Adaptive Community Assets

A report prepared for the Eastern Alliance for Greenhouse Action

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Author/s	Mitchell Perry Stephanie Doumtsis Boris Lam Isabel Haro
Checked	Jim Binney
Approved	Jim Binney

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Contact

Jim Binney
Director, Natural Capital Economics
jim.binney@nceconomics.com

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The analysis uses a cost-benefit analysis framework, which is the framework that underpins most business cases. The scope of the project includes direct damages to the asset classes of buildings, roads, drainage, natural assets and built assets in open space from the climate hazards of coastal flooding, inland flooding, bushfires, and heatwaves.

Damages to council assets are quantified in terms of average annual damages (AADs), which reflect the average damage per year that would occur over a very long period. This is effectively the same way that the insurance sector values risk. Present day AADs are in the range of $90-$120 million, with AADs increasing to between $210-$300 million in the nearer future (~2050) and to between $400-$540 million in the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 350% in the more distant future from present day.

The results highlight that AADs from climate hazards to community assets in Greater Melbourne will increase significantly with climate change and without adaptation as hazards become more frequent and as more assets become exposed. Heatwaves are identified as having the most significant impact followed by coastal flooding and then inland flooding. A contributing factor to this, is that all community assets are exposed to heatwaves, which is not the case for other hazards. Relative to other climate hazards, bushfires are not found to cause significant AAD in Greater Melbourne.

The project has relied on best available pre-existing and publicly available data sets. This data has some limitations, which if addressed will improve the robustness of AAD estimates and enable the development of more convincing business cases for adaptation initiatives. This includes the need to incorporate AAD estimates from smaller, more frequent events, where data was limited, as the cumulative cost of these events can be significant due to their repeated nature. As the estimates of AAD are based on specific climate events only and do not incorporate indirect tangible (e.g. loss of service) and intangible (e.g. morbidity) costs, the results are likely to underestimate costs in present day and for future time periods for the examined climate change scenario.

Based on the findings of the project, a list of recommendations for next steps by councils have been made. These recommendations are not required to be undertaken sequentially. They include:

- Refining base case estimates of AADs when new information becomes available, including through ensuring inland flooding extents and depth information is available for present day and future climate scenarios for a range of event probabilities and through refining asset sensitivity assumptions which reflect expected damage from hazard events to each asset type.
- Expanding the scope of the base case assessment to include indirect tangible and intangible impacts
- Using the results to undertake cost-benefit analysis of adaptation options
- Beginning to integrate climate change considerations into long term financial plans
- Beginning to integrate climate change considerations into asset management practices

1 Project overview

The Adaptive Community Assets project (the project) delivers a "first pass" assessment of the value of damages from climate hazards to council owned assets (community assets) across Greater Melbourne, without adaptation. It aims to assist councils to better manage climate change related risks[1] by providing evidence to inform adaptation decisions and to advocate for funding. The outputs of the project will also enable future evaluations and comparisons of the costs and benefits of different climate change adaptation options for community assets.

The project draws on the first 3 steps of the Costs and benefits of climate change adaptation options for community assets framework (CBA Framework) as shown in Figure 1. The CBA Framework was developed as part of an earlier scoping study (phase 1) undertaken in November 2021. The scope of the project includes damages to the asset classes of buildings, roads, drainage, natural assets and built assets in open space from the climate hazards of coastal flooding, inland flooding, bushfires, heatwaves, and severe storms.

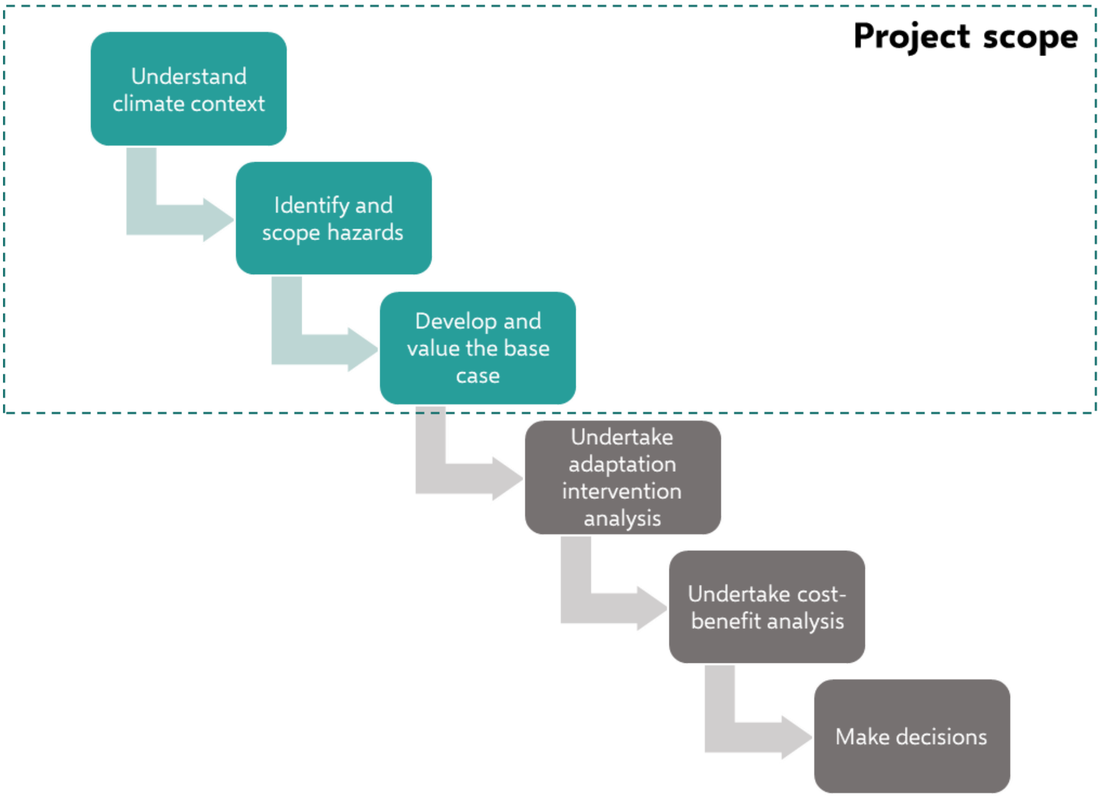

Figure 1. Overview of the project scope with reference to the CBA framework

[1] Councils have a responsibility to manage climate change related risks under the Local Government Act 2020 (DELWP, 2020).

2 Approach

The project approach is based on the first 3 steps outlined in the CBA Framework. The CBA Framework provides a method to use cost-benefit analysis (CBA) to assess the economic viability of different adaptation options designed to improve the resilience of council assets to climate change. This is the same economic approach that underpins most business cases and is the preferred methodology of the Department of Treasury and Finance. To facilitate the use of CBA, the CBA Framework also includes references to risk and adaptation analysis, which is an input into the CBA. In addition, the CBA Framework provides resources which can be drawn on to complete the CBA, where there are gaps or insufficient detail available. An overview of the components of the CBA Framework is shown in Figure 2.

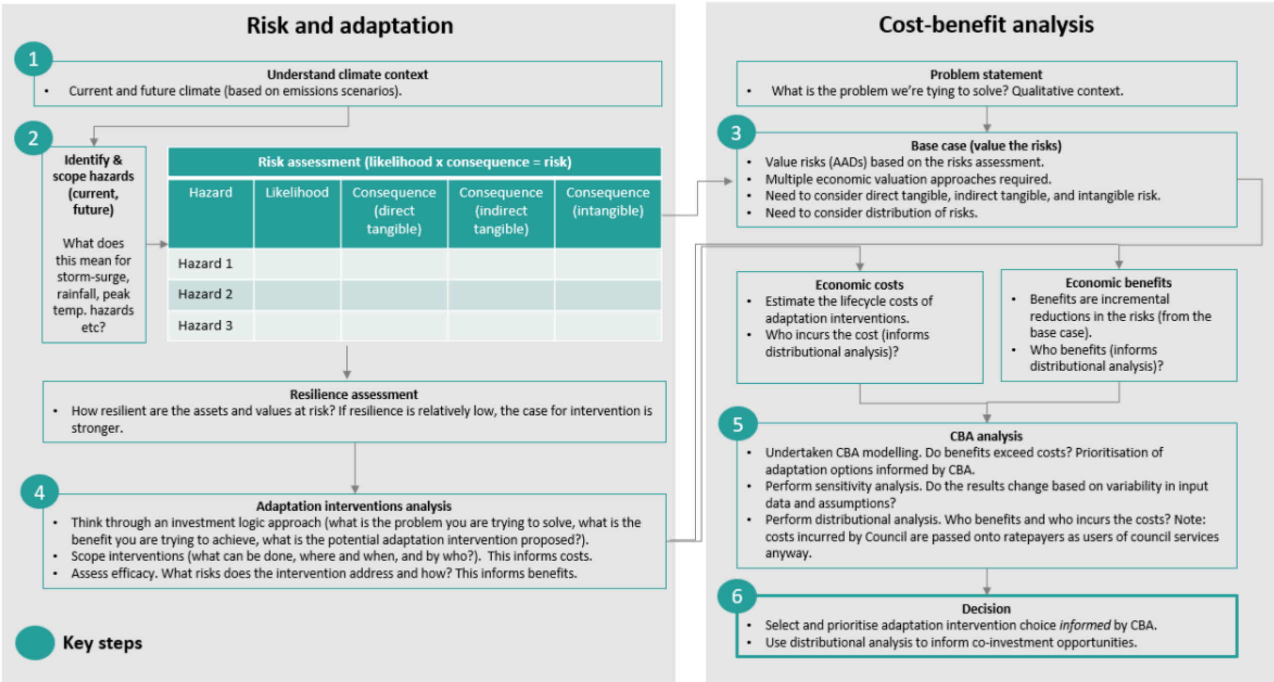

Figure 2. Overview of the CBA framework components

2.1 Step 1: Understand climate context

To understand the likely effects of climate change on council assets across Greater Melbourne, there is a need to understand the climate context or how the climate is expected to change (NCE, 2021). The Victorian Climate Projections 2019 (VCP19) provide a set of projections which can be used for this purpose.

In understanding the climate context, multiple climate models need to be considered. This is necessary as projections about the future climate are uncertain. This uncertainty is driven by the unknown future levels of greenhouse gas emissions, how the climate will respond to these emissions, and natural climate variability (Climate Change in Australia, 2020; CMSI, 2020).

The VCP19 provide summaries of the projected changes across 10 regions in Victoria with one region being the Greater Melbourne climate region. These climate projections are based on new and existing modelling to provide a range of plausible outcomes. The new modelling is based on simulations of the Conformal Cubic Atmospheric Model (CCAM), which draws on six global climate models downscaled to a 5 km resolution over Victoria. The previous modelling draws on a wider range of global climate models (GCM) (Clarke et al.,2019).

Table 1 provides a summary of the expected annual changes in 11 climate variables for the Greater Melbourne region. These results reflect averages across the region. They are based on the CCAM results but indicate where GCM results expand the potential range. The results shown reflect a high emission scenario (representative concentration pathways [RCP] of 8.5).

Table 1. Annual regionally averaged changes (relative to 1986-2005) for Greater Melbourne region (RCP8.5) based on CCAM results

		2030 (2020-39)			2050 (2040-59)			2090 (2080-99)		
Variable	Units	Lower	Median	Upper	Lower	Median	Upper	Lower	Median	Upper
Maximum daily temperature	°C	0.98^	1.19	1.55	1.46^	1.93	2.74	2.77^	4.01	5.35
Minimum daily temperature	°C	0.64^	0.72	0.99†	1.21^	1.37	1.90	2.48	2.85	3.79†
Mean temperature	°C	0.8^	0.86	1.2†	1.34^	1.55	2.21	2.57	3.24	4.36
Precipitation	%	-13.71	-8.60	-2.23†	-19.27	-7.71	2.08†	-28.11	-20.12	6.4†
Relative humidity	%	-2.2^	-1.44	-0.41†	-3.16^	-1.75	0.29	-6.37	-4.09	0.81
Pan evaporation	%	7.21	10.12	13.32	7.75	16.75	24.90	14.61	34.78	50.97
Solar radiation	%	1.41^	2.54	3.38†	1.23^	3.71	4.57†	1.49^	6.71	7.88
Wind speed	%	-2.71	-1.85	0.33†	-3.46	-2.44	-0.51†	-5.08^	-2.58	-0.33†
1-in-20 year hottest day	°C	-0.95	0.26	3.78	0.69	2.71	4.50	1.14	4.38	6.37
1-in-20 year wettest day	%	-26.54	-12.45	29.24	-18.76	-5.87	45.51	-19.90	13.47	34.88
1-in-20 year coldest day	°C	0.05	0.45	0.86	0.52	0.95	1.14	1.63	2.38	2.93

^GCM results give a lower limit that is lower than the CCAM results.

†GCM results give an upper limit that is higher than the CCAM results.

~There are no comparable GCM results available

Source: Clarke et al. (2019)

The expected changes in climate variables suggest a trend of Greater Melbourne continuing to become warmer and drier. By the 2050s, these trends are expected to make the climate of Greater Melbourne more like the climate of Wangaratta (DELWP, 2019). Further results are available from Climate Change in Australia. This includes changes in additional climate variables by season, results for a RCP 4.5 emission scenario and changes for the 2070 future time period.

2.2 Step 2: Identify and scope hazards

This section describes the exposure analysis undertaken to identify and scope the climate hazards which have the potential to impact on community assets in Greater Melbourne. This process involved collecting and analysing spatial information on the locations of community assets as well as the spatial extent of hazard events. These spatial datasets were then overlayed to find where asset footprints and hazard extents overlap, representing instances where assets are exposed/or at risk from specific climate hazards.

The following climate hazards have been considered as part of the exposure analysis:

- **Bushfires** – an unplanned vegetation fire including grass fires, forest fires and scrub fires (Australian Institute of Disaster Resilience, n.d.).
- **Coastal flooding** – when seawater temporarily or permanently floods an area due to a combination of sea level rise, high tides, wind, low air pressure and/or waves (Climate Council of Australia, 2022).
- **Heatwaves** – a period of at least three days where the combined effect of high daytime maximum and overnight minimum temperatures (daily mean temperature) is unusual within the local climate (Bureau of Meteorology, n.d.).
- **Inland flooding** – a combination of riverine and surface water flooding. Riverine flooding occurs when a river exceeds its capacity, inundating nearby areas. Surface water flooding occurs when sustained rainfall or short-duration heavy rainfall events cause the ground to reach saturation point and drainage systems to overflow, resulting in the build-up of excess water (Climate Council of Australia, 2022).
- **Severe storms** – storms that produce any of the following: Hailstones with a diameter of 2cm, wind gusts of 90kmh or greater, overland flow, storm water or inundation, tornadoes (Bureau of Meteorology as cited in Insurance Council of Australia, 2021).

The exposure analysis is undertaken for three planning horizons: present day, nearer future and more distant future. The present day planning horizon aims to reflect current climate conditions, with the nearer future and more distant future aiming to approximately reflect hazard extents in 2050 and 2100. The nearer future planning horizon was chosen to assist with immediate decision making (e.g. asset adaptation) as many policies and projects are evaluated over timeframes of less than 30 years. The more distant future scenario was chosen to illustrate how the severity of climate change impacts may increase over time with increasing concentrations of greenhouse gas emissions.

Where possible, the layers and assumptions used to understand exposure in each planning horizon take account of future changes in hazard extents and likelihoods based on projected changes in climate under a high emissions scenario (RCP 8.5 or equivalent). This approach presents a plausible 'worst case' scenario and was chosen to 'stress test' the climate resilience of council assets and identify if significant action is required.

The spatial layers used to perform the exposure analysis are shown in Table 2. These layers were identified as providing the most up to date publicly available information on hazard extents. As more up to date layers become available, the exposure analysis could be repeated to gain further insight on assets likely exposed to each hazard. The spatial information on community assets used for the exposure analysis was collected from councils. Insufficient data was available to support an exposure assessment of severe storms. Therefore, a case study has been included in section 3.7 to highlight recent experiences.

Table 2. Hazard extent layers used for exposure analysis for each planning horizon

Hazard	Extent layer	Planning horizon			Climate model (RCP scenario)	Source
		Present day	Nearer future (~2050)	More distant future (~2100)		
Bushfires	Bushfire Prone Areas - areas likely to be subject to bushfires	Used to inform exposure across present and future planning horizons			n/a	DEEC, 2022a
	Bushfire Management Overlay - Areas where there is potential for extreme bushfire behaviour	Used to inform exposure across present and future planning horizons			n/a	DEEC, 2022b
Coastal flooding	Sea level rise (SLR)	Based on sea level in 2009	Based on 20cm SLR (2040)	Based on 82cm SLR (2100)	A1FI	DELWP, 2009
	Storm tide inundation - inundation from 1-in-100 year storm tide level	Based on sea level in 2009	Based on 20 cm SLR with storm surge increased by 6% (2040)	Based on 82 cm SLR with storm surge increased by 19% (2100)	A1FI scenario in combination with 'high' wind	DELWP, 2009
Heatwaves	Number of heatwaves per year - based on excess heat factor for a given time period	Based on climate baseline (1986 – 2005)	Based on 2050s (2035 – 2064)	Based on 2090s (2075 – 2104)	HadGEM2-CC (RCP8.5)[1]	DELWP, 2021
Inland flooding	Waterway 1% AEP flood extent	Used to inform exposure across present and future planning horizons			n/a	Melbourne Water (2017a & b)
	Overland Flow 1% AEP flood extent	Used to inform exposure across present and future planning horizons				
Severe storms	Publicly available data to assess exposure to severe storms at a regional or local level is limited. The potentially significant impact from severe storms is illustrated through a case study shown in 3.7	n/a			n/a	n/a

[1]Comparatively hottest and driest climate future enabling a "stress test" approach.

2.3 Step 3: Develop and value the base case

The base case represents the outcome for community assets if climate change adaptation is not implemented (i.e. the status quo, business as usual or counterfactual). It also provides a 'do nothing differently' scenario against which adaptation initiatives can be assessed.

For the project, the base case reflects direct tangible damages to assets (i.e. damage to assets and the cost of repair). Indirect tangible and intangible impacts have not been considered. Indirect impacts include the flow-on impacts that are not directly caused by the climate hazard, but arise because of the event, such as disruption to public services. Intangible impacts include impacts such as morbidity that are more challenging to quantify.

Under the base case, damages to council assets are quantified in terms of average annual damages (AAD), which reflect the average damage per year that would occur over a very long period. This approach is like how insurance companies' value risk and takes account of the fact that damages from climate hazards will differ from year to year. AAD estimates are calculated for each of the three planning horizons of present day, nearer future (~2050), more distant future (~2100).

The framework used to estimate the base case for the project is illustrated in Figure 3. The key components of the framework are described in section 2.4.

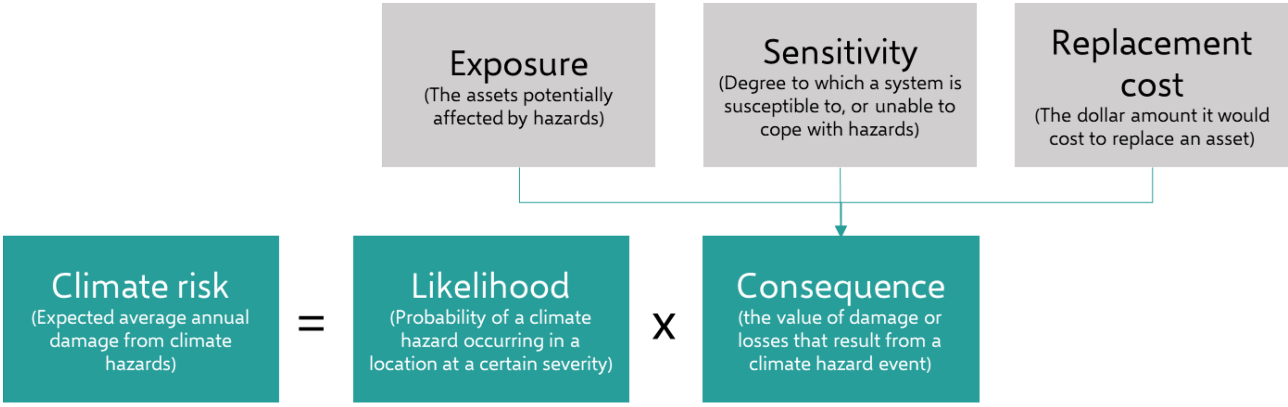

Figure 3. Framework for estimating the base case

2.4 Base case inputs and assumptions

The following section describes the key components of the base case and relevant inputs and assumptions used in the analysis.

Exposure (E)

Exposure refers to the footprint of assets which are in areas that a susceptible to specific climate hazard events (e.g. bushfires, heatwaves, coastal flooding, and inland flooding events). Exposure was assessed in step 2, using spatial analysis to identify assets located within climate hazard extents. The hazard extents layers used for this assessment for each planning horizon are shown in Table 2. The exposure analysis underpins the base case assessment and is focused on the existing community asset base only.

Sensitivity (S)

Sensitivity reflects an assets susceptibility to damage from specific climate hazard events. Sensitivity of assets is informed by guidance from IPWEA (2021), which considers the type of assets and its construction materials. Sensitivity values were tested and refined through a memo to council representatives. which sought input on the potential sensitivity of various council owned assets to exposure from climate hazards events, based on each representative's own knowledge and/or experience. This approach was used to ground truth assumptions in the absence of detailed modelling or quantitative empirical data.

Table 3 presents the generic sensitivity ratings applied and the associated proportion of damage to assets expected from a climate hazard event, irrespective of its location. The application of sensitivity ratings to each asset category is detailed in Appendix A – Base case inputs.

Table 3. Generic sensitivity ratings applied to assets

Sensitivity rating	Asset damage (% of asset value)[1]		
	Low	Mid	High
Not exposed	0	0	0
Low	0	10	20
Low-moderate	10	20	50
Moderate-high	20	50	90
High	50	90	100

[1] Note that damage from heatwaves is assumed to occur across an asset's useful life. The useful life assumptions used are shown in Appendix A – Base case inputs. Damage from other climate hazard events is assumed to occur when the event occurs.

[2]Direct damages from sea level rise are incorporated in to AAD estimates, however, damages incurred would not be expected to be incurred annually (i.e. sea level rise leads to one off permanent loss)

Replacement cost (R)

Replacement cost refers to the estimated cost to replace or repair an existing asset which has been damaged by a climate hazard. Estimates of replacement cost are proportional to the amount of damage incurred and based on the cost associated with replacing an existing asset with a new asset rather than an asset of equal value (i.e. does not factor in depreciation). This approach assumes that any damage from hazards is repaired each year but does not assume any additional general maintenance costs or asset betterment to improve future resilience to climate hazards.

Asset replacement cost estimates are informed by the Rawlinsons Australian Construction Handbook (2022), as well as information on replacement cost collected from councils in phase 1. The replacement cost values applied to each asset type are shown in Appendix A – Base case inputs. These values are proportionally adjusted in the model depending on the assumed impact from each hazard.

Consequences (C) [E x S x R]

Consequences reflect the negative impact of climate hazard events. In the project, they represent the dollar value of asset damages, or the cost of repair attributed to a climate hazard event. They are based on the proportion of the asset's footprint exposed, the sensitivity of an asset to damage, and the replacement cost of the asset. In this project, consequences do not include indirect tangible and intangible costs and only consider damage to existing assets (i.e. no consideration is made to estimate damages for planned or future development).

Likelihood (L)

Likelihood represents the probability of different hazard events occurring each year. Where possible, assigned likelihoods align with the assumptions which underpin the hazard extents (i.e. the likelihood of the modelled event). Where this information is unavailable, changes in likelihood due to climate change have been informed by projected changes in key climate variables. This is a simplifying assumption to enable 'first pass' estimates of base case damages, which should be revised when new information becomes available.

The assigned likelihoods for each climate hazard event for each planning horizon are shown in Table 4. Table 4 also includes comments on the assumptions used to inform changes in likelihood with climate change. In the absence of project specific data, sensitivity testing was performed using ±20% of likelihood values. The likelihood of exposure for assets which are not located within the extents of the assessed climate hazard events is assumed to be zero (i.e. they are excluded from the results).

Table 4. Assumed annual likelihood of climate hazards for each planning horizon

Hazard	Extent layer	Planning horizon			Comments
		Present day	Nearer future (~2050)	More distant future (~2100)	
Bushfires	Bushfire Prone Areas (BPA)	0	0	0	The likelihood of a random asset being destroyed by bushfire is assumed to be very low (i.e. zero) in BPA.
	Bushfire Management Overlay (BMO)	0.015%	0.022%	0.031%	Present day bushfire risk in the BMO is based on the probability of a random home on the urban–bushland interface being destroyed being 1 in 6,500 (McAneney et al., 2009). Likelihood is assumed to increase based on the percentage increase in the number of very high fire danger days in Melbourne[1].
Coastal flooding	Sea level rise	100%	100%	100%	For coastal flooding, likelihood is assumed to remain constant with changes observed across hazard extents.
	Storm tide inundation (1-in-100 year storm tide level)	1%	1%	1%	
Heatwaves	Number of heatwaves per year	21.0%	70.2%	100.0%	Present day and nearer future (2050) likelihood is proportionate to the average number of heatwaves expected to occur across Greater Melbourne in 2090[2].
Inland flooding	Waterway 1% ARI flood extent	1.0%	1.4%	2.4%	Based on increased rainfall intensity under a RCP 8.5 scenario as modelled by Jacobs (2020).
	Overland Flow 1% ARI flood extent	1.0%	1.4%	2.4%	

[1] There is high confidence that the number of fire days where the Forest Fire Danger Index is greater than the 95th percentile for 1986–2005 is projected to increase at Melbourne by a median value of 7.7 days per year (or a 42% increase) by the 2050s under high emissions (RCP8.5) (DELWP, 2019)

[2] The average number of heatwaves per year (based on excess heat factor) across Greater Melbourne is expected to increase from 1.8 heatwaves to 6.0 and 8.6 heatwaves by 2050 and 2090, respectively. Based on the HadGEM2-CC model for a high emission scenario (RCP8.5).

Climate risk [C x L]

Climate risk refers to the potential for adverse consequences from climate-related hazard events. It is assessed by multiplying the likelihood of a hazard occurring by the value of the negative consequence. This approach provides an assessment of risk in terms of AAD, which reflect the average damage per year that would occur over a very long period.

2.5 Data gaps and limitations

The project has relied on best available pre-existing and publicly available data sets to understand the impacts of climate hazards on community assets across Greater Melbourne. This approach provides a relative cost-effective means of determining 'first pass' estimates of AAD to community assets and is useful for identifying key gaps in existing data.

The key data gaps identified are described in Table 5 and colour coded according to expected significance. The most significant gaps are highlighted red, with less significant gaps highlighted amber and the least significant gaps highlighted green. Addressing keys gaps in data will assist with the development of more robust estimates of AAD and more convincing business cases for major adaptation initiatives.

Table 5. Key gaps and limitation of the data used to assess the impacts of climate hazards on community assets rated according to significance (Red=High, Amber=Medium, Green=Low)

Inputs and assumptions	Key data gaps				
	Heatwaves	**Sea level rise**	**Storm tide inundation**	**Inland flooding**	**Bushfires**
Hazard extent layers	Scale of modelling provides an adequate understanding of each asset's exposure to heatwaves, however, for simplicity, exposure to heatwaves is applied universally across Greater Melbourne.	Due to the scale of the modelling, spatial layers used are expected to provide a relatively coarse assessment of exposure at an asset level. No accompanying information on inundation depths is available. Modelling is relatively outdated (i.e. baseline is 2009).		Spatial layers used do not account for changes in inundation extent with climate change or account for events of different recurrence intervals beyond 1%. No accompanying information on inundation depths is available.	Spatial layers used provide a high-level view of assets potentially exposed to risk from bushfires. Layers provide limited understanding of how the level of risk changes by location or as protection measures are implemented. Factors which influence the risk of bushfires include fuel, weather, and topography.
Likelihood assumptions	Likelihood assumptions align with the VCP19.	Likelihood assumptions align with the assumptions which underpin the modelling for relevant hazard extents.		Likelihood assumptions are based on relatively recent modelling but are not linked to relevant hazard extents.	Likelihood of assets being affected by bushfires is based on academic literature but are not linked to relevant hazard extents.
Sensitivity assumptions	Sensitivity assumptions are based on relatively coarse input information and do not account for differing levels of damage from hazard events of different severity. A lack of empirical data/understanding on the amount of damage caused to community assets by climate hazards and in particular heatwaves, is a key data gap.				
Replacement cost unit rates	Asset replacement cost estimates are informed by the Rawlinsons Australian Construction Handbook (2022), as well a high-level information on replacement cost of different asset types collected from councils. Data on the replacement of each specific asset would improve the quality of this information.				
Useful life assumptions	Useful life assumptions are relatively generic. Data on the remaining useful life of each specific asset would improve the robustness of this information.				

