dsquared

Department of Planning and Environment

Williamtown Special Activation Precinct

Climate Change Adaptation Plan

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01	18/06/2021	Draft for review	PD	JP
02	06/07/2021	100% Draft issue for comment	PD	JP
03	08/12/2021	Final draft issue	PD	JP
04	09/02/2022	Final draft exhibition issue	PD	JP
05	17/02/2022	Final issue	PD	JP

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Our mission is to reduce the impact on the environment of our client's actions by providing innovative solutions, challenging perceived thinking, and pushing the boundaries of achievement whilst using all resources in a sustainable way.

We confirm that all work has been undertaken in accordance with our ISO 9001 accredited quality management system.

Contents

This document comprises the Climate Change Adaptation Plan for the Williamtown Special Activation Precinct (SAP) and summarises the predicted local climate change scenarios and risks, and proposes mitigation measures for incorporation into the final SAP technical reports, Structure Plan and Delivery Plan. The following provides a summary of the main climate change projections and impacts:

There are a number of identified triggers for the development of this Plan:

- The significant capital investment required to construct new buildings and infrastructure and the need to ensure that they remain in safe efficient operation throughout their operating life, and for the SAP master plan development timeline which extends to 2061.
- The significant business and societal risk impacts as a result of climate change and the flow on impact on the health and productivity of business and the broader community.
- The need to ensure that future impacts on the environment are mitigated, and that the expected economic performance of the structure plan developments is not overly compromised by climate change impacts.

This Plan has been prepared in accordance with the Australian Greenhouse Office (AGO) guidance document: *Climate Change Impacts & Risk Management – A Guide for Business and Government*, *Climate Risk Ready NSW Guide* and guidance included within AS 5334:2013 *Climate Change Adaptation for Settlements and Infrastructure.*

Climate change projections used in this Plan are based on the NARCLiM 1.0 data available from the *Adapt NSW* website, published by the State of New South Wales, Department of Planning and Environment (DPE), the *CSIRO Climate Change In Australia (CCIA) Technical Report* 2015, and other sources relevant to the SAP. It should be noted that the NARCLiM projections have utilised the SRES A2 scenario which was identified as the most likely scenario at the time but differ slightly from the Representative Concentration Pathways (RCPs) incorporated into the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report*. However, SRES A2 projections follow a similar pathway to the RCP8.5 projections and at this time are recommended for climate change risk assessments.

It should also be noted that the upcoming NARCLiM 1.5 and 2.0 updates will change some of the climate projections once complete and may result in risk ratings changing. As a result, this Plan should be reviewed following the NARCLiM 1.5 and 2.0 updates to ensure the climate impacts and risk assessments are accurate.

The SAP development timeframe extends to 2061, at which point the SAP development program is expected to have reached a conclusion with the required economic growth having been achieved at a sustainable level. For the purposes of aligning the climate change risk assessment time frame with available climate change projection data, the following two milestones have been used:

- **Near-future (2020-39):** being at a point reaching mid-way in the SAP development timeline, coinciding with the milestone for the completion of a number of key infrastructure projects. It should be noted that many of these near future climate change projections have already been met, and in some cases exceeded, and therefore should already be incorporated into the design criteria of the SAP.
- **Far-future (2060-79):** being at the point closest to the ultimate conclusion of the SAP program.

The above climate change projections and timeframes have been incorporated into a climate change risk assessment which considers the likelihood and consequence of the identified climate change impacts. A climate change risk assessment workshop was held via Zoom on 9th June 2021 to review the future projected climate change risks and how they might impact on the Williamtown SAP. Stakeholders attending the workshop and contributing to the risk assessment included representatives of Regional Growth NSW, DPE, Regional Growth NSW Development Corporation (RGDC), Port Stephens Council, and technical consultants Aurecon and dsquared.

To facilitate the risk assessment and collate a record of the outcomes, a MURAL online collaboration board was developed, and workshop participants asked to complete the risk rating and add other issues or considerations related to existing or proposed mitigation strategies. The MURAL board was also left open to participants to add feedback and further comments for three weeks following the workshop. This ensured everyone had the opportunity to review the risks and provide comment.

The climate change risk assessment has highlighted the complex nature of the Williamtown SAP, with many of the risks resulting in high or extreme impacts unless adequate mitigation measures are implemented.

Throughout the development of the Structure Plan and Master Plan, and during the stakeholder engagement undertaken to develop this Climate Change Adaptation Plan, it is clear that the climate change mitigation measures will only be followed through into action if there is a clear, strong, and fully funded governance structure in place. The over-arching recommendation is that a formalised governance structure is in place, with supporting policy, planning and operational legislative requirements, monitoring and reporting mechanisms facilitating the implementation of the Climate Change Adaptation Plan. The governance structure will require membership and investment from multiple agencies and businesses to be successful.

In order to assist with providing some focus for the Delivery Plan development, DPE have requested a summary of the top climate change impacts resulting from this risk assessment. These are summarised as follows with key measures identified for the Master Plan, Delivery Plan and Governance Structure.

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
Temperature increase and increased hot days	Increase of 2.0 to 2.5°C 12 to 32 days above 35°C	1. Increased building energy use for cooling. 2. Increased heat island in public spaces and around developed/ industrial areas. 3. Rising utility infrastructure demand (electricity and water). 4. Heat stress for the community population, including workforce, residents and visitors (relative heat wave impacts).	**Master Plan:** The final Master Plan incorporates infrastructure and public realm designs that are resilient to increasing temperatures, including smart and integrated utility infrastructure that captures, stores and shares excess energy and water (e.g. rainwater/stormwater harvesting and reuse and energy storage), increased landscaping, vegetation and tree canopy cover, and areas of respite for employees, the community and visitors (both internal and external areas). **Delivery Plan:** The Delivery Plan incorporates provisions to improve utility network capacity, resilience of buildings and infrastructure, passive design, minimum energy and water efficiency standards, renewable energy and energy storage provisions, alternative water supplies, landscaping and vegetation and materials that decrease urban heat island effect.

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
		5. Reduced reliability and functionality of infrastructure services including roads/rails, public buildings, and electricity supply.	**Governance:** The SAP governance structure incorporates operational responses and monitoring to ensure that the mitigation measures are effective, in particular a community resilience plan for heat stress and to monitor utility infrastructure reliability. This could be captured as part of an ISO 14001 Environmental Management System (EMS) with the UNIDO Eco-Industrial Park (EIP) Framework embedded which includes provisions for ongoing monitoring and KPIs.
Increased rainfall intensity	1.0-2.0m flood depths during 1% AEP event	1. Increased frequency and intensity of extreme rainfall events impact on flood levels causing damage to buildings and road infrastructure. 2. Increased waterway and catchment area flooding impacting stormwater management systems by decreasing their drainage capacity and effectiveness. 3. Increased risk of PFAS mobilisation including infiltration of ground water.	**Master Plan:** The final Master Plan incorporates increased rainfall intensity and flood levels as part of major infrastructure designs and development areas, with stormwater management systems and drainage designed to mitigate flooding, and reduce erosion and stormwater pollution, both within the Williamtown SAP and to surrounding properties. Based on the Final Structure Plan which incorporates local and regional flood paths, drainage pathways and flood mitigation areas it is expected that this risk will be mitigated, however it is essential that this is carried forward into the Master Plan, Delivery Plan and associated enabling infrastructure works. **Delivery Plan:** The Delivery Plan incorporates provisions for the SAP and developments to reduce stormwater flow, erosion and pollution including Water Sensitive Urban Design (WSUD), onsite rainwater/stormwater harvesting and reuse and increased permeable surfaces and landscaping, while ensuring any onsite reuse is cognisant of PFAS contamination. This should be incorporated into an integrated water cycle with onsite systems interconnected with precinct stormwater management systems and drainage. **Governance:** The Governance structure incorporates ongoing PFAS monitoring and remediation. As per the above an ISO 14001 EMS + UNIDO EIP Framework approach will assist in ensuring a monitoring and improvement program is in place.

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
Sea Level Rise (SLR)	0.77m SLR	1. Higher inundation risk of built infrastructure including roads, buildings, utility infrastructure and community services. 2. Increased risk for coastal erosion due to higher sea level and expected increase in frequency and intensity of storm surges. 3. Increased risk of PFAS mobilisation and widespread contamination.	**Master Plan:** The final Master Plan incorporates sea level rise projections in the planning of infrastructure, with critical and major infrastructure and emergency access roads located outside of or raised above tidal inundation levels. Due to coastal adaptation and existing levees falling outside of the SAP boundary and responsibility, this should be developed cognisant of any improvements that may be implemented outside of the SAP to reduce this risk. **Delivery Plan:** It is expected that the above provisions in the Master Plan will mitigate the majority of this risk with inundation levels used to inform site levels and zoning, however longer-term projections may pose a greater risk and become an operational risk. The Delivery Plan should also incorporate provisions that ensure development does not occur in flood areas at risk of tidal inundation. In addition, any changes to the Master Plan and Delivery Plan design as part of the enabling works must fully consider the climate change risks. **Governance:** The Governance structure incorporates a collaborative model for understanding and planning for sea level rise and associated impacts that may pose a risk to the SAP, but are outside of the SAP's boundary and control.
Increased bushfire risk/intensity	1 to 2 days increase in extreme fire weather days per annum, occurring in spring and summer.	1. Bushfire season expected to start earlier and extend into prescribed burning season (spring). 2. Increased risk ratings and fire life safety standards for new and replaced infrastructure. 3. Damage/loss of utility infrastructure (electricity, water pumping stations, telecommunications).	**Master Plan:** The Master Plan incorporates adequate bushfire buffer zones and emergency access and evacuation routes, and ensures critical infrastructure (e.g. utility infrastructure) is located in lower bushfire risk areas. **Delivery Plan:** The Delivery Plan incorporates improved building standards including increased bushfire risk ratings, and increased air filtration for mechanical ventilation and air tightness testing for critical services (healthcare, emergency services).

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
		4. Disruption to transport and evacuation routes due to road closures. 5. Impact on airport operations due to reduced visibility, ash, and direct flame impact on runway operations. 6. Loss of biodiversity and threatened species (particularly in Environmental Protection Area). 7. Bushfire smoke inundation due to increase in potential frequency/ intensity	**Governance:** The SAP governance structure incorporates operational responses and monitoring to ensure that the mitigation measures are effective, in particular for heat stress and to monitor utility infrastructure reliability. This could be captured as part of an ISO 14001 EMS with the UNIDO Eco-Industrial Park (EIP) Framework embedded which includes provisions for ongoing monitoring and KPIs. In addition, the EMS could drive environmental improvement programs such as the monitoring and improving biodiversity outcomes.
Loss of biodiversity		1. Migration or loss of species that are unable to cope with increasing temperature. 2. Increased invasive weed and pest animals competing with native flora and fauna. 3. Increased risk of severe bushfire events.	**Master Plan:** The Master Plan maintains and supports existing biodiversity in the Environmental Protection Area and wildlife corridors, and incorporates quality landscaped outdoor areas that support increased vegetation and biodiversity, cognisant of bushfire risk. **Delivery Plan:** The Delivery Plan incorporates minimum requirements for landscaping and vegetation for new developments and the design guidelines incorporate landscaping and planting guides that support local biodiversity. A biodiversity and natural habitat management plan is developed, either as part of the Delivery Plan or as an outcome of the Delivery Plan. **Governance:** The SAP governance structure incorporates provisions for biodiversity monitoring and improvement. The biodiversity and natural habitat management plan could be captured as part of the ISO 14001 EMS and associated environmental improvement programs.

Detailed risk assessment and mitigation measure schedules are provided in Sections 4 and 5 of this report.

The risk assessment and review process has identified a series of mitigation measures that will need to be implemented in order to reduce the risk impact resulting from climate change. A number of these mitigation measures require a review of the draft Structure Plan, a review of the measures by the Structure Team Technical Consultants, and may result in a change or input to the finalised Master Plan document, subject the results of these further reviews. These are scheduled in Section 6 of this report.

The mitigation measures may also require further analysis, including cost-benefit analyses and more detailed design investigations, to confirm if they are adequate in reducing the residual risk level.

The ongoing development of the SAP and the initiation of all new supporting infrastructure projects and investor led projects, will be driven by the SAP Delivery Plan. The Delivery Plan will reference a series of supporting documents which may include but may not necessarily be limited to:

- Design and Development standards and guidelines;
- Performance targets to be achieved including energy, water, waste, and environmental protection;
- Planning Rules including a new SAP SEPP, Port Stephens Council LEPs; and
- A SAP Environmental Management System (EMS) framework.

The Delivery Plan is due to be prepared following the release of the Master Plan and we reinforce the importance of ensuring that climate change risks and mitigation measures are fully recognised within it. The requirements for inclusion in the Delivery Plan are scheduled in Section 7 of this report. This includes ongoing reviews of the climate change risks and impacts in the event any changes are made to the development areas and as new data or projections become available.

1 Introduction

1.1 Introduction

The Department of Planning and Environment (DPE, or the Department) has appointed dsquared to establish Climate Change Risk Assessment and Adaptation considerations to embed into the Special Activation Precinct Master Plans and Delivery Plans (prepared by Regional Growth Development Corporation NSW), for the Williamtown Special Activation Precinct (SAP).

The objectives of this appointment are to:

- ensure there is an understanding and consideration of climate change risks and adaptation considerations within the Williamtown SAP, Activation Precinct SEPP, and Master Plan;
- identify and assess climate change risks to the Williamtown SAP and local government area (LGA) including the impact of these risks on natural and built assets and future development scenarios, insofar as they impact on the SAP developable areas;
- initiate consultation with key stakeholders to develop a greater understanding and consideration of climate change risk and adaptation opportunities for each of the Williamtown SAP developable areas;
- develop a robust Climate Change Risk Assessment for the Williamtown SAP consistent with DPE's Guide to Climate Change Risk Assessment for NSW Local Government (2019); and
- develop adaptation considerations for integration into the Williamtown SAP consistent with the OEH Checklist for best practice adaptation planning and implementation (2013).

This Climate Change Adaptation Plan has been developed based on the technical studies, the outcomes of the Enquiry by Design (EbD) workshop in February 2021 and the final draft structure plan and focusses on climate change related impacts for the entire Williamtown SAP boundary. As a result, some of the identified risks and mitigation measures may not be applicable, however are intended to guide the development of the Master Plan.

This document comprises the Climate Change Adaptation Plan for the Williamtown Special Activation Precinct (SAP) and summarises the established local climate change scenario projections and risks, and proposes mitigation measures (if required) for incorporation into final SAP technical reports, structure plan, and master plan.

dsquared would like to acknowledge the invaluable input of multiple technical consultants and stakeholders who participated in the workshop and contributed to the MURAL board.

1.2 Scope

The scope of this assessment is the Williamtown Special Activation Precinct located within the Port Stephens Local Government Area (LGA), approximately 14 kilometres north-east of Newcastle CBD and forms part of the lower Hunter region. The final Structure Plan is outlined below (refer Figure 1).

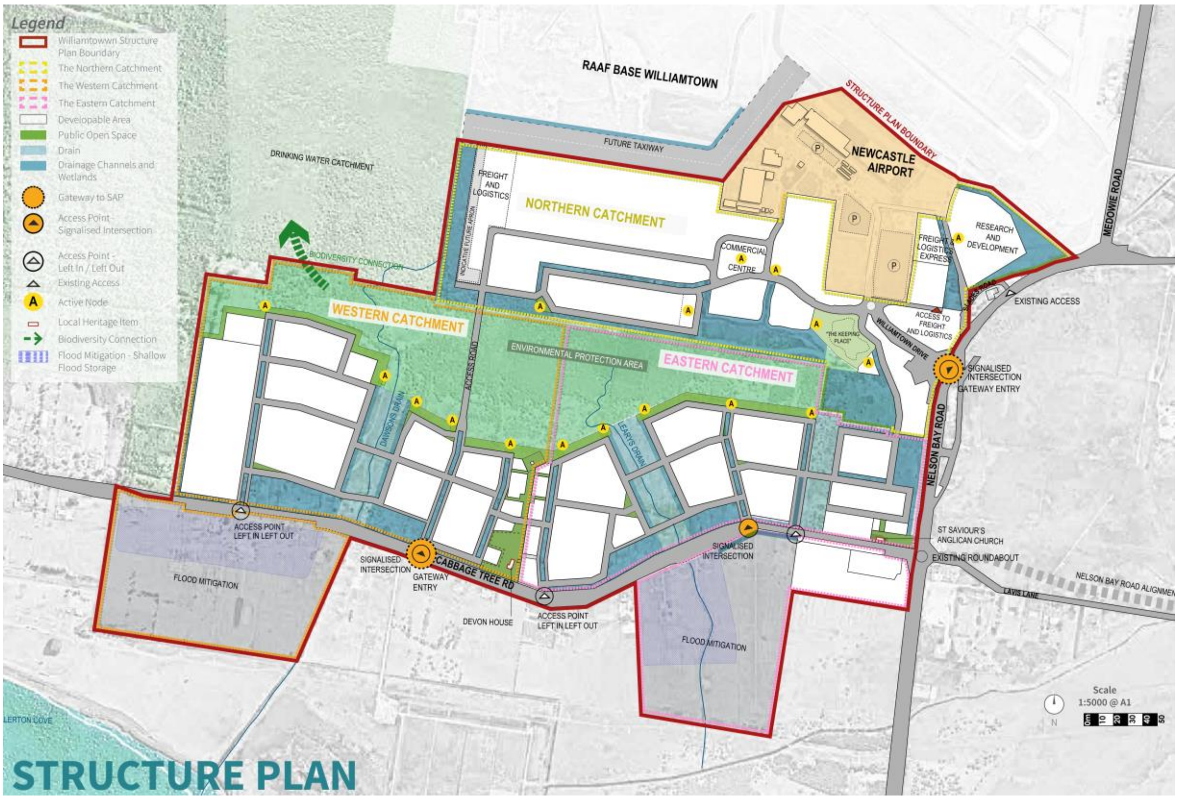


Figure 1: Williamtown SAP Structure Plan

It should be noted that this plan investigates the impacts of climate change on the wider Study Area, proposed precinct boundary in the Structure Plan and on crucial infrastructure (e.g. roads, utilities) that serves the Williamtown SAP. This is outlined in the below plan (refer Figure 2) which outlines the original Study Area (Boundary 1) and wider context (Boundary 2).

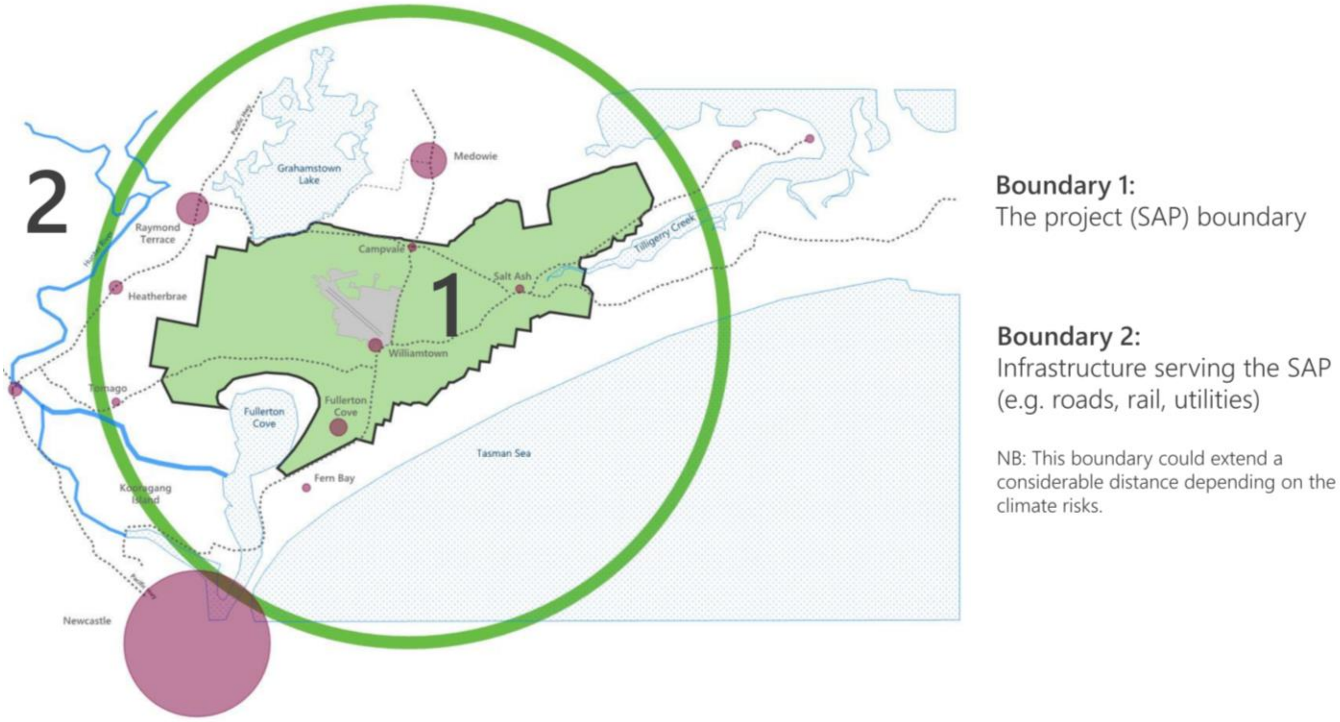


Figure 2: Scope Boundary and Williamtown SAP Study Area. Source: dsquared

1.3 Methodology

This Plan has been prepared in accordance with the Australian Greenhouse Office (AGO) guidance document AS 5334:2013 *Climate Change Adaptation for Settlements and Infrastructure* following the workflow as shown in Figure 3.

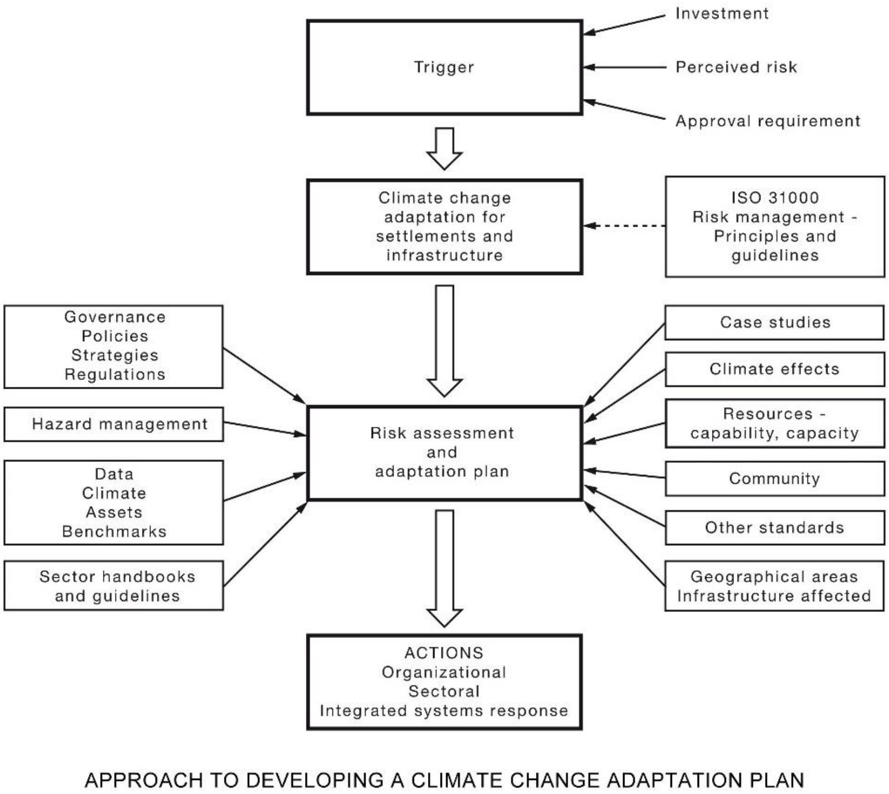


Figure 3: AS 5334:2013 Climate Change Adaption Plan Approach

The climate change risk assessment of this Plan is aligned with the five-step process as outlined in the AGO Guide (refer Figure 4) and AS/NSZ 2018 Standard and adopted by the State of NSW and Office of Environment and Heritage (OEH) *Guide to Climate Change Risk Assessment for NSW Local Government 2011* to identify and evaluate the risks of climate change to council assets, its operations and provided services.

Figure 4: Steps in the risk management process. Source: AGO

It allows organisations to prioritise risks and develop mitigating strategies as basis for decision-making and planning, and to implement risk managing initiatives which enhance their resilience against the challenges of climate change.

The methodology used to translate this workflow into a CCAP is summarised as follows.

Table 1: Methodology

<table>
<tr><td>Inception</td></tr>
<tr><td>Hold an inception meeting facilitated using Zoom to:
• confirm project objectives, methodology and milestones;
• agree workshop structure and time;
• agree risk categories suitable to the Special Activation Precinct and responsible stakeholders; and
• discuss workshop attendees.
Receive all current technical and structure plan teams reports and a briefing on the SAP, so that SAP-specific methodologies and programmes can be drafted for discussion.</td></tr>
<tr><td>Desktop Analysis</td></tr>
<tr><td>Undertake a desktop analysis comprising:
• benchmarking of existing risk frameworks and plans for similar projects to enable successful facilitation of a risk workshop and context for the integration of adaptation considerations;
• review and consideration of technical reports prepared for the SAP to estimate the impacts of climate change and integration into the climate change snapshot and risk assessment processes;
• undertake a gap analysis to determine if additional work by the SAP project teams will be necessary to support the climate change risk assessment;
• review and collation of climate change data and risks to provide Snapshots of key projections for the SAP. The Climate Risks considered will include:
▪ Climate (including large-scale climate patterns e.g., El Niño)
▪ Temperature (including hot days/ cold nights);
▪ Rainfall (including frequency/ intensity);
▪ Flooding;
▪ Bushfire (including bushfire smoke inundation)
▪ Solar Radiation;
▪ Wind;
▪ Humidity;
▪ Evapotranspiration;
▪ Biodiversity; and
Undertake all risk assessments cognisant of:
▪ AS ISO 31000:2018.
▪ NARCLIM 1.0 Climate Projections.</td></tr>
</table>

- NSW Government Asset Management Policy TPP 19-07.

- mapping and/or visual representation of key climate change risks within the SAP.

Risk Assessment
Undertake a risk assessment comprising: • preparing a Risk Matrix for review by the Department and use during the workshop; • preparing a brief summary report containing relevant information to enable participants to contribute effectively to a Risk Assessment workshop; • conducting an online climate change risk assessment with a multidisciplinary stakeholder group within an agreed risk management framework. The presentations will be provided via Zoom with the ability to directly capture stakeholder feedback via an online system called Mural. • prepare the findings of the risk workshop in a brief report including a Risk Register, key themes and Top 5 risks for the Special Activation Precinct; and • presenting these findings to the Special Activation Precinct team and other relevant stakeholders. Risk assessments should be consistent with Australian and New Zealand Standard for Risk Management, AS/NZS 4360:2004 and Australian Greenhouse Office's (2006) Climate change impact and risk management - A guide for business and government.
Adaptation Action Integration
Adaptation actions are then considered and integrated into the SAP Technical Studies, Structure Plan, and Delivery Plan, as follows: • prepare Adaptation considerations which identify options to embed the consideration of climate change within the Special Activation Precinct framework including the Master Plan and/or Delivery Plan; • adaptation considerations prepared for input into a Master Plan should recommend Performance Criteria with associated targets. Consideration should be given to alignment with any existing performance criteria where a working document is available; and • adaptation considerations prepared for input into a Delivery Plan should recommend Performance Measures. Consideration should be given to alignment with any existing performance measures where a working or final document is available. Recommendations should be separated by discipline to ease their integration into technical consultant reports, and the delivery plans. Recommendations and targets should be aligned with any known SEPP, Delivery Plan, Sustainability Plan, EMS, or other frameworks either known or to be developed.

1.4 Identified triggers

There are a number of identified triggers for the development of this Plan:

- the significant capital investment required to construct new buildings and infrastructure and the need to ensure that they remain in safe efficient operation throughout their operating life, and for the SAP master plan development timeline which extends to 2060;
- the significant business and societal risk impacts as a result of climate change and the flow on impact on the health and productivity of business and the broader community; and
- the need to ensure that future impacts on the environment are mitigated, and that the expected economic performance of the structure plan developments is not overly compromised by climate change impacts.

1.5 Time frame for risk assessment

Available climate change modelling consistently uses averages forecast over 20-year time periods, commonly 2030 (2020-2039), 2050 (2040-2059), 2070 (2060-2079), and 2090 (2080-2099), although a number of studies include other timeframes and milestones.

Climate change projections are generally modelled from a reference period of 1986 to 2005, with the CSIRO projections based on a slightly longer reference period spanning 1981 to 2010.

The SAP development timeframe extends to 2056, at which point the SAP program development program is expected to have reached a conclusion with the required economic growth having been achieved at a sustainable level. For the purposes of aligning the climate change risk assessment time frame with available climate change projection data, the following two milestones will be used:

- 2030: being at a point reaching mid-way in the SAP development timeline, coinciding with the milestone for the completion of a number of key infrastructure projects; and
- 2070: being at the point closest to the ultimate conclusion of the SAP program.

However, some climate change risks require the consideration of longer timeframes to make current decisions on the development and management of mitigating strategies including, and particularly, for critical infrastructure.

Flooding - The 2007 DECC Guide for the practical consideration of climate change in floodplain risk management (FRM) assists local NSW councils in the preparation and implementation of their FRM plans. The guidelines are based on a 2090-2100 timeframe for sea-level-rise and 2070 timeframe for rainfall intensities. Note that most sensitivity analysis use a combination of sea-level-rise ARI events and flood producing rainfall ARI events.

1.6 Global emissions scenarios

The rate and extent of future climate change impacts will be directly proportional to the actual change in atmospheric greenhouse gases. Because of the variability in modelling accuracy, climate change projections are typically based on a range of greenhouse gas intensity scenarios called Representative Concentration Pathways, or RCPs which are part of the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report*. The four commonly referenced RCPs range from aspirational (RCP2.6) through intermediate (RCP4.5 and RCP6.0) to very high (RCP8.5).

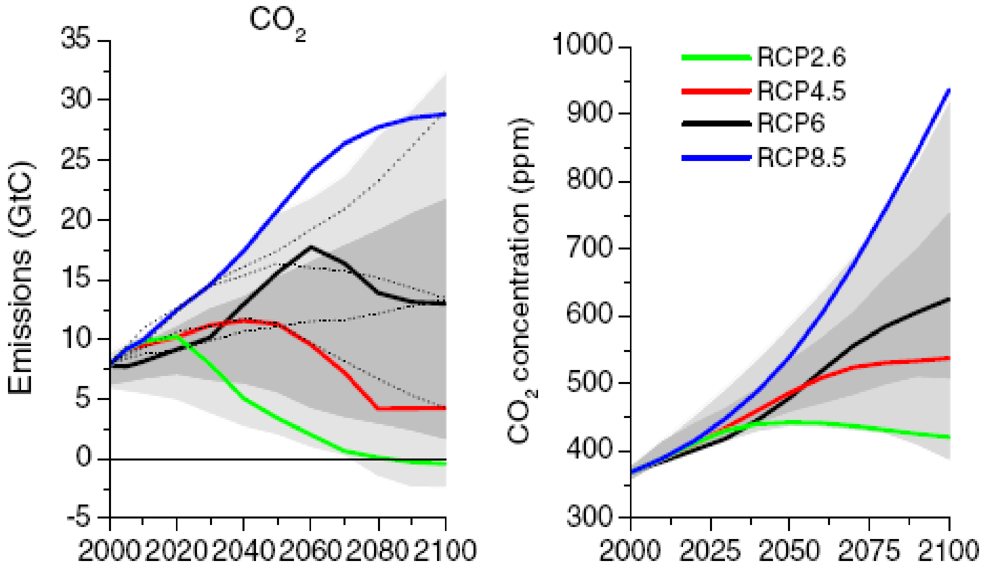


Figure 5: Summary of carbon dioxide level scenarios (RCPs)

The majority of the climate change projections used in this Plan are based on the NARCLiM 1.0 data available from the *Adapt NSW* website, published by the State of New South Wales, Department of Planning and Environment (DPE). It should be noted that the NARCLiM projections have utilised the SRES A2 scenario which was identified as the most likely scenario at the time but differ slightly from the RCPs from the IPCC *Fifth Assessment Report*. However, SRES A2 projections follow a similar pathway to the RCP8.5 projections and at this time are recommended for climate change risk assessments.

It should be noted that the upcoming NARCLiM 1.5 and 2.0 updates will change some of the climate projections once complete and may result in risk ratings changing. As a result, this Plan should be reviewed following the NARCLiM 1.5 and 2.0 updates to ensure the climate impacts and risk assessments are accurate.

The below provides a summary of the RCPs for further information:

- RCP2.6 is an emissions pathway which is required to meet the maximum 2.0°C temperature limit under the Paris Agreement. It is considered to be too conservative, with many of the projections already having been reached (meaning, emissions are already exceeding this pathway);
- RCP4.5 is an intermediate pathway with emissions peaking earlier than the RCP6.0 model (around 2040) and CO_2 concentration reaching 540 ppm by 2100. However, in this scenario, emission reduction measures are not sufficient to meet the Paris Agreement target of limiting mean surface temperature increases to 2°C or lower by 2100 (projected to reach over 2.4°C). This scenario is considered to be possible to occur in the event of current policy commitments are achieved and there is an increase in emission reduction measures however under current emission projections this pathway is not being achieved; and
- RCP8.5 is referred to as a business-as-usual (BAU) pathway under NSW Government guidelines and is to be included in a risk assessment as the projected scenario, with CO_2 concentrations continuing to rapidly rise, reaching 940 ppm by 2100. There is a large difference between RCP4.5 and RCP8.5 and so it is important to consider this in the context of the anticipated building and infrastructure life.

