5.1.5 Victoria

Key findings

- Between 27,600 and 44,600 residential buildings in Victoria may be at risk of inundation from a sea-level rise of 1.1 metres and storm tide associated with a 1-in-100 year storm.
- The current replacement value of the residential buildings at risk is between $6.5 billion and $10.3 billion.
- Local government areas (LGA) of Kingston, Hobsons Bay, Greater Geelong, Wellington and Port Phillip collectively represent close to 70 per cent of the residential buildings at risk in Victoria
- There are approximately 4,700 residential buildings located within 110 metres of 'soft' erodible shorelines.

The population context

Almost a quarter of Australia's population resides in Victoria.[67] A significant proportion live along the urban coast of metropolitan Melbourne (including the Mornington Peninsula) and Geelong, with increasing population growth in regional coastal communities, such as the Surf Coast LGA.

In 2007–08, the largest population growth and highest rate of increase in Victoria occurred in the outer suburban LGA of Wyndham (increase of 8,900 people), which is located on a coastal plain on the western side of Port Phillip Bay.[68] Wyndham has been identified as an urban growth corridor in *Melbourne 2030* [69], and will also be the location of *Wyndham Harbour*, a new $440 million waterfront development.[70]

In regional Victoria, the highest rate of growth is along the coast. In 2007–08, the Greater Geelong LGA had the largest population growth (increase of 3,000 people).[71] This continued the growth trend of the previous decade (1996–2006) during which the population increased by over 22,000 people.[72] The coastal LGAs of Surf Coast (3.6 per cent), Bass Coast (2.3 per cent) and Queenscliff (2.2 per cent) showed the fastest population growth in regional Victoria in 2007–08.[73]

The nature of the coast

About a quarter (24 per cent) of the Victorian open coast is hard rock shore, the majority of which is classified as cliffed, reflecting in part the exposure of the western Victoria coast to high wave energy. While a large proportion is classified as sandy coast, much

Photo credit: Victorian Government Department of Sustainability and Environment

Erosion along Ninety Mile Beach.

of this is also classified as rocky coast with at least 20 per cent of the coast being sandy beaches backed by bedrock. These may erode but will not exhibit significant shoreline recession except where the rock is a soft-rock type.[74]

Over 29 per cent of the Victorian open coast is sandy coast backed by soft sediment, with potential for significant shoreline retreat with sea-level rise. Ninety Mile Beach in East Gippsland is an example of this type of coast and was significantly eroded in 2007.

Cliffed soft-rock shores are also a notable feature of the Victorian open coast (6 per cent) compared to most other states; these include the well known soft limestone coasts near Port Campbell which are actively receding and can be expected to recede faster with sea-level rise.

Muddy shores (which include many muddy-sand tidal flats) figure significantly in Victoria (33 per cent), albeit these include shores in Corner inlet and Westernport Bay which arguably are not open coast shores but coastal re-entrants. Nevertheless these are shores with high potential for mobility with sea-level rise, including significant retreat. Subsidence may also add to this potential in the area around Corner Inlet.[75]

Photo credit: A.D. Short

Dutton Way in Portland.

Existing risk

Coastal areas in Victoria already have some risk of exposure to natural hazards without the compounding effects of climate change. For instance, Lakes Entrance in East Gippsland is a low-lying town vulnerable to inundation from flooding and storm surge (Box 5.7).

Coastal erosion can also be of concern for some beaches due to the dynamic nature of the coastline and the impacts of development. For instance, a 4.5 kilometre sea wall has been built along Dutton Way in Portland to halt coastal erosion that threatened a road. The erosion is thought to have been caused by a breakwater that was built in 1960.[76]

A number of beaches around Port Phillip Bay are also affected by erosion. A recent report[77] has prioritised 30 beaches for nourishment projects around the Bay to address coastal erosion. The top seven prioritised beaches include Altona, Elwood, Mt Martha North, Portarlington, North Aspendale, Half Moon Bay and Eastern Beach Geelong. Initial cost estimates for nourishment of these seven beaches alone is more than $6 million.[78]

Photo credit: Newspix/Andrew Batsch

Mt Martha Beach, Victoria.