3 Results

This section of the report presents the estimates of AADs to community assets across Greater Melbourne under the base case[2]. It also provides a summary of results for each council and the results of the sensitivity analysis. The base case damage estimates for each council are provided in more detail in Appendix B – Results by council.

3.1 Base case results for Greater Melbourne

Figure 4 presents the estimated AADs from climate hazards to community assets in Greater Melbourne across three planning horizons (present day, nearer future and more distant future) for the base case or "do nothing differently scenario. Present day average annual damages are in the range of $90-$120 million, with damages increasing to between $210-$300 million in the nearer future (~2050) and to between $400-$540 million in the more distant future (~2100), based on P10 and P90 estimates[3]. This is an increase in AAD of about 150% in the nearer future and 350% in the more distant future from present day. It should be noted that these estimated ranges are based on the current asset portfolio. Any additional assets added to the portfolio that are not established in a resilient fashion will add to the future risks.

The base case results highlight that damages from climate hazards to community assets in Greater Melbourne will increase significantly with climate change, as hazards become more frequent and as more assets become exposed. Estimates of the value of damages are presented across a range of possible outcomes, with the outcomes dependent on the likelihood of hazards and the sensitivity and value of assets.

[2] As shown in Table 13 of Appendix A – Base case inputs, Mornington Peninsula did not provide data on natural assets and Banyule, Brimbank, Casey, Frankston, Greater Dandenong and Port Phillip did not provide data on built assets in open space. Therefore, AADs to these assets are excluded from the results.

[3] Percentiles describe a range that a statistic falls into. The 10^{th} (P10) and 90^{th} (P90) percentiles represent the values below which 10% and 90% of the results fall. Therefore, the average annual damage ranges presented, exclude the highest and lowest 10% of values to provide a robust estimate of the spread.

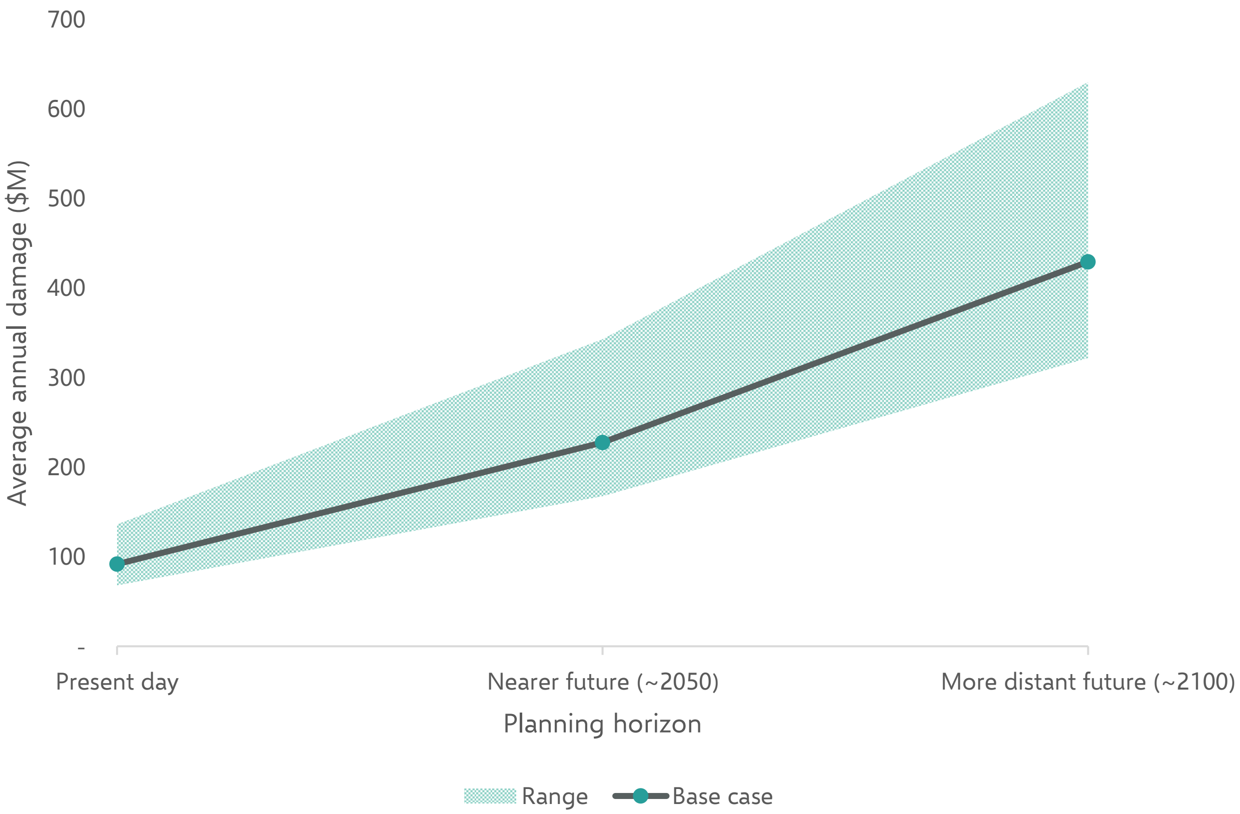

Figure 4. Base case damages from climate hazards to community assets in Greater Melbourne

3.2 Base case results by asset class for Greater Melbourne

Table 6 presents the AADs under the base case from climate hazards to community assets in Greater Melbourne across three planning horizons by asset class. AADs to roads and natural assets from climate hazards are found to be the highest in each planning horizon, followed by buildings and then drainage assets. AADs to built assets in open space are significantly less than AADs to other asset types.

Table 6 also highlights the expected change in AADs for each asset class between present day and the nearer future and more distant future time horizons. AADs are estimated to increase by more than 100% across all asset classes between present day and the nearer future and by at least 300% between present day and the more distant future. The most significant increase is for drainage assets with AADs increasing by more than 180% and 500% from present day to the nearer future and more distant future, respectively (primarily a function of increases in the frequency and severity of major rainfall events). This highlights the significant effect climate change may have on the cost of maintaining the existing community asset base.

Table 6. Base case AAD from climate hazards across each planning horizon for each asset class (mid estimates)

Asset type	Average annual damage ($000)			% change in AAD from present day	
	Present day	Nearer future (~2050)	More distant future (~2100)	Nearer future (~2050)	More distant future (~2100)
Buildings	20,464	40,828	89,064	100%	335%
Roads	31,900	89,497	149,687	181%	369%
Drainage	5,713	16,200	35,180	184%	516%

Asset type	Average annual damage ($000)			% change in AAD from present day	
	Present day	Nearer future (~2050)	More distant future (~2100)	Nearer future (~2050)	More distant future (~2100)
Natural assets	31,903	77,404	148,675	143%	366%
Built assets in open space	1,709	3,526	6,701	106%	292%

3.3 Base case results by climate hazard for Greater Melbourne

Figure 5 presents the AADs under the base case from climate hazards to community assets in Greater Melbourne across three planning horizons by hazard type and asset class. It highlights which hazards are expected to cause the most damage and to which asset classes, over time. The error bars reflect the range in possible outcomes, with the variance related to the range in input values used. The estimates of AAD are based on specific climate events[4] only and do not incorporate indirect tangible and intangible costs, meaning the results may underestimate impacts.

Figure 5. shows heatwaves as having the most significant impact on community assets in present day, followed by coastal flooding and inland flooding. This is consistent with estimates in the nearer future and more distant future. In the more distant future, sea level rise rather than storm-tide inundation is the main driver of increasing damages from coastal flooding. Relative to other hazards assessed, bushfires are not found to cause a significant level of damage to community assets.

[4] AADs from smaller, more frequent inundation events have not been incorporated due to a lack of data for the Greater Melbourne region. The cumulative cost of smaller inundation events can be significant even though they cause less widespread damage due to the repeating nature of damage and other effects (Melbourne Water, 2015).

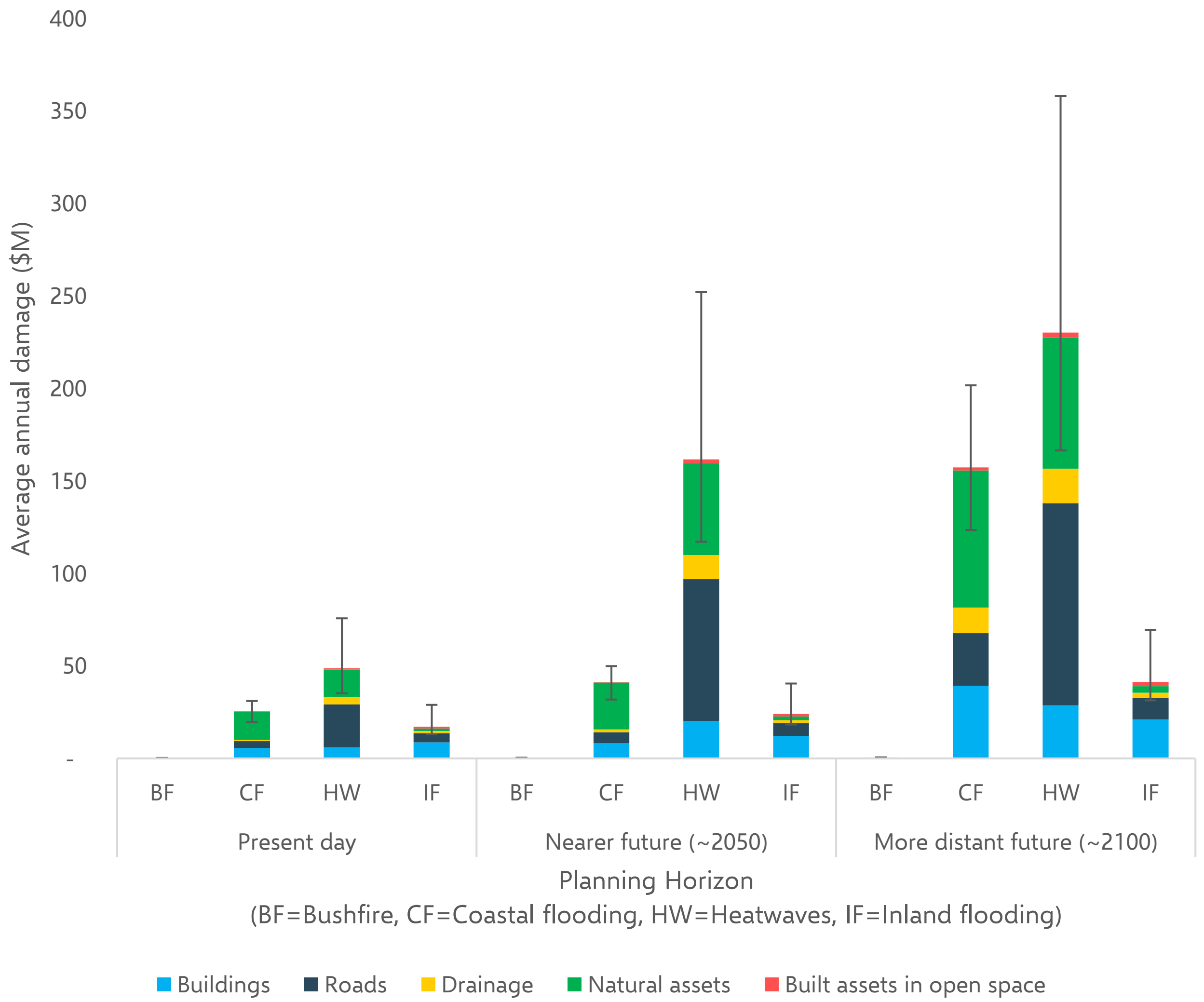

Figure 5. Base case AAD from climate hazards to community assets in Greater Melbourne presented by hazard and asset class

The value of AADs is expected to be highest for road assets. These assets are exposed and sensitive to a range of climate hazards and can also have a significant replacement cost. Natural assets and building assets are also shown to be significantly impacted. Natural assets are widely exposed to climate hazards, while building assets can have a high replacement cost, relative to many other community assets.

3.4 Aggregate results by council (all hazards and asset classes)

Table 7 presents the AAD estimates from climate hazards to community assets for each council in Greater Melbourne. These results highlight how AADs will increase over time with climate change. The AAD estimates for each council are provided in more detail in Appendix B – Results by council.

Table 7. Base case AAD from climate hazards across each planning horizon for each council (mid estimates)

Council	Average annual damage ($000)			% change in AAD from present day	
	Present day	Nearer future (~2050)	More distant future (~2100)	Nearer future (~2050)	More distant future (~2100)
Banyule	6,948	12,865	20,493	85%	195%
Bass Coast	1,783	4,356	7,127	144%	300%
Bayside	1,325	4,220	6,859	219%	418%

Council	Average annual damage ($000)			% change in AAD from present day	
	Present day	Nearer future (~2050)	More distant future (~2100)	Nearer future (~2050)	More distant future (~2100)
Boroondara	1,166	3,296	4,837	183%	315%
Brimbank	1,915	5,789	8,377	202%	338%
Cardinia	2,560	6,659	10,121	160%	295%
Casey	5,584	16,028	25,696	187%	360%
Darebin	759	2,077	3,056	174%	303%
Frankston	3,648	8,838	20,505	142%	462%
Glen Eira	861	1,945	2,966	126%	245%
Greater Dandenong	2,610	7,199	10,764	176%	312%
Hobsons Bay	19,959	31,906	79,800	60%	300%
Hume	6,620	20,797	29,909	214%	352%
Kingston	3,592	7,595	24,049	111%	569%
Knox	2,439	6,790	9,958	178%	308%
Manningham	1,998	6,003	8,682	200%	334%
Maribyrnong	872	2,172	6,879	149%	688%
Maroondah	962	3,006	4,327	212%	350%
Melbourne	2,025	4,203	26,237	108%	1,196%
Melton	3,868	12,184	17,516	215%	353%
Monash	1,075	3,048	4,458	183%	315%
Moonee Valley	1,688	4,508	7,590	167%	350%
Merri-bek	1,300	3,819	5,552	194%	327%
Mornington Peninsula	5,178	15,941	26,852	208%	419%
Nillumbik	901	2,626	3,814	191%	323%
Port Phillip	1,328	3,558	13,918	168%	948%
Stonnington	633	1,745	2,605	175%	311%
Whitehorse	1,234	3,795	5,475	208%	344%
Whittlesea	1,924	6,118	8,784	218%	356%
Wyndham	1,724	5,115	8,695	197%	404%
Yarra City	750	1,913	2,785	155%	271%
Yarra Ranges	2,459	7,340	10,620	199%	332%

3.5 Base case results by council and hazard

Table 8 presents the AAD estimates from each climate hazard to community assets for each council in Greater Melbourne. This more detailed view of results is useful for understanding which climate hazard/hazards is driving the overall change in AADs through time. The drivers of AAD differ across each council and depend on the council's location and size, exposure to hazards, and the value of its existing asset base. For many councils, coastal flooding and in particular sea level rise is a key driver of large increases in AADs from baseline to the more distant future. This table also illustrates the significant damage being cause by heat. A contributing factor to this, is that all community assets are exposed to heatwaves, which is not the case for other hazards.

Table 8. Base case AAD from each climate hazards across each planning horizon for each council (mid estimates)

Council	Average annual damage ($000)											
	Bushfires			Coastal flooding			Inland flooding			Heatwaves		
	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future
Banyule	0	0	0	0	0	0	5,339	7,475	12,814	1,609	5,390	7,678
Bass Coast	4	6	8	1,209	2,468	4,432	14	19	33	556	1,863	2,654
Bayside	0	0	0	186	874	1,995	240	336	575	899	3,011	4,289
Boroondara	0	0	0	6	13	35	309	432	741	851	2,851	4,061
Brimbank	0	0	0	0	0	0	320	448	768	1,594	5,341	7,608
Cardinia	23	33	47	57	84	388	905	1,268	2,173	1,574	5,274	7,513
Casey	7	9	13	224	383	2,931	1,180	1,652	2,832	4,174	13,984	19,920
Darebin	0	0	0	0	0	0	238	333	571	521	1,744	2,485
Frankston	17	25	35	1,897	3,647	12,976	329	461	790	1,405	4,706	6,703
Glen Eira	0	0	0	0	0	0	481	674	1,155	380	1,271	1,811
Greater Dandenong	1	1	1	77	89	348	705	987	1,692	1,828	6,123	8,722
Hobsons Bay	0	0	0	17,422	24,819	69,411	724	1,013	1,737	1,813	6,074	8,653
Hume	9	13	18	0	0	0	699	978	1,677	5,912	19,806	28,214
Kingston	0	0	0	2,342	4,092	18,916	351	492	843	899	3,012	4,291

Council	Average annual damage ($000)											
	Bushfires			Coastal flooding			Inland flooding			Heatwaves		
	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future	Baseline	Nearer future	More distant future
Knox	5	7	10	0	0	0	702	983	1,686	1,731	5,800	8,262
Manningham	32	46	65	0	0	0	322	451	774	1,644	5,506	7,843
Maribyrnong	0	0	0	226	365	4,231	183	257	440	463	1,550	2,209
Maroondah	1	2	3	0	0	0	111	155	265	850	2,849	4,058
Melbourne	0	0	0	784	1,881	22,925	256	358	613	985	1,964	2,698
Melton	3	5	7	0	0	0	393	551	944	3,471	11,629	16,565
Monash	0	0	0	0	0	0	284	398	682	791	2,650	3,775
Moonee Valley	0	0	0	62	73	1,060	520	728	1,247	1,107	3,708	5,282
Merri-bek	0	0	0	0	0	0	274	384	658	1,025	3,435	4,894
Mornington Peninsula	22	31	44	428	1,075	5,466	515	722	1,237	4,213	14,113	20,105
Nillumbik	20	28	40	0	0	0	182	255	437	699	2,343	3,338
Port Phillip	0	0	0	408	946	10,099	240	337	577	679	2,276	3,242
Stonnington	0	0	0	0	0	42	194	271	465	440	1,474	2,099
Whitehorse	1	1	2	0	0	0	172	241	414	1,060	3,552	5,059
Whittlesea	1	2	3	0	0	0	167	233	400	1,756	5,883	8,380
Wyndham	0	0	0	159	403	1,873	272	381	654	1,293	4,331	6,169
Yarra City	0	0	0	122	175	234	187	262	450	440	1,475	2,102
Yarra Ranges	55	79	112	0	0	0	405	567	972	1,998	6,694	9,536

Figure 6 to Figure 9 present the AAD estimates for each council from climate hazards for the nearer future scenario by council area on a map of Greater Melbourne. These maps assist with understanding how AAD estimates compare between councils located in similar regions. Only councils which have assets exposed to the relevant hazard are highlighted on each map.

Figure 6 indicates that Yarra Ranges has the highest level of bushfire risk as it has the highest estimate of AAD in the nearer future. Several inner-city councils are not exposed to bushfires, and several other councils have very low levels of risk, based on very low estimates of AAD relative to other councils.

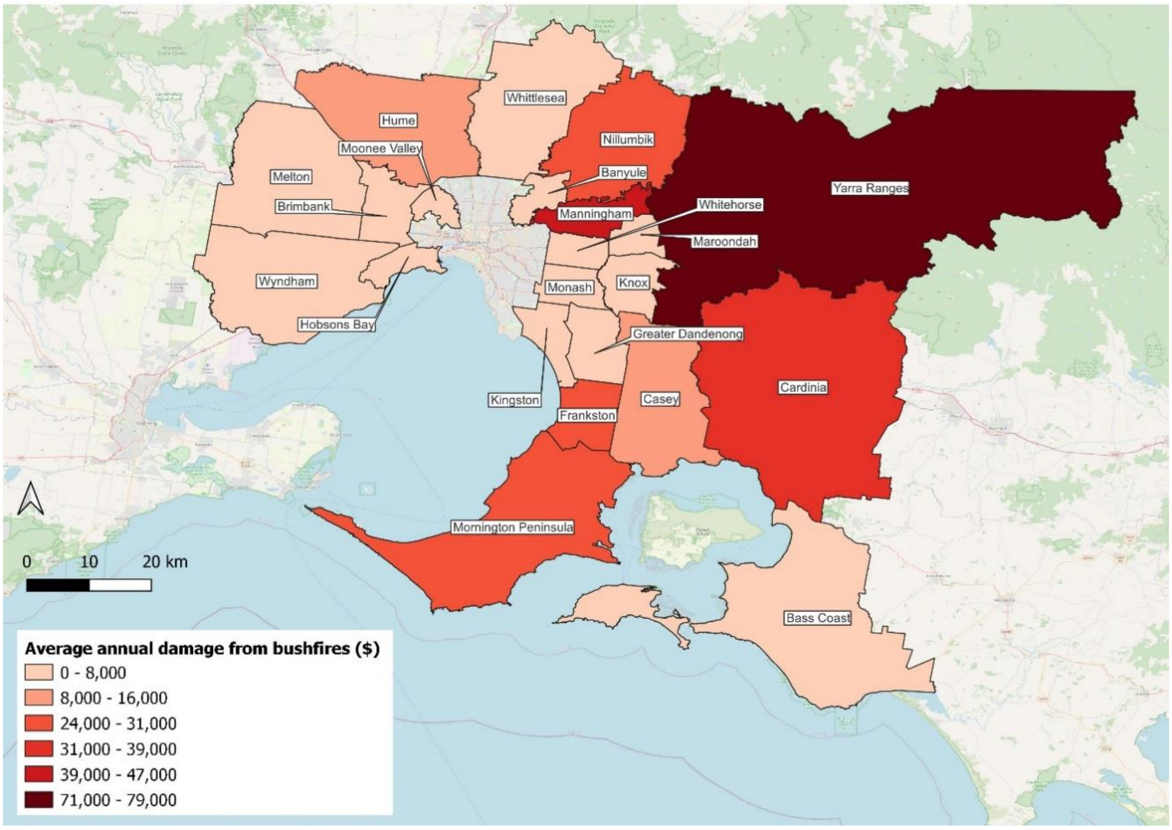

Figure 6. AAD estimates from bushfires to council assets in the nearer future presented by council area across Greater Melbourne (mid estimates)

Figure 7 shows that primarily it is councils located on the coast that have assets exposed and at risk from coastal flooding. It is the community assets of Hobson bay and Frankston that are assessed to have the highest level of risk based on having the highest estimates of AAD in the nearer future scenario.

Figure 8 shows AAD estimates related to heatwaves. The actual impact of heatwaves is assumed to be consistent across Greater Melbourne (e.g. they impact on public building in a similar way), with all council assets being exposed. AAD estimates are the highest for Hume.

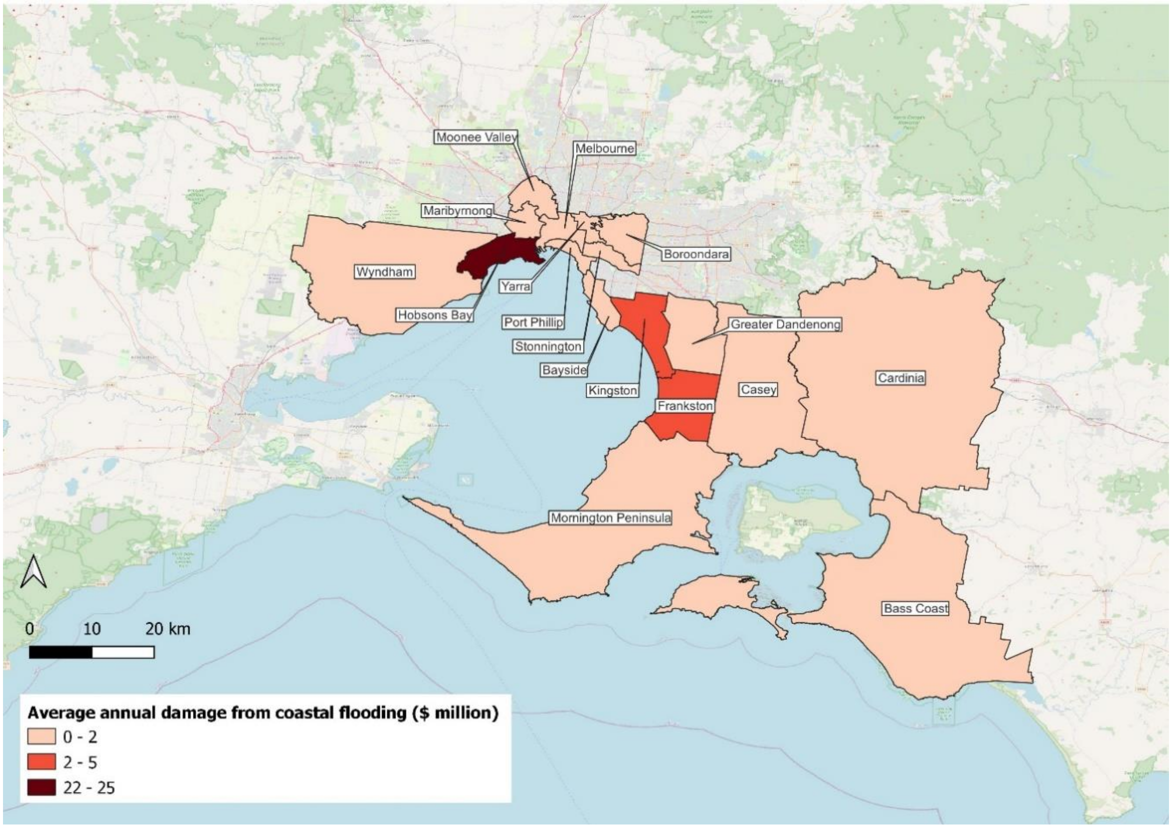

Figure 7. AAD estimates from coastal flooding to council assets in the nearer future presented by council area across Greater Melbourne (mid estimates)

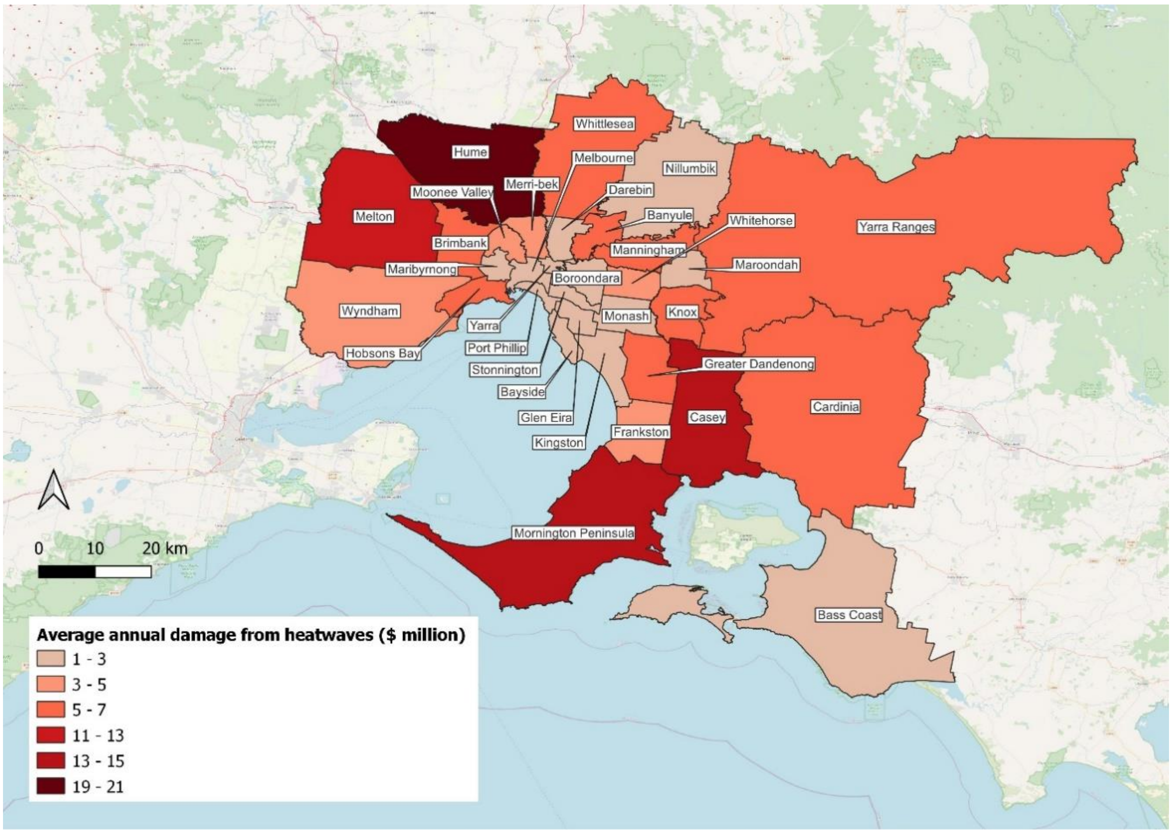

Figure 8. AAD estimates from heatwaves to council assets in the nearer future presented by council area across Greater Melbourne (mid estimates)

Figure 9 shows AAD estimates related to inland flooding. It shows that Banyule has the highest estimates of AAD from inland flooding in the nearer future. Councils surrounding Banyule are estimated to have lower levels of AAD and therefore lower levels of risk. Casey is also shown as having relatively high risk with a comparatively high estimate of AAD in the nearer future.