1.7 Sources of information

The following sources of information have been used in developing this Plan:

- Final Structure Plan – Issued 12th November 2021
- NARCliM (NSW/ACT Regional Climate modelling in conjunction with University of NSW);
- New South Wales – Climate change snapshot, published 2014 by NSW Office of Environment and Heritage;
- Climate Change in Australia Technical Report 2015, published by the NRM and CSIRO;
- Climate Change in Australia, Projections Cluster Trend Pamphlet – East Coast, published 2015 by CSIRO and BOM;
- CSIRO State of the Climate 2018;
- CSIRO State of the Climate 2020;
- CSIRO Climate Change In Australia (CCIA) Website, Climate Change Calculator and Data Set Viewers. http://www.climatechangeinaustralia.gov.au;
- Bureau of Meteorology (BOM) Database;
- Fact Sheet: Climate Change in NSW, NSW Office of Environment and Heritage;
- Williamtown Salt Ash Floodplain Risk Management Study and Plan, published September 2017 by BMT;
- Floodplain Risk Management Guideline - Practical Consideration of Climate Change (DECC Guideline 2007), published October 2007 by the NSW Department of Environment and Climate Change;
- Floodplain Risk Management Guide, published 2018 by NSW Office of Environment and Heritage;
- NSW Climate Impact Profile, published 2010 by NSW Department of Environment, Climate Change & Water;
- Australian Rainfall & Runoff – A Guide to Flood Estimation, published 2019 by Commonwealth of Australia (Geoscience Australia)
- Priorities for Biodiversity Adaptation to Climate Change, published 2010 by NSW Department of Environment, Climate Change and Water (DECCW)
- Online Air Quality Data Service, NSW Department for Planning, Industry and Environment https://www.dpie.nsw.gov.au/air-quality/air-quality-data-services/data-download-facility; and
- CoastAdapt online service
- Technical Reports prepared by the Williamtown SAP Structure Plan team, including:
  - Planning Analysis Options_Final, prepared by Mecone
  - Social Infrastructure Needs and Options Analysis Report_Final, prepared by Cred
  - Sustainability Options Final, prepared by Umwelt
  - Final Utilities Infrastructure Scenarios Report, prepared by Aurecon
  - PFAS and non-PFAS Contamination Scenarios Final Report, prepared by Aurecon
  - Traffic and Transport Scenarios Report Rev1, prepared by Aurecon
  - Final Flooding and Water Cycle Management Scenarios Report, prepared by Aurecon
  - Hydrogeology Scenarios Final Report, prepared by Aurecon

- Final Geotechnical Scenarios Report, prepared by Aurecon
- Final Aeronautical Limitations & Bird Strike Scenario Report, prepared by Aurecon
- Final Renewable Energy Scenario Report, prepared by Aurecon
- Bushfire Scenario Analysis_Final, prepared by ERM
- Biodiversity Scenario Analysis_Final, prepared by ERM
- Noise Scenario Analysis_Final, prepared by ERM
- Scenarios Heritage Assessment_Final, prepared by ERM
- Economics Scenarios Report v2.0b, prepared by Deloitte
- Social Infrastructure Report_Draft, prepared by Cred
- Sustainability Draft Report, prepared by Umwelt
- Utilities Infrastructure Report_Draft, prepared by Aurecon
- Traffic and Transport Draft Report, prepared by Aurecon
- Geotechnical Report, prepared by Aurecon
- Aeronautical Limitations & Bird Strike Scenario Report_Draft, prepared by Aurecon
- Renewable Energy Report V0 Draft, prepared by Aurecon
- Air Quality Report_Draft, prepared by ERM
- Bushfire Assessment Report Draft, prepared by ERM
- Heritage Assessment Report_Draft, prepared by ERM
- Noise Assessment Report_Draft, prepared by ERM
- Market Sounding and Economics Report v1.4, prepared by Deloitte

1.8 Stakeholder engagement

A climate change risk assessment workshop was held via Zoom on 19th May 2021 to review the future projected climate change risks and how they might impact on the Williamtown Special Activation Precinct. A MURAL board was developed, and workshop participants shared issues and considerations related to the risk assessment process, both to this MURAL board and also verbally.

Workshop participants and MURAL risk assessment contributors included:

- Caitlin Elliot, DPE
- Amanda Silver, DPE
- Melinda Hillery, DPE, Senior Project Officer, Climate Resilience and Net Zero Emissions Branch
- Ryan Falkenmire, Port Stephens Council
- Jess Morris, Port Stephens Council
- Alan Bawden, Rural Fire Service (RFS)
- Joanne Woodhouse, Environmental Resources Management (ERM)
- Jane Jackson, Meridian Urban
- Yannick Michel, Aurecon
- Greg Lee, Aurecon
- Kai Neville, Umwelt

Following the Climate Change Risk Assessment Workshop, a review of the identified climate impacts was undertaken and consolidated into a climate risk assessment table captured in Section 4 and 5 of this report.

1.9 Plan Author

The report has been prepared by Jacob Potter, Senior ESD Consultant at consultancy firm dsquared.

Jacob is a passionate ESD and Sustainability Consultant with extensive experience in energy, resource and carbon management in both public and private sectors.

Qualifications and accreditations include a Master of Sustainable Design, Bachelor of Architectural Studies, Graduate Certificate, Energy and Resources – Policy and Practice, Green Star Accredited Professional (Design & As-Built and Performance) and WELL Accredited Professional.

Jacob has extensive experience in climate change risk assessment and adaptation planning in Australia, including working on Regional Climate Adaptation Plans for the South Australian (SA) Government, developing climate risk assessments for the NSW Government Special Activation Precinct (SAP) projects, undertaking infrastructure climate risk assessments for the SA Department for Education and developing Climate Change Adaptation Plans for projects across South Australia.

dsquared is a Certified Carbon Neutral company and appointed in 2019 as Carbon Neutral Adelaide Ambassadors and operates under an accredited ISO 14001 Environmental Management System.

2 Site Information

2.1 Location

The Williamtown SAP is located within the Port Stephens Local Government Area (refer Figure 6), approximately 14 kilometres north-east of Newcastle CBD and forms part of the lower Hunter region. The below outlines the Williamtown SAP Study Area in the context of the Port Stephens LGA (refer Figure 6), and the Study Area with surrounding towns and infrastructure (refer Figure 7).

Figure 6: Williamtown SAP Study Area in context. Source: Google/Dsquared

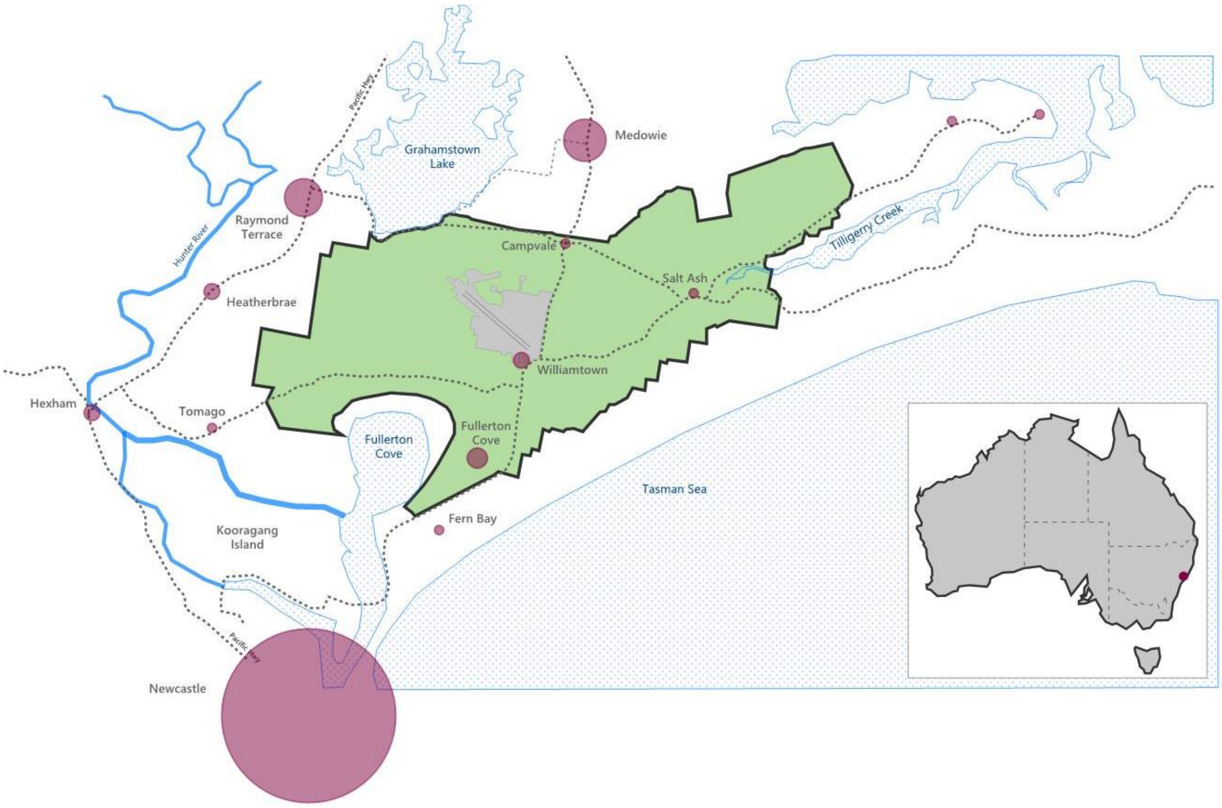


Figure 7: Williamtown SAP Study Area in context;. Source: dsquared

To obtain the most relevant data for future climate change projections, the investigated area has been identified to form parts of the following climate regions/ clusters:

- NARCliM Hunter region
- CSIRO cluster East Coast and sub-cluster South

2.2 Final Structure Plan

Following detailed technical studies being undertaken, a final Structure Plan (refer Figure 8) has been developed which outlines the final SAP boundary and development areas. The below provides an illustrative summary of the final Structure Plan which incorporates approximately 137 hectares of developable area with an additional 64 hectares of drainage to the South of Cabbage Tree Road.

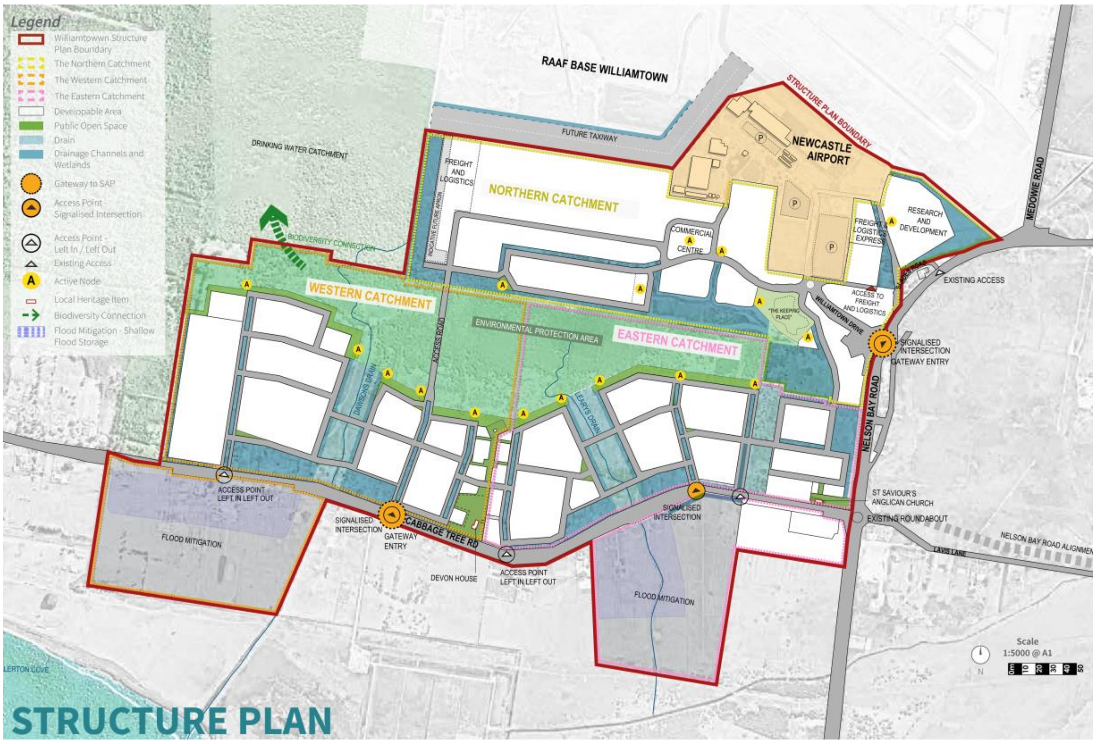


Figure 8: Final Williamtown SAP Structure Plan

2.2.1 Hunter Region

The Williamtown SAP is located in the Hunter region which covers an area of approximately 26,100km² and extends from west of Murrurundi and Merriwa to Newcastle on the NSW east coast. The Hunter River is flowing 460km from its headwaters in the Barrington Tops to the Tasman Sea at Newcastle.

The Hunter Region is one of twelve climate regions defined by the NSW and ACT Regional Climate Model (NARCliM) to provide high resolution climate change projections and assist with strategic planning initiatives across NSW.

The 12 models under the IPCC high emission scenario (RCP8.5) run by NARCliM have produced datasets for three time periods, whereby the modelled data for the period from 1990 to 2009 serves as baseline for climate change projections for the near future (2020 to 2039) and far future (2060 to 2079). The datasets for the most commonly used variables are available via the Adapt NSW website.

Figure 9: Williamtown SAP location in context; Hunter Region. Source: OEH (edited)

2.2.2 East Coast (South)

The Williamtown SAP is also located in the CSIRO Climate Change sub-cluster defined as "East Coast (South)" (refer Figure 10 and Figure 11). The East Coast cluster comprises NRM regions in the southern central part of the eastern seaboard of Australia. The predominantly sub-tropical climate regionally varies across the East Coast cluster with some tropical influences in the north and temperate in the south, and generally cooler climate along the coastline compared to the regions' backcountry.

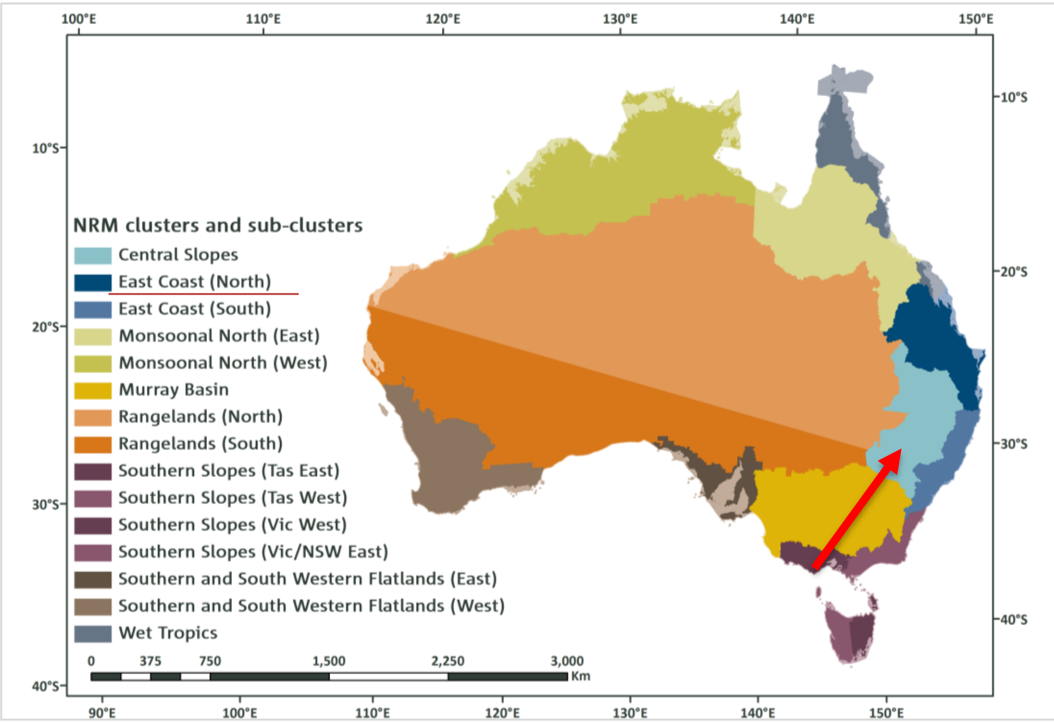


Figure 10: CSIRO Climate Change Regions Map. Source: CCIA Technical Report 2015

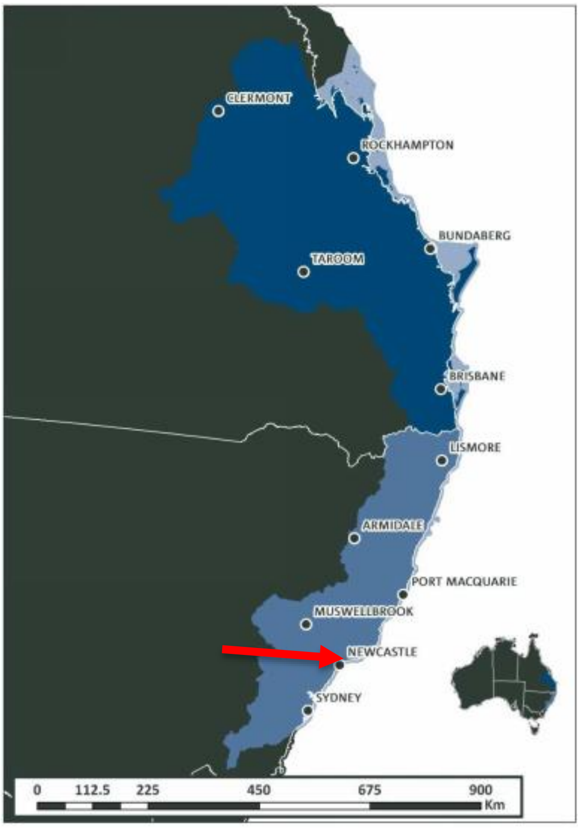


Figure 11: CSIRO Climate Change Regions Map – East Coast. Source: CSIRO

2.3 Climate

The climate of the Hunter region is sub-tropical to temperate with distinct seasonal variations in temperature that become lesser closer to the coast. Rainfall varies across the region with more than 1,100mm per year near the coast and less than 600mm in parts of the upper Hunter.

The most representative weather station with long-term observation data within the Williamtown SAP is located at the RAAF airbase. Climate data has therefore been sourced from the Bureau of Meteorology (BOM) Williamtown RAAF weather station (#061078) (refer Figure 12).

The annual mean temperatures range from a high of 28.3°C in January to a low of 17.2°C in July (1942-2021), providing the area with moderate to warm temperatures all-year round.

Temperatures in summer and autumn are typically warm with the highest average rainfall occurring from January to June. Springs and winters are mild and have on average 25 to 50% less average rainfall.

For the period from January to May, the average monthly rainfall varies between 99.5 mm in January and 125.2 mm in March. It peaks to 124.6 mm in June before dropping by approximately 40% to around 72.6 mm in July. Until December rainfall varies around an average of 75 mm ranging from as low as 60.1 mm in September to 81.6 mm in November.

Mean humidity for the region is 73%, ranging from a daytime low of 64% in October to a high of 80% in June.

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years		Plot	Map
Temperature																	
Mean maximum temperature (°C)	28.3	27.7	26.3	23.8	20.4	17.7	17.2	18.8	21.5	23.8	25.6	27.4	23.2	71	1942 2021		
Mean minimum temperature (°C)	18.2	18.1	16.4	13.2	10.1	8.0	6.4	6.9	9.1	12.0	14.4	16.6	12.4	71	1942 2021		
Rainfall																	
Mean rainfall (mm)	99.5	118.3	125.2	109.3	108.6	124.6	72.6	72.8	60.1	75.9	81.6	78.6	1121.5	70	1942 2021		
Decile 5 (median) rainfall (mm)	76.8	95.6	110.6	90.7	94.4	103.1	55.6	55.3	49.8	57.4	78.3	61.8	1087.9	68	1942 2021		
Mean number of days of rain ≥ 1 mm	7.1	7.4	8.3	7.5	7.7	8.4	6.4	6.1	5.6	7.2	7.2	7.1	86.0	68	1942 2021		
Other daily elements																	
Mean daily sunshine (hours)	7.4	7.2	7.0	6.9	6.1	5.6	6.4	7.5	7.7	7.6	7.6	7.7	7.1	59	1957 2016		
Mean number of clear days	7.3	5.7	7.5	8.4	8.8	8.9	11.3	12.2	11.0	8.3	6.7	7.1	103.2	63	1942 2010		
Mean number of cloudy days	12.0	12.0	11.3	10.0	11.4	10.8	9.1	7.9	8.3	11.5	11.2	11.8	127.3	63	1942 2010		
9 am conditions																	
Mean 9am temperature (°C)	23.0	22.5	21.2	18.2	14.3	11.6	10.5	12.2	15.7	18.8	20.5	22.2	17.6	63	1942 2010		
Mean 9am relative humidity (%)	72	76	77	76	79	80	77	71	66	64	66	68	73	59	1942 2010		
Mean 9am wind speed (km/h)	11.9	10.6	10.2	11.4	13.7	15.9	16.4	16.8	15.3	14.4	14.4	12.9	13.7	63	1942 2010		
9am wind speed vs direction plot																	
3 pm conditions																	
Mean 3pm temperature (°C)	26.5	26.1	24.9	22.5	19.3	16.8	16.2	17.6	20.0	21.9	23.8	25.6	21.8	63	1942 2010		
Mean 3pm relative humidity (%)	59	62	61	59	60	60	55	50	50	54	55	56	57	59	1942 2010		
Mean 3pm wind speed (km/h)	21.9	20.6	18.9	17.2	15.8	17.5	18.7	20.9	22.0	22.5	23.5	23.5	20.2	63	1942 2010		
3pm wind speed vs direction plot																	

red = highest value blue = lowest value

Figure 12: Climate data summary. Source: Bureau of Meteorology (BOM).
Climate statistics for Australian locations (bom.gov.au)

The weather in the Williamtown SAP is also under the significant influence of large-scale climate patterns such as El Niño Southern Oscillation (ENSO) and East Coast Lows (ECLs).

- **East Coast Lows (ELCs).** These intense low-pressure systems occur on average several times each year and bring strong and gusty winds, sustained heavy rainfall and high seas that result often in widespread damage. They can form at any time of the year, with significant ECLs occurring on average about 10 times each year. However, despite their damaging character, ELCs are an important component for NSW's water security bringing heavy soaking rainfall to fill the state's water reservoirs.
- **El Niño Southern Oscillation (ENSO).** The El Niño phase of ENSO is associated with warmer seas in the central and eastern tropical Pacific, leading to hotter and drier conditions in NSW which increases the risk for severe fire weather across the state. The La Niña phase is associated with a cooler sea surface and often with above average winter/spring rainfall over much of the area.
- **Indian Ocean Dipole (IOD).** IOD is a measure of changes in sea-surface temperature patterns in the northern Indian Ocean. Positive IOD conditions result in less rainfall, whereas negative conditions bring more, with the greatest impact being experienced west of the Great Dividing Range. Positive IOD events are more likely during El Niño years and negative ones are more likely during La Niña.
- **Southern Annular Mode (SAM).** SAM is a north–south shift in the belt of strong westerly winds across the south of Australia, affecting cold fronts, storm activity and rainfall. A positive SAM results in less rain, whereas a negative one results in more rainfall, stronger westerly winds and more intense low-pressure systems. The SAM system has its greatest influence on winter rainfall in southern NSW.

These natural climate drivers influence annual variations in the NSW climate, including weather events like droughts and floods, and lead to extreme conditions when appearing combined. The NSW climate is also affected by other climate drivers such as easterly troughs, upper-level troughs, trade winds, frontal systems, cloud bands and blocking highs.

3.1 Introduction

The following is a summary of Climate Change Scenarios and projections that have been used as the basis for the identification of climate change impacts, and the associated risk assessment.

3.2 Carbon Dioxide

Source: adapted from CSIRO Climate Change In Australia (2015) Technical Report, CSIRO State of the Climate 2018,

Atmospheric carbon dioxide concentrations will continue to rise from a 2020 baseline of 400ppm, reaching 540ppm by 2090 in the RCP4.5 scenario, and 940ppm by 2090 in the RCP8.5 scenario (refer Figure 13).

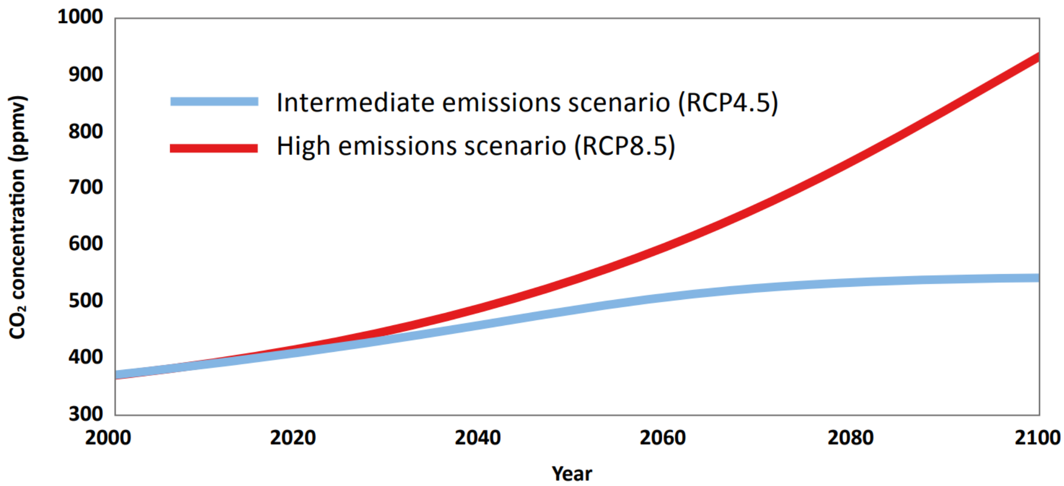


Figure 13: Atmospheric carbon dioxide levels for RCP4.5 and RCP8.5

The World Health Organisation (WHO), the International WELL Building Institute, and the Green Building Council of Australia recommend that internal building carbon dioxide concentrations are limited to a maximum of 700ppm if a high cognitive function is to be expected from the occupants. The WHO advises that human health risk is expected where exposed to CO_2 levels of higher than 1,000 ppm for prolonged periods.

3.3 Temperature

Source: Hunter – Climate change snapshot, Adapt NSW, CSIRO Projections for Australia's NRM regions – East Coast (South), CSIRO Climate Change In Australia (2015) Technical Report, and CSIRO Projections Tools.

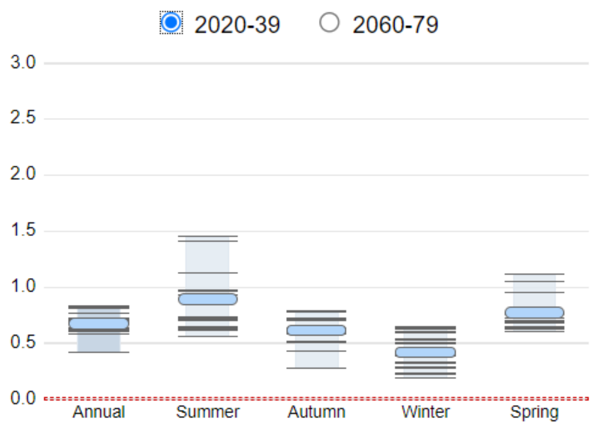
Temperatures have increased over the past century, with the rate of warming higher since 1960. Mean temperature increased between 1910 and 2013 by around 0.8. The recent decades have been the warmest on record for both daily minimum and daily maximum temperatures in the cluster.

Maximum, minimum, and mean temperatures are predicted to continue to increase substantially in all seasons, with periods of hot weather getting longer and hotter.

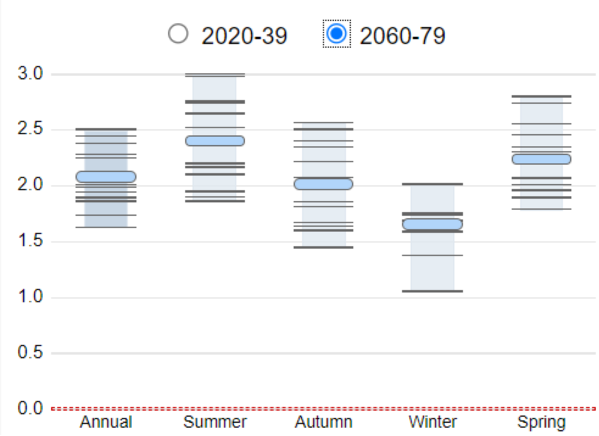
Frost risk days (minimum temperatures under 2 °C) are expected to degrease.

For Williamtown the annual mean temperature is projected to rise by 0.7°C by 2030 and 2.1°C by 2070 (refer Figure 14).

