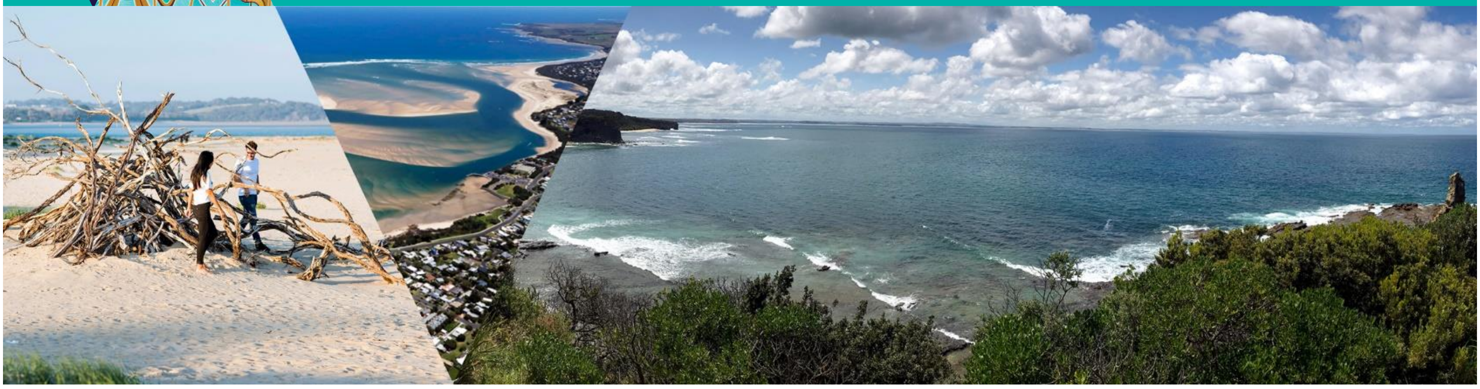
Cape to Cape Resilience Project

Hazard Mapping Supplement



Information in this document assists interpretation of coastal hazard mapping and provides background for the modelling and analysis undertaken as part of the Cape to Cape Resilience Project.

More information about coastal hazards and modelling is available in Factsheets #3 and #4, and you can learn more about vulnerability and risk in Factsheet #5.

These are available on the website **engage.vic.gov.au/cape-cape-resilience-project**. We recommend reading these to understand more.

Coastal Hazard Assessment

The Inverloch Region Coastal Hazard Assessment (CHA) is a core technical investigation that has been undertaken as part of the Cape to Cape Resilience Project.

Informed by extensive analyses of the region’s geological formation, local conditions, and historic and recent changes along the Cape to Cape coastline, the project team developed various computer models to simulate conditions of the local coastal, estuarine and catchment areas.

These models assessed:

- Storm-tide
- Waves
- Sediment transport
- Shoreline response (erosion / accretion).

Looking at both present day conditions and predicted future changes, such as rising sea levels and changing wind and wave climates, the models have been used to examine how the coastline might change and respond.

Modelling considered a range of current and future weather conditions to estimate the potential impact of coastal hazards, erosion (sand loss) and inundation (flooding) and sea level rise. This combined local weather events like coastal storms (e.g. wind, waves, tides) and coastal and hinterland (catchment) rainfall.

Event – Where weather conditions affecting a specific place are notably different from typical, day-to-day conditions normally experienced at that location (e.g. a storm event).

Coastal storm events are driven by a wide variety of natural processes, combining meteorology (weather) such as wind, rainfall and temperature, and oceanography (conditions of the sea) such as tides, currents, and waves.

Events vary in magnitude (size) and duration (time). They may last from hours up to several days.

Annual Exceedance Probability (AEP) – on average, the probability of an event occurring in any given year. A higher AEP means it is more likely the event will occur in any one year.

The 10%, 5% and 1% AEPs have been modelled for the following time periods: present day, 2040, 2070 and 2100.