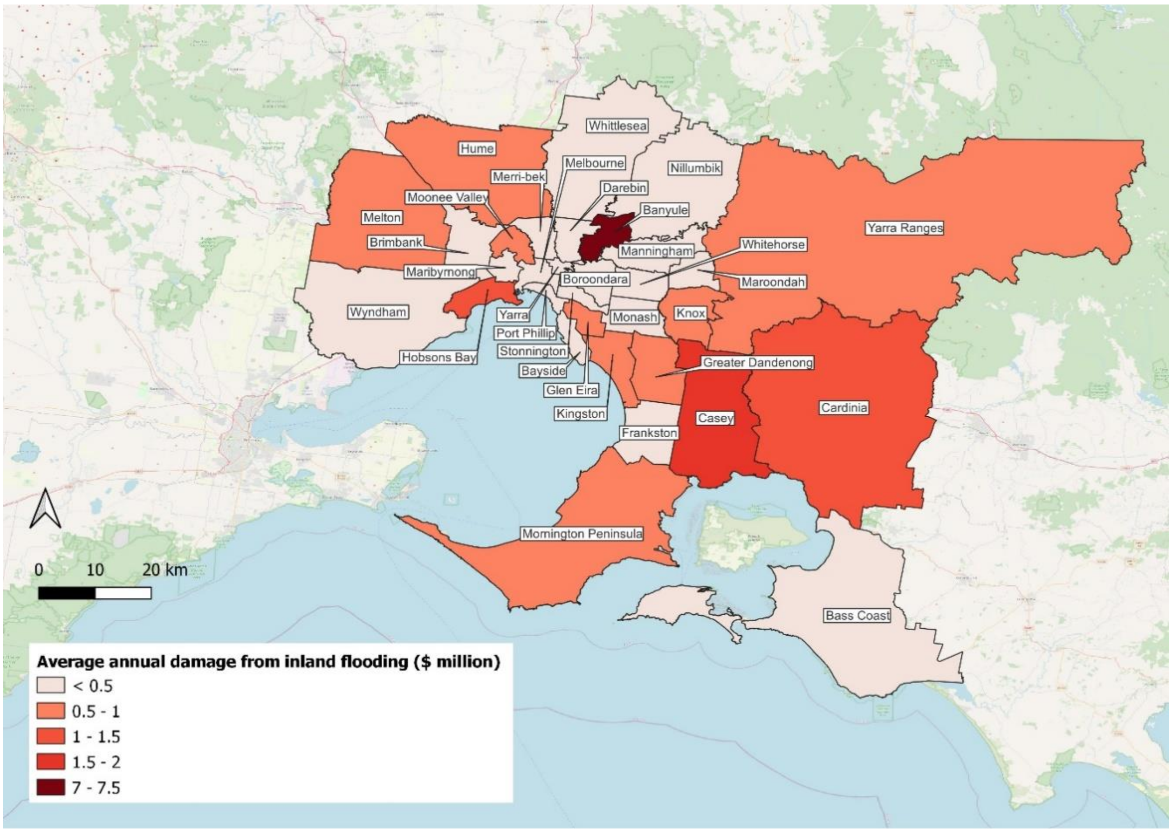

Figure 9. AAD estimates from inland flooding to council assets in the nearer future presented by council area across Greater Melbourne (mid estimates)

3.6 Sensitivity analysis

Sensitivity analysis is an important component of economic analysis, particularly when there are high levels of uncertainty around key inputs, and/or where there are limitations on the quality of the data available. Performing sensitivity analysis can significantly improve the robustness of the results by providing an understanding of how the results of the analysis change with changes in the values of input parameters or assumptions, and by identifying which inputs have the most significant influence on the results.

For this project, sensitivity analysis was performed using a Monte Carlo simulation with 20,000 iterations, to identify which inputs have the most significant influence on the variability of the final results. This provides insight into which variables to prioritise in future work to refine estimated values.

The findings from the sensitivity testing are presented in Figure 10. Inputs generally fall into one of the below key categories:

- Sensitivity – Inputs which reflect the degree of damage caused to each asset from each hazard.
- Replacement cost – the inputs used to estimate the dollar value of damages.
- Likelihood – the inputs which reflect the likelihood (probability) of each climate hazard occurring within any given year.
- Useful economic life of asset – the inputs used to adjust the impacts on heatwaves to an annualised value.

Figure 10 shows to what degree each input is contributing to the variance in AADs. It shows that replacement cost – roads, useful life – roads, and sensitivity to heatwaves - roads are all significant drivers of variability. A contributing factor to this finding is the fact that across Greater Melbourne, there is a large number of roads exposed to climate hazards, relative to other assets. This finding suggests refinement and improvement of information used for road inputs would be the most effective means to refine estimates of AADs. The likelihood of heatwaves, replacement cost -sports fields, also sensitivity to heatwaves – parks and reserves also contribute to the variance in AAD estimates, but to a lesser degree than road inputs.

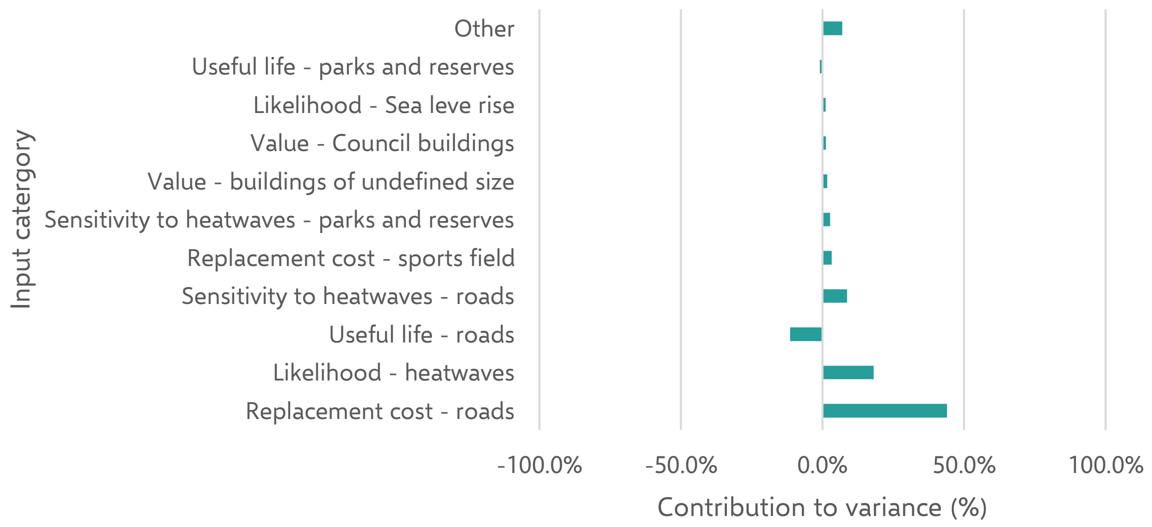

Figure 10. Top 10 inputs contributing to the variance in base case damages for the nearer future

The sensitivity variables were based on relatively coarse assumptions at an asset type level as data/information to undertake a more granular assessment was not available at this time. Due to this, a wide range was placed around estimates of sensitivity when conducting the analysis. This approach explains why the sensitivity variables have a big influence on the variance in estimates.

In additions to sensitivity analysis, a comparison between the results of this project and the results of the South East Councils Climate Change Alliance's (SECCCA) Asset Vulnerability Assessment (AVA) was undertaken to sense check the results. The AVA presents vulnerability ratings for assets whereas this project estimates AAD. This meant only a high-level comparison across asset classes was possible. The project findings were found to be relatively consistent, although the AVA project did not recognise drainage assets (e.g. pipes and pits) as being vulnerable to heat.

3.7 Severe storms case study

AAD estimates from severe storms have not been incorporated into the base case as publicly available data to assess exposure to severe storms at a regional or local level is very limited. The potentially significant impact from severe storms is illustrated through a case study shown in Box 1.

Box 1. Case Study: Severe storms

Severe storms in the Yarra Ranges

By Jan Wisniewski

This case study is based on an interview with Yarra Ranges Council officers conducted on 24 October 2022, and examines the impact of the June 2021 storm on the Yarra Ranges Council's assets. Representatives from the council recovery team were interviewed to discuss the challenges involved. The duration of the storm and direction of the winds were unprecedented, according to one representative. This brought down approximately 25,000 trees, which damaged roads, bridges, and drains (Yarra Ranges Council, 2022a; McKenzie, 2022). One year on from the storm, the Yarra Ranges Council (2022b) had incurred costs of $10.3 million for "removing, processing and disposing of the fallen trees, and repairing roads". However, the council estimated totals costs as high as $31.4 million once all "services supporting the recovery" were factored in (Ibid.).

Figure 11. One of approximately 25,000 trees brought down during a severe storm in the Yarra Ranges in June 2021

To cover the initial costs relating to council assets, Council requested financial assistance from the Victorian and federal government under standard Disaster Recovery Funding Arrangements (DRFA) (Yarra Ranges Council 2022a). However, the recovery team representatives pointed to a "real bottleneck at the assessment point" for such funding in Victoria. This delay and perceived lack of clarity from government on the potential success of the council's claims caused concerns regarding the cash flow required to "start repair work and to fund clean-up work".

The recovery team representatives explained these concerns were somewhat eased by three cash advances from government, the first of which came in January 2022. However, they also highlighted the difficulty of complying with the DRFA claims requirements, citing damage to drainage as an example. There is often an "accumulation of events that causes a break during a wet season", which makes it difficult to pinpoint "the exact event it's linked to", explained one representative. This may exclude the damage from a DRFA claim. In reaction to this, the recovery team representatives said the council now clearly instruct contractors hired for repair and debris clean-up to deliver photographic evidence of damage.

Unfortunately, there are larger issues surrounding the collection of asset condition data. To "make a claim for a reconstruction program, you need to be able to demonstrate the asset condition prior to the event, and that has to be relatively recent," explained one representative. However, to conduct the required audits is a challenge for most resource constrained councils. Moreover, gathering clear "post-event data" takes time as well, suggested the representative. While councils cannot leave assets like roads damaged for an extended period, repairing them effectively "strips back your evidence base".

A further issue with the "exacting standards" of the DRFA is that they require councils to rebuild assets identical to their original structure, explained one representative. This prevents the upgrade of infrastructure to be more resilient to future storms, for example, unsealed roads. Moreover, some of these roads bore the extra weight of the trucks used to clean up debris, which lowers their resilience to future events even further.

Insured council assets are excluded from DRFA claims, explained the recovery team representatives. There were six council facilities extensively damaged in the storm. This included Monbulk Aquatic Centre and Mt Dandenong Preschool (Yarra Ranges Council 2022a). The recovery team representatives stated that while no local government can afford to fully insure all its assets, they believed that the insurance quotes for the damage to these assets in June 2021 were highly undervalued. One reason for this, is that insurers have not "considered the complexity" of rebuilding facilities with "planning overlays", suggested one representative. Such overlays are part of the reason the council is debating whether to rebuild Mt Dandenong Preschool on its existing site, explained the representatives. Of all the damaged assets, the loss of the services related to Monbulk Aquatic Centre had the greatest community impact, suggested one recovery team representative. The facility reopened more than a year after the storm, in September 2022. Moreover, this entails more costs to the council, as it is now in negotiation regarding the loss of income for the contractors running the aquatic services.

4 Recommendations and next steps

The base case results highlight that AADs from climate hazards to community assets in Greater Melbourne will increase significantly with climate change as hazards become more frequent and as more assets become exposed. Present day average annual damages are in the range of $90-$120 million, with damages increasing to between $210-$300 million in the nearer future (~2050) and to between $400-$540 million in the more distant future (~2100). Heatwaves are identified as having the most significant impact followed by coastal flooding and then inland flooding.

Based on the findings of the project, a list of recommendations for next steps have been made below. These recommendations are not required to be undertaken sequentially.

1. **Refine base case estimates of damage and update results when new information becomes available -** Opportunities to refine the base case include addressing key data gaps and refining the key inputs as described in section 2.5 and below:

1.1. **Exposure and likelihood inputs** - The project utilised publicly available spatial layers of hazard extents to perform the exposure analysis. Key opportunities to improve these layers include:

- Ensuring coastal flooding extents reflect latest climate projections.
- Ensuring depth information is available to accompany coastal and inland flooding hazard extents. This data assists with estimating damages to assets
- Ensuring inland flooding hazard extents are available for a range probabilistic events and time intervals which consider projected changes in climate.
- Undertaking bushfire modelling to create extent layers which reflect specific probabilistic events

1.2. **Sensitivity inputs -** The base case estimates draws on generic sensitivity ratings for each type of asset which are based on the type of asset and its materials. Refinement to the sensitivity ratings used, through further consultation with asset managers and experts in this field, will improve the robustness of the base case results. Given the efforts required to undertake this bespoke sensitivity analysis, it is recommended that this is only undertaken for high-value assets.

1.3. **Replacement cost inputs -** The replacement cost estimates used in valuing the base case are informed by the Rawlinsons Australian Construction Handbook (2022) as well as council data collected in phase 1. Review of more granular data, at an asset-by-asset level or further consultation with council staff may help to refine replacement cost estimates and therefore the base case results. Again, focus on higher-value assets as well as the replacement cost of roads, which is key driver of the variance in AADs.

2. **Expand the scope of the base case assessment to include indirect tangible and intangible impacts** – The project focused on the direct impacts of climate hazards to council assets. Climate hazard events will also have a significant impact on councils' ability to deliver its services as well as direct (e.g. damage to private property), indirect (e.g. transport or business disruptions) and intangible (e.g. impacts to physical and mental health) impacts on the broader community. Expanding the scope of the base case in future work to consider these broader impacts will give council useful information to assist with prioritising adaptation and improving the resilience of the local community to climate change. This is particularly the case for council's services where performance measures are based on the use of an asset, rather than the asset itself. For example, the benefits from the use of a library are based on visits to the library and the use of the library catalogue. Therefore, the damage from an event that impacts on a library would be the direct

damage to the library (assets) *and* the loss of benefits derived from the use of the library catalogue by residents.

3. **Undertake cost-benefit analysis of adaptation options** – The base case is a critical input into a CBA of adaptation options as it provides a 'do nothing differently' scenario against which adaptation initiatives can be assessed. The base case developed in this project can be used by councils across Greater Melbourne to begin undertaking CBA of adaptation options. The use of this approach will assist them to better understand and compare the costs and benefits of different adaptation options. The steps for undertaking a CBA of adaptation options are detailed in the CBA Framework (see Figure 1).

   Types of adaptation options can include actions to reduce the severity of hazards, actions to reduce the sensitivity of assets, and actions to reduce asset exposure. A range of potential adaptation actions for each hazard are shown in Table 9.

Table 9. Potential adaptation options for climate hazards

Adaptation action	Heatwaves	Coastal flooding	Inland flooding	Bushfires
Reduce hazard severity	Use vegetation for shade and evaporative cooling	Rehabilitate coastal vegetation	Install on-site detention systems to reduce peak flows	Conduct hazard reduction burning
Reduce asset sensitivity	Use more heat resistant material	Raise building floor/road heights	Use removable fixtures and fittings	Treat timber with fire-retardant chemicals
Reduce asset exposure	Not applicable	Build mitigation structures (e.g. sea walls)	Increase drainage capacity	Relocate assets

4. **Begin integrating climate change considerations into long term financial plans** – The results of the project indicate that the costs associated with maintaining the existing community asset base will grow significantly with climate change. To respond, councils need to begin incorporating these costs into long term financial plans, including as part of asset renewal and capital works forecasts, to ensure these plans adequately account for and communicate the financial resources required to continually provide community services and infrastructure over the long term.

5. **Begin integrating climate change considerations into asset management practices** – The result of the project highlights the significant degree to which climate change may impact assets. To respond and improve asset resilience, councils may consider making changes to how they manage and maintain assets. This may include:

5.1. **Increasing the knowledge base of council asset management staff on the likely impacts of climate change on assets** – The results of this study provide strong evidence of the likely economic impact of climate change on assets. Sharing these results among asset management personnel will assist to increase their understanding of the likely impacts of climate change on assets, which in turn is expected to improve future decision making in relation to asset management with climate change and assist with identifying opportunities for adaptation.

5.2. **Identifying opportunities to manage climate risk through asset management activities** – When maintaining and replacing components of assets, there is an opportunity to increase the resilience of assets to climate hazards. This is a staged approach to adaptation and can be useful in instances of constrained capital.

5.3. **Document asset management approaches for responding to assets that are damaged by climate hazards** – Delays in maintenance can increase the susceptibility of assets to damage from climate hazards. A maintenance program which considers this as well as responses to extreme weather events and consequent damage to assets has the potential to moderate impacts.

5.4. **Measure and report on the impacts of climate change on assets** – Measuring and reporting on the impacts of climate hazards on assets will provide much needed information to understand assets most at risk and in need of adaptation and provide evidence of the need for additional funding support. The How Well Are We Adapting web-based tool can assist councils to track the impact of climate change and evaluate and report on their responses.

5.5. **Maintaining an up-to-date asset register which includes key asset details** – An up-to-date asset management system will support future work to assess climate change impacts and the comparison of costs and benefits of adaptation.

5.6. **Ensuring 'contributed assets' are resilient** – Where assets are typically 'contributed assets' initially developed as part of a development approval (or similar) such as stormwater assets in new developments, ensure they meet high levels of resilience. This will mitigate the likelihood that the base case of the asset portfolio and the subsequent fiscal risk to council will not unnecessarily increase.

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Appendix A – Base case inputs

Sensitivity ratings

Table 10 shows the sensitivity ratings applied to each asset type for each climate hazard. Sensitivity of assets to each climate hazard is informed by guidance from IPWEA (2021), which considers the type of assets and its construction materials. Sensitivity values were tested with a small group of representatives from Councils and were refined based on this process.

Table 10. Sensitivity ratings applied to each asset type for climate hazard (L=Low, L-M=Low-moderate, M-H=Moderate-high, H=High)

Asset category	Asset type	Shape	Reference asset	Sensitivity rating					Source
				Heatwaves	Sea level rise	Storm-tide inundation	Inland flooding	Bushfires	
Buildings	Amenities	Polygons	Garage	L	H	L-M	L-M	H	IPWEA, 2021
Buildings	Amenities	Point	Garage	L	H	L-M	L-M	H	IPWEA, 2021
Buildings	Community	Polygons	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Buildings	Community	Point	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Buildings	Council	Polygons	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Buildings	Council	Point	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Buildings	Industrial	Polygons	Garage	Low	H	L-M	L-M	H	IPWEA, 2021
Buildings	Industrial	Point	Garage	Low	H	L-M	L-M	H	IPWEA, 2021
Buildings	Outdoor use	Polygons	Verandah	Low	H	L-M	L-M	H	IPWEA, 2021
Buildings	Outdoor use	Point	Verandah	Low	H	L-M	L-M	H	IPWEA, 2021
Buildings	Non council	Polygons	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Sensitivity rating					Source
				Heatwaves	Sea level rise	Storm-tide inundation	Inland flooding	Bushfires	
Buildings	Sports facilities	Polygons	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Buildings	Undefined size	Point	Weatherboard - Timber	L-M	H	M-H	M-H	H	IPWEA, 2021
Drainage	Stormwater pipe	Lines	Stormwater - RCP (concrete)	L-M	H	L-M	L-M	L-M	IPWEA, 2021
Drainage	Stormwater pit	Point	Stormwater - RCP (concrete)	L-M	H	L-M	L-M	L-M	IPWEA, 2021
Drainage	Culvert	Lines	Stormwater - RCP (concrete)	L-M	H	L-M	L-M	L-M	IPWEA, 2021
Natural assets	Garden bed	Point	Groundcover	L-M	H	L-M	L-M	H	DIT, 2015 /NCE assumptions
Natural assets	Landscaping	Polygons	Groundcover	L-M	H	L-M	L-M	H	DIT, 2015 /NCE assumptions
Natural assets	Parks and reserves	Polygons	Groundcover	L-M	H	L-M	L-M	H	DIT, 2015 /NCE assumptions
Natural assets	Sports field	Polygons	Groundcover	L-M	H	L-M	L-M	H	DIT, 2015 /NCE assumptions
Natural assets	Tree	Point	n/a	L-M	H	L-M	L-M	H	NCE assumption
Natural assets	Other natural assets	Polygons	Groundcover	L	H	L	L	H	DIT /NCE assumptions
Built assets in open space	Barbecue	Point	Electrical	M-H	H	M-H	M-H	H	IPWEA, 2021
Built assets in open space	Lighting	Point	Electrical	M-H	H	M-H	M-H	H	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Sensitivity rating					Source
				Heatwaves	Sea level rise	Storm-tide inundation	Inland flooding	Bushfires	
Built assets in open space	Other	Point	Park seat / Picnic table / Rubbish bin	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Other services	Point	Electrical	M-H	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Built assets in open space	Playground and sports equipment	Point	Park seat / Picnic table / Rubbish bin	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Playground/Sport area	Polygons	Astro turf	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Street furniture	Point	Park seat / Picnic table / Rubbish bin	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Court	Point	Astro turf	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Court	Polygons	Astro turf	Low	H	L	L	H	IPWEA, 2021
Built assets in open space	Drinking fountain	Point	Pump	L	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Built assets in open space	Fencing	Lines	Post / Rail / Mesh Fence	L	H	M-H	M-H	H	IPWEA, 2021
Built assets in open space	Fence	Point	Post / Rail / Mesh Fence	L	H	M-H	M-H	H	IPWEA, 2021
Built assets in open space	Other	Point	Park seat / Picnic table / Rubbish bin	L	H	L	L	H	IPWEA, 2021
Built assets in open space	Other	Polygons	Park seat / Picnic table / Rubbish bin	L	H	L	L	H	IPWEA, 2021
Built assets in open space	Pool	Polygons	Reservoir - concrete structure	L	H	M-H	M-H	H	Based on IPWEA and NCE estimates

Asset category	Asset type	Shape	Reference asset	Sensitivity rating					Source
				Heatwaves	Sea level rise	Storm-tide inundation	Inland flooding	Bushfires	
Built assets in open space	Railing	Lines	Handrail - Metal	L	H	L	L	H	Based on IPWEA and NCE estimates
Built assets in open space	Ramp	Polygons	Paved footpath	L	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Built assets in open space	Retaining wall	Lines	Retaining walls - Timber	L	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Built assets in open space	Shade sail	Polygons	Shade cloth	L	H	L	L	H	Based on IPWEA and NCE estimates
Built assets in open space	Sign	Point	Sign - exterior	L	H	L	L	H	Based on IPWEA and NCE estimates
Built assets in open space	Street furniture	Point	Park seat / Picnic table / Rubbish bin	L	H	L	L	H	IPWEA, 2021
Built assets in open space	Water infrastructure	Point	Pump	M-H	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Built assets in open space	Playground and sports surface	Polygons	Astro turf	L	H	L-M	L-M	H	IPWEA, 2021
Built assets in open space	Irrigation pipe	Lines	Stormwater - RCP (concrete)	L-M	H	L-M	L-M	H	IPWEA, 2021
Built assets in open space	Raingarden	Point	Groundcover	L-M	H	L-M	L-M	H	DIT, 2015 /NCE assumptions
Built assets in open space	Fountain	Polygons	Pump	M-H	H	M-H	M-H	H	Based on IPWEA and NCE estimates
Roads	Footbridge	Polygons	Bridge - Concrete deck	L-M	H	M-H	M-H	L-M	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Sensitivity rating					Source
				Heatwaves	Sea level rise	Storm-tide inundation	Inland flooding	Bushfires	
Roads	Jetty/Pier/Boardwalk/Platform	Point	Decking - Timber	L	H	L-M	L-M	L-M	Based on IPWEA and NCE estimates
Roads	Jetty/Pier/Boardwalk/Platform	Polygons	Decking - Timber	L	H	L-M	L-M	L-M	Based on IPWEA and NCE estimates
Roads	Stairs	Point	Staircase - metal	L	H	L	L	L-M	IPWEA, 2021
Roads	Stairs	Polygons	Staircase - metal	L	H	L	L	L-M	IPWEA, 2021
Roads	Vehicle bridge	Polygons	Bridge - Concrete deck	L-M	H	M-H	M-H	L-M	IPWEA, 2021
Roads	Private and state roads	Polygons	Urban spray sealed road	L-M	H	M-H	M-H	L-M	IPWEA, 2021
Roads	Car park	Point	Paved footpath	L	H	M-H	M-H	L-M	IPWEA, 2021
Roads	Footpath/Pathway/Sealed	Polygons	Paved footpath	L	H	M-H	M-H	L-M	IPWEA, 2021
Roads	Road	Polygons	Urban spray sealed road	L-M	H	M-H	M-H	L-M	IPWEA, 2021

Replacement cost estimates

Table 11 shows the unit rate values applied to each type of asset to estimate its replacement cost. A low, middle, and high unit rate was used to estimate a range in replacement cost for each asset to account for uncertainty around the exact replacement cost of each asset. Replacement cost estimates are informed by the Rawlinsons Australian Construction Handbook (2022), as well as information on replacement cost collected from councils in phase 1.