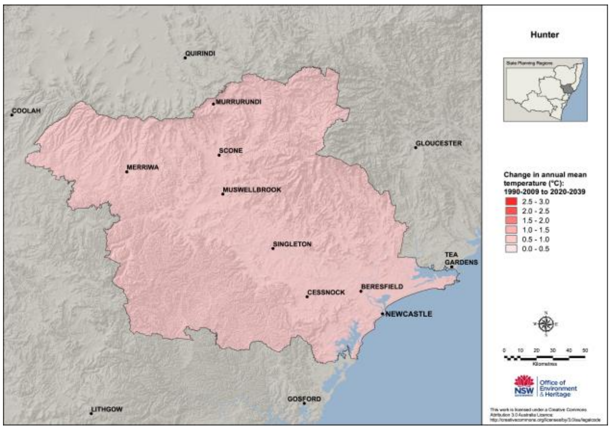
Mean Temperature 2020-2039

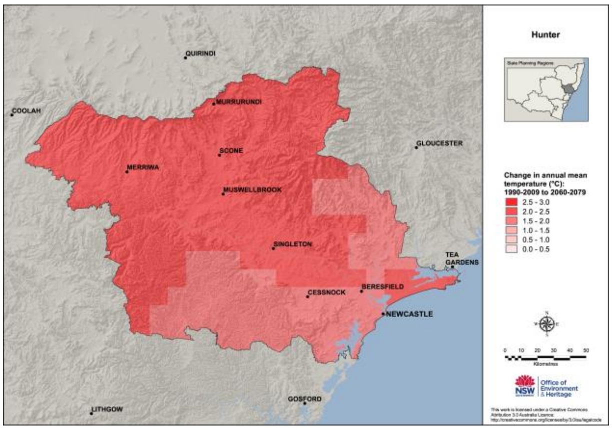


Mean Temperature 2060-2079

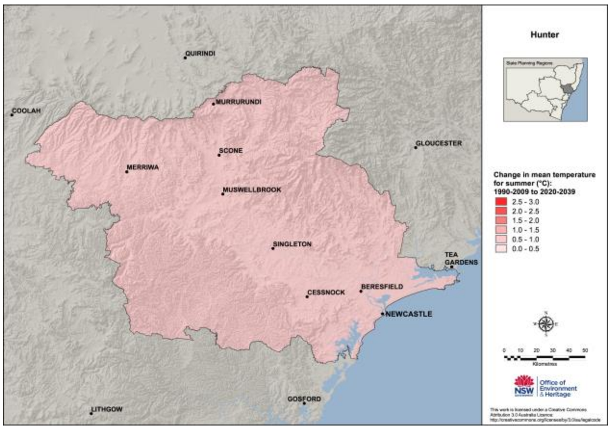


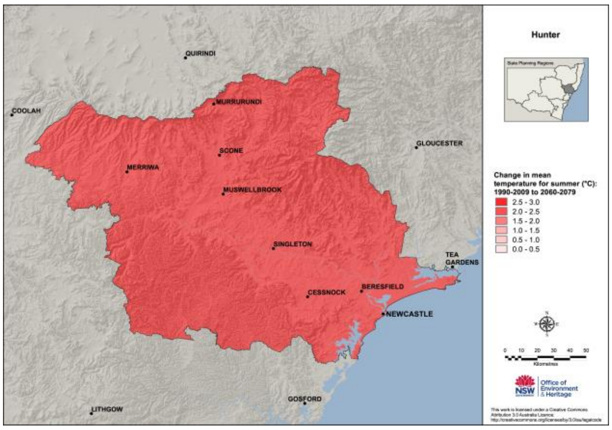
Annual





Summer





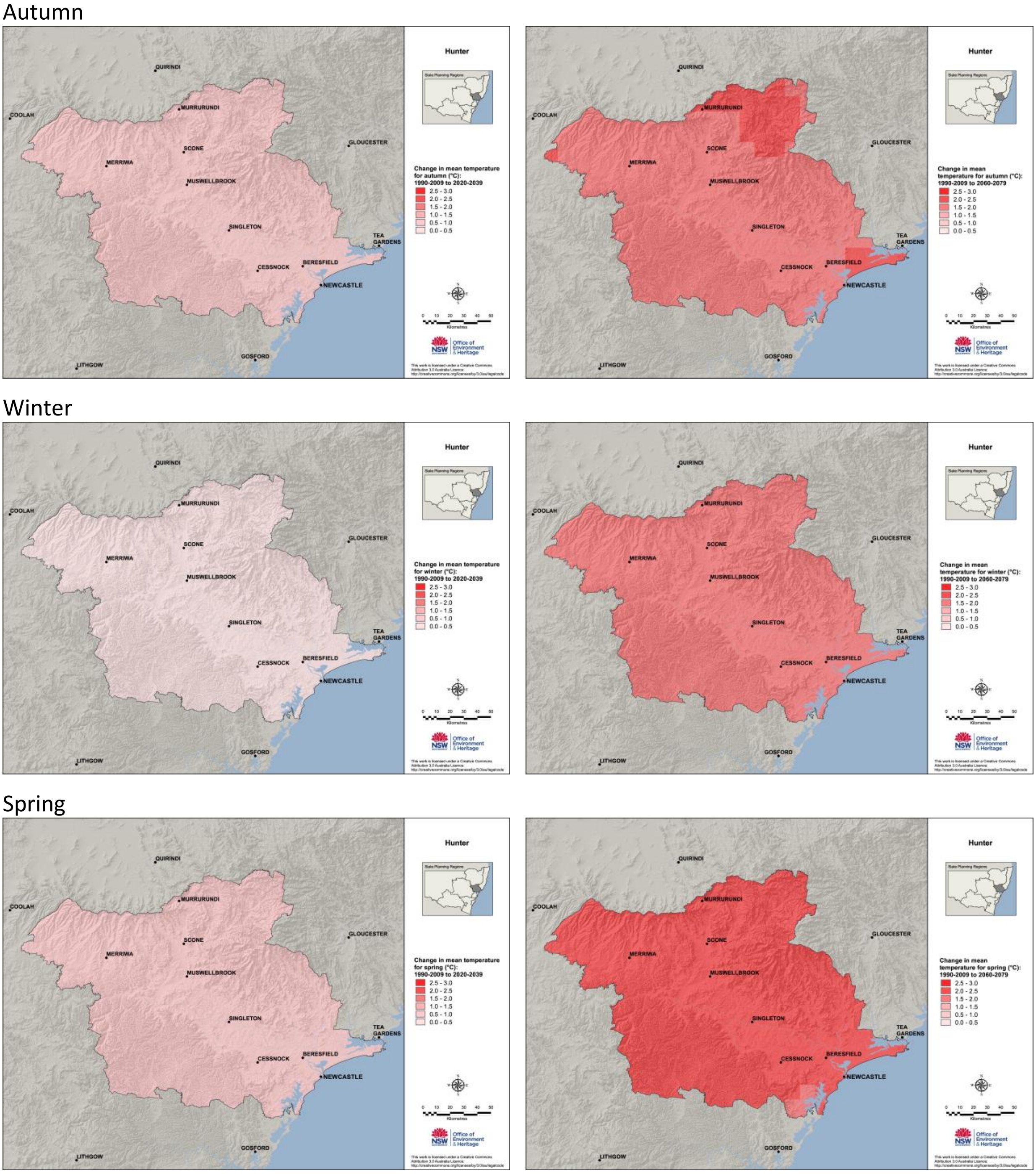


Figure 14: Predicted change in mean temperature for the Hunter Region for the near (left) and far future (right). Source: Adapt NSW

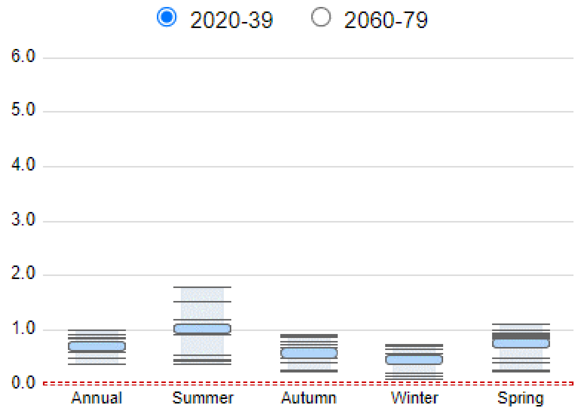
3.3.1 Maximum temperature

The average annual maximum temperature is projected to rise by 0.7°C in the near future and 2.0°C in the far future across the SAP (refer Figure 15).

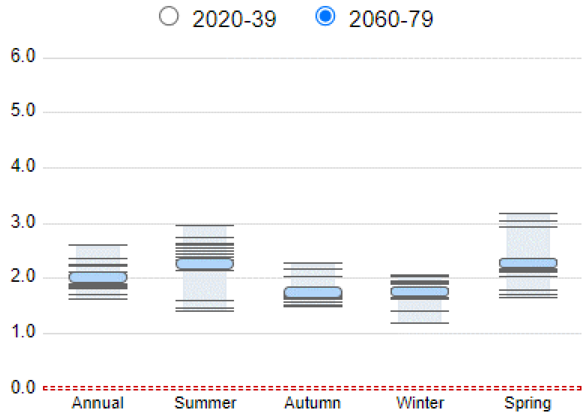
For the 2020-2039 period in Williamtown, maximum temperatures in summer, autumn and spring are expected to rise between 0.5°C-1.0°C and 0.0°C-0.5°C in winter.

For the 2060-2079 period in Williamtown, maximum temperatures in spring and summer are expected to rise between 2.0°C-2.5°C and 1.5°C-2.0°C in winter and autumn.

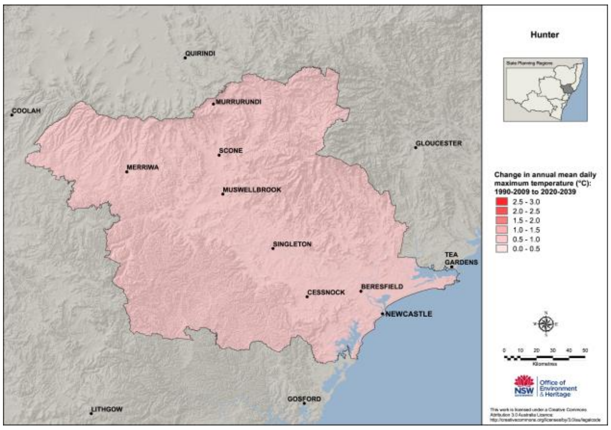
Maximum Temperature 2020-2039

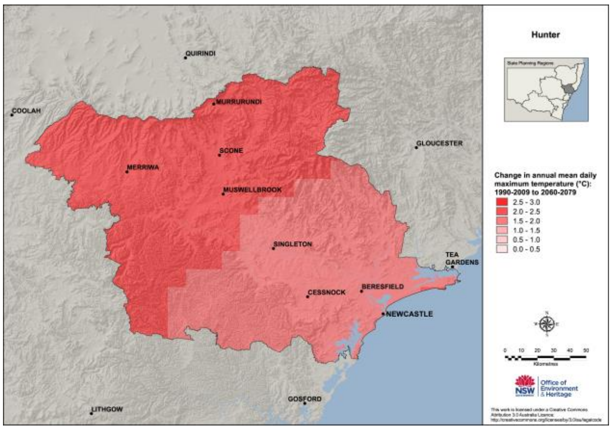


Maximum Temperature 2060-2079

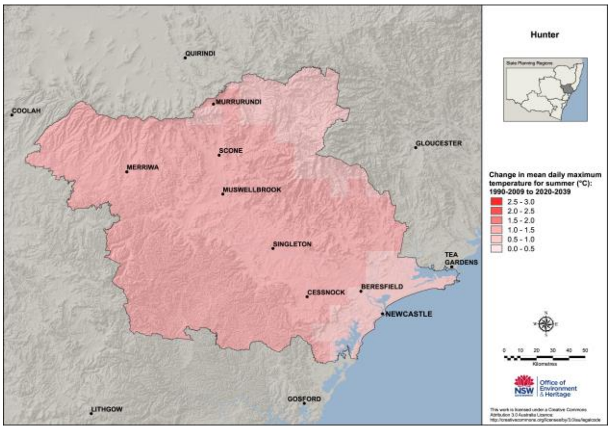


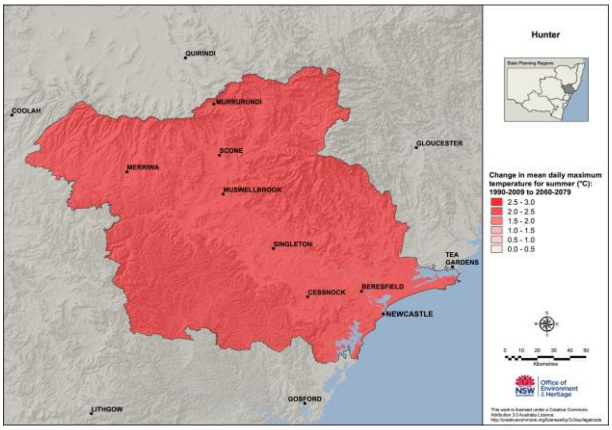
Annual



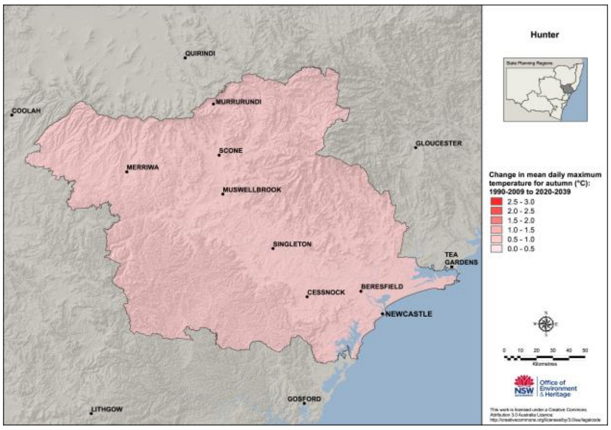


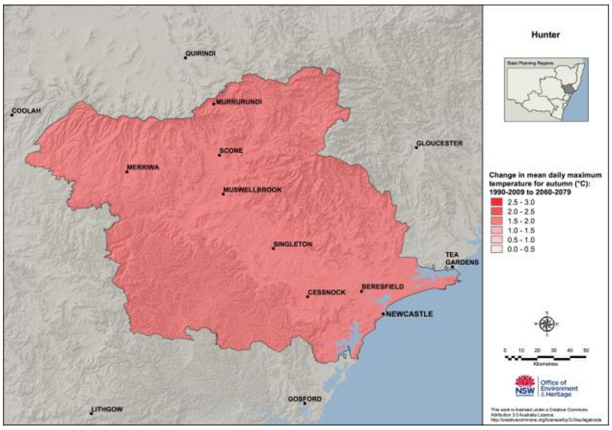
Summer



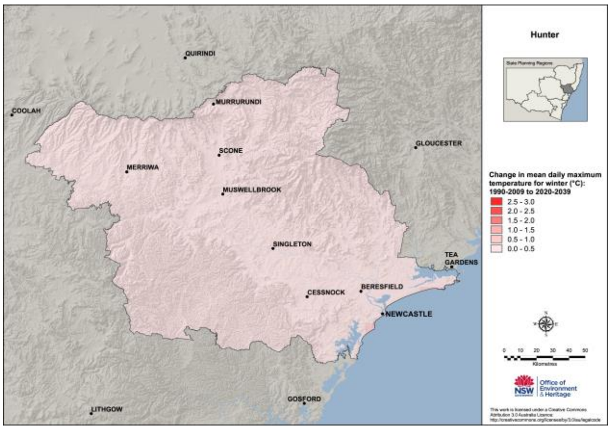


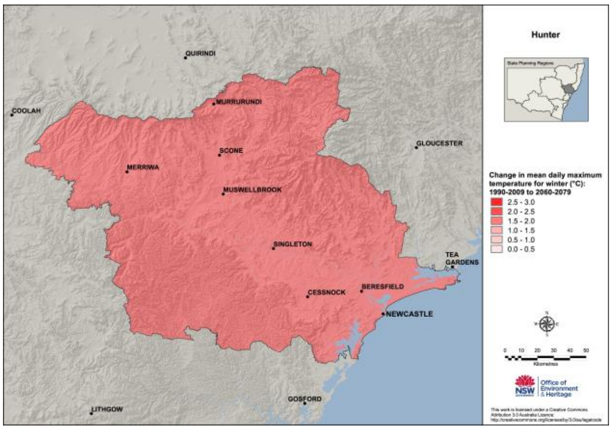
Autumn



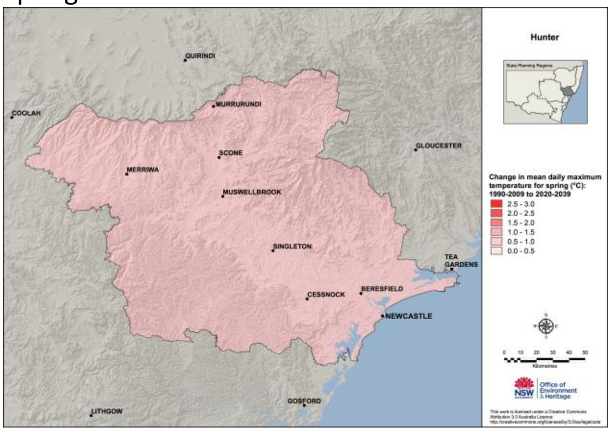


Winter





Spring



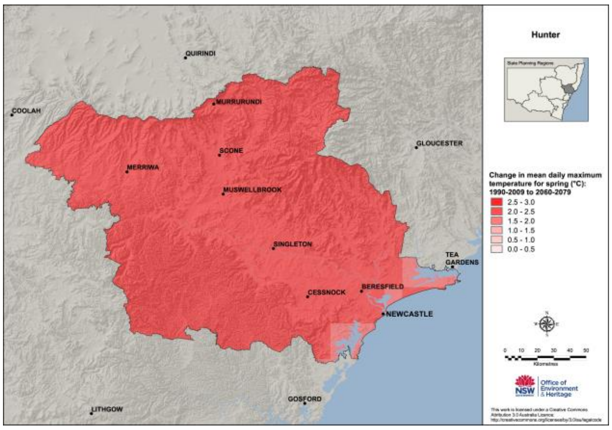


Figure 15: Predicted change in maximum temperature for the Hunter region for the near (left) and far future (right). Source: Adapt NSW

3.3.2 Hot Days (maximum temperature above 35°C)

With the trend of increasing temperatures, it is expected that more heat extremes occur in the future. Based on the model results and understanding of the physical processes the projections show a significant increase in the temperatures reached on the hottest days, the frequency of hot days and duration of warm swells.

Currently the Hunter Region experiences an average of 10 to 20 days above 35°C, while the number of hot days is projected to increase by an average of 9 days per year by 2030 and 26 days per year by 2070. For the near future, the projected changes are expected to occur mainly in spring and summer, while there is a likelihood for the far future that these changes also extend into autumn (refer Figure 16 and Figure 17).

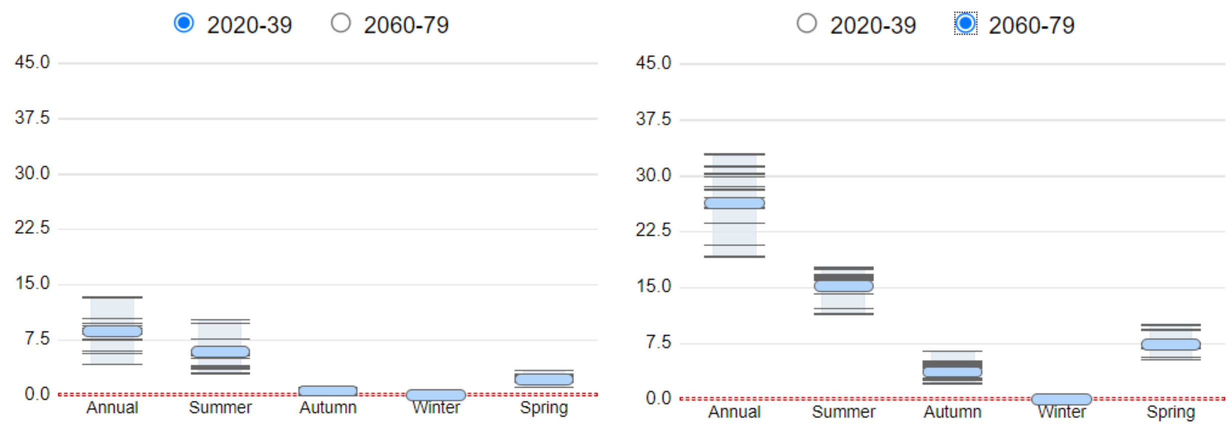


Figure 16: Annual heat chart (number of days above 35°C) for near (left) and far future projections (right). Source: Adapt NSW

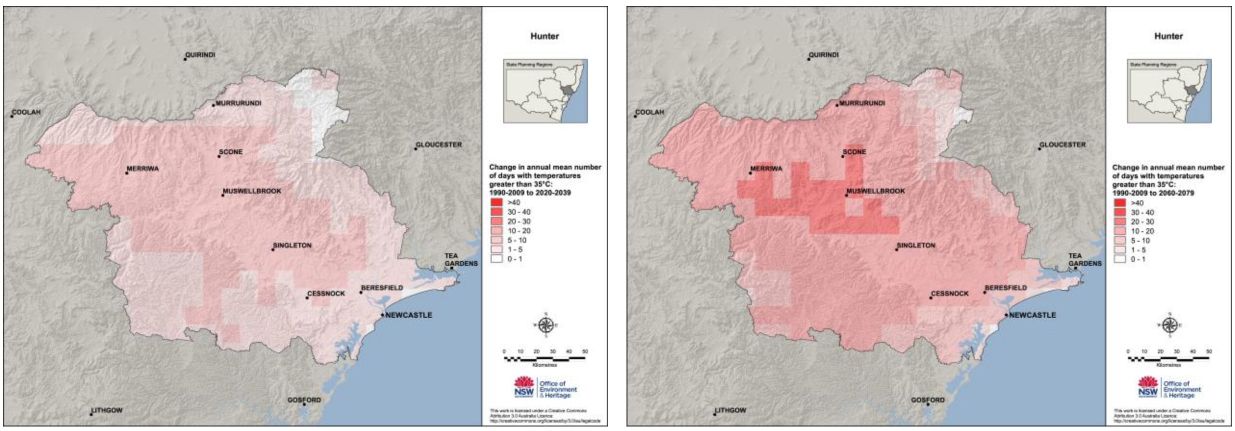


Figure 17: Projected change in annual mean number of days with temperatures above 35°C for the near (left) and far future (right). Source: Adapt NSW

Historical weather data by BOM show that on average Williamtown experiences approximately 10 days above 35°C and 1-2 days above 40°C.

The following table provides a summary of current average (1981–2010) annual number of days above 35°C and 40°C for Newcastle and estimates for 30-year periods centred on 2030, 2050, and 2070 (RCP4.5 and RCP8.5) (refer Table 2). The estimates are derived by applying the Median, 10th and 90th percentile projections to observed daily temperature data for 1981-2010 using the CSIRO Threshold Calculator and ACCESS1-0 model.

Table 2: Projected days above temperature threshold for Newcastle. Source: CSIRO Climate Change Projections

Threshold *Historical data from 1981-2010 in brackets []*		2030	2050	2070
Over 35°C [3.4]	RCP4.5	5.5 (5.0 to 6.2)	6.6 (5.9 to 8.8)	7.5 (6.0 to 9.7)
	RCP8.5	5.8 (5.1 to 7.1)	8.2 (6.3 to 11.5)	11.4 (8.2 to 17.9)
Over 40°C [0.2]	RCP4.5	0.4 (0.3 to 0.6)	0.7 (0.6 to 1.0)	0.8 (0.5 to 1.2)
	RCP8.5	0.5 (0.3 to 0.7)	0.9 (0.7 to 1.4)	1.3 (0.8 to 2.3)

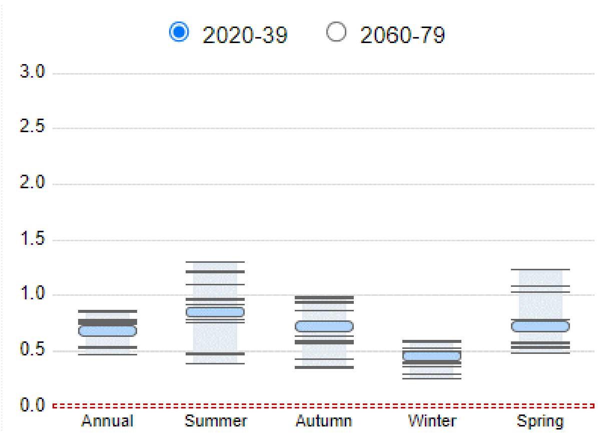
3.3.3 Minimum temperature

The average annual minimum temperature is projected to rise by 0.7°C in the near future and 2.1°C in the far future across the SAP (refer Figure 18).

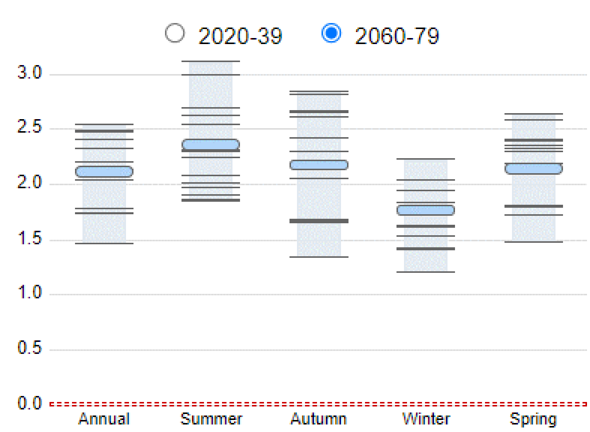
For the 2020-2039 period in Williamtown, minimum temperatures are expected to rise between 0.5°C-1.0°C across all seasons.

For the 2060-2079 period in Williamtown, minimum temperatures in summer, autumn and spring are expected to rise between 2.0°C-2.5°C and 1.5°C-2.0°C in winter.

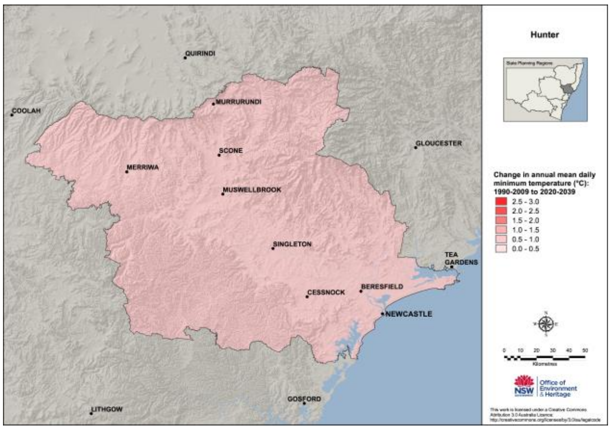
Minimum Temperature 2020-2039

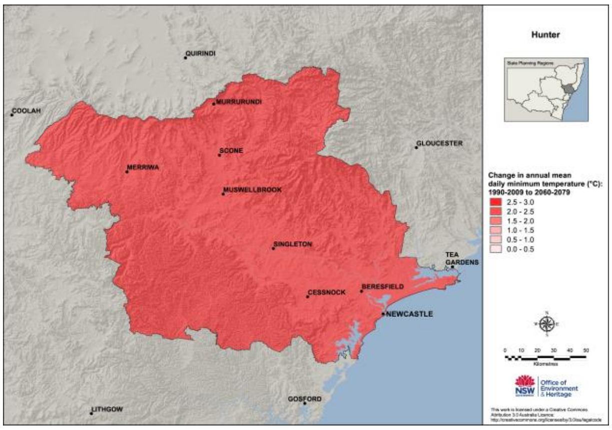


Minimum Temperature 2060-2079

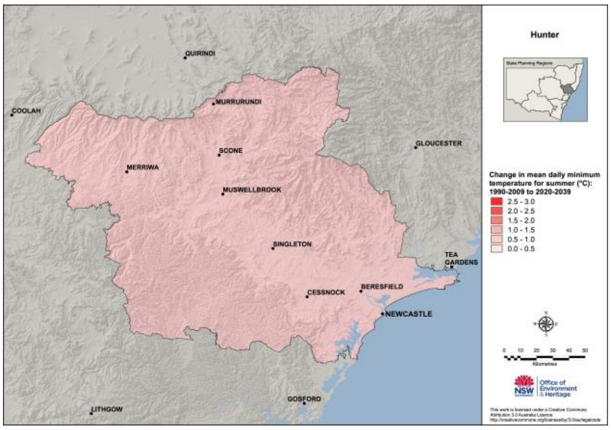


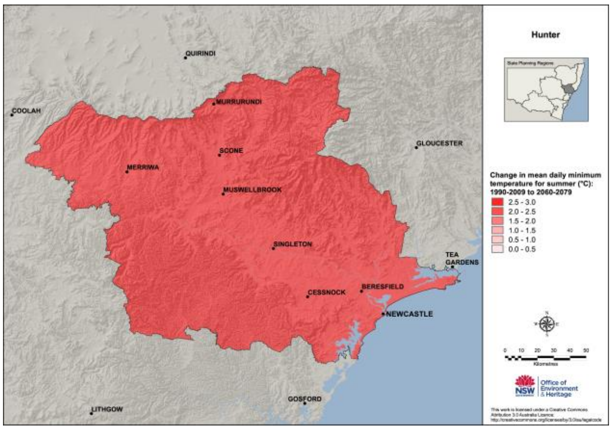
Annual



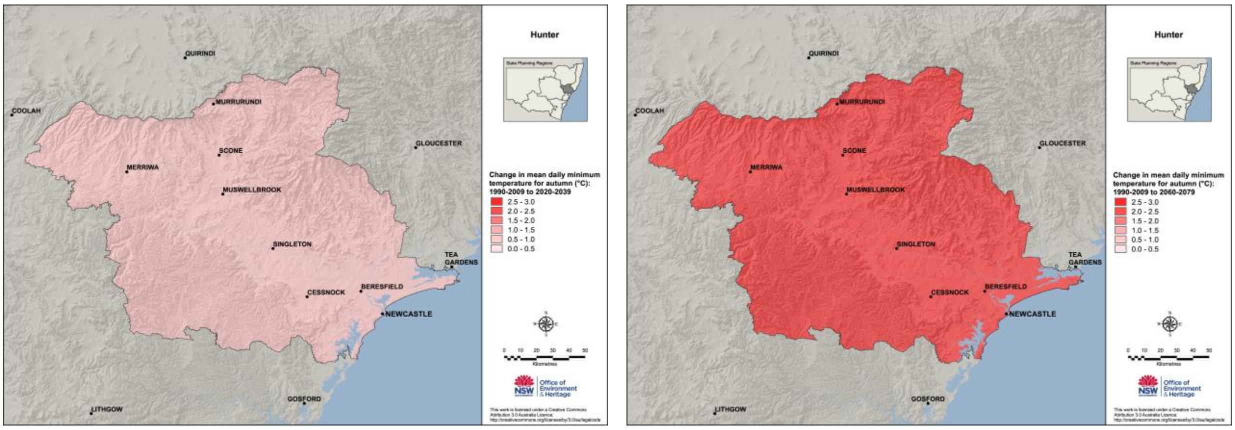


Summer

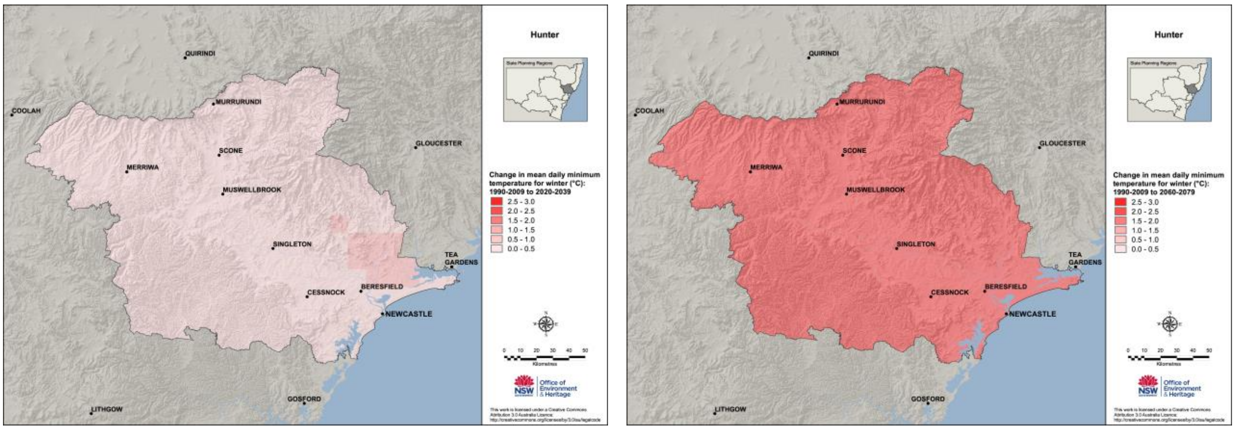




Autumn



Winter



Spring

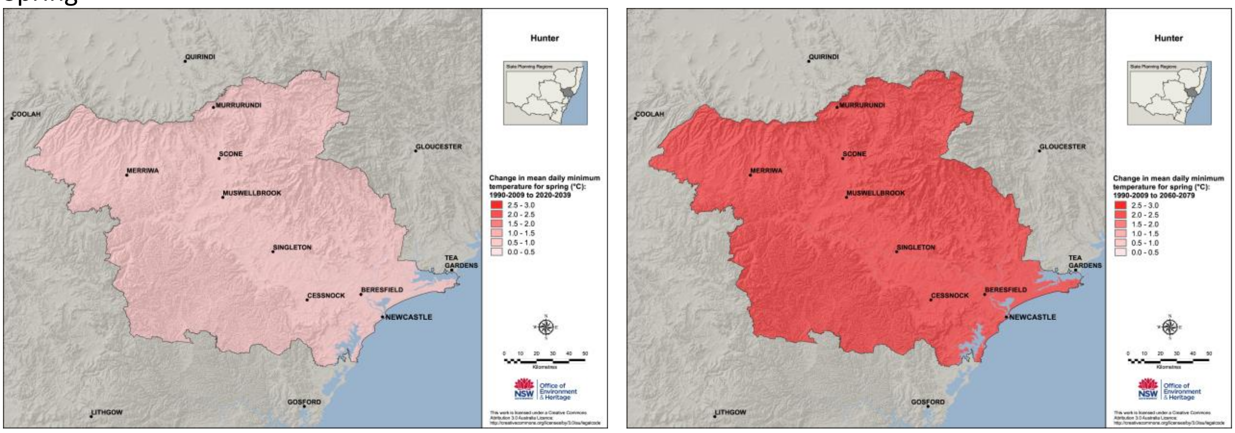


Figure 18: Predicted change in minimum temperature for the NENW region for the near (left) and far future (right). Source: Adapt NSW

3.3.4 Cold nights (minimum temperature below 2°C)

The average mean minimum temperature for Williamtown is 6.4°C, and is expected to rise by 0.5-1.0°C in the near future and 2.0-2.5°C by 2070 decreasing the chance for the SAP to experience temperatures below 2°C at all.

Naturally, the frequency of frost-risk days is projected to decrease. For the Hunter Region, the number of cold nights with temperatures below 2°C is projected to decrease by an average of 6 nights per year by 2030 and 17 nights per year by 2070 (refer Figure 19).

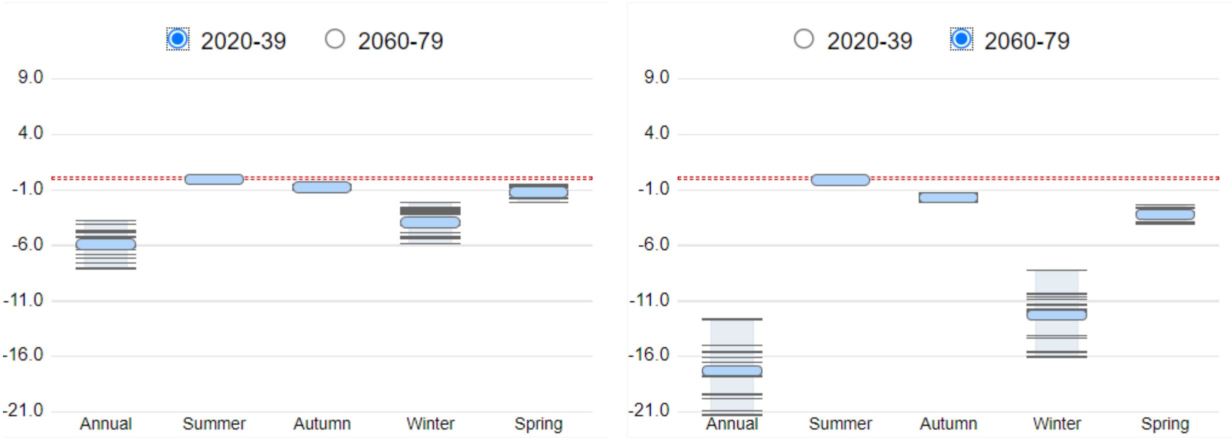


Figure 19: Annual cold nights chart (number of nights below 2°C) for near (left) and far future projections (right). Source: Adapt NSW

However, almost no changes are projected for the region's coastal areas (refer Figure 20).

