

Adaptation Action Plan

Planning for Climate and Natural
Hazards

59916011

Prepared for
Hawkesbury City Council

9 February 2016



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Document Information

Prepared for: Hawkesbury City Council
Project Name: Planning for Climate and Natural Hazards
File Reference: 59916011 v3 R002
Adaption Planning Action Plan.docx
Job Reference: 59916011
Date: 9 February 2016

Effective Date: 09/02/2016

Date Approved: 09/02/2016

Document History

Version	Effective Date	Description of Revision	Prepared by:	Reviewed by:
V1	28/08/15	Draft	JC	LD
V2	01/09/15	Final	JC	LD
V3	09/02/16	Revised Final	JC	LD

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Executive Summary

In 2012, Hawkesbury City Council (Council) commissioned a report on Planning for Climate and Natural Hazards (GHD, 2012). This report identified 27 risks to Council and its objectives, across nine theme areas:

- Flooding of Urban and Built Areas;
- Building Resilience and Coordinated Emergency Management;
- Managing Development to Consider Climate Changes in Growth Areas;
- Bushfire Risk Management;
- The Natural Environment Response to Temperature, Rainfall and other Climatic Changes;
- Protecting the Region’s Heritage and Community Infrastructure, especially from Storms;
- Stormwater Drainage, Infrastructure and Water Quality; and
- The Built Environment’s Response to Temperature, Rainfall and Other Climatic Changes.

To aid Council in responding to these themes Cardno was engaged to prepare an Adaptation Action Plan. As part of this process Cardno undertook a detailed literature review of adaptation actions across NSW and, through a technical workshop process, identified three types of recommended actions:

- Adaptation Actions – recommended actions (typically infrastructure works or policies) that effectively and directly mitigate current and future natural hazards;
- Requisite Research and Management - tasks that may directly mitigate current natural hazards and enable council to implement the identified Adaptation Actions; and
- Secondary Response measures - measures that may directly or indirectly contribute to reductions in current and future natural hazards.

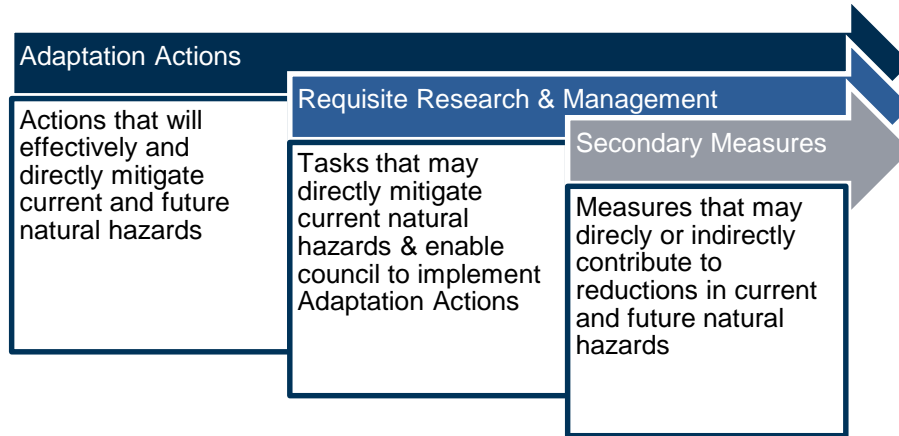
After evaluating over 150 potential actions, Cardno selected 16 Adaptation Actions, many of which addressed multiple theme areas. These actions were selected based on the number of risks they addressed, the significance of the addressed risks (as determined by GHD (2012)), the perceived practicality to Council and the ability for its benefits to be quantitatively determined. Beyond these 16, 36 secondary response measures were also identified for Council’s consideration.

Sub Plan Theme	ID No.	Adaptation Action	Time-frame	Key Performance Indicators
Building Resilience and Emergency Management	1	Provision of off-grid utilities at safe refuge areas and at key Council properties.	Short	Number and distribution of off-grid systems.
Building Resilience and Emergency Management	2	Business Continuity Plan	Short	Implementation of Business Continuity Plan.
Building Resilience and Emergency Management	3	Engineering Controls for Landslip	Medium	Reduction in frequency of landslip and associated damage / delays.
Building Resilience and Emergency Management Built Environment’s Response	4	Retrofitting of existing buildings	Medium	Proportion of Council facilities with sustainable insulation and cooling.
Building Resilience and Emergency Management	5	Maintenance Support for Residents in High Risk Areas	Medium	Provision of services to at risk facilities. Reduction in average damage costs or insurance claims.
Managing Development to Consider Climate Changes in Growth Areas	6	Reduction in use of hard stand areas	Medium	Reduction in proportionate presence of hard stand in new development design.

Sub Plan Theme	ID No.	Adaptation Action	Time-frame	Key Performance Indicators
Managing Development to Consider Climate Changes in Growth Areas Built Environment's Response	7	Implementation of Water Sensitive Urban Design standards	Medium	Number of WSUD systems developed; Measurable reduction in temperature; Increased water storage capacity.
Bushfire Risk Management	8	Establishment of Council disaster management fund	Medium	Costs associated with bushfire clean-up.
Bushfire Risk Management Built Environment's Response	9	Encourage adoption of fire resilient property standards and installations for residents	Medium	Number of properties compliant with AS3959 as a minimum. Reduction in fire damage costs.
Maintaining Roads and Bridges Built Environment's Response	10	Use of road materials to minimize maintenance costs	Short	Annual maintenance costs
Maintaining Roads and Bridges	11	Relocation of key asset crossing locations	Medium	Frequency of asset closure.
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes Stormwater Drainage, Infrastructure and Water Quality	12	Erosion control and rehabilitation of watercourses	Medium	Increase in number of watercourses in good condition. Overall improvement in watercourse condition.
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes Stormwater Drainage, Infrastructure and Water Quality	13	Water quality monitoring	Medium	Development of water quality database. Improvement in water quality.
Heritage and Community Infrastructure	14	Emergency response protection for key heritage assets	Medium	Lowered maintenance costs to heritage assets
Stormwater Drainage, Infrastructure and Water Quality	15	Utilisation of grey-water systems	Medium	Grey water recycling systems installed on Council assets
Stormwater Drainage, Infrastructure and Water Quality	16	Encourage the uptake of stormwater harvesting systems	Short	Number of stormwater harvesting systems installed on new developments.

While these actions represent Cardno's recommended list of works to address the identified risks, the process of evaluating these actions also demonstrated that:

- In many instances there may be a significant range of research and documentation that would be required to enable the Adaptation Actions to be applied effectively within the LGA; and
- Progressive Adaptation of management plans (i.e. periodic updating of existing plans (e.g. DISPLAN) to meet current conditions) is often the most effective way through which nature hazard risks can be assessed.



It is considered that Council may want to evaluate the research tasks summarised below in advance of implementing the recommended Adaptation Actions. The nature of the recommended Adaptation Actions is such that the economic performance of each action would be able to be assessed through economic cost benefit analysis; any costs associated with requisite research and management tasks would need to be considered as part of overall Adaptation Action costs.

