



Planning for Sea Level Rise Guidelines

February 2017

Port Phillip and
Westernport
Region



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1 Introduction

Due to increases in ocean warming and loss of mass from glaciers and ice sheets, global mean sea levels will continue to rise during the 21st century (IPCC Fifth Assessment Report 2013). This will increase the risk of coastal hazards, necessitating appropriate planning and building controls for areas at risk of current or future tidal inundation.

Purpose of these guidelines

These *Planning for Sea Level Rise* guidelines set out the specific requirements that apply to development proposals in areas that will be affected by tidal inundation (including storm surge and wave action) as a result of predicted sea level rise. The aim of these guidelines is to ensure that proposed development is compatible with any flood risk.

These guidelines were developed to:

- help property owners, developers, designers and builders to understand the specific requirements that apply in areas at risk of tidal inundation
- detail the relevant considerations to be taken into account by Melbourne Water when assessing development proposals
- provide for consistency and transparency in decision-making.

Consistent with state planning policy to 'plan for possible sea level rise of 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes ...', these guidelines apply to areas that will be affected by tidal inundation within the Port Phillip and Westernport region.

The guidelines detail how the planning benchmarks for sea level rise established for Victoria should be applied to different development types. They establish the predicted future flood levels for Port Phillip Bay and Western Port – the flood levels that Melbourne Water applies for planning purposes. In addition, they specify appropriate freeboard and minimum floor level requirements to ensure flood protection for different development types.

This 2017 revision of the guidelines updates the adopted flood levels for Western Port to reflect the findings of the *Western Port Local Coastal Hazard Assessment* (DEPI et. al. 2015) and Melbourne Water's more recent flood modelling, as well as providing additional detail on general development assessment criteria. These guidelines are intended to form part of a broader response to planning for sea level rise. They will be reviewed and updated as more detailed risk and hazard assessment information becomes available, and in response to any relevant climate change adaptation planning advances.

This document should be used in conjunction with the principles and core requirements contained in Melbourne Water's *Guidelines for Development in Flood-prone Areas* (2007) and any relevant statewide guidelines.

¹ The WPLCHA was commissioned by the Victorian Government's then *Future Coasts* program and delivered by DEPI in partnership with Melbourne Water, South East Councils Climate Change Alliance, Bass Coast Shire Council, Cardinia Shire Council, the City of Casey and the Mornington Peninsula Shire Council.

Get in touch with Melbourne Water — early in the development process



Reviews of tidal data and updates to local coastal hazard assessments may lead to revised flood levels from time to time. Therefore, we recommend that permit applicants obtain up-to-date flood levels relevant to the property prior to commencing detailed planning and design.

We also advise applicants to engage with us early in the design process so that you can get a timely appreciation of any applicable site-specific requirements.

Development Enquiries

Melbourne Water

PO Box 4342,
Melbourne, VIC, 3001

Telephone 131 722

Email land.development@melbournewater.com.au

Flood Level Data

To order flood level information, contact one of the following providers:

SAI Global

saiglobal.com

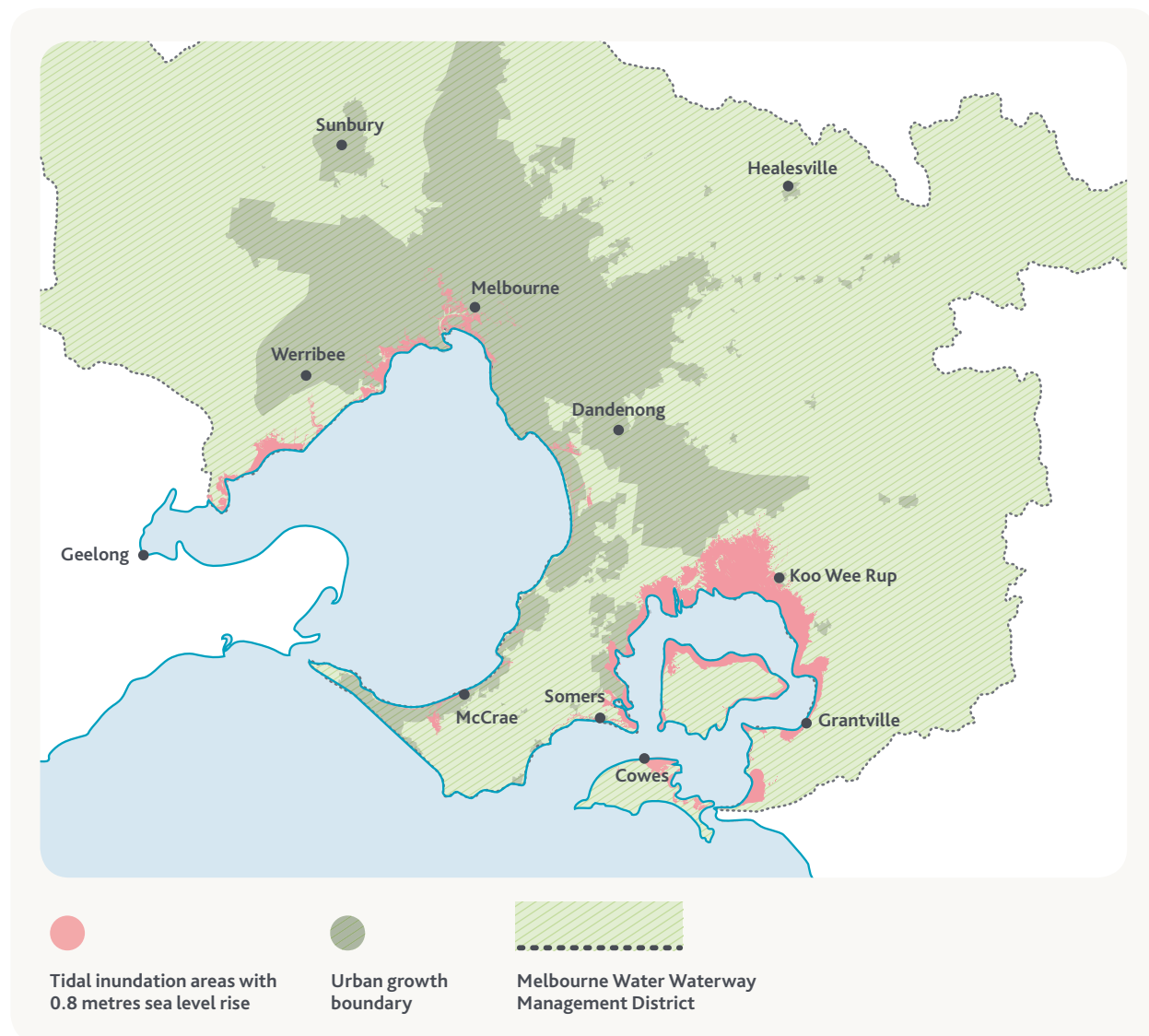
Telephone 1300 730 000

Landata

land.vic.gov.au

Telephone (03) 8636 2456

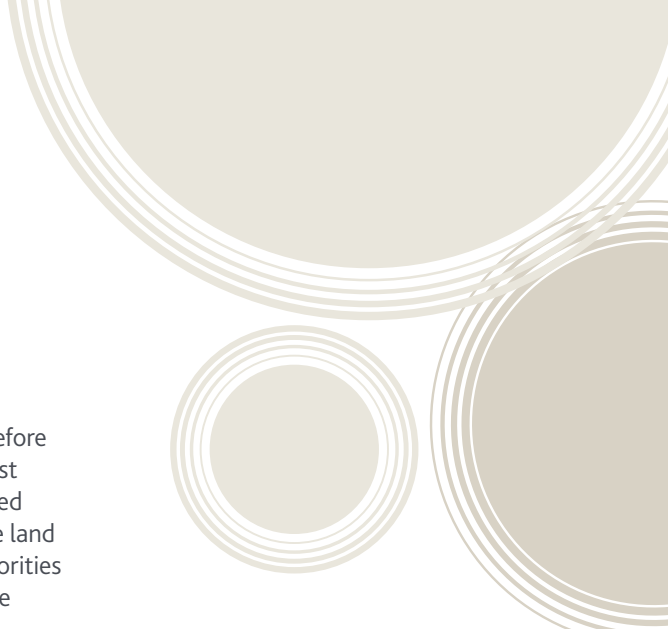
2100 tidal inundation areas in the Port Phillip and Westernport region



Melbourne Water's role in planning for sea level rise

Melbourne Water has floodplain management functions which are established under the *Water Act 1989*, with related functions under the *Planning and Environment Act 1987* and the *Building Regulations 2006*.

As the floodplain management authority, Melbourne Water is a determining referral authority under Section 55 of the *Planning and Environment Act 1987* and Clause 66.03 of the *Victoria Planning Provisions (VPP)* for planning permit applications to develop or subdivide land affected by a flood overlay control in a municipal planning scheme. In this capacity, we assess proposals and ensure developments are compatible with any flood risk through the application of appropriate development requirements.



In the absence of a flood overlay control, Clause 65 of the VPPs states that 'Before deciding on an application or approval of a plan, the responsible authority must consider, as appropriate ... The degree of flood, erosion or fire hazard associated with the location of the land and the use, development or management of the land so as to minimise any such hazard'. These guidelines support responsible authorities in considering flood hazard from predicted sea level rise in accordance with the requirements of Clause 65.

Where flooding information has not been included in the planning schemes and where arrangements have been entered into with councils, we can also provide advice on development proposals under the provisions of Section 52 of the *Planning and Environment Act 1987*.

In certain circumstances, and where we have determined that land is liable to flooding by including advice about predicted sea level rise on a Property Information Statement issued under Section 158 of the *Water Act 1989*, Melbourne Water also has a role in recommending minimum floor levels for building permits issued under regulation 802 of the *Building Regulations 2006*.

The *Victorian Floodplain Management Strategy* (DELWP 2016) clarifies that Melbourne Water is accountable for maintaining guidelines that detail the way in which the state planning policies regarding sea level rise should be applied in the context of the Port Phillip and Westernport region. (These state planning policies are detailed later.)

Our floodplain management role in planning for sea level rise currently does not extend to the consideration of coastal processes contributing to coastal physical vulnerability such as erosion and saline incursion. While councils may also request a coastal vulnerability risk assessment, it is not our role to provide comments and approval on these assessments.

2 Guiding our decisions: sea level rise policy and planning benchmarks

The sea level rise policy and planning benchmarks established for Victoria are set out in state policies and strategies. These provide the strategic basis for Melbourne Water's approach to development assessment.

What guides our development assessment

The Victorian Coastal Strategy 2014

The *Victorian Coastal Strategy* (VCS) (Victorian Coastal Council 2014), made under the *Coastal Management Act 1995*, establishes the sea level rise planning benchmarks and policy for decision-making for Victoria, as summarised here:

- *Plan for possible sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology, when assessing risks and coastal impacts associated with climate change.*
- *In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).*
- *For new greenfield development outside of town boundaries, plan for not less than 0.8 metre sea level rise by 2100.*

The VCS states, 'It is important to note that these benchmarks are for a horizon up to 2100. Sea level rise is likely to continue beyond this horizon'.

The State Planning Policy Framework

When assessing development applications, Melbourne Water must consider the relevant objectives and strategies of the State Planning Policy Framework (SPPF). The SPPF has also assisted in providing the strategic justification for applying the planning benchmarks to different development types, as detailed later in these guidelines.

The sea level rise planning benchmarks for Victoria established in the VCS (above) are given effect as planning strategies in Clause 13.01-1 *Coastal Inundation and Erosion* of the SPPF.



These, and other key strategies of the SPPF relevant to development assessment in planning for sea level rise, are:

Clause 13.01-1 Coastal Inundation and Erosion

- *In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).*
- *Plan for possible sea level rise of 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.*
- *Consider the risks associated with climate change in planning and management decision-making processes.*
- *For new greenfield development outside of town boundaries, plan for not less than 0.8 metre sea level rise by 2100.*
- *Ensure that land subject to coastal hazards are identified and appropriately managed to ensure that future development is not at risk.*
- *Ensure that development or protective works seeking to respond to coastal hazard risks avoids detrimental impacts on coastal processes.*
- *Avoid development in identified coastal hazard areas susceptible to inundation (both river and coastal), erosion, landslip/landslide, acid sulfate soils, bushfire and geotechnical risk.*

Clause 13.02-1 Floodplain Management

- *Identify land affected by flooding, including floodway areas, as verified by the relevant floodplain management authority, in planning scheme maps. Land affected by flooding is land inundated by the 1 in 100 year flood event or as determined by the floodplain management authority.*
- *Avoid intensifying the impacts of flooding through inappropriately located uses and developments.*
- *Locate emergency and community facilities (including hospitals, ambulance stations, police stations, fire stations, residential aged care facilities, communication facilities, transport facilities, community shelters and schools) outside the 1 in 100 year floodplain and, where possible, at levels above the height of the probable maximum flood.*
- *Locate developments and uses which involve the storage or disposal of environmentally hazardous industrial and agricultural chemicals or wastes and other dangerous goods (including intensive animal industries and sewage treatment plants) must not be located on floodplains unless site design and management is such that potential contact between such substances and floodwaters is prevented, without affecting the flood carrying and flood storage functions of the floodplain.*

Planning Practice Note 53

Planning Practice Note 53: Managing coastal hazards and the coastal impacts of climate change (DELWP 2015) provides guidance on planning for coastal development in coastal areas. It summarises sea level rise policy and planning benchmarks as set out in the VCS and given effect in the SPPF to guide statutory planning decision-making. It also details the process for referring a planning permit application or development proposal to a floodplain manager.