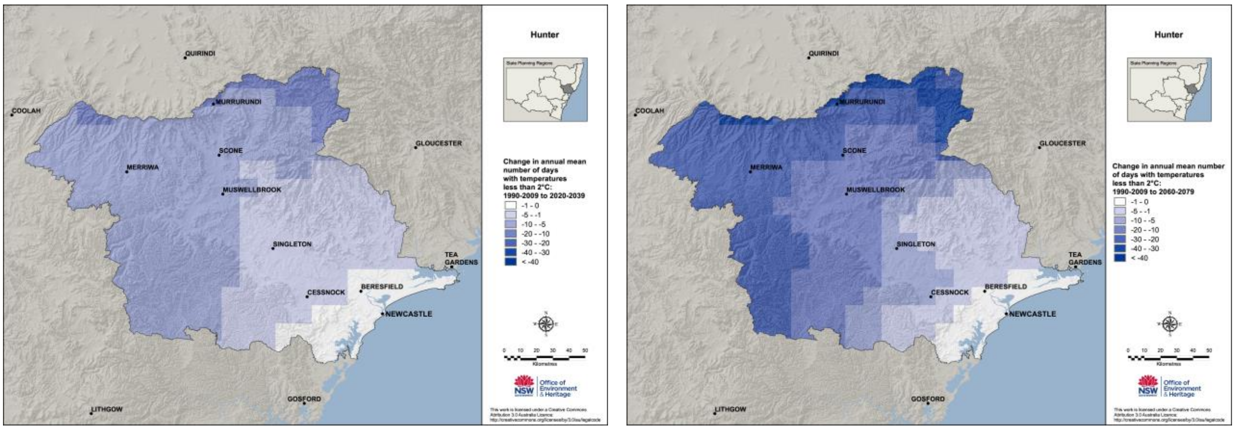


Figure 20: Projected change in annual mean number of days with temperatures below 2°C for the near (left) and far future (right). Source: Adapt NSW

The following table provides a summary of current average (1981–2010) annual number of days below 2°C (frost risk) for Newcastle and estimates for 30-year periods centred on 2030, 2050, and 2070 (RCP4.5 and RCP8.5) (refer Table 3). The estimates are derived by applying the Median, 10th and 90th percentile projections to observed daily temperature data for 1981-2010 using the CSIRO Threshold Calculator and ACCESS1-0 model.

Table 3: Projected days below temperature threshold for Newcastle. Source: CSIRO Climate Change Projections

Threshold *Historical data from 1981-2010 in brackets []*		2030	2050	2070
Below 2°C [2.5]	RCP4.5	0.03 (0.03 to 0.03)	0.03 (0.0 to 0.03)	0.01 (0.0 to 0.03)
	RCP8.5	0.03 (0.03 to 0.3)	0.01 (0.0 to 0.03)	0.0

3.4 Rainfall

Source: Adapt NSW, CSIRO Projections for Australia's NRM regions – East Coast (South), CSIRO Climate Change In Australia (2015) Technical Report, Hunter – Climate change snapshot, and CSIRO Projections Tools.

Due to the complexities of rain causing weather systems, reliable predictions of rainfall trends are challenging. Seasonal rainfall projections for the near and far future span both drying and wetting scenarios and should be used with care.

For the Hunter Region, the majority of models agree that annual rainfall will increase in the near and far future (refer Figure 21). Summer rainfall is expected to decrease in the near future but increase by approximately 10% by 2070. While in both, near and far future predictions autumn rainfall is projected to increase, by 2070, a slight downward trend for winter rainfall and upward trend for spring rainfall is expected.

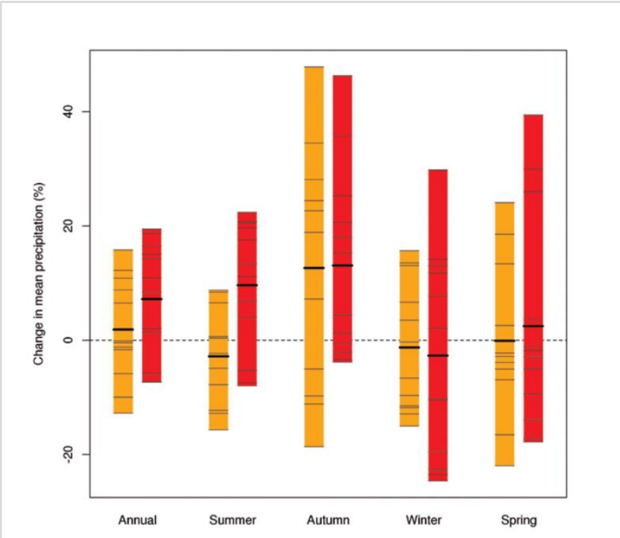
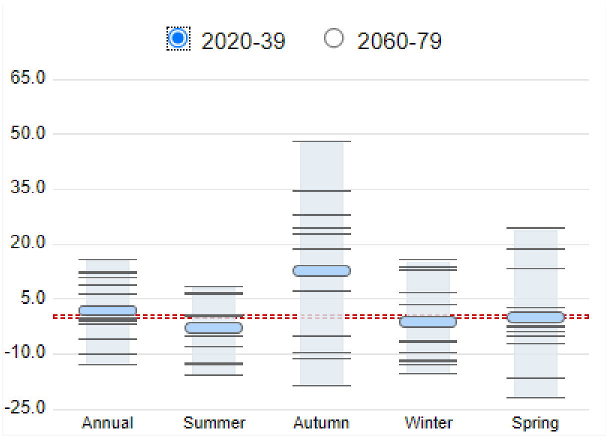


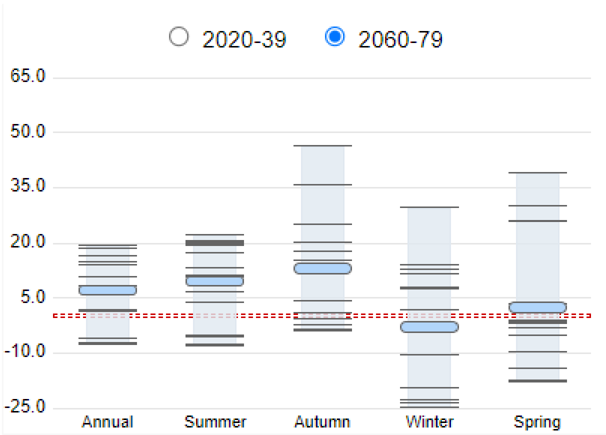
Figure 21: Projected changes in average rainfall for the Hunter Region, annually and by season (2030 yellow; 2070 red).

The following images show that by 2070 rainfall is expected to increase throughout all seasons in the Williamtown SAP area in order of up to 20% in summer and autumn (refer Figure 22: Projected annual and seasonal change in mean rainfall
for the near (left) and far future (right). Source: Adapt NSW.

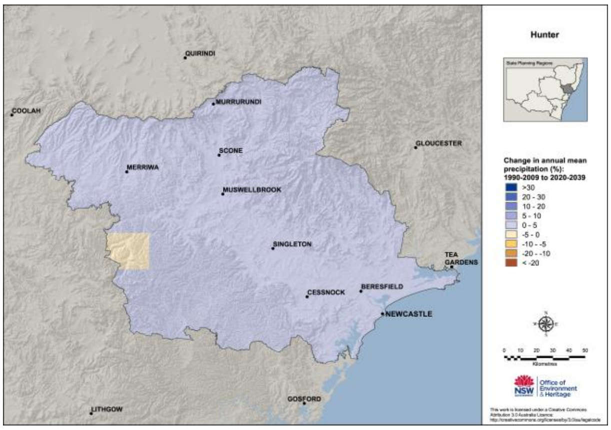
Average rainfall 2020-2039

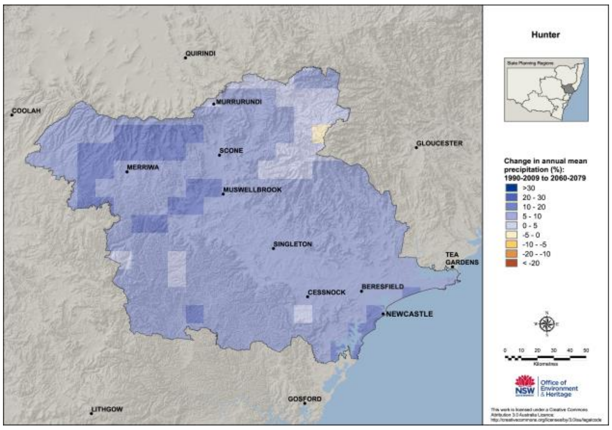


Average rainfall 2060-2079

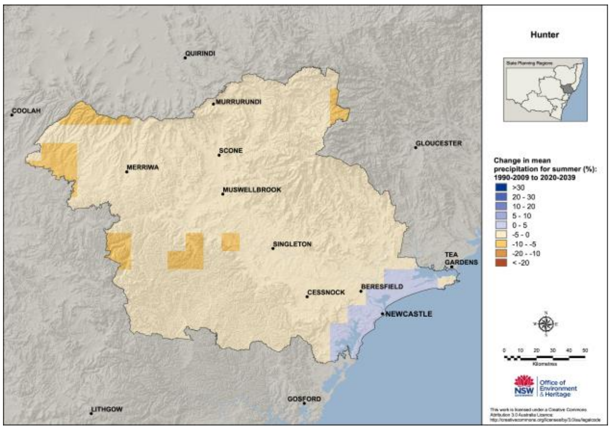


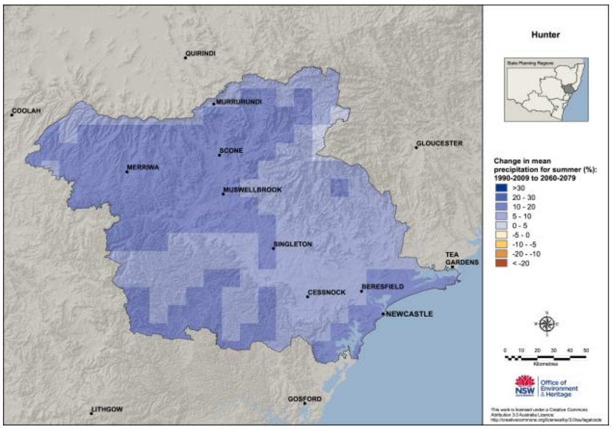
Annual



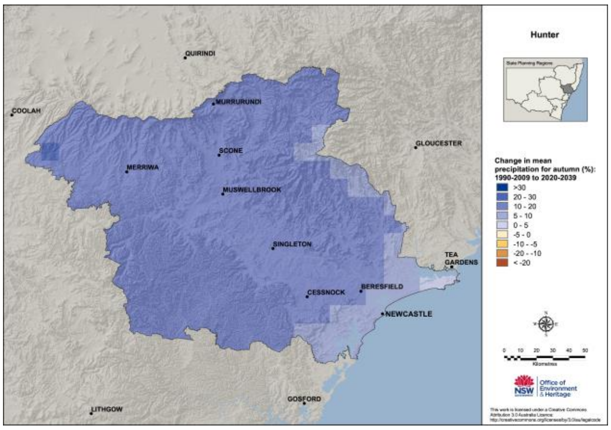


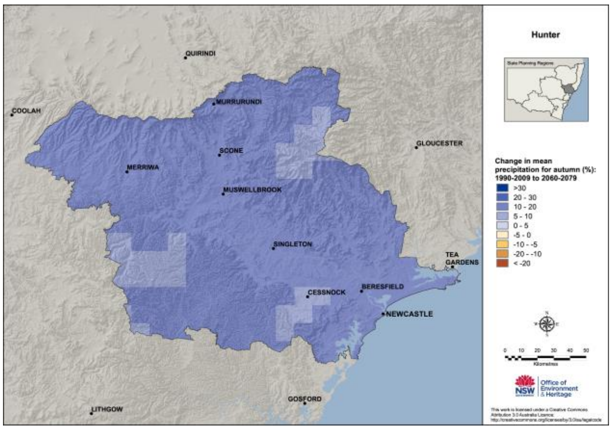
Summer



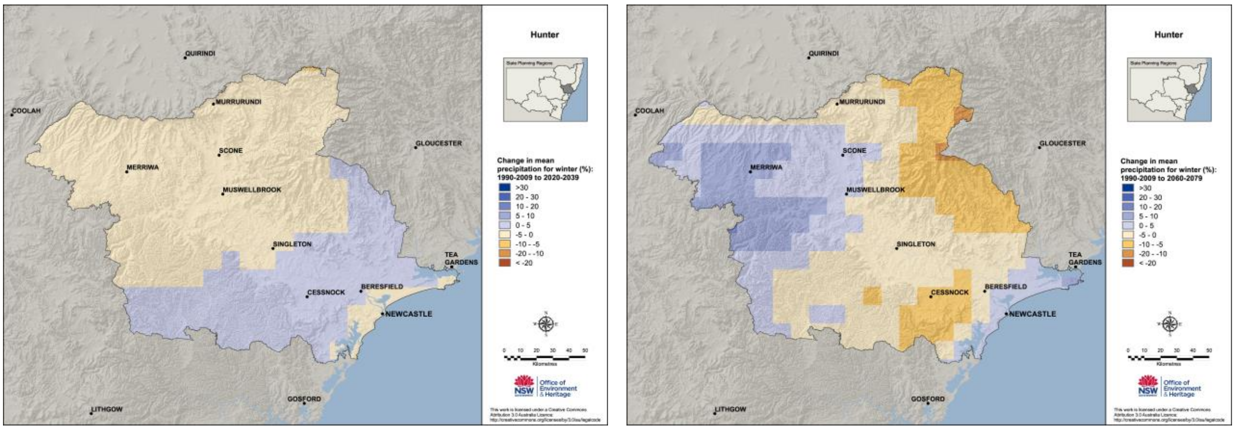


Autumn





Winter



Spring

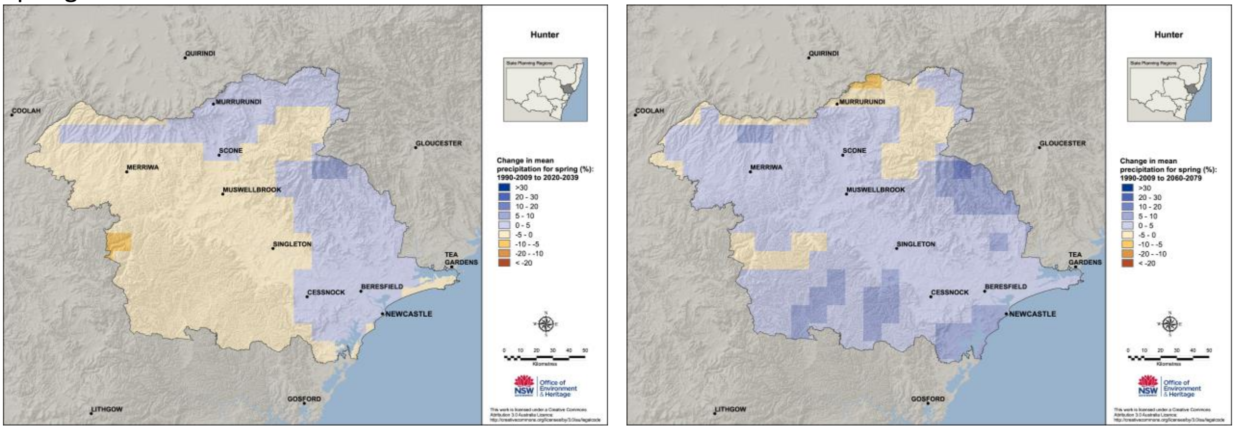


Figure 22: Projected annual and seasonal change in mean rainfall
for the near (left) and far future (right). Source: Adapt NSW

Table 4 demonstrates the uncertainty in the rainfall projections with only slight variations across the periods.

The table provides a summary of current average (1981–2010) annual number of days above the 99.9th and months below the 10th historic percentile for Newcastle and estimates for 30-year periods centred on 2030, 2050 and 2070 (RCP4.5 and RCP8.5) (refer Table 4). The estimates are derived by applying the Median, 10th and 99.9th percentile projections to observed daily temperature data for 1981-2010 using the CSIRO Threshold Calculator and ACCESS1-0 model.

Table 4: Projected rainfall days/ month above 99.9th/ below 10th historic percentile for Newcastle. Source: CSIRO

Factor *Historical data from 1981-2010 in brackets []*		2030	2050	2070
Days per year above historic 99.9th percentile rainfall [0.31]	RCP4.5	0.5 (0.3 to 0.9)	0.5 (0.3 to 0.9)	0.6 (0.3 to 1.0)
	RCP8.5	0.4 (0.2 to 0.7)	0.4 (0.2 to 0.5)	0.6 (0.3 to 1.1)
Months below historic 10th percentile rainfall [1.1]	RCP4.5	1.2 (1.0 to 1.5)	1.2 (1.0 to 1.3)	1.2 (0.9 to 1.6)
	RCP8.5	1.2 (1.0 to 1.5)	1.3 (1.0 to 1.7)	1.2 (1.0 to 1.5)

The following illustrations show the modelled rainfall trend for the East Coast (South) region applying RCP4.5 and RCP8.5 emission scenarios and using the ACCESS1-0 model (refer Figure 23 and Figure 24). The grey band shows the range of model results summarised using the median (central grey line) and 10th to 90th percentile range of the projected. The blue and red lines show the historic and future simulation from the one selected model.

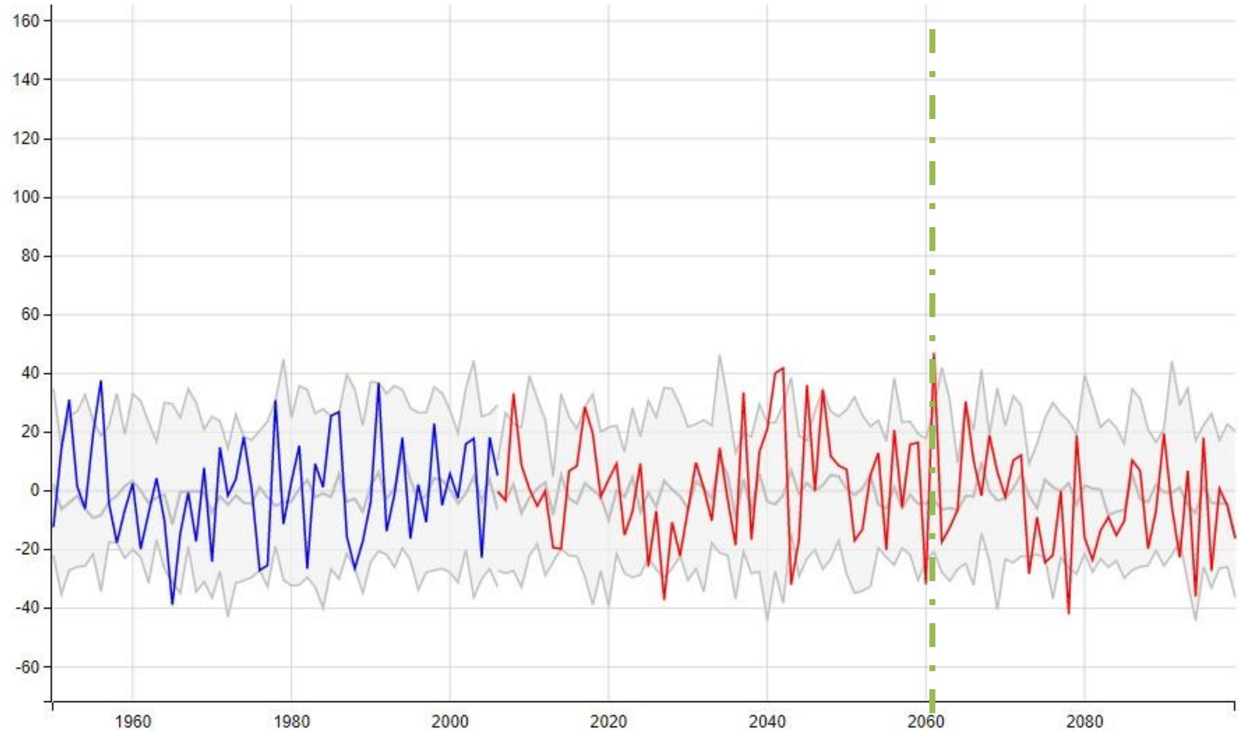


Figure 23: Projected rainfall trend for East Coast (South) region, RCP4.5.
Source: CSIRO Climate Change Projections

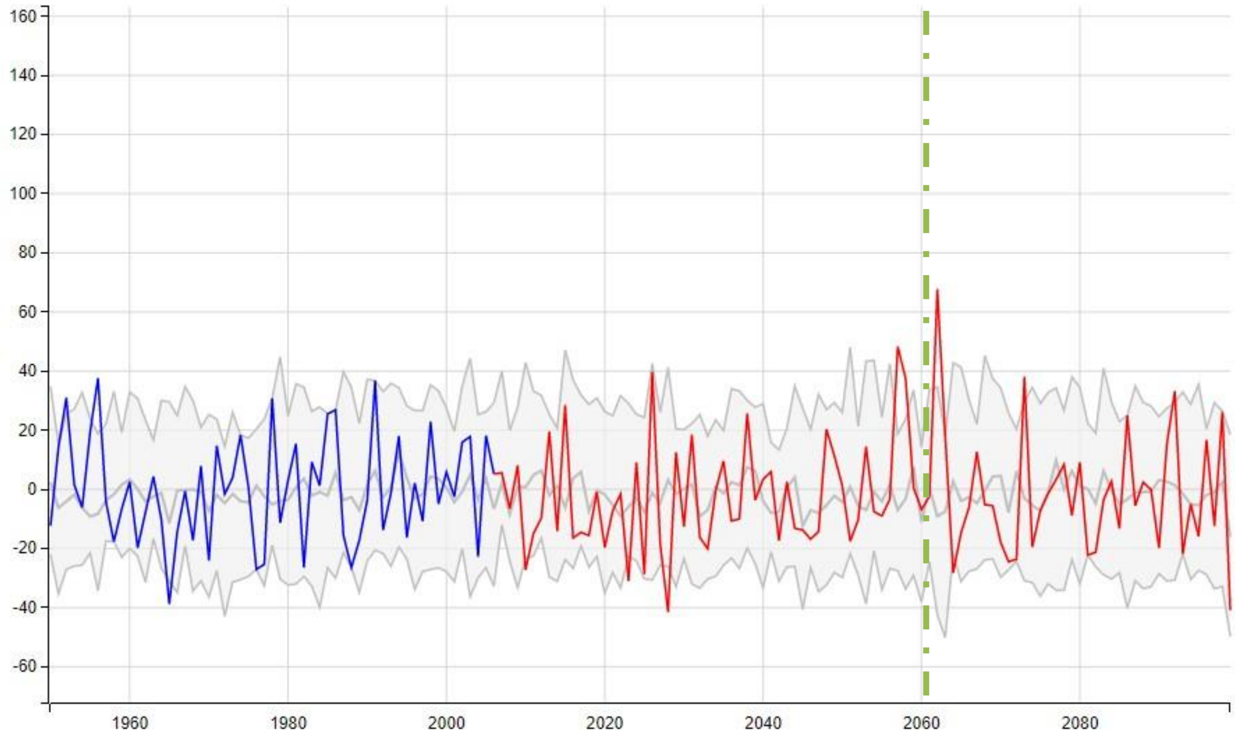


Figure 24: Projected rainfall trend for East Coast (South) region, RCP8.5.
Source: CSIRO Climate Change Projections

3.4.1 Rainfall Intensity

While there is a high uncertainty across the models about the future trend of annual rainfall, all models agree that frequency and magnitude of extreme rainfall events will increase over the course of the century in the East Coast cluster (refer Figure 25).

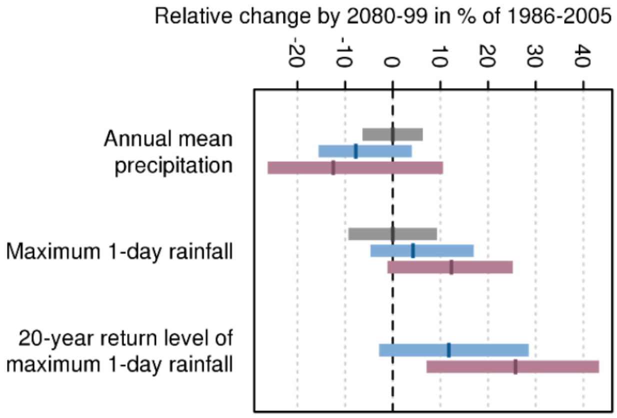


Figure 25: Modelled differences (per cent) in annual average rainfall, rainfall on the wettest day of the year, and rainfall on the wettest day in 20 years for 2080-2099 compared to 1986 to 2005 under RCP4.5 (blue) and RCP8.5 (purple). Natural climate variability is represented by the grey bar. Source: CSIRO

For the East Coast cluster, rainfall during summers is predicted to become heavier, while rainfall intensity for winter and spring is expected to decrease with less clearer changes in autumn (refer Figure 26).

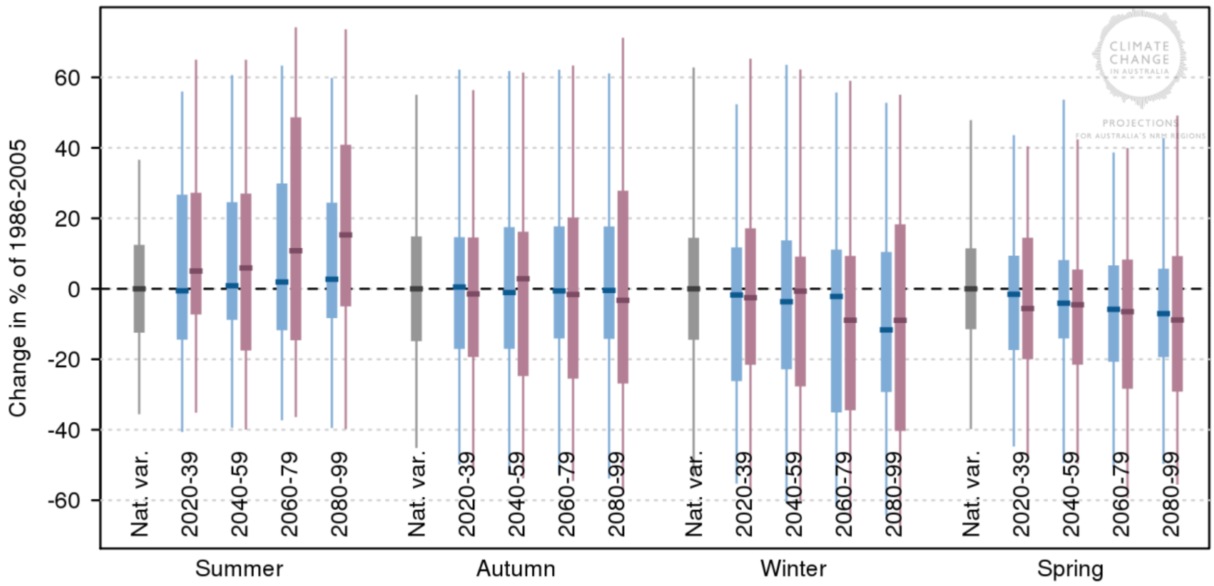


Figure 26: Projected changes for seasonal wettest day compared to 1986–2005 (RCP4.5 (blue), RCP8.5 (purple), median (dark horizontal lines)). Natural climate variability is represented by the grey bar.
Source: CSIRO Climate Change Projections

The frequency of extreme rainfall events in summer, autumn and spring is projected to increase and to decrease in spring for the East Coast cluster (refer Figure 27).

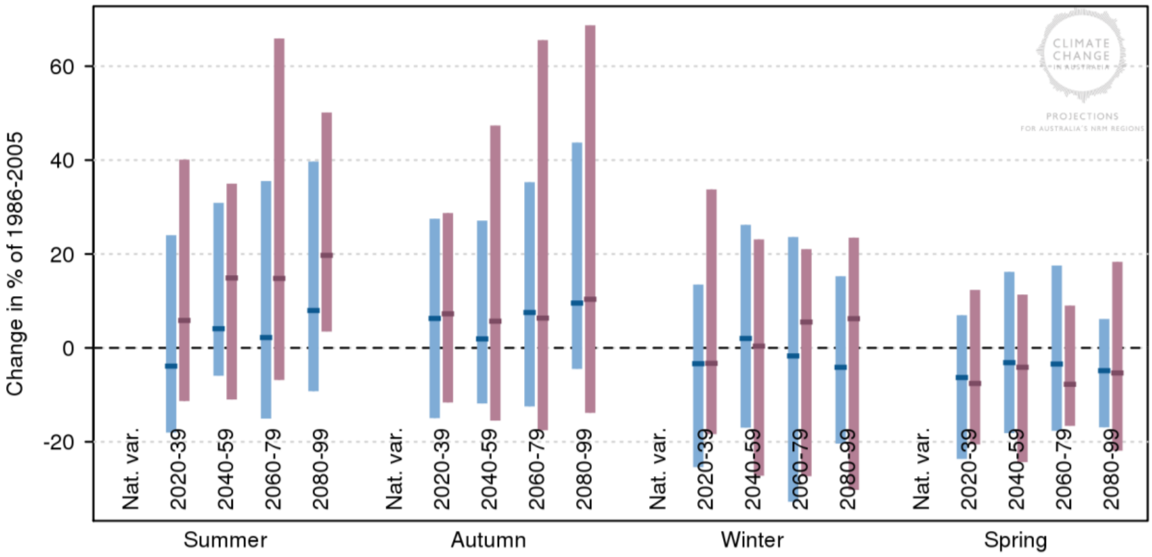


Figure 27: Projected changes in seasonal 1-in-20year wettest day compared to 1986–2005 (RCP4.5 (blue), RCP8.5 (purple), median (dark horizontal lines)). Natural climate variability is represented by the grey bar.
Source: CSIRO Climate Change Projections

As a result of this increase in extreme rainfall events, frequency, duration and height of flooding are also expected to rise.

3.5 Flooding

Source: Williamtown Salt Ash Floodplain Risk Management Study and Plan, Australian Rainfall & Runoff Guide, and Flooding and Water Cycle Management Scenarios Report

Across all models, extreme rainfall events are predicted to increase and sea level to rise increasing the risk of flooding. In 2007 the guideline for Practical Consideration of Climate Change was published by NSW Department of Environment and Climate Change (DECC Guideline 2007) setting the following benchmarks (RCP8.5/ high emissions pathway) to be considered in local floodplain management across the state:

- Sea Level Rise of 0.4m by 2050 and 0.9m by 2100; and
- Rainfall Intensity increase of 10% - 30%

The Australian Rainfall and Runoff Data Hub provides the following projected rainfall intensities under RCP4.5 and RCP8.5 emission scenarios for Williamtown (refer Figure 28).

Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Figure 28: Projected increase in rainfall intensities, Williamtown. Source: ARR

Port Stephens Council has adopted these climate change provisions for flood planning across the LGA.

As outlined in the Flooding and Water Cycle Management report by Aurecon, flooding within the Williamtown SAP is mainly caused by the following three mechanisms:

- **Regional Flooding** - Inundation from the Hunter River flood events;
- **Local Flooding** – Rainfall on the local catchment areas and drainage channels; and
- **Tidal Inundation** – Tides in Fullerton Cove and Port Stephens

Due to their difference in scale, flood levels and influence of the three mechanisms vary across the SAP.

The most predominant source of flooding in the area is Regional Flooding, hence, informs flood planning levels for the SAP.

The BMT report modelled the flood inundation extends of 20% Annual Exceedance Probability (AEP), 1% AEP and Probable Maximum Flood (PMF) events (refer Figure 29) in the area. As shown below, under existing conditions approximately, half of the precinct to the south as well as its north-west corner are already impacted by flood events. Particularly, the floodplain corridor from Tilligerry Creek to Fullerton Cove, along both sides of Nelson Bay Road, shows significant flooding.