Sub Plan Theme	Requisite Research
Building Resilience and Emergency Management Maintaining Roads and Bridges Stormwater Drainage, Infrastructure and Water Quality	Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan
Building Resilience and Emergency Management	Review of emergency access routes
Building Resilience and Emergency Management	Mapping of static water supply
Building Resilience and Emergency Management Stormwater Drainage, Infrastructure and Water Quality	Monitoring performance of sewage and stormwater systems
Building Resilience and Emergency Management	Consideration of vegetation storm resilience around assets
Bushfire Risk Management	Review location of fire breaks
Bushfire Risk Management Maintaining Roads and Bridges	Review of emergency access routes
Bushfire Risk Management Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes	Mapping of fire tolerant and intolerant vegetation communities
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes	Undertake disaster risk assessment of natural assets and develop a Management Plan
Stormwater Drainage, Infrastructure and Water Quality	Model stormwater impact from increased storm activity and incorporate into design guidelines
Built Environment's Response	Shade audits of public areas
Built Environment's Response	Develop inspection regimes for Council assets and infrastructure

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1 Introduction

1.1 Planning for Climate and Natural Hazards Risk

In 2012, Hawkesbury City Council (Council) commissioned a report on Planning for Climate and Natural Hazards (GHD, 2012). The purpose of the study was to:

- > Identify and assess the risks that a changing climate may pose to meeting the objectives and aspirations that are set out in the Hawkesbury Community Strategic Plan 2010-30 and other key strategic plans; and
- > Determine the adaptation planning themes and approaches that may be adopted and implemented by Council so as to manage the risks that may arise in association with a changing climate.

The study identified 27 risks faced by the Local Government Area (LGA) across nine key theme areas. Based on the perceived level of risk and Council's ability to manage these risks, the themes were prioritised into first, second and third order priorities (**Table 1-1**).

Table 1-1 Adaptation Planning Themes

Theme	Priority	Description
Flooding of Urban and Built Areas	1	Significant high risks to property, community and people due to flooding of residential areas will be exacerbated by projected climate changes.
Building Resilience and Coordinated Emergency Management	1	Higher risks may eventuate over time in regard to pressures placed on emergency resources and personnel to respond to natural hazard events (especially bushfires and floods) occurring more frequently or in greater magnitudes. Moderate risks were associated with the impacts of adverse temperature changes and the effects on community health and services. Moderate risks were associated with the impacts of adverse temperature changes and the effects on the local rural and agricultural aspects of the LGA. Lower risks to the community are associated with urban water shortages and the need to restrict water use.
Managing Development to Consider Climate Changes in Growth Areas	1	There is an opportunity to incorporate climate change resilience into new developments in the growth areas.
Bushfire Risk Management	2	Under extreme climate changes, the risks posed by bushfire to community property, health and safety may be heightened.
Maintaining Roads and Bridges	2	Higher risks primarily result due to pressures placed on Council's budget and resources available for infrastructure provision, in particular to address wear and tear of roads and bridges, which may eventuate if extreme climate changes are experienced.
The Natural Environment Response to Temperature, Rainfall and Other Climatic Changes	2	Higher risks to local environment and water quality are associated with the extreme climate change projections. Moderate to high risks associated with changes to water quality and recreational use of the water may arise due to increased flow variability and temperatures.
Protecting the Region's Heritage and Community Infrastructure, especially From Storms	2	Moderate to high risks may arise and be exacerbated due to the exposure of the community's heritage and community facilities and Council buildings to storms and extreme weather conditions.

Theme	Priority	Description
Stormwater Drainage, Infrastructure and Water Quality	2	Moderate to high risks may arise and be exacerbated by Council's stormwater infrastructure being unable to cope with increases in storm intensities and having its capacity breached.
The Built Environment's Response to Temperature, Rainfall and Other Climatic Changes	3	Lower to moderate risks may be brought about by the response of buildings and settlements to extreme changes in temperature and rainfall.

1.2 Adaptation Action Plan - Objectives

In accordance with these identified themes, Council is looking to establish a plan of action that responds to the risks (both present and future) associated with variation in natural hazards. In particular, Council is looking to establish practicable actions that address the identified risks by:

- > Protecting existing public and private assets or activities undertaken within the LGA;
- > Ensuring planned and future developments consider and adapt to variation in natural hazard; and
- > Updating and enhancing preparedness and response to natural hazards and how they may vary over time.

This report provides a strategic plan of action for each of the nine adaption planning theme areas, identifying key practicable works and activities that address the risks identified by GHD (2012). Proposed actions have been recommended based on:

- > Review of best practice across NSW and Australia;
- > The environmental, social and economic characteristics of the LGA; and
- > Professional judgement.

1.2.1 Flooding of Urban and Built Areas

In 2012, extensive flooding across south-eastern Australia, including the Hawkesbury-Nepean Valley, led to the initiation of the Hawkesbury-Nepean Valley Flood Management Review to consider flood planning, flood mitigation and flood response in the Hawkesbury-Nepean Valley. The NSW Government has established a task force to lead Stage Two of the Review into flood management and preparedness in the Hawkesbury-Nepean Valley. Stage Two builds upon the preliminary investigations completed in Stage One which looked at the current flood management and planning in the valley to identify opportunities to improve the ways in which future floods are managed. The task force is currently working with key stakeholders, including local councils, the insurance industry, flood and water management and other government agencies, to further define its adaptation options. The immediate priority of the task force is building the resilience and preparedness of the communities and businesses of the Hawkesbury-Nepean Valley to future flood. Stage Two of the review will undertake a detailed cost benefit assessment of the most practical and cost effective flood mitigation options for the government to consider.

The work undertaken by the task force is seen to be addressing the highest priority theme identified by the GHD (2012) report: Flooding of Urban and Built areas. Consequently, it was agreed with Council that the Adaptation Action Plan would not address this theme as to limit overlap with the work being completed by the Hawkesbury-Nepean Valley Flood Management Review Taskforce. Rather, the Adaptation Action Plan focuses on the other eight themes identified. It is noted that there is considerable overlap between the theme areas with many of the identified risks (and corresponding actions) affecting multiple theme areas.

1.2.2 Report Structure

This report has been structured in the following manner:

- > **Introduction** – an overview of the Adaptation Action Plan;
- > **Adaptation** – a definition of the natural hazards assessed;

- > **Methodology** – a description of the process undertaken to formulate the action plan;
- > **Adaptation Action Plan** – recommended adaptation actions addressing:
 - Building Resilience and Coordinated Emergency Management;
 - Managing Development to Consider Climate Changes in Growth Areas;
 - Bushfire Risk Management;
 - The Natural Environment Response to Temperature, Rainfall and other Climatic Changes;
 - Protecting the Region’s Heritage and Community Infrastructure, especially from Storms;
 - Stormwater Drainage, Infrastructure and Water Quality;
 - The Built Environment’s Response to Temperature, Rainfall and Other Climatic Changes; and
- > **Recommendations and Next Steps** – recommendations to aid implementation of the plan.

2 Adaptation

The Hawkesbury City Council LGA faces a diverse range of climate and natural hazards conditions, many of which are forecast to change in nature into the future. These changes have the potential to alter the interactions, impacts and risks, faced by Council, the community and environment. GHD (2012) provides a summary of the key ways in which the LGA may be affected by changing natural hazards, including:

- > Increased bushfire risk through forecast higher temperatures and wind speeds;
- > Increased bushfire risk through altered rainfall patterns affecting the availability of fuel;
- > Long term changes to inland catchment rainfall patterns can alter flooding risks;
- > Sea-level rise may make some coastal catchment areas more vulnerable to flooding, with effects felt further inland;
- > Changes to rainfall patterns may generate hydro-geological responses (e.g. landslide, subsidence);
- > Changes to rainfall patterns may influence the soil and water-table properties, affecting land use and development;
- > Increase storm intensity and associated damages; and
- > Higher frequency occurrence of fog and frost.