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A range of storm "events" were modelled and included smaller magnitude storm conditions which are generally more frequent (likely to occur), and larger magnitude storm conditions that are generally less frequent (unlikely to occur). Events were also modelled for different sea level rise scenarios, reflecting sea level rise projections to 2100 as well as different catchment flows.

Planning horizon	Sea level rise (m)	Event (AEP)
2021 (Present day)	0.0	10%
		5%
		1%
2040	0.2	10%
		5%
		1%
2070	0.5	10%
		5%
		1%
2100	0.8	10%
		5%
		1%
2100	1.1	10%
		5%
		1%
2100	1.4	10%
		5%
		1%

The assessment considers:

Multiple event likelihoods

Smaller, more frequent events through to larger, less likely events

Multiple sea level rise scenarios (planning horizons)

0.0 m (Present day)

0.2 m (2040)

0.5 m (2070)

0.8 m (2100)

1.1 m and 1.4 m (2100, based on recent global estimates)

The model results provide coastal hazard estimates ("hazard extents") which can be mapped to help determine areas along the Cape to Cape coastline that may be exposed to coastal inundation, erosion and sea level rise.

Estimates use local ground surface elevations to understand possible flow paths and associated flooding, and erosion responses based on shoreline profiles.

For each hazard type, all future hazard extents have been estimated based on "present day" ground and seabed elevations (topography and bathymetry).

Estimates do not consider possible future shoreline changes as part of

We can explore vulnerability and risk, by considering the values, uses and infrastructure located in the identified hazard areas. This can highlight how vulnerability and risk varies for different hazard types, weather events, climate conditions and over different timeframes.

We use this exposure analysis to inform the risk and vulnerability assessment, determining where adaptation (hazard mitigation) might be necessary.

This approach allows us to understand the emerging exposure and risk, for more frequent (typical) events and more extreme events, as well how these change into the future.

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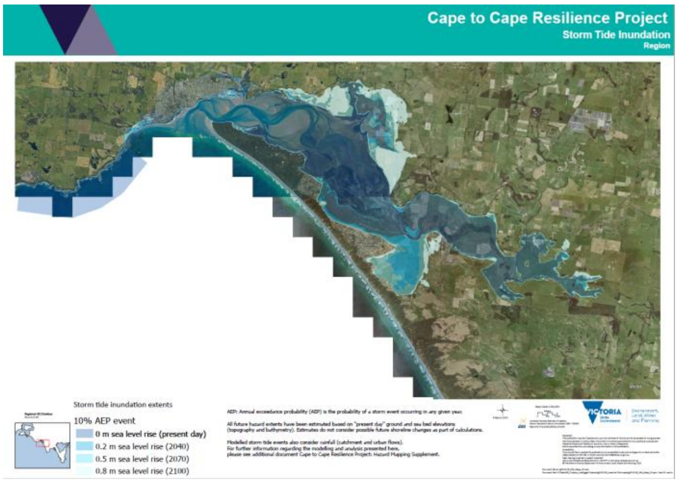
Inundation mapping

Mapped inundation bands represent areas that may be prone to periodic inundation from storms due to local weather conditions, combining flooding from the sea with rainfalls. Inundation is event based and temporary (short-term flooding).

The mapped bands provide an indication of areas that may be impacted by inundation (without any intervention) and identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a permanent loss of coastal land.**

Storm tide has been mapped by:

- Planning horizon (sea level rise scenario)
- Storm event (AEP)



Example map for temporary, event-based inundation

Mapping for each planning horizon (sea level rise scenario)

e.g. All AEP events for 0.2 m sea level rise (2040)

Inundation bands	Event*
	10% AEP
	5% AEP
	1% AEP

*Reflects storm-tide event probabilities, with a combined rainfall event.