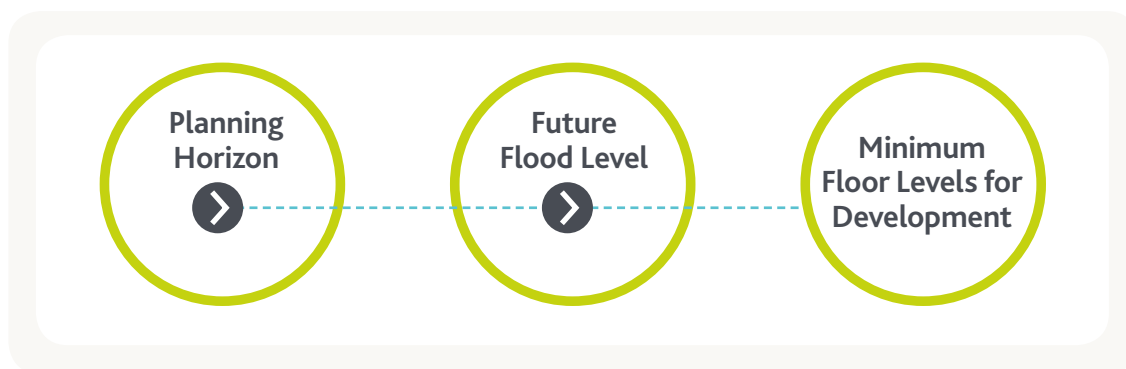
3 Applying the planning benchmarks to development assessment

This section details how the planning benchmarks for sea level rise established for Victoria should be applied to different development types in the Port Phillip and Westernport region.

How we apply the planning benchmarks to different development types

Before assessing an application, we identify the appropriate planning horizon; that is, how far into the future we are planning, and the corresponding future flood level based on current sea level rise projections.

We recommend floor levels be raised above the relevant predicted future flood level.



How we determine the planning horizon

The 1% Annual Exceedance Probability (AEP) flood (that is, a flood with a 1% chance of occurring in any given year) is the current design flood event for the land use planning and building systems in Victoria.

In planning for sea level rise, Melbourne Water adopts either the predicted 2040 1% AEP flood level or the predicted 2100 1% AEP flood level, depending on the planning horizon considered to be suitable for the development.

Consistent with the planning benchmarks, 0.2 metres sea level rise is assumed for developments planned to 2040, whereas 0.8 metres sea level rise is assumed for developments requiring a long-term planning approach, to 2100.

Important flood risk factors

We consider the following important flood risk factors when establishing whether we apply the predicted 2040 1% AEP flood level or the predicted 2100 1% AEP flood level to development assessment:

- the potential for the development to significantly increase flood risk by increasing the potential for property damage or the number of occupants at risk of flooding
- the likely asset life of the development or the ease with which a development could be rebuilt to higher flood protection standards in future
- whether the development is isolated or in a remote rural area
- the proximity and intensity of surrounding development already built to a lower flood protection standard
- the opportunity to apply a long-term planning approach for entire new development areas or redevelopment areas (e.g. greenfield or urban renewal areas)
- the likelihood and practicality of mitigation or adaptation activities being undertaken at some stage in future to protect the area in question
- the sensitivity of a particular use and development to inundation (e.g. hospital or childcare centre).

Predicted future flood levels by development type

The State Planning Policy Framework (SPPF) identifies the need to plan to 2100 and enables planning to 2040 for urban infill. Here, we provide further detail on how to apply the relevant clauses of the SPPF to different development types in the Port Phillip and Westernport region.

Urban infill development

- Single dwellings, dwelling extensions and small multi-unit developments

The majority of applications that Melbourne Water currently assesses in areas affected by future for sea level rise are dispersed urban infill development comprising new or replacement dwellings, minor dwelling extensions and smaller urban subdivisions in established urban areas.

These types of developments may be assessed against the predicted 2040 1% AEP flood level given the proximity of surrounding urban development already built to a lower flood protection standard, and the shorter asset life typical of single dwellings. This approach is consistent with state policy directions.

- Multistorey residential buildings

Multistorey buildings, such as apartment buildings, will be complex to rebuild at the end of the design life of the building. This difficulty in upgrading to future flood protection standards will pose an increased flood risk over time; therefore, a long-term planning approach to 2100 is preferred for these types of buildings.

- Commercial and mixed-use buildings

Standalone urban infill development comprising a retail premises or office will be assessed against the predicted 2040 1% AEP flood level. In the case of multistorey commercial or mixed-use buildings the predicted 2100 1% AEP flood level will be applied.

Greenfield development

Planning policy identifies the need to apply a long-term planning approach to 2100 for new greenfield development. Therefore, greenfield development will be assessed against the predicted 2100 1% AEP flood level. Greenfield development includes the construction of buildings and subdivisions in greenfield areas.

Urban renewal areas

Similar to greenfield development, urban renewal areas provide an opportunity to apply a long-term planning approach to an entire development or redevelopment area. Also, these areas will see an increased number of occupants at risk of flooding in future. Therefore, urban renewal development will be assessed against the predicted 2100 1% AEP flood level.

Emergency, community or hazardous facilities

The SPPF provides for the application of more stringent flood controls to emergency, community and hazardous facilities, including hospitals, ambulance stations, police stations, fire stations, residential aged care facilities, communication facilities, transport facilities, community shelters, schools and buildings associated with hazardous uses, including intensive animal industries and sewage treatment plants or where hazardous chemicals may be stored. For this reason such development will be assessed against the predicted 2100 1% AEP flood level.

Isolated or rural development

For isolated or rural development there is little likelihood of mitigation or adaptation activities being undertaken in future, and therefore these types of development will be assessed against the predicted 2100 1% AEP flood level.

Summary: predicted future flood levels for development assessment

The table below summarises the relevant predicted future flood level to be applied to each development type for development assessment.

Predicted future flood levels for development assessment	
Development type	Predicted future flood level
Urban infill development (single dwelling/retail/office in established urban areas)	2040 1% AEP flood level
Greenfield development Urban renewal area development Emergency, community or hazardous facilities Isolated or rural development All other development	2100 1% AEP flood level

4 Flood levels for Port Phillip Bay and Western Port

This section details the current 1% AEP flood levels adopted by Melbourne Water for Port Phillip Bay and Western Port, as well as the predicted 2040 1% AEP flood level and predicted 2100 1% AEP flood level, on the basis of 0.2 metres and 0.8 metres sea level rise, respectively.

Current adopted flood levels

Port Phillip Bay

Melbourne Water has adopted 1.6 metres AHD as the current 1% AEP flood level for Port Phillip Bay. This level has been determined from a frequency analysis of observed tide levels from a tidal gauging station located at St Kilda Marina. This flood level makes some allowance for wave action.

(For further information on the derivation of the current 1% AEP flood level for Port Phillip Bay, refer to Appendix A.)

Western Port

Following the release of the *Western Port Local Coastal Hazard Assessment* (WPLCHA) (DEPI et.al.) in June 2015, and some additional wind analysis work with inundation modelling, Melbourne Water has updated the Western Port flood levels. As a result, we have adopted graduated 1% AEP flood levels across Western Port, ranging from 2.1 metres AHD at the southern end of the bay to 3.3 metres AHD at the north east shore of Western Port.

Flood levels for Western Port vary from north to south because of its unique hydrodynamic setting. Recent analysis of a range of wind directions has been undertaken to determine peak flood levels around the bay with consideration of storm surge. Together, these comprise the current adopted 1% AEP flood levels for Western Port.