Box 5.7 Gippsland Lakes and Lakes Entrance

One of the most vulnerable coastal areas in Australia is that of the Gippsland Lakes including Ninety Mile Beach and Corner Inlet. Many of the issues confronting this region are detailed in a report to the Gippsland Coastal Board.[79] A narrow and in part receding coastal barrier naturally blocks off low-lying islands and coastal flats bordering the lakes (Figure 5.22).

As was shown in 2007, the region is subject to a convergence of driving forces. Catchment riverine floods raise lake levels that have difficulty escaping to the sea through the 'trained' entrance at Lakes Entrance at times of high tide coupled with a storm surge accompanying high waves. Strong local winds act to raise water levels in the down-wind sections of the lakes enhancing the flooding effects.[80] The result is extensive inundation of low-lying townships, such as Lakes Entrance.

Historical records show that flood levels at Lakes Entrance have reached 1.8 metres AHD. Much of the terrain on which this township has developed is situated below this level[81], as shown by the visualisation of 1.8 metre AHD flooding in Figure 5.23. Added to the existing risk for the region are the compounding possibilities of continued land subsidence facilitating more barrier recession and inundation in the southern part of the region. A breach of the Ninety Mile Beach barrier, exposing the lakes to a new tidal inlet and salinisation, together with the impacts of rising sea levels (especially as the warm East Australian Current moves farther south) and enhanced effects of storm surges are likely to lead to collapse of existing lake ecosystems and changes to land use in east Gippsland.

Photo credit: Victorian Government Department of Sustainability and Environment

Figure 5.22 Eroding beach and dune at Ninety Mile Beach south of Seaspray in 2007 showing an exposure of exhumed tidal flat and backbarrier sediments as the sand barrier recedes landwards.

Figure 5.23 Simulated 1.8m AHD flooding in Lakes Entrance. Source: Wheeler et al. 2007[82]

Source: Gippsland Coastal Board 2008[83]; Wheeler et al. 2007[84]

Methodology – key points and caveats

- Inundation analysis is based on 1.1 metres of sea-level rise using medium resolution elevation data.
- A *storm tide allowance* (1-in-100 year event) based on CSIRO modelling is included in the analysis for Tasmania, Victoria and New South Wales, although storm tide values for New South Wales are likely to be underestimates as they do not include a wave setup component.
- For the other states where the CSIRO modelling was not available (Queensland, Western Australia, Northern Territory, and South Australia) an allowance for *modelled high water level* (e.g. high tide) was included in the analysis.
- The analysis does not take account of existing coastal protection, such as seawalls, or riverine flooding associated with intense rainfall events.
- The inundation analysis is of existing residential buildings only (sourced from NEXIS database).
- More detailed analysis may change the relative order of local government areas and the magnitude and timing of projected impacts.
- Refer to Chapter 3 for further details.

Climate change risk to settlements

Inundation analysis suggests that between 27,600 and 44,600 residential buildings in Victoria may be at risk of inundation from a sea-level rise of 1.1 metres and storm tide associated with a 1-in-100 year storm. Based on this analysis, Victoria has the third highest number of residential buildings at risk of inundation in Australia. The current replacement value of the residential buildings at risk is between $6.5 billion and $10.3 billion.

Local government areas that have the greatest level of risk are Kingston, Hobsons Bay, Greater Geelong, Wellington and Port Phillip, which represent close to 70 per cent of residential buildings at risk in Victoria (upper range; Figure 5.24). With the exception of Wellington, all four LGAs are located on Port Phillip Bay.

Inundation footprints of Altona in Hobsons Bay LGA and Geelong are shown in Figures 5.25 and 5.26.

Between 6,400 and 9,000 buildings in the LGA of Kingston may be affected by storm tide by 2100, with the upper range representing 30 per cent of the current residential building stock. While the LGA of Queenscliff has a relatively smaller number of buildings at risk in comparison to Kingston, a quarter of the existing residential building stock may be at risk of storm tide inundation by 2100. A significant proportion of residential buildings in Hobsons Bay, Wellington and Port Phillip may also be at risk, with the upper estimates representing between 17 per cent and 22 per cent of the current building stock.