GHD (2012) also recognises that Council's responsibility in light of these impacts are a function of its goals and objectives. Under the Hawkesbury Community Strategic Plan (2013 – 2032), Council's vision comprises:

- > Looking after people and place;
- > Caring for the environment;
- > Linking the Hawkesbury;
- > Supporting business and local jobs; and
- > Shaping our future together.

The management of both current natural hazards and any changes to the hazards or additional hazards that may arise, is a critical component of Council's responsibility in realising this vision, as it seeks to provide services to its community. In general the management of changes to hazards can be addressed in one of two main ways:

- > Mitigation – reducing the magnitude of the change in natural hazard itself (e.g. through emission reductions or geoengineering); and
- > Adaptation – limiting the vulnerability of an environment, community, asset or activity through policy, management, response or infrastructure.

While Council may have the responsibility and capability to address both of these components, both the GHD (2012) report and this Adaptation Action Plan focus on the identification of adaptation responses to perceived natural hazard risk. Climate and natural hazard adaptation for the purpose of this action plan, are actions taken in response to actual or anticipated changes in natural hazards that lead to a reduction in risks or realisation of benefits. This is consistent with other adaptation planning approaches taken by local government agencies within NSW (e.g. HCCREMS, 2010).

This Action Plan represents a planned, proactive approach to respond to climate and natural hazards in the Hawkesbury Local Government Area (LGA). Actions may work directly or indirectly to mitigate risk:

- > Direct – e.g. increasing the capacity of the stormwater network will directly mitigate flood risk by limiting stormwater overflows; and
- > Indirect – e.g. increasing the static supply of water will indirectly mitigate against bushfire risk by increasing the capacity of vulnerable communities to respond to bushfire should one occur.

Actions to be considered focussed on activities considered implementable by Council and within its remit and responsibilities, noting that both private individuals, State and Federal authorities may also have responsibilities in regards to adoption of adaptation measures. The type of adaptation actions considered with this report included:

- > Policies, strategies and plans;
- > Regulations and standards;
- > Data collection and research;
- > Structural works; and
- > Education and behavioural changes.

Figure 2-1 provides a more detailed breakdown the type of measures considered. However, based on consultation with Council and the scope of previous work undertaken by Council in this space, the Adaptation Action Plan has focussed on identification of actions with direct demonstrable benefits to aid in expediting justification and implementation of adaptation response.

Figure 2-1 Types of Adaptation measures to be considered by Council (HCCREMS, 2010a)

Control category	Description and examples
Coordinated, regional approach	Coordinated, regional approaches to managing an issue: <ul style="list-style-type: none"> - Regional institution or organisation - Regional alliance or network - Shared regional framework or approach
Strategies and plans	Local strategies and plans: <ul style="list-style-type: none"> - Strategic plans - Management plans
Regulations / standards	Regulations, standards and statutory planning frameworks: <ul style="list-style-type: none"> - Local planning schemes - Building design standards - Planning provisions that prevent new infrastructure from being built in high risk areas - Council by-laws
Internal procedures	Practices and procedures at an organisational level: <ul style="list-style-type: none"> - Improve decision making processes - HR management practices - OH&S practices
Data collection / information / research	Information / data collection or research that improves understanding of relationship between climate change and risk: <ul style="list-style-type: none"> - Research on relationship between past and potential future variations in climate and performance of economic, social and environmental systems - Research on relationship between changes to frequency and magnitude of extreme events and critical thresholds - Assessment of adaptation options
Structural or 'on-ground' works	Engineering solutions and practices: <ul style="list-style-type: none"> - Infrastructure protection measures - Inherent design of infrastructure maximising resilience - Environmental protection or remediation works - Energy / water efficient design
Education, behavioural	Educate and inform community about climate change risks and adaptation measures Educate community about approaches to and benefits of changing behaviour
Spread or displace risk	Insurance and diversification strategies: <ul style="list-style-type: none"> - Use of insurance products to off-lay the risk - Risks shared between different agencies / entities - Geographical diversification (e.g. of raw materials)

3 Methodology

Based on the scope of measures to be considered as part of Council's adaptation response, the following process was adopted to develop the Adaptation Action Plan:

- 1) Review the of the known natural hazard risks facing the Hawkesbury LGA (**Appendix A**).
- 2) Generation of a comprehensive list of adaptation actions through literature review and Cardno's professional experience. This included:
 - Adelaide City Council, 2011, Climate Change Adaptation Action Plan 2011-2013.
 - Department of the Environment and Water Resources, 2007, Climate Change Adaptation Actions for Local Government. Australian Greenhouse Office, Department of the Environment and Water Resources, Australian Government.
 - Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS), 2010, Climate Change Risk Assessment and Adaptation Plan: Coastal Councils, Hunter Councils NSW
 - Hunter and Central Coast Regional Environmental Management Strategy (HCCREMS), 2010, Climate Change Risk Assessment and Adaptation Plan: Rural Councils, Hunter Councils NSW
 - Inglis, J., Whittaker, S., Dimitriadis, A. and Pillora, S. 2014. Climate Adaptation Manual for Local Government – Embedding resilience to climate change. Australian Centre of Excellence for Local Government, University of Technology, Sydney.
 - International Council for Local Environmental Initiatives - Local Government for Sustainability, 2008, Cities for Climate Protection Australia Adaptation Initiative, Local Government Climate Change Adaptation Toolkit.
 - Kiama Municipal Council, 2009, Climate Change Adaptation Strategy and Action Plan. Prepared by SKM for Kiama Municipal Council
 - Ku ring gai Council, *date unavailable*., Climate Change Adaptation Strategy.
 - Manly Council, 2008, Climate Change Actions for Manly LGA 2008-2038. Prepared by Cardno for Manly Council.
 - Mansfield Shire Council, 2009, Climate Change Adaptation Report. Prepared by GHD for Mansfield Shire Council.
 - New England Strategic Alliance of Councils (NESAC), 2009, Climate Change Adaptation Action Plan. Prepared by SKM for NESAC.
 - OEHL, 2012, Checklist for best practice adaptation planning and implementation.
 - Pillora, S., 2010, Australian Local Government and Climate Change, Working Paper No. 1. UTS Centre for Local Government.
 - Port Stephens Council, 2009, Adaptation Action Plan. Prepared by BMT WBM for Port Stephens Council.
 - Shoalhaven City Council, *date unavailable*, Adaptation Plan: Increasing the Resilience of Shoalhaven City Council using adaptive choices.
 - Southern Metropolitan Councils, 2009, Climate Change Climate Risk Management and Adaptation Action Plan for the Southern Metropolitan Council. Prepared by GHD for Southern Metropolitan Regional Council.
 - Western Suburbs Regional Organisation of Councils (WESROC), 2010, Climate Change Risk Assessment and Adaptation Plan. Prepared by Coastal Zone Management Pty Ltd for WESROC.

- 3) Internal workshop to review applicability of potential options for the Hawkesbury LGA based on:
 - The number of risks addressed by the identified action and the perceived efficacy of the action;
 - Council's ability or responsibility to undertake the action; and
 - The extent to which the action would generate demonstrable benefits.

The workshop included technical specialists in ecology and ecosystems, climate change response, ecologically sustainable development, hydrology and transport.

In total, 150 actions relevant to the eight theme areas were identified.

- 4) Development of a prioritised list of Adaptation Actions and implementation responsibilities for the eight theme areas.

3.1 Identification of Recommended Actions

As part of the literature review and workshop it was recognised that while there are a number of potential adaptation actions that may be undertaken to directly address the risks identified in the GHD report, the suitability of these actions is highly dependent upon Council having sufficient information to make informed decisions as to how and where these actions may be applied.

