Central Coast Council

Draft Climate Change Policy

Community Workshop Information Pack

January 2019

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Contents

Agenda:
Climate Change Policy Workshops
February – March 2019

Thank you for your registering your spot at one of the upcoming Climate Change Policy workshops.

Below is an outline of the workshop agenda for your information.

Workshops will start at 6pm and finish at 8:30pm.

To make the most of the workshops, please ensure you have read the information pack provided.

Agenda

Item	Time	Presenter
Introduction	10 minutes	Facilitator
Presentation: - The straight story - Climate change overview - What is a policy and why it's needed - Draft Climate Change Policy overview - Key high level themes identified in initial survey	15-20 minutes	Council officers
Workshop format explained	10 minutes	Facilitator
Workshop breakout	45 minutes	All participants
Workshop summary – what you said	20 minutes	All and Council officers
Q&A session	20 minutes	All
Close and next steps	10 minutes	Facilitator

House Rules for Workshops

Everyone is welcome and encouraged to participate in the workshop process however there are some general rules to ensure respect and equity.

1. Everyone’s input is equally valued
2. Respect each speaker
3. Respect differences
4. Support everyone's right to be heard - share ‘air time’.
5. Ask for clarification when needed
6. You will have an opportunity to ask questions
7. Phones on silent to encourage full participation
8. Keep it clean - do not use obscene or offensive language

We want this to be a positive and productive environment, so if you do not adhere to these guidelines, you may be asked to leave.

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CENTRAL COAST COUNCIL

CCP 2018

CLIMATE CHANGE POLICY

Issue Date: **August 2018**

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History of Revisions:

Version	Date	TRIM Doc. #
1		

DCP 2018 Schedule of Amendments

Effective Date	Amendment	Reason
2018	N/A	Initial Adoption by Council

A. POLICY SUMMARY

A1 The Central Coast Council Climate Change Policy (The Policy) sets out Council's position relating to climate change with a view to maximising the economic, social and environmental wellbeing of Council and guides the planning and development of the Central Coast Region's resilience to climate change.

A2 The Policy enables council to align its operational and strategic planning with NSW State policy setting and actions.

A3 The Policy is a whole of Council commitment as well as support community initiatives to deal with climate change.

B. POLICY BACKGROUND

B1 There is 97% of global scientific consensus that the acceleration of climate change beyond the earlier predictions is exacerbated by anthropogenic activities.

B2 In 2015, 195 countries agreed on the United Nations Paris Agreement on climate change. The key objective was to limit the increase in global temperatures to well below 2 degrees and pursue efforts to limit the rise to 1.5 degrees. The commitment is to achieve net-zero emissions globally by the second half of the century.

B3 In 2016, the Australian Government ratified the Paris Agreement. The current targets for Australia are to reduce greenhouse gas emissions by 26-28% below the 2005 levels by 2030. Australia's policy agrees to meet international commitments on greenhouse gas emission reduction while maintaining energy security and affordability.

B4 In 2016, the NSW Government endorsed the Paris Agreement and took action consistent with the level of effort to achieve Australia's commitment to the Paris Agreement through implementation of the NSW Climate Change Policy Framework. The current targets for NSW are to achieve net-zero emissions by 2050.

B5 In 2016, the *Central Coast Regional Plan 2036* set a goal to protect the natural environment. Direction 14 of the Regional Plan requires the management of climate change related risks and the improvement of the regions resilience to hazards such as flooding, coastal erosion, bushfire, mine subsidence and land contamination.

B6 On 12 May 2016, the former Gosford City and Wyong Shire Councils amalgamated forming the Central Coast Council. This Policy aligns with the Council's Corporate Vision to build a vibrant and sustainable Central Coast.

B7 The Community Strategic Plan outlines the community's objectives and climate change expectations when delivering Council's goods and services to the community. This Policy will be implemented in accordance with the Community Strategic Plan.

B8 Approximately $US23 trillion worth of private investments are required globally for net zero emissions target by 2050 and new industries are crucial to realise this goal.

C. THE POLICY

Purpose

C1 To empower Central Coast Council as a climate leader and enabler for change.

C2 To ensure the risks associated with the changing climate on the environment and the community are recognised, understood and where practical managed by Council.

C3 To inform core functions of the Central Coast Council, including Council's response to strategic decision making, planning processes and operations.

C4 To provide direction on Climate Change for Council and the Central Coast region and strengthen the quadruple bottom line reporting framework (governance, environment, social and economic).

C5 To commit Council to the strategic principles and policy statements to manage climate change risks for natural and built systems within the Central Coast Local Government Area, and Council business using a combination of sustainable adaptation and mitigation measures.

Strategic Principles

C5 **Ecological Sustainable Development:** Ability to effectively integrate social, economic and environmental consideration in decision making through the implementation of the four principles a) precautionary principles, b) inter-generational equity, c) conservation of biological diversity and ecological integrity and d) improved valuation, pricing and incentive mechanism.

C6 **Holistic approach**: Ability to identify and understand the complex interacting and interdependent components that builds capacity to anticipate and adapt to change.

C7 **Science or Evidence based**: Ability to facilitate evidence based decision making to deal with the changing circumstances.

C8 **Collective decision making**: Ability to collaborate with the key internal and external stakeholders to generate diversity and flexibility in adaptation options through learning and shared responsibility.

C9 **Proactivity and continuity**: Ability to be proactive and establish an on-going process for learning and adaptation to deal with the complex challenges posed by the changing climate.

C10 **Place-based approach**: Ability to enhance Council and community capacity for climate resilience that is context specific, knowledge based and collaborative.

D. POLICY COMMITMENT STATEMENTS

D1 Acknowledge the importance of shared responsibility across all levels of Council, community and business in addressing climate change and transitioning towards a Net Zero Emission Central Coast Region.

D2 Establish a Corporate Governance Framework to lead a whole of Council approach when dealing with emergency risks including those associated with climate change within the Integrated Planning and Reporting Framework and the Central Coast Council Community Strategic Plan.

D3 Establish a holistic and systemic approach to monitor and understand the climate change risks and their impact on ecological, social, economic and physical built forms systems.

D4 Recognise the need for an effective and progressive response to the threat of climate change risks with the best available scientific knowledge.

D5 Align Council's corporate greenhouse gas emissions reduction target with the Australian Government's Paris commitment to reduce emissions by 26-28% below the 2005 levels by 2030 and the NSW Government's aspirational objective to achieve net-zero emissions by 2050.

D6 Develop a Central Coast greenhouse gas emissions inventory using regional data and establish baselines for an incremental pathway to meet a net zero emissions target for Council as basis for the Climate Change Action Plan (i.e. 2025, 2030 and 2050).

D7 Establish a Climate Change Action Plan for Council that outlines mitigation and adaptation management actions across Council business that are consistent with the principles of ecological sustainable development.

D8 Involve the community and stakeholders using a place-based approach in the decision making process for the development of a Climate Change Action Plan encompassing climate mitigation, adaptation and resilience.

D9 Consider climate change risks in Council's strategic planning process, namely; urban growth and development and land use zoning including the development of planning controls and guidelines to facilitate local investments.

D10 Review and update the sea level rise planning levels and coastal hazards based on Representative Concentration Pathway Scenarios 8.5 and latest scientific research adopted by the Intergovernmental Panel on Climate Change for planning in coastal areas and developing appropriate plans and strategies that recognise the long term need to protect, redesign, rebuild, elevate, relocate or retreat as sea levels rise.

D11 Support initiatives and education programs to enhance the Central Coast community's understanding and resilience to climate change risks; and provide directions for sustainable climate change mitigation and adaption activities.

D12 Identify and develop systems and relevant planning mechanisms to consider Council's corporate climate change risks, ongoing disaster response and recovery activities.

D13 Address the impacts of climate change in biodiversity conservation and natural resource management planning, wildlife connectivity and reduce ecosystem degradation across the Central Coast region.

D14 Invest in climate resilience opportunities through advancing technology, innovation and continuous improvement in the planning and management of existing built and natural assets, infrastructure renewal projects and renewable resources.

D15 Consider climate change risks and opportunities in the asset life cycle analysis for all new and existing infrastructure assets through adaptation and mitigation strategies.

D16 Establish an energy efficient and renewable energy guideline for the creation and renewal of Council's energy using assets as well as stimulate private sector investment in climate actions such as renewable energy initiatives.

D17 Commit to continually improving Council's energy efficiency and productivity.

D18 Conduct an annual corporate greenhouse gas emissions inventory including direct (scope 1) and indirect (Scope 2) emissions utilising *National Greenhouses and Energy Reporting Act 2007*.

D19 Reduce greenhouse gas emissions in the production, use and disposal of goods and services through Council procurement processes as well as influence Community efforts through partnerships.

D20 Identify and keep abreast of opportunities to finance climate change initiatives and investing savings from climate actions towards advancing sustainable development goals for Central Coast.

D21 Create accountability and confidence by supporting the carbon neutral supply chain through implementation of the Australian Government's National Carbon Offset Standards and Carbon Neutral Certification requirements.

D22 Establish climate partnerships between Council and the business community to identify and develop private investment opportunities for economic stability and growth.

E. POLICY IMPLEMENTATION

E1 This Policy covers all elected members of Council, all personnel employed by Council, any person or organisation contracted to or acting on behalf of Council, any person or organisation employed to work on Council premises or facilities and all activities of the Council.

E2 This policy does not confer any delegated authority upon any person. All delegations to staff are issued by the Chief Executive Officer.

E3 This policy should be read in conjunction with the Central Coast Council Code of Conduct.

E4 It is the personal responsibility of all Council employees and agents thereof to have knowledge of, and to ensure compliance with this policy.

F. DEFINITIONS

F1 **Council** means Central Coast Council, being the organisation responsible for the administration of Council affairs and operations and the implementation of Council policy and strategies.

F2 **Climate change** means a change of climate over an extended period, typically decades or longer, which is caused by human activity or natural climate variability that have direct and indirect impact on the environment, community and Council business.

F3 **Climate resilience** means building capacity to cope with climate change, to recover from the impacts of these climatic changes and to adapt using a combination of sustainable adaptation and mitigation measures.

F4 **Greenhouse gas emissions (GHGs)** means emissions of carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, a hydrofluorocarbon gas, a perfluorocarbon gas or any other gas prescribed by legislation for the purposes of this definition.

F5 **Holistic approach** means consideration of all the systems, processes and the interdependencies that influence the environment, Council and Community capacity to adapt and mitigate change on an on-going basis.

F6 **Place-based approach** means consideration of a context specific approach to plan for places for people by involving the people in the decision making process to maximise their connectivity to the place.

F7 **Climate adaptation** means consideration of the actions on an on-going basis for preparation in dealing with the impacts of climate change.

F8 **Climate mitigation** means consideration of the actions to reduce the impacts of climate change.

F9 **Representative Concentration Pathways (RCPs)** means the concentration of greenhouse gas in the atmosphere that equate to global mean temperature rise. Four different scenarios for global warming were projected (RCP2.6, RCP4.5, RCP6, and RCP8.5) and this information is translated to indicate the possible future sea level rise. The RCP2.6 low emission scenario indicates high investment in active removal of greenhouse gases from the atmosphere from the baseline years. While this translates to insignificant sea level rise, this scenario increases the risk of failure by 85% such as in infrastructure planning. On the contrary RCP8.5 indicates the high scenario i.e. high concentration level of GHGs and higher sea level rise. Hence, planning for the high risk scenarios is precautionary and reduces the risk of failure to only 15%.

F10 **Precautionary principle** means that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Hence, decision making processes should effectively integrate both long term and short term economic, environmental, social and equitable considerations where there are threats of serious or irreversible environmental damage. In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment, and
(ii) an assessment of the risk-weighted consequences of various options.

F11 **Inter-generational equity** means that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generation.

F12 **Conservation of biodiversity and ecological integrity** means that conservation of biological diversity and ecological integrity should be a fundamental consideration.

F13 **Improved valuation, pricing and incentive mechanism** means that environmental factors should be included in the valuation of assets and services, such as:

(i) polluter pays – that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement, and
(ii) the users of goods and services should pay prices based on the full life cycle of costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste, and
(iii) environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structures, including market mechanisms, that enable those best placed to maximise benefits or minimise costs to develop their own solutions and responses to environmental problems.

Office of Environment & Heritage

AdaptNSW

Central Coast
Climate change snapshot

Overview of **Central Coast Region** climate change

Based on long-term (1910–2011) observations, temperatures in the Central Coast Region have been increasing since about 1960, with higher temperatures experienced in recent decades.

The region is projected to continue to warm during the near future (2020–2039) and far future (2060–2079), compared to recent years (1990–2009). The warming is projected to be on average about 0.7°C in the near future, increasing to about 1.9°C in the far future. The number of hot days is projected to increase, and there are projected to be fewer cold nights.

The warming trend projected for the region is large compared to natural variability in temperature, and is of a similar order to the rate of warming projected for other regions of NSW.

Front Cover: North Avoca. The weathered crater-like rock pools have a teal blue, grey colour in the rock while the surrounding surface rock is orange red. Very surreal. Focus to foreground. Copyright: Leah-Anne Thompson. Page 2: Mystic serene flowing tropical rainforest waterfall, Somersby Falls, Gosford, New South Wales, Australia. Copyright: worldswildlifewonders. Page 4: The Hawkesbury River, Windsor, New South Wales, Australia. Copyright: Phillip Minnis. Page 7: Sunrise at Hargraves Beach, Noraville, NSW, Australia with sunrays, sunburst and silhouetted rock formations. Copyright: Leah-Anne Thompson. Page 9: Whispering reeds (Phragmites Australis), softly swaying and moving gracefully in the blue, golden wetlands area of Tuggerah Lakes near Long Jetty at sunset. Copyright: Leah-Anne Thompson.

Projected changes

Projected temperature changes	
Maximum temperatures are projected to increase in the near future by 0.3 – 1.0°C	Maximum temperatures are projected to increase in the far future by 1.4 – 2.5°C
Minimum temperatures are projected to increase in the near future by 0.4 – 0.8°C	Minimum temperatures are projected to increase in the far future by 1.4 – 2.5°C
The number of hot days will increase	The number of cold nights will decrease
Projected rainfall changes	
Rainfall is projected to decrease in spring and winter	Rainfall is projected to increase in summer and autumn
Projected Forest Fire Danger Index (FFDI) changes	
Average fire weather is projected to increase in summer and spring	Severe fire weather is projected to increase in summer and spring

Regional snapshots

NSW and ACT Regional Climate Modelling project (NARCliM)

The climate change projections in this snapshot are from the NSW and ACT Regional Climate Modelling (NARCliM) project. NARCliM is a multi-agency research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. NSW Government funding comes from the Office of Environment and Heritage (OEH), Sydney Catchment Authority, Sydney Water, Hunter Water, NSW Office of Water, Transport for NSW, and the Department of Primary Industries.