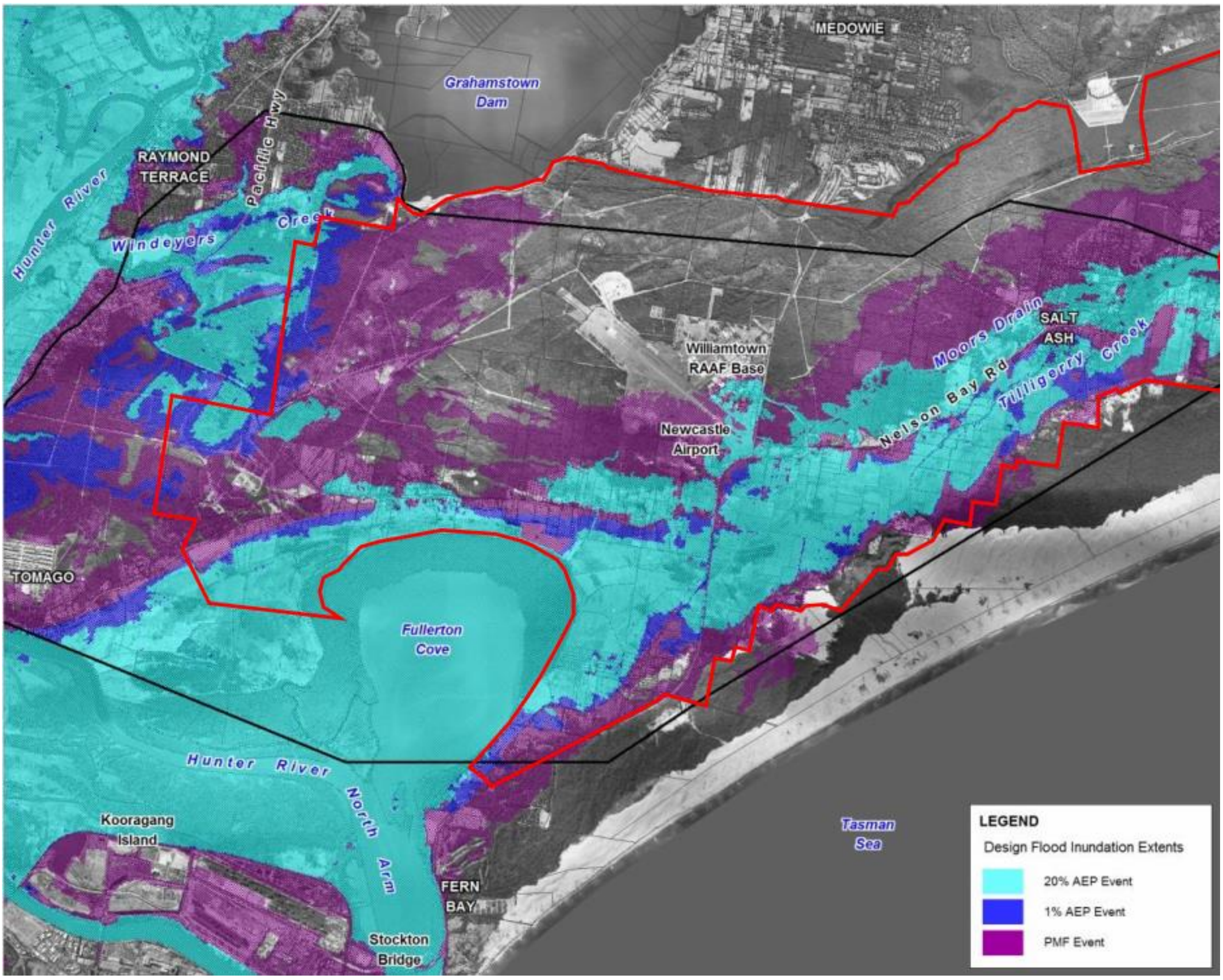


Figure 29: Design Flood Inundation Extents – Existing Condition. Source: BMT

The following chapters explain the individual impact of the three mechanisms on flooding in the area under existing conditions and projected climate change conditions.

However, it is understood that all three mechanisms have the potential to coincide with each other. For example, high water levels in Fullerton Cove and Port Stephens limit the drainage ability for local catchments to discharge freely resulting in an increased risk of flood inundation for the area. A scenario that will worsen with an expected sea-level rise of 0.74m by 2100 along the Port Stephens Councils' coast.

3.5.1 Regional Flooding

Regional flooding is considered to be flooding caused by the Hunter River catchment which may have a varying flood inundation potential.

As the 1% AEP event flood map (refer Figure 30) shows, under current conditions an overtopping of the Fullerton Clove levee is expected inundating the floodplains between Fullerton Cove and Tilligerry Creek with flood depths in the order of 0.5-1.0m.

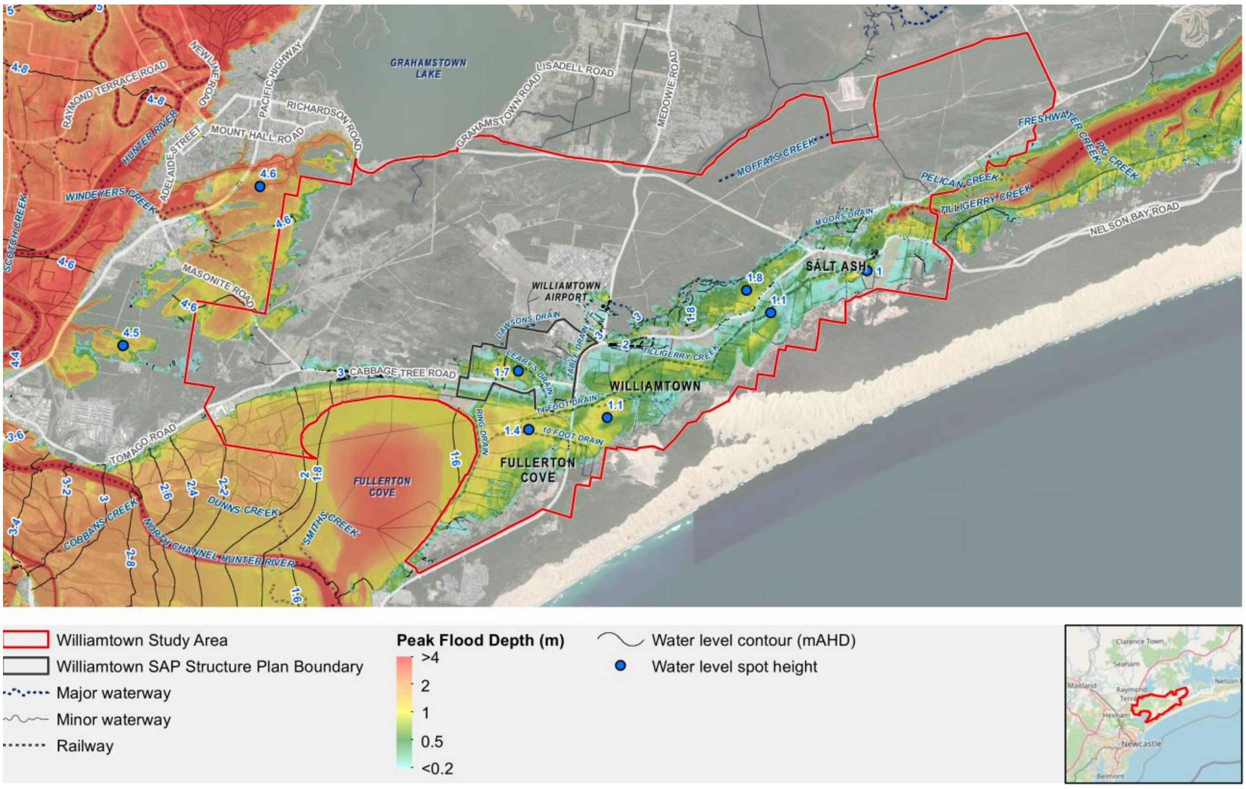


Figure 30: Regional 1% AEP Design Event – Modelled Flood Depths and Levels **Existing Condition**. Source: Aurecon

The climate change predictions show a trend of flood developing rainfall events to be more frequent and intense. As a result, higher peak flows and runoff volumes are expected to be feed into the Hunter River translating into an increase of Regional Flood inundation in the Williamtown SAP.

Figure 31 illustrates the flood influence of a 1% AEP event for the year 2100 under climate change conditions of +0.9m Sea Level Rise and Rainfall Intensity 20% (Flow) with flood depths are expected to increase to 1.0-2.0m across the floodplain.

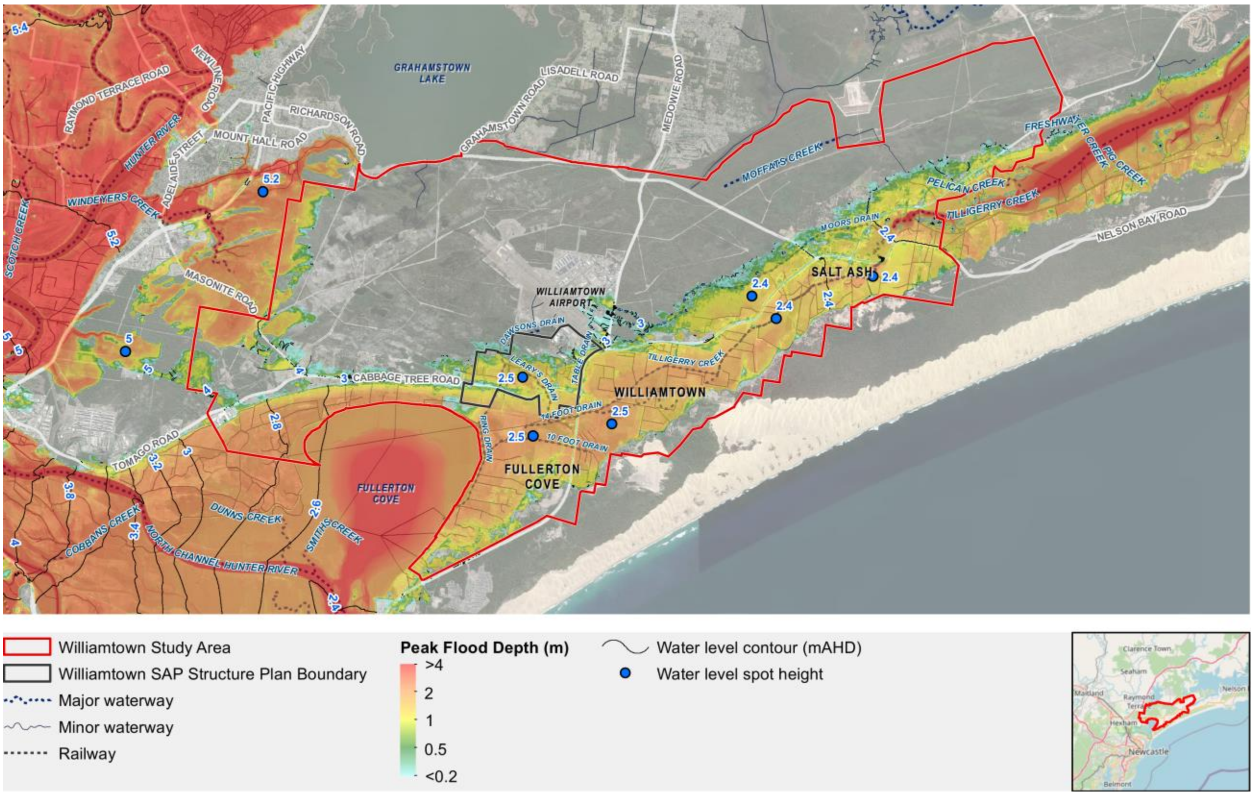


Figure 31: Regional 1% AEP Design Event – Modelled Flood Depths and Levels 2100 under +0.9m Sea Level Rise and 20% Flow. Source: Aurecon

Regional flooding under Probable Maximum Flood (PMF) conditions will influence a significant part of the Williamtown SAP including the Newcastle Airport. Flood depths under present conditions reach 4m or higher and are expected to further increase as consequence of more frequent and intense rainfall events.

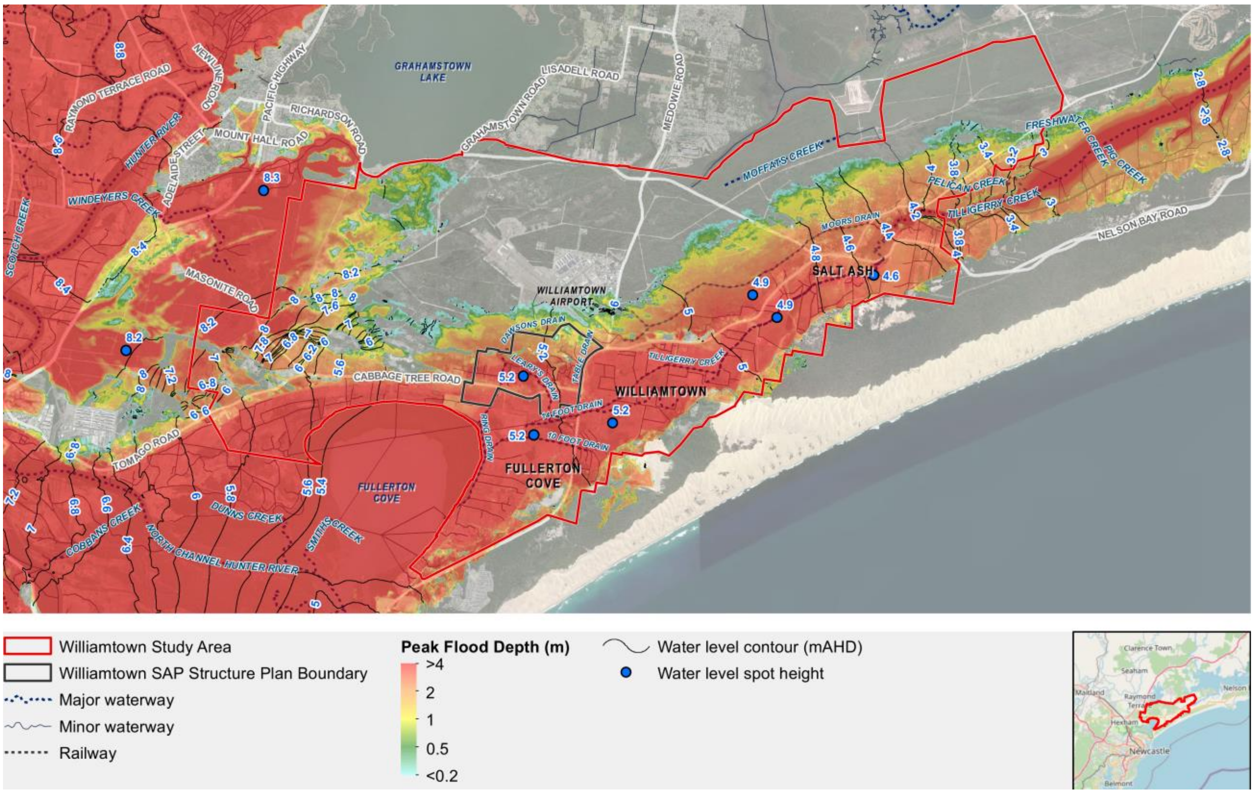


Figure 32: PMF peak flood depths and levels under Regional Flooding conditions. Source: Aurecon

3.5.2 Local Flooding

Local flooding is defined as being caused by flood producing rainfall over local catchment areas within the SAP, particularly

- Windeyers Creek,
- The Moors Drain,
- Tilligerry Creek, and
- Minor drainage channels feeding into Fullerton Cove, Tilligerry Creek or Hunter River.

The influence of Local Flooding is less severe than Regional Flooding but its likelihood to coincide with regional flooding and tidal inundation events limits its drainage ability and may result in expanded inundation duration.

The following results are taken from the Aurecon report, which is based on previous investigations by Umwelt (2018) and BMT (2017).

Under existing conditions, 1% AEP event flood depths range from 0.1 to 0.3m in most of the investigated area (refer Figure 33). However, some parts along the Tilligerry Creek Floodplains could reach flood depths of up to 1.0m.

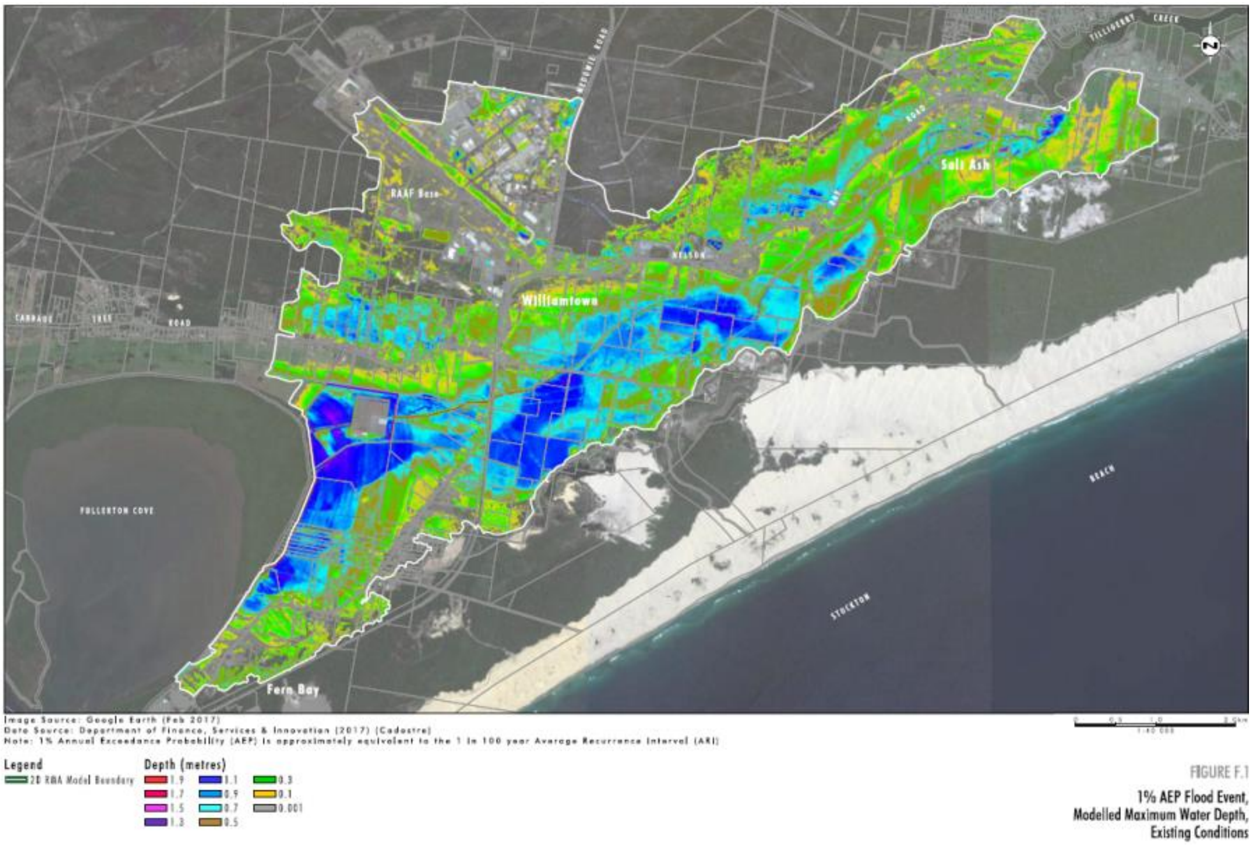


Figure 33: Peak flood depths of 1% AEP flood event from local catchments – Existing Conditions. Source: Aurecon

Under future climate change conditions, modelled 1% AEP flood depths are expected to increase with flood levels ranging from 0.1 to 0.7m outside the Tilligerry Floodplains and up to 1.5m (refer Figure 34). However, future flood depths between the northern of Cabbage Tree Road and to the south of Newcastle Airport appear to be similar to present flood levels.

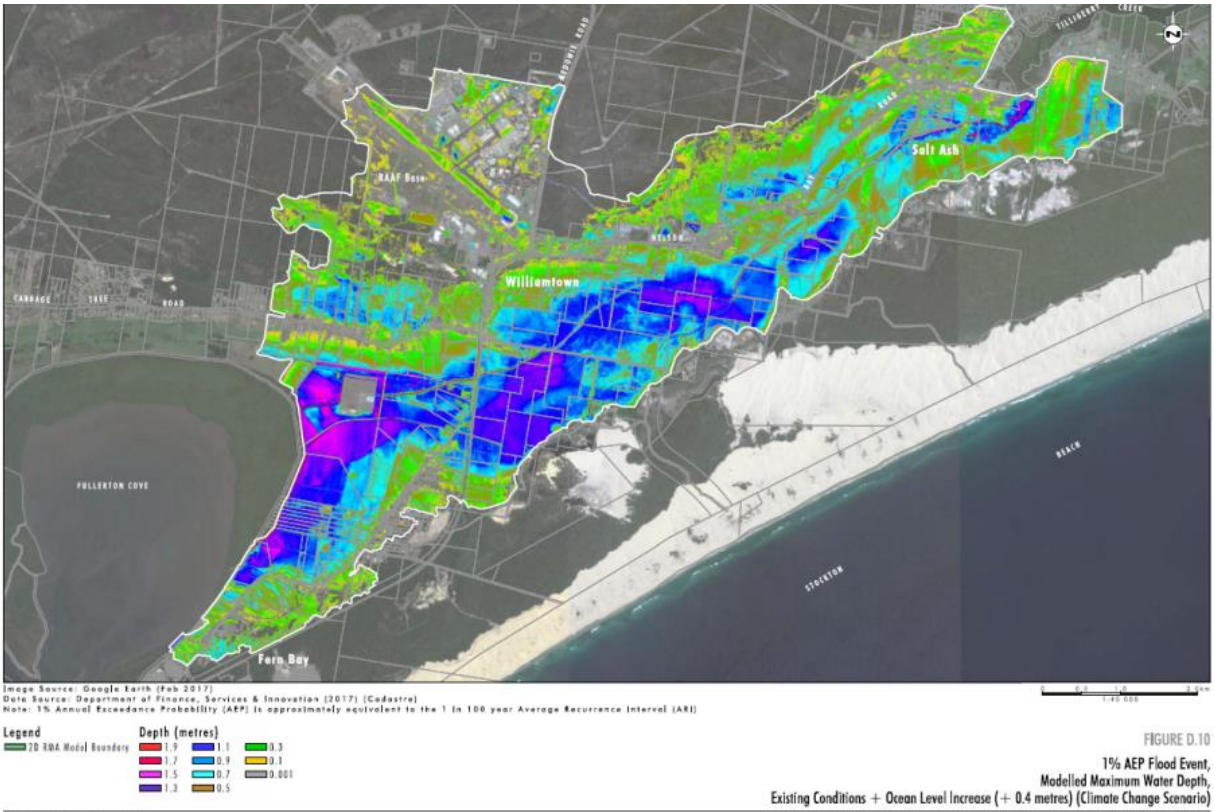


Figure 34: Peak flood depths of 1% AEP flood event from local catchments – Climate Change Conditions (Existing conditions +0.4m sea level rise). Source: Aurecon

3.5.3 Tidal Inundation/ Sea-Level rise

It is understood that tidal inundation is in close correlation with sea levels. As climate change projections expect mean sea level continue to rise and height of extreme sea-level events to increase, frequency and duration of tidal inundation is also expected to increase. Between 1966 and 2009, the average rate of relative sea-level rise for Australia was 2.1 mm/year which increased by 50% to 3.1 mm/year in the last third of the same period (1993-2009).

Using the resources of the CoastAdapt website, sea levels are expected to rise by approximately 0.19m in the near future (2030) and 0.58m in the far future (2070) along the coastline of the Port Stephens Council under RCP8.5 conditions (Figure 35).

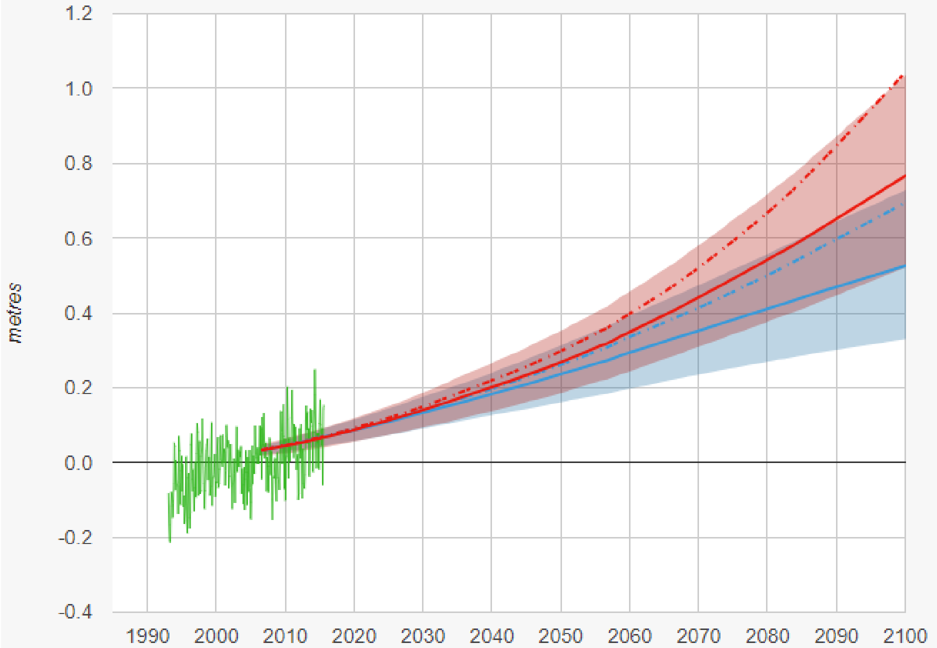


Figure 35: Sea Level Rise projections for RCP4.5 (blue) and RCP8.5 (red) emission scenarios for Port Stephens Council. Source: CoastAdapt

Port Stephens Council has adopted a sea-level-rise allowance of 0.4m by 2050 and 0.9m by 2100 under the high emissions scenario (RCP8.5) for floodplain planning in the LGA which is also consistent with the DECC Guideline (2007).

Based on the estimated sea-level-rise (refer Figure 35), flooding of coastal areas has been modelled by CoastAdapt. The inundation under a high sea-level rise scenarios (RCP8.5) uses a sea-level-rise of 0.27m by 2050 and 0.77m by 2100 combined with the nominal Highest Astronomical Tide (HAT) resulting in a maximum inundation level above mean sea level of 1.41m by 2050 (refer Figure 36) and 1.71m by 2100 (refer Figure 37).

Figure 36: Flood inundation due to SLR + HAT under RCP8.5 by 2050. Source: CoastAdapt

Figure 37: Flood inundation due to SLR + HAT under RCP8.5 by 2100. Source: CoastAdapt

As the inundation is modelled using high-resolution digital elevation data and a simple 'bucket fill' approach, existing levees and floodgates across the Williamtown SAP, which are managing and limiting the extent of tidal inundation to the lower lying floodplain areas, are not taking into account.

However, the Aurecon report points out that although these measures may be oversized (i.e. higher than current water levels) for present conditions they are likely to fail due to the expected increase in sea levels. As the report shows, the combination of high tides and projected future sea levels will bring existing water managing infrastructure to its limits.

The modelled tidal flood inundation (refer Figure 38) by the Coastal Risk Australia 2100 website illustrate the extension of flooding into additional areas by 2100 under a RCP8.5 emission scenario and an expected sea-level rise of 0.74m.

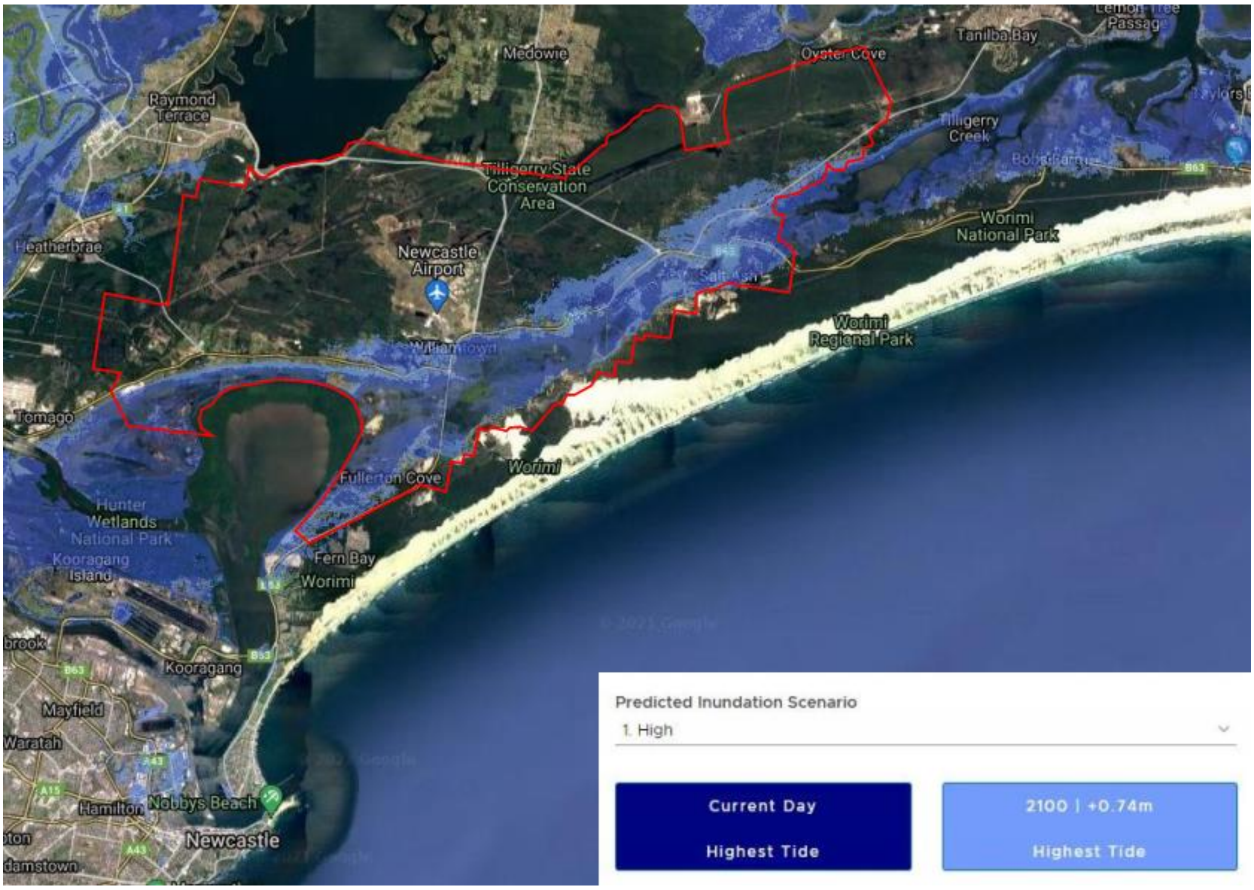


Figure 38: Tidal Inundation under current (dark blue) and projected 2100 (light blue) conditions. Source: Coastal Risk Australia 2100

Even a small increase in sea level can have devastating effects on coastal habitats and farther inland. Besides increasing the risk for flooding, rising sea levels can cause destructive erosion, contamination of groundwater layer and agricultural soil with salt, and destroy the natural habitats of flora and fauna.

3.6 Bushfire

Source: Bushfire Scenario Analysis, Bushfire Assessment Report, CSIRO Projections for Australia's NRM regions – East Coast (South), CSIRO Projections Tools, NASA, and Port Stephens Council

The impact of climate change on temperatures, humidity, and weather extremes will influence the frequency, duration and severity of bushfire events. Projected higher temperatures, increased evapotranspiration, and extreme but fewer rainfall events will increase the risk for severe bushfire events by extending dry periods, reducing water availability, and creating higher fuel load (dry vegetation).

Figure 39 shows the bush fire prone land within the Port Stephens Council wherein the Williamtown SAP is located. The bush fire prone land is separated into 3 categories based on vegetation type and potential bush fire risk:

- **Vegetation Category 1 (red):** Land considered to be the highest risk for bushfire and surrounded by a 100m buffer (buffer is yellow)
- **Vegetation Category 2 (light orange):** Land is considered to be a lower bush fire risk than categories 1 and 3. Surrounded by a 30m buffer (buffer is yellow).
- **Vegetation Category 3 (dark orange):** Land is considered to be a medium bush fire risk. Surrounded by a 30m buffer (buffer is yellow)

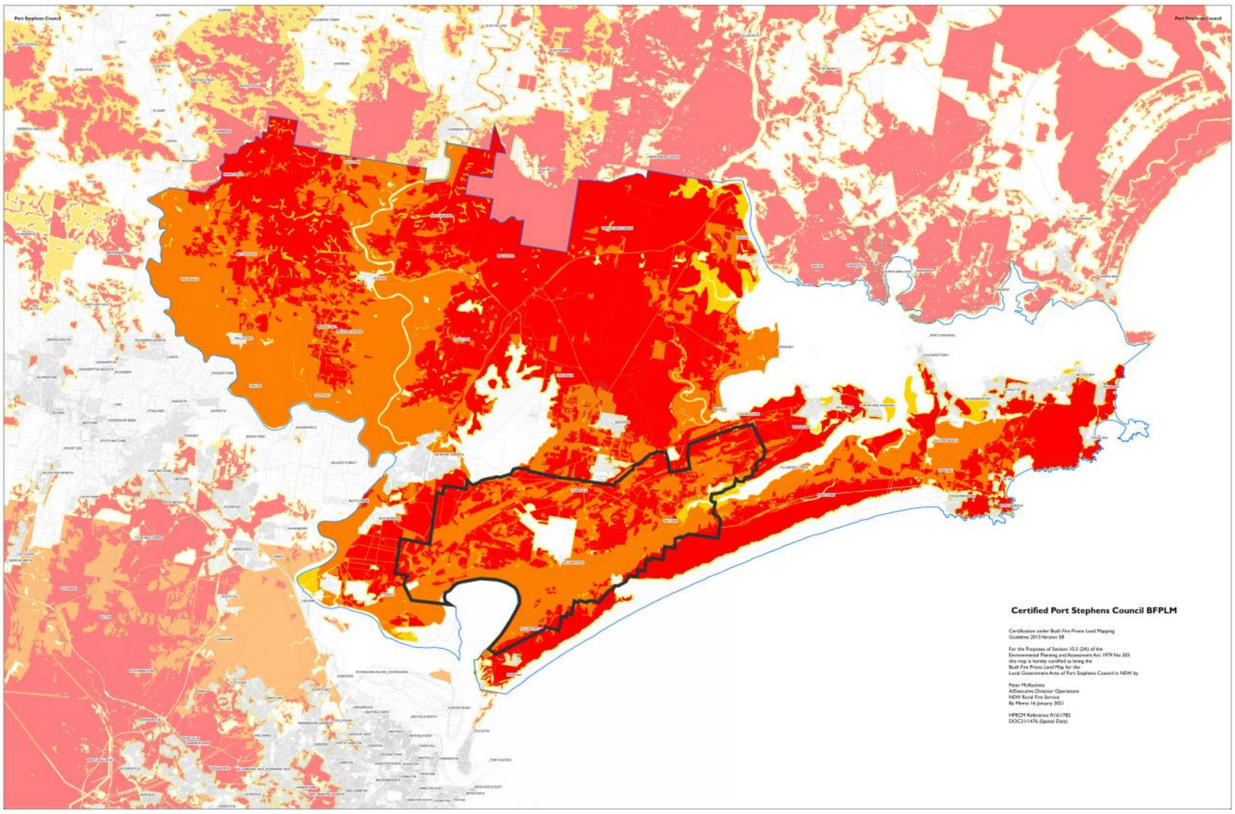


Figure 39: Bushfire prone land map with SAP Study Area. Source: Port Stephens Council

The Bushfire Scenario Analysis Report by ERM has assessed all three scenario options and identified that 42% to 66% of the area (depending on the scenario) is mapped as Vegetation Category 1 bushfire prone land, thus is at high risk to be directly impacted by bushfire.