(For further information on the WPLCHA and the additional wind analysis work, refer to Appendix B.)

Predicted flood levels in 2040 and 2100

Port Phillip Bay

For Port Phillip Bay, the predicted 2040 1% AEP flood level is 1.8 metres AHD. This assumes 0.2 metres sea level rise above the current adopted 1% AEP flood level of 1.6 metres AHD.

The predicted 2100 1% AEP flood level is 2.4 metres AHD, assuming 0.8 metres sea level rise.

Western Port

For Western Port, the predicted 2040 1% AEP flood levels range from 2.3 metres AHD to 3.5 metres AHD. This assumes 0.2 metres sea level rise above the current adopted 1% AEP flood levels which range from 2.1 metres AHD to 3.3 metres AHD.

The predicted 2100 1% AEP flood levels range from 2.9 metres AHD to 4 metres AHD. This is based on modelling 0.8 metres sea level rise at the ocean side of the bay; however, because of the bathymetry and wind variations across the bay, this has not resulted in all future flood levels consistently 0.8 metres above current flood levels.

(The predicted 2040 and 2100 1% AEP flood levels, as they vary around Western Port, are shown later in these guidelines.)

Summary: applicable flood levels

This table summarises Melbourne Water's adopted current, and predicted future flood levels for Port Phillip Bay and Western Port.

Applicable flood levels to Australian height datum (AHD)			
Region	Current adopted 1% AEP flood level	Predicted 2040 1% AEP flood level	Predicted 2100 1% AEP flood level
Port Phillip Bay	1.6 metres	1.8 metres	2.4 metres
Western Port			
North east	3.3 metres*	3.5 metres*	4.0 metres*#
South	2.1 metres*	2.3 metres*	2.9 metres*#

* Flood levels for Western Port vary around the bay. Please contact Melbourne Water for site-specific flood levels.

Predicted 2100 1% AEP flood levels for Western Port have been determined from flood modelling and are not a simple addition of 0.8 metres to current 1% AEP flood levels.

Predicted future flood extents

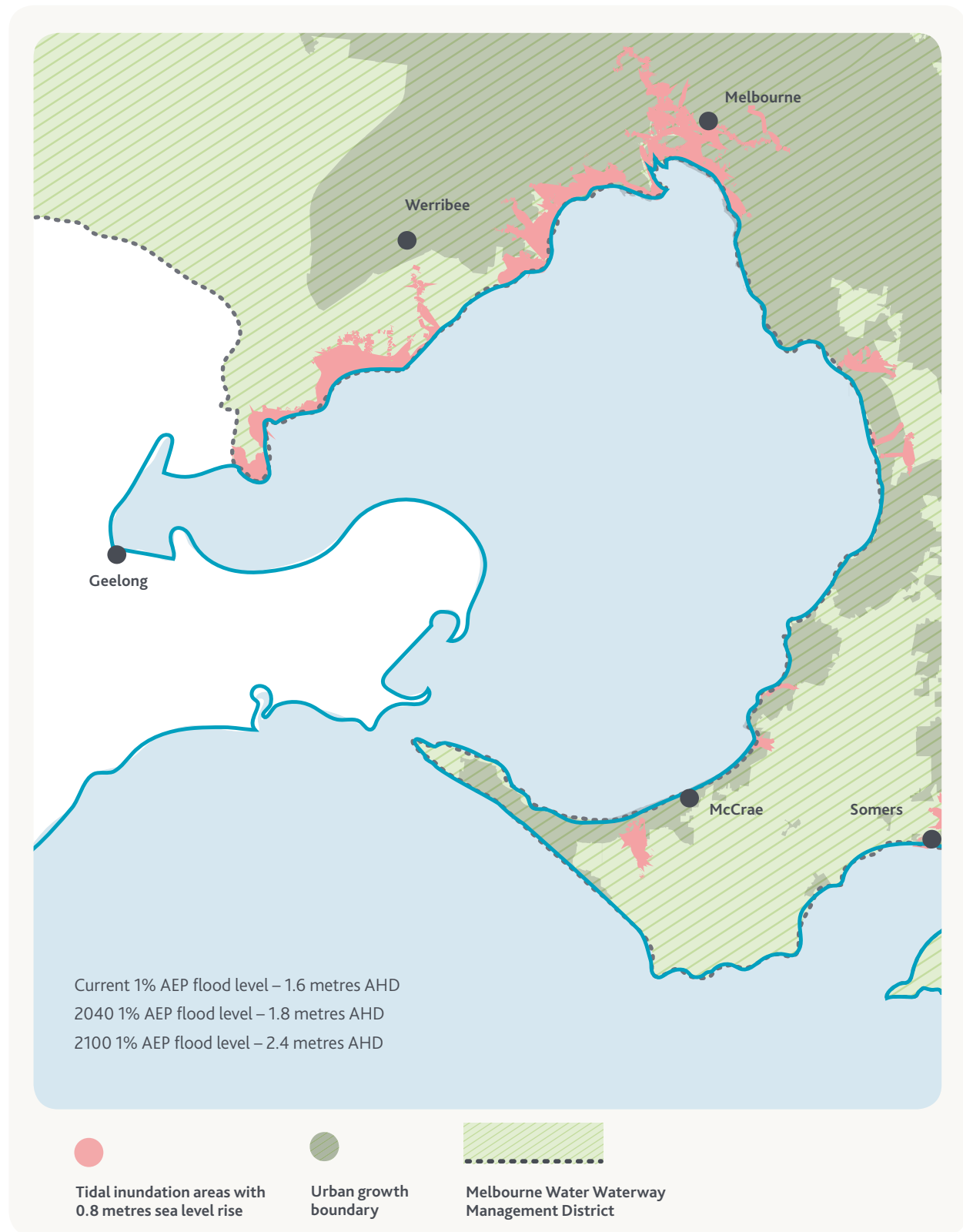
For strategic planning purposes, Melbourne Water has prepared flood extent mapping showing land predicted to be inundated by the 2100 1% AEP flood for Port Phillip Bay and Western Port.

In addition, Melbourne Water has updated Property Information Statements issued under Section 158 of the *Water Act 1989* to identify land liable to flooding from predicted sea level rise.