The NARCliM project has produced a suite of twelve regional climate projections for south-east Australia spanning the range of likely future changes in climate. NARCliM is explicitly designed to sample a large range of possible future climates.

Over 100 climate variables, including temperature, rainfall and wind are available at fine resolution (10km and hourly intervals). The data can be used in impacts and adaptation research, and by local decision makers. The data is also available to the public and will help to better understand possible changes in NSW climate.

Modelling overview

The NARCliM modelling was mainly undertaken and supervised at the Climate Change Research Centre. NARCliM takes global climate model outputs and downscales these to provide finer, higher resolution climate projections for a range of meteorological variables. The NARCliM project design and the process for choosing climate models has been peer-reviewed and published in the international scientific literature (Evans et. al. 2014, Evans et. al. 2013, Evans et. al. 2012).

Go to climatechange.environment.nsw.gov.au for more information on the modelling project and methods.

Interpreting climate projections can be challenging due to the complexities of our climate systems. 'Model agreement', that is the number of models that agree on the direction of change (for example increasing or decreasing rainfall) is used to determine the confidence in the projected changes. The more models that agree, the greater the confidence in the direction of change.

In this report care should be taken when interpreting changes in rainfall that are presented as the average of all of the climate change projections, especially when the model outputs show changes of both wetting and drying. To understand the spread of potential changes in rainfall the bar charts should be considered along with the maps provided in this document. Help on how to interpret the maps and graphs in this report is provided in Appendix 1.

Summary documents for each of the state planning regions of NSW are available and provide climate change information specific to each region.

The snapshots provide descriptions of climate change projections for two future 20-year time periods: 2020–2039 and 2060–2079.

1. The climate projections for 2020–2039 are described in the snapshots as **NEAR FUTURE, or as 2030**, the latter representing the average for the 20-year period.

2. The climate projections for 2060–2079 are described in the snapshots as **FAR FUTURE, or as 2070**, the latter representing the average of the 20-year period.

Further information about the regions will be released in 2015.

Introduction

This snapshot presents climate change projections for the Central Coast region of NSW. It outlines some key characteristics of the region, including its current climate, before detailing the projected changes to the region's climate in the near and far future.

Location and topography

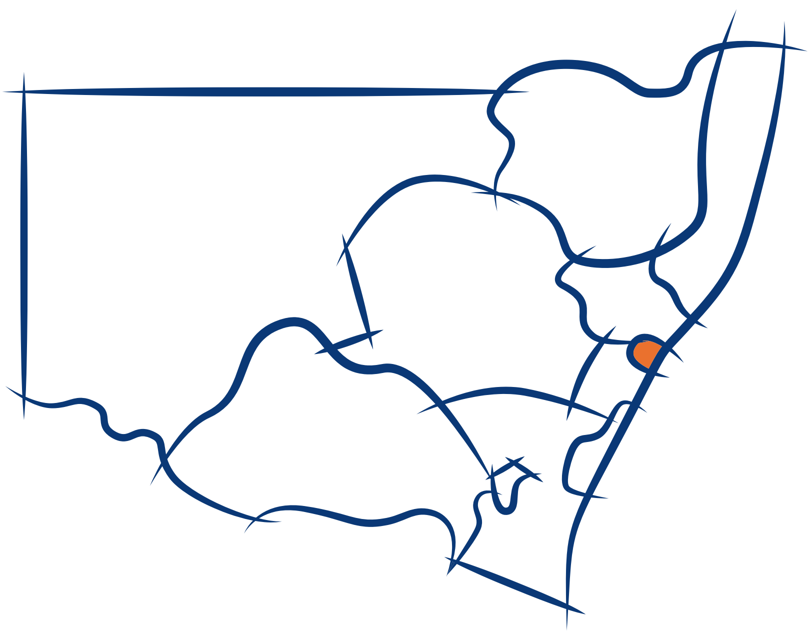
Well known for its beaches, lakes and the Hawkesbury River, the Central Coast Region extends from Broken Bay in the south to Forresters Beach in the north. The Central Coast region lies on Hawkesbury sandstone, with the Hornsby plateau the dominant geological feature.

Population and settlements

The Central Coast region has a population of approximately 322,600 people. There are two major town centres, Gosford and Wyong. The main industries in the region include retail, hospitality and construction. Tourism is also a major industry in this region.

Natural ecosystems

The region covers the catchments of the Wyong River and Mangrove Creek and is characterised by a large coastal plain fringed by a steep escarpment that rises abruptly to the sandstone plateaux of the hinterland. The terrain of the region has a large influence on its ecosystems. The orographic influence of Watagan Range creates an area of high rainfall, providing sufficient moisture to support the major areas of wet sclerophyll forest and rainforest. The region's sandstone plateaux are largely covered in dry sclerophyll forest. The coastal plain supports large areas of freshwater and saline wetland ecosystems, including large coastal lakes such as Tuggerah Lake. The region marks a transition zone for many plant and animal species between the sub-tropical influences of the north to the cooler, temperate conditions of the south. Reserves in the region include the coastal sandstone plateaux of Brisbane Waters and Dharug national parks, and the moist forests of Jilliby State Conservation Area.



Climate of the region

CURRENT CLIMATE

The Central Coast region has a fairly uniform climate. It is wettest along the coast and drier inland. It is warm in summer across the region. Winters are mild but temperatures are cooler away from the coast.

Temperature

In summer average temperatures are around 20–22°C throughout most of the region. In winter, average temperatures range from 12–14°C along the coast and are slightly cooler inland.

Maximum temperatures during summer range from 24–26°C along the coast and 26–28°C inland. In winter, average minimum temperatures range from 8–10°C around the coastal lakes to 4–6°C inland away from the coast.

Long-term trends in the temperature record indicate that the temperature in the Central Coast Region has been increasing since around 1960. The largest increase in temperature has come in recent decades.

Temperature extremes

Temperature extremes, both hot and cold, occur infrequently but can have considerable impacts on health, infrastructure and our environment. Changes to temperature extremes often result in greater impacts than changes to average temperatures.

Hot days

The Central Coast Region experiences fewer than 10 hot days per year (maximum temperatures above 35°C).

Cold nights

The Central Coast experiences very few cold nights per year (temperatures less than 2°C).

Rainfall

Rainfall is fairly uniform across the region but there can be great variability from year to year.

There is more rain during summer and autumn, and in areas closer to the coast. Annual rainfall ranges from 1200–1600 mm near the coast to between 800–1200 mm further inland.

The region has experienced considerable rainfall variability with intermittent periods of wetter and drier conditions. During much of the first half of the 20th century the region experienced drier than average conditions. The first decade of the 21st century was characterised by below average rainfall during the Millennium Drought. This dry period ended with two of the wettest years on record for Australia (2010–2011), with 2010 the third wettest year on record for NSW.

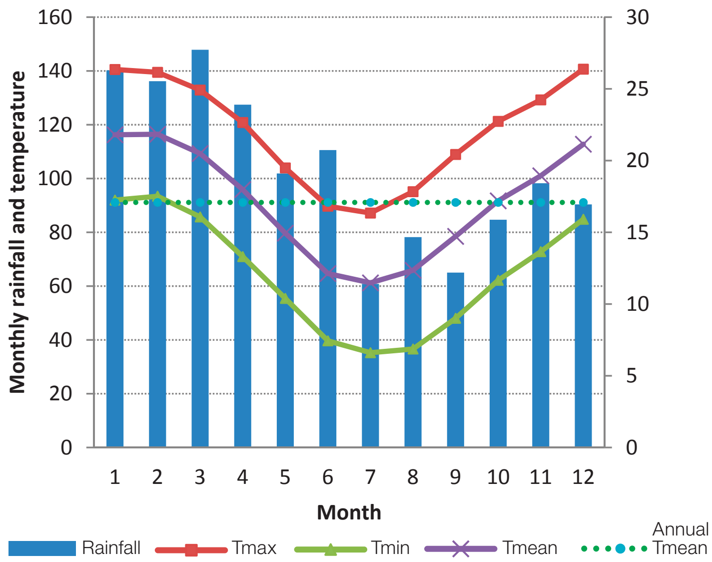
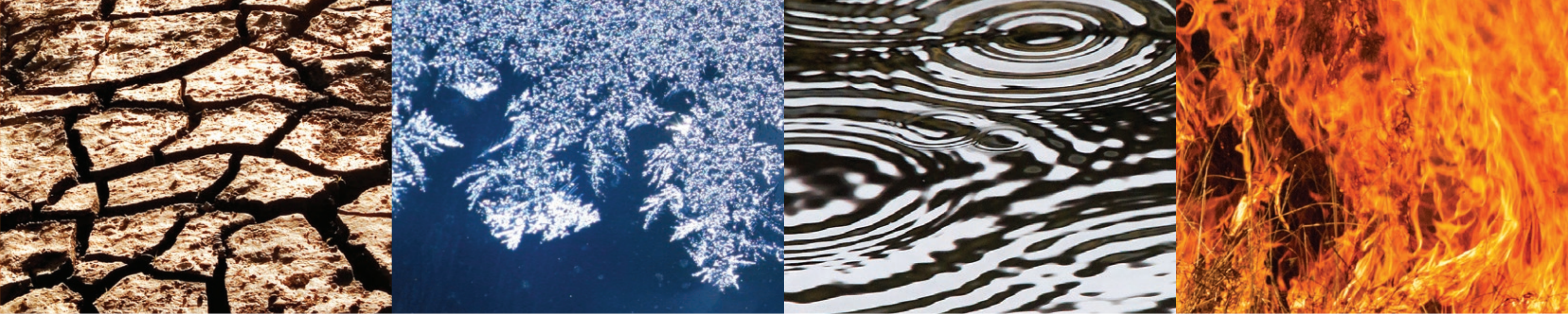


Figure 1: Seasonal rainfall and temperature variations (AWAP[1] data for 1960–1991)

1. Australian Water Availability Project, see www.csiro.au/awap/.



Fire weather

The risk of bushfire in any given region depends on four ‘switches’. There needs to be enough vegetation (fuel), the fuel needs to be dry enough to burn, the weather needs to be favourable for fire to spread, and there needs to be an ignition source (Bradstock 2010). All four of these switches must be on for a fire to occur. The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. The FFDI combines observations of temperature, humidity and wind speed with an estimate of the fuel state.

Long-term observations of FFDI come from daily measurements of temperature, rainfall, humidity and wind speed at only a small number of weather stations in Australia, with 17 stations located in NSW and the ACT (Lucas 2010).

There are no long term FFDI estimates available for the Central Coast. The two closest stations with long term data are Sydney Airport and Williamtown. The average annual FFDI estimated for the period 1990–2009 is 5.5 in Sydney and 5.4 in Williamtown. The highest average FFDI occurs in spring and summer.

Fire weather is classified as ‘severe’ when the FFDI is above 50. FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic.

Severe fire weather days happen on average 1.4 days per year at Sydney and Williamtown, and are more likely to occur in summer and spring.

Average FFDI					
Station	Annual	Summer	Autumn	Winter	Spring
Sydney Airport	5.5	6.1	4.1	4.5	7.4
Williamtown	5.4	6.7	3.4	4.1	7.4
Number of severe fire weather days (FFDI>50)					
Sydney Airport	1.4	0.6	0.1	0.1	0.7
Williamtown	1.4	0.7	0	0	0.7

Table 1: Baseline FFDI values for meteorological stations within the Central Coast Region.

Temperature

Climate change projections are presented for the near future (2030) and far future (2070), compared to the baseline climate (1990–2009). The projections are based on simulations from a suite of twelve climate models run to provide detailed future climate information for NSW and the ACT.

Temperature is the most reliable indicator of climate change. Across the Central Coast all of the models agree that average, maximum and minimum temperatures are increasing.

Summary temperature

Maximum temperatures are projected to increase in the near future by 0.7°C

Maximum temperatures are projected to increase in the far future by 1.9°C

Minimum temperatures are projected to increase by near future by 0.7°C

Minimum temperatures are projected to increase by far future by 2.1°C

There are projected to be more hot days and fewer cold nights

Projected regional climate changes

The Central Coast is expected to experience an increase in all temperature variables (average, maximum and minimum) for the near future and the far future (Figure 2).

Maximum temperatures are projected to increase by 0.7°C in the near future and by 1.9°C in the far future (Figure 2b). The largest changes occur in summer when maximum temperatures are projected to increase by 2.1°C in the far future (Figure 2b). Increased maximum temperatures are known to impact human health through heat stress and increasing the numbers of heatwave events.

Minimum temperatures are projected to increase by 0.7°C in the near future and by 2.1°C in the far future (Figure 2c). Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health.

These increases are projected to occur across the Central Coast (Figures 3–6).

The long-term temperature trend indicates that temperatures on the Central Coast have been increasing since approximately 1960, with the largest increase in temperatures in the most recent decades.

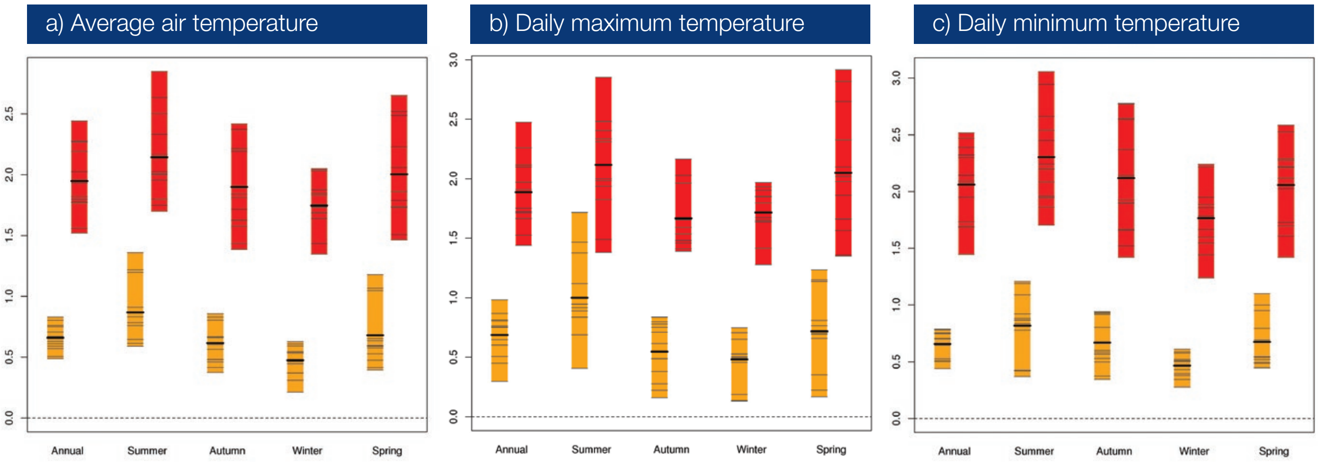


Figure 2: Projected air temperature changes for the Central Coast Region, annually and by season (2030 yellow; 2070 red): a) average, b) daily maximum, and c) daily minimum. (Appendix 1 provides help with how to read and interpret these graphs).