As **Error! Reference source not found.** shows, the area of the Preferred Structure Plan is predominantly classified as Vegetation Category 1 and 3 with approximately 35% of the area between Cabbage Tree Road and Newcastle Airport being at a high bushfire risk.

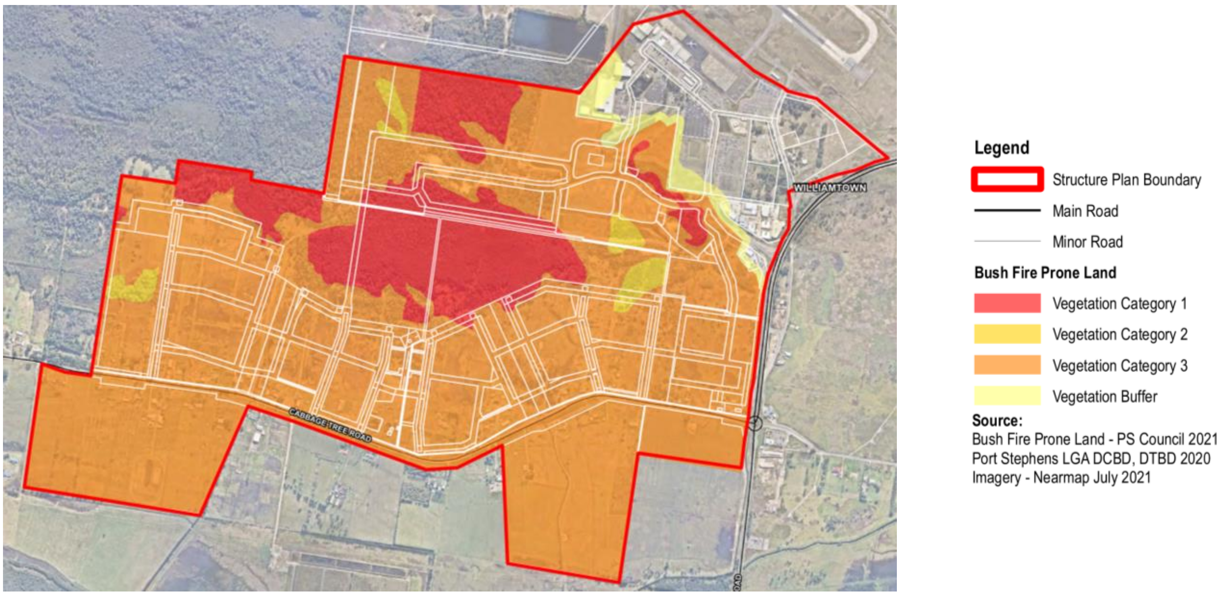


Figure 40: Bushfire prone land map, final Structure Plan. Source: ERM

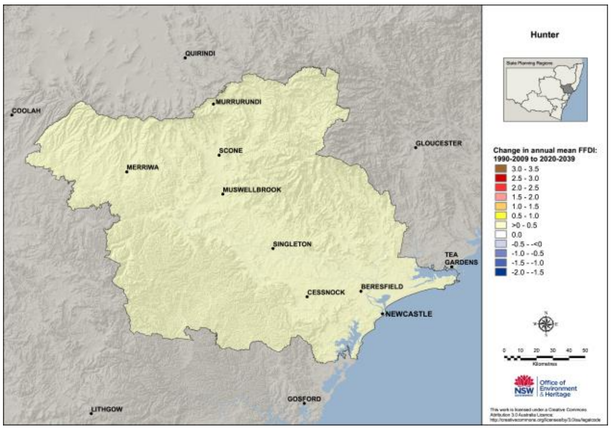
The Forest Fire Danger Index (FFDI) is used to quantify fire weather by combining observations of temperature, humidity and wind speed and is classified as severe when the FFDI is greater than 50.

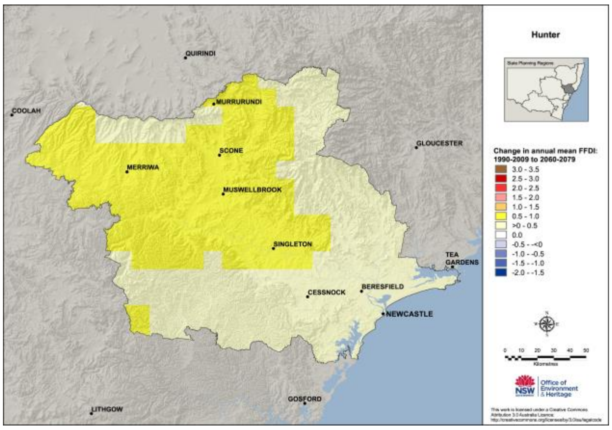
Bushfire producing conditions will worsen due to climate change and increase the chance of severe fire-weather which is projected to occur mainly in summer and, particularly, spring for the Hunter region (refer Figure 41). However, there is only a minimal increase predicted for the Williamtown SAP

Mean FFDI 2020-2039

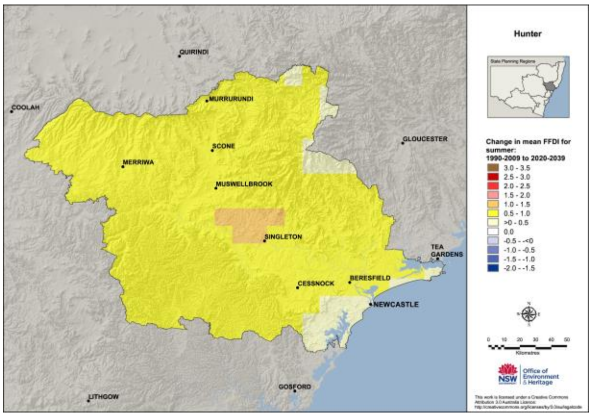
Mean FFDI 2060-2079

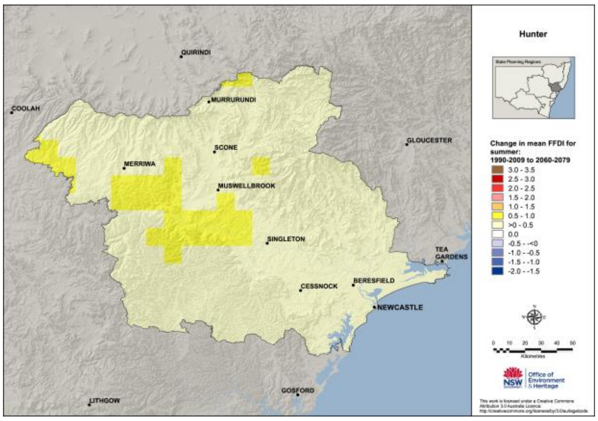
Annual



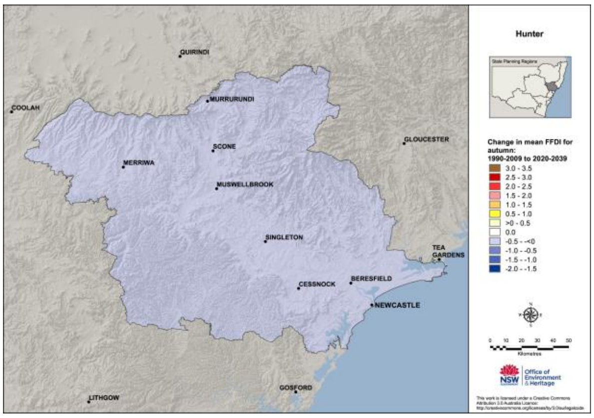


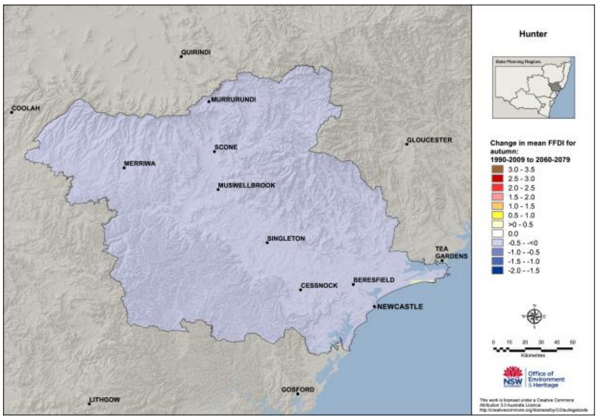
Summer



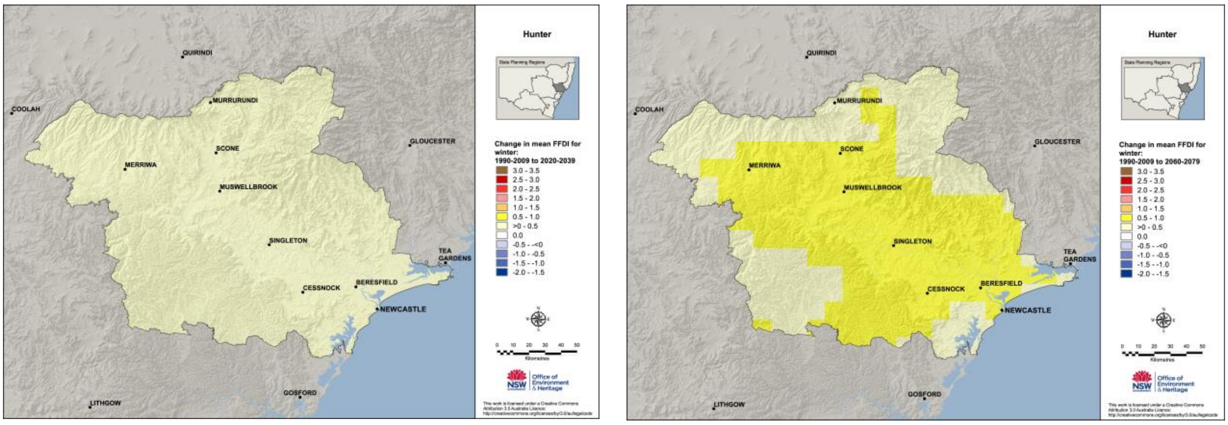


Autumn





Winter



Spring

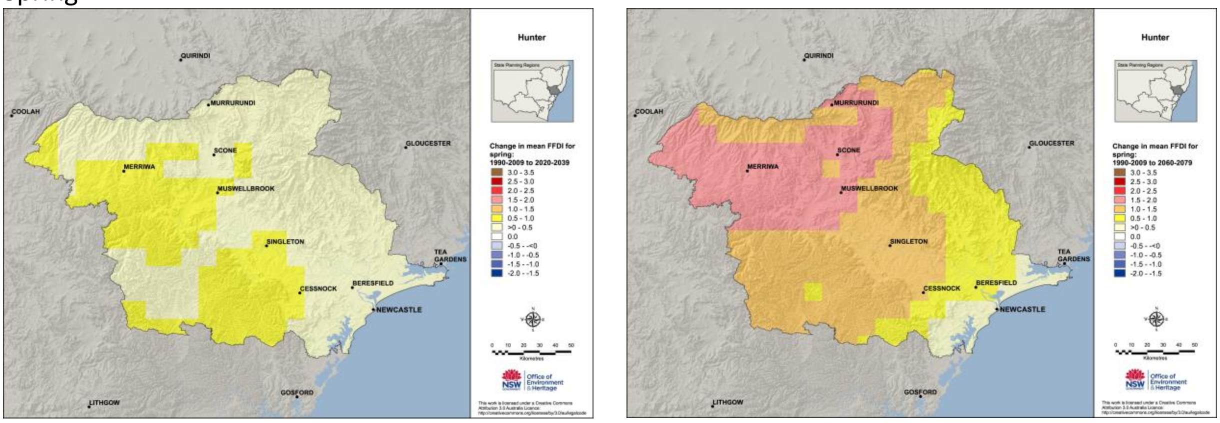
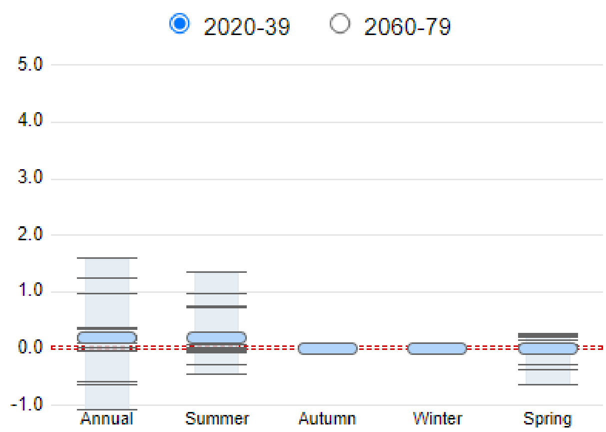


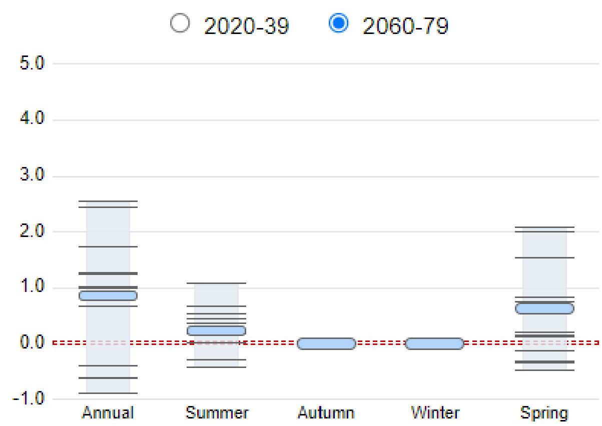
Figure 41: Projected annual and seasonal change in mean FFDI for the near (left) and far future (right). Source: Adapt NSW

The current number of severe fire days (FFDI >50) in Williamtown is 1.4 per year which is predicted to increase in the near and far future. Severe fire weather is predicted to minimal increase in the near and far future with being the largest during the prescribed burning season (spring) (refer Figure 42). However, the magnitude of the change is unclear and depends on rainfall projections and its seasonal variations.

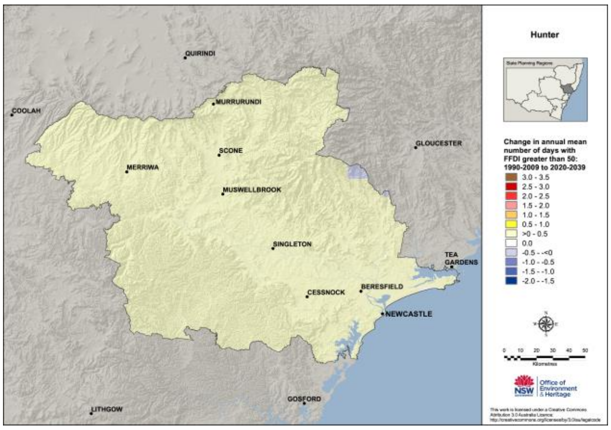
Severe FFDI 2020-2039

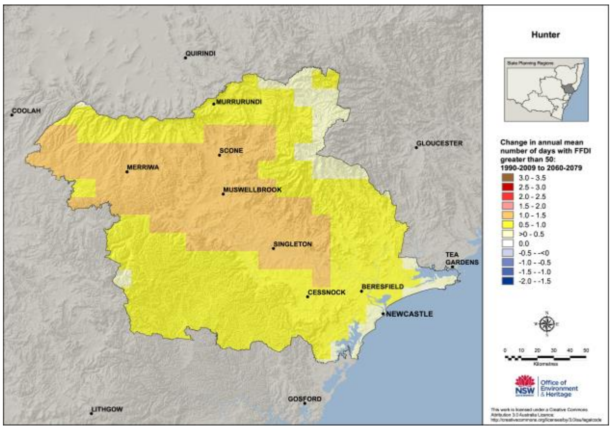


Severe FFDI 2060-2079

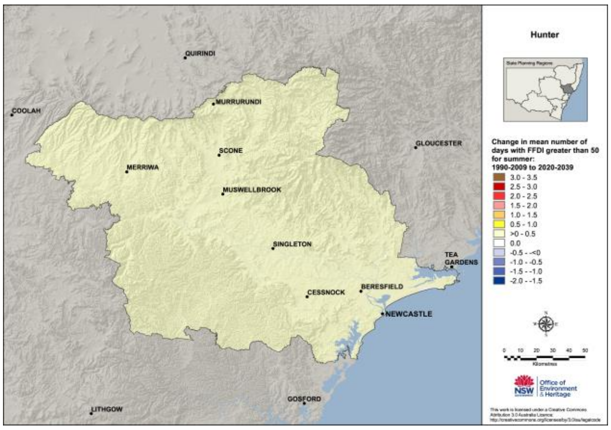


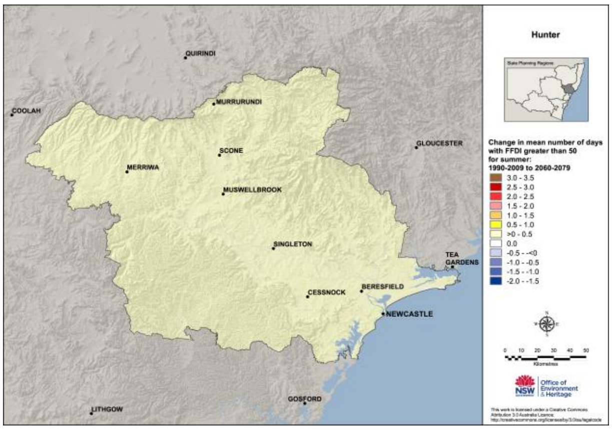
Annual



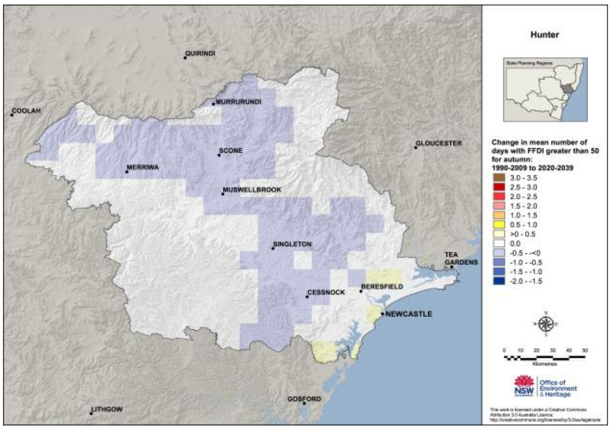


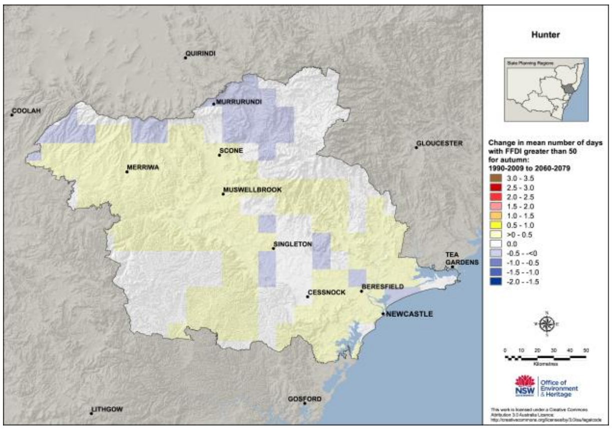
Summer



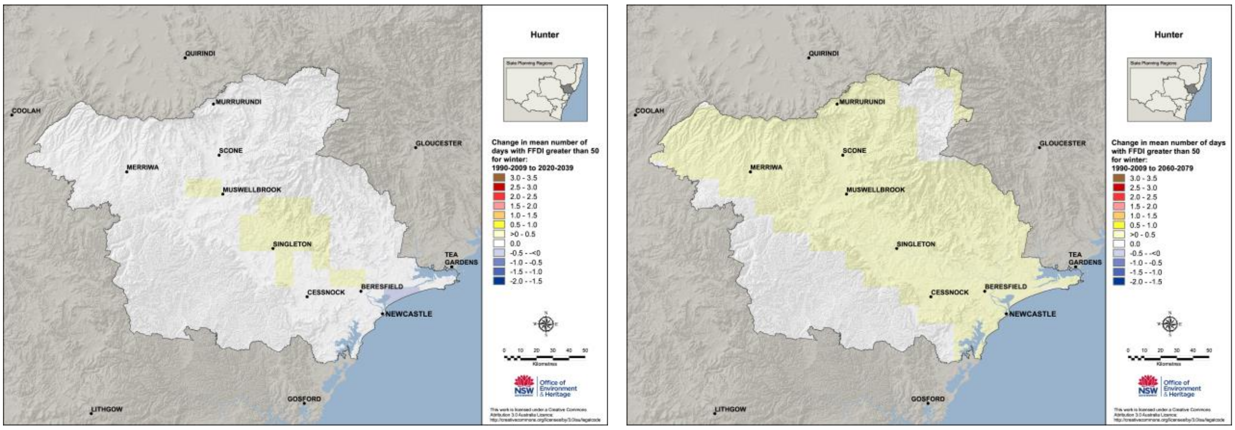


Autumn





Winter



Spring

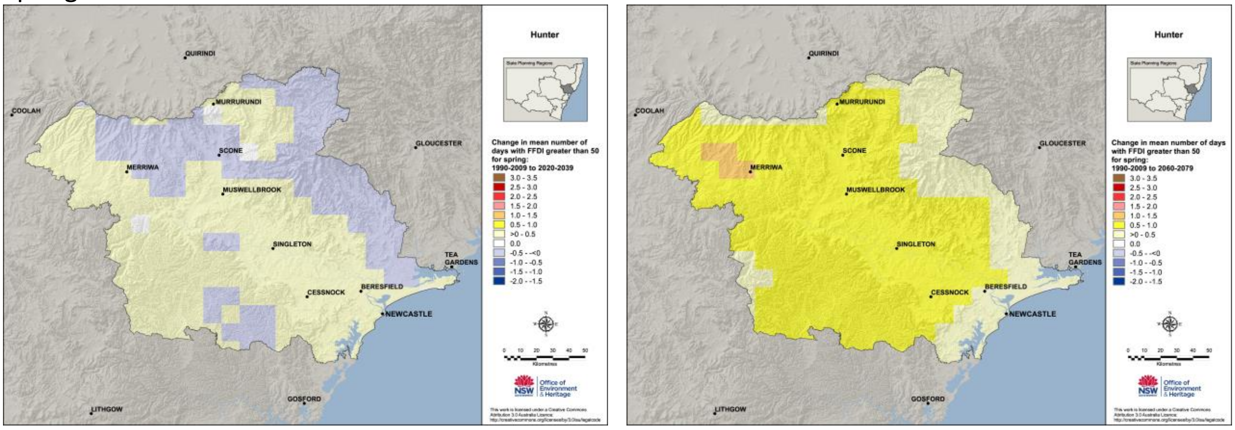


Figure 42: Projected annual and seasonal change in mean number of days with severe FFDI for the near (left) and far future (right). Source: Adapt NSW

We have further assessed the risk to the Williamtown SAP resulting from bushfire smoke inundation.

Being surrounded by areas largely mapped as medium to high bushfire prone land, the area could be at risk for smoke inundation even so no direct bushfire occurs on SAP ground. For example, on 30th December 2019 during the Black Summer Bushfires, smoke from bushfires in the Barrington Tops was carried all the way down to Port Stephens coast (refer Figure 43).

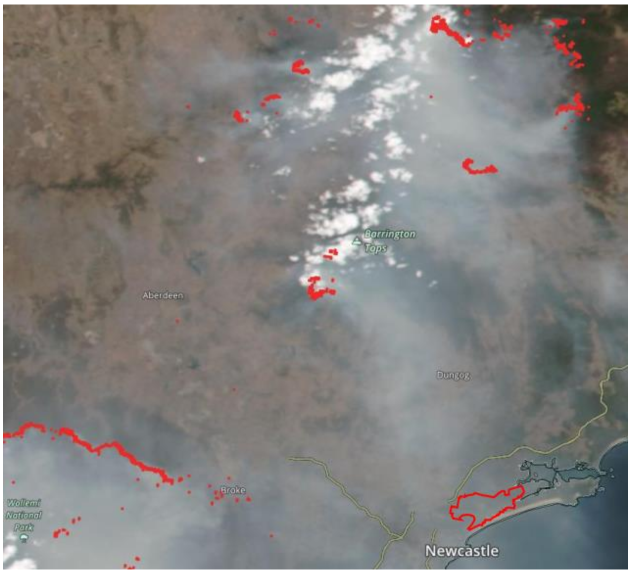


Figure 43: Inundation from bushfire smoke on Dec 30th, 2019. Source: NASA

Air quality data is obtained from the NSW Government, DPE database to assess the impact of PM2.5 and PM10 particulars. The station with PM10 and PM2.5 monitoring data closest to the SAP is located at Newcastle.

Figure 44 illustrates the average daily PM2.5 and PM10 concentrations from April 2019 to April 2020 in the investigated area with the World Health Organisation threshold for human health of 50 µg/m³ for PM10 and 25 µg/m³ for PM2.5 particles.

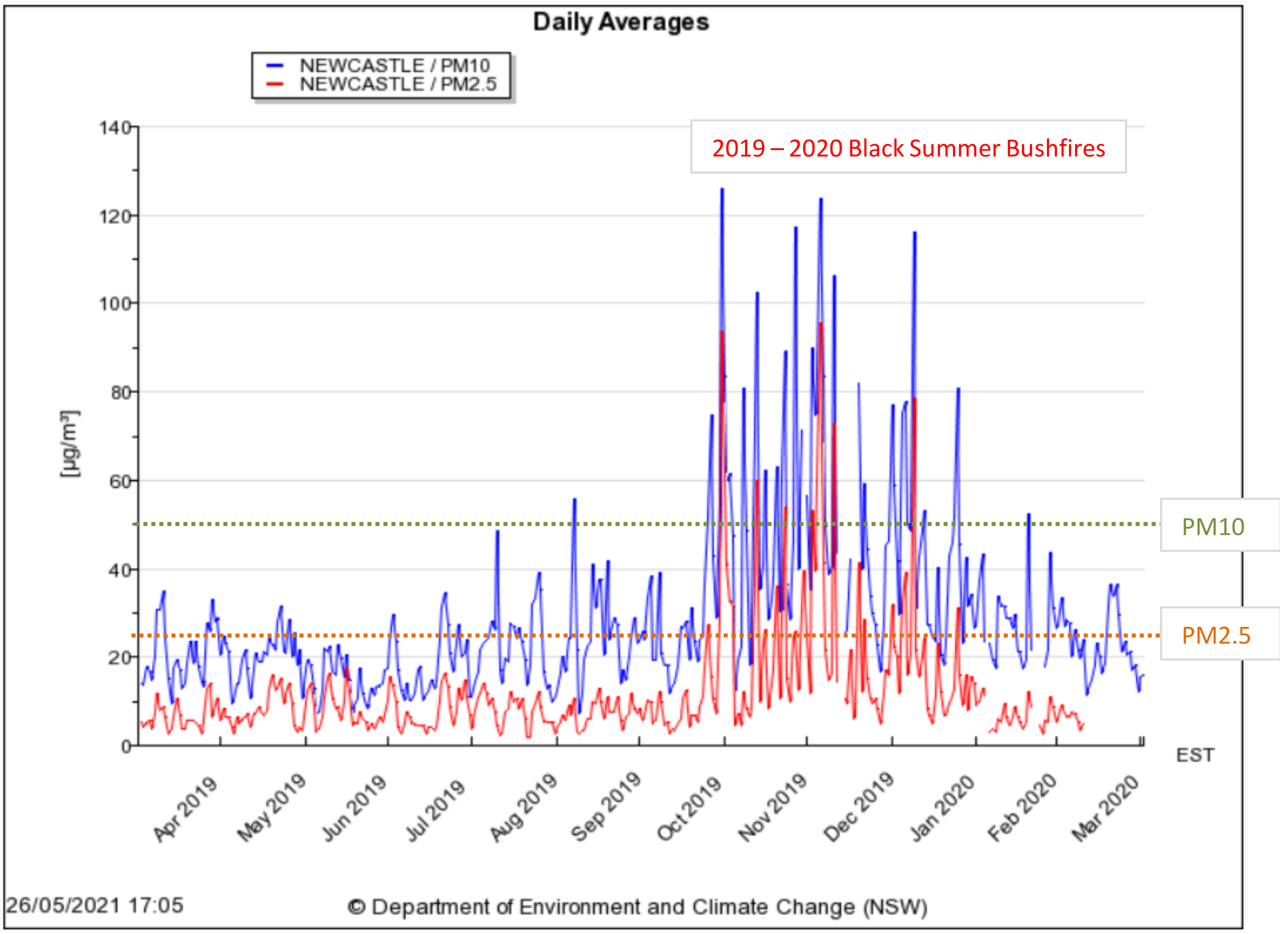


Figure 44: Daily average PM2.5 and PM10 levels in Newcastle, NSW. Source: DPE

Figure 45 shows that during bushfires the Williamtown SAP may be at high risk of being exposed to PM2.5 and PM10 levels above the threshold as a result of bushfire smoke inundation. During the 2019-2020 Black Summer Bushfires it occurred that the WHO threshold in the area for PM2.5 particulars was exceeded on 6 out of 7 days and for PM10 particulars on 5 out of 7 days.

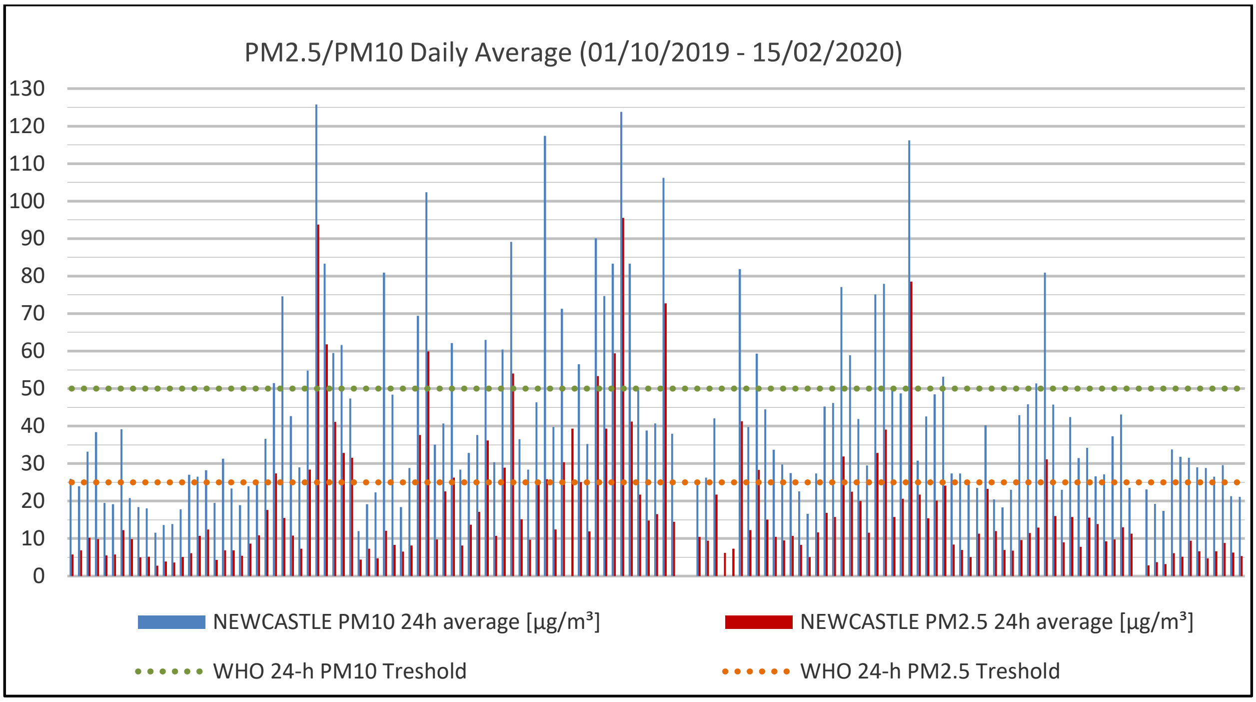


Figure 45: PM2.5 and PM10 daily average concentration during 2019-2020 Black Summer Bushfires, Newcastle. Source: DPE

3.7 Solar Radiation

Source: CSIRO Regional Climate Change Explorer – Sub-cluster East Coast (South)

Across all models, a slight increase in solar radiation is predicted particularly in winter and spring. However, little changes of the seasonal mean values across all RCPs reflect the high uncertainty in the predictions (refer Figure 46).