Mapping by storm event

e.g. 1% AEP inundation event for all planning horizons

Inundation bands		Planning horizon
	0 m sea level rise	Present day
	0.2 m sea level rise	2040
	0.5 m sea level rise	2070
	0.8 m sea level rise	2100

Approach and assumptions

Modelled storm tide events also consider rainfall (catchment and urban flows). This emphasises possible storm tide impacts by reflecting the limited capacity (space) for inland areas and networks to handle coastal flooding during storm events.

Storm tide event	Rainfall event
10% AEP	1% AEP catchment flow event and a 1% AEP urban flow event
5% AEP	
1% AEP	10% AEP catchment flow event and a 20%* AEP urban flow

*20% AEP urban flow event has been nominated based on standard design capacity of typical urban stormwater networks. This applies to Inverloch township.

In the Cape to Cape study area there are some catchment and coastal storms event that are unlikely to occur at the same time, due to the local weather processes (such as pressure systems) that are required to generate the different types of storms.

For example, a 1% AEP storm tide event and 1% AEP catchment flow (rainfall) event are known to be very, very unlikely to occur together. As these storm combinations are unlikely, they were not modelled together as they would provide limited insight of future conditions.

While not included on these maps, increased projected sea level rise scenarios have also been assessed and included the inundation analysis (i.e. 1.1 m and 1.4 m).

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Erosion inundation mapping

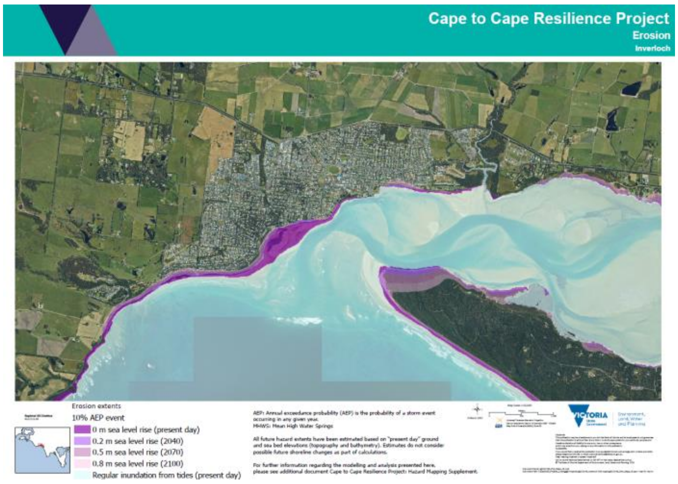
Mapped erosion bands represent areas that may be prone to short and/or longer-term coastal erosion processes.

The bands provide an indication of areas that may be impacted by erosion (in the absence of intervention) and assist to identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a predicted loss of coastal land.**

The approach to the erosion modelling has followed the leading practice techniques for determining erosion hazard areas. Estimation methods have included consideration of shoreline classes (sandy shorelines, low-earth scarp, hard and soft earth).

Storm tide has been mapped by:

- Planning horizon (sea level rise scenario)
- Storm event (AEP)



Example map for temporary, event-based erosion

Mapping for each planning horizon (sea level rise scenario)

e.g. All AEP events for 0.2 m sea level rise (2040)

Erosion bands	Event
(dark purple)	10% AEP
(light purple)	5% AEP
(pale pink)	1% AEP

Mapping by storm event

e.g. 1% AEP erosion event for all planning horizons

Erosion bands	Planning horizon	
(dark purple)	0 m sea level rise	Present day
(light purple)	0.2 m sea level rise	2040
(mauve)	0.5 m sea level rise	2070
(pale pink)	0.8 m sea level rise	2100

Approach and assumptions

Erosion hazard extent estimates consider:

- Short term shoreline change arising due to storms
- Long term shoreline change based on ongoing trends and fluctuations
- Shoreline response to sea level rise (shifting further landward due to increasing water levels and waves reaching further inland), based on shoreline elevation and shape, type (i.e. sand, rock, cliff etc.) and how it might respond to wave action.