Further, it was recognised that, given the rate of change and uncertainty in natural hazards, one of the most effective measures of addressing these risks is ensuring that Council undertake on-going management measures that are effective in addressing existing natural hazards risks, regardless of whether or not there is a forecast change in hazard and committing to the on-going review and update of these practices.

As such the development of this adaptation plan identified three broad categories of actions:

- 1) **Adaptation Actions** – Recommended actions that will effectively reduce Council's and the community's exposure to the identified risks.
- 2) **Requisite Research and Management** – Tasks that:
 - Represent best practice to be undertaken to address existing natural hazard risks regardless of whether or not there is a forecast change in hazard;
 - Develop the knowledge base that would further the ability of Council to understand its risks and capacity to adapt; or
 - Significantly support the implementation of prioritised Adaption Actions.

It is likely the Requisite Research and Management would need to be undertaken in advance or in parallel to the identified Adaptation Actions

- 3) **Secondary Response Measures** – Measures which, based on the risk assessment of the GHD report, are not considered to be as efficacious as the prioritised Adaptation Actions but may warrant further investigation by Council.

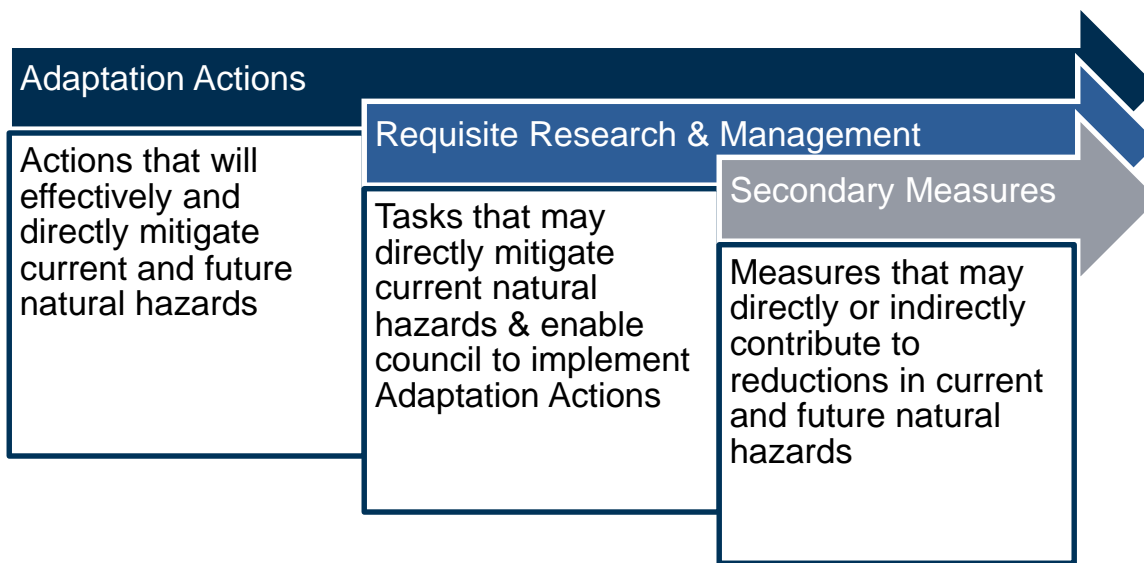
This hierarchy of actions is shown in **Figure 3-1**. The Requisite Research and Management tasks were often seen to be measures that would be considered 'no regrets' options. These options typically involved ongoing compliance, education and further investigations aimed at improving resilience to threats, and increasing preparedness and decision-making ability for broader risks now and in the future. In general, implementation of all 'no regrets' options should be pursued as part of normal day-to-day duties by Council and other relevant management authorities. In many ways, the Requisite Research and Management may represent the highest priority steps to be undertaken if not currently pursued. Through the periodic review and updating of these measures, Council would be able to address as significant range of natural hazard risks, both current and forecast.

Where relevant the Requisite Research and Management and Secondary Response Measures are reported within each of the theme areas as detailed in Section 4. It is noted that development of this Adaptation Action Plan did not include a detailed review of all Council's activities, infrastructure and planning. As such, there may be a number of Adaptation Actions, Requisite Research and Management and Secondary Response

Measures that are currently being undertaken by Council. Similarly, the development of this plan considered a wide range of actions, some of which were not considered favourable in addressing a risk, or with the potential to generate additional risks. These actions are listed in **Appendix B**.

It is also noted that there may be synergies in Council undertaking regional action with other local governments, regional bodies or state bodies. This report has not specifically identified actions that may be undertaken at a regional scale. However, it is likely that many of the actions recommended may be applicable in a regional context and may generate increase net benefits if undertaken through a regional approach. Examples of regional approaches to address natural hazards include strategies adopted by the Hunter and Central Coast Councils, the Southern Metropolitan Councils, and the Barwon South West communities in Victoria. It is recommended the Council consider the potential for integration of actions recommended in this report with those adopted by other governmental organisations.

Figure 3-1 Recommended Action Hierarchy



4 Adaptation Action Plan

4.1 Building Resilience and Coordinated Emergency Management

Theme	Priority	Details
Building Resilience and Coordinated Emergency Management	1	<p><i>Higher risks may eventuate over time in regard to pressures placed on emergency resources and personnel to respond to natural hazard events (especially bushfires and floods) occurring more frequently or in greater magnitudes.</i></p> <p><i>Moderate risks were associated with the impacts of adverse temperature changes and the effects on community health and services.</i></p> <p><i>Moderate risks were associated with the impacts of adverse temperature changes and the effects on the local rural and agricultural aspects of the LGA.</i></p> <p><i>Lower risks to the community are associated with urban water shortages and the need to restrict water use.</i></p>

Table 4-1 summarises the various actions identified that address the risks associated with Building Resilience and Coordinate Emergency Management. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures. Note that the numbers provided in brackets after each action correspond to the reference number given to each action that was considered in this assessment. The actions and their corresponding reference numbers are listed in **Appendix B**.

Table 4-1 Summary of Actions – Building Resilience and Coordinated Emergency Management

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<ol style="list-style-type: none"> 1. Provision of off-grid utilities (including static water supply) (144) 2. Business Continuity Plan (143) 3. Engineering Controls for Landslip (42) 4. Retrofitting of existing buildings (80, 102) 5. Maintenance support for residents in high risk areas (29) 	<ul style="list-style-type: none"> ▪ On-going communication on environmental risks (2) ▪ Provision of an up-to-date DISPLAN that considers climate change risks (5, 8) – to be regularly updated ▪ Undertake disaster risk assessment of key infrastructure (27, 58) and determine an Asset Management Plan (7). ▪ Review of emergency access routes (10, 38, 39) ▪ Mapping of static water supply (25) ▪ Utilisation of grey-water systems (71) ▪ Monitoring performance of sewage and stormwater systems (93) ▪ Use of design standards that consider change in natural hazard (11, 17, 18, 40, 90) ▪ Heat emergency plans (56) ▪ Consideration of vegetation storm resilience around assets (60, 61, 127) 	<ul style="list-style-type: none"> ▪ Public drinking fountains (122) ▪ Shading (53) ▪ Additional RFS facilities (31) ▪ House Buddy Program (119) ▪ Establishment of new safe refuge areas (34) ▪ Establishment of new access roads (35) ▪ Water Security storage and access plans (87) ▪ Development of an irrigation plan (106) ▪ Review of recreational space and consolidation (118, 130) ▪ Increase static water supply (30) ▪ Encourage adoption of fire resilient property standards and installations for residents (16, 21) ▪ Invest in R&D projects (23, 134) ▪ Provision of transport options in extreme conditions (123)

4.1.2 Adaptation Action: Off-Grid Utilities

1									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓		✓				
Timeframe	Short			Council's role			Facilitator		
Type of Action	Structural Works			Risks Addressed			1, 3, 5, 6, 7, 8, 22, 24, 25		
Description	Provision of off-grid utilities at safe refuge areas and at key Council properties. A scheme may involve subsidies for private residents. Off-grid utilities will lower the cost to the community following emergency events. Utilities to be provided should consider water, power, waste and telecommunications.								
Link to other Actions	Action 2, 4 and 5								
Performance Indicators	Number and distribution of off-grid systems.								