Table 11. Unit rates applied to estimate the replacement cost of types of assets

Asset category	Asset type	Shape	Reference asset (Rawlinsons)	Unit rates			Units	Source
				Low	Mid	High		
Buildings	Amenities	Polygons	Public toilets	1,662	3,369	5,160	sqm	Council data
Buildings	Community	Polygons	Childcare centre/Library	2,412	3,499	5,593	sqm	Council data
Buildings	Council	Polygons	Residential houses	1,321	2,828	4,873	sqm	Council data
Buildings	Industrial	Polygons	Garage	1,005	1,993	3,312	sqm	Council data
Buildings	Non council	Polygons	n/a	-	-	-	n/a	n/a
Buildings	Outdoor use	Polygons	Pergola/Verandah	816	2,244	3,350	sqm	Council data
Buildings	Sports facilities	Polygons	Recreation centre	1,724	3,362	5,177	sqm	Council data
Buildings	Undefined size	Point	Pergola/Verandah (50m2) /Garage (100m2) /Residential house (200m2)	40,795	895,917	4,467,558	each	Rawlinsons/Council data
Drainage	Culvert	Lines	Precast concrete box culvert	217	454	1,326	m	Rawlinsons/Council data
Drainage	Stormwater pipe	Lines	Drainage - concrete pipe	208	261	427	m	Council data
Drainage	Stormwater pit	Point	In situ concrete pit: 600 - 900mm deep (Pg 503)	1,429	2,103	2,597	each	Rawlinsons
Natural assets	Landscaping	Polygons	Landscaping	7	29	51	sqm	Rawlinsons
Natural assets	Parks and reserves	Polygons	Groundcover	6	12	83	sqm	Rawlinsons/Council data
Natural assets	Sports field	Polygons	Groundcover	6	12	221	sqm	Rawlinsons/Council data
Natural assets	Tree	Point	Large tree	230	531	2,132	each	Rawlinsons/Council data
Natural assets	Garden bed	Point	Large Shrub/Planters	13	727	1,440	each	Rawlinsons
Natural assets	Other natural assets	Polygons	Groundcover	6	12	83	sqm	Rawlinsons/Council data

Asset category	Asset type	Shape	Reference asset (Rawlinsons)	Unit rates			Units	Source
				Low	Mid	High		
Built assets in open space	Barbecue	Point	Electrical services - commercial lighting - single light point/small car park pole lighting	5,590	9,525	14,733	each	Rawlinsons/Council data
Built assets in open space	Court	Point	Tennis courts	23,000	40,900	58,800	each	Rawlinsons/Council data
Built assets in open space	Court	Polygons	Synthetic grass	70	145	165	sqm	Rawlinsons/Council data
Built assets in open space	Drinking fountain	Point	Drinking fountain	2,280	5,452	7,080	each	Rawlinsons/Council data
Built assets in open space	Fencing	Lines	Fencing and gates	90	149	358	m	Rawlinsons/Council data
Built assets in open space	Fence	Point	Single/Double gate	525	888	1,250	each	Rawlinsons
Built assets in open space	Lighting	Point	Electrical services - commercial lighting - single light point/small car park pole lighting	106	612	7,681	each	Rawlinsons/Council data
Built assets in open space	Other	Point	Seating	580	930	1,280	each	Rawlinsons
Built assets in open space	Other	Polygons	Synthetic grass	125	145	221	sqm	Rawlinsons/Council data
Built assets in open space	Other services	Point	Electrical services - commercial lighting - single light point/small car park pole lighting	106	2,403	4,700	each	Rawlinsons
Built assets in open space	Playground and sports equipment	Point	Seating	580	930	7,745	each	Rawlinsons/Council data
Built assets in open space	Pool	Polygons	Pools	1,446	1,904	2,362	sqm	Rawlinsons
Built assets in open space	Railing	Lines	Metal work - Handrails	99	257	415	m	Rawlinsons
Built assets in open space	Ramp	Polygons	Paved footpath	63	75	87	Sqm	Rawlinsons

Asset category	Asset type	Shape	Reference asset (Rawlinsons)	Unit rates			Units	Source
				Low	Mid	High		
Built assets in open space	Retaining wall	Lines	Retaining walls - brickwork	348	440	776	Sqm	Rawlinsons/Council data
Built assets in open space	Shade sail	Polygons	Shade cloth	8	8	9	sqm	Rawlinsons
Built assets in open space	Sign	Point	Road sign	309	455	624	each	Rawlinsons/Council data
Built assets in open space	Street furniture	Point	Seating	580	2,554	4,581	each	Rawlinsons/Council data
Built assets in open space	Water infrastructure	Point		161	1,605	3,211		Council data
Built assets in open space	Playground and sports surface	Polygons	Synthetic grass	70	145	696	sqm	Rawlinsons/Council data
Built assets in open space	Irrigation pipe	Lines	Drainage - concrete pipe	146	848	1,550	m	Rawlinsons
Built assets in open space	Raingarden	Point	n/a	6	12	83	sqm	Rawlinsons/Council data
Built assets in open space	Fountain	Polygons		208	261	427	m	Council data
Roads	Footbridge	Polygons	Footbridge	820	900	1,452	Sqm	Rawlinsons/Council data
Roads	Footpath/Pathway/Sealed	Polygons	Paved footpath	52	70	131	Sqm	
Roads	Jetty/Pier/Boardwalk/Platform	Point		2,084	8,667	10,400	each	Rawlinsons
Roads	Jetty/Pier/Boardwalk/Platform	Polygons	Wharves	417	1,733	2,080	sqm	Rawlinsons/Council data
Roads	Road	Polygons	Suburban road	18	48	85	Sqm	Council data
Roads	Stairs	Point		4,995	5,333	5,670	Each	Rawlinsons/Council data

Asset category	Asset type	Shape	Reference asset (Rawlinsons)	Unit rates			Units	Source
				Low	Mid	High		
Roads	Stairs	Polygons	Staircases	549	587	624	Sqm	Rawlinsons/Council data
Roads	Vehicle bridge	Polygons	Bridgeworks	1,760	2,044	4,426	sqm	Rawlinsons/Council data
Roads	Private and state roads	Polygons	n/a	-	-	-	n/a	n/a
Roads	Car park	Point	n/a	523	697	1,308	n/a	Council data

Asset useful life estimates

Table 12 shows the useful life assumptions applied to each type of asset. Useful life assumptions were used to distribute the cost of heatwaves on asset, across their life. Damage from other climate hazard events is assumed to occur when the event occurs. A low, middle, and high estimate was applied to account for uncertainty around each asset's exact useful life. Useful life estimates were informed by IPWEA (2021).

Table 12. Useful life of asset assumptions

Asset category	Asset type	Shape	Reference asset	Useful life (years)			Source
				Low	Mid	High	
Buildings	Amenities	Polygons	Garage	40	50	60	IPWEA, 2021
Buildings	Amenities	Point	Garage	40	50	60	IPWEA, 2021
Buildings	Community	Polygons	Weatherboard - Timber	60	75	90	IPWEA, 2021
Buildings	Community	Point	Weatherboard - Timber	60	75	90	IPWEA, 2021
Buildings	Council	Polygons	Weatherboard - Timber	60	75	90	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Useful life (years)			Source
				Low	Mid	High	
Buildings	Council	Point	Weatherboard - Timber	60	75	90	IPWEA, 2021
Buildings	Industrial	Polygons	Garage	40	50	60	IPWEA, 2021
Buildings	Industrial	Point	Garage	40	50	60	IPWEA, 2021
Buildings	Outdoor use	Polygons	Verandah	45	60	70	IPWEA, 2021
Buildings	Outdoor use	Point	Verandah	45	60	70	IPWEA, 2021
Buildings	Non council	Polygons	Weatherboard - Timber	60	75	90	IPWEA, 2021
Buildings	Sports facilities	Polygons	Weatherboard - Timber	60	75	90	IPWEA, 2021
Buildings	Undefined size	Point	Weatherboard - Timber	60	75	90	IPWEA, 2021
Drainage	Stormwater pipe	Lines	Stormwater - RCP (concrete)	60	98	150	IPWEA, 2021
Drainage	Stormwater pit	Point	Stormwater - SEP	50	72	100	IPWEA, 2021
Drainage	Culvert	Lines	Stormwater - RCP (concrete)	60	98	150	IPWEA, 2021
Natural assets	Garden bed	Point	Groundcover	8	10	12	IPWEA, 2021
Natural assets	Landscaping	Polygons	Groundcover	8	10	12	IPWEA, 2021
Natural assets	Parks and reserves	Polygons	Groundcover	8	10	12	IPWEA, 2021
Natural assets	Sports field	Polygons	Groundcover	8	10	12	IPWEA, 2021
Natural assets	Tree	Point	n/a	24	60	96	IPWEA, 2021
Natural assets	Other natural assets	Polygons	Groundcover	8	10	12	IPWEA, 2021
Built assets in open space	Barbecue	Point	Electrical	15	20	25	IPWEA, 2021
Built assets in open space	Lighting	Point	Electrical	15	20	25	IPWEA, 2021
Built assets in open space	Other	Point	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021
Built assets in open space	Other services	Point	Electrical	15	20	25	IPWEA, 2021
Built assets in open space	Playground and sports equipment	Point	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Useful life (years)			Source
				Low	Mid	High	
Built assets in open space	Playground/Sport area	Polygons	Astro turf	8	10	12	IPWEA, 2021
Built assets in open space	Street furniture	Point	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021
Built assets in open space	Court	Point	Astro turf	8	10	12	IPWEA, 2021
Built assets in open space	Court	Polygons	Astro turf	8	10	12	IPWEA, 2021
Built assets in open space	Drinking fountain	Point	Pump	15	23	30	IPWEA, 2021
Built assets in open space	Fencing	Lines	Post / Rail / Mesh Fence	20	28	35	IPWEA, 2021
Built assets in open space	Fence	Point	Post / Rail / Mesh Fence	20	28	35	IPWEA, 2021
Built assets in open space	Other	Point	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021
Built assets in open space	Other	Polygons	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021
Built assets in open space	Pool	Polygons	Reservoir - concrete structure	50	65	80	IPWEA, 2021
Built assets in open space	Railing	Lines	Handrail - Metal	40	50	60	IPWEA, 2021
Built assets in open space	Ramp	Polygons	Paved footpath	30	46	60	IPWEA, 2021
Built assets in open space	Retaining wall	Lines	Retaining walls - Timber	45	60	72	IPWEA, 2021
Built assets in open space	Shade sail	Polygons	Shade cloth	14	15	16	IPWEA, 2021
Built assets in open space	Sign	Point	Sign - exterior	8	10	12	IPWEA, 2021
Built assets in open space	Street furniture	Point	Park seat / Picnic table / Rubbish bin	12	15	18	IPWEA, 2021
Built assets in open space	Water infrastructure	Point	Pump	15	23	30	IPWEA, 2021
Built assets in open space	Playground and sports surface	Polygons	Astro turf	8	10	12	IPWEA, 2021
Built assets in open space	Irrigation pipe	Lines	Stormwater - RCP (concrete)	60	98	150	IPWEA, 2021
Built assets in open space	Raingarden	Point	Groundcover	8	10	12	IPWEA, 2021
Built assets in open space	Fountain	Polygons	Pump	15	23	30	IPWEA, 2021
Roads	Footbridge	Polygons	Bridge - Concrete deck	60	86	100	IPWEA, 2021

Asset category	Asset type	Shape	Reference asset	Useful life (years)			Source
				Low	Mid	High	
Roads	Jetty/Pier/Boardwalk/Platform	Point	Decking - Timber	15	28	40	IPWEA, 2021
Roads	Jetty/Pier/Boardwalk/Platform	Polygons	Decking - Timber	15	28	40	IPWEA, 2021
Roads	Stairs	Point	Staircase - metal	50	60	70	IPWEA, 2021
Roads	Stairs	Polygons	Staircase - metal	50	60	70	IPWEA, 2021
Roads	Vehicle bridge	Polygons	Bridge - Concrete deck	60	86	100	IPWEA, 2021
Roads	Private and state roads	Polygons	Urban spray sealed road	15	22	33	IPWEA, 2021
Roads	Car park	Point	Paved footpath	30	46	60	IPWEA, 2021
Roads	Footpath/Pathway/Sealed	Polygons	Paved footpath	30	46	60	IPWEA, 2021
Roads	Road	Polygons	Urban spray sealed road	15	22	33	IPWEA, 2021

Asset data from councils

Table 13 highlight gaps in the spatial data on community assets received from councils. Gaps were predominantly found in relation to built assets in open space data. This relates to assets like street furniture. In some instance, councils provided building data in point rather than polygon form, which makes it more difficult to assess the exposure of the asset and its replacement cost.

Table 13. Summary of the asset data provided by each council

Council	Provided data				
	Buildings	Roads	Drainage	Natural assets	Built assets in open space
Banyule	✓	✓	✓	✓	X
Bass Coast	✓	✓	✓	✓	✓
Bayside	✓	✓	✓	✓	✓
Boroondara	✓	✓	✓	✓	✓

Council	Provided data				
	Buildings	Roads	Drainage	Natural assets	Built assets in open space
Brimbank	✓	✓	✓	✓	✓
Cardinia	✓	✓	✓	✓	X
Casey	✓	✓	✓	✓	X
Darebin	✓	✓	✓	✓	✓
Frankston	✓	✓	✓	✓	X
Glen Eira	Point form	✓	✓	✓	✓
Greater Dandenong	✓	✓	✓	✓	X
Hobsons Bay	✓	✓	✓	✓	✓
Hume	✓	✓	✓	✓	✓
Kingston	✓	✓	✓	✓	✓
Knox	Point form	✓	✓	✓	✓
Manningham	✓	✓	✓	✓	✓
Maribyrnong	Point form	✓	✓	✓	✓
Maroondah	✓	✓	✓	✓	✓
Melbourne	✓	✓	✓	✓	✓
Melton	✓	✓	✓	✓	✓
Monash	✓	✓	✓	✓	✓
Moonee Valley	✓	✓	✓	✓	✓
Merri-bek	✓	✓	✓	✓	✓
Mornington Peninsula	✓	✓	✓	X	✓
Nillumbik	✓	✓	✓	✓	✓
Port Phillip	✓	✓	✓	✓	X
Stonnington	✓	✓	✓	✓	✓
Whitehorse	✓	✓	✓	✓	✓

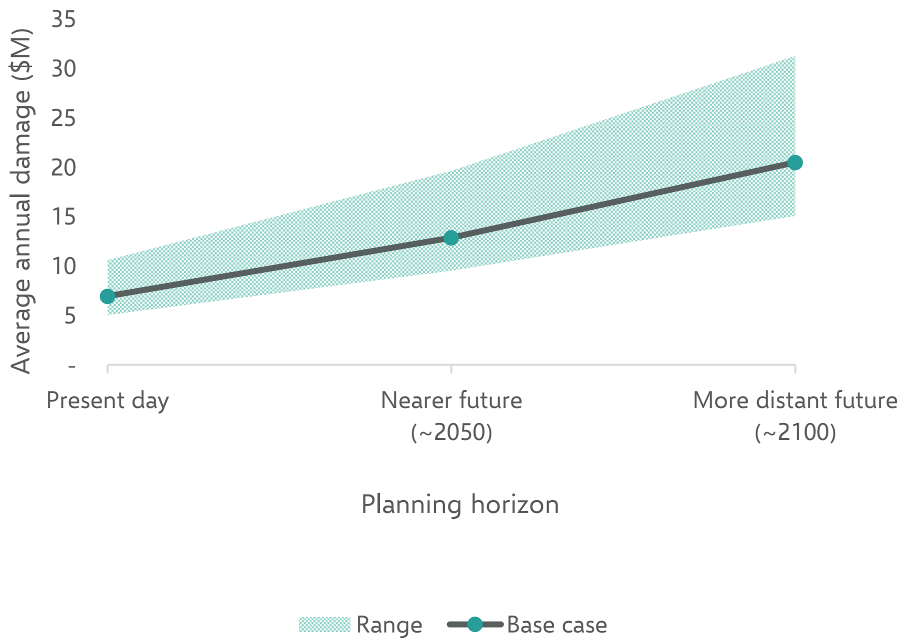
Council	Provided data				
	Buildings	Roads	Drainage	Natural assets	Built assets in open space
Whittlesea	Point form	✓	✓	✓	✓
Wyndham	✓	✓	✓	✓	✓
Yarra City	✓	✓	✓	✓	✓
Yarra Ranges	✓	✓	✓	✓	✓

Appendix B – Results by council

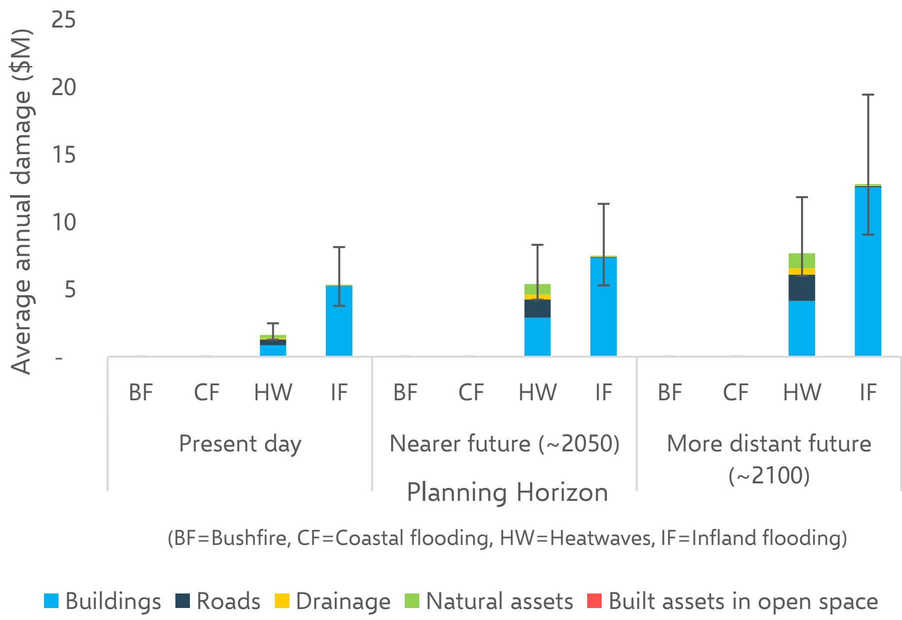
Banyule - Estimated damages from climate hazards without adaptation (Base case)

For Banyule, average annual damages (AADs) are estimated to be in the range of $5-$11 million for the present day, $9-$11 million for the nearer future (~2050) and, $15-$31 million for the more distant future (~2100). This is an increase in AADs of about 100% in the nearer future and 200% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Banyule under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

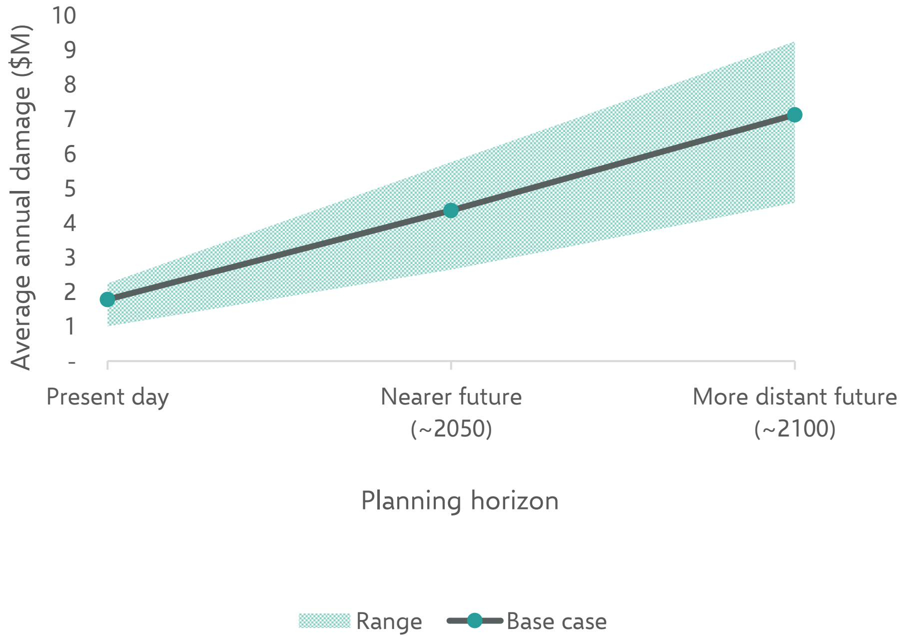
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Banyule broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

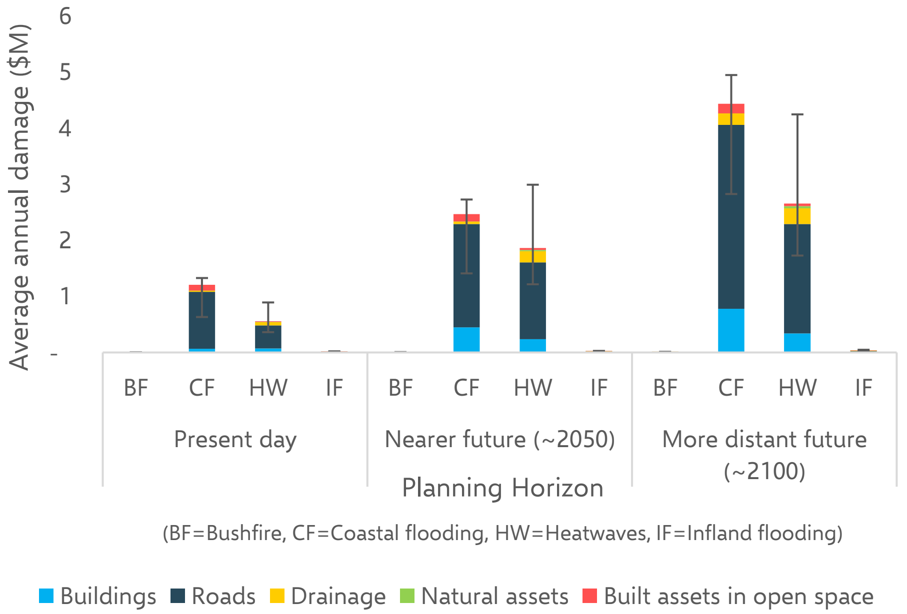
Bass Coast - Estimated damages from climate hazards without adaptation (Base case)

For Bass Coast, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $3-$6 million for the nearer future (~2050) and, $5-$9 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Bass Coast under the base case or “do nothing differently” scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

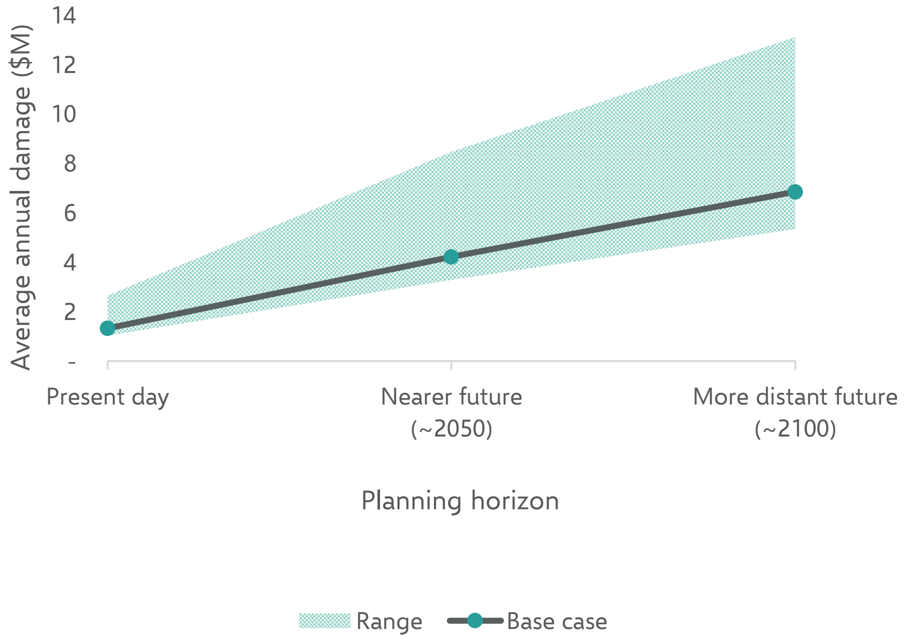
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Bass Coast broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

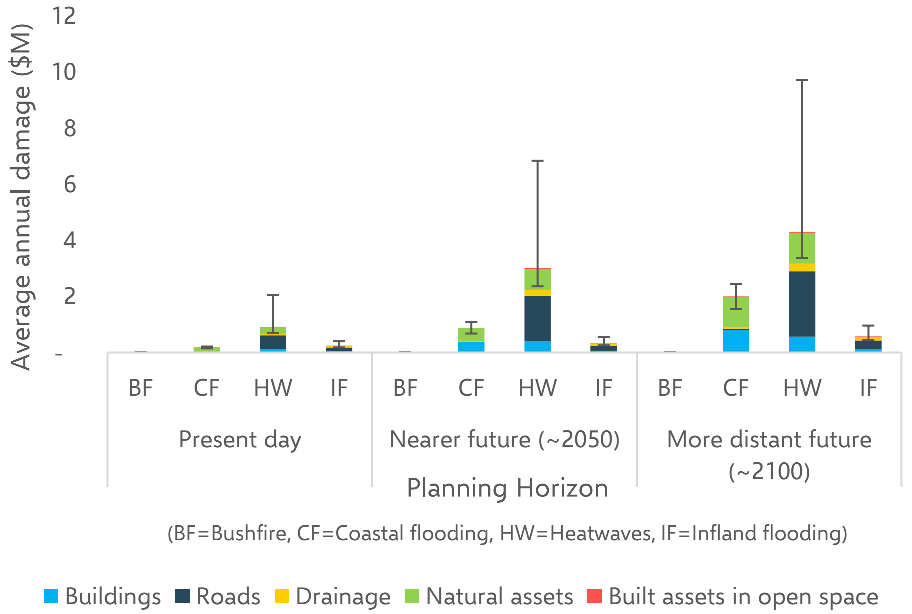
Bayside - Estimated damages from climate hazards without adaptation (Base case)

For Bayside, average annual damages (AADs) are estimated to be in the range of $1-$3 million for the present day, $3-$8 million for the nearer future (~2050) and, $5-$13 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 400% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Bayside under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

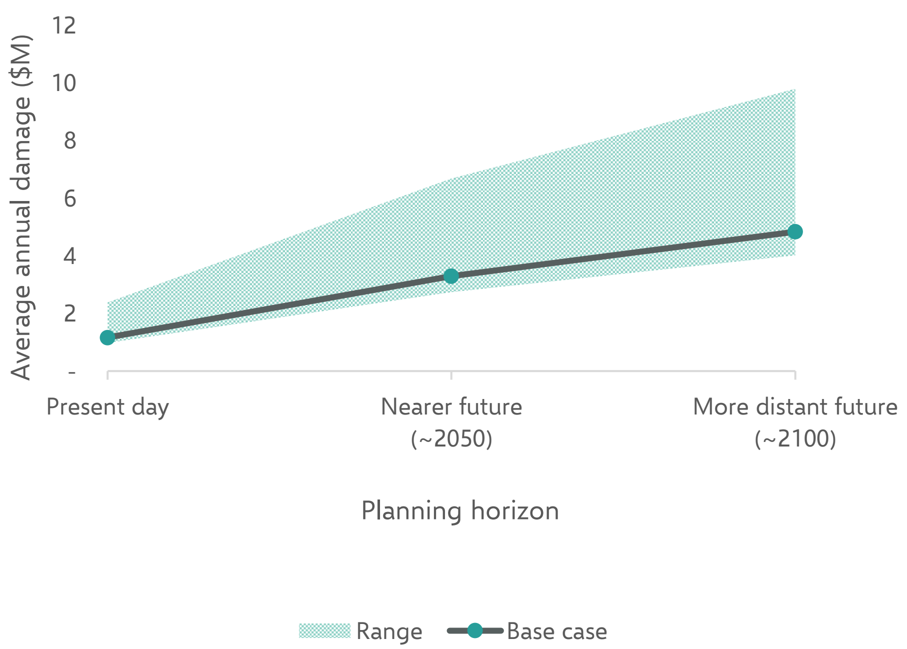
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Bayside broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