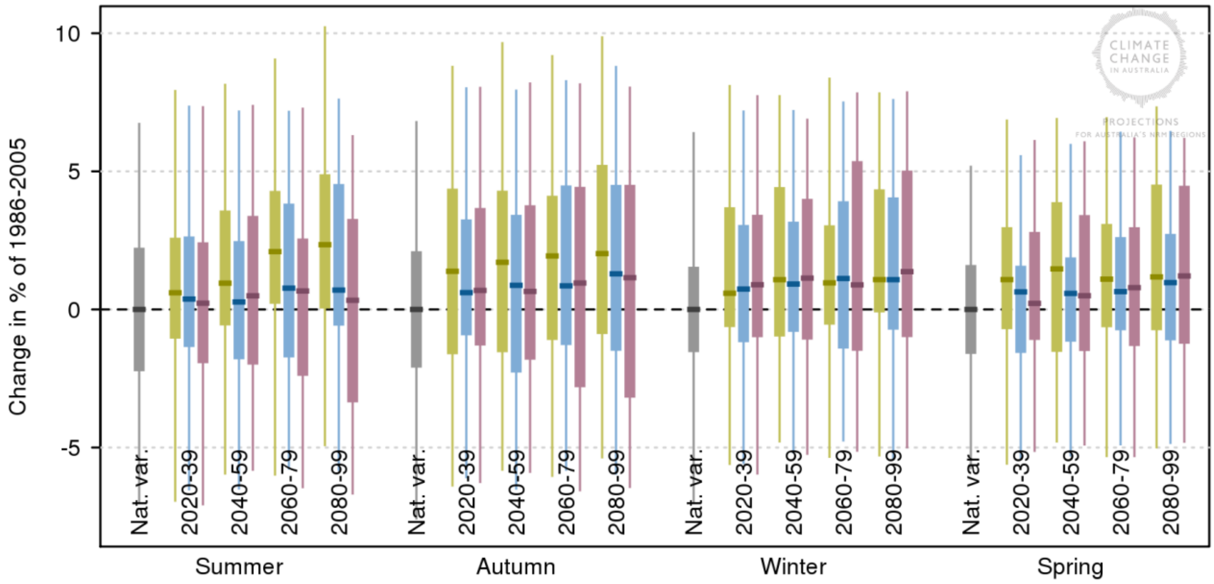


Figure 46: Projected seasonal solar radiation changes for the East Coast cluster with RCP2.6 (green), RCP4.5 (blue), RCP8.5 (purple) and median (dark horizontal lines). Natural climate variability is represented by the grey bar. Source: CSIRO

3.8 Wind

Source: CSIRO Climate Change Projections

For the East Coast region, predicted seasonal changes in surface wind speeds are expected to increase for spring and summer, particularly under RCP8.5 scenario. Changes for autumn and winter are less unclear (refer Figure 47) with an average declining trend.

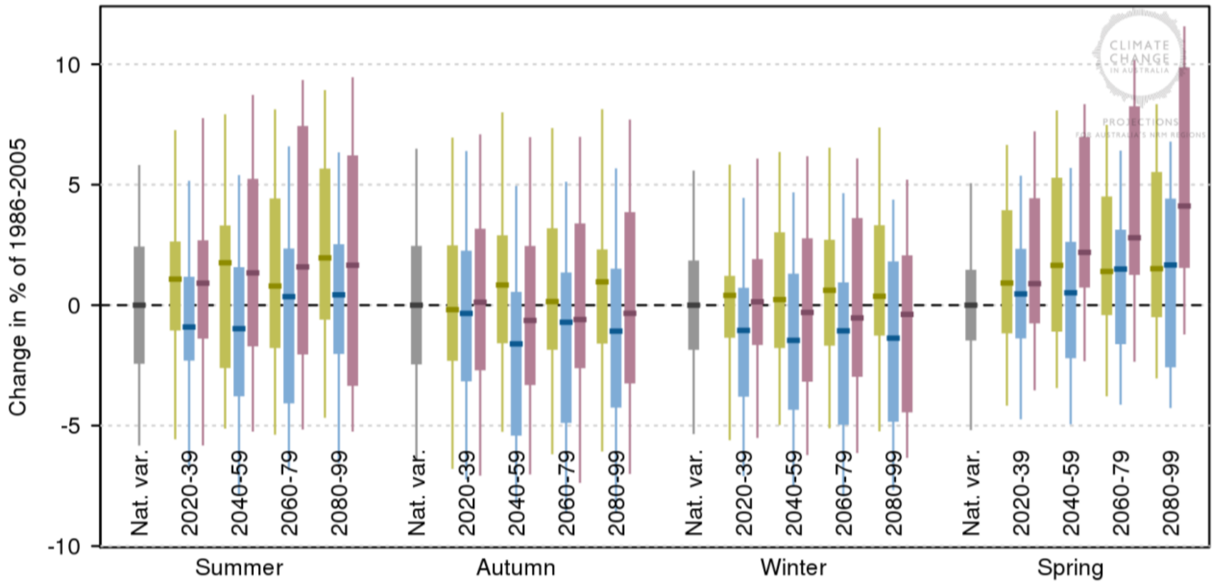


Figure 47: Projected seasonal wind speed changes for the East Coast cluster with RCP2.6 (green), RCP4.5 (blue), RCP8.5 (purple) and median (dark horizontal lines). Natural climate variability is represented by the grey bar. Source: CSIRO

3.9 Humidity

Source: CSIRO Climate Change Projections

A tendency for a decline in relative humidity is projected for all seasons (refer Figure 48).

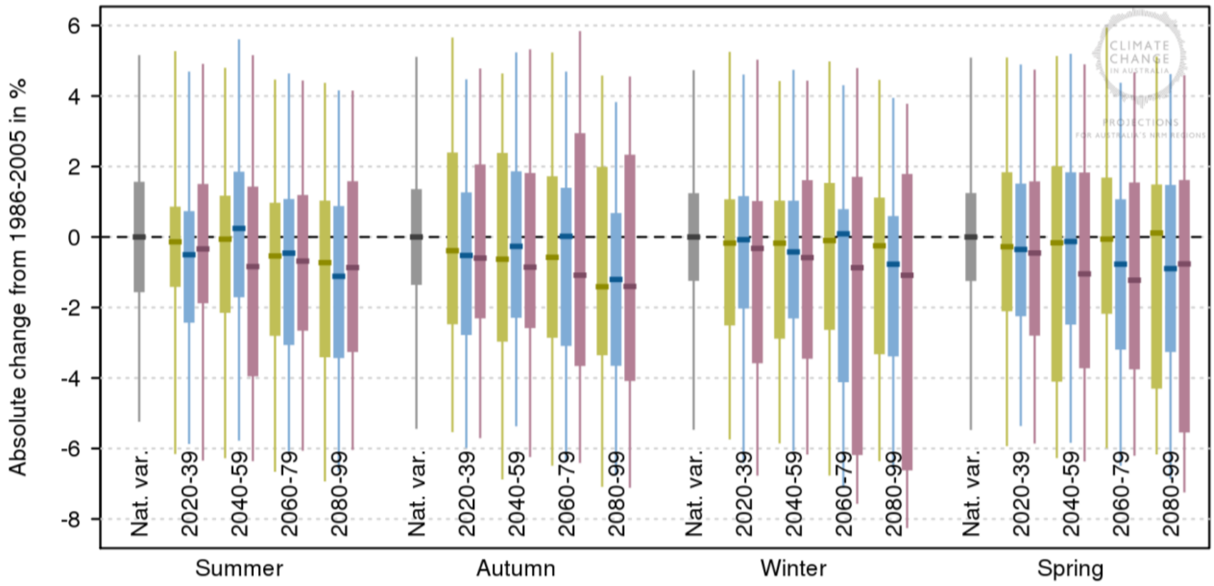


Figure 48: Projected seasonal humidity changes for East Coast with RCP2.6 (green), RCP4.5 (blue), RCP8.5 (purple) and median (dark horizontal lines). Natural climate variability is represented by the grey bar. Source: CSIRO Climate Change Projections

3.10 Evapotranspiration

Source: CSIRO Climate Change Projections

Potential water evapotranspiration (the combined effect of evaporation from water bodies, and the transfer of water from vegetation to the atmosphere) is projected to increase in all seasons as warming progresses (refer Figure 49).

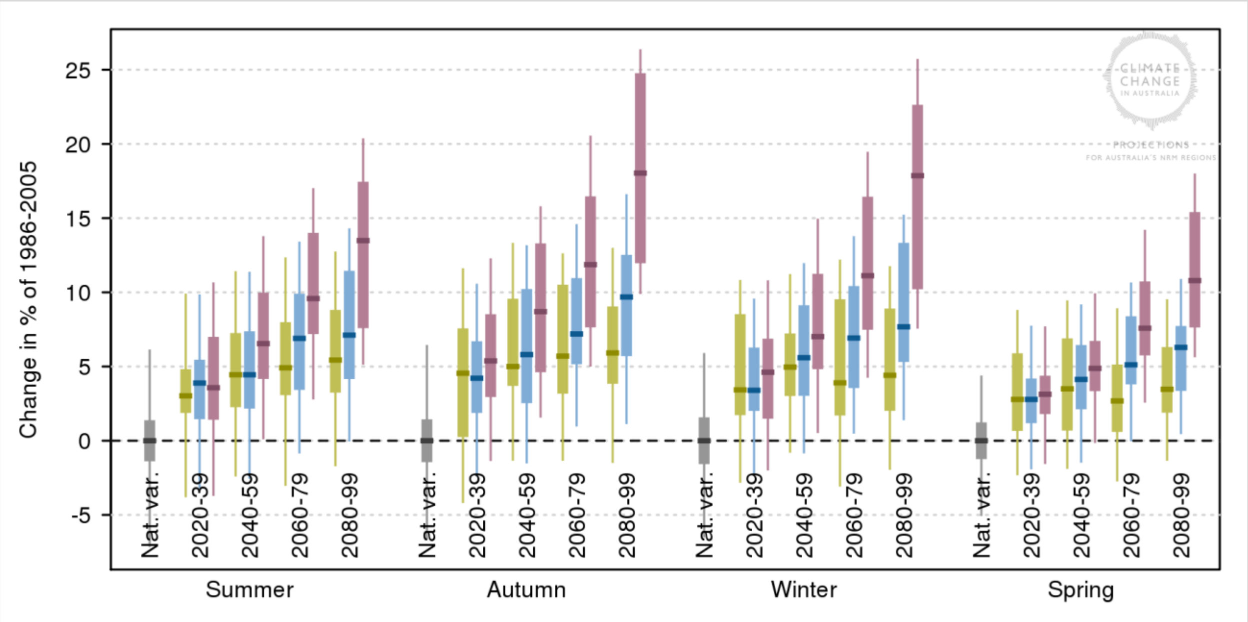


Figure 49: Projected seasonal evapotranspiration changes for East Coast with RCP2.6 (green), RCP4.5 (blue), RCP8.5 (purple). Source: CSIRO

Prospected rising evapotranspiration will fuel severe bushfire conditions by reducing water availability, creating drier vegetation and hotter surface temperatures.

Another effect of increased evapotranspiration is a higher rainwater runoff, as the dried-out soil has a reduced capability for absorbing surface water leading to an increased risk for flooding and erosion of bushland and farmland.

3.11 Biodiversity

Source: ERM Biodiversity Scenario Analysis, and Priorities for Biodiversity Adaptation to Climate Change

The ERM report concludes that climate change is expected to have a major impact on the biodiversity within the Williamtown SAP.

Approximately 60% of the SAP is identified as **High Biodiversity Value** area (ERM), accommodating a significant number of threatened and endangered species of flora and fauna. The combination of climate change impacts including temperature increases, rainfall variability and bushfire frequency is expected to significantly influence the biodiversity and increase threats from pest animals and weeds, habitat loss, and droughts.

While some species are expected to adapt to and benefit from the predicted changes others will experience negative impacts and may not fully recover. Previous adaptation strategies including evolving, moving, or behavior change may become more difficult for species the faster climate conditions change.

3.12 Summary

A summary of the climate change projections for the 2030 and 2070 development milestones used as basis for the risk assessment is as follows (refer Table 5):

Table 5: Climate change projections summary

Climate change risk		2030 Climate Change Projection	2070 Climate Change Projection
	Temperature increase	By 0.7°C	By 2.1°C
	Prolonged periods of high temperatures	5.1 to 7.1 days above 35°C	8.2 to 17.9 days above 35°C
	Reduced cold nights	0.0-0.3 nights below 2°C	Zero nights below 2°C
	Increased annual rainfall	Potential for small increase but largely variable annual rainfall harvest for the region. Largely variable rainfall for spring, summer and winter with 5% rainfall of both increase and decrease. 5 to 10% increase in rainfall during autumn.	5-10% increase in annual rainfall harvest for the region. 10-20% increase in rainfall during summer and autumn. Up to 5% increase in rainfall during winter and spring
	Increased rainfall intensity	Increased variability with higher rainfall intensity, however difficult to quantify.	Increased variability with higher rainfall intensity, however difficult to quantify.
	Increased flood inundation due to extreme rainfall events	Present 0.5-1.0m flood depths during 1% AEP event	By 2100 1.0-2.0m flood depths during 1% AEP event
	Sea Level Rise (SLR)	By 2050 0.27m SLR	By 2100 0.77m SLR
	Increased bushfire risk/intensity	Minimal change compared to current conditions.	Up to 1 day increase in extreme fire weather days per annum, most likely to occur in spring.

Climate change risk		2030 Climate Change Projection	2070 Climate Change Projection
	Increased solar radiation	Minor increase in solar radiation projected.	Minor increase in solar radiation projected.
	Increased wind speed	1.5% increase in mean wind speed in summer and spring. No change in autumn and winter	2.0 to 4.5% increase in mean wind speed in summer and spring, respectively. No change in autumn and winter
	Loss of biodiversity	High potential of exacerbation due to climate change and other human-induced impacts.	High potential of exacerbation due to climate change and other human-induced impacts.

4.1 Introduction

The purpose of this section of the report is to summarise the risk assessment undertaken to determine the perceived impact of the climate change projections on the developable areas and supporting infrastructure within the Williamtown SAP Study Area and final Structure Plan (refer Figure 50) and final Structure Plan (refer Figure 51).

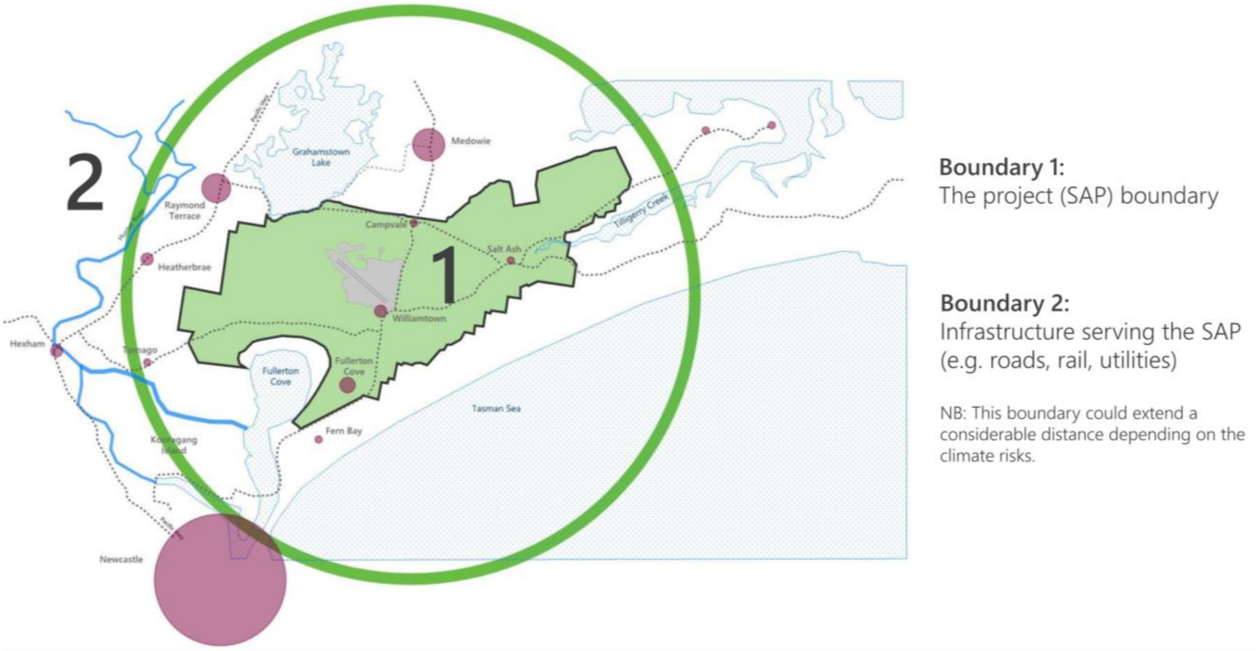


Figure 50: Risk Assessment zones and Williamtown SAP Study Area

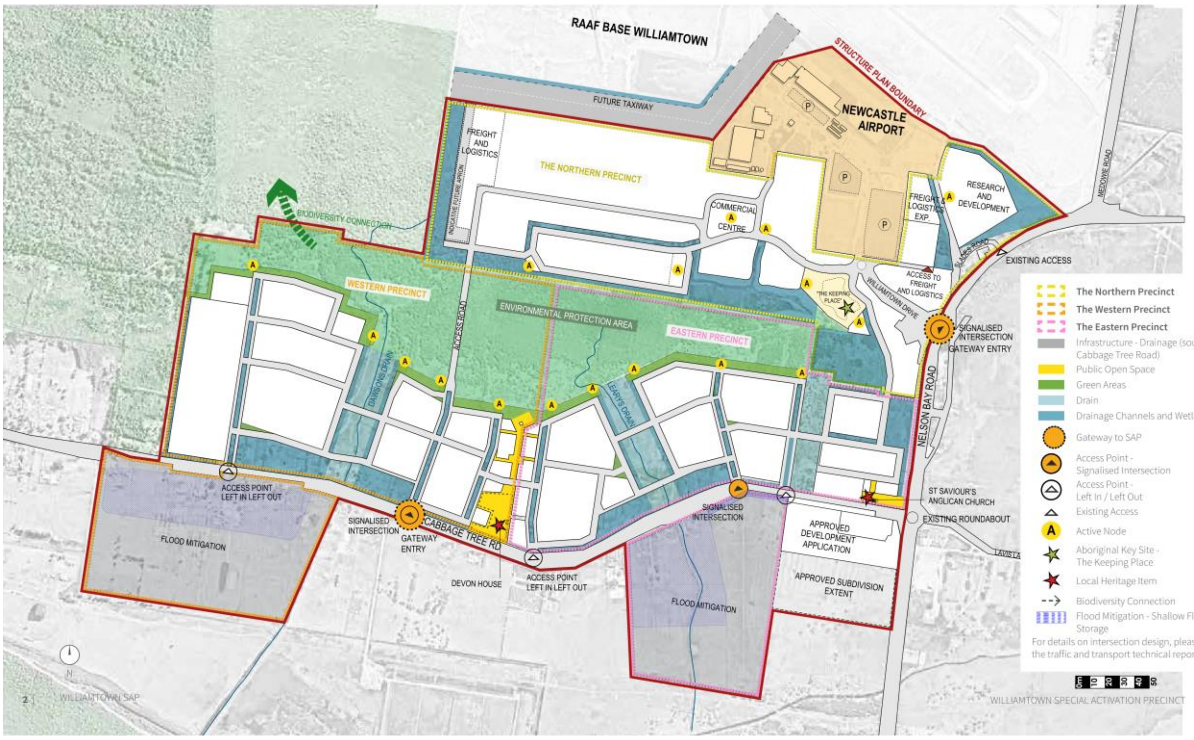


Figure 51: Final Williamtown SAP Structure Plan

The risk assessment was undertaken in three stages (refer Table 6):

Table 6: Risk assessment stages and consultation

Risk assessment stage	Summary
Stage 1	Stakeholders were provided the opportunity to provide risk assessment inputs during a risk assessment workshop held on 19th May 2021.
Stage 2	Stakeholders were provided access to the Moree SAP CCAP MURAL board to continue to add feedback and comments to the risk assessment undertaken during the workshop.
Stage 3	dsquared have undertaken a review of the stakeholder input, and all supporting technical reports for the Williamtown SAP, and have consolidated the risk assessment, supplementing it with technical input as required.

4.2 Scope of risk assessment

The scope of the risk assessment is limited to the developable areas identified in the SAP Structure Plan and the associated connecting services and transport infrastructure.

The scope of this risk assessment does not include:

- Specific risks to flora and fauna and associated mitigation measures. In general, the combined climate change impacts will have an impact on biodiversity with high level impacts and potential mitigation measures identified. However, specialist input for these risks is required and as they are larger in scope than the Williamtown SAP and this CCAP;
- any places or infrastructure outside of the SAP boundary including interconnecting services and transport infrastructure.

4.3 Risk assessment criteria

The risk assessment criteria used has been undertaken adapted from *AS 5334:2013 Climate Change Adaptation for Settlements and Infrastructure* and utilises the NSW Climate Risk Assessment Tool.

A multi-criteria analysis framework has been used to assign a risk level to each identified risk impact.

The first step is to identify the likelihood of the event occurring using the following categories and guidance:

Table 7: Risk likelihood

Rating	Recurrent risks	Single events
Almost certain	Could occur several times per year	More likely than not – probability greater than 50%
Likely	May arise about once per year	As likely as not – 50/50 chance
Possible	May arise once in 10 years	Less likely than not but still appreciable – probability less than 50% but still quite high

Rating	Recurrent risks	Single events
Unlikely	May arise once in 10 to 25 years	Unlikely but not negligible – probability low but noticeably greater than zero
Rare	Unlikely during the next 25 years	Negligible – probability very small, close to zero

The second step is to quantify the consequence of the impact using the following categories and guidance (refer Table 8):

Table 8: Risk consequence

Consequence and success criteria	Public safety	Local growth and economy	Community and lifestyle	Environment and sustainability	Public administration	Infrastructure
Catastrophic	Large numbers of serious injuries or loss of lives	Regional decline leading to widespread business failure, loss of employment and hardship	The region would be seen as very unattractive, moribund and unable to support its community	Major widespread loss of environmental amenity and progressive irrecoverable environmental damage	Public administration would fall into decay and cease to be effective	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service.
Major	Isolated instances of serious injuries or loss of lives	Regional stagnation such that businesses are unable to thrive and employment does not keep pace with population growth	Severe and widespread decline in services and quality of life within the community	Severe loss of environmental amenity and a danger of continuing environmental damage	Public administration would struggle to remain effective and would be seen to be in danger of failing completely	Extensive infrastructure damage requiring major repair. Major loss of infrastructure service.
Moderate	Small numbers of injuries	Significant general reduction in economic performance relative to current forecasts	General appreciable decline in services	Isolated but significant instances of environmental damage that might be reversed with intensive efforts	Public administration would be under severe pressure on several fronts	Limited infrastructure damage and loss of service. Damage recoverable by maintenance and minor repair.
Minor	Serious near misses or minor injuries	Individually significant but isolated areas of reduction in economic performance relative to current forecasts	Isolated but noticeable examples of decline in services	Minor instances of environmental damage that could be reversed	Isolated instances of public administration being under severe pressure	Localised infrastructure service disruption. No permanent damage. Some minor restoration work required.

Consequence and success criteria	Public safety	Local growth and economy	Community and lifestyle	Environment and sustainability	Public administration	Infrastructure
Insignificant	Appearance of a threat but no actual harm	Minor shortfall relative to current forecasts	There would be minor areas in which the region was unable to maintain its current services	No environmental damage	There would be minor instances of public administration being under more than usual stress but it could be managed	No infrastructure damage, little change to service.

The *likelihood* rating and the *consequence* rating are then considered together using the following matrix (refer Table 9) to establish the *risk rating*:

Table 9: Risk matrix

		Consequence				
		Insignificant	***Minor***	***Moderate***	***Major***	***Catastrophic***
Likelihood	***Almost certain***	Medium	Medium	High	Extreme	Extreme
	Likely	Low	Medium	High	High	Extreme
	Possible	Low	Medium	Medium	High	High
	Unlikely	Low	Low	Medium	Medium	Medium
	Rare	Low	Low	Low	Low	Medium

The risk ratings are contextualised as follows:

Low: The risk is of low importance and may be considered negligible. Unless the climate impact significantly increases over time no risk mitigation measures are considered necessary, with mitigation undertaken as a result of general routine maintenance.

Medium: The risk is significant as the impact will be measurable, and action will be required in order to mitigate the risk, such as a change in design standards and how assets are maintained and managed.

High: The risk is significant and will have a catastrophic impact and action must be undertaken as a high priority in order to mitigate the risk, at a senior management and governance level.

Extreme: The risk to the project is extreme and requires immediate action to mitigate the risk.

4.4 Risk assessment

A consolidated risk assessment is as follows (refer Table 10):

Table 10: Consolidated risk assessment

Climate change risk	Risk description	2030 Climate Change Risk Rating	2070 Climate Change Risk Rating
Temperature increase	Increased building energy use during hot period	Low	Medium
	Increased load on utility infrastructure and likelihood of brown outs / black outs	Low	Medium
	Increased heat island in public spaces and around developed/ industrial areas	Medium	High
	Increased water consumption associated with green infrastructure maintenance	Low	Medium
Increased hot days	Heat stress for the community population, including workforce, residents and visitors (relative heat wave impacts)	Medium	High
	Heat stress/ impacts on flora and fauna	Medium	High
	Increased demand and utilisation of public infrastructure for respite (parks/ reserves)	Medium	Medium
	Reduced reliability and functionality of infrastructure services including roads/rails, public buildings, and electricity supply	Low	High
Reduced cold nights	Reduced heating requirements in buildings in winter	n/a	n/a
	Changes to fauna lifecycle of those species dependent on winter hibernation (i.e. microbats)	Medium	High
Increased annual rainfall	Increased rainwater and stormwater harvesting potential	n/a	n/a
Increased rainfall intensity	Waterway flooding within and outside the SAP impacting access (including emergency vehicles)	Medium	Extreme
	Waterway flooding impacting built infrastructure	Medium	Extreme
	Increased erosion impacting built infrastructure (roads, walkways, etc.)	Low	High

Climate change risk	Risk description	2030 Climate Change Risk Rating	2070 Climate Change Risk Rating
	Increased waterway and catchment area flooding impacting stormwater management systems by decreasing their drainage capacity and effectiveness	Medium	High
	Increased risk of PFAS mobilisation due to extreme rainfall events and associated flooding	High	High
Sea Level Rise (SLR)	Inundation of built infrastructure including roads, buildings, utility infrastructure and community services	Medium	Extreme
	Stranded assets and relocation of infrastructure to higher elevations	Low	High
	Reduced flood protection function of Fullerton Cove levee	Low	Extreme
	Increased risk of PFAS mobilisation due to SLR and associated higher flooding risk and groundwater level	High	Extreme
	Flooding within and outside the SAP impacting access (including emergency vehicles)	Medium	High
	Increased risk for coastal erosion	Medium	High
Increased bushfire risk/intensity	Bushfire season expected to start earlier and extend into prescribed burning season (spring)	Medium	Extreme
	Increased risk ratings and fire life safety standards for new and replaced infrastructure	Low	High
	Damage/loss of utility infrastructure (electricity, water pumping stations, telecommunications)	Medium	High
	Loss of biodiversity and threatened species (particularly in Enviro zone)	High	High
	Inadequate buffers that do not incorporate climate change projections with increased likelihood of built infrastructure being impacted	Medium	High
	Impact on airport operations due to reduced visibility, ash, and direct flame impact on runway operations	Low	Medium

Climate change risk	Risk description	2030 Climate Change Risk Rating	2070 Climate Change Risk Rating
	Bushfire smoke inundation due to increase in potential frequency/ intensity	Medium	High
	Disruption to transport and evacuation routes due to road closures	Low	Medium
Increased solar radiation	Increased solar PV generation	n/a	n/a
Increased wind speed	Impacts on infrastructure due to increased sand movement across Stockton Bight	Low	Medium
	Impact on amenity during spring and summer	Low	Medium
	Damage to infrastructure due to increase in frequency and intensity of storm events	Medium	High
	Increased flood inundation due to combination of high tide and extreme storm events	Low	High
Loss of biodiversity	Migration or loss of species that are unable to cope with increasing temperature.	High	Extreme
	Fauna unable to migrate due to the lack of wildlife corridors	High	Extreme
	Increased invasive weed and pest animals competing with native flora and fauna	Medium	High
	Vegetation loss due to fragmentation i.e. flood inundation, dune transgression, new developments	Low	High

5 Risk Mitigation

5.1 Introduction

The purpose of this section of the report is to consider the risks identified, and propose mitigation strategies to be adopted by the Master Plan and Delivery Plan in order to reduce these risks to an appropriate level.

The risk mitigation measures have been adopted from those proposed during the stakeholder engagement process, captured on the MURAL board, and supplemented through consultation with the Technical Consultant team and input from dsquared.

As the SAP development program extends to at least 2060, the mitigation measures are those which deal with the climate risk rating at the 2070 milestone. The mitigation measures have been developed with the aim of reducing all current risk ratings to a residual risk rating of no higher than Medium.