4.1.3 Adaptation Action: Business Continuity Plan

2									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓		✓				
Timeframe	Short			Council's role			Manager		
Type of Action	Policies, Strategies & Plans			Risks Addressed			1, 6, 8, 19, 24		
Description	Establishment of a Council Business Continuity Plan to ensure the activities of Council may continue following emergency events. This should consider the likely frequency of events and the potential associated downtime. Council may want to consider roll out of a scheme encouraging local business participation in Business Continuity Planning								
Link to other Actions	Action 1								
Performance Indicators	Implementation of Business Continuity Plan								

4.1.4 Adaptation Action: Engineering Controls for Landslip

3									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓			✓	✓		
Timeframe	Medium			Council's role			Manager		
Type of Action	Structural Works			Risks Addressed			9		
Description	Upgrading of engineering controls at key locations that are currently known to have landslip risk and with the potential to deteriorate into the future. This may include an audit of existing known and unknown locations. In particular, sites in proximity to roads or utility corridors, and heritage sites should be evaluated.								
Link to other Actions	Action 2 and 5								
Performance Indicators	Reduction in frequency of landslip and associated damage / delays								

4.1.5 Adaptation Action: Retrofitting of existing buildings

4									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓					✓	
Timeframe	Medium			Council's role			Manager		
Type of Action	Structural Works			Risks Addressed			1, 24, 25		
Description	Retrofitting of existing Council managed buildings with addition of insulation materials and effective and efficient cooling systems. Council may be able to encourage retrofitting to private individuals through marketing and incentives and by setting an example with public buildings). Retrofitting of facilities will increase the availability of safe refuge areas (particularly under heat stress), reduce emergency health costs and potentially lower emissions.								
Link to other Actions	Action 1, 2 and 5								
Performance Indicators	Proportion of Council facilities with sustainable insulation and cooling								

4.1.6 Adaptation Action: Maintenance Support for Residents in High Risk Areas

5									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓		✓			✓	
Timeframe	Medium			Council's role			Manager		
Type of Action	Policies, Strategies & Plans			Risks Addressed			1, 3		
Description	Council may provide additional support for property maintenance services for at risk individuals or properties to lower the risk of property damage and loss of life under storm events (e.g. provision of addition chipping or green waste removal services in high risk areas).								
Link to other Actions	-								
Performance Indicators	Provision of services to at risk facilities. Reduction in average damage costs or insurance claims.								

4.1.7 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- On-going communication on environmental risks: To educate residents and businesses about preventative practices prior to and during extreme events. Distribution of community educative information can be done through rates notices.
- Provision of an up-to-date DISPLAN that considers climate change risks – to be regularly updated: The DISPLAN outlines emergency management procedures and communication pathways for use during and post-disaster. A review of the DISPLAN should consider if it includes procedures for all likely threats to the region and whether equipment, communication lines, evacuation routes and safe refuge areas are available and adequate for all threats.
- Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan: Assets for consideration include stormwater, sewage, roads and footpaths, bridges, treatment plants and waste facilities. Threats include salinity, bushfire, flooding, drought and landslide.
- Review of emergency access routes: A review of the emergency access and evacuation routes for fire and flood to determine if there are any risks and to address limitations such as missing links. A condition assessment of current access routes would assist in disaster planning and maintenance scheduling. This action should be completed prior to the establishment of new access roads to determine if new access routes are necessary and where they would be most effective. This should be completed in conjunction with a review of the location of safe refuge areas.
- Mapping of static water supply: Prepare a GIS map of surface and arterial water supply and catchments (location and quantity) within the LGA. This would assist in protection of water supplies and catchments, particularly open catchments where stock graze. If the information is made available to RFS this may assist in disaster relief efforts.
- Utilisation of grey-water systems: Incorporation of greywater recycling into public infrastructure.
- Monitoring performance of sewage and stormwater systems.

- Use of design standards that consider change in natural hazard: Update LEP and DCP with latest standards and best practice for bushfire resilience, heat, stormwater and other climate and natural hazard risks.
- Heat emergency plans: Adopt heat emergency planning for public / recreational / tourism events held within the LGA.
- Consideration of vegetation storm resilience around ground assets: This may involve conducting regular surveys to identify trees that present a high risk of collapse or limb drop and remove trees or limbs as appropriate, particularly trees in high risk areas; or the replacement of canopy trees with tree species that can withstand high velocity winds.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.1.8 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Public drinking fountains: To provide ready access to water in public places for people and pets in hot weather.
- Shading: Shade provision policies for street furniture, shelters and awnings. Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres.
- Additional RFS facilities: A new RFS station or the provision of Community Fire Units in vulnerable locations to increase disaster management capacity.
- House Buddy Program: This program would assist neighbourhoods to monitor vulnerable residents in time of extreme risks (heat, flood and bushfire). Existing Council programs can be used to facilitate this program (e.g. Emergency Preparedness Response Project by Peppercorn Services Inc.)
- Establishment of new safe refuge areas: Safe refuge locations are outlined in the DISPLAN. For safe refuge areas to be viable in disaster events, the facilities must have off-grid utilities (water and electricity). This links to the action for the provision of off-grid utilities.
- Establishment of new access roads: This action is dependent on the review of emergency access routes, which will indicate if and where new roads may be needed.
- Water Security storage and access plans: A water security strategy may include the establishment of alternative water supplies and an increase in emergency storage capacity. A water monitoring program to detect and report algal blooms, water borne diseases and other potential contaminants may also be considered.
- Development of an irrigation plan: An irrigation plan could be utilised to reduce mains water usage by developing a prioritised list of assets requiring irrigation, identifying alternative supplies of water, and identifying alternative solutions to irrigation (e.g. Application of mulches, increased mowing heights etc.).
- Review of recreational space and consolidation: Linked to the irrigation plan, this action would identify recreational spaces that would be too expensive to keep up to standard during drought or increased temperatures, and those that need to be upgraded. A regional sporting complex to replace several smaller recreational facilities may be considered to reduce maintenance requirements.
- Increase static water supply: The increase of static water supply volume via the use of rainwater tanks and stormwater harvesting. A static water supply would assist with the provision of off-grid utilities and provide strategic water supply points for emergency purposes (heat wave or fire).
- Encourage adoption of fire resilient property standards and installations for residents. To encourage residents to increase the fire resilience of their properties by adopting building standards and installations that are compliant with AS3959 as a minimum.