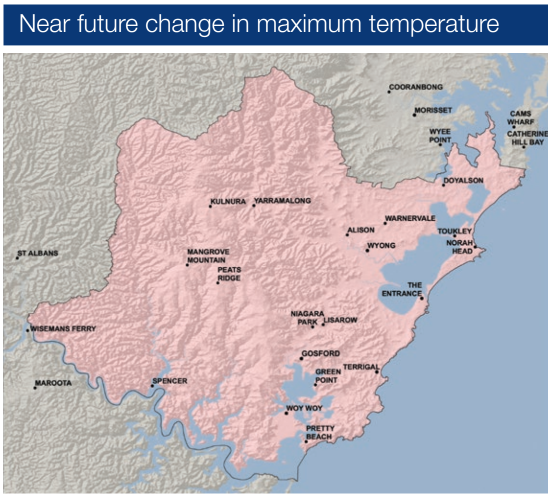


Figure 3: Near future (2020–2039) change in annual average maximum temperature, compared to the baseline period (1990–2009).

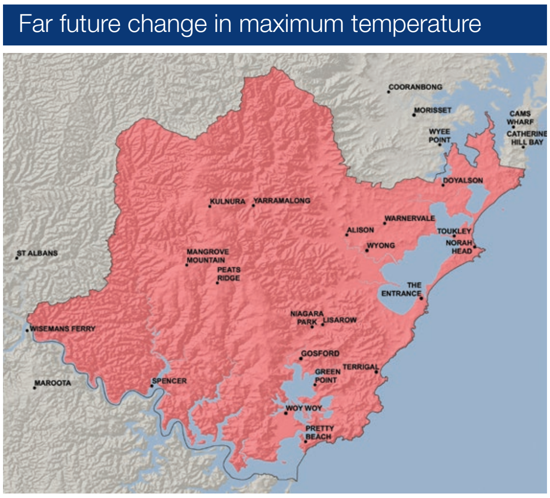


Figure 4: Far future (2060–2079) change in annual average maximum temperature, compared to the baseline period (1990–2009).

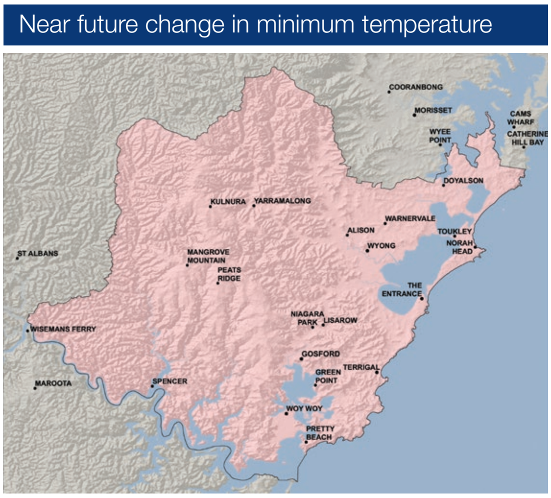


Figure 5: Near future (2020–2039) change in annual average minimum temperature, compared to the baseline period (1990–2009).

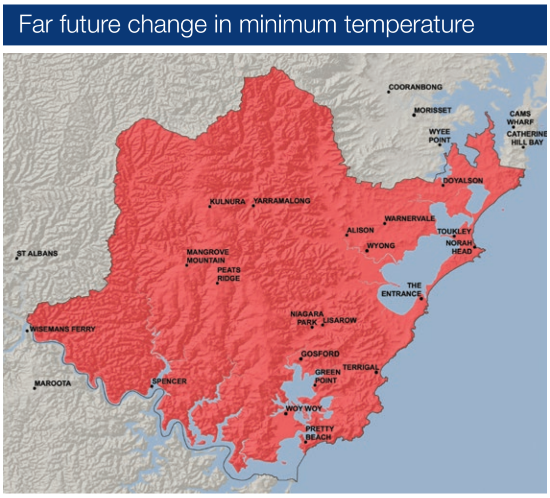
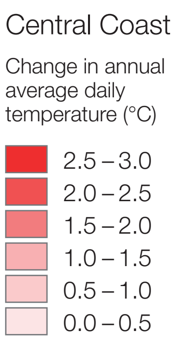


Figure 6: Far future (2060–2079) change in annual average minimum temperature, compared to the baseline period (1990–2009).



Hot days

DAYS PER YEAR ABOVE 35°C

The Central Coast Region sees fewer than 10 hot days each year (temperatures above 35°C). International and Australian experiences show that prolonged hot days increase the incidence of illness and death – particularly among vulnerable population groups such as people who are older, have a pre-existing medical condition or who have a disability. Seasonal changes are likely to have considerable impacts on bushfire danger, infrastructure development and native species diversity.

Projected regional climate changes

The Central Coast is expected to experience more hot days in the near future and the far future.

The region, on average, is projected to experience an additional three hot days per year in the near future (0–4 days across the 12 models) and seven more hot days in the far future (2–11 days across the 12 models) (Figure 7).

These increases are projected to occur mainly in spring and summer (Figure 7). The increases are uniform across the region (Figures 8 and 9).

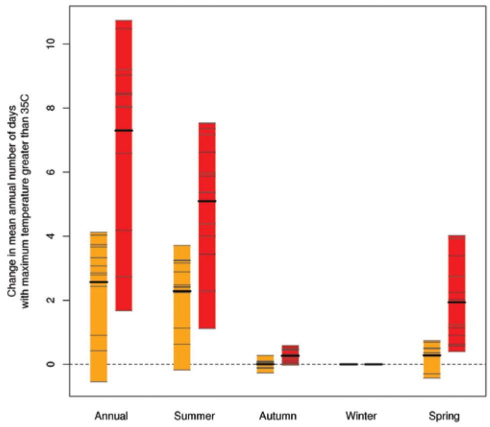


Figure 7: Projected changes in the number of hot days (with daily maximum temperature of above 35°C) for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

Near future change in days per year above 35°C

Figure 8: Near future (2020–2039) projected changes in the number of days per year with maximum temperatures above 35°C.

Far future change in days per year above 35°C

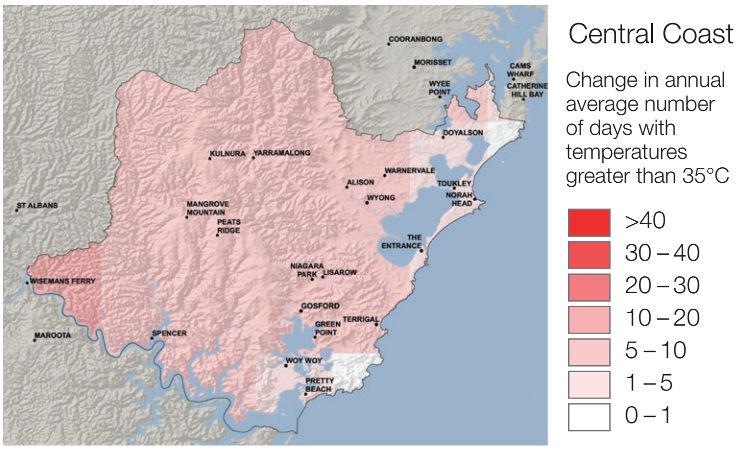


Figure 9: Far future (2060–2079) projected changes in the number of days per year with maximum temperatures above 35°C.

Cold nights

DAYS PER YEAR BELOW 2°C

Most of the emphasis on changes in temperatures from climate change has been on hot days and maximum temperatures, but changes in cold nights are equally important in the maintenance of our natural ecosystems and agricultural/horticultural industries; for example, some common temperate fruit species require sufficiently cold winters to produce flower buds.

Projected regional climate changes

The Central Coast currently does not have very many cold nights and there are projected to be fewer cold nights in future (Figure 10).

The projected decreases occur inland (Figures 11 and 12). The maps show little change along the coast where overnight temperatures seldom fall below 2°C.

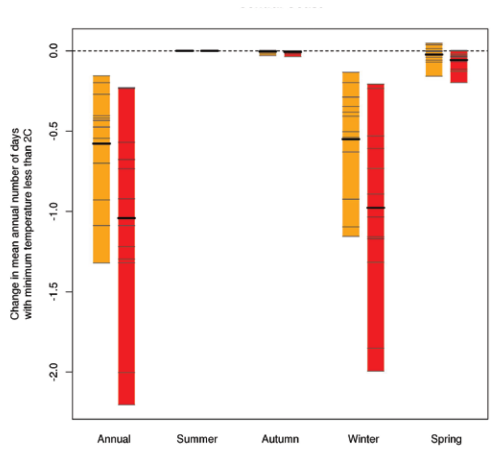


Figure 10: Projected changes in the number of low temperature nights for the Central Coast, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

Near future change in number of cold nights (below 2°C) per year

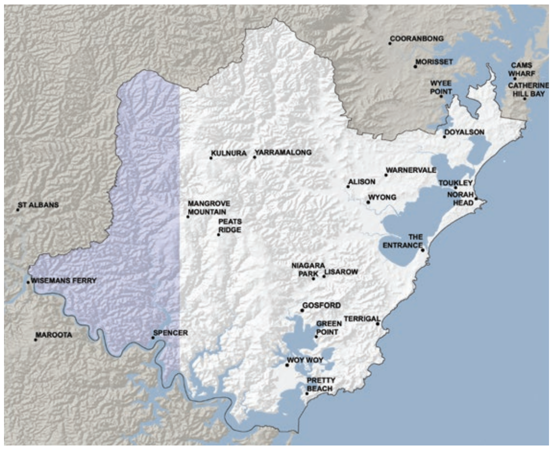
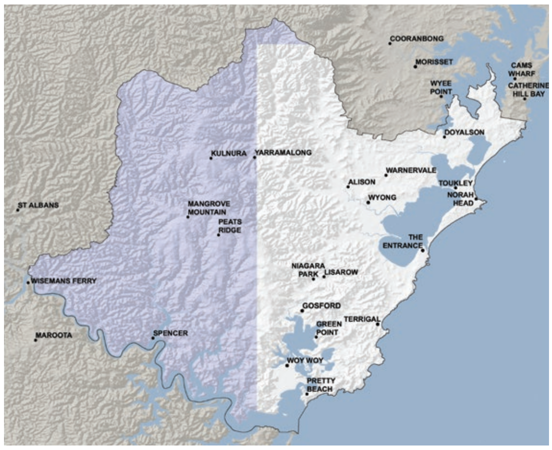


Figure 11: Near future (2020–2039) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

Far future change in number of cold nights (below 2°C) per year



Central Coast

Change in annual average number of days with temperatures less than 2°C

- -1 – 0
- -5 – -1
- -10 – -5
- -20 – -10
- -30 – -20
- -40 – -30
- < -40

Figure 12: Far future (2060–2079) change in the number of days per year with minimum temperatures below 2°C, compared to the baseline period (1990–2009).

Rainfall

Changes in rainfall patterns have the potential for widespread impacts. Seasonal shifts in rainfall can impact native species' reproductive cycles as well as impacting agricultural productivity; for example crops that are reliant on winter rains for peak growth.

Rainfall changes are also associated with changes in the extremes, such as floods and droughts, as well as secondary impacts such as water quality and soil erosion that occur as a result of changes to rainfall intensity.

Modelling rainfall is challenging due to the complexities of the weather systems that generate rain. 'Model agreement', that is the number of models that agree on the direction of change (increasing or decreasing rainfall) is used to determine the confidence in the projected change. The more models that agree, the greater the confidence in the direction of change.

Care should be taken when interpreting changes in rainfall from averaging climate change projections when the model outputs project changes of both wetting and drying. To understand the spread of potential changes in rainfall the bar charts should be considered along with the maps provided in this document.

Rainfall is projected to increase in autumn

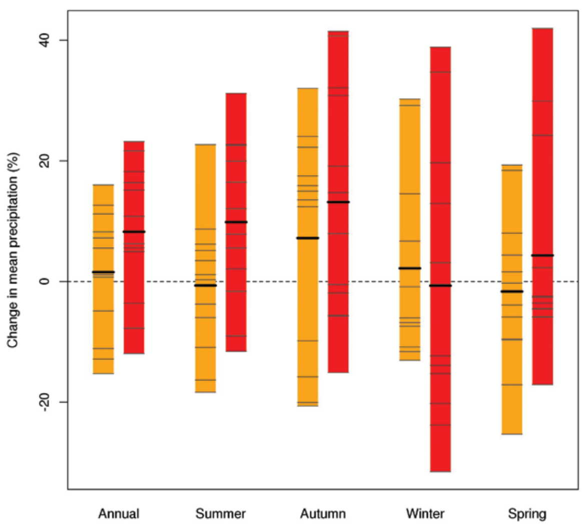


Figure 13: Projected changes in average rainfall for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

Projected regional climate changes

For the Central Coast Region the majority of models agree that autumn rainfall will increase in the near future (7 out of 12) and far future (8 out of 12). The projected increase is greatest inland in the near future, but is more uniform in the far future (Figures 13, 14b and 15b).

Summer rainfall is projected by the majority of the models to increase in the near future (7 out of 12 models) and the far future (9 out of 12 models) (Figure 13).

Spring rainfall is projected to decrease by the majority of models in the near future (7 out of 12 models) and to increase in the far future (8 out of 12 models).

Winter rainfall is projected to decrease by the majority of the models (7 out of 12 models) in both the near and far future.

Seasonal rainfall projections for both the near and far futures span both drying and wetting scenarios. The range in the near future is: summer (–18% to +23%), autumn (–21% to +32%), winter (–13% to +30%), and spring (–25% to –19%); in the far future the range is: summer (–12% to +31%), autumn (–15% to +41%), winter (–32% to +39%), and spring (–17% to –42%) (Figure 13).