The Erosion Hazard Zone is estimated based on erosion rates at three different timescales

Erosion Hazard Zone	= **Short Term** storm event change	+ **Long Term** historic change	+ **Long Term** future change due to sea level rise

For this analysis "long term shoreline change" is based on an assessment of aerial imagery between 1950 and 2021 (~70 year period).

While not included on these maps, higher erosion rates and increased sea level rise scenarios (i.e. 1.1 m and 1.4 m) have also been assessed and included the erosion analysis.

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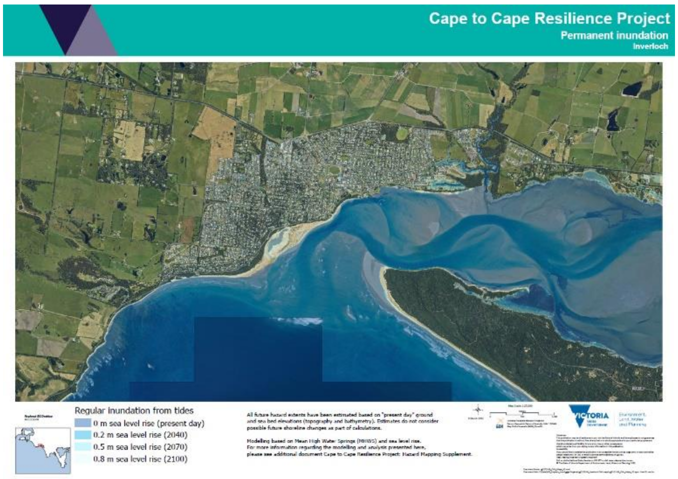
Permanent inundation

Regular inundation from tides

Mapped areas of permanent inundation due to sea level rise represent areas that are likely to be prone to regular inundation by tidal patterns.

The mapped bands provide an indication of areas that may be impacted by increasing sea levels (in the absence of intervention) and assist to identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a predicted loss of coastal land.**

> **Tidal range** – the difference between the water level at high tide and the previous or following low tide water level.
>
> **Spring tides** – larger tides, when the tides' range is at its maximum. Occur on full or new moon phases.
>
> **Neap tide** – smaller tides, when the tides' range is at its minimum.
>
> **Mean High Water Spring (MHWS)** –the highest water level reached by spring tides, under average meteorological conditions.



Example map for regular inundation from tides

Local Mean High Water Springs (MHWS) water levels, also incorporating up to 0.8 m sea level rise by 2100, have been used to represent regularly occurring water levels due to tides.

Regular inundation from tides= MHWS + sea level rise

Local MHWS conditions

		(in metres AHD)		
Tidal Plane	**Stony Point**	**Venus Bay (Offshore)**	**Inverloch Jetty**	**Tarwin Lower Jetty**
Mean High Water Spring (MHWS)	1.15	1.00	0.94	0.95

Mapping by sea level rise scenario

Regular inundation from tides – bands		Planning horizon
	0 m sea level rise	Present day
	0.2 m sea level rise	2040
	0.5 m sea level rise	2070
	0.8 m sea level rise	2100

What does it mean if things are showing up inside a hazard band? (i.e. roads, houses, habitats)

Just because an asset, value or something we use is showing up inside a hazard band, doesn't mean we need to panic. The hazard bands provide an indication of areas potentially at risk from coastal hazard events. They do not represent a predicted loss of coastal land or loss or damage to values and assets.

These hazard bands can highlight areas that may potentially be impacted by different coastal hazard types if no efforts were made to change how we manage these areas. They help us to identify focus areas for adaptation actions, by allowing us to quantify exposure, vulnerability and risk and inform strategic decisions for the future management of these areas.

They are also attempting to predict possible conditions well into the future, so this means we have some time to allow us to carefully and proactively plan our response to these future hazards.

What sea level rise scenarios are we using and why?