- Invest in R&D projects: Investment in research and development projects to identify adaptive actions for use in Hawkesbury LGA.
- Provision of transport options in extreme conditions: Provide transport for vulnerable residents to reach safe refuge areas. May be implemented in conjunction with the House Buddy Program.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.2 Managing Development to Consider Climate Changes in Growth Areas

Theme	Priority	Details
Managing Development to Consider Climate Changes in Growth Areas	1	<i>There is an opportunity to incorporate climate change resilience into new developments in the growth areas.</i>

Table 4-2 summarises the various actions identified that address the risks associated with managing natural hazards in Council's growth areas. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-2 Summary of Actions – Managing Development to Consider Climate Changes in Growth Areas

Adaptation Action	Requisite Research & Management	Secondary Response Measures
6. Reduction in use of hard stand areas (4) 7. Implementation of Water Sensitive Urban Design standards (15)	<ul style="list-style-type: none"> ▪ Use of design standards that consider change in natural hazard (11, 17, 18, 40, 90) ▪ Strengthen DCP standards for ESD (particularly in growth areas) (128) 	<ul style="list-style-type: none"> ▪ Review insurance on Council assets to ensure adequacy (13, 137) ▪ Review emergency management fund based on disaster damages assessment (138)

4.2.2 Adaptation Action: Reduction in Use of Hard Stand

6									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
		✓	✓	✓		✓		✓	✓
Timeframe	Medium			Council's role			Advisory / Manager		
Type of Action	Structural Works			Risks Addressed			1, 12		
Description	Incorporation of increased soft stand areas as part of design (or retrofit). Soft stand areas may provide increase permeability (reducing flood risk), reduce local temperatures, and may offer increase pollutant capture. Visual amenity of soft stand areas is often higher than hardstand. It is noted that maintenance costs associated with permeable and flexible surfaces may exceed hard stand areas.								
Link to other Actions	Action 7								
Performance Indicators	Reduction in proportionate presence of hard stand in new development design								

4.2.3 Adaptation Action: Water Sensitive Urban Design

7									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
		✓	✓	✓				✓	✓
Timeframe	Medium			Council's role			Advisory / Manager		
Type of Action	Structural Works			Risks Addressed			1, 12, 17		
Description	Implementation of water sensitive urban design standards into development assessment criteria is an effective way to reduce heat, particularly in Richmond, Windsor and other town centres. Such systems also allow for the capture of water and re-use (e.g. irrigation or as standing water for emergency response)								
Link to other Actions	Action 1, 5 and 6								
Performance Indicators	Number of WSUD systems developed; Measurable reduction in temperature; Increased water storage capacity								

4.2.4 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Use of design standards that consider change in natural hazard: Update LEP and DCP with latest standards and best practice for bushfire resilience, heat, stormwater and other climate and natural hazard risks.
- Strengthen DCP standards for ESD (particularly in growth areas): New and upgraded buildings to include ecologically sustainable design features which consider the impacts of projected climate change including passive heating and cooling, solar or wind generated energy and appropriate solar orientation and recycled water. Use appropriate designs to minimise lifecycle costs and maximise building performance.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.2.5 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Review insurance on Council assets to ensure adequacy: Additional studies may be required to determine the risk to Council assets and the potential for insurance premiums to increase.
- Review emergency management fund based on disaster damages assessment: Assess feasibility of developing a readily accessible emergency management fund in order to have provision for clean-up and rebuild costs due to extreme weather events. Gather data and present the business case to increase Council resources to deal with natural disasters.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.3 Bushfire Risk Management

Theme	Priority	Details
Bushfire Risk Management	2	<i>Under extreme climate changes, the risks posed by bushfire to community property, health and safety may be heightened.</i>

Table 4-3 summarises the various actions identified that address the risks associated with bushfire risk management. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

It is noted that Actions 1, 2, 5 and 7 also address risks associated with Bushfire Risk Management.

Table 4-3 Summary of Actions – Bushfire Risk Management

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<p>8. Establishment of Council disaster management fund (138)</p> <p>9. Encourage adoption of fire resilient property standards and installations for residents (16, 21)</p>	<ul style="list-style-type: none"> ▪ Use of design standards that consider changes in natural hazard (11, 17, 18, 40, 90) ▪ Installation of fire danger signage (33) ▪ Review location of fire breaks (37) ▪ Review of emergency access routes (10, 38, 39) ▪ Mapping of fire tolerant and intolerant vegetation communities (24) ▪ Community engagement relating to fire safety (36) ▪ Maintenance of Council parks and BBQ facilities (148) 	<ul style="list-style-type: none"> ▪ Review insurance on Council assets to ensure adequacy (13, 137) ▪ Invest in R&D Projects (23, 134) ▪ Additional RFS facilities (31) ▪ Bushfire Neighbourhood Watch (146) ▪ Coordination of land care activities with bushfire risk management (147)

4.3.2 Adaptation Action: Bushfire Disaster Management Fund

8									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓	✓	✓				
Timeframe	Medium			Council's role			Manager		
Type of Action	Policies, Strategies & Plans			Risks Addressed			1, 5, 12		
Description	Assess the feasibility of developing a readily accessible emergency management fund in order to have provision for clean-up and rebuild costs due to bushfire (or other disaster) events. The level of any existing funding in this space may require additional funding as the likelihood and severity of bushfire events increases.								
Link to other Actions	Action 1, 2, 5 and 7								
Performance Indicators	Costs associated with bushfire clean-up, for example, asbestos.								

4.3.3 Adaptation Action: Encourage adoption of fire resilient property standards and installations for residents

9									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓	✓	✓				
Timeframe	Medium			Council's role			Facilitator		
Type of Action	Policies, Strategies & Plans			Risks Addressed			1, 3, 5		
Description	Encourage changes to existing and new developments, to include improved protection and adaptations to increased bushfire risk. For the purpose of this action, fire resilient properties are defined as those that demonstrate compliance with AS3959 as a minimum.								
Link to other Actions	Action 4 and 5								
Performance Indicators	Number of properties compliant with AS3959 as a minimum. Reduction in fire damage costs.								

4.3.4 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Use of design standards that consider change in natural hazard: Update LEP and DCP with latest standards and best practice for bushfire resilience, heat, stormwater and other climate and natural hazard risks.
- Installation of fire danger signage across the LGA.

- Review location of fire breaks: The location and condition assessment of fire breaks will provide useful information in case of bushfire. The data collection exercise may also reveal deficiencies in the location of fire breaks across the LGA.
- Review of emergency access routes: A review of the emergency access and evacuation routes for fire and flood to determine if there are any risks and to address limitations such as missing links. A condition assessment of current access routes would assist in disaster planning and maintenance scheduling. This action should be completed prior to the establishment of new access roads to determine if new access routes are necessary and where they would be most effective. This should be completed in conjunction with a review of the location of safe refuge areas.
- Mapping of fire tolerant and intolerant vegetation communities.
- Community engagement relating to fire safety: this is an important component of Council's community support. However, it is also noted that the NSW Rural Fire Service and NSW Fire and Rescue provide educational materials for bushfire safety.
- Maintenance and upgrade of Council recreational and public vegetated space that minimises the risk of fires starting.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.3.5 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Review insurance on Council assets to ensure adequacy: Additional studies may be required to determine the risk to Council assets and the potential for insurance premiums to increase.
- Review emergency management fund based on disaster damages assessment: Assess feasibility of developing a readily accessible emergency management fund in order to have provision for clean-up and rebuild costs due to extreme weather events. Gather data and present the business case to increase Council resources to deal with natural disasters.
- Invest in R&D Projects: Investment in research and development projects to identify adaptive actions for use in Hawkesbury LGA.
- Additional RFS facilities: A new RFS station or the provision of Community Fire Units in vulnerable locations to increase disaster management capacity. A review of the location and adequacy of current facilities in the LGA would be required prior to the construction or deployment of new facilities and equipment.
- Establishment of Bushfire Neighbourhood Watch systems to encourage local responsibility for bushfires and prevention of anti-social behaviour that may increase bushfire risk
- Council co-ordination and co-operation within and between local and regional landcare / gardening associations to promote integration of bushfire management practices (e.g. selection of species than minimise ground fuel).