Projections for the region's annual average rainfall range from a decrease (drying) of 15% to an increase (wetting) of 16% by 2030 and still span both drying and wetting scenarios (–12% to +23%) by 2070.

The Central Coast currently experiences considerable rainfall variability from year-to-year and this variability is also reflected in the projections.

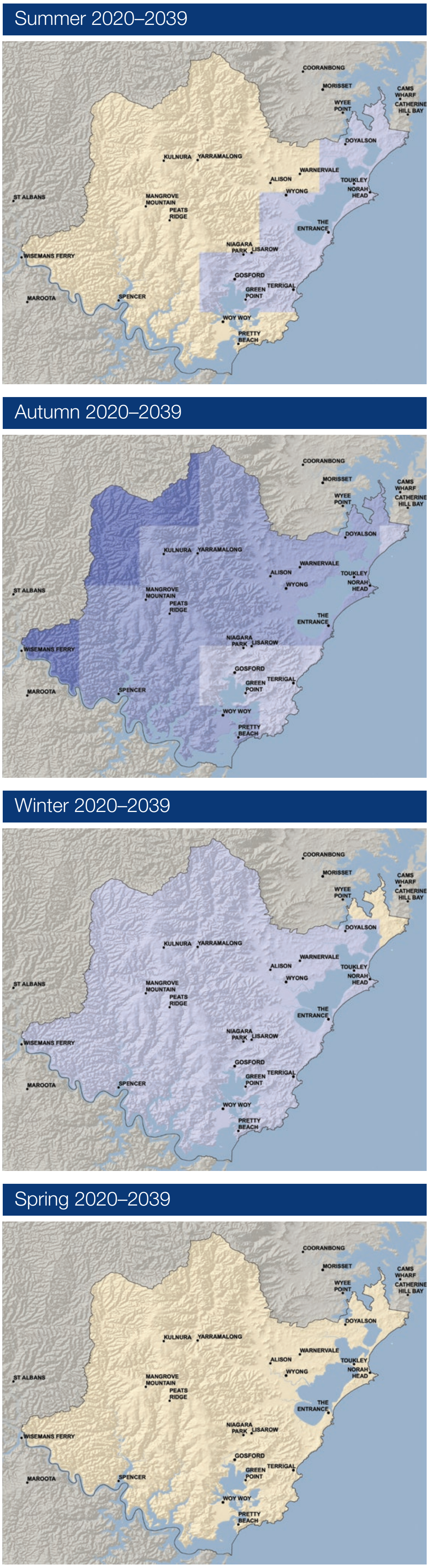


Figure 14: Near future (2020–2039) projected changes in average rainfall by season.

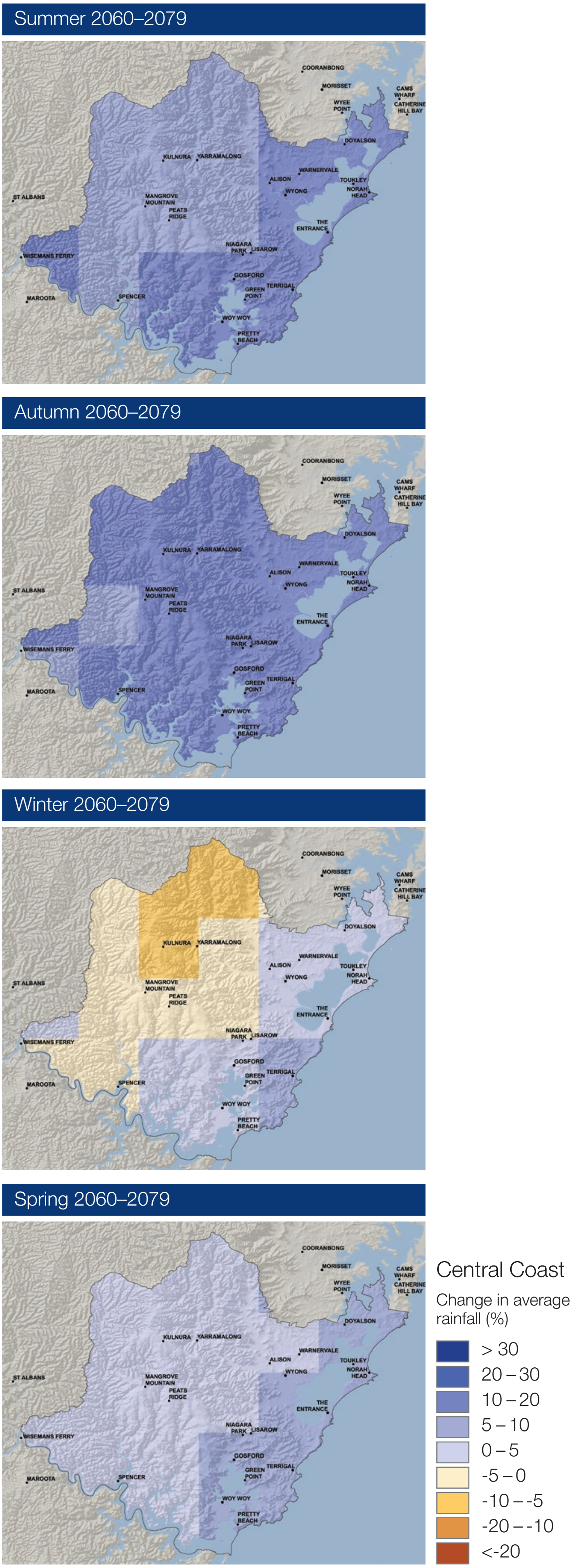


Figure 15: Far future (2060–2079) projected changes in average rainfall by season.

Fire weather

The Bureau of Meteorology issues Fire Weather Warnings when the FFDI is forecast to be over 50. High FFDI values are also considered by the Rural Fire Service when declaring a Total Fire Ban.

Average FFDI values are often used to track the status of fire risk. These values can be used when planning for prescribed burns and help fire agencies to better understand the seasonal fire risk. The FFDI is also considered an indication of the consequences of a fire if one was to start – the higher the FFDI value the more dangerous the fire could be.

FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25-49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic.

Severe and average fire weather is projected to increase

Severe fire weather in the near future is projected to decrease in autumn

Projected regional climate changes

The Central Coast is expected to experience an increase in severe and average fire weather in the near future and the far future (Figures 16 and 17).

Increases in severe fire weather are projected in summer and spring (Figures 17 and 19). Although these changes are small in magnitude (approx 1 more day every year) they are projected in prescribed burning periods (spring) and the peak fire risk season (summer) (Figure 19).

Average fire weather is projected to increase in all seasons by 2030 except for autumn (Figure 18). The increases are in prescribed burning periods (spring) and the peak fire risk season (summer), reducing the ability for preventative works.

Autumn is projected to have a decreased fire risk. As fire weather measurements take into account rainfall, it is likely that the decrease in autumn FFDI is due to projected increases in autumn rainfall (compare Figures 14 and 15 with Figures 18 and 19).

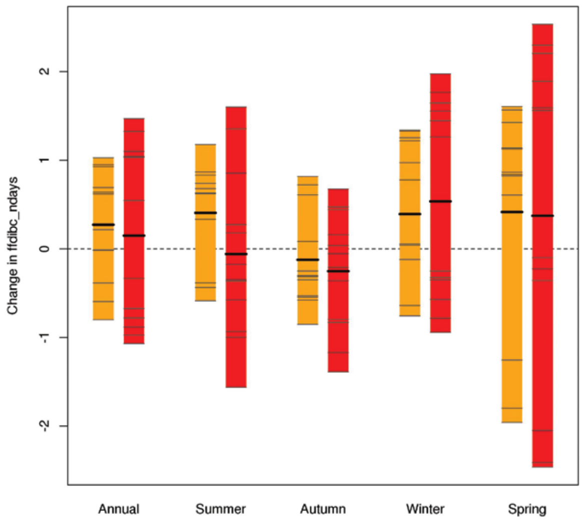


Figure 16: Projected changes in the average daily forest fire danger index (FFDI) for the Central Coast Region, annually and by season (2030 yellow; 2070 red). (Appendix 1 provides help with how to read and interpret these graphs).

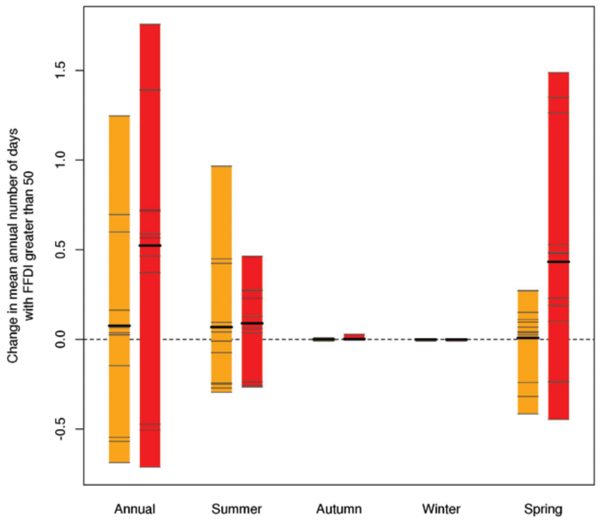


Figure 17: Projected changes in average annual number of days with a forest fire danger index (FFDI) greater than 50 for the Central Coast Region, annually and by season (2030 yellow; 2070 red).

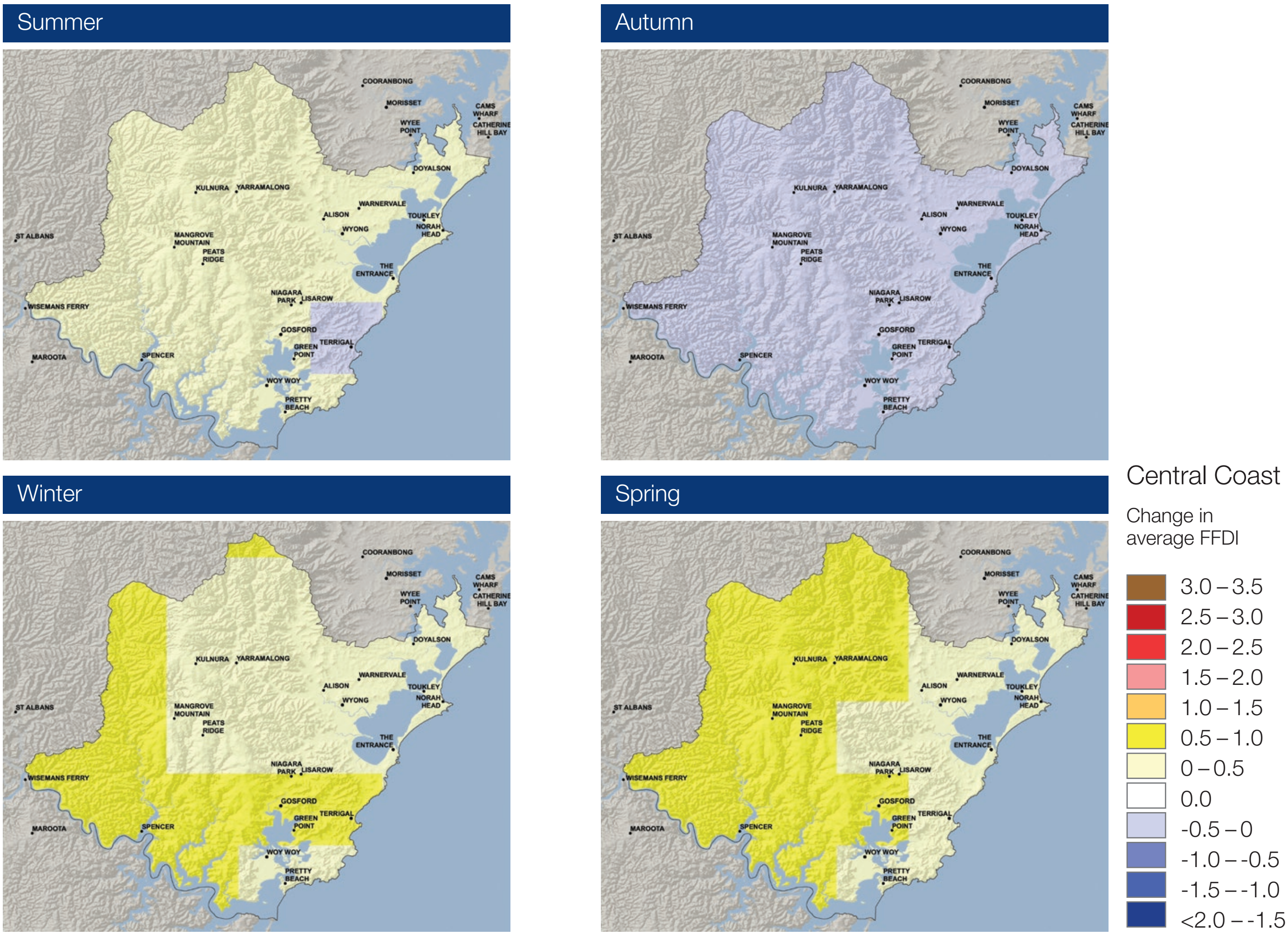


Figure 18: Far future (2060–2079) projected changes in average daily FFDI, compared to the baseline period (1990–2009).