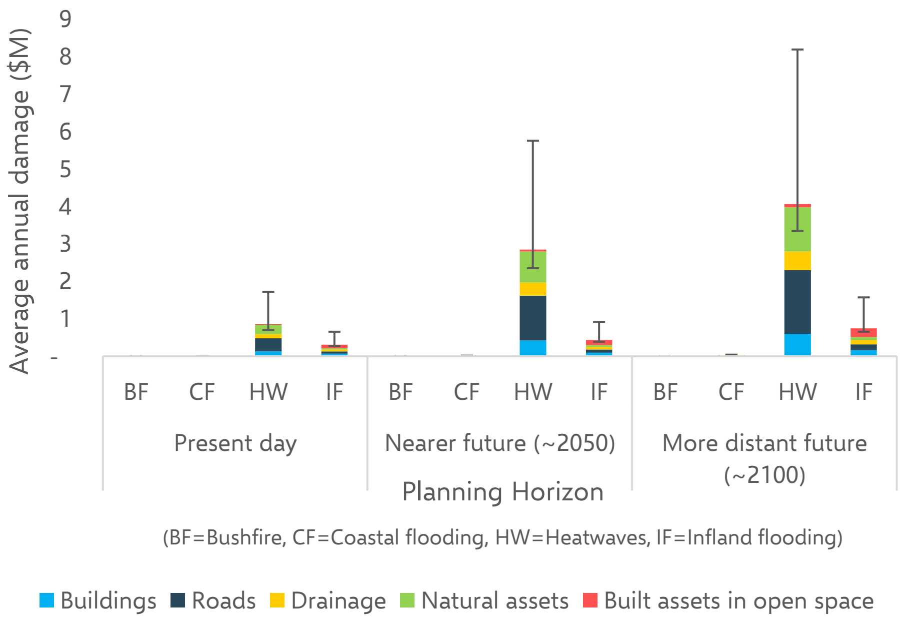
Boroondara - Estimated damages from climate hazards without adaptation (Base case)

For Boroondara, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $3-$7 million for the nearer future (~2050) and, $4-$10 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Boroondara under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

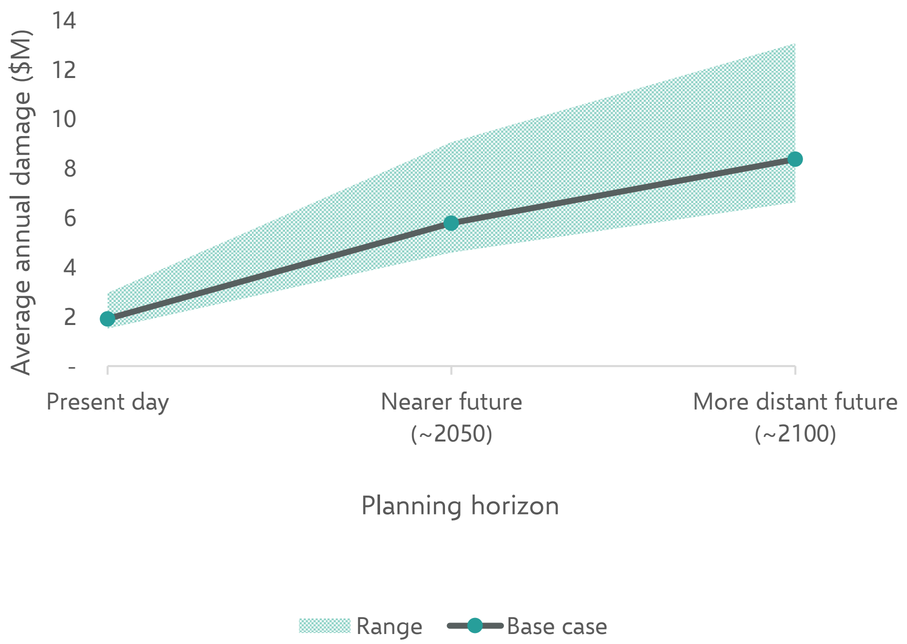
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Boroondara broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

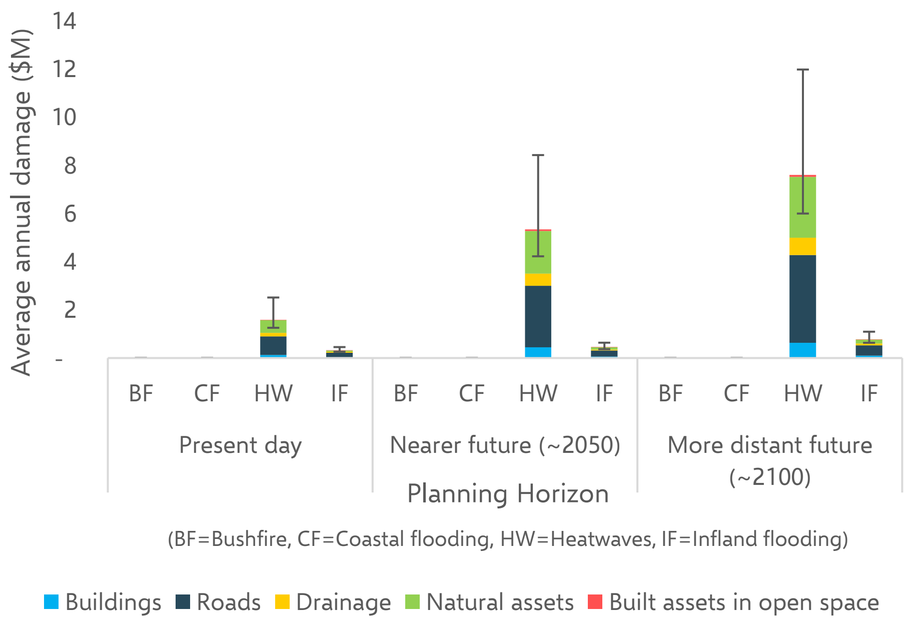
Brimbank - Estimated damages from climate hazards without adaptation (Base case)

For Brimbank, average annual damages (AADs) are estimated to be in the range of $2-$3 million for the present day, $5-$9 million for the nearer future (~2050) and, $7-$13 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Brimbank under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

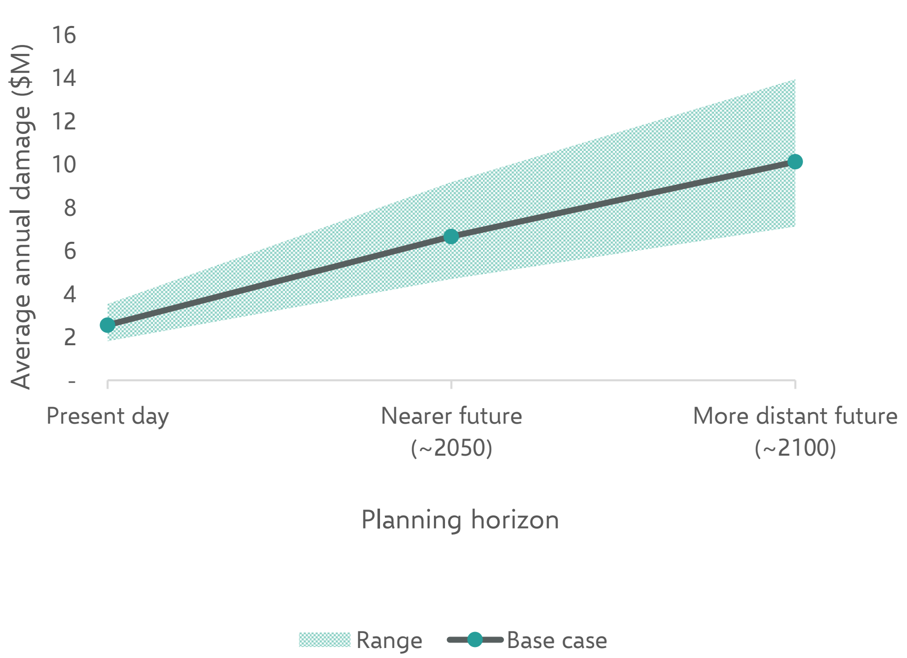
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Brimbank broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

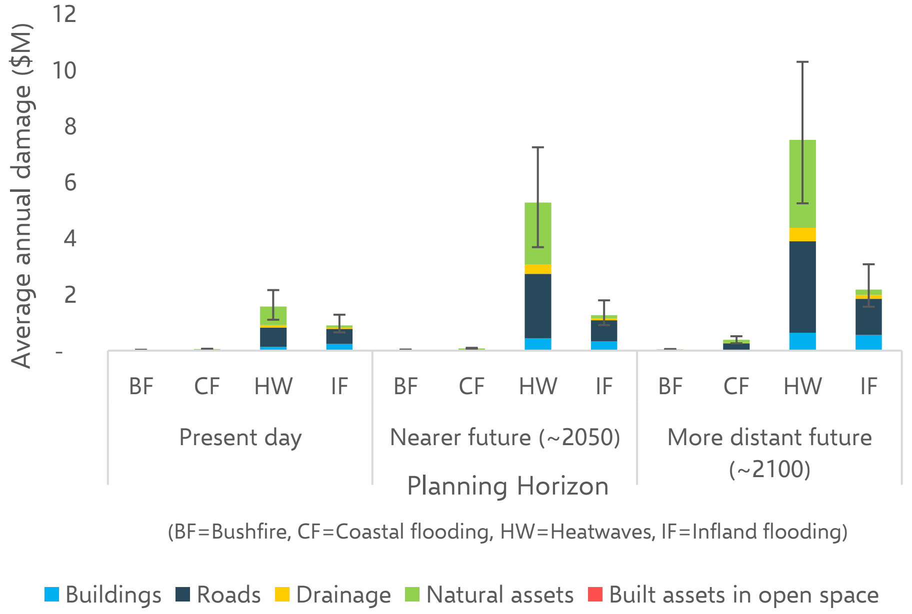
Cardinia - Estimated damages from climate hazards without adaptation (Base case)

For Cardinia, average annual damages (AADs) are estimated to be in the range of $2-$4 million for the present day, $5-$9 million for the nearer future (~2050) and, $7-$14 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Cardinia under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

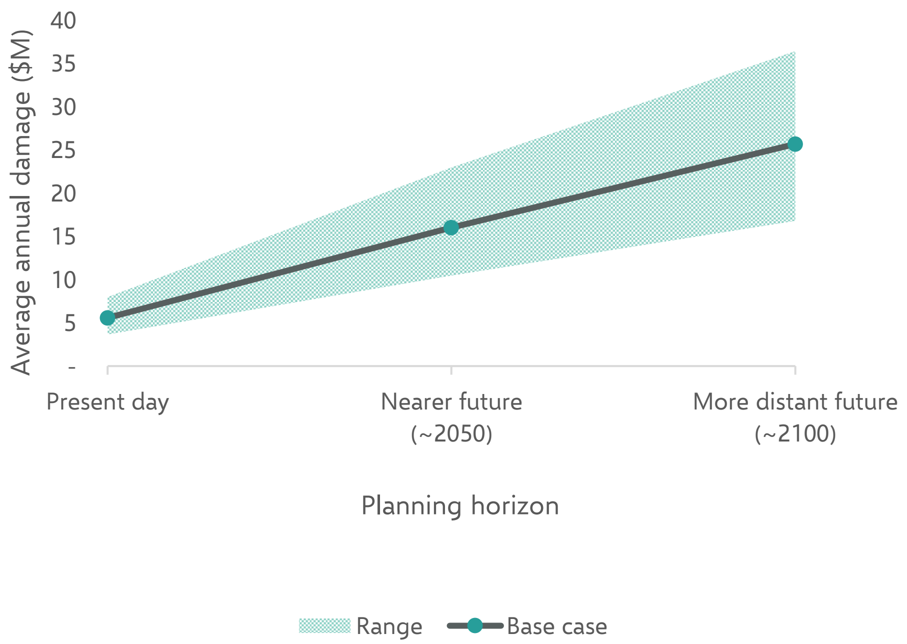
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Cardinia broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

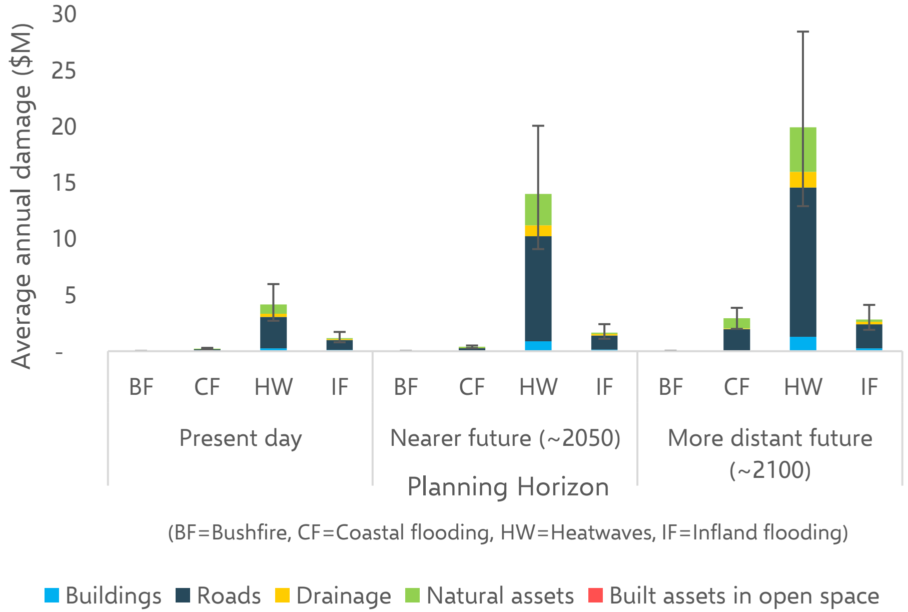
Casey - Estimated damages from climate hazards without adaptation (Base case)

For Casey, average annual damages (AADs) are estimated to be in the range of $4-$8 million for the present day, $10-$23 million for the nearer future (~2050) and, $17-$36 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Casey under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

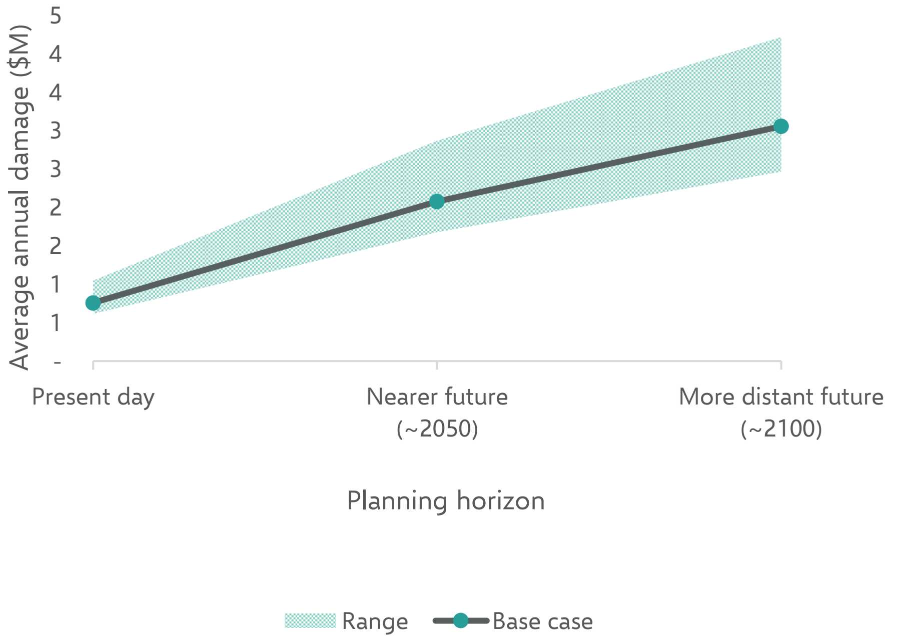
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Casey broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

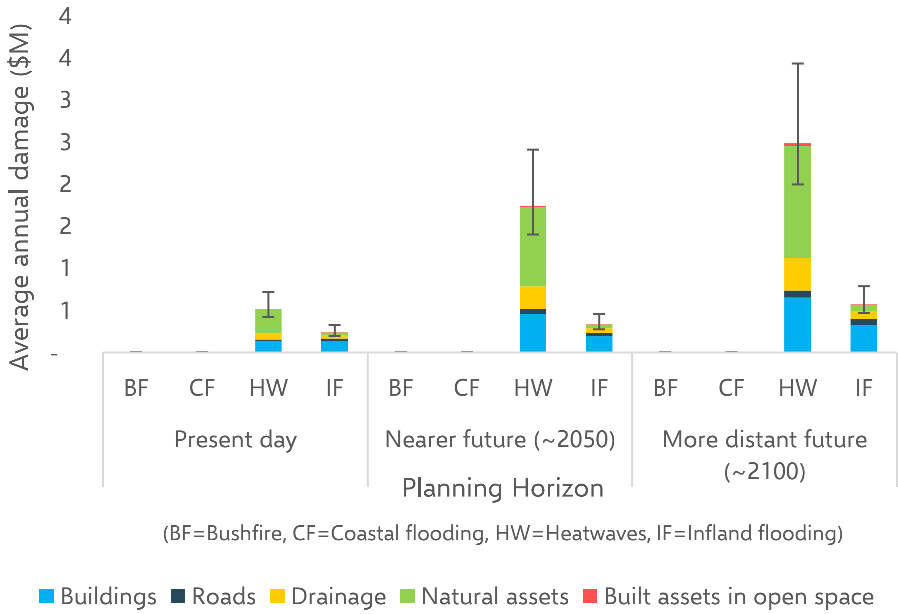
Darebin - Estimated damages from climate hazards without adaptation (Base case)

For Darebin, average annual damages (AADs) are estimated to be in the range of $1 million for the present day, $2-$3- million for the nearer future (~2050) and, $2-$4 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



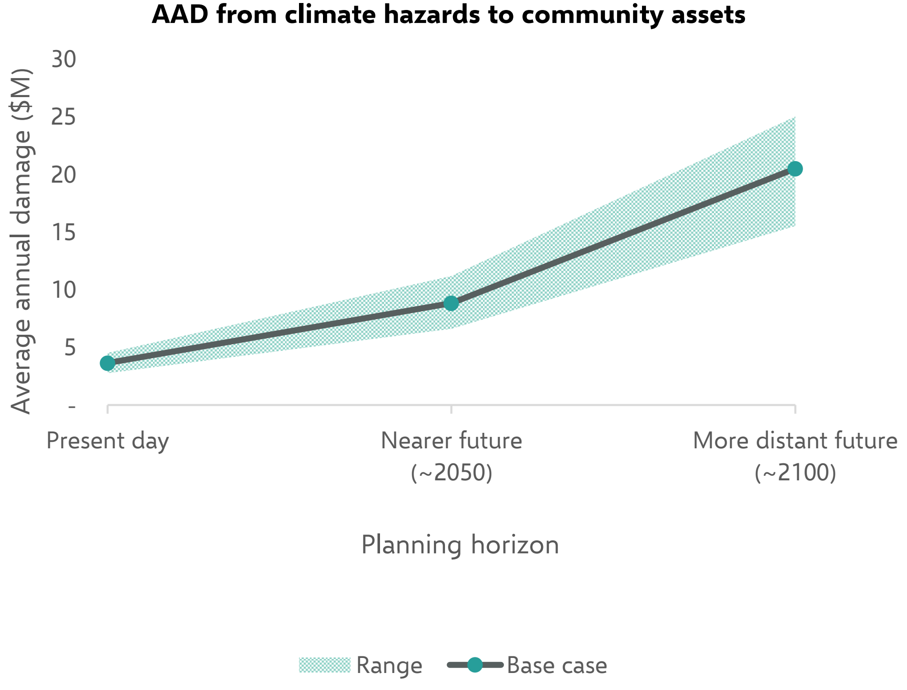
The above figure presents the estimated AADs from climate hazards to community assets in Darebin under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

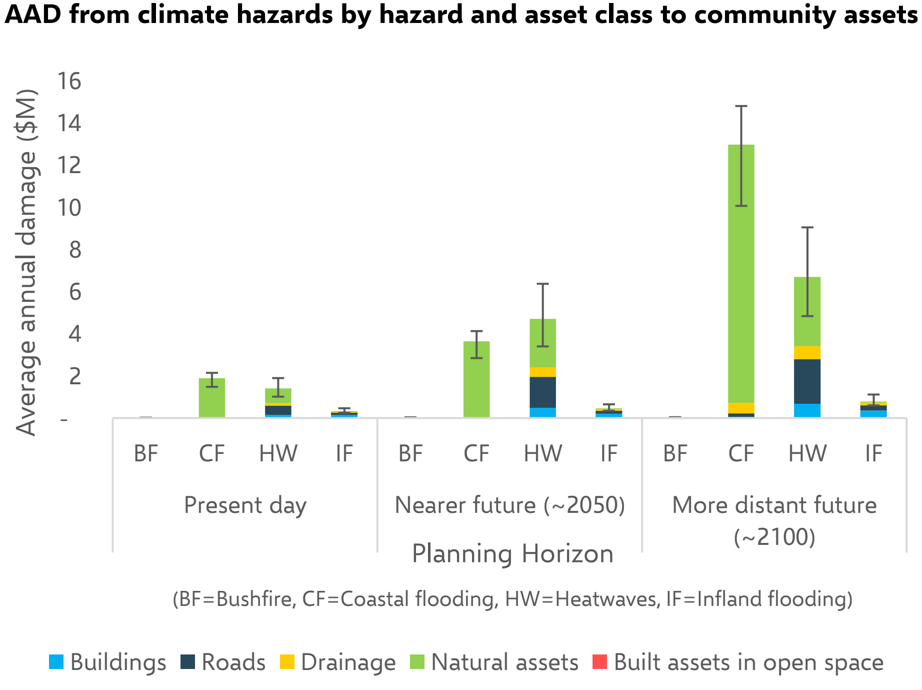
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Darebin broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

Frankston - Estimated damages from climate hazards without adaptation (Base case)

For Frankston, average annual damages (AADs) are estimated to be in the range of $3-$5 million for the present day, $7-$11 million for the nearer future (~2050) and, $16-$25 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 450% in the more distant future from present day.





The above figure presents the estimated AADs from climate hazards to community assets in Frankston under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

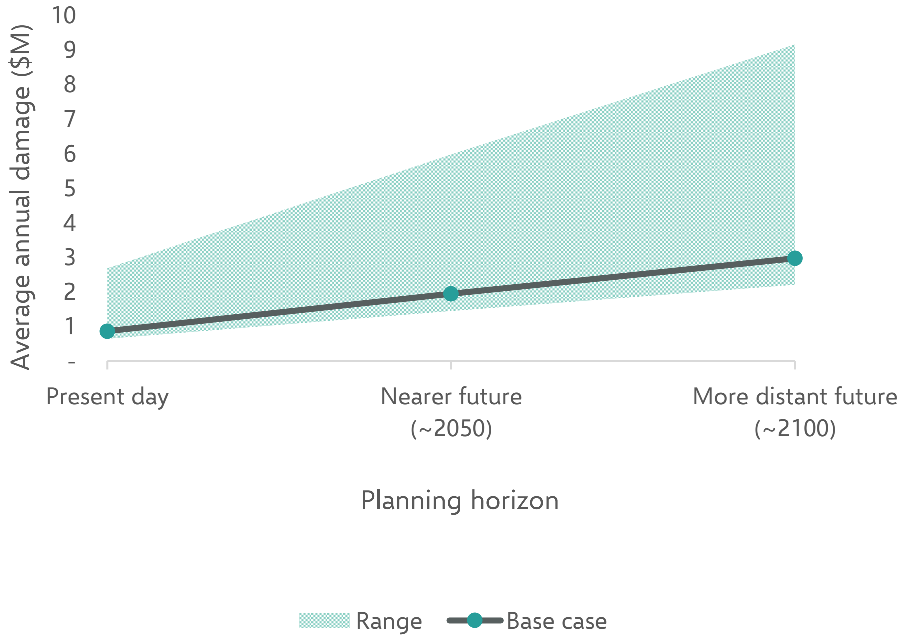
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Frankston broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

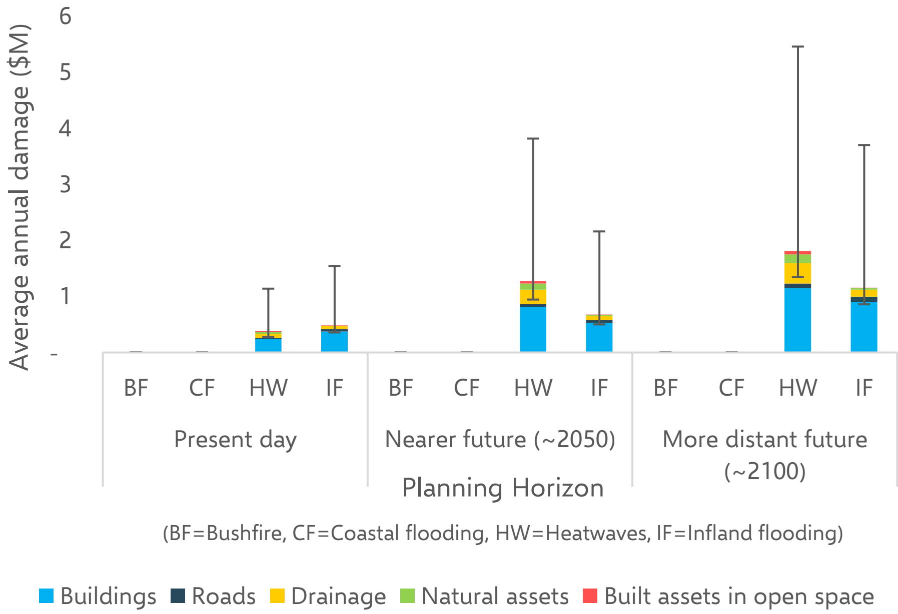
Glen Eira – Estimated damages from climate hazards without adaptation (Base case)

For Glen Eira, average annual damages (AADs) are estimated to be in the range of $1-$3 million for the present day, $1-$6 million for the nearer future (~2050) and, $2-$9 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 250% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Glen Eira under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

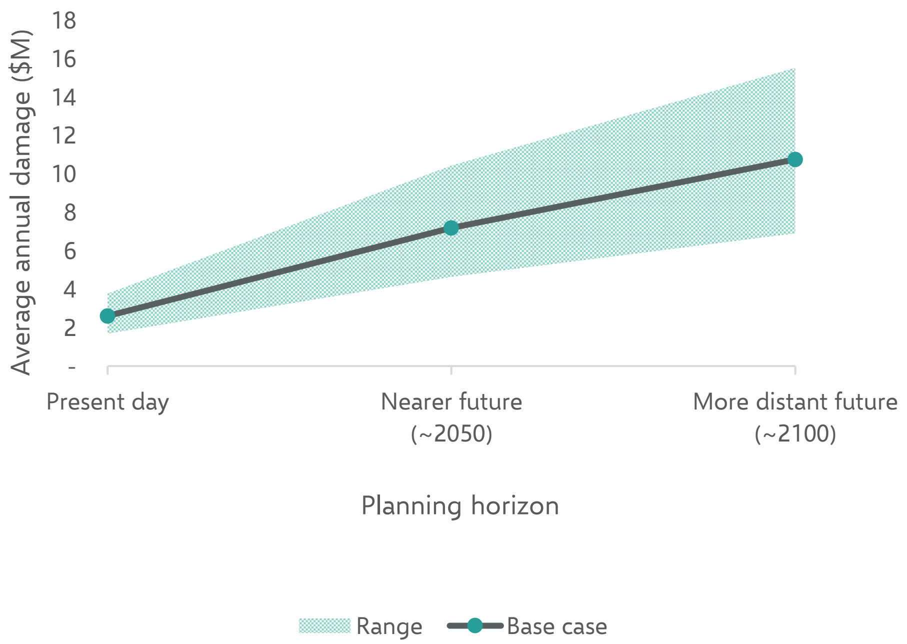
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Glen Eira broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

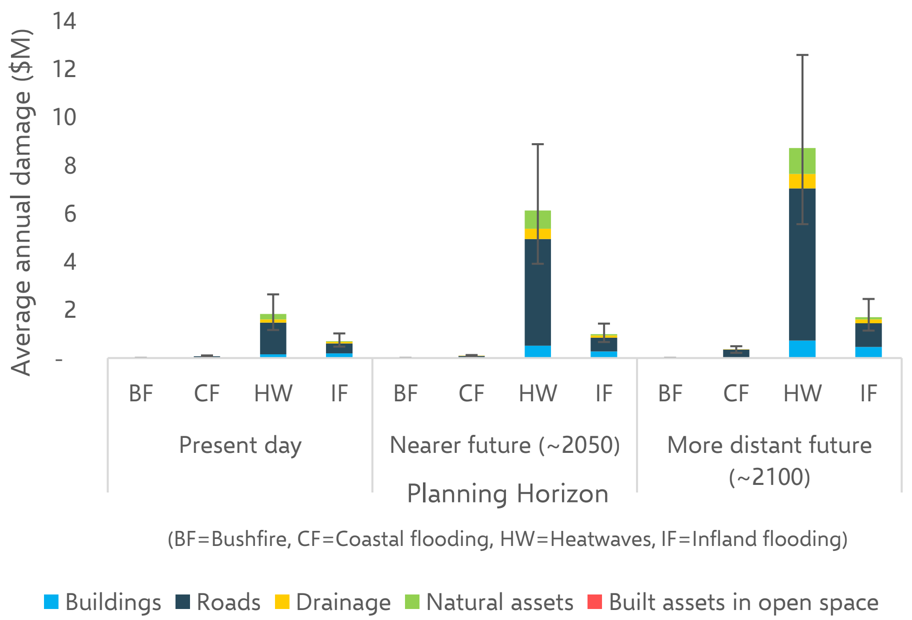
Greater Dandenong - Estimated damages from climate hazards without adaptation (Base case)