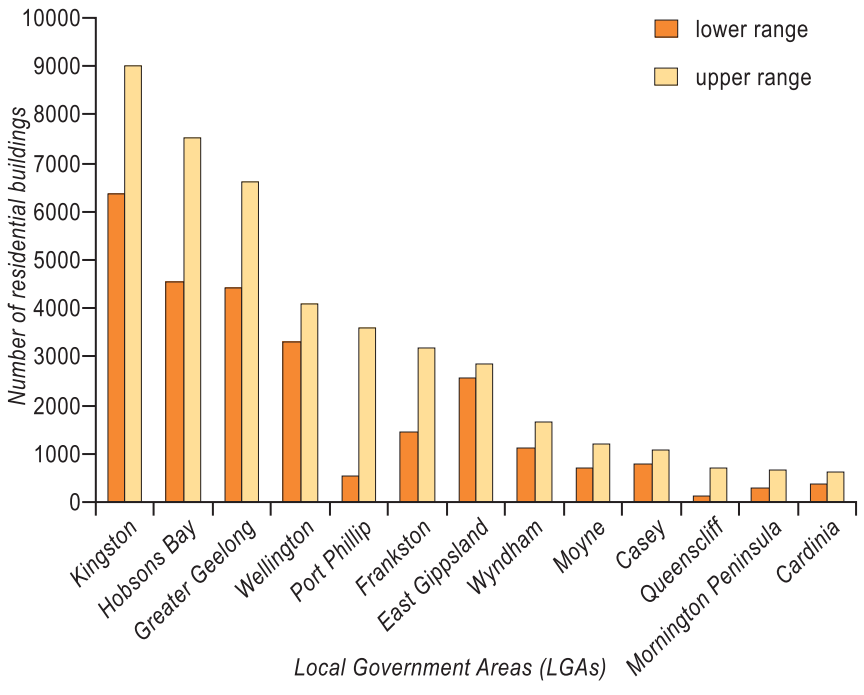

Figure 5.24 Estimated number of existing residential buildings in Victoria at risk of inundation from a sea-level rise of 1.1 metres and 1-in-100 year storm tide.

Figure 5.25 Images of Altona (Hobsons Bay LGA) in 2009 and with simulated inundation from a sea-level rise of 1.1 metres and a 1-in-100 year storm tide using medium resolution elevation data (not suitable for decision-making). © CNES 2009 / imagery supplied courtesy of SPOT Imaging Services and Geospatial Intelligence PTY LTD

Figure 5.26 Images of Geelong (Greater Geelong LGA) in 2009 and with simulated inundation from a sea-level rise of 1.1 metres and a 1-in-100 year storm tide using medium resolution elevation data (not suitable for decision-making). © CNES 2009 / imagery supplied courtesy of SPOT Imaging Services and Geospatial Intelligence PTY LTD

Approximately 15 per cent of the residential buildings in the LGA of Moyne in south west Victoria may also be at risk of inundation by storm tide. The small coastal town of Port Fairy accounts for some of this risk, with recent modelling of sea-level rise, storm tide and increased rainfall intensities highlighting the compounding effects of climate change impacts (Box 5.8).[85]

The Port Phillip LGA, which has the fifth highest level of risk in Figure 5.24, has been the focus of a recent study of the potential impacts of climate change (refer to Box 5.9). Mapping of storm surge and sea-level rise projections in the City of Port Phillip identified the St Kilda foreshore and the area immediately surrounding the Elwood Canal as being particularly vulnerable to inundation.[86] The study also noted the compounding effects of stormwater flooding during severe storms.

Four of the five local government areas that comprise the Western Port Region (Frankston, Casey, Mornington Peninsula, Cardinia and Bass Coast) are within the top LGAs shown in Figure 5.24. A recent study[87] of the impacts of climate change in the region found that the extent of inundation from a 1-in-100 year storm surge event could increase by up to 63 per cent by 2070, with implications for approximately 1,000 existing dwellings (Refer to Box 5.10).

Although the inundation analysis for this report has not included analysis of commercial buildings and transport infrastructure, these assets will also be at risk of inundation. The recent study of the Western Port Region[88] identified that the inundation exposure of roads is expected to increase by 73 per cent by 2070, with an additional 37 kilometres of roads potentially exposed to 1-in-100 year storm surge events. Sections of the Nepean Highway and other public infrastructure could also be exposed to 1-in-100 year storm surge events, as could the Blue Scope Steel industrial facility, some Esso/BHP Billiton facilities in Hastings, and the Harwood aerodrome in Casey.