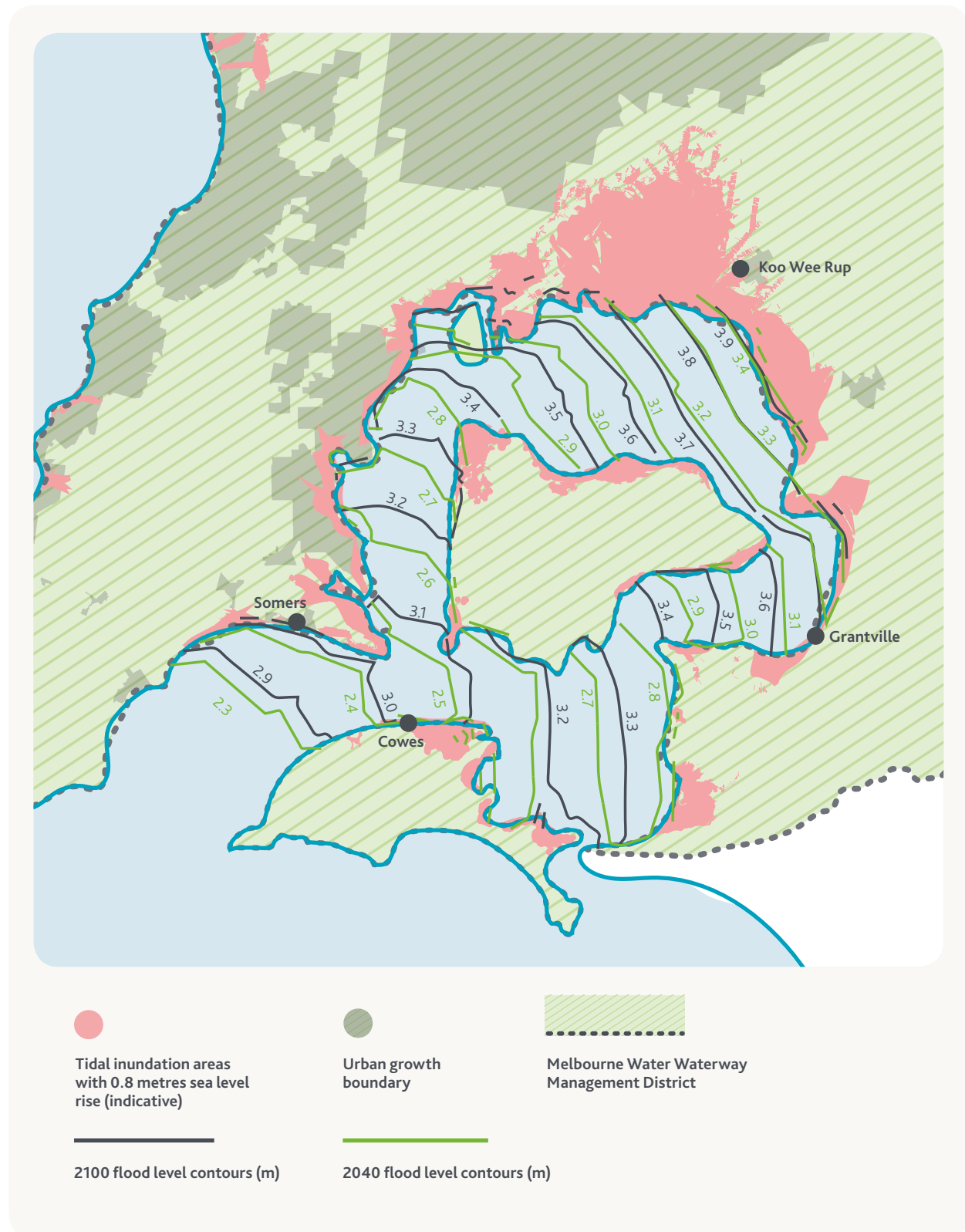
Development applications within these areas should be assessed in accordance with these guidelines to ensure the development requirements are met. (See the next section for development requirements.)

**Disclaimer: The maps contained in this document are indicative only and are not intended for assessment purposes.*

Tidal inundation areas and flood levels for Port Phillip Bay



Tidal inundation areas and flood levels for Western Port





5 Requirements for development

This section includes the requirements that apply to development proposed in areas affected by tidal inundation to ensure people, property and infrastructure are protected from floods. This includes appropriate freeboard and minimum floor level requirements for development.

Areas affected by tidal inundation as well as riverine flooding or overland flows may be subject to additional requirements, in accordance with Melbourne Water's *Guidelines for Development in Flood-prone Areas* (2007).

General requirements

There are a number of requirements that apply to development proposed in areas affected by flooding to ensure that development is compatible with the level of flood risk.

In the context of tidal inundation, the development requirements of most relevance aim to protect people from flood hazards and to protect property or infrastructure from flood damage.

When we assess development proposals, the depth of flooding at a property is an important factor we take into consideration to ensure that site and access safety can be achieved. We also take into consideration the frequency and extent of tidal inundation affecting a site, as well as the distance to high ground.

Due to the tidal nature of extreme sea levels, the duration of a 1% AEP flood event is typically short, and is not as critical a consideration for development as it can be with riverine flooding. Similarly, tidal inundation floodwaters are unlikely to be fast-flowing, and so velocity is also not a critical consideration.

Provided flood depths and risks are not too great, development can proceed with raised floor levels to protect people, buildings and their contents.

Refer to Melbourne Water's *Guidelines for Development in Flood-prone Areas* (2007) for more information on general development requirements.

Freeboard

Freeboard is the difference between the floor level of a building and the 1% AEP flood level. Freeboard requirements are designed to ensure that valuable buildings and their contents, and the people in those buildings, are safely above the 1% AEP flood level. Lifting the minimum floor height reduces the risk of damage to development from inundation.

Under the Victorian Building Regulations 2006, floor level heights for buildings should be set a minimum 300 millimetres above the applicable flood level, or as otherwise determined by the floodplain management authority.

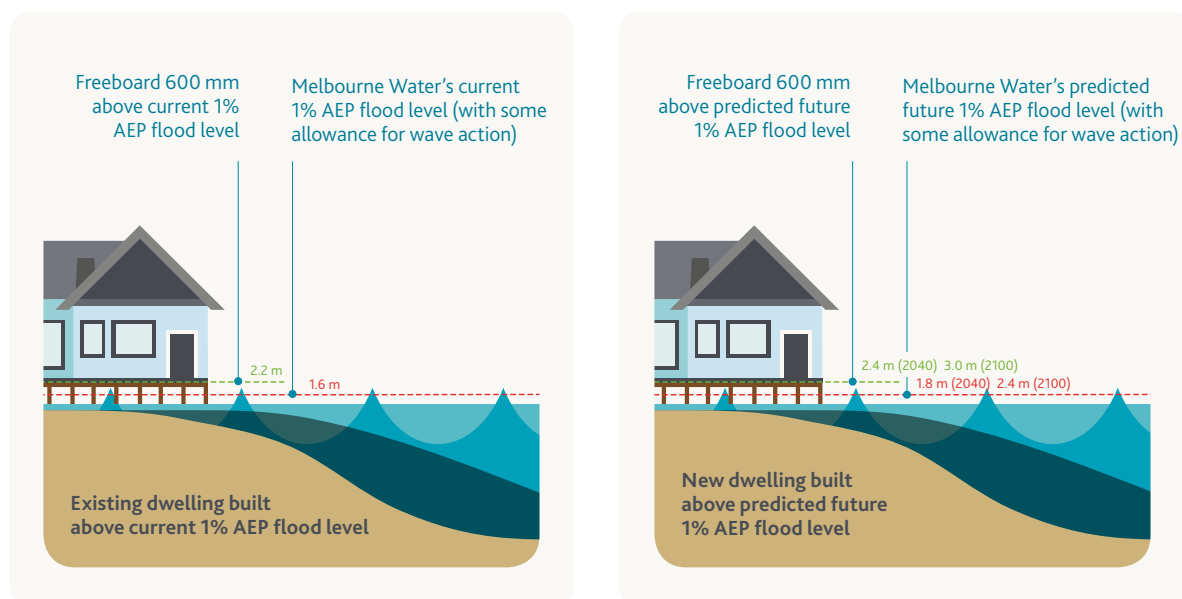
Higher minimum freeboards are required by Melbourne Water to manage increased risk associated with tidal inundation due to wave action and other storm surge activity, and are consistent with our practice in relation to open waterways.