For Greater Dandenong, average annual damages (AADs) are estimated to be in the range of $2-$4 million for the present day, $5-$10 million for the nearer future (~2050) and, $7-$16 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Greater Dandenong under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

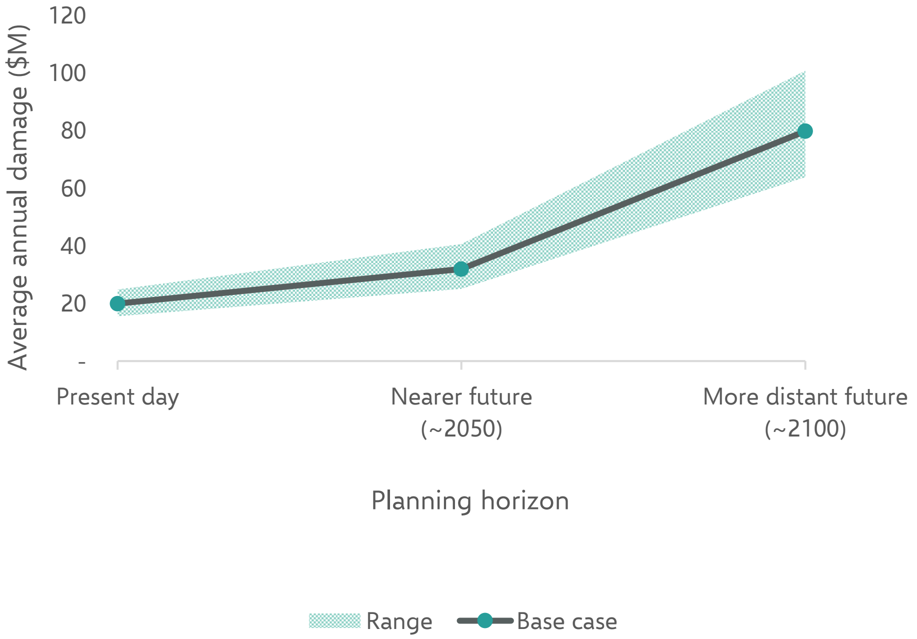
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Greater Dandenong broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

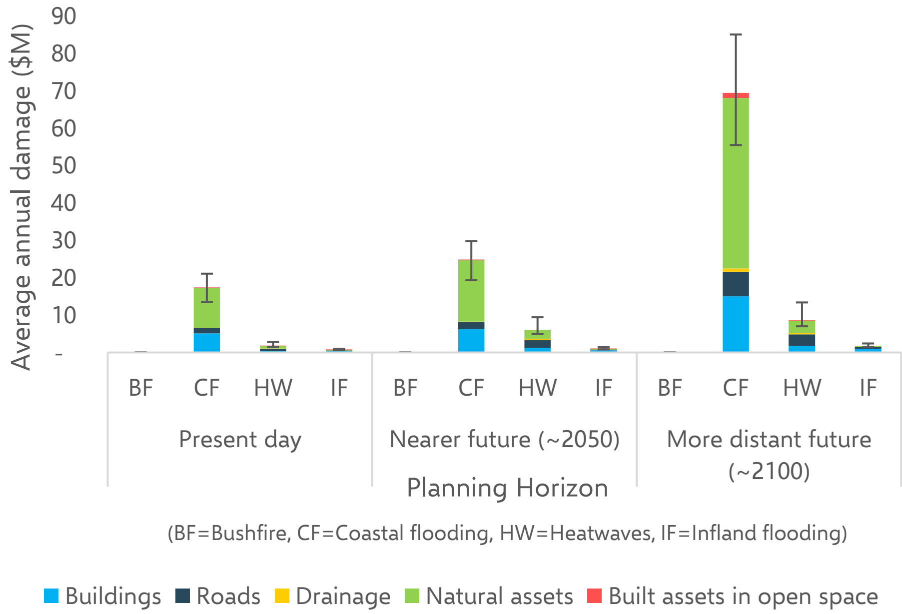
Hobsons Bay - Estimated damages from climate hazards without adaptation (Base case)

For Hobsons Bay, average annual damages (AADs) are estimated to be in the range of $16-$25 million for the present day, $25-$41 million for the nearer future (~2050) and, $64-$101 million for the more distant future (~2100). This is an increase in AADs of about 50% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Hobsons Bay under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

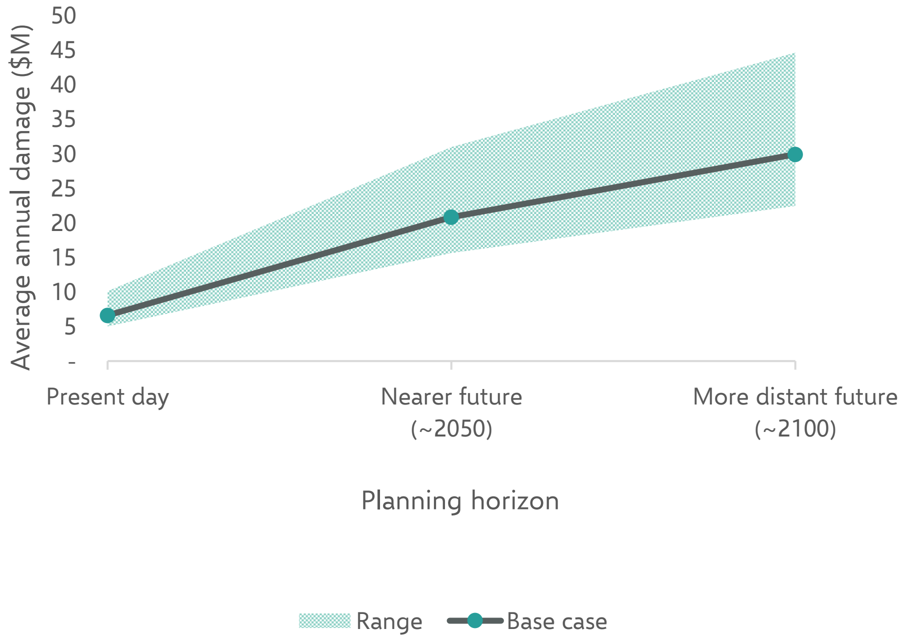
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Hobsons Bay broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

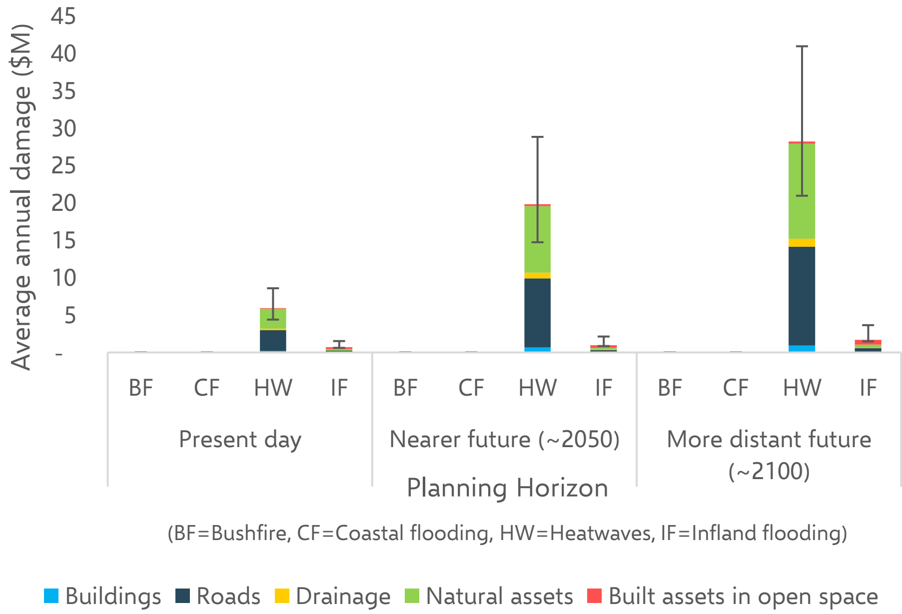
Hume - Estimated damages from climate hazards without adaptation (Base case)

For Hume, average annual damages (AADs) are estimated to be in the range of $5-$10 million for the present day, $16-$31 million for the nearer future (~2050) and, $22-$45 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Hume under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

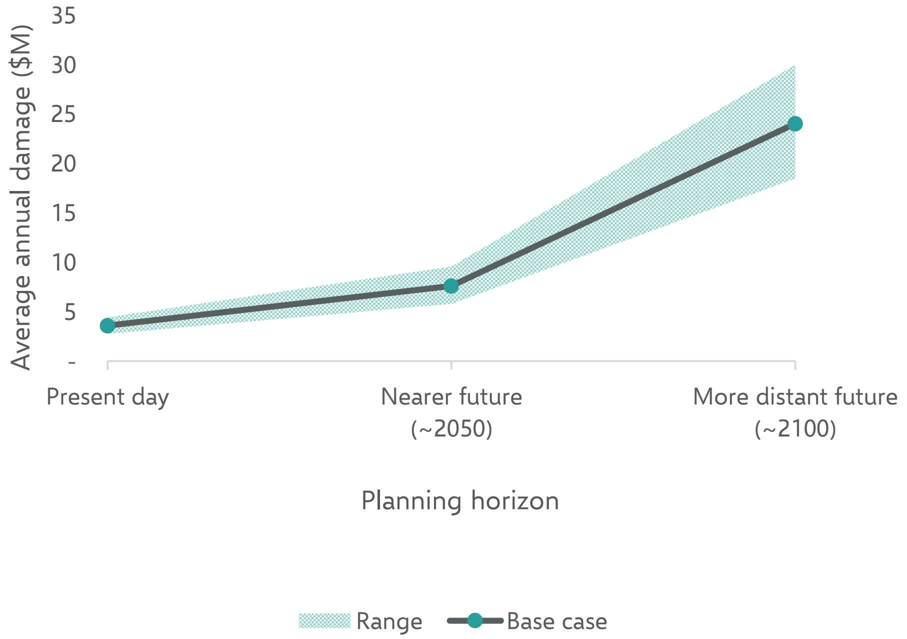
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Hume broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

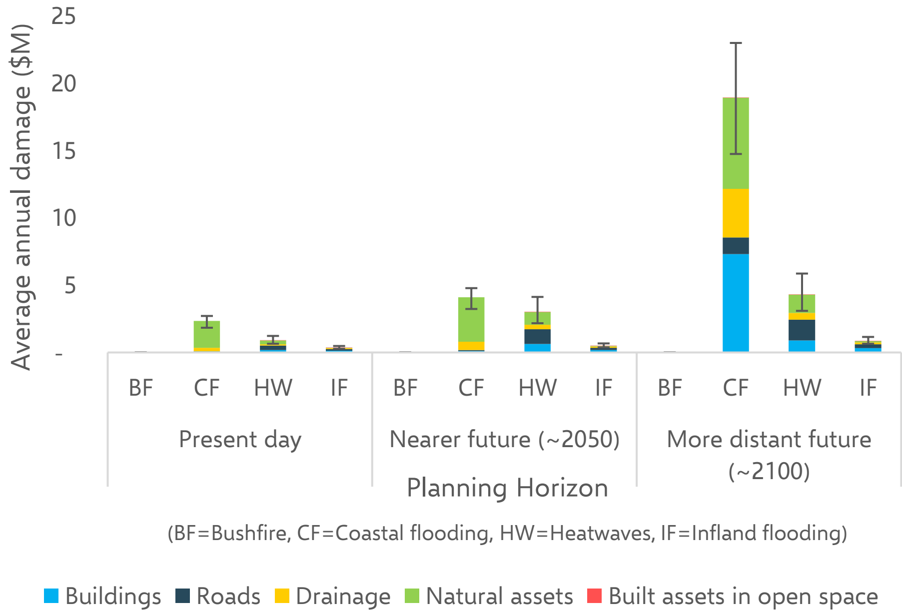
Kingston - Estimated damages from climate hazards without adaptation (Base case)

For Kingston, average annual damages (AADs) are estimated to be in the range of $3-$4 million for the present day, $6-$10 million for the nearer future (~2050) and, $18-$30 million for the more distant future (~2100). This is an increase in AADs of about 100% in the nearer future and 550% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Kingston under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

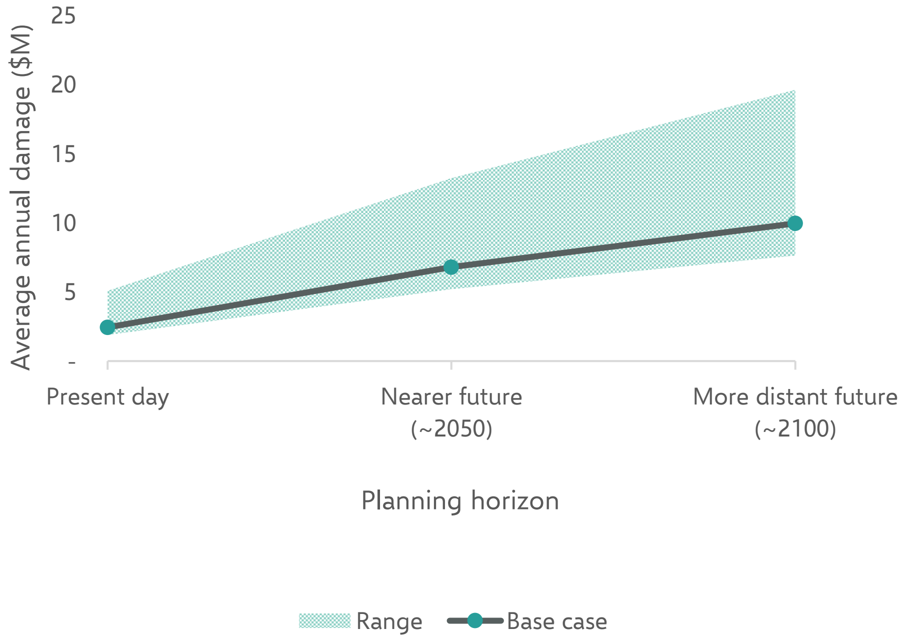
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Kingston broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

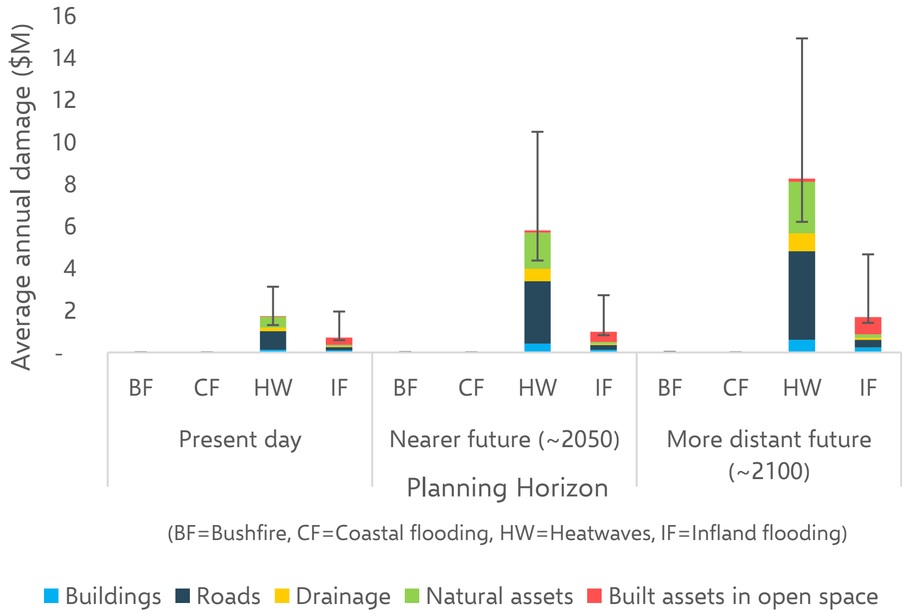
Knox - Estimated damages from climate hazards without adaptation (Base case)

For Knox, average annual damages (AADs) are estimated to be in the range of $2-$5 million for the present day, $5-$13 million for the nearer future (~2050) and, $8-$20 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Knox under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

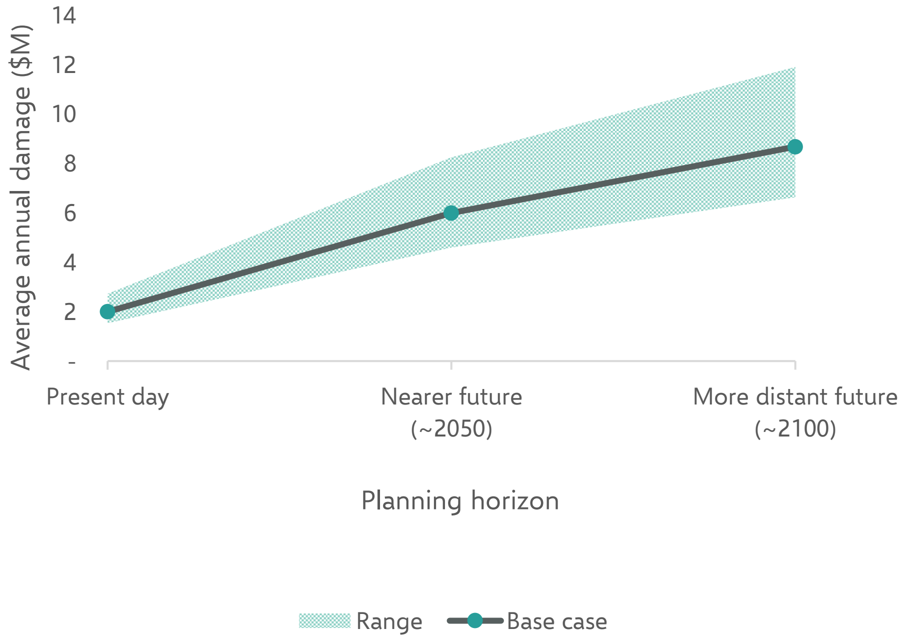
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Knox broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

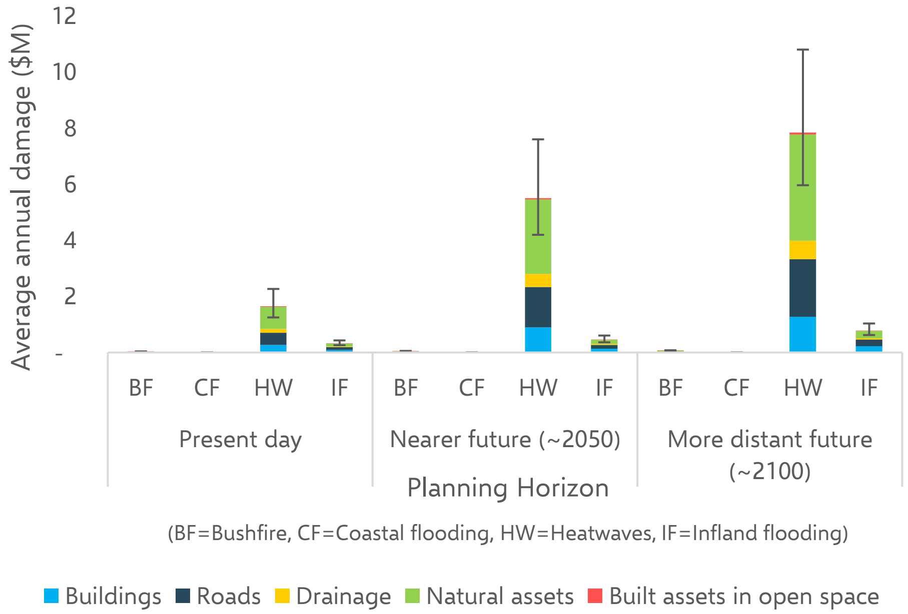
Manningham- Estimated damages from climate hazards without adaptation (Base case)

For Manningham, average annual damages (AADs) are estimated to be in the range of $2-$3 million for the present day, $5-$8 million for the nearer future (~2050) and, $7-$12 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Manningham under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

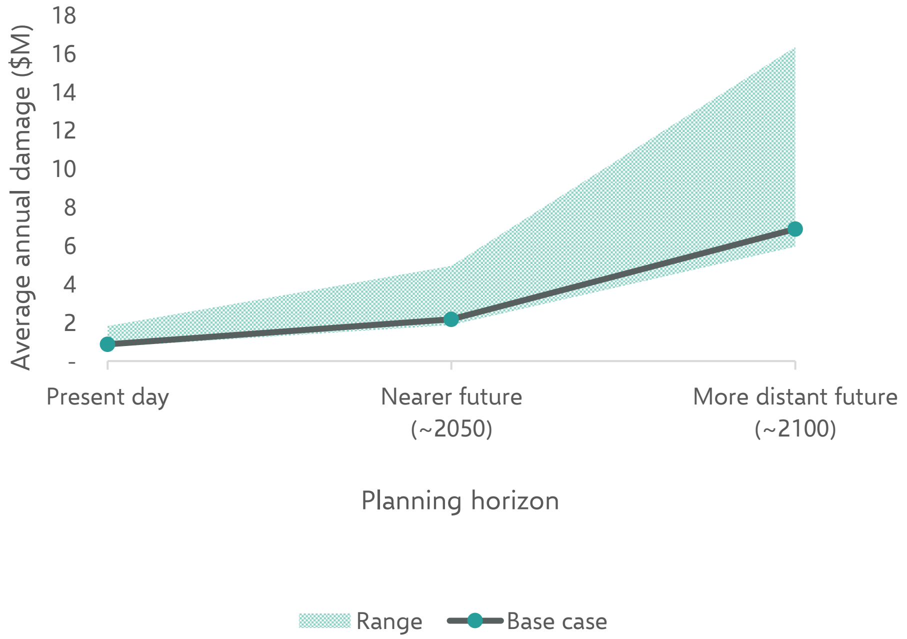
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Manningham broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

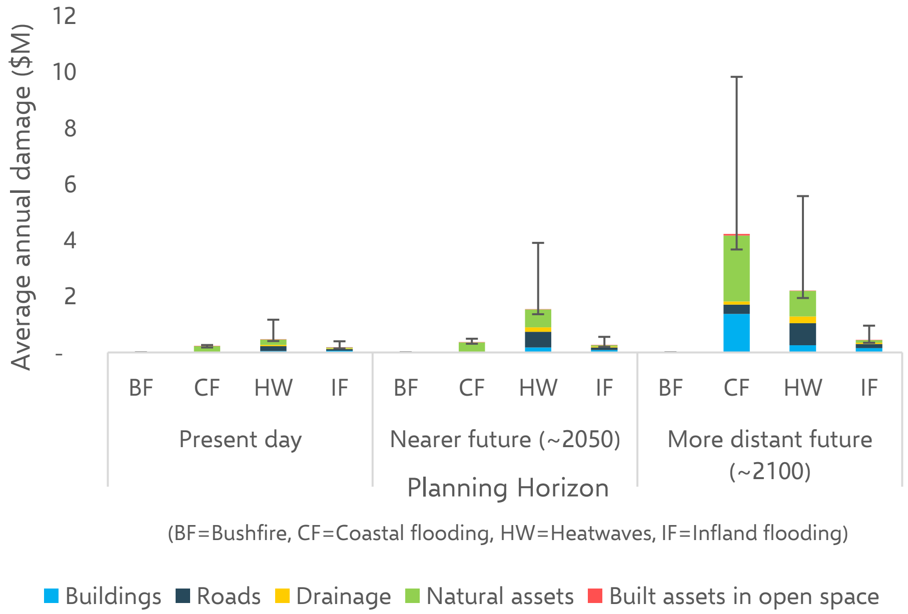
Maribyrnong - Estimated damages from climate hazards without adaptation (Base case)

For Maribyrnong, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $2-$5 million for the nearer future (~2050) and, $6-$16 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 700% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Maribyrnong under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

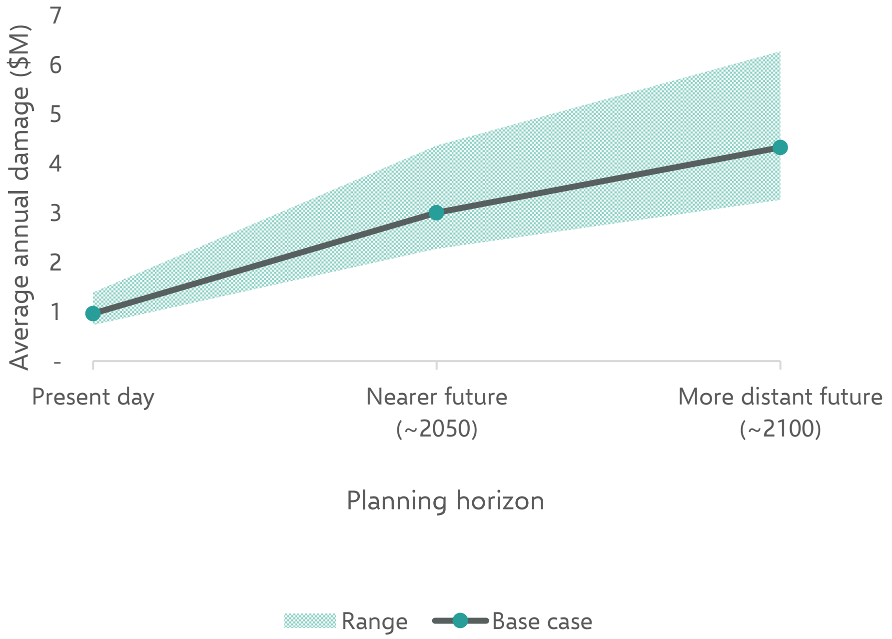
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Maribyrnong broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

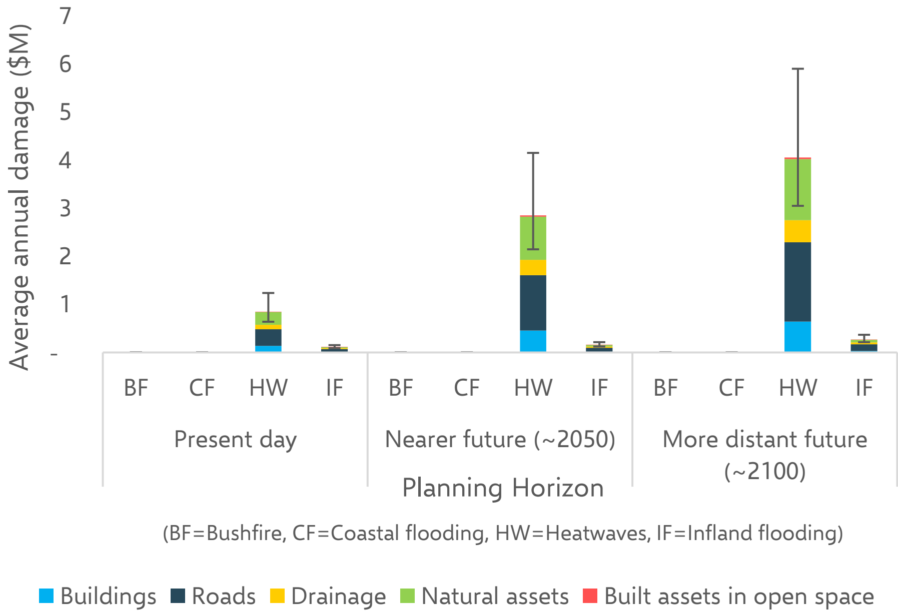
Maroondah - Estimated damages from climate hazards without adaptation (Base case)