The recent Port Phillip study (Box 5.9) also identified a number of commercial and tourist areas that may be affected by the combined effects of storm surge inundation and storm water flooding, including the commercial and tourist precinct of Acland Street, the Catani Gardens, St Kilda Sea Baths, The Esplanade and Beaconsfield Pde, and the St Kilda Marina.[89]

Erosion due to higher sea levels is also a key risk for coastal areas. There are approximately 4,700 residential buildings located within 110 metres of 'soft', erodible shorelines in Victoria, of which approximately 550 are located within 55 metres of 'soft' coasts. Of the coastal LGAs, the Mornington Peninsula has the highest number, with approximately 1,140 residential buildings within 110 metres, and 90 within 55 metres of 'soft' shorelines (Figure 5.27). Similarly, the Greater Geelong and Bayside LGAs have approximately 750 and 620 residential buildings, respectively, within 110 metres of 'soft' coast. There are also properties along the barrier dunes of Ninety Mile Beach in Gippsland that would be at risk; many more would be exposed around the lakes if the sand barrier was breached and a new inlet created. In the absence of coastal protection measures or other adaptation responses, these buildings may be at risk of increased erosion with sea-level rise and storm surge due to their location and the nature of the shoreline.

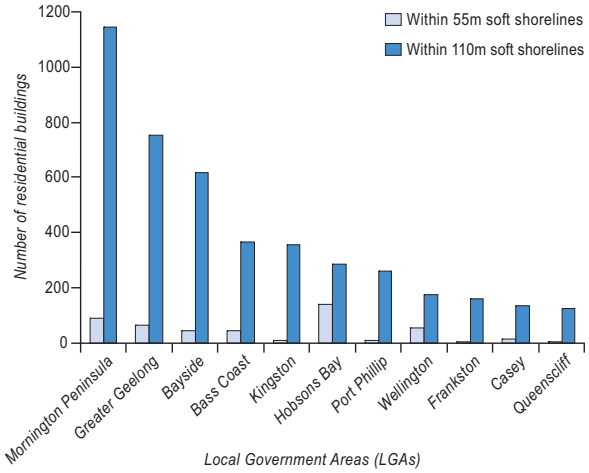

Figure 5.27 Number of residential buildings located within 55 metres and 110 metres of 'soft' shorelines in Victoria.

Box 5.8 Port Fairy regional flood study

The coastal town of Port Fairy in the LGA of Moyne is vulnerable to climate change, particularly sea-level rise and higher rainfall intensity. Modelling of three scenarios of sea-level rise, storm surge and higher rainfall intensities highlight the potential for significant impacts by 2100 under future climate change. As shown in the below table, the number of properties at risk of inundation could increase significantly with climate change.

The study also highlighted the potential shift in the frequency of flood events as a result of climate change. For instance, a 1 per cent AEP (1-in-100 year) event under the current climate could have a shorter recurrence interval with climate change. This has implications for future planning, particularly as flood damage in Port Fairy increases considerably with storm events above the current 5 per cent AEP (1-in-20 year event).

Source: Bishop and Womersley 2009[90]

	Existing climate	Moderate impact scenario	Intermediate impact scenario	High impact scenario
Scenario	1% AEP (1-in-100 year event)	0.4m mean sea-level rise 0.03m storm surge 30% increase in rainfall intensity on 1% AEP	0.8m mean sea-level rise 0.07m storm surge 50% increase in rainfall intensity on 1% AEP	1.2m mean sea-level rise 0.1m storm surge Hydrograph based on estimated 1946 flood characteristics
Above floor flooding	50	114	143	211
Properties inundated	141	110	86	20
Additional dwellings at risk of inundation	-	50	74	286
Total properties subject to inundation	191	274	303	517

Box 5.9 City of Port Phillip – a case study

A recent study has identified that sea-level rise is expected to be the most significant climate change issue for the City of Port Phillip, due to the associated impacts of coastal erosion and storm surge.

A risk assessment of coastal erosion and storm surge highlighted four key risks, including:

- 'Infrastructure instability' due to the potential effects of erosion and storm surge on the base of buildings and infrastructure. Luna Park, the St Kilda Baths, the St Kilda Pier and Marina, and residential properties in the vicinity of the Elwood Canal were identified as being at risk.
- Loss of beaches due to coastal development preventing the landward movement of the shoreline. The Middle Park and St Kilda beaches are considered the most vulnerable.
- Impacts on planning zones, due to the increased exposure from climate change influencing local planning.
- Flooding of coastal properties due to reduced protection from eroded beaches, particularly during severe storms and storm surge events. Property values may be affected as a result.