Freeboard requirements for tidal inundation

In areas prone to tidal inundation, building floor levels should be at least 600 millimetres above the relevant predicted future 1% AEP flood level, and floor levels of outbuildings should be at least 300 millimetres above the relevant predicted future 1% AEP flood level.

The freeboard requirement for outbuildings is lower than that required for buildings, on the basis that the impacts from flooding to the contents and uses of outbuildings are usually not as severe.

Freeboard for current and future tidal inundation



Additional freeboard considerations

Subdivisions

For greenfield subdivisions, it is necessary to fill the site to a minimum of 600 millimetres above the applicable flood level.

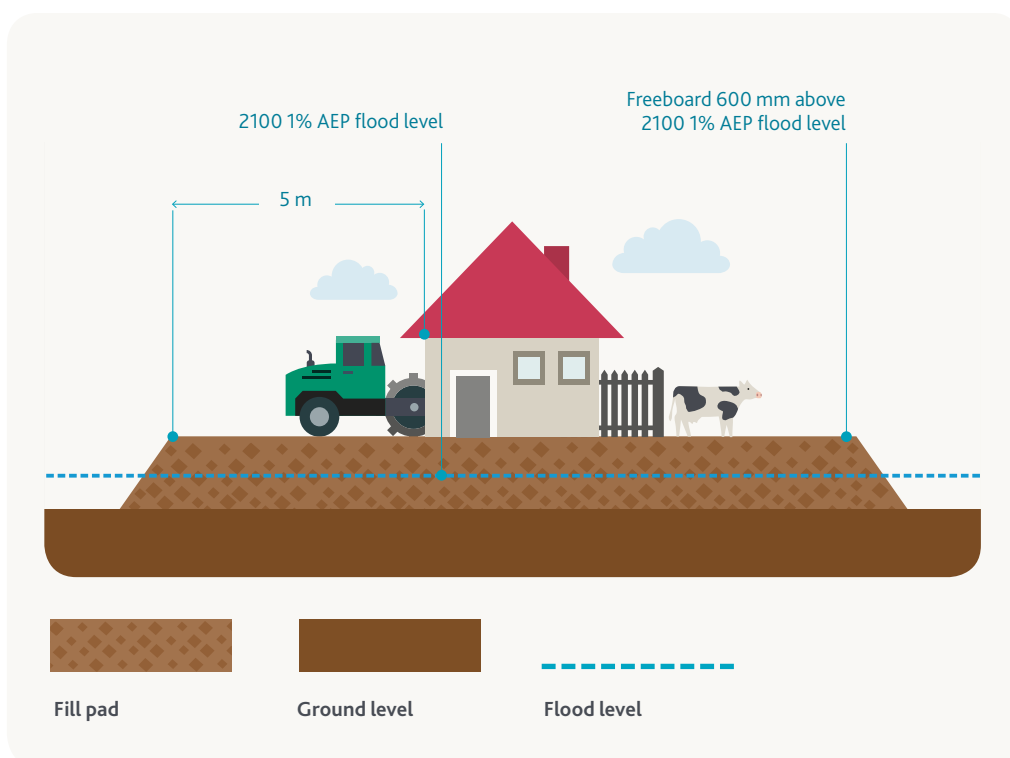
We will assess smaller subdivisions in established urban areas on a case-by-case basis and may support them if compatible with future flood risk.

Isolated or rural development

Fill pads are recommended for isolated or rural development comprising dwellings. Fill pads will provide an area around the dwelling that may act as a place of refuge for livestock and storage for machinery.

A fill pad is required to extend at least 5 metres beyond the building and a minimum of 600 millimetres above the applicable flood level.

Fill pads are not required for non-habitable outbuildings; however, minimum floor level requirements are still applicable.



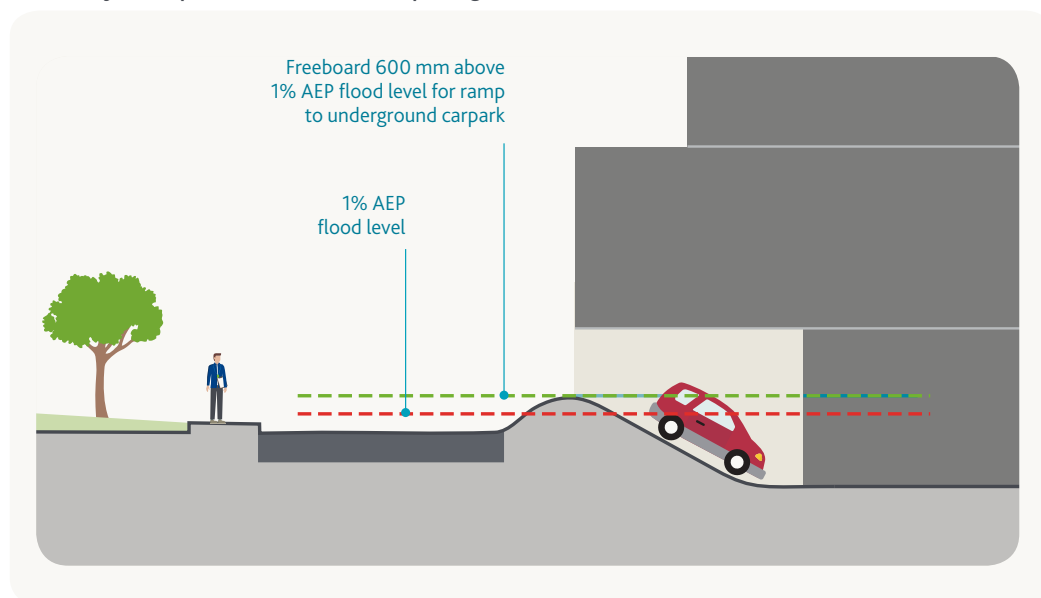
Basements / underground car parks

Entries to basements (non-habitable floors below ground level e.g. underground car parks) with finished floor levels below the relevant predicted future 1% AEP flood level should incorporate a continuous apex of any entry or exit ramp that is at least 600 millimetres above the predicted future 1% AEP flood level.

Melbourne Water does not support the reliance on mechanical mechanisms or other engineered solutions (e.g. flood gates, retaining walls, levees) to achieve appropriate levels of protection because of failure risk.

However, where entry levels cannot be raised above the relevant predicted future flood level due to local constraints, we may allow self-closing flood gates to provide the freeboard protection.