Global sea levels are expected to rise between 0.61 and 1.10 metres by 2100 above 1986-2005 levels under a high-emissions scenario, with a global average 0.84 metres.

Victoria's policy setting requires planning for not less than 0.8 m sea level rise by 2100.

> Policy 6.1 of the Marine and Coastal Policy states "Plan for sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, flooding, coastal processes and local conditions such as topography and geology, when assessing risks and coastal impacts associated with climate change."

Our modelling and assessment has considered six different sea level rise scenarios:

- 0.0 m (Present day)
- 0.2 m (2040)
- 0.5 m (2070)
- 0.8 m (2100)
- 1.1 m and 1.4 m (2100, based on recent global estimates)

While each sea level rise projection has been linked to a time period, the stated time is indicative and may need to be revised as more localised sea level projections are developed and/or updated.

The mapping presents 0.0 m, 0.2 m, 0.5 m and 0.8 m scenarios, while our detailed analysis in the Inverloch Region Coastal Hazard Assessment (CHA) also includes consideration of 1.1 m and 1.4 m scenarios.

How accurate are these hazard bands and the modelling?

The coastal models we use have been developed based on extensive scientific knowledge and research. However, they can only provide a simplified representation of the real world. While there are some limitations in the models and the model results, computer models help to improve our understanding and fill knowledge gaps.

We take a cautious approach to understanding coastal hazard exposure and risk. This means our modelling and analysis is conservative (i.e. may overestimate hazards in some areas) and includes a range of assumptions to estimate hazards and the response of different parts of our shoreline.

This project has allowed us to develop and refine modelling and analysis specifically for the Cape to Cape region, giving us a more detailed understanding our local hazards. This means we now have some of the most up-to-date hazard modelling in Victoria. As a result, it has helped to reduce some of our uncertainty of the current and future coastal environment and allows us to make informed decisions on how we manage these coastal areas.

Cape to Cape Resilience Project

What do you mean by "AEP event" and what's the difference between a 10%, 5% and 1% AEP?

AEP is the Annual Exceedance Probability – on average, the probability of a storm event occurring in any given year. A higher AEP means it is more likely the event will occur in any one year. The 10%, 5% and 1% AEPs have been modelled for the following time periods: present day, 2040, 2070 and 2100.

The percentage values are statistical probabilities, based on analysis of measured and modelled data of local conditions. If we compare the 10% AEP and a 1 % AEP events:

- A 10% AEP event is smaller in size (magnitude) and happens more regularly – it has a 10% chance of occurring in any given year.
- A 1% AEP event is bigger in size (magnitude), and less likely to occur (lower statistical probability). It will likely result in more impacts and damage arising due to the event.

Looking at a range of weather events of various AEPs, allows us to establish an understanding and to quantify potential impacts of more frequent events as well as more unlikely events. Often, experiencing several smaller events can result in higher management costs and impacts that a single big event, due to needing more regular maintenance, repairs and clean-up efforts, despite the storm being smaller in size.

When these storm events occur, how long do the hazard impacts last?

The event duration depends on the hazard type. Some of these bands represent short term event-based scenarios that have more temporary impacts. For example, storm tide inundation events might flood some of the lower-lying areas, but then the water levels drop once the storm is over, and the tides go down (generally over a day or two). Similarly, a storm may cause some event-based erosion on the beach (storm-bite), but over time, the beach gradually recovers during calmer conditions.

There are other hazards that have longer lasting impacts. With rising sea levels, some low-lying areas may start to get regularly inundated due to tidal processes, rather than just in storms. This is a more permanent change. Also, some eroded shorelines may not be able to fully recover back to their previous conditions following a storm, due to changes in conditions, such as a reduction or loss of sediment (sand) supply, resulting in the progressive retreat of shoreline position over time.

ISBN 978-1-76105-935-3 **(pdf/online/MS word)** (to be displayed exactly as shown)

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