5.2 Risk mitigation

A consolidated risk mitigation strategy is as follows (refer Table 11):

Table 11: Risk mitigation strategies

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
Temperature increase	Increased building energy use during hot period	Medium	1. The capacity of utility infrastructure (i.e. water and electricity networks) will need to be considered together with the anticipated growth as a result of the SAP as part of infrastructure planning. 2. New buildings and systems are to be designed with energy efficiency and energy use intensity standards established to reduce demand through efficient/sustainable design.	Low
	Increased load on utility infrastructure and likelihood of brown outs / black outs	Medium	1. The capacity of utility infrastructure (i.e. water and electricity networks) will need to be considered together with the anticipated growth as a result of the SAP as part of infrastructure planning. 2. Promotion of onsite renewable energy generation and battery back-ups.	Low

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	Increased heat island in public spaces and around developed/ industrial areas	High	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect, while not increasing bushfire risk.	Medium
	Increased water consumption associated with green infrastructure maintenance	Medium	1. Specify local native vegetation that requires less water and maintenance but is able to cope with projected temperature increase. 2. Integrate WSUD into streetscapes to integrate stormwater capture and treatment.	Low
Increased hot days	Heat stress for the community population, including workforce, residents and visitors (relative heat wave impacts)	High	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect, while not increasing bushfire risk. 2. Provide adequate capacity for community heat stress respite e.g. free access to air conditioned/shaded spaces such as libraries, shopping, and community centres. 3. Design new buildings which are thermally resilient and therefore act as a first line of defence against heat stress. 4. Develop an existing building upgrade programme to introduce an equivalent level of thermal resilience as new buildings. 5. Implement a community resilience plan including networked communications, health and heat stress support programmes, particularly for those particularly vulnerable to heat stress e.g. outdoor workers.	High
	Heat stress/ impacts on flora and fauna	High	1. Support and maintain wildlife corridors to allow animals to migrate and seek shelter.	High
	Increased demand and utilisation of public infrastructure for respite (parks / reserves)	Medium	1. Provide adequate capacity for community heat stress respite e.g. free access to air conditioned/shaded spaces such as community centres, libraries and shops.	Medium
	Reduced reliability and functionality of infrastructure services including roads/rails,	High	1. Implement an effective program of infrastructure monitoring, maintenance and upgrades.	Medium

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	public buildings, and electricity supply		2. Design and construct new infrastructure capable of withstanding future climate change projected impacts. 3. Consider the provision of new supporting infrastructure to improve reliability, for example water storage and energy storage systems such as batteries.	
Reduced cold nights	Reduced heating requirements in buildings in winter	n/a	No risk identified for the SAP	n/a
	Changes to fauna lifecycle of those species dependent on winter hibernation (i.e. microbats)	High	1. Wildlife is expected to have a small amount of capacity to adapt or migrate to regions with more suitable climate conditions. However some species will not be able to adapt or migrate and a detailed biodiversity study into the impacts of climate change is required.	High
Increased annual rainfall	Increased rainwater and stormwater harvesting potential	n/a	No risk identified for the SAP	n/a
Increased rainfall intensity	Waterway flooding within and outside the SAP impacting access (including emergency vehicles)	Extreme	1. Raise essential emergency routes (Nelson Bay Rd, Cabbage Tree Rd) above predicted flood levels to ensure flood immunity and prevent surrounding communities from flooding by overtopping.	Medium
	Waterway flooding impacting built infrastructure	Extreme	1. Avoid new developments in designated floodplain areas. 2. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 3. Water management strategies to be incorporated in land use planning and development guidelines.	Extreme

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	Increased erosion impacting built infrastructure (roads, walkways, etc.)	High	1. Water sensitive urban design (WSUD) measures to be incorporated in all developable areas. 2. Incorporate 'soft' measures (i.e. trees) to reduce erosion and water runoff.	Low
	Increased waterway and catchment area flooding impacting stormwater management systems by decreasing their drainage capacity and effectiveness	High	1. Integrated water management plan, to be developed to place clear targets and supporting infrastructure plans in place for future demand and capacity changes. 2. Improve drainage and discharge capacity of existing network.	Medium
	Increased risk of PFAS and non-PFAS contaminants mobilisation due to extreme rainfall events and associated flooding	High	1. PFAS contamination needs consideration in floodplain management and water sensitive urban design strategies to manage flooding and water quality across the SAP. 2. Flood retention to mitigate impacts on downstream development. 3. Floodplain storage offsets and preserving floodway capacity to mitigate impacts on upstream and adjacent development. 4. Augmentation of existing drainage works to improve effectiveness of flood mitigation works. 5. Accommodating flood impacts and acquiring/repurposing severely flood affected property. 6. If feasible, groundwater pumped, treated and reinjected into the aquifer. 7. Passive treatment systems constructed of PAC to be installed downstream to deal with small amounts of PFAS contamination.	High

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
Sea Level Rise (SLR)	Inundation of built infrastructure including roads, buildings, utility infrastructure and community services	Extreme	1. Avoid new developments in designated floodplain areas. 2. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 3. Water management strategies to be incorporated in land use planning and development guidelines.	Medium
	Stranded assets and relocation of infrastructure to higher elevations	High	1. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater.	Medium
	Reduced flood protection function of Fullerton Cove levee	Extreme	1. Consider raising Fullerton Cove levee.	Medium
	Increased risk of PFAS mobilisation due to SLR and associated higher flooding risk and groundwater level	Extreme	1. Augmentation of existing drainage works to improve effectiveness of flood mitigation works. 2. Accommodating flood impacts and acquiring/repurposing severely flood affected property.	Extreme
	Flooding within and outside the SAP impacting access (including emergency vehicles)	Extreme	1. Raise essential emergency routes (Nelson Bay Rd, Cabbage Tree Rd) above predicted flood levels to ensure flood immunity and prevent surrounding communities from flooding by overtopping.	Medium
	Increased risk for coastal erosion	High	1. Consider use of soft methods such as 'Green Belt', artificial reef and/or soft rock structures to reduce wave impact and storm surges by stabilising shoreline.	Medium
Fire weather	Bushfire season expected to start earlier and extend into prescribed burning season (spring)	Extreme	1. Organised local prevention burns to maintain vegetation build up all year-round 2. Incorporate indigenous fire practices in bushfire management	Extreme

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	Increased risk ratings and fire life safety standards for new and replaced infrastructure	High	1. Consider bushfire risk rating and resilience when designing and building all new infrastructure. 2. Include "build back better" requirements in the development assessment rules (SAP SEPP and Delivery Plan) when restoring infrastructure after a bushfire event.	Medium
	Damage/loss of utility infrastructure (electricity, water pumping stations, telecommunications)	High	1. Establish reasonable clear zones and ensure proper maintenance of vegetation build up beneath power lines or around significant assets. 2. Undertake a Strategic Bushfire Risk Assessment to understand the bushfire hazard risk and ensure proposed uses that are compatible with the bushfire risk e.g. if there is a high risk avoid vulnerable uses / increasing density 3. Asset owners to undertake a network review of redundancy in power and water systems. Asset owners to model and understand how they would run their networks if certain connections were taken offline due to fire. Scenario analysis to be run and understood in case of emergencies. 4. Need to consider the resilience of planned infrastructure to natural hazard events, including the cost benefits of buildings and infrastructure to withstand bushfire inundation.	Medium
	Loss of biodiversity and threatened species (particularly in Enviro zone)	High	No specific mitigation strategies have been proposed, as this is a secondary impact of large-scale bushfire occurrence.	High
	Inadequate buffers that do not incorporate climate change projections with increased likelihood of built infrastructure being impacted	High	1. Ensure land use considers fire risk. 2. Make sure industries and land uses vulnerable to fire/smoke are provided with appropriate evacuation capabilities and are located away from the hazards	High
	Impact on airport operations due to reduced visibility, ash, and	Medium	No mitigation strategy has been identified for this. This is considered to be a secondary impact of bushfire.	Medium

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	direct flame impact on runway operations			
	Bushfire smoke inundation due to increase in potential frequency/ intensity	High	No mitigation strategy has been identified for this for the outdoor areas. This is considered to be a secondary impact of bushfire. 1. All new buildings constructed highly airtight with mechanical ventilation system and capable of accommodating MERV14 filters. 2. Blower door testing of municipal emergency assembling facilities to assess the feasibility and implementation of airtightness and mechanical ventilation upgrades.	High
	Disruption to transport and evacuation routes due to road closures	Medium	1. Ensure road networks have adequate capacity to cater for a full evacuation at all points during the SAP development and growth cycle.	Medium
Increased solar radiation	Increased solar PV generation	n/a	No risk identified for the SAP	n/a
Wind speed	Impacts on infrastructure due to increased sand movement across Stockton Bight	Medium	1. Incorporation of sensitive wind fencing structures in landscaping to reduce intensive sand movement	Low
	Impact on amenity during spring and summer	Medium	No mitigation strategy has been identified for this.	Low
	Damage to infrastructure due to increase in frequency and intensity of storm events	High	1. Establish reasonable clear zones and ensure proper maintenance of vegetation build up next to power lines or around significant assets.	Medium

Climate change risk	Risk description	2070 Risk Rating	Mitigation Measures	Residual Risk Rating
	Increased flood inundation due to combination of high tide and extreme storm events	High	1. Water management strategies to be incorporated in land use planning and development guidelines. 2. Avoid new developments in designated floodplain areas. 3. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 4. Consider raising Fullerton Cove levee.	Medium
Loss of biodiversity	Migration or loss of species that are unable to cope with increasing temperature.	Extreme	1. Develop a biodiversity and natural habitat management plan, including a governance and finance structure, and implement it	High
	Fauna unable to migrate due to the lack of wildlife corridors	Extreme	1. Establish appropriate wildlife corridors between different National parks and reserves.	High
	Increased invasive weed and pest animals competing with native flora and fauna	High	1. Identify and monitor biodiversity value of local areas. 2. Establish pest and weed management program, including education of local residents and land owners 3. Prioritise pest management efforts and allocate resources to most beneficial areas	Medium
	Vegetation loss due to fragmentation i.e. flood inundation, dune transgression, new developments	High	1. Implement mitigation strategies as outlined above to minimise fragmentation of natural vegetation and habitats. 2. Incorporating biodiversity assessment in land use planning and development guidelines with new developments in areas with low level of biodiversity, incorporated sensitive design strategies in medium biodiversity areas and no new developments in high biodiversity areas.	High

6 Inputs to Master Plan

6.1 Introduction

The risk assessment and review process has identified a series of mitigation measures that will need to be implemented in order to reduce the risk impact resulting from climate change. A number of these mitigation measures require a review of the draft Master Plan, a review of the measures by the Structure Team Technical Consultants, and may result in a change or input to the finalised Master Plan document, subject the results of these further reviews.

The purpose of this section of the report is to summarise those mitigation measures that require action by the Structure Plan/Master Plan teams, and where possible to allocate the lead role in actioning this to a Technical Consultant.

It is noted that a number of identified mitigation measures have already been documented in sufficient detail in the Technical Reports and Structure Plan such that no further action is required. These are summarised in Section 7 of this report, which schedules the mitigation Measures that need to be followed through via the SAP Delivery Plan.

6.2 Inputs to Master Plan

Mitigation Measures requiring review and input from the Structure Plan/Master Plan teams are scheduled as follows (refer Table 12):

Table 12: Structure Plan/Master Plan - Mitigation measures

Climate change risk	Risk description	Mitigation Measures	Recommended action	Lead Technical Consultant
Temperature increase	Increased heat island in public spaces and around developed/ industrial areas	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect, while not increasing bushfire risk.	1. Review urban planning and development strategies to check if adequate provisions have been made, while appropriately planning for increased bushfire risks.	Roberts Day / Cred

Climate change risk	Risk description	Mitigation Measures	Recommended action	Lead Technical Consultant
Increased hot days	Heat stress for the community and workers, including residents and visitors (relative heat wave impacts) Increased demand and utilisation of public infrastructure for respite (parks/ reserves)	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect. 2. Provide adequate capacity for community heat stress respite e.g. free access to air conditioned/shaded spaces such as community centres and outdoor areas.	1. Review Public Space strategy and Structure Plan to check if adequate provisions have been made including indoor and outdoor areas of respite, in particular around higher density areas and industrial zones which are expected to have higher heat load.	Roberts Day / Cred
	Reduced reliability and functionality of infrastructure services including roads/rails, public buildings, and electricity supply	1. Consider the provision of new supporting infrastructure to improve reliability, for example water storage, and energy storage systems such as batteries.	1. Review Technical Study reports and update if additional provisions, such as electrical infrastructure upgrades and energy storage provisions, are required.	Aurecon
Increased rainfall intensity	Increased erosion impacting built infrastructure (roads, walkways, etc.)	1. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 2. Water sensitive urban design (WSUD) measures to be incorporated in all developable areas. 3. Incorporate 'soft' measures (i.e. trees) to reduce erosion.	1. Review Flooding and Water Cycle Management and Hydrogeology reports and update if additional provisions are required. 2. Confirm latest Structure Plan incorporates sufficient provisions for increased rainfall intensity.	Aurecon / Roberts Day
Sea Level Rise (SLR)	Inundation of built infrastructure including roads, buildings, utility infrastructure and community services	1. Avoid new developments in designated floodplain areas. 2. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing	1. Review Flooding and Water Cycle Management and Hydrogeology reports and update if additional provisions are required.	Aurecon / Roberts Day

Climate change risk	Risk description	Mitigation Measures	Recommended action	Lead Technical Consultant
		properties and developments, and substantially impede the flow of floodwater. 3. Water management strategies to be incorporated in land use planning and development guidelines.	2. Confirm latest Structure Plan incorporates risks identified in the Climate Change Risk Assessment Workshop.	
Increased bushfire risk/intensity	Disruption to transport and evacuation routes due to road closures	1. Ensure road networks have adequate capacity cater for a full evacuation at all points during the SAP development and growth cycle.	1. Review Traffic and Transport report and update if additional provisions are required.	Aurecon / Roberts Day
Loss of biodiversity	Migration or loss of species that are unable to cope with increasing temperature.	1. Develop a biodiversity and natural habitat management plan, including a governance and finance structure, and implement it	1. Review Biodiversity report and update if additional provisions are required.	ERM / Roberts Day
	Increased invasive weed and pest animals competing with native flora and fauna	1. Identify and monitor biodiversity value of local areas and potential climate impacts.		
	Vegetation loss due to fragmentation i.e. flood inundation, new developments	1. Incorporate biodiversity assessments in land use planning and development guidelines with new developments in areas with low level of biodiversity, incorporated sensitive design strategies in medium biodiversity areas and no new developments in high biodiversity areas.		

7 Inputs to Delivery Plan

7.1 Introduction

The ongoing development of the Williamtown SAP and the initiation of all new supporting infrastructure projects and investor led projects, will be driven by the SAP Delivery Plan. The Delivery Plan will reference a series of supporting documents which may include but may not necessarily be limited to:

- Design and Development standards and guidelines;
- Performance targets to be achieved including energy, water, waste, and environmental protection;
- Planning Rules including a new SAP SEPP, and Port Stephens Council LEPs; and
- A SAP Environmental Management System (EMS) framework.

The Delivery Plan is due to be prepared following the release of the Master Plan and, DPE have expressed the importance of ensuring that climate change risks and mitigation measures are fully recognised within it.

This section of the report therefore summarises the mitigation measures that need to be recognised and incorporated within the Delivery Plan.

7.2 Governance

Throughout the development of the Structure Plan and Master Plan, and repeatedly voiced again during the stakeholder engagement undertaken to develop this CCAP, it has been made clear that climate change mitigation measures will only be followed through into action if there is a clear, strong, and fully funded governance structure in place.

The over-arching recommendation is that a formalised governance structure is in place, with supporting policy, planning and operational legislative requirements, monitoring and reporting mechanisms facilitating the implementation of the CCAP. The governance structure will require membership and investment from multiple agencies and businesses to be successful.

7.3 Inputs to Delivery Plan

The inputs required to the Delivery Plan and supporting documents are scheduled as follows (refer Table 13):

Table 13 Delivery Plan Inputs

p	Risk description	Mitigation Measures	Delivery Plan action
Temperature increase	Increased building energy use during hot periods	1. The capacity of utility infrastructure (i.e. water and electricity networks) will need to be considered together with the anticipated growth as a result of the SAP as part of infrastructure planning. 2. New buildings and systems are to be designed with energy efficiency and energy use intensity standards established to reduce demand through efficient/sustainable design.	1. Include utility infrastructure growth planning in the Delivery Plan. 2. Include new building design standards in the Delivery Plan.
	Increased load on utility infrastructure and likelihood of brown outs / black outs	1. The capacity of utility infrastructure (i.e. water and electricity networks) will need to be considered together with the anticipated growth as a result of the SAP as part of infrastructure planning. 2. Promotion of onsite renewable energy generation and battery back-ups.	1. Include utility infrastructure growth planning in the Delivery Plan. 2. Include renewable energy provisions in Delivery Plan.
	Increased heat island in public spaces and around developed/ industrial areas	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect, while not increasing bushfire risk.	1. Include minimum requirements for green infrastructure in the Delivery Plan, and associated design and development guidelines, to reduce heat island effect.
	Increased water consumption associated with green infrastructure maintenance	1. Specify local native vegetation that requires less water and maintenance but is able to cope with projected temperature increase.	1. Include minimum landscaping and planting requirements in the Delivery Plan, and associated design and development guidelines.

p	Risk description	Mitigation Measures	Delivery Plan action
Increased hot days 	Heat stress for the community population, including residents and visitors (relative heat wave impacts)	1. Urban development planning to include green landscaping, tree canopies, and other natural ways to reduce heat island effect, while not increasing bushfire risk. 2. Provide adequate capacity for community heat stress respite e.g. free access to air conditioned/shaded spaces such as community centres and outdoor areas. 3. Design new buildings which are thermally resilient and therefore act as a first line of defence against heat stress. 4. Develop an existing building upgrade programme to introduce an equivalent level of thermal resilience as new buildings. 5. Implement a community resilience plan including networked communications, health and heat stress support programmes, particularly for those particularly vulnerable to heat stress.	1. Include minimum requirements for green infrastructure in the Delivery Plan to reduce heat island effect. 2. Incorporate and monitor community support and respite facilities and services as part of formal governance systems (e.g. ISO 14001 EMS) 3. Include new building design standards in the Delivery Plan. 4. Include an upgrade program for existing buildings in the Delivery Plan, and guidance on how to upgrade the buildings to meet the future standards required. 5. Develop a community resilience plan to be included in the Delivery Plan
	Heat stress/ impacts on flora and fauna	1. Support and maintain wildlife corridors to allow animals to migrate and seek shelter.	1. Include this requirement in the Delivery Plan and governance structures (e.g. ISO 14001 EMS).
	Increased demand and utilisation of public infrastructure for respite (parks/ reserves)	1. Provide adequate capacity for community heat stress respite e.g. free access to air conditioned/shaded spaces such as community facilities and commercial areas.	1. Include this requirement in the Delivery Plan and governance structures (e.g. ISO 14001 EMS).
	Reduced reliability and functionality of infrastructure services including roads/rails,	1. Implement an effective program of infrastructure monitoring, maintenance and upgrades.	1. Include this requirement in the Delivery Plan and governance structures (e.g. ISO 14001 EMS).

p	Risk description	Mitigation Measures	Delivery Plan action
	public buildings, and electricity supply	2. Design and construct new infrastructure capable of withstanding future climate change projected impacts. 3. Consider the provision of new supporting infrastructure to improve reliability, for example water storage and energy storage systems such as batteries.	2. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
Increased rainfall intensity 	Waterway flooding within and outside the SAP impacting access (including emergency vehicles)	1. Raise essential emergency routes (Nelson Bay Rd, Cabbage Tree Rd) above predicted flood levels to ensure flood immunity and prevent surrounding communities from flooding by overtopping.	1. Include this requirement in the Delivery Plan, and associated design and development guidelines, for the upgrade of existing roads and provision of new roads.
	Waterway flooding impacting built infrastructure	1. Avoid new developments in designated floodplain areas. 2. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 3. Water management strategies to be incorporated in land use planning and development guidelines.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
	Increased erosion impacting built infrastructure (roads, walkways, etc.)	1. Include increased rainfall intensity and erosion risks in infrastructure planning and designs. 2. Water sensitive urban design (WSUD) measures to be incorporated in all developable areas. 3. Incorporate 'soft' measures (i.e. trees) to reduce erosion.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.

p	Risk description	Mitigation Measures	Delivery Plan action
	Increased waterway and catchment area flooding impacting stormwater management systems by decreasing their drainage capacity and effectiveness	1. Integrated water management plan to be developed to place clear targets and supporting infrastructure plans in place for future demand and capacity changes. 2. Improve drainage and discharge capacity of existing network.	1. Develop integrated water management plan, including water hierarchy guidance, and include requirements in the Delivery Plan.
	Increased risk of PFAS and non-PFAS contaminants mobilisation due to extreme rainfall events and associated flooding	1. PFAS contamination needs consideration in floodplain management and water sensitive urban design strategies to manage flooding and water quality across the SAP. 2. Flood retention to mitigate impacts on downstream development. 3. Floodplain storage offsets and preserving floodway capacity to mitigate impacts on upstream and adjacent development. 4. Augmentation of existing drainage works to improve effectiveness of flood mitigation works. 5. Accommodating flood impacts and acquiring/repurposing severely flood affected property. 6. If feasible, groundwater pumped, treated and reinjected into the aquifer. 7. Passive treatment systems constructed of PAC to be installed downstream to deal with small amounts of PFAS contamination.	1. Include guidance relating for these requirements in the Delivery Plan, and associated design and development guidelines. 2. Include monitoring of PFAS contamination remediation as part of development requirements in the Delivery Plan and continue engaging with the Department of Defence for latest PFAS remediation programs.

p	Risk description	Mitigation Measures	Delivery Plan action
Sea Level Rise (SLR)	Inundation of built infrastructure including roads, buildings, utility infrastructure and community services	1. Avoid new developments in designated floodplain areas. 2. Local land filling as option to reduce flood affection on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 3. Water management strategies to be incorporated in land use planning and development guidelines.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
	Reduced flood protection function of Fullerton Cove levee	1. Consider raising Fullerton Cove levee.	This mitigation measure is outside of the SAP boundary and direct control, however will require a coordinated approach across government.
	Increased risk of PFAS mobilisation due to SLR and associated higher flooding risk and groundwater level	1. Augmentation of existing drainage works to improve effectiveness of flood mitigation works. 2. Accommodating flood impacts and acquiring/repurposing severely flood affected property.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
	Flooding within and outside the SAP impacting access (including emergency vehicles)	1. Raise essential emergency routes (Nelson Bay Rd, Cabbage Tree Rd) above predicted flood levels to ensure flood immunity and prevent surrounding communities from flooding by overtopping.	1. Include this in the Delivery Plan, and associated design and development guidelines. 2. Incorporate emergency management requirements into governance structure (e.g. as part of ISO 14001 EMS)
	Increased risk for coastal erosion	1. Consider use of soft methods such as 'Green Belt', artificial reef and/or soft rock structures to reduce wave impact and storm surges by stabilising shoreline.	This mitigation measure is outside of the SAP boundary and direct control, however will require a coordinated approach across government.

p	Risk description	Mitigation Measures	Delivery Plan action
Increased bushfire risk/intensity	Bushfire season expected to start earlier and extend into prescribed burning season (spring)	1. Organised local prevention burns to maintain vegetation build up all year-round 2. Incorporate indigenous fire practices in bushfire management	1. Include this requirement in the Delivery Plan and governance structures (e.g. ISO 14001 EMS). 2. Incorporate operational requirements in governance structure (e.g. ISO 14001 EMS) and coordinate with appropriate lead agency.
	Increased risk ratings and fire life safety standards for new and replaced infrastructure	1. Consider bushfire risk rating and resilience when designing and building all new infrastructure. 2. Include "build back better" requirements in the development assessment rules (SAP SEPP and Delivery Plan) when restoring infrastructure after a bushfire event.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
	Damage/loss of utility infrastructure (electricity, water pumping stations, telecommunications)	1. Establish reasonable clear zones and ensure proper maintenance of vegetation build up beneath power lines or around significant assets. 2. Undertake a Strategic Bushfire Risk Assessment to understand the bushfire hazard risk and ensure proposed uses that are compatible with the bushfire risk e.g. if there is a high risk avoid vulnerable uses / increasing density 3. Asset owners to undertake a network review of redundancy in power and water systems. Asset owners to model and understand how they would run their networks if certain connections were taken offline due to fire. Scenario analysis to be run and understood in case of emergencies. 4. Need to consider the resilience of planned infrastructure to natural hazard events, including the	This mitigation measure relates to electricity and distribution network operators however is critical to ensure electricity supplies are maintained. 2. Include requirements for asset owners in the Delivery Plan for new businesses entering the SAP, and in the EMS for existing and new businesses and agencies. 3. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines, and incorporate emergency management requirements in governance structure (e.g. ISO 14001 EMS)

p	Risk description	Mitigation Measures	Delivery Plan action
		cost benefits of buildings and infrastructure to withstand bushfire inundation.	4. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.
	Inadequate buffers that do not incorporate climate change projections with increased likelihood of built infrastructure being impacted	1. Ensure land use considers fire risk with appropriate buffers incorporated based on the increased climate projections. 2. Make sure industries or uses vulnerable to fire/smoke are provided with appropriate evacuation capabilities and are located away from the hazards.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines
	Bushfire smoke inundation due to increase in potential frequency/ intensity	1. All new buildings constructed highly airtight with mechanical ventilation system and capable of accommodating MERV14 filters. 2. Blower door testing of municipal emergency assembling facilities to assess the feasibility and implementation of airtightness and mechanical ventilation upgrades.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines. Will also improve energy efficiency and building performance.
	Disruption to transport and evacuation routes due to road closures	1. Ensure road networks have adequate capacity cater for a full evacuation at all points during the SAP development and growth cycle.	1. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines. 2. Incorporate emergency management requirements in governance structure (e.g. ISO 14001 EMS)
Wind speed	Impacts on infrastructure due to increased sand movement across Stockton Bight	1. Incorporation of sensitive wind fencing structures in landscaping to reduce intensive sand movement	This mitigation measure is outside of the SAP boundary and direct control, however will require a coordinated approach across government.

p	Risk description	Mitigation Measures	Delivery Plan action
	Damage to infrastructure due to increase in frequency and intensity of storm events	1. Establish reasonable clear zones and ensure proper maintenance of vegetation build up next to power lines or around significant assets.	This mitigation measure relates to electricity and distribution network operators however is critical to ensure electricity supplies are maintained.
	Increased flood inundation due to combination of high tide and extreme storm events	1. Water management strategies to be incorporated in land use planning and development guidelines. 2. Avoid new developments in designated floodplain areas. 3. Local land filling as option to reduce flooding impacts on new developments, while not increasing flood risk for existing properties and developments, and substantially impede the flow of floodwater. 4. Consider raising Fullerton Cove levee.	1. Consider incorporating in the Delivery Plan, and associated design and development guidelines. 2. Incorporate emergency management requirements into governance structure (e.g. as part of ISO 14001 EMS). 4. This mitigation measure is outside of the SAP boundary and direct control, however will require a coordinated approach across government.
Loss of biodiversity	Migration or loss of species that are unable to cope with increasing temperature. Fauna unable to migrate due to the lack of wildlife corridors Increased invasive weed and pest animals competing with native flora and fauna Vegetation loss due to fragmentation i.e. flood inundation, dune transgression, new developments	1. Develop a biodiversity and natural habitat management plan, including pest and weed management and a governance and finance structure, and implement it. 2. Support the establishment of appropriate wildlife corridors between different National parks and reserves. 3. Incorporate biodiversity assessments in land use planning and development guidelines with new developments in areas with low level of biodiversity, incorporated sensitive design strategies in medium biodiversity areas and no new developments in high biodiversity areas.	1. Develop a biodiversity and natural habitat management plan as part of the Delivery Plan, noting this will be complex and may take a significant period of time to fully develop, and so the Delivery Plan may just call for its development rather than fully developing it. Also include in the governance structure and EMS. 2. Include guidance relating to these requirements in the Delivery Plan, and associated design and development guidelines.

8 Summary and conclusion

The climate change risk assessment has highlighted the complex and diverse nature of the Williamtown SAP, with many of the risks resulting in high or extreme impacts unless adequate mitigation measures are implemented.

A number of the climate change impacts are significant enough to remain at a high or extreme level, even if all practicable mitigation measures are implemented, as climate change events such as temperature rise are predicted to radically impact on the existing agricultural economies, community growth and resilience, and flora, Fauna, biodiversity and human safety resulting from the increase in bushfire frequency and intensity.

Throughout the development of the Structure Plan and Master Plan, and during the stakeholder engagement undertaken to develop this Climate Change Adaptation Plan, it is clear that the climate change mitigation measures will only be followed through into action if there is a clear, strong, and fully funded governance structure in place.

The need to establish the SAP governance structure and a framework to delivery this, including the Delivery Plan, SAP SEPP, SAP EMS, and to ensure it is adequately resourced and funded throughout the development program period, is an essential requirement.

In order to assist with providing some focus for the Delivery Plan development, DPE have requested a summary of the top 5 climate change impacts resulting from this risk assessment. These are summarised as follows (refer Table 14):

Table 14: Top 5 climate change impacts

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
Temperature increase and increased hot days	Increase of 2.0 to 2.5°C 12 to 32 days above 35°C	6. Increased building energy use for cooling. 7. Increased heat island in public spaces and around developed/ industrial areas. 8. Rising utility infrastructure demand (electricity and water). 9. Heat stress for the community population, including workforce, residents and visitors (relative heat wave impacts).	**Master Plan:** The final Master Plan incorporates infrastructure and public realm designs that are resilient to increasing temperatures, including smart and integrated utility infrastructure that captures, stores and shares excess energy and water (e.g. rainwater/stormwater harvesting and reuse and energy storage), increased landscaping, vegetation and tree canopy cover, and areas of respite for employees, the community and visitors (both internal and external areas). **Delivery Plan:** The Delivery Plan incorporates provisions to improve utility network capacity, resilience of buildings and infrastructure, passive design, minimum energy and water efficiency standards, renewable energy and energy storage provisions, alternative water supplies, landscaping and vegetation and materials that decrease urban heat island effect.

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
		10. Reduced reliability and functionality of infrastructure services including roads/rails, public buildings, and electricity supply.	**Governance:** The SAP governance structure incorporates operational responses and monitoring to ensure that the mitigation measures are effective, in particular a community resilience plan for heat stress and to monitor utility infrastructure reliability. This could be captured as part of an ISO 14001 Environmental Management System (EMS) with the UNIDO Eco-Industrial Park (EIP) Framework embedded which includes provisions for ongoing monitoring and KPIs.
Increased rainfall intensity	1.0-2.0m flood depths during 1% AEP event	4. Increased frequency and intensity of extreme rainfall events impact on flood levels causing damage to buildings and road infrastructure. 5. Increased waterway and catchment area flooding impacting stormwater management systems by decreasing their drainage capacity and effectiveness. 6. Increased risk of PFAS mobilisation including infiltration of ground water.	**Master Plan:** The final Master Plan incorporates increased rainfall intensity and flood levels as part of major infrastructure designs and development areas, with stormwater management systems and drainage designed to mitigate flooding, and reduce erosion and stormwater pollution, both within the Williamtown SAP and to surrounding properties. Based on the Final Structure Plan which incorporates local and regional flood paths, drainage pathways and flood mitigation areas it is expected that this risk will be mitigated, however it is essential that this is carried forward into the Master Plan, Delivery Plan and associated enabling infrastructure works. **Delivery Plan:** The Delivery Plan incorporates provisions for the SAP and developments to reduce stormwater flow, erosion and pollution including Water Sensitive Urban Design (WSUD), onsite rainwater/stormwater harvesting and reuse and increased permeable surfaces and landscaping, while ensuring any onsite reuse is cognisant of PFAS contamination. This should be incorporated into an integrated water cycle with onsite systems interconnected with precinct stormwater management systems and drainage. **Governance:** The Governance structure incorporates ongoing PFAS monitoring and remediation. As per the above an ISO 14001 EMS + UNIDO EIP Framework approach will assist in ensuring a monitoring and improvement program is in place.

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
Sea Level Rise (SLR)	0.77m SLR	4. Higher inundation risk of built infrastructure including roads, buildings, utility infrastructure and community services. 5. Increased risk for coastal erosion due to higher sea level and expected increase in frequency and intensity of storm surges. 6. Increased risk of PFAS mobilisation and widespread contamination.	**Master Plan:** The final Master Plan incorporates sea level rise projections in the planning of infrastructure, with critical and major infrastructure and emergency access roads located outside of or raised above tidal inundation levels. Due to coastal adaptation and existing levees falling outside of the SAP boundary and responsibility, this should be developed cognisant of any improvements that may be implemented outside of the SAP to reduce this risk. **Delivery Plan:** It is expected that the above provisions in the Master Plan will mitigate the majority of this risk with inundation levels used to inform site levels and zoning, however longer-term projections may pose a greater risk and become an operational risk. The Delivery Plan should also incorporate provisions that ensure development does not occur in flood areas at risk of tidal inundation. In addition, any changes to the Master Plan and Delivery Plan design as part of the enabling works must fully consider the climate change risks. **Governance:** The Governance structure incorporates a collaborative model for understanding and planning for sea level rise and associated impacts that may pose a risk to the SAP, but are outside of the SAP's boundary and control.
Increased bushfire risk/intensity	1 to 2 days increase in extreme fire weather days per annum, occurring in spring and summer.	8. Bushfire season expected to start earlier and extend into prescribed burning season (spring). 9. Increased risk ratings and fire life safety standards for new and replaced infrastructure. 10. Damage/loss of utility infrastructure (electricity, water pumping stations, telecommunications).	**Master Plan:** The Master Plan incorporates adequate bushfire buffer zones and emergency access and evacuation routes, and ensures critical infrastructure (e.g. utility infrastructure) is located in lower bushfire risk areas. **Delivery Plan:** The Delivery Plan incorporates improved building standards including increased bushfire risk ratings, and increased air filtration for mechanical ventilation and air tightness testing for critical services (healthcare, emergency services).

Climate change risk	Climate change projection 2070	Most significant impacts	Mitigation summary
		11. Disruption to transport and evacuation routes due to road closures. 12. Impact on airport operations due to reduced visibility, ash, and direct flame impact on runway operations. 13. Loss of biodiversity and threatened species (particularly in Environmental Protection Area). 14. Bushfire smoke inundation due to increase in potential frequency/ intensity	**Governance:** The SAP governance structure incorporates operational responses and monitoring to ensure that the mitigation measures are effective, in particular for heat stress and to monitor utility infrastructure reliability. This could be captured as part of an ISO 14001 EMS with the UNIDO Eco-Industrial Park (EIP) Framework embedded which includes provisions for ongoing monitoring and KPIs. In addition, the EMS could drive environmental improvement programs such as the monitoring and improving biodiversity outcomes.
Loss of biodiversity		4. Migration or loss of species that are unable to cope with increasing temperature. 5. Increased invasive weed and pest animals competing with native flora and fauna. 6. Increased risk of severe bushfire events.	**Master Plan:** The Master Plan maintains and supports existing biodiversity in the Environmental Protection Area and wildlife corridors, and incorporates quality landscaped outdoor areas that support increased vegetation and biodiversity, cognisant of bushfire risk. **Delivery Plan:** The Delivery Plan incorporates minimum requirements for landscaping and vegetation for new developments and the design guidelines incorporate landscaping and planting guides that support local biodiversity. A biodiversity and natural habitat management plan is developed, either as part of the Delivery Plan or as an outcome of the Delivery Plan. **Governance:** The SAP governance structure incorporates provisions for biodiversity monitoring and improvement. The biodiversity and natural habitat management plan could be captured as part of the ISO 14001 EMS and associated environmental improvement programs.

The risk assessment and review process has identified a series of mitigation measures that will need to be implemented in order to reduce the risk impact resulting from climate change. A number of these mitigation measures require a review of the draft Master Plan, a review of the measures by the Structure Team Technical Consultants, and may result in a change or input to the finalised Master Plan document, subject the results of these further reviews.

The ongoing development of the SAP and the initiation of all new supporting infrastructure projects and investor led projects, will be driven by the SAP Delivery Plan. The Delivery Plan will reference a series of supporting documents which may include but may not necessarily be limited to:

- Design and Development standards and guidelines;
- Performance targets to be achieved including energy, water, waste, and environmental protection;
- Planning Rules including a new SAP SEPP, and Port Stephens Council LEPs; and
- A SAP Environmental Management System (EMS) framework.

The Delivery Plan is due to be prepared following the Master Plan being developed and we reinforce the importance of ensuring that climate change risks and mitigation measures are fully recognised within it. This includes ongoing reviews of the climate change risks and impacts in the event any changes are made to the development areas and as new data or projections become available.