For Maroondah, average annual damages (AADs) are estimated to be in the range of $1 million for the present day, $2-$4 million for the nearer future (~2050) and, $3-$6 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Maroondah under the base case or “do nothing differently” scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

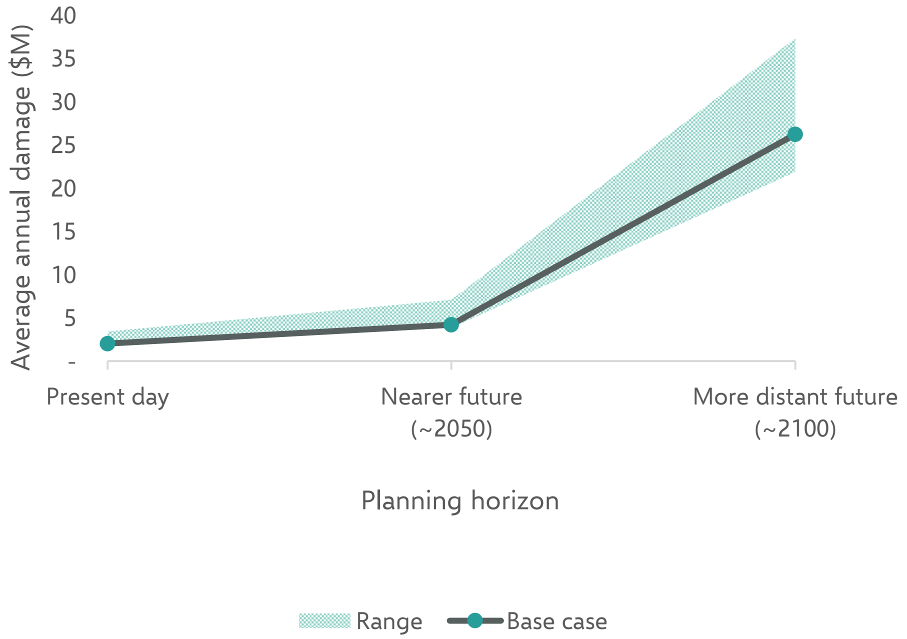
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Maroondah broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

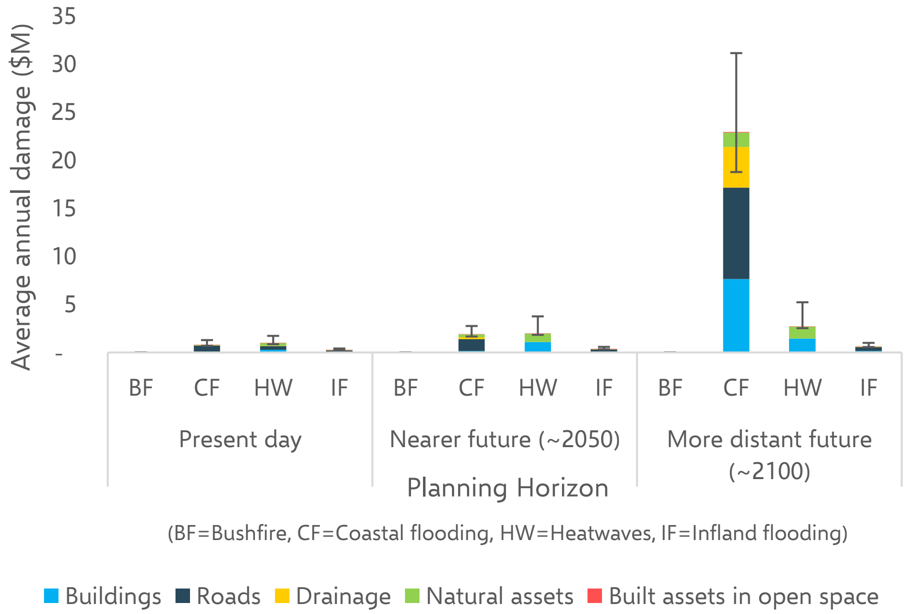
Melbourne - Estimated damages from climate hazards without adaptation (Base case)

For Melbourne, average annual damages (AADs) are estimated to be in the range of $2-$3 million for the present day, $4-$7 million for the nearer future (~2050) and, $22-$37 million for the more distant future (~2100). This is an increase in AADs of about 100% in the nearer future and 1200% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Melbourne under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

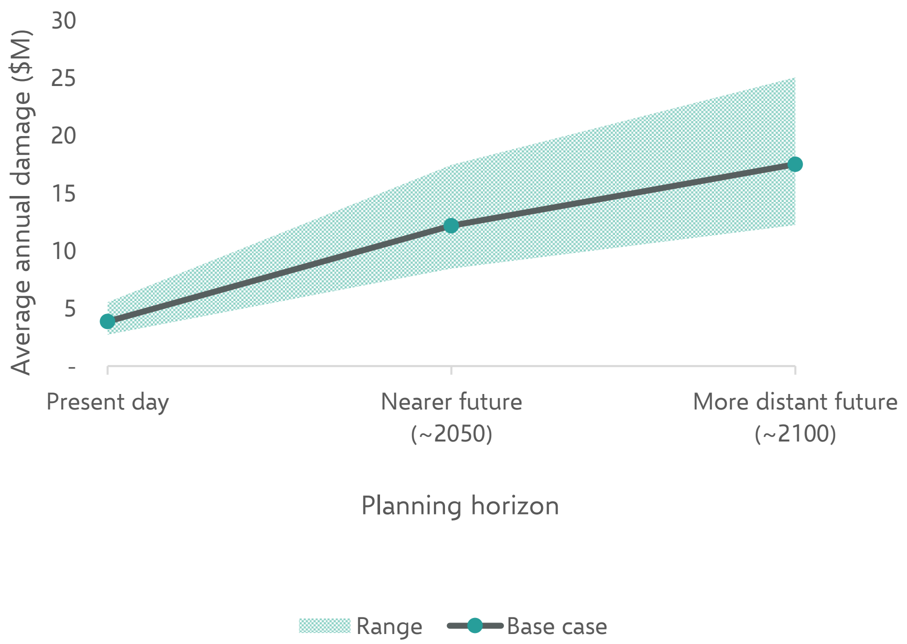
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Melbourne broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

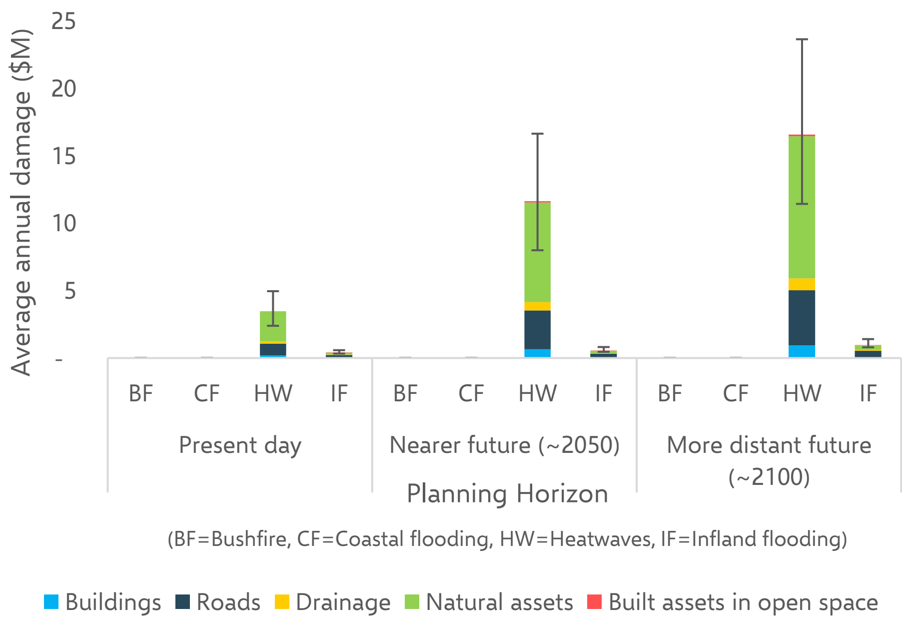
Melton - Estimated damages from climate hazards without adaptation (Base case)

For Melton, average annual damages (AADs) are estimated to be in the range of $3-$6 million for the present day, $8-$17 million for the nearer future (~2050) and, $12-$25 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Melton under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

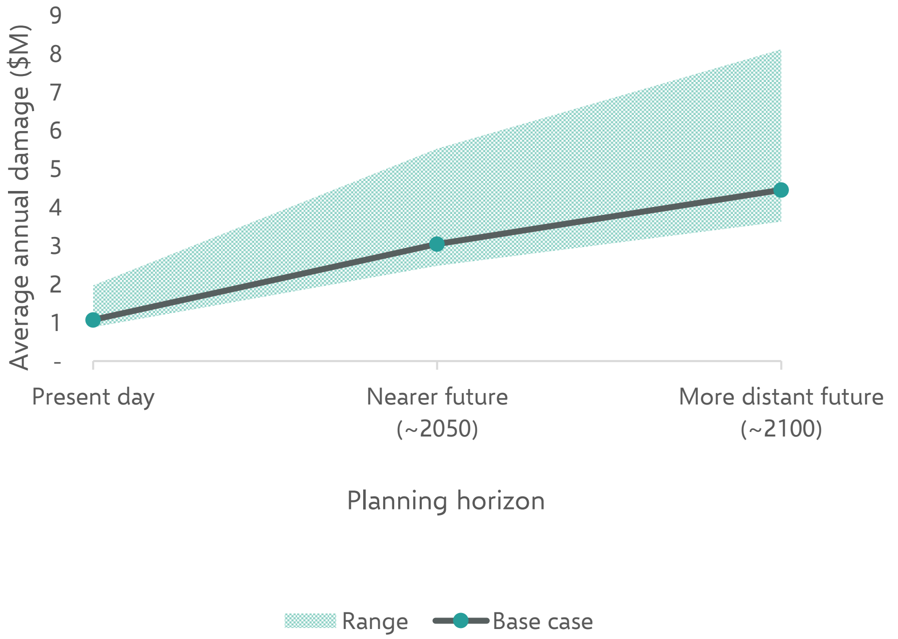
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Melton broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

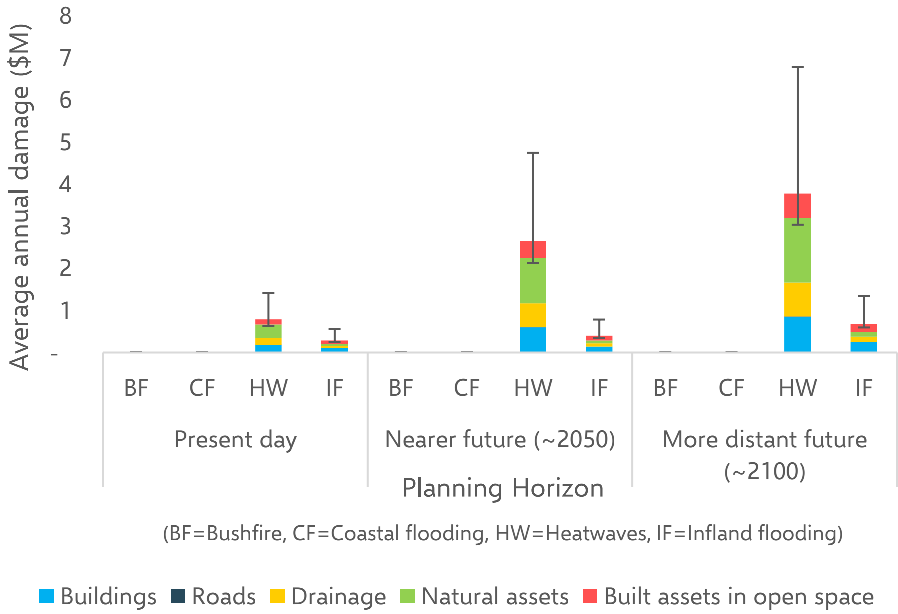
Monash - Estimated damages from climate hazards without adaptation (Base case)

For Monash, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $2-$6 million for the nearer future (~2050) and, $4-$8 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Monash under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

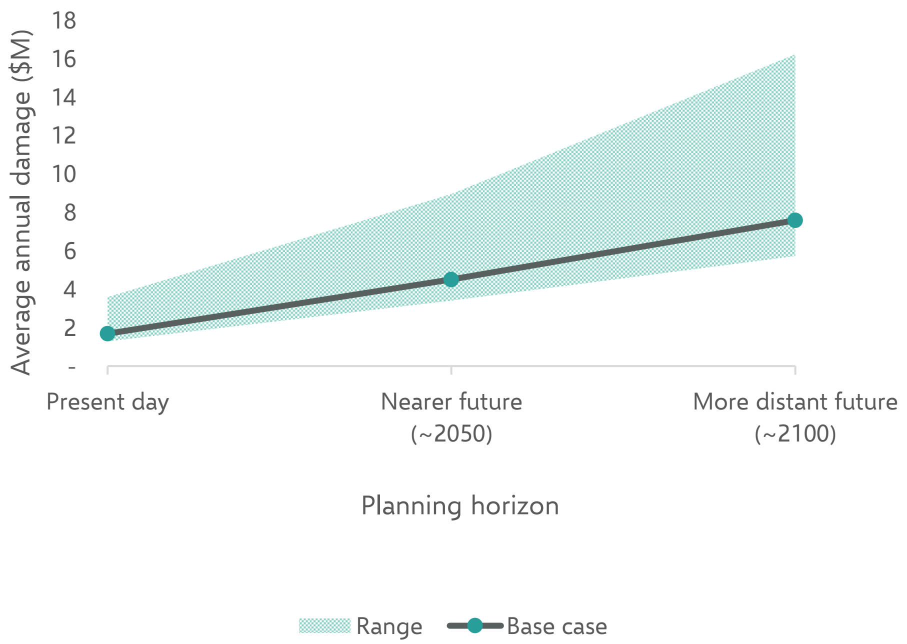
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Monash broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

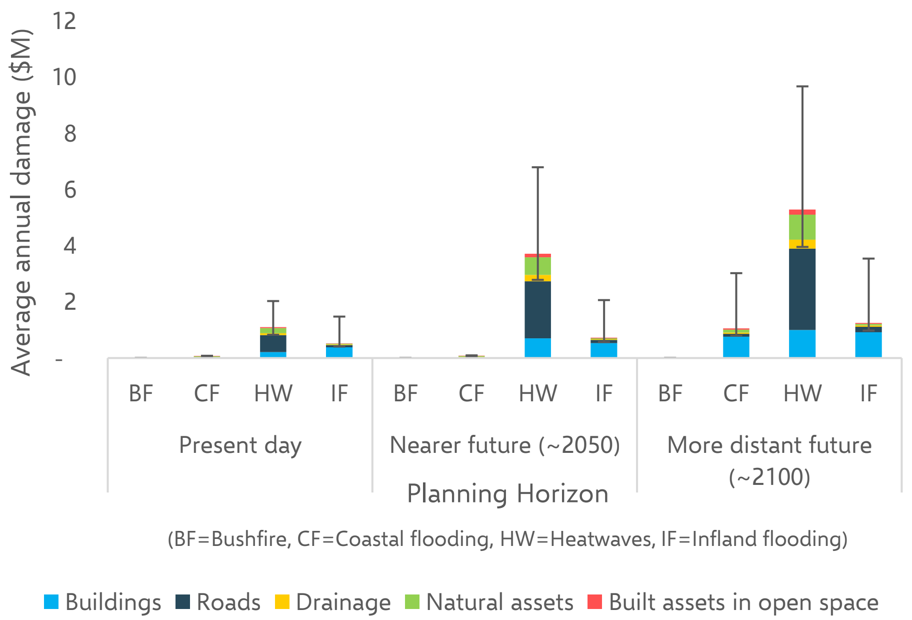
Moonee Valley - Estimated damages from climate hazards without adaptation (Base case)

For Moonee Valley, average annual damages (AADs) are estimated to be in the range of $1-$4 million for the present day, $3-$9 million for the nearer future (~2050) and, $6-$16 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Moonee Valley under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

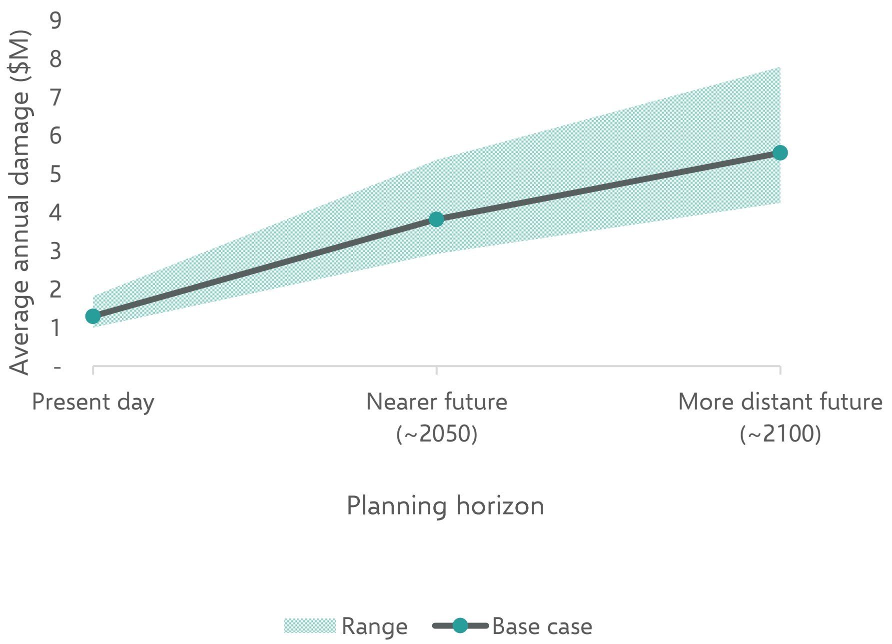
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Moonee Valley broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

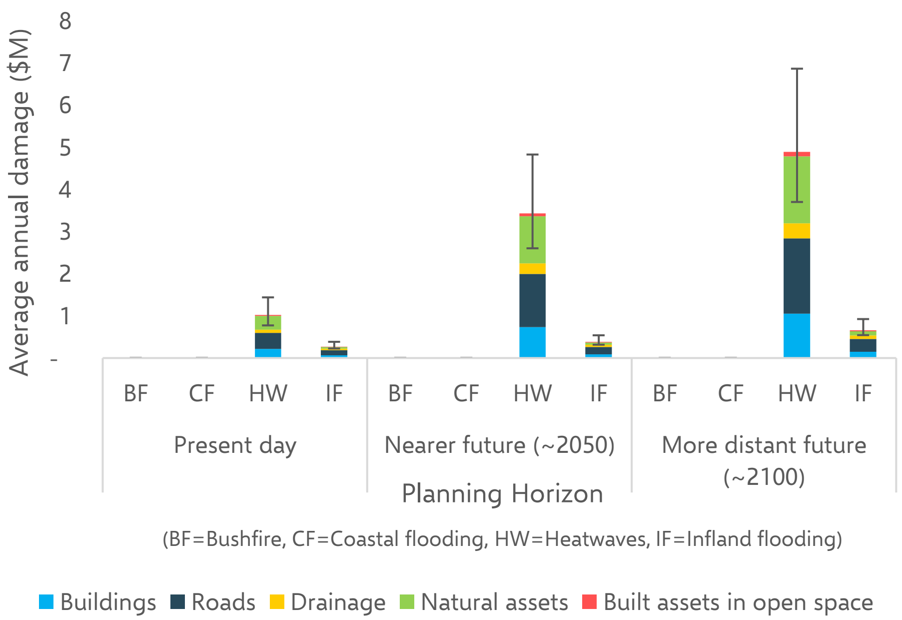
Merri-bek - Estimated damages from climate hazards without adaptation (Base case)

For Merri-bek, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $3-$5million for the nearer future (~2050) and, $4-$8 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Merri-bek under the base case or “do nothing differently” scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

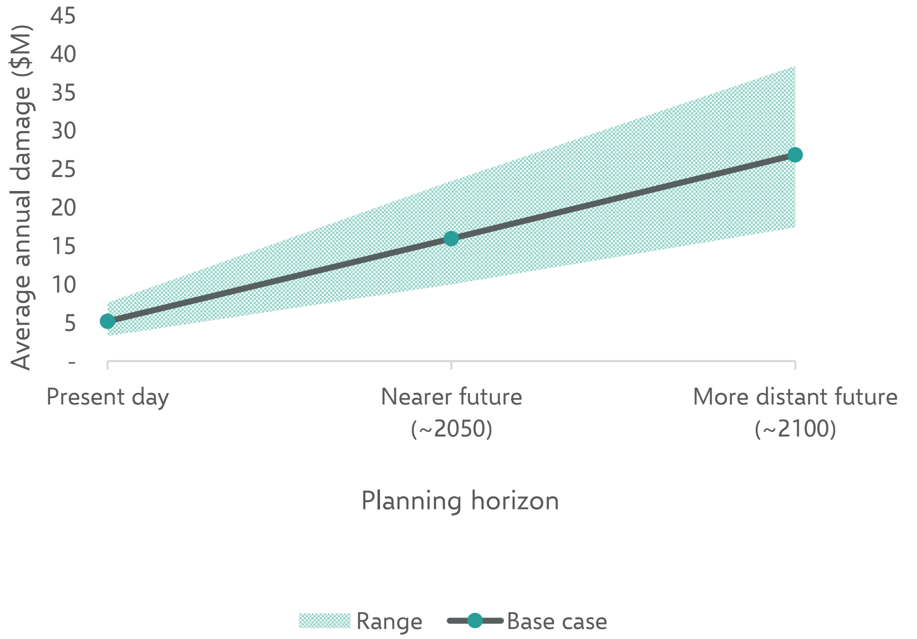
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Merri-bek broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

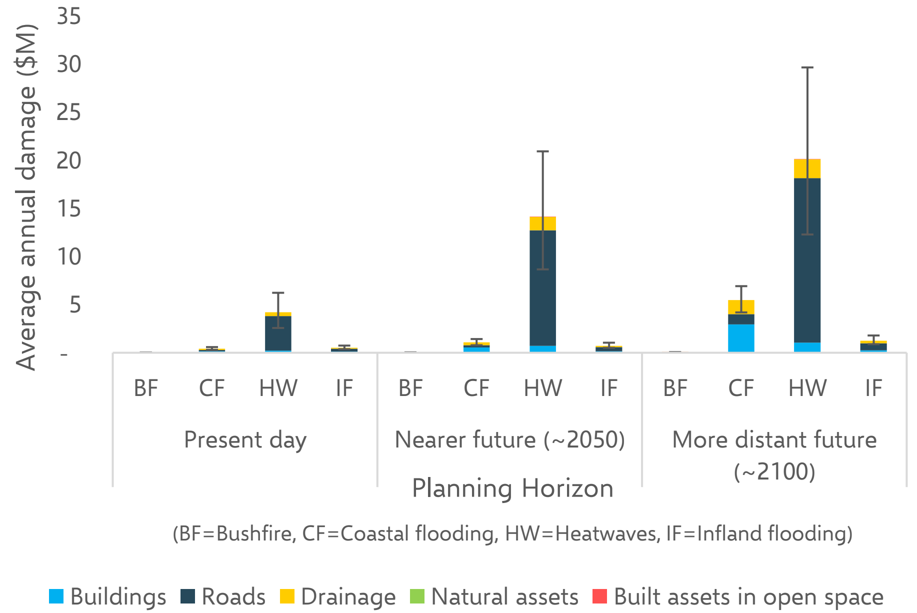
Mornington Peninsula - Estimated damages from climate hazards without adaptation (Base case)

For Mornington Peninsula, average annual damages (AADs) are estimated to be in the range of $3-$8 million for the present day, $10-$23 million for the nearer future (~2050) and, $17-$38 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 400% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Mornington Peninsula under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

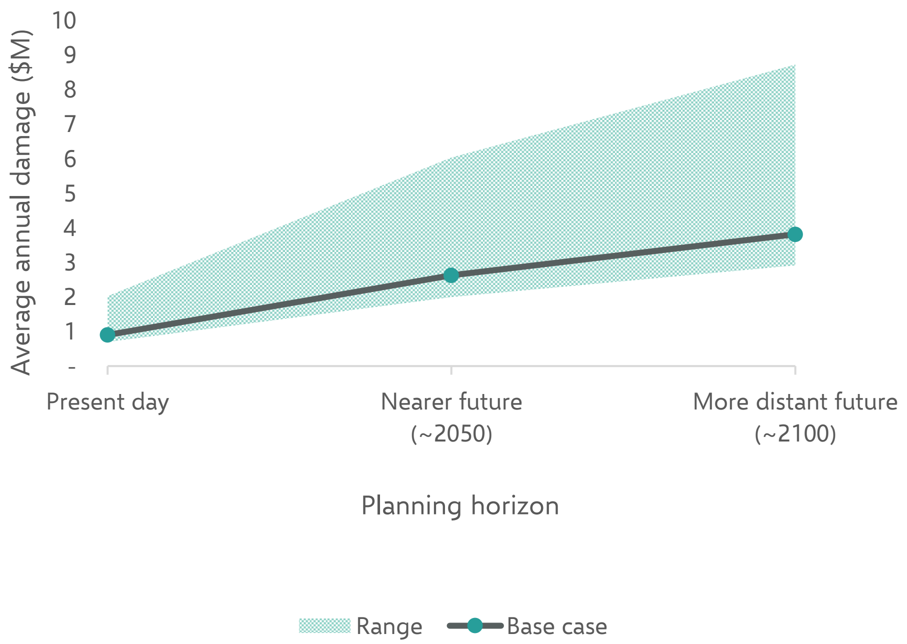
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Mornington Peninsula broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

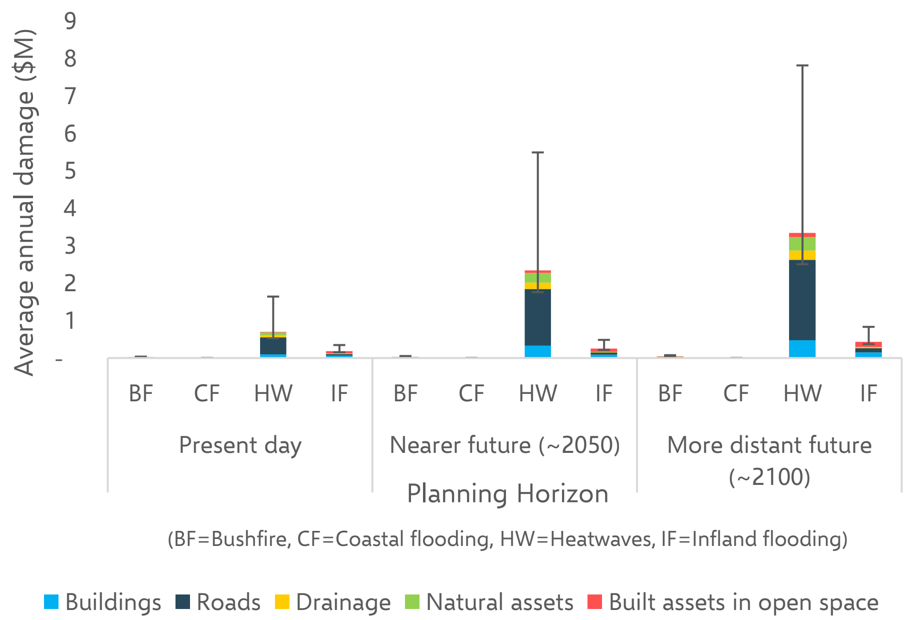
Nillumbik - Estimated damages from climate hazards without adaptation (Base case)

For Nillumbik, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $2-$6 million for the nearer future (~2050) and, $3-$9 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Nillumbik under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

