim its property.
>
> (Emery, 1982)

Coastal cliff erosion is a natural process and so it is not feasible to prevent it entirely. Coastal cliff hazards need to be assessed on an individual basis by geotechnical experts, local councils, communities, businesses and other relevant stakeholders to explore not only the practicality of managing the hazard but the potential impacts of the management options. Management bodies will need to make strategic decisions about the type of management strategy they employ taking into account the costs and benefits of the action, environmentally, economically and socially. It is also important to view the coast in a holistic manner and consider the impacts a management strategy may have on neighbouring parts of the coast.

Before deciding which management path to follow, councils and communities should ask themselves the following questions to determine the feasibility of defending, adapting or withdrawing communities and existing infrastructure.

Is there an immediate risk of cliff failure?

- If so, is the hazard posing a risk to public safety?
- How quickly is the cliff eroding?
- What is the estimated time frame before the cliff will pose a hazard?
- What is the extent of property and infrastructure at risk from erosion and the estimated value?
- What impacts can be expected from the remedial or preventative measures on social, cultural and environmental values?
- What is the expected financial cost of construction of defences and the ongoing cost of maintenance?
- Is this a localised or regional problem?

Initially asking these questions and then more comprehensively investigating the hazards on the ground will hold councils and communities in good stead. It will lead to make informed decisions when determining whether it is viable to either mitigate the hazard through defence structures, adapt communities to accommodate for the hazard through controlling coastal uses or to withdraw existing infrastructure entirely.

It is important to find a balance between the management option that will be the most economical, provide the greatest benefits to the environment and minimise negative impacts on communities in order to conserve coastal landscapes for future generations.

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