It is anticipated that the two most significant risks from storm surge up to 2020 will be the impacts on beaches and local planning (in preparation for projected flooding and other impacts in the longer-term), with 'infrastructure instability' also a potential issue from coastal erosion in the short-term. By 2050, flooding of coastal properties is also expected to be a significant risk, with the risk increasing further by 2100.

Mapping of storm surge and sea-level rise projections (refer Figure 5.28) identified areas particularly vulnerable to inundation both now and under climate change. These include the St Kilda foreshore and the area immediately surrounding the Elwood Canal.

It is also important to note that there are an estimated 4,000 residential properties at risk of flooding from waterways and drains under a 'current climate' 1-in-100 year storm event. A 1-in-100 year storm under climate change would impact a larger area.

Figure 5.28 Projected storm surge inundation in the City of Port Phillip (including sea-level rise; based on 2007 data).

Source: City of Port Phillip 2007[91]

Box 5.10 Impacts of climate change on settlements in the Western Port Region

The five local government areas of Bass Coast, Cardinia, Casey, Frankston and Mornington Peninsula form the Western Port region of Victoria. Climate change threats likely to impact the region include coastal inundation and erosion from sea-level rise and storm surge, extreme rainfall and inland flooding, and changes to fire weather conditions.

Simulations undertaken by CSIRO suggest that the extent of inundation from a 1-in-100 year storm surge event could increase by up to 63 per cent by 2070. Within the shorter term (2030), the land area at risk of inundation from storm surge is likely to increase by only 4-15 per cent. In addition, the frequency of such events could increase, with a storm surge associated with a 1-in-100 year storm today potentially becoming a 1-in-20 year to annual storm surge event by 2070.

By 2070, inundation from a 1-in-100 year storm could affect more than 1,000 existing dwellings and property to a value of approximately $780 million[92]. The Mornington Peninsula Shire appears to have the highest level of exposure, accounting for approximately 60 per cent of the exposed population and dwellings in 2070.

The study used sea-level rise scenarios of up to 0.17 metres for 2030 and up to 0.49 metres for 2070, which were combined with wind speed change scenarios to calculate 1-in-100 year storm surge height return levels.

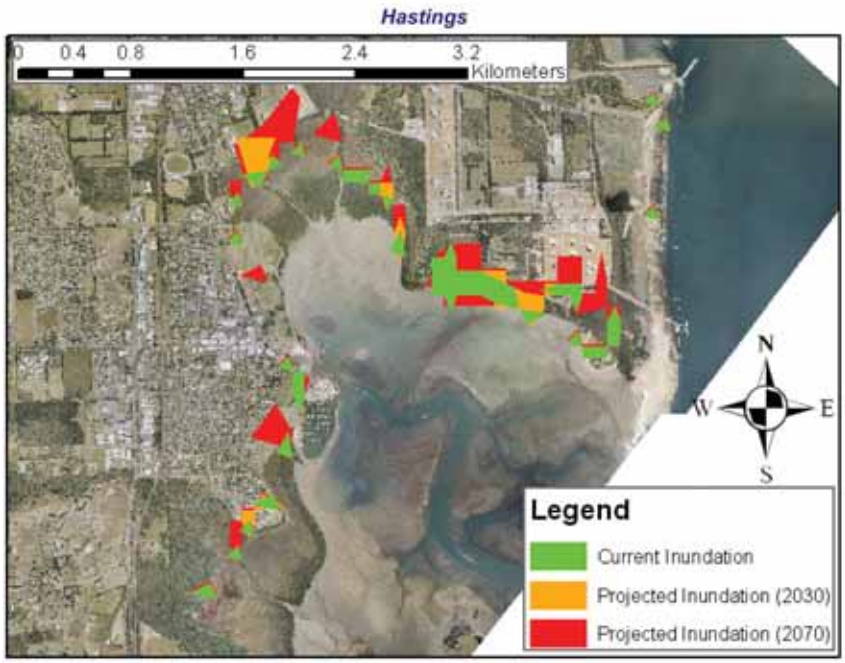

Figure 5.29 Current and projected area of inundation from 1-in-100 year storm surge events in Hastings (Mornington Peninsula Shire Council).

Source: Kinrade et al 2008[93]