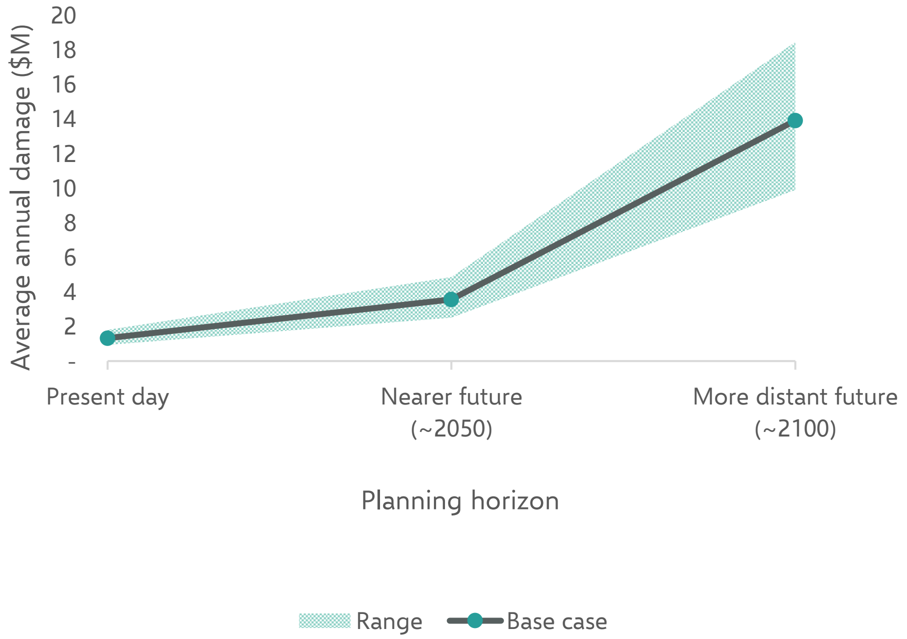
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Nillumbik broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

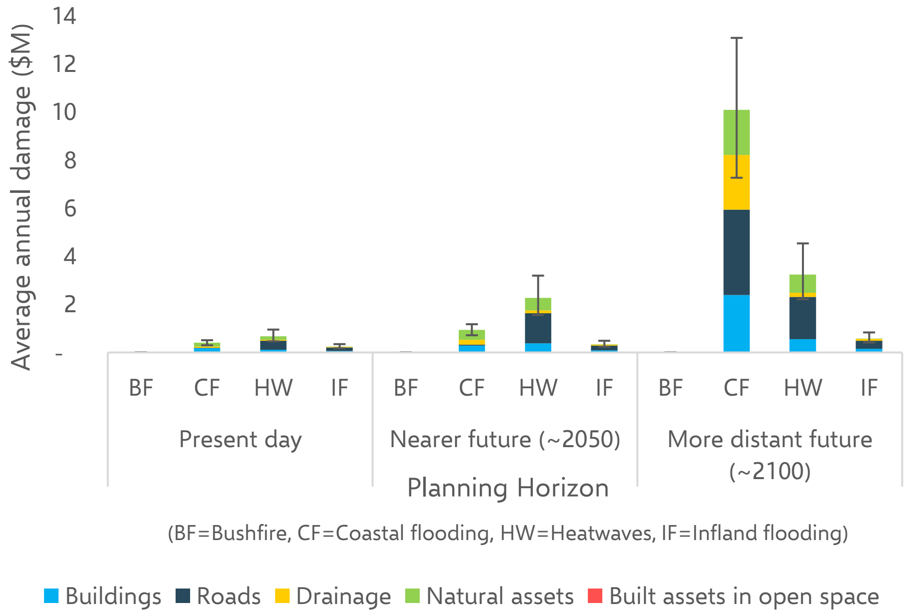
Port Phillip - Estimated damages from climate hazards without adaptation (Base case)

For Port Phillip, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $3-$5 million for the nearer future (~2050) and, $10-$18 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 950% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Port Phillip under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

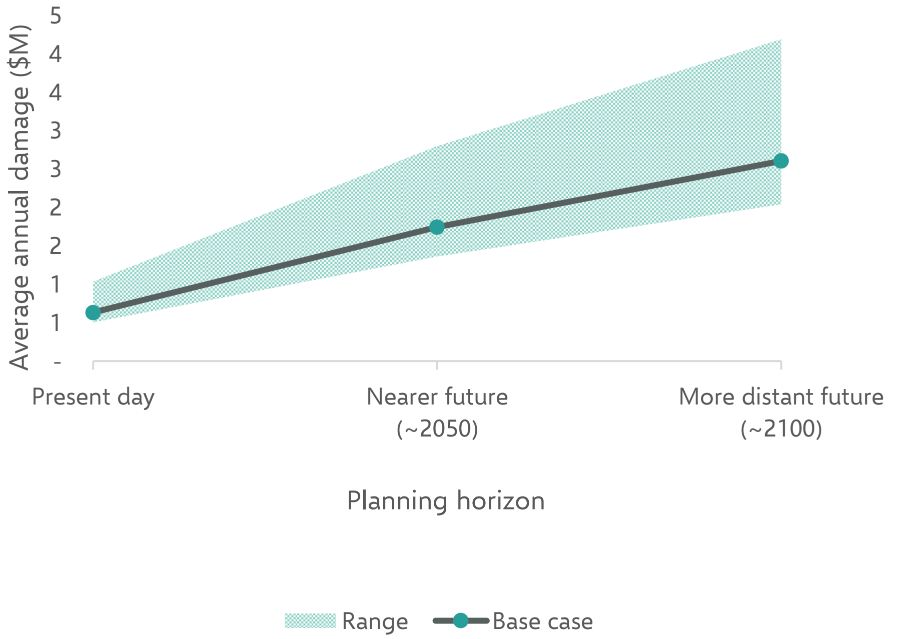
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Port Phillip broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

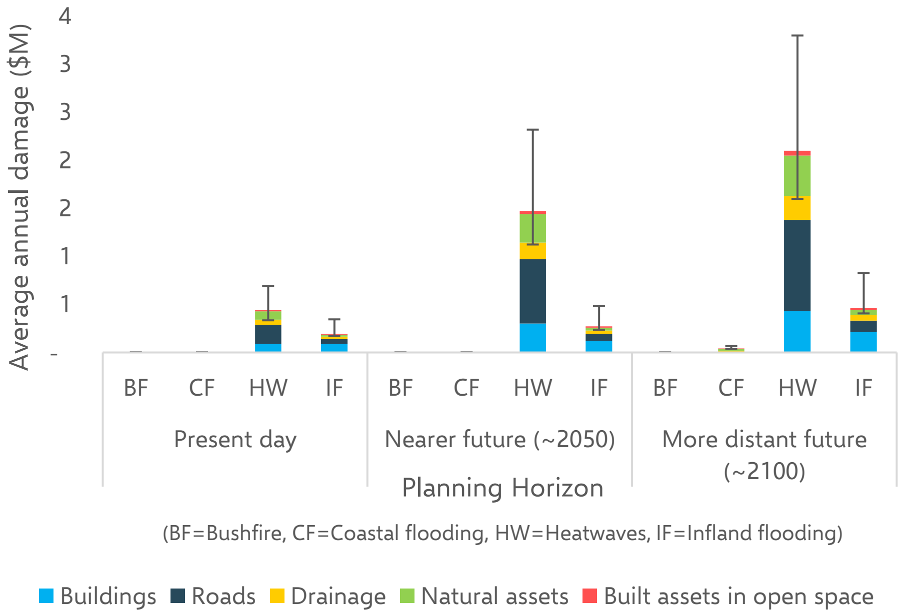
Stonnington - Estimated damages from climate hazards without adaptation (Base case)

For Stonnington, average annual damages (AADs) are estimated to be in the range of $1 million for the present day, $1-$3 million for the nearer future (~2050) and, $2-$4 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Stonnington under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

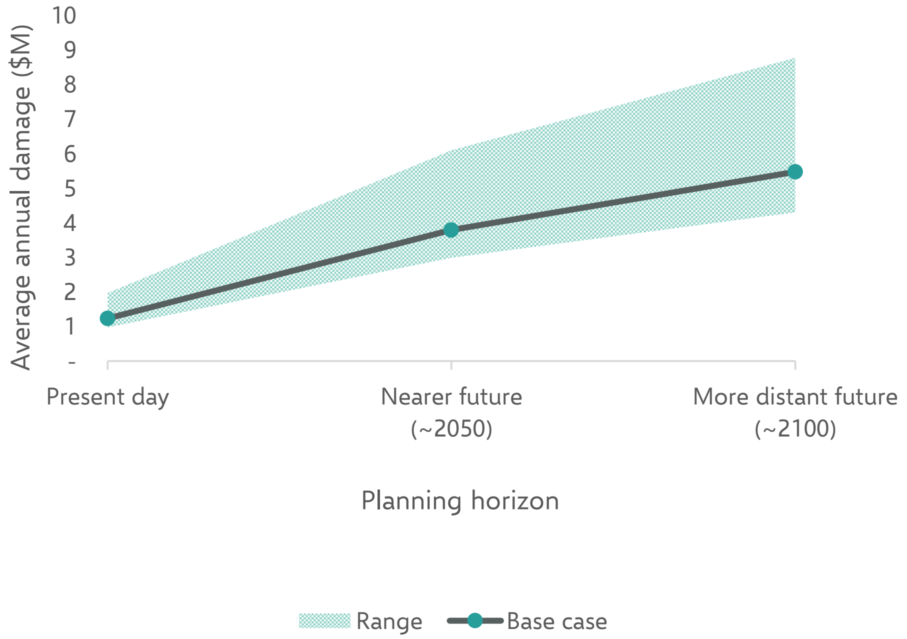
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Stonnington broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

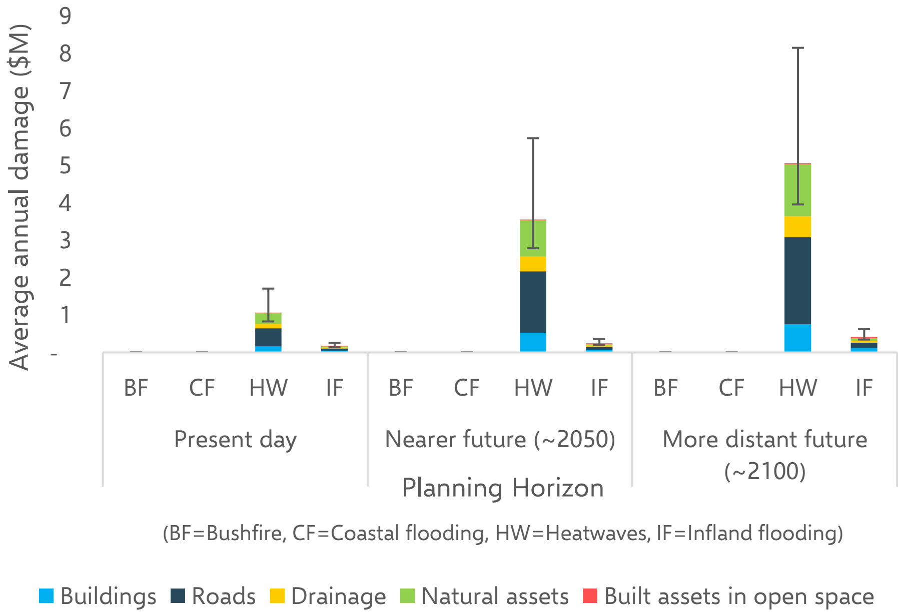
Whitehorse - Estimated damages from climate hazards without adaptation (Base case)

For Whitehorse, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $3-$6 million for the nearer future (~2050) and, $4-$9 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Whitehorse under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

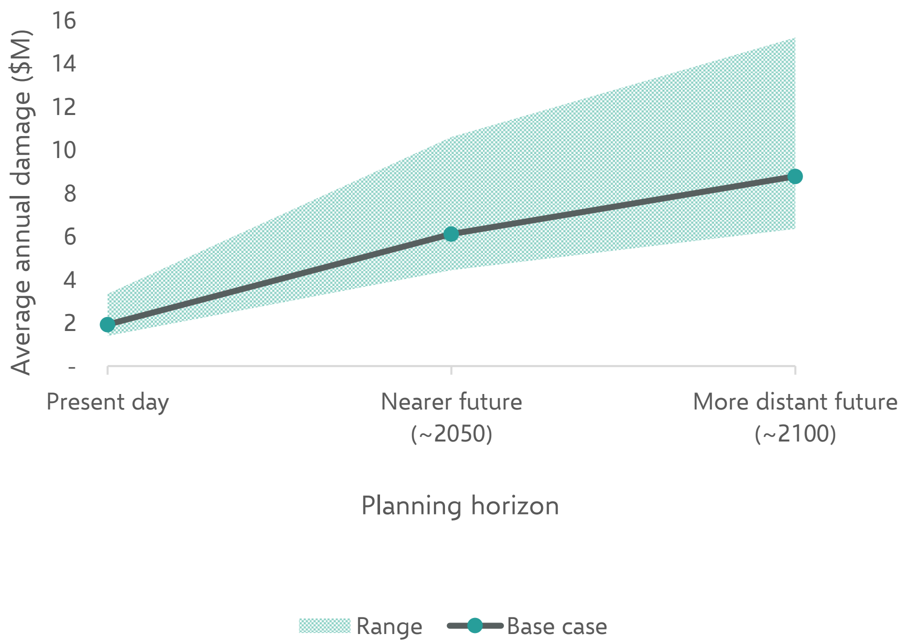
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Whitehorse broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

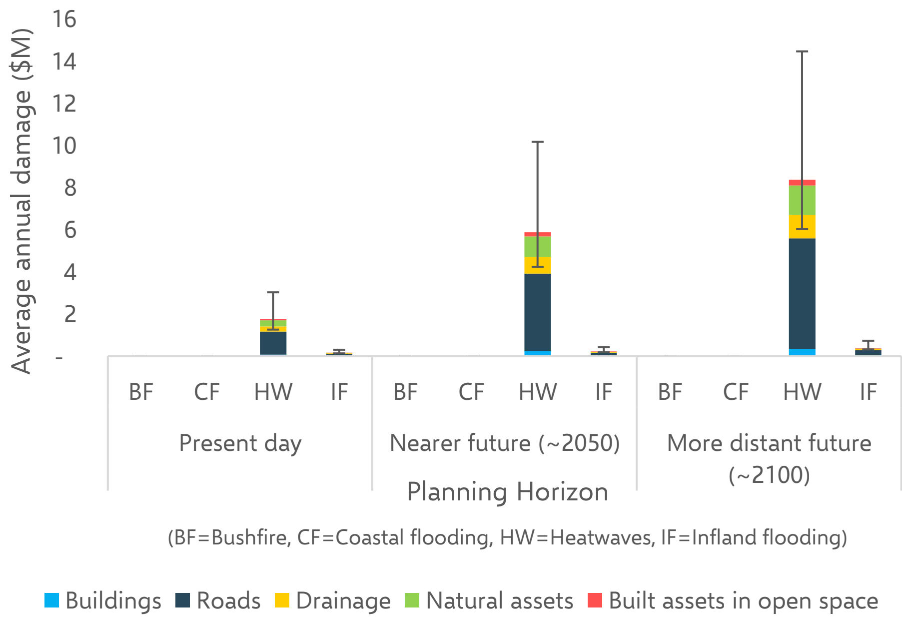
Whittlesea - Estimated damages from climate hazards without adaptation (Base case)

For Whittlesea, average annual damages (AADs) are estimated to be in the range of $1-$3 million for the present day, $4-$11 million for the nearer future (~2050) and, $6-$15 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community



The above figure presents the estimated AADs from climate hazards to community assets in Whittlesea under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

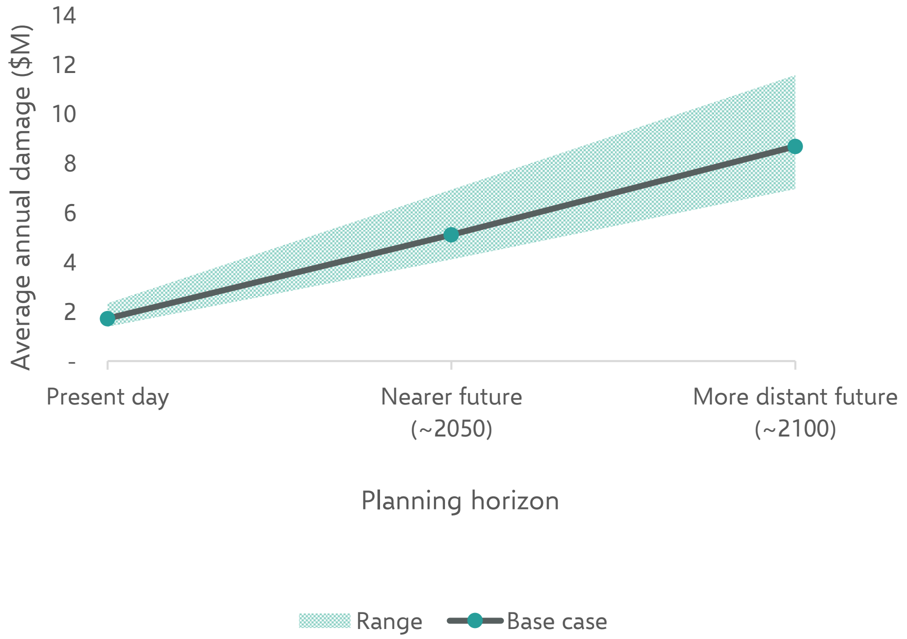
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Whittlesea broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

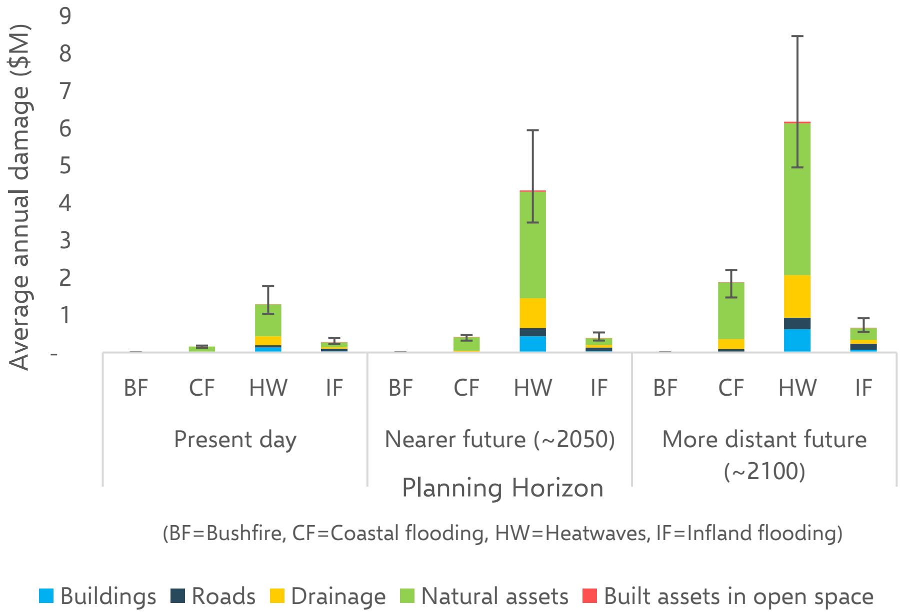
Wyndham - Estimated damages from climate hazards without adaptation (Base case)

For Wyndham, average annual damages (AADs) are estimated to be in the range of $1-$2 million for the present day, $4-$7 million for the nearer future (~2050) and, $7-$12 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 400% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Wyndham under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

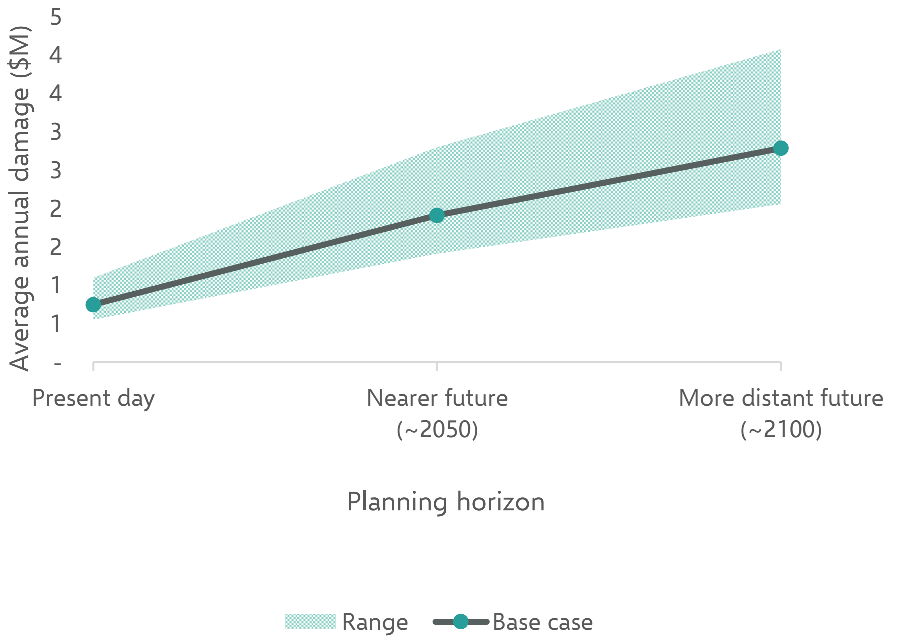
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Wyndham broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

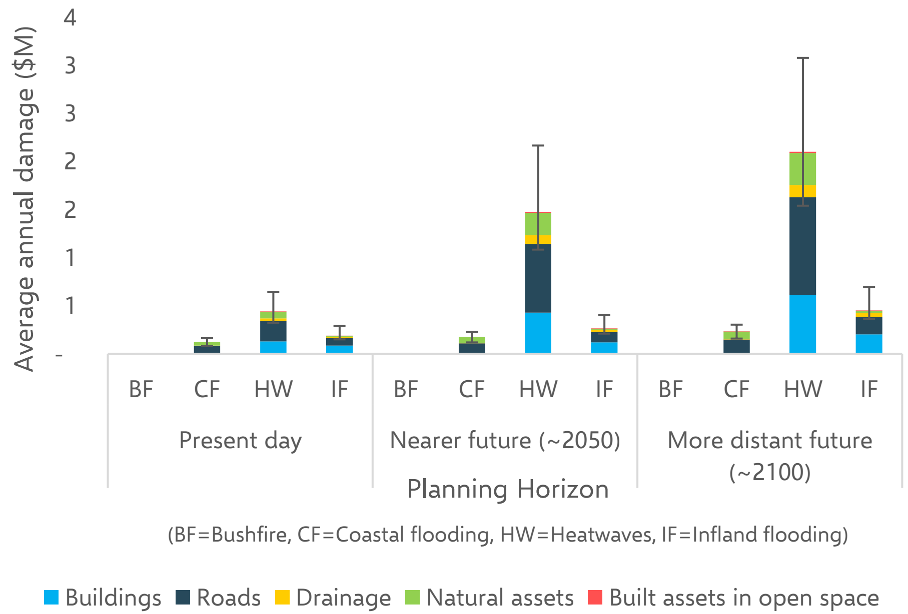
Yarra City - Estimated damages from climate hazards without adaptation (Base case)

For Yarra City, average annual damages (AADs) are estimated to be in the range of $1 million for the present day, $1-$3 million for the nearer future (~2050) and, $2-$4 million for the more distant future (~2100). This is an increase in AADs of about 150% in the nearer future and 300% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Yarra City under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

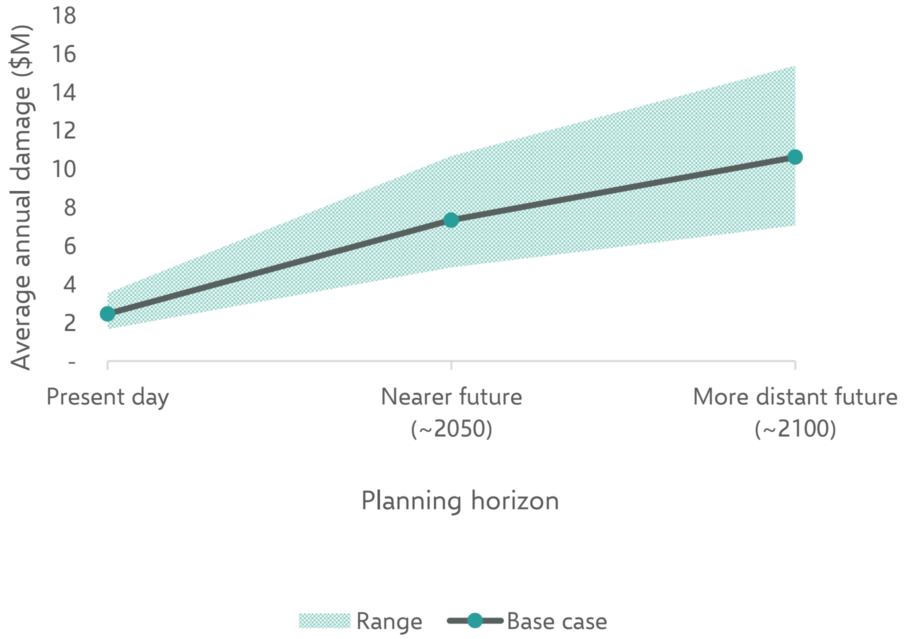
Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Yarra City broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

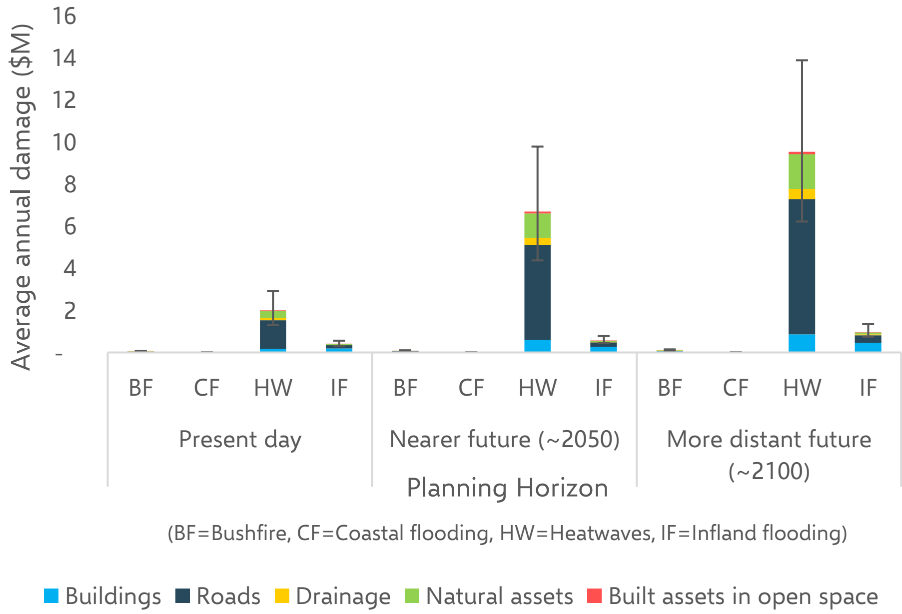
Yarra Ranges - Estimated damages from climate hazards without adaptation (Base case)

For Yarra Ranges, average annual damages (AADs) are estimated to be in the range of $2-$4 million for the present day, $5-$11 million for the nearer future (~2050) and, $7-$15 million for the more distant future (~2100). This is an increase in AADs of about 200% in the nearer future and 350% in the more distant future from present day.

AAD from climate hazards to community assets



AAD from climate hazards by hazard and asset class to community assets



The above figure presents the estimated AADs from climate hazards to community assets in Yarra Ranges under the base case or "do nothing differently" scenario. The base case highlights that AADs from climate hazards to community asset will increase with climate change as hazards become more frequent and more assets become exposed.

Estimates of AAD are presented across a range, with the outcome dependent on the realised likelihood of hazards and the sensitivity and value of assets. The estimates of AAD are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.

The above figure presents the AADs under the base case from climate hazard to community assets in Yarra Ranges broken down by hazard and asset class. This highlights which hazards are expected to cause the most damage and to which asset classes. The error bars reflect the range in possible outcomes. Again, the estimates of damage are based on specific climate events and do not incorporate indirect tangible and intangible costs, meaning the results likely underestimate impacts.