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.4 Maintaining Roads and Bridges

Theme	Priority	Details
Maintaining Roads and Bridges	2	<i>Higher risks primarily result due to pressures placed on Council's budget and resources available for infrastructure provision, in particular to address wear and tear of roads and bridges, which may eventuate if extreme climate changes are experienced.</i>

Table 4-4 summarises the various actions identified that address the risks associated with maintain road and bridge infrastructure. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-4 Summary of Actions – Maintaining Roads and Bridges

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<p>10. Use of road materials to minimize maintenance costs (116)</p> <p>11. Relocation of key asset crossing locations (149)</p>	<ul style="list-style-type: none"> ▪ Undertake disaster risk assessment of key infrastructure (27, 58) and determine an Asset Management Plan (7). ▪ Review of emergency access routes (10, 38, 39) ▪ Updating of road design standards to ensure materials and design reflect natural hazard risks (41) 	<ul style="list-style-type: none"> ▪ Establishment of new access roads (35) ▪ Replacement of high maintenance cost assets (150)

4.4.2 Adaptation Action: Road material choice

10									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
						✓			
Timeframe	Short			Council's role			Facilitator		
Type of Action	Structural Works			Risks Addressed			11, 15, 16		
Description	Adoption of pavement material as part of road maintenance (or new road construction) that limit the costs to Council under higher intensity storm events and high temperatures. Decreased degradation rates of road condition will also minimize risk of road failure under storm events.								
Link to other Actions	Action 11								
Performance Indicators	Annual road pavement maintenance costs								

4.4.3 Adaptation Action: Relocation of asset crossing locations

11									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
		✓	✓		✓	✓			
Timeframe	Medium			Council's role			Manager		
Type of Action	Structural Works			Risks Addressed			15, 16		

Description	Relocation of road and bridge infrastructure to elevate if frequent 1:100 flood events and to reduce fire damage. This may also be expanded to utility provision. The reduction in maintenance may offset the capital costs. Assets to be replaced would need to be identified through an Asset Management Plan.
Link to other Actions	Action 1, 3, 5
Performance Indicators	Frequency of asset closure.

4.4.4 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan. Assets for consideration include stormwater, sewage, roads and bridges, treatment plants and waste facilities. Threats include salinity, bushfire, flooding, drought and landslide.
- Review of emergency access routes: A review of the emergency access and evacuation routes for fire and flood to determine if there are any risks and to address limitations such as missing links. A condition assessment of current access routes would assist in disaster planning and maintenance scheduling. This action should be completed prior to the establishment of new access roads to determine if new access routes are necessary and where they would be most effective. This should be completed in conjunction with a review of the location of safe refuge areas.
- Adoption and continuous review of the design standards to be applied. Guidelines used should provide guidance on the asset life span (often very high for road/bridge infrastructure) and the subsequent appropriate design criteria.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.4.5 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Establishment of new access roads. This action is dependent on the review of emergency access routes that will indicate if and where new roads may be needed.
- Where environmental conditions are anticipated to significantly increase asset (e.g. bridges) maintenance costs into the future, Council may want to consider the feasibility of upgrading existing assets to lower maintenance cost options.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.5 **The Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes**

Theme	Priority	Details
<i>The Natural Environment Response to Temperature, Rainfall and Other Climatic Changes</i>	2	<i>Higher risks to local environment and water quality are associated with the extreme climate change projections.</i>

Table 4-5 summarises the various actions identified that address the risks associated with the natural environment's response to climatic changes. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-5 Summary of Actions – The Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<p>12. Erosion control and rehabilitation of watercourses (50)</p> <p>13. Water quality monitoring (51)</p>	<ul style="list-style-type: none"> ▪ Implementation of Water Sensitive Urban Design standards (15) ▪ Mapping of fire tolerant and intolerant vegetation communities (24) ▪ Undertake disaster risk assessment of natural assets and develop a Management Plan (28, 45). ▪ Condition assessment of watercourses within the LGA (151). 	<ul style="list-style-type: none"> ▪ Invest in R&D Projects (23, 134) ▪ Develop pest, weed and invasive species management strategy (48)

4.5.2 Adaptation Action: Erosion control and rehabilitation of watercourses

12									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
							✓		✓
Timeframe	Medium			Council's role			Manager		
Type of Action	Policies, Strategies & Plans			Risks Addressed			5, 13, 26		
Description	<p>Implementation of erosion controls and rehabilitation of watercourses within the LGA will improve water quality and riparian condition. A prioritised listed of watercourses should be developed to assist in the allocation of resources.</p> <p>This action will rely on the completion of a condition assessment of watercourses within the LGA to assist in securing funding for works from external agencies.</p> <p>The implementation of this action may be assisted by the development of a pest, weed and invasive species management strategy to guide the rehabilitation of riparian areas.</p>								
Link to other Actions	Action 13, 15, 16								
Performance Indicators	Increase in number of watercourses in good condition. Overall improvement in watercourse condition.								

4.5.3 Adaptation Action: Water quality monitoring

13									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
							✓		✓
Timeframe	Medium			Council's role			Manager		
Type of Action	Policies, Strategies & Plans			Risks Addressed			6, 7, 13, 17, 22, 26		
Description	Water quality monitoring, particularly of high value assets such as water supply areas and recreational waterways, is a proactive approach to reduce risk to human and ecosystem health. This action may include both water quality sampling and the installation of remote water quality monitoring devices that provide an up to date record of water quality in high value waterways. Trends in water quality can also be used as a predictive tool for algal blooms, and habitat and fish health. Understanding water quality in the LGA can assist Council with understanding what needs improvement and where, and ultimately allow Council to allocate funding.								
Link to other Actions	Action 12, 15, 16								
Performance Indicators	Development of water quality database. Improvement in water quality.								

4.5.4 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Implementation of Water Sensitive Urban Design standards.
- Mapping of fire tolerant and intolerant vegetation communities.
- Undertake disaster risk assessment of natural assets and develop a Management Plan: Natural assets may include threatened species and their habitats, creeks and waterways, parks and ovals, and national parks.
- Condition assessment of watercourses within the LGA to determine high priority areas for rehabilitation.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.5.5 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Invest in R&D Projects: Investment in research and development projects to identify adaptive actions for use in Hawkesbury LGA.
- Develop pest, weed and invasive species management strategy that takes into account changed climatic conditions. This may include a literature review of current knowledge on potential impact of weeds and revisions to mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.6 Protecting the Region’s Heritage and Community Infrastructure, especially From Storms

Theme	Priority	Details
Protecting the Region’s Heritage and Community Infrastructure, especially From Storms	2	<i>Moderate to high risks may arise and be exacerbated due to the exposure of the community's heritage and community facilities and Council buildings to storms and extreme weather conditions.</i>

Table 4-6 summarises the various actions identified that address the risks associated with the region’s heritage and community infrastructure. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-6 Summary of Actions – Protecting the Region’s Heritage and Community Infrastructure, especially from Storms

Adaptation Action	Requisite Research & Management	Secondary Response Measures
14. Emergency response protection for key heritage assets (145)	<ul style="list-style-type: none"> Develop inspection regimes for Council assets and infrastructure (124, 125) Management plan for core heritage areas (68) 	<ul style="list-style-type: none"> Review insurance on Council assets to ensure adequacy (13, 137) Review emergency management fund based on disaster damages assessment (138) Encourage adoption of storm resilient installations on properties (62). Undercover parking for Council fleet (64) Consideration of vegetation storm resilience around assets (60, 61, 127) Retrofitting of existing buildings (80, 102)