Multistorey development with basement carparking



Floor level concessions

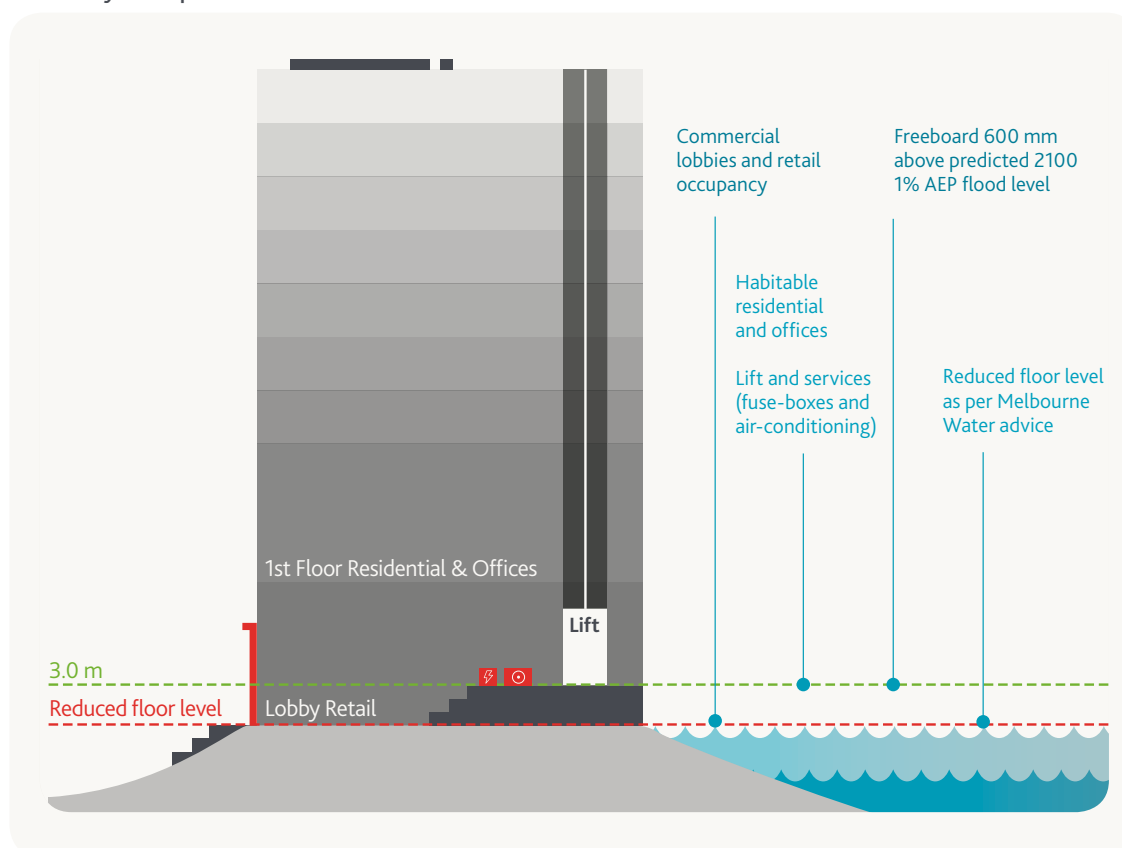
Where we consider that the existing surface levels and design constraints at a proposed development site create access problems, some floor level concessions may apply.

In these cases, a minimum freeboard of 600 millimetres above the predicted 2100 1% AEP flood level will still be required for habitable residential or office floors, and for lifts and services (such as fuse-boxes and air-conditioning). However, minimum floor levels for commercial lobbies and retail occupancies may be marginally reduced at our discretion.

The onus is on the applicant to demonstrate that meeting the minimum floor level requirements will result in an impractical outcome. In addition, you should discuss these proposals with us before lodging any formal application.

The figure below shows an example of how floor level concessions may apply to a multistorey residential or office building in a low-lying area of Port Phillip Bay where access problems exist at a site

Multistorey development with floor level concessions





6 Examples of development proposals

The following examples demonstrate how to calculate the minimum floor level requirements for different development types and locations using these guidelines.

Example 1: Residential urban infill

A proposal includes demolishing an existing dwelling and constructing a replacement dwelling with a garage in an established urban area in Elwood, within the Port Phillip catchment.

These guidelines state:

- The predicted future flood level applicable to urban infill development is the 2040 1% AEP flood level.
- The predicted future flood level for the Port Phillip Bay catchment in 2040 is 1.8 metres AHD.
- The minimum freeboard is 600 millimetres for buildings and 300 millimetres for outbuildings.

Minimum floor level requirements:

- The dwelling floor level should be at least 600 millimetres above 1.8 metres AHD, which is 2.4 metres AHD.
- The garage floor level should be at least 300 millimetres above 1.8 metres AHD, which is 2.1 metres AHD.



Example 2: Urban renewal area development – multistorey office building

A new 8 storey office building is proposed on a vacant site in the Docklands, within the Port Phillip Bay catchment. The site has been identified as being liable to flooding from predicted sea level rise.

These guidelines state:

- The predicted future flood level applicable to urban renewal areas is the 2100 1% AEP flood level.
- The predicted future flood level for the Port Phillip Bay catchment in 2100 is 2.4 metres AHD.
- The minimum freeboard for buildings is 600 millimetres.

Minimum floor level requirements:

- Melbourne Water considers the existing surface levels and design constraints at the site create access problems for the building. Some floor level concessions therefore apply, where the freeboard requirements may be reduced.
- The floor level for the offices, lift and services would need to be at least 600 millimetres above 2.4 metres AHD, which would be 3.0 metres AHD.
- The floor level for the building lobby and any ground level café or other retail may be marginally reduced to address access constraints as advised by Melbourne Water.

Example 3: Greenfield subdivision

A greenfield subdivision is proposed on Phillip Island, within the Western Port catchment. The site has been identified as being liable to flooding from predicted sea level rise.

These guidelines state:

- The predicted future flood level applicable to greenfield subdivision is the 2100 1% AEP flood level.

Given the flood levels within the Western Port catchment are graded, the applicant has confirmed with Melbourne Water that the applicable flood level for the subject site on Phillip Island in 2100 is 2.9 metres AHD.

Finished surface level requirement:

- The site should be filled to a minimum 600 millimetres above 2.9 metres AHD, which is 3.5 metres AHD.



Glossary and abbreviations

Glossary

1% AEP flood also known as the 1 in 100 year Average Recurrence Interval (ARI) flood, has a 1% chance of occurring in any given year.

Freeboard is the difference between the floor level of a building and the 1% AEP flood level.

Greenfield areas include areas not previously developed for urban purposes, outside the established urban area, and may include land inside the Urban Growth Boundary.

Greenfield development comprises development, including subdivision, that occurs in greenfield areas.

Outbuilding is a non-habitable building being a private garage, carport, shed, or the appurtenances to a building used for domestic purposes.

Tidal inundation refers to the flooding of land by sea waters associated with the rise and fall of the tides.

Urban renewal areas includes areas designated as urban renewal areas or precincts in Plan Melbourne or as identified by the Minister for Planning or as shown in municipal planning schemes.