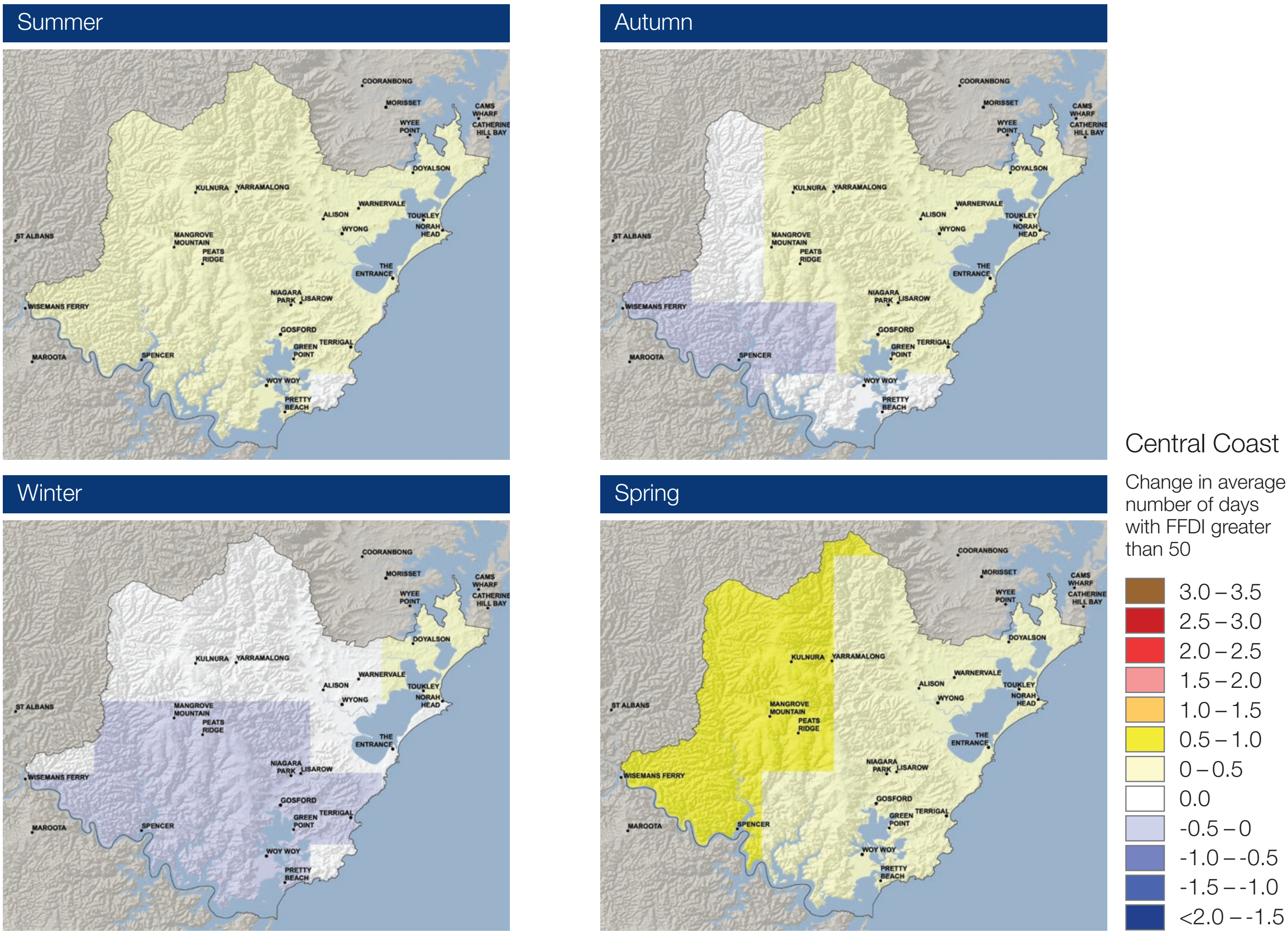


Figure 19: Far future (2060–2079) projected changes in average annual number of days with a FFDI greater than 50, compared to the baseline period (1990–2009).

Appendix 1 Guide to reading the maps and graphs

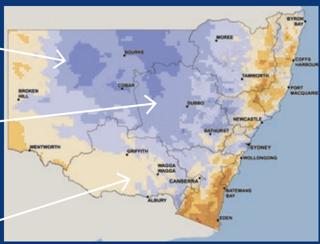
This document contains maps and bar graphs of the climate change projections. The maps present the results of the twelve models as an average of all twelve models. The bar graphs show projections averaged across the entire state and do not represent any particular location within the state. The bar graphs also show results from each individual model. See below for more information on what is displayed in the maps and bar graphs.

How to read the maps

The maps display a **10km** grid.

NSW has been divided into State Planning Regions and each region has a Local Snapshot report.

The colour of each grid is the **average of all 12 models** outputs for that grid.



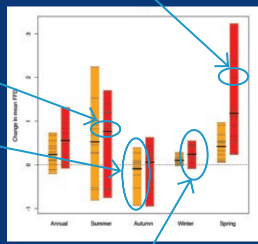
How to read the bar graphs

The thin grey lines are the **individual models**. There are 12 thin lines for each bar.

The thick line is **the average of all 12 models** for the region.

The length of the bar shows the **spread of the 12 model values** for the region

Each bar is the **average for one model** for the region. They do not represent a single location in the region.



Note: The yellow bars represent near future scenarios (2020–2039), while the red bars represent far future scenarios (2060–2079).

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See also www.environment.nsw.gov.au

Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (environment information and publications requests)
Phone: 1300 361 967 (national parks, climate change and energy efficiency information and publications requests)
Fax: (02) 9995 5999
TTY users: phone 133 677 then ask for 131 555
Speak and Listen users: phone 1300 555 727 then ask for 131 555
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

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What are the RCPs?

RCP stands for 'Representative Concentration Pathway'. To understand how our climate may change in future, we need to predict how we will behave.

For example, will we continue to burn fossil fuels at an ever-increasing rate, or will we shift towards renewable energy?

Current emissions are tracking close to the RCP8.5 pathway

The RCPs try to capture these future trends. They make predictions of how concentrations of greenhouse gases in the atmosphere will change in future as a result of human activities.

The four RCPs range from very high (RCP8.5) through to very low (RCP2.6) future concentrations. The numerical values of the RCPs (2.6, 4.5, 6.0 and 8.5) refer to the concentrations in 2100.

2 °C increase in temperature is recognised as the threshold at which climate change becomes **dangerous**.

Effort to curb emissions	Energy generation	New technology	Transport		Temperature 2081–2100 (average increase relative to 1986-2005)	Sea level 2081–2100 (average rise relative to 1986-2005)	Extreme weather 2081–2100	Adaptation required
Low	Coal-fired power		Cars, trucks	RCP 8.5	3.7 °C	0.63 m	Large increase	High level at high cost
Medium	Mix		Mix	RCP 6.0	2.2 °C	0.48 m	Moderate increase	Medium level at medium cost
Medium	Renewable		Mix	RCP 4.5	1.8 °C	0.47 m	Moderate increase	Medium level at medium cost
High	Renewable	Emissions capture	Bicycles, public transport	RCP 2.6	1.0 °C	0.4 m	Small increase	Low level at low cost

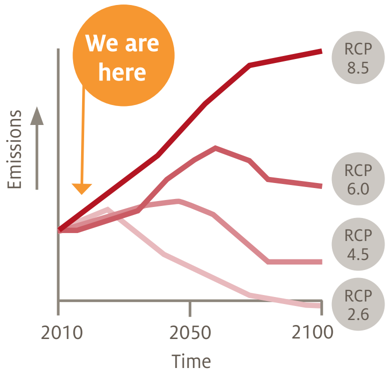
Where do the RCPs come from?

The RCPs were used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2014 as a basis for the report's findings.

Previous IPCC assessment reports used a set of scenarios known as SRES (Special Report on Emissions Scenarios), which start with socioeconomic circumstances from which emissions trajectories and climate impacts are projected. In contrast, RCPs fix the emissions trajectory and resultant radiative forcing rather than the socioeconomic circumstances.

We can use the RCPs to plan for the future

Scientists use the RCPs to model climate change and build scenarios about the impacts. You can use these scenarios to plan for the future.



If we follow the RCP 8.5 pathway, **more adaptation** will be needed.

If we follow the RCP 2.6 pathway, **less adaptation** is needed.

RCP 8.5 leads to much greater temperature increases, and this means greater impacts and greater costs. To adapt to these changes will also cost more. A balance must be struck between the cost of impacts and the cost of adaptation.

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Why should we adapt to climate change?

1 Because climate change is inevitable.

Our options to tackle climate change:

> Geoengineering

Large-scale projects to change the radiation balance (e.g. using solar reflectors in space) or to increase uptake of CO_2 (e.g. by ocean iron fertilisation)

But

- The technology is unproved and may not work
- It may have unexpected results
- It doesn't address the cause
- It could be expensive
- It does not address the direct effects of CO_2, such as ocean acidification

> Mitigation

Reducing our production of greenhouse gases to limit climate change (e.g. by shifting to renewable energies, or through reforestation)

But

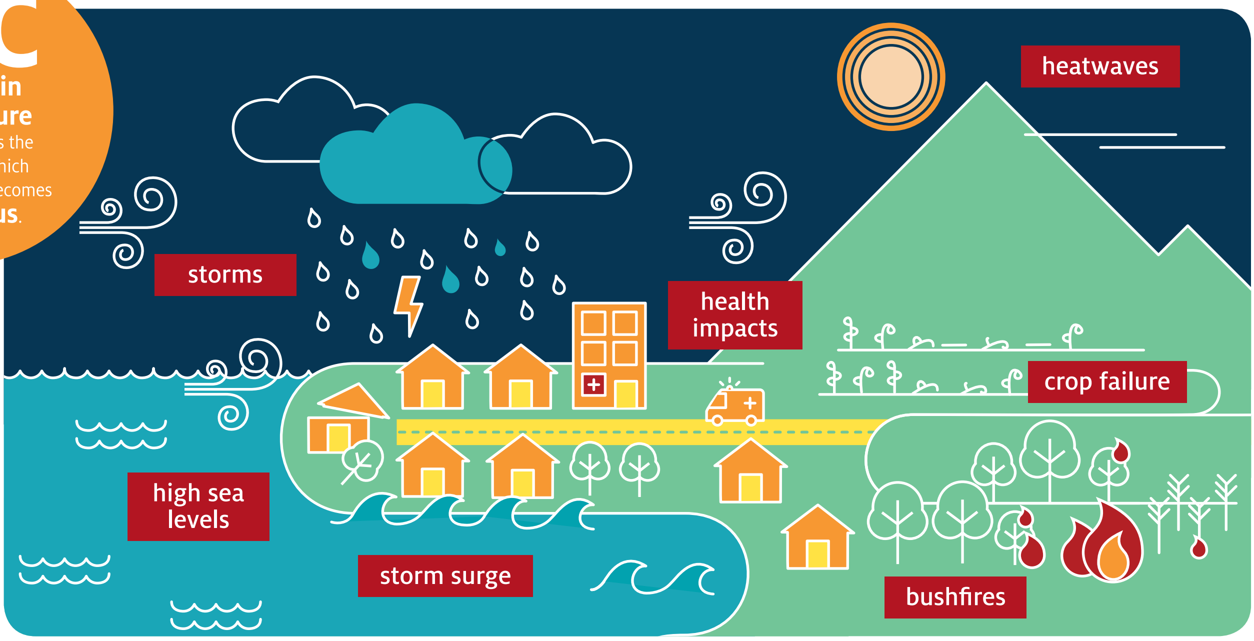
Despite ongoing global efforts – changes in climate are already happening

An increase in global temperature of **2.7°C is still predicted** given current emissions reduction commitments.

2 Because otherwise, the negative impacts will be too great.

Sea-level rise **Extreme weather events**

2°C increase in temperature is recognised as the threshold at which climate change becomes **dangerous**.



Along Australia's coast, the effects will include inundation because of sea-level rise, storm surge and flooding from rivers. About 85% of Australians live within 50 km of the coast, where much of our vital infrastructure is located.

3 > Adaptation is essential.

Actions to limit the negative impacts of climate change and take advantage of any positive opportunities

Although many places and sectors will experience negative effects of climate change, at least in the early decades, climate change may, in some places, have a beneficial effect.

For example, warmer temperatures may increase crop productivity in cooler regions of Australia, and there may also be business opportunities. Adaptation is also about taking advantage of these positive effects. Towards the end of the 21st century, it is likely that the impacts will be negative almost everywhere.

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What should we consider in adapting to sea-level rise?

1 To adapt, we can:

Avoid

Identify future 'no-build areas' and use planning tools to prevent new development in areas at risk now or in future

$

Accommodate

Continue to use the land but accommodate changes by building on piles, converting agriculture to fish farming or growing flood- or salt-tolerant crops

$$$

Protect

Use hard structures (eg sea walls) or soft solutions (eg dunes and vegetation) to protect land from the sea. May be prohibitively expensive, especially in the long term

$$$

Retreat

Withdraw, relocate or abandon assets that are at risk; ecosystems are allowed to retreat landward as sea levels rise

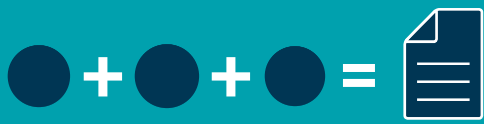
$$

Attack

Reclaim land; used in areas of very high land values (eg The Netherlands, Hong Kong, Singapore). Generally not appropriate for Australia and has large economic and environmental costs

$$$$

2 These options can be combined to develop a plan of action.



3 Choices will need to consider:

Cost of response

$ $$$

Low – high

Potential cost to government and regulators

Cost of avoided impacts

(including social and environmental costs and benefits as well as economic ones)

Use of the land

(including its strategic importance, for example as an airport, defence, port facility etc)

Value of the land and its assets

(including ecosystem service, amenity, historical, cultural values)

$

Length of protection

Short- to long-term protection

Why is sea-level rise important?

Sea-levels are rising because of climate change

Thermal expansion

Warmer water expands, therefore global warming is causing the water in our oceans to expand

+

Melting ice

Global warming is melting our glaciers and the Greenland and Antarctic land-based ice sheets

=

Higher sea levels

The amount of sea-level rise depends on the amount of climate change

Sea levels are now 19 cm higher

than they were at the beginning of the 20th century

and

will continue to rise over the next centuries

half a metre or more by the end of the century; around 6 m if the Greenland ice sheet melts completely

however

if we limit our emissions,

sea-level rise could be reduced

but not for many decades, even centuries because oceans respond very slowly to change

Sea-level rise creates risks for our coasts

Higher water levels

Floods

+

Higher wave heights

Storm surges

=

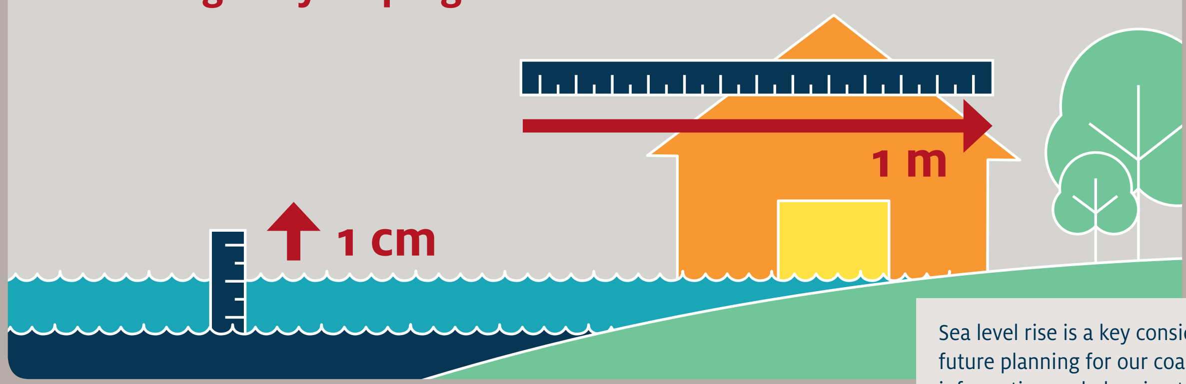
Threats

to land, roads, railways, hospitals, schools, houses

A rough rule of thumb

Approximately a 1 cm rise in sea level on a gently sloping beach...

...will bring the water 1 m further landward



Sea level rise is a key consideration for future planning for our coasts. Further information and planning tools are available at www.coastadapt.com.au

Coastal climate change infographic series
www.coastadapt.com.au

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What are the options for adapting to sea-level rise?

There are five types of options for adapting to sea-level rise:

In choosing your options you will need to consider:

$ $$$ Low – high
Potential cost to government and regulators

Short- to long-term
Protection

1 Planning options

Scope objectives, strategies and policies ($)
Taking account of risk and sensitivity to impact

Coastal hazard mapping ($$)
Mapping areas at risk of erosion and inundation, and mapping minimum floor height to avoid risk

Risk management ($)
Cost–benefit analysis, vulnerability assessment, impact assessment

Emergency planning and preparedness ($$)
Prepare emergency plans for flooding, upgrade resources to match risk

2 Regulatory options

Regulation of land use
Zoning to regulate land use, establish minimum setback and building elevation etc.

Development permits ($)
Requirements or regulation on specific developments to protect from hazard

Building regulation ($)
Control design elements (e.g. materials)

3 Land use change or restriction options

Transfer of development potential ($)
Land swap to allow development on low-risk land

Land acquisition ($$$)
Purchase land at high risk and rezone

Land trusts
Manage land for conservation benefits, restrict development

Easements and covenants ($)
Restrictions or conditions attached to land title

Foreshore tenure ($)
Lease or license from crown so adjoining properties can develop integrated foreshore management

4 Structural options

Structural elevation ($$)
Infill to raise land for building or habitable areas above flood risk

Sea walls, groynes etc ($$$)
Hard shoreline structures to protect from flooding

Other hard protection ($$$)
Storm-surge barrier, secondary protection e.g. raised roads

Flood proofing ($)
Use building materials that can withstand short-term flooding, locate services (e.g. electricity) above flood level

Scour protection ($$)
Foundation protection for new or existing buildings

5 Soft options

Dune building or rehabilitation ($$)
Creation or rehabilitation of dunes or offshore islands to buffer flood risk

Coastal wetland creation or restoration ($$)
Buffer to reduce wave energy

Beach nourishment ($$$)
Addition of sediment to continually replenish loss from natural erosion

You are also likely to need to combine options

For example, zoning of at-risk areas as unsuitable for development + a sea wall to protect high-value assets already in place

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Understanding **CoastAdapt** inundation maps

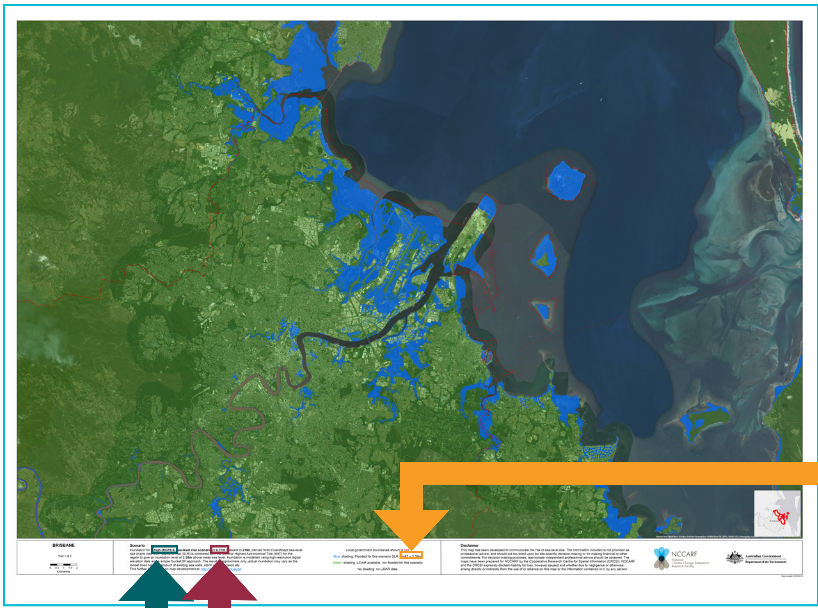
Key

Blue shading: inundated

Green shading: not inundated

Grey shading: no data

Blue and green shading: LiDAR data available.



HAT
Highest Astronomical Tide

'...combined with the nominal Highest Astronomical Tide (HAT)...' To make the map, sea level rise is added to the HAT – the average of recorded high tides – to give an estimate of the worst case inundation risk.

RCP (8.5)

The RCP is the scenario of future greenhouse gas concentrations in the atmosphere. RCP8.5 is a very high greenhouse gas scenario. For 2100, we also supply maps for RCP4.5 (low concentrations).

0.77 m

0.77 m is the amount the sea is expected to rise at this location by 2100 under RCP8.5 (based on CSIRO modelling). For 2100 there is a map for RCP4.5 also. For 2050, there is only a map for RCP8.5– there is little difference between scenarios before the second half of the 21st century.

Why are there differences between inundation maps?

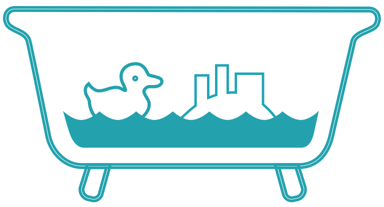
Not all inundation maps look the same: check the scenario, the date, does the map use bathtub modelling or hydrodynamic modelling, does the map account for tides? Use maps for different dates and different scenarios to evaluate the range of risk to your area.

What is bathtub modelling?

The ***bucket fill*** or ***bathtub*** method of modelling simply raises water levels over existing topography.

Benefits of bathtub models

- simple and easy to generate so can explore several scenarios
- good for looking at a regional scale
- easy to link to other maps (e.g. GIS)



Limitations of bathtub models

Does not consider:

- tidal flows in estuaries
- protection from seawalls and other structures
- wind and waves so gives little guidance on storm surge
- rainfall coming downstream and making flooding worse.

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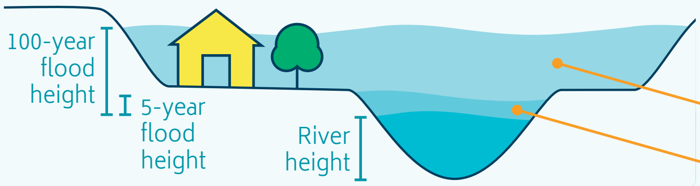
What is a **100-year flood?**

A '1-in-100-year flood' refers to a flood height that has a long-term likelihood of occurring once in every 100 years (also called a 100 year recurrence interval).

Another way of describing this flood event is: a flood height that has a long-term average **1 per cent chance of happening in any given year**. Risk experts refer to this as a 0.01 Annual Exceedance Probability.

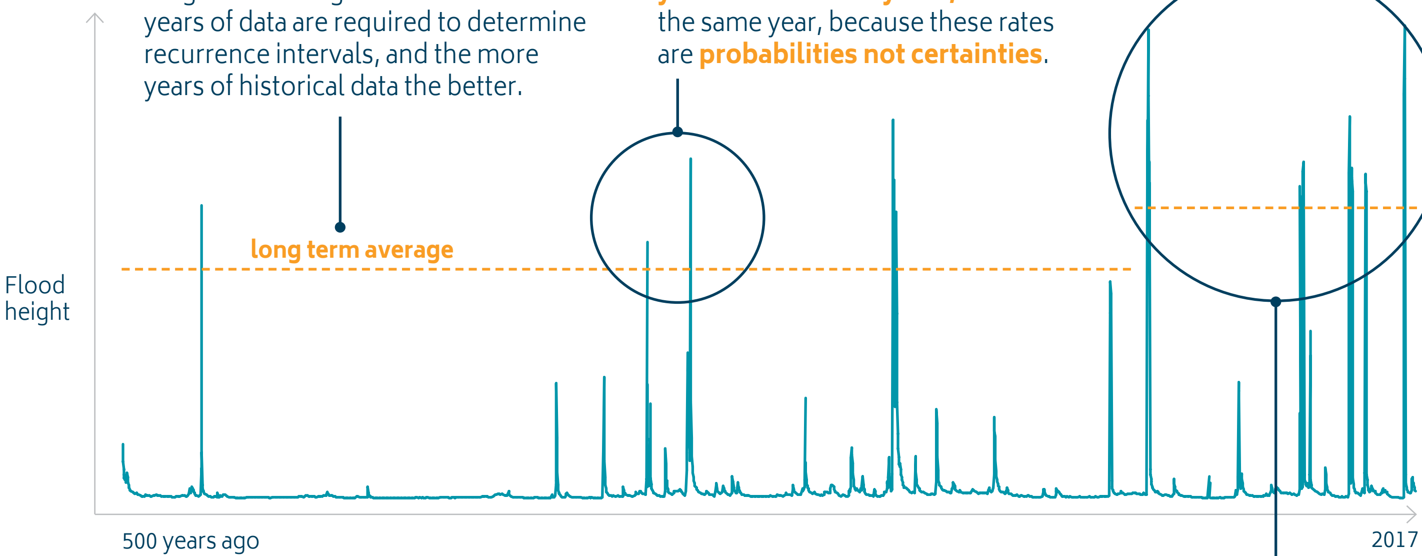


Recurrence interval	Probability of occurence per year	% chance in any year	Annual exceedance probability (AEP)
100 years	1 in 100	1%	0.01
5 years	1 in 5	20%	0.20

The probability of a flood event is calculated using statistical techniques.

Statistical techniques are based on long-term averages – 100 or more years of data are required to determine recurrence intervals, and the more years of historical data the better.

It's possible to have **two '1-in-100-year floods' in 100 years,** or even in the same year, because these rates are **probabilities not certainties**.



Climate change is increasing the probability of floods in some places, so a 1-in-100-year flood might become a 1-in-50-year flood.

Human activities can also affect flood probabilities in other ways, for example through land clearance and channel straightening.

Thinking about flood probabilities can help you decide **whether or not to take action.**

Where the probability of an event occurring is higher than 50% within the lifespan of your asset, you should consider action to prepare for it. Where an event is less probable, you might undertake minimal preparation – depending on the value and purpose of your asset.

Australian Government
Department of the Environment and Energy
CoastAdapt
NCCARF National Climate Change Adaptation Research Facility

What **shapes** our coastlines?

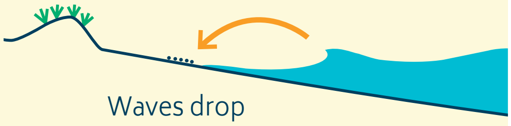
The processes that shape our coast are:

Erosion

Land is broken down by waves ...

... and sediment is carried away

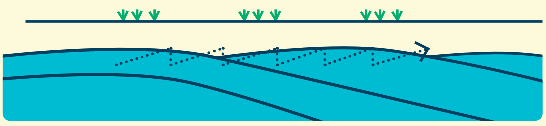
Deposition



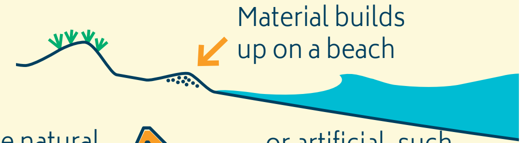
Waves drop sediment

Transportation

Waves and tides transfer sediment somewhere else

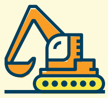


Accretion

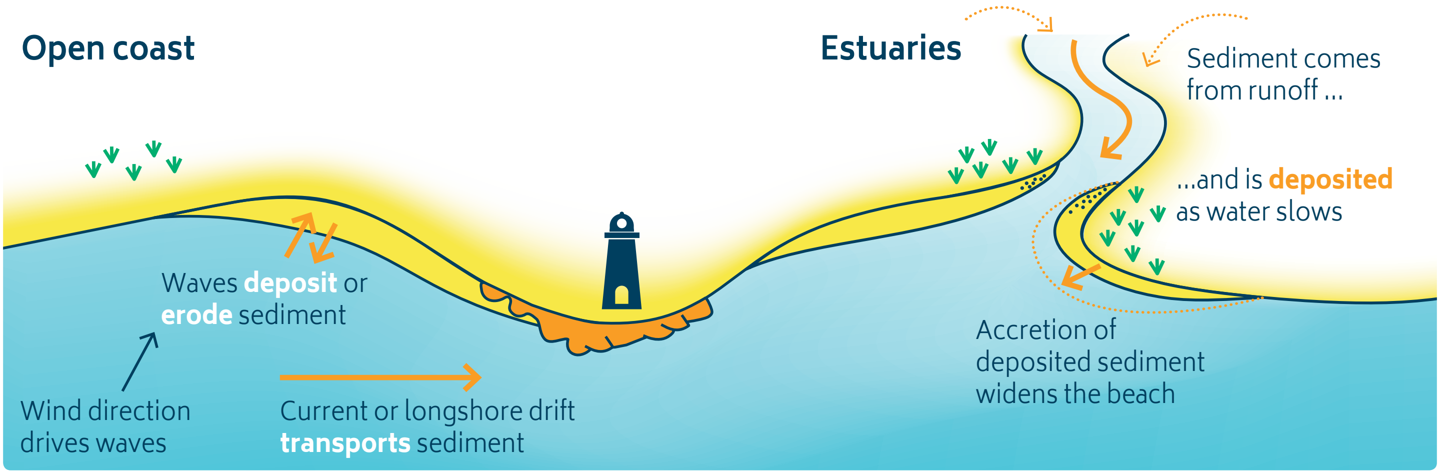


Material builds up on a beach

Can be natural, caused by depostion ...



... or artificial, such as beach fill deposited by a digger



Changes in coastlines happen:

... over hours to days, during storms	... over weeks to months, such as seasonal changes in the ocean	... over years, such as the occurrence of El Niño and La Niña events	... over decades or millennia, such as through changes in sea level and the height of the land (e.g. during an Ice Age).