Victoria Planning Provisions are a set of state standard planning provisions or template from which all planning schemes in Victoria are formed.

Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DELWP	Department of Environment, Land, Water and Planning
DEPI	Department of Environment and Primary Industries (former)
IPCC	Intergovernmental Panel on Climate Change
SPPF	State Planning Policy Framework
VCS	Victorian Coastal Strategy (2014)
VFMS	Victorian Floodplain Management Strategy (2016)
VPP	Victorian Standard State Planning Provisions
WPLCHA	Western Port Local Coastal Hazard Assessment (2015)



Appendices

Appendix A: Origins of Port Phillip Bay flood levels

The Melbourne and Metropolitan Board of Works (MMBW)² adopted 1.6 metres AHD as the 1% AEP flood level for Port Phillip Bay over 20 years ago. This level was adopted on the basis of the highest tide level ever recorded in the bay, which occurred during the major flood event on the Yarra River catchment in December 1934.

Originally this peak level was thought to be 1.52 metres AHD, and this was rounded up to 1.6 metres AHD as a starting water level for flood modelling on various waterways.

The MMBW Hydrology and Flood Warning Unit undertook a further study in 1987. A frequency analysis of flood high tide levels that occurred during the 1934 flood found that the maximum level at Williamstown in the 1934 flood event was more likely to have been 1.33 metres AHD.

In 2005, Melbourne Water's Hydrology and Flood Warning Team undertook an initial frequency analysis of tide levels for a tidal gauging station located at St Kilda Marina. The results of this analysis found the 1% AEP design tide level to be 1.30 metres AHD for St Kilda Marina.

In 2009, Melbourne Water completed further investigations comprising a frequency analysis of the annual maximum series of observed tide levels for St Kilda Marina. Using 31 years in available data (1977-2008), this study found that a reasonable flood level for a 1% AEP event to be 1.4 metres AHD. We added a minor allowance for wave action to this level to arrive at 1.6 metres AHD. This confirms the appropriateness of adopting 1.6 metres AHD as the 1% AEP flood level for Port Phillip Bay.

Melbourne Water tidal flood levels (vs) CSIRO tidal flood levels

You will note that 1% AEP flood levels adopted by Melbourne Water are different to those contained in the CSIRO report *The Effect of Climate Change on Extreme Sea Levels in Port Phillip Bay* (2009). This is because our process considers all available records on flood events and flood levels, while the CSIRO does not factor in tide levels regarded as outliers (i.e. severe storm events/levels considered to be statistical anomalies). For example, in calculating the existing 1% AEP sea level at St Kilda, the CSIRO calculated a level of 1.15 metres AHD, whereas we calculated a level of 1.4 metres AHD (both for still water with no wave action).

In addition, CSIRO flood levels are based on 'still water' levels, which are an average of the peaks and troughs of any wave action. However, in our view it is the peaks of the waves that should be considered when setting floors levels. Property damage is increased significantly when floors become wet – even if only for a short period of time.

Melbourne Water's flood levels make some allowance for wave action. However, when we assess a development proposal, we give consideration to the adequacy of these levels based on the location of the development

² The Melbourne and Metropolitan Board of Works (MMBW) is Melbourne Water's predecessor. The MMBW merged with a number of smaller urban water authorities to form Melbourne Water in 1992.



Appendix B: Updated Western Port flood levels

Western Port Local Coastal Hazard Assessment

The *Western Port Local Coastal Hazard Assessment* (WPLCHA), commissioned by the State Government's then *Future Coasts* program and delivered by DEPI in partnership with Melbourne Water and others³, provides information on the extent of coastal hazards and their physical impacts for the coastal environment of Western Port, with a focus on inundation and erosion. A hydrodynamic model was used as part of this project to assess inundation hazards.

Key outputs of the study include inundation extents and water surface elevation contours for each of the modelled sea level rise scenarios (+0.2m, +0.5m and +0.8m to 2040, 2070 and 2100 respectively).

Following on from the work undertaken as part of the WPLCHA, Melbourne Water carried out additional inundation modelling and mapping of Western Port.

Due to the large expanse of shallow intertidal areas in the north and north east of the bay, and the amplification of tides in Western Port, there is potential for significant wave set up due to local winds, and a range of wind directions needed to be assessed to determine the peak flood levels around the bay.

The outcome of this additional modelling is that 1% AEP storm tide inundation extents have been prepared for current mean sea level and 0.8 metres sea level rise for each wind direction tested. The combined extents reveal that the greatest inundation occurs in the north east of Western Port, resulting from south west and southerly winds. These pushed the water inland towards Pakenham South and Cardinia. At this northern end the extent is similar for the current mean sea level and +0.8m sea level rise scenarios.

³ The WPLCHA was commissioned by the State Government's then *Future Coasts* program and delivered by DEPI in partnership with Melbourne Water, South East Councils Climate Change Alliance, Bass Coast Shire Council, Cardinia Shire Council, the City of Casey and the Mornington Peninsula Shire Council.

Western Port wind analysis and inundation modelling

In November 2015, Melbourne Water undertook inundation modelling and mapping of Western Port following on from the work undertaken as part of the *Western Port Local Coastal Hazard Assessment*.

The modelling was done using the coupled Mike 21 Flexible Mesh Hydrodynamic and Spectral Wave Model. This model allows the grid size defining surface levels to be adjusted so that accurate results can be obtained while keeping model data to a reasonable level. Grid sizes range from 100 metres in offshore areas down to a 1 metre grid along the shore and in inland areas.

To develop an understanding of storm surges in Western Port, the water level gauge data from Stony Point was analysed. A continuous data set was available from 1993 to 2011 and all storm surge events greater than 0.4 metres were extracted and used to develop a synthetic storm surge. The 1% AEP synthetic storm surge has a duration of five days, so occurs over several tide cycles, and has a peak storm surge height of 0.82 metres (McInnes 2009).

The typical wind and wave conditions were then reviewed by assessing the maximum wind speeds during the period storm surges greater than 0.4 metres. Maximum wind speeds of 18 metres per second or greater tend to accompany storm surges of 0.6 metres or more, with the most number of wind events over 15 metres per second coming from the west to north west. Wind direction and speed can vary through these storm surge events.

We adopted a 1% AEP design wind speed of 25.1 metres per second for the modelling based on Australian Standard, *AS1170.2-1989 'SAA Loading Code, Part 2: Wind Loads'*. This is consistent with the wind speeds assessed above, but using a constant velocity and direction is likely to produce slightly conservative results as compared to varying wind speed and direction.

Due to the large expanse of shallow intertidal areas in the north and north east of the bay, and the amplification of tides in Western Port, there is potential for significant wave set up due to local winds, and a range of wind directions need to be assessed to determine the peak flood levels around the bay.

The Mike 21 Flexible Grid model was used to assess flood levels in Western Port for constant 25.1 metres per second wind speeds and using the synthetic storm surge added to the astronomical tidal time series for wind directions of 135°, 180°, 240°, 270° and 315°. Both existing mean sea level and 2100 with +0.8 m sea level rise were assessed.



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