Human activities can impact the coast on all of these timescales

Climate change may affect coastal processes

Sea level rise

increases erosion, increase inundation

Wave climate changes

increase/decrease wave run-up, increase/decrease erosion and accretion, change transportation

Storm frequency intensity and/or direction changes

changes to wave and storm surge patterns

Rainfall and runoff changes

increase/decrease sediment supply to rivers

Coastal climate change infographic series
www.coastadapt.com.au

Australian Government
Department of the Environment and Energy
CoastAdapt
NCCARF National Climate Change Adaptation Research Facility

FMA Online Resources Series

Climate Change and Sea Level Rise — The Science

Resource No.1

Version 2. 25 April 2018

***Disclaimer**: The aim of Floodplain Management Australia's 'Online Resources Series' is to provide FMA members with a snap shot of available web-based links to a range of topics relevant to floodplain risk management. The resources listed for a particular topic are by no means complete and have not been verified by FMA for accuracy or currency. All text provided is referenced as being used directly from the web-based links provided. You should use this resource as a starting point for your own research on a particular floodplain risk management topic. Remember to always check the copyright and referencing requirements when using any of these resources.*

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.

Thousands of scientists from all over the world contribute to the work of the IPCC. Review is an essential part of the IPCC process, to ensure an objective and complete assessment of current information. IPCC aims to reflect a range of views and expertise. The IPCC reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. It does not conduct any research nor does it monitor climate related data or parameters.

Approximately every seven years, the IPCC releases its Assessment Report. These are published materials composed of the full scientific and technical assessment of climate change, generally in three volumes, one for each of the Working Groups of the IPCC, together with their Summaries for Policymakers, plus a Synthesis Report. The most recent Assessment Report is the Fifth Assessment Report (AR5) released in 2014. The previous Assessment Report was the Fourth Assessment Report (AR4) released in 2007 and the Third Assessment Report (AR4) was released in 2001. The Sixth Assessment Report (AR6) is due to be finalised in 2021.

Representative Concentration Pathways

Scientists investigating how the earth's climate will respond to future conditions take into account a number of factors. These include the amount of future greenhouse gas emissions, developments in technology, changes in energy generation and land use, global and regional economic circumstances and population growth.

So that outputs from different modelling systems can be compared, a standard set of scenarios are used to provide a consistent set of starting conditions, historical data and possible future emissions for use across the various branches of climate science. Findings of the IPCC Fifth Assessment Report (AR5) are based on a new set of scenarios called Representative Concentration Pathways (RCPs).

There are four pathways: RCP8.5, RCP6.0, RCP4.5 and RCP2.6. The four RCPs cover a range of emission scenarios with and without climate mitigation policies. For example, RCP8.5 is based on minimal effort to reduce emissions; RCP2.6 requires strong mitigation efforts, with early participation from all emitters followed by active removal of atmospheric carbon dioxide.

The Third (2001) and Fourth (2007) IPCC Assessment Reports used a set of scenarios known as SRES (Special Report on Emissions Scenarios). The SRES scenarios start with socio-economic 'storylines' from which emissions trajectories and climate impacts are projected.

More information on Representative Concentration Pathways can be found here.

CSIRO Australian Climate Futures Project

Australian Climate Futures is a decision-support tool to assist understanding and application of climate change projections for impact assessment and adaptation planning.

Australian Climate Futures includes projections from global and regional climate models as well as statistically downscaled results. The global climate model (GCM) data (where grid sizes are between approximately 60 and 300 square kilometres) are from the modelling experiments that informed the IPCC's Fifth Assessment Report (2104) as well as those used for the earlier Fourth Assessment Report (2007).

Projected changes from the latest models can be explored for 14 future time periods (2025, 2030, 2035,…2090) and four scenarios of greenhouse gas concentrations (RCP2.6, RCP4.5, RCP6.0 and RCP8.5).

Projections from the earlier models are available for three future time periods (2030, 2055 and 2090) and three SRES emissions scenarios (B1 (low emissions) , A1B (medium emissions) and A2 (high emissions).

Users can explore, and obtain data for, projected monthly, 3-monthly, 6-monthly and annual changes in up to 16 climate variables:

- temperature
- maximum temperature
- minimum temperature
- rainfall (mean)
- heavy rainfall (99th percentile; SRES only)
- extreme rainfall (1-in-20 year daily maximum; RCPs only)
- solar radiation (mean)
- wind-speed (mean)
- strong wind (99th percentile; SRES only)
- extreme wind (1-in-20 year daily maximum; RCPs only)
- relative humidity (mean)
- evapotranspiration (mean; Morton Wet Environment Areal Potential Evapotranspiration; AR5 only)
- evaporation (mean; Morton Areal Potential Evaporation; SRES only)
- time in drought (SPI based)
- sea level pressure (mean)
- sea surface temperature (mean).

Results are available for a range of regions across Australia. NSW is divided into about five regions. The CSIRO Climate Futures Project has a range of four projection tools with increasing level of complexity.

Other national organisations with expertise in science of Climate Change and Sea Level Rise

The CSIRO Climate Science Centre is a research program in the CSIRO's Oceans and Atmosphere. The Centre brings together the core of CSIRO's capability in climate modelling and observations of the atmosphere and ocean. The mission of the Centre is to deliver the climate knowledge Australia needs to inform an effective national response to the challenges of a variable and changing climate. The Sea Level, Waves and Coastal Extremes team is part of CSIRO's Climate Science Centre.

The Sea Level, Waves and Coastal Extremes Team website includes detailed information on their key areas of research — sea level change, waves, coastal extremes and ocean energy. The following information is provided under sea level change:

- why does sea level change
- past sea level change
- future sea level change
- measurements and data, including sea level measurements, sea level data and links to a range of publications on sea level change

The OzCoasts website provides comprehensive information about Australia's coast, including its estuaries, coastal waterways and climate change impact. OzCoasts is managed by the Seabed Mapping and Coastal Information section at Geoscience Australia. Detailed information and more online links about climate change and sea level rise are provided on the Ozcoasts website.

The Australian Academy of Science published The Science of Climate Change in February 2015 with the aim to address confusion created by contradictory information in the public domain. It sets out to explain the current situation in climate science, including where there is consensus in the scientific community and where uncertainties exist.

The Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) released the Sea Level Rise Report Card in 2012.

NSW and ACT Regional Climate Modelling (NARCliM) Project

The NSW and ACT Regional Climate Modelling (NARCliM) Project is a research partnership between the NSW and ACT governments and the Climate Change Research Centre at the University of NSW. The AdaptNSW website (part of the NSW Office of Environment and Heritage) has a wealth of information about climate change in NSW.

The NARCliM project began in 2011 in response to the need by regional decision makers and impact assessment researchers for high resolution climate change projections. Previously climate change information had been at a scale that could not be used for localised decisions. NARCliM has produced an ensemble of robust regional climate projections for south-eastern Australia that can be used by the NSW and ACT community to plan for the range of likely future changes in climate.

The NARCliM projections have been generated from four global climate models (GCMs) dynamically downscaled by three regional climate models (RCMs), producing a 12 model ensemble. This has produced data for the entire Murray-Darling Basin at a 10km grid size, known as the NARCliM domain.

Here is a good presentation about statistical downsizing from global climate models by Matthew Riley from NSW Office of Environment and Heritage in approx. early 2014.

NARCliM uses a single emissions scenario, the SRES A2 scenario. At the time that NARCliM started, in 2010, the SRES emission scenarios underpinning the IPCC's Third Assessment Report (2001) and Fourth Assessment Report (2007) were the only set of emission scenarios available at that time. The SRES A2 emission scenario was selected for the NARCliM climate projections because the global emissions trajectory suggested that it was the most likely scenario. Recent publications have confirmed that we are tracking at the higher end of the A2 scenario.

NARCliM runs the 12 models were run for three time periods: 1990 to 2009 (base), 2020 to 2039 (near future with 2030 being the average of the 20 year period), and 2060 to 2079 (far future with 2070 being the average of the 20 year period).

The NARCLiM divides south-eastern Australia into 11 regions. For each region data is provided on:

- likely changes in climate (temperature and rainfall) by 2030 and 2070
- likely changes to severe fire weather by 2030 and 2070
- likely changes to hot days (maximum temperatures > 35°C)
- likely changes to cold nights (minimum temperatures < 2°C)

For each region users can download a Climate Change Snapshot Report, the data for the mapped climate projections (in ASCII format) and all of the maps in the report separately. Or users can use the interactive map to get results for each region or even each 10km grid.

Australian Rainfall and Runoff — incorporation of increased rainfall intensities form climate change

The latest version of Australian Rainfall and Runoff — A guide to Flood Estimation (Commonwealth of Australia (Geoscience Australia), 2016) (ARR) is now available online. A discussion of how to consider increased rainfall intensities (or equivalent rainfall depths) due to climate change is presented in:

- Book 1: Scope and Philosophy. Chapter 6: Climate Change Considerations: (Advanced Draft — dated 6 July 2016):
- Section 6.1: Introduction.
- ***Section 6.2: Climate Futures Web Tool*** — as discussed above and found at the following link.
- ***Section 6.3: Interim Climate Change Guideline***. The 'Climate Change Guideline', is a 'six-step process to be used to incorporate climate change risks into decisions involving the estimation of design flood characteristics. The process uses a decision tree approach that enables the practitioner to define the nature of the information needed for a particular problem and to reach an appropriate course of action':
- Step 1 — Set the effective service life or planning horizon (Section 6.3.1)
- Step 2 — Set the flood design standard (Section 6.3.2)
- Step 3 — Consider the purpose and nature of the asset or activity and consequences of its failure (Section 6.3.3)
- Step 4 — Carry out a climate change risk screening analysis (Section 6.3.4)
- Step 5 — Consider climate change projections and their consequences (Section 6.3.5)
- Step 6 — Consider statutory requirements (Section 6.3.6)
- Section 6.4: Worked Example

- Section 6.5: Global Climate Model (GCM) Consensus for Natural Resource Management (NRM) Clusters
- Section 6.6: References

Section 6.2 of ARR states that “generally, there is more confidence in Global Climate Models (GCM) simulations of temperature than for rainfall. Thus (ARR) provides an adjustment factor for (rainfall) Intensity-Frequency Duration (IFD) curves informed by temperature projections alone. … given the uncertainty in rainfall projections and their considerable regional variability, an increase in rainfall (intensity or depth) of 5% per degree (Celsius) (°C) of local warming is recommended.”

Section 6.3.5 of ARR provides Equation 1.6.1:

$$I_p = I_{\mathrm{ARR}} \times 1.05^{T_m}$$

where: I_p = the projected rainfall intensity or equivalent depth due to climate change

I_{ARR} = the design rainfall intensity (or depth) for current climate conditions as determined by ARR

T_m = the midpoint (or median) of the ‘projected increase in annual mean surface temperature’ from the Climate Futures Web Tool for a given Natural Resource Management (NRM) Cluster, service life or planning horizon and Representative Climate Pathway (RCP).

Sea level rise mapping in Australia

The OzCoasts website provides a series of initial sea level rise maps to illustrate the potential impacts of climate change for key urban areas around Australia (Sydney, Hunter and NSW Central Coast, Adelaide, Melbourne, South East Queensland (including Brisbane and Gold Coast) and Perth and south to Mandurah.

The maps have been prepared by combining a sea level rise value with a high tide value. They illustrate an event that could be expected to occur at least once a year, but possibly more frequently, around the year 2100. Maps are available to show three sea level rise scenarios: low sea level rise (0.5m), medium sea level rise (0.8m) and high sea level rise (1.1m). These sea level rise scenarios are for a 2100 period, relative to 1990.

The BETA version of Coastal Risk Australia (CRA) is an interactive map tool that allows the user to investigate the extent of coastal inundation associated with sea level rise to the year 2100 for all areas around the Australian coastline. There are two options for visualising the potential inundation from sea level rise in 2100:

- ***predicted*** — where one of three sea level rise scenarios can be selected:
  - low — current day highest tide + 0.44 metre
  - medium — current day highest tide + 0.54 metre
  - high — current day highest tide + 0.74 metre
- ***manual*** — where a sea level rise value from 0.0 metre to 10.0 metres (in 0.1 metre increments) above mean sea level can be selected

Sea level rise — NSW

The current NSW Government Policy for sea level rise is outlined on the NSW Office of Environment and Heritage (OEH) web site and states that "*following a review by the NSW Chief Scientist and Engineer and stage one coastal management reforms, the NSW Government announced that councils would have the flexibility to determine their own sea level rise projections to suit their local conditions. The Government would no longer prescribe state wide sea level rise projections for use by councils and the 2009 NSW Sea Level Rise Policy Statement would no longer be NSW Government policy*".

The review by the NSW Chief Scientist and Engineer referred to on the NSW OEH website is entitled '*Assessment of the science behind the NSW Government's sea level rise planning benchmarks'* (April 2012) and was based on the IPCC's Fourth Assessment Report (2007).

The NSW Office of Environment and Heritage released 'Guidelines on incorporating sea level rise into flood risk and coastal hazard assessment guidelines' in August 2010. The OEH web site notes that "*These documents will be revised as part of the coastal reform process. In the interim, reference to the NSW sea level rise planning benchmarks in these documents should be taken as referring to council's adopted sea level rise projections*".

In March 2018, the NSW State Government announced the details of the Stage 2 Coastal Management Reforms, comprising a coastal management framework with the following elements:

- Coastal Management Act 2016 (CM Act)
- State Environmental Planning Policy (Coastal Management) 2018
- NSW Coastal Management Manual
- Coastal Management Programs
- NSW Coastal Council
- Coastal and Estuary Grants Program.

Versions and updates: Resource No.1 — Climate Change and Sea Level Rise — The Science

Version 1	30 October 2016	Sample included in November 2016 FMA Quarterly Meeting Papers and uploaded to Members' Section of FMA website
Version 2	25 April 2018	All text and links reviewed and updated. Consolidated 'Other national organisations with expertise in science of Climate Change and Sea Level Rise'. Added link to NSW Stage 2 Coastal Management Reforms / Coastal Management Framework

FMA Online Resources Series

Flood Insurance Information

Resource No.2

Version 2. 28 October 2018

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Insurance Council of Australia

The Insurance Council of Australia (ICA) is the representative body of the general insurance industry in Australia. ICA members, which include both insurers and reinsurers, represent approximately 95 per cent of total premium income written by private sector general insurers. ICA members provide insurance products ranging from those usually purchased by individuals (such as home and contents insurance, travel insurance, motor vehicle insurance) to those purchased by small businesses and larger organisations (such as product and public liability insurance, professional indemnity insurance, commercial property, and directors and officers insurance).

Insurance Council of Australia — Data Globe

The ICA is working closely with all levels of government and consumers to help communities understand risks and work towards practical solutions. The ICA has initiated several programs to tackle the impacts of extreme weather and the availability of hazard data to help understand risk and develop a more sustainable response to managing catastrophes. One of these key projects is the ICA Data Globe.

The ICA Data Globe project coordinates insurance company access to an extensive database of natural hazard information, including flood, earthquake, bushfire, storm surge and cyclone exposures at an individual property level.

Though providing hazard data to insurers is an important step to assist with accurate risk calculation, the tool also helps to identify where hazard mapping is missing, or where mitigation efforts to reduce existing hazards may deliver an insurance affordability outcome for local residents.

Data collected by the ICA can be visualised in the Data Globe Hazard Mapping web browser at resolutions that allow identification of individual addresses.

Insurance Council of Australia — Catastrophe Database

The ICA Catastrophe Database commenced in 1967 and records insurance loss estimates for declared insurance catastrophe events across Australia. Up until about July 2018, a summary of the Catastrophe Database was available for download from the ICA Data Globe website.

Unfortunately access to the ICA Catastrophe Database has recently been restricted to member companies of the ICA, approved researchers and relevant bodies who support capital allocation and reinsurance processes.

Insurance Council of Australia — Understand Insurance Website

The Understand Insurance website practical information to find out more about insurance and make decisions that meet your needs. It looks at what insurers do, how insurance products work and why you might need insurance. It also explores understanding your risks, what to consider when choosing a product and an insurer, how to manage the cost of a premium and how to lodge a claim.

The website contains lots of downloads, glossaries, resources, fact sheets, tools and calculators.

The Insurance Explained page has some useful information with answers to questions such as 'What is general insurance?', 'How insurance can help you?', 'What do insurers do?', 'How insurance works' and information on different types of insurance. The 'Do you have enough insurance?' page has a good overview of underinsurance and non-insurance

Insurance Council of Australia — Property Resilience and Exposure Program (PREP)

The Insurance Council of Australia's Property Resilience Exposure Program (PREP) provides local government and the insurance industry with more robust information on the resilience of housing stock. It enables councils and shires to engage with the insurance industry on the issue of insurance affordability, where the primary drivers may be poor-quality hazard data, or a lack of information on development controls and existing buildings. PREP seeks to improve the alignment between the data and hazard mapping relied upon by insurers to price risk, and the information local governments harness for development control and town planning purposes.

PREP has four modules:

- Module 1 – existing hazard mapping provided by a participating local government that meets a minimum standard
- Module 2 – building survey data for all addresses, provided by a participating local government, that insurers can use to recognise the resilience many properties already have by virtue of existing development controls
- Module 3 – a resilience heat map provided by the PREP process for participating local governments. PREP will identify areas where properties are at greater risk than others (through poor design and building controls), and identify those that may require high-priority mitigation and intervention to reduce the potential impact of the hazard on that community.
- Module 4 – best-available hazard data and building information for underwriters. This improves their capacity to price risk at an individual address level, and to acknowledge the full benefit that local development controls and mitigation may have delivered in reducing property owners' vulnerability to extreme weather

NRMA Insurance — Information and Tools

In April 2018, NRMA Insurance made changes to cover relating to 'flood', 'rainwater run-off' and 'storm surge'. NRMA automatically provides cover for flood, rainwater run-off and storm surge and it is understood that prior to April 2018, NRMA did not cover for storm surge. The following definitions and information is provided from the NRMA website:

- ***flood*** — flood is the covering of normally dry land by water that has escaped or been released from the normal confines of a lake, river, creek or other natural watercourse (even if they've been modified) or any reservoir, canal or dam. Floods can occur when a long period of rain causes rivers, creeks and dams to overflow. This can affect large inland areas and spread over hundreds of kilometres. Although you may not have had rain in your area, a river can still break its banks because of heavy rain upstream.

- **rainwater run-off** — rainwater run-off is water that flows over the ground or backs up because of a storm. It can occur when a large amount of rain falls in a storm and causes drainage systems to fail, spilling water into nearby areas and damaging property. NRMA Insurance treats storm and rainwater run-off as separate events.
- ***storm surge*** — storm surge is an increase in sea level because of an intense storm or cyclone and associated waves. Storm surge does not include sea actions caused by normal tidal movements like high tides or king tides. NRMA Insurance also now covers for tsunami.

NRMA Insurance provides a similar tool to the ICA Data Globe, called 'Saferhomes' that provides 'low', 'medium', 'high' and 'no rating' for theft, home fire, water leaks and cyclone. Prior to around March 2018, risk levels for bushfire and flood were provided, but unfortunately, this information is no longer available via this tool.

FMA ICA Flood Insurance Fact Sheets

Floodplain Management Australia (FMA), together with the ICA, has prepared the following Flood Insurance Fact Sheets, which are available on the FMA website:

- Sharing Flood Risk Information with Insurers
- Flood Insurance Pricing
- Insurer Flood Data Requirements

In 2014, the FMA also prepared a flood insurance fact sheet template which can be used for community education purposes. The fact sheet templates, one for inland councils and one for coastal areas, can be tailored to suit individual requirements.

Versions and updates: Resource No.2 — Flood Insurance Information — Tools and Stats

Version 1	25 April 2018	Initial release as follow up to February 2018 FMA Quarterly Meeting Communication Director's Report
Version 2	28 October 2018	Web links checked. Access to ICA Catastrophe Database now restricted (no longer public access). Public access to ICA DataGlobe restored via new web link.

Local Government and Insurance

Flood Insurance Pricing

As of March 2015, more than 93% of home building and contents insurance policies contain flood cover as a standard inclusion. This is largely due to rapid improvements in access to flood information, as well as insurers' ability to understand and price the risk of flood damage to properties across Australia. Prior to 2007, information about flood risk in Australia was considered so poor that most insurers were unable to provide flood cover.

Things have changed. We now know approximately 15% of properties in Australia are at some risk of flooding. For these properties, insurers may charge an additional flood insurance premium in order to collect sufficient premiums to meet the cost of future claims as they arise.

Whilst all insurers approach premium calculation in different ways, this fact sheet outlines the common approaches and generic process followed.

General insurance pricing in Australia

General insurers take on their customers' risk, turning them into a 'policyholder', allowing them to manage the financial burden of damage resulting from a specific event such as a flood. Insurers identify and then manage the costs of these risks to make sure there is enough money coming in through premiums to pay claims.

Broadly speaking, general insurance in Australia is risk rated. In a risk rated insurance market, an insurer calculates the premium payable on the basis of various factors specific to an individual property, such as the likely frequency and size of a claim and the estimated value of such claims during the term of an insurance policy.

Why flood risk is assessed separately to other risks

For events such as house fire, earthquake and hail damage, the chance of an event occurring is fairly evenly distributed – neighbouring properties will have roughly the same risk of being affected by an event and making an insurance claim.

Flood risk is different – most properties in Australia have little or no risk of being flooded. While around 15% of properties in Australia have some level of flood risk, only 2-3% of properties have a high risk.

The minority of properties which are at high or extreme risk of flooding contribute disproportionately to the claims paid out by insurers, and are more likely to make repeated claims. To ensure they are able to continue offering flood insurance in a sustainable manner, insurers need to charge an additional flood insurance premium that reflects the level of flood risk at each property.

What is a 'flood'?

Since 2014, all home building, home contents, small business and strata insurance policies have adopted a common definition of "flood":

> *"The covering of normally dry land by water that has escaped or been released from the normal confines of any lake, or any river, creek or other natural watercourse, whether or not altered or modified; or any reservoir, canal, or dam."*

Events such as a ruptured hot water system, water entering through windows and eves during a storm, sea level rise and storm surge are not considered "flooding" for insurance purposes. These events may be covered under other elements of an insurance policy.

Consumers should always read their Product Disclosure Statement (PDS) when entering into an insurance contract, to understand which events are covered under their policy.

Factors that affect a flood premium

Flood insurance premiums generally reflect the level of flood risk at a property and the cost of repairing or rebuilding the property. In practice, this can be broken down to three factors which would be assessed by all insurers when setting a flood premium for a property:

- ✓ Likelihood of flooding;
- ✓ Expected depth of flooding relative to the insured building; and
- ✓ Expected cost of recovery.

Likelihood and depth of flooding are assessed at an individual address level, using results from computer flood modelling which simulates how water flows through a catchment. Expected cost of recovery includes repair, rebuild and replacement costs, temporary accommodation, and other factors such as the potential shortage of materials and labour after a flood event.

Some insurers may also consider property-specific information such as number of storeys, floor levels, building materials used and construction type

Information insurers use to assess the level of flood risk at a property level

Insurers prefer to use the highest quality flood modelling available - this usually means a local or state government flood study. Where government makes flood hazard data available to the industry, the raw data is:

- incorporated into the industry's National Flood Information Database (NFID) which provides an assessed depth of flooding (if any) for all addresses in Australia in a format usable by underwriters; and

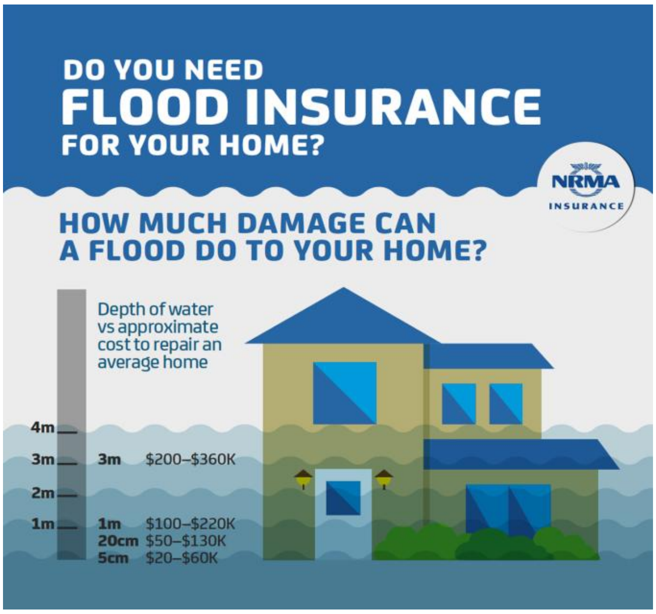
- shared with all participating insurers.

In areas where a government chooses not to share data with insurers or where government flood data is not available, insurers are often forced to refer to alternative sources of flood data including historical flood extents and non-government flood modelling datasets. You can read more about this in the ***Sharing Flood Risk Information*** fact sheet.

The cost of damage caused by floods

Flood damage can range from just ruining carpets and contents, to destroying entire kitchens, electrical wiring and even causing structural failure requiring a complete rebuild - the cost of recovering from even minor flooding can be surprisingly high.

The diagram below shows indicative costs to recover from floods of various depths, from one insurance company:



Flood insurance premiums are proportional to the flood risk at a property – this high cost of recovery can unfortunately result in high premiums in areas with a high likelihood of flooding.

Why insurers charge a flood premium for properties outside a Council's flood risk zone

Most local governments only apply planning controls in areas identified as 1-in-100-year flood zones (i.e. a 1% chance of flooding per year).

Flood insurance covers ALL flood events, including much larger (or less-likely) floods than the 1-in-100-year event. In some parts of Australia, extreme flood events can occur with depths 8-10m higher than the 1-in-100 year event, affecting properties well outside the 1-in-100-year flood zone.

In reality, if you live in a 1-in-100-year flood zone there is a 55% chance that you will experience a flood event larger than the 1-in-100-year flood within an 80-year lifetime. As insurers cover all flood events they have to take all flood risk into account when setting flood premiums, not just the flood risk up to the 1-in-100-year event.

Insurers do not assess flood risk based on postcodes

Flood hazard is very location-specific and insurers understand that it is not possible to make confident estimates of flood risk based on a postcode. To ensure that insurance premiums reflect the risk at each individual address, insurers have access to address-specific flood hazard data through the National Flood Information Database (NFID) and other sources.

Insurers don't include climate change or sea level rise in the cost of premiums

You may have seen media reports about projected sea-level rise or climate change scenarios leading to higher insurance premiums. This is a myth. Insurers are not covering risk in 25, 10 or 5 years time. They are covering the next 12 months from when a policy begins. This means insurers are interested in current risk and set premiums based on the current risk, not the risk under any projected future climate scenarios.

What to do if you think an insurer has assessed flood risk incorrectly

The insurance industry makes significant investments in sourcing the best quality up-to-date flood information. However insurers do not have access to all information relevant to every property. This is more likely for newer subdivisions which have been raised to reduce flood risk, for houses elevated on piers to reduce flood vulnerability, and for houses built on the high part of large rural blocks.

If you have evidence that an insurer has incorrectly assessed risk of flooding (e.g. a Council flood study, floor level survey, site-specific flood report or similar), please contact the insurer directly to discuss. Many major insurers have dedicated flood premium review processes in place and welcome information that helps improve the accuracy of their flood risk assessments. The Insurance Council of Australia (ICA) can also assist in reviewing information if an insurer cannot. Providing the insurer or ICA documentation will assist in this discussion.

It is also important to shop around if you are not satisfied by the premium or cover offered by your insurer.

Go to insurancecouncil.com.au or floods.org.au for further information including contact details.

Legislative Requirements (external links)

Office of Environment and Heritage - Coastal management manual

Office of Environment and Heritage - Floodplain development manual

NSW Planning and Environment - Coastal management

Additional Reading – Federal Government (external links)

Australia's 2030 Emissions Reduction Target

National Climate Resilience and Adaption Strategy 2015

Australian Government review of climate change policies 2017

Australia’s emissions projections 2018 - Summary fact sheet

Understanding climate change, Australian climate change research, Future Climate Change, Intergovernmental Panel on Climate Change

Australian climate change research

Future Climate Change

Intergovernmental Panel on Climate Change

Australia’s Changing Climate

Climate Change in Australia – East Coast Projections

Climate Change in Australia –Projections for Selected Australian Cities

Greenhouse Gas Scenarios – Representative Concentration Pathways

Additional Reading – NSW Government (external links)

Climate Change Policy Framework

Emissions in NSW Fact Sheet

Climate Change in NSW Fact Sheet

Climate Change NSW Snapshot

Climate Change Central Coast Snapshots

Central Coast Regional Plan

Additional Reading - CoastAdapt (external links)

CoastAdapt infographics

Understanding CoastAdapt inundation maps

Additional Reading - CSIRO (external links)

Oceans and climate change

Planning for sea-level rise

Strengthening Australia’s resilience to climate change

Adapting cities and coast for climate change

Additional Reading – Bureau of Meterology (external links)

Annual Climate Statement

Climate updates

Long-term temperature record

Climate change and variability

Extremes and records

Additional Reading – United Nations (external link)

Paris Agreement, 2015