4.6.2 Adaptation Action: Protection for Heritage Assets

14									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓					✓	
Timeframe	Medium			Council’s role			Facilitator		
Type of Action	Structural Works			Risks Addressed			1, 24, 25		
Description	Where unique heritage items have been identified which have maintenance costs and potential high costs following emergency events (e.g. through hail/ tree/wind/flood damage) installation of site specific emergency response measures may be appropriate (e.g. Dutchdam barriers, deployable protective roofing). The potential for subsidence due to alterations in ground conditions may also need to be considered and reinforcement of heritage assets applied.								
Link to other Actions	Action 1, 2 and 5								
Performance Indicators	Lowered maintenance costs to heritage assets								

4.6.3 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Develop inspection regimes for Council assets and infrastructure: This action may be undertaken in conjunction with the heritage management plan to assist Council in the early identification of cracking and structural distress and enable early intervention. This action also includes the inspection of other Council infrastructure, such as Council buildings, roads and pavements.
- Development of a management plan for all heritage items that considers its environmental risks, exposure and likely maintenance costs. This may be part of a larger Council Asset Management Plan.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.6.4 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Review insurance on Council assets to ensure adequacy: Additional studies may be required to determine the risk to Council assets and the potential for insurance premiums to increase.
- Review emergency management fund based on disaster damages assessment: Assess feasibility of developing a readily accessible emergency management funds in order to have provision for clean-up and rebuild costs due to extreme weather events. Gather data and present the business case to increase Council resources to deal with natural disasters.
- Encourage adoption of storm resilient installations on properties: Storm resilience will reduce damage and clean-up costs. An example of a storm resilient installation may include security shutters on windows.
- Undercover parking for Council fleet: This actions aims to minimise or prevent damage to Council vehicles and equipment during severe storms (e.g. falling trees and hail).
- Management plan for core heritage areas: This action may include a disaster risk assessment of heritage items, particularly in the town centres, and the development of management actions to mitigate and adapt to climate threats.
- Consideration of vegetation storm resilience around assets: This may involve conducting regular surveys to identify trees that present a high risk of collapse or limb drop and remove trees or limbs as appropriate, particularly trees in high risk areas; or the replacement of canopy trees with tree species that can withstand high velocity winds.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.7 **Stormwater Drainage, Infrastructure and Water Quality**

Theme	Priority	Details
Stormwater Drainage, Infrastructure and Water Quality	2	<i>Moderate to high risks may arise and be exacerbated by Council's stormwater infrastructure being unable to cope with increases in storm intensities and having its capacity breached.</i>

Table 4-6 summarises the various actions identified that address the risks associated with stormwater management and infrastructure. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-7 Summary of Actions – Stormwater Drainage, Infrastructure and Water Quality

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<p>15. Utilisation of grey-water systems (71)</p> <p>16. Encourage the uptake of stormwater harvesting (74, 79)</p> <p>Actions 12 and 13 directly address this risk as well.</p>	<ul style="list-style-type: none"> ▪ Implementation of Water Sensitive Urban Design standards (15) ▪ Undertake disaster risk assessment of key infrastructure (27, 58) and determine an Asset Management Plan (7). ▪ Monitoring performance of sewage and stormwater systems (93) ▪ Model stormwater impact from increased storm activity (82) and incorporate into design guidelines (83) 	<ul style="list-style-type: none"> ▪ Review insurance on Council assets to ensure adequacy (13, 137) ▪ Development of an irrigation plan (106)

4.7.2 Adaptation Action: Utilisation of grey-water systems

15									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓						✓
Timeframe	Medium			Council's role			Manager		
Type of Action	Structural Works			Risks Addressed			1, 8, 24		
Description	Incorporation of greywater recycling into public infrastructure to reduce reliance on the use of mains water. This will build resilience during drought periods.								
Link to other Actions	Action 1, 7								
Performance Indicators	Grey water recycling systems installed on Council assets								

4.7.3 **Adaptation Action: Encourage the uptake of stormwater harvesting systems**

16									
Applicability to other focus Area	Flooding	Emergency Management	Growth Areas	Bushfire Risk Management	Roads and Bridges	Natural Environment Response	Heritage and Community Infrastructure	Stormwater, Drainage and Water Quality	Built Environment Response
			✓						✓
Timeframe	Short			Council's role			Facilitator		
Type of Action	Policies, Strategies & Plans			Risks Addressed			1, 8, 24		
Description	Encourage changes to existing and new developments, to include stormwater harvesting systems. This action aims to limit mains water use and will provide resilience in times of drought.								
Link to other Actions	Action 1, 7								
Performance Indicators	Number of stormwater harvesting systems installed on new developments.								

4.7.4 **Requisite Research and Management**

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Implementation of Water Sensitive Urban Design standards.
- Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan: This action would involve the assessment of risk to Councils stormwater and sewer assets (McGraths Hill Treatment Plant, South Windsor Treatment plan, CDS unit and GPTs).
- Monitoring performance of sewage and stormwater systems to identify any system failures or issues.
- Model stormwater impact from increased storm activity and incorporate into design guidelines. Additional studies to model this impact may be undertaken as part of the disaster risk assessment and the outcomes incorporated into Council's capital works program.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.7.5 **Secondary Response Measures**

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Review insurance on Council assets to ensure adequacy: Additional studies may be required to determine the risk to Council assets and the potential for insurance premiums to increase.
- Development of an irrigation plan: An irrigation plan could be utilised to reduce mains water usage by developing a prioritised list of assets requiring irrigation, identifying alternative supplies of water, and identifying alternative solutions to irrigation (e.g. application of mulches or increased mowing heights).

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

4.8 The Built Environment's Response to Temperature, Rainfall and Other Climatic Changes

Theme	Priority	Details
The Built Environment's Response to Temperature, Rainfall and Other Climatic Changes	3	<i>Lower to moderate risks may be brought about by the response of buildings and settlements to extreme changes in temperature and rainfall.</i>

Table 4-8 summarises the various actions identified that address the risks associated with the built environment's response to changes in conditions. The subsequent sections provide further detail on each of the Adaptation Actions; as well as relevant Requisite Research and Management and Secondary Response Measures.

Table 4-8 Summary of Actions – The Built Environment's Response to Temperature, Rainfall and Other Climatic Changes

Adaptation Action	Requisite Research & Management	Secondary Response Measures
<p>Key actions within this theme have been detailed as recommended actions within other themes, including:</p> <p>Action 4: Retrofitting of existing buildings (80, 102)</p> <p>Action 7: Water sensitive urban design</p> <p>Action 9: Encourage adoption of fire resilient property standards and installations (16, 21)</p> <p>Action 10: Use of road materials to minimize maintenance costs and heat absorption (116)</p>	<ul style="list-style-type: none"> ▪ Use of design standards that consider change in natural hazard (11, 17, 18, 40, 90) ▪ Use of design standards that consider subsidence / heave in infrastructure foundation design (99) ▪ Shade audits of public areas (54) ▪ Develop inspection regimes for Council assets and infrastructure (124, 125) 	<ul style="list-style-type: none"> ▪ Review insurance on Council assets to ensure adequacy (13, 137) ▪ Review emergency management fund based on disaster damages assessment (138) ▪ Invest in R&D Projects (23, 134) ▪ Provision of additional public shading (53)

4.8.2 Requisite Research and Management

A number of other tasks were identified that were considered to be predicate steps seen as necessary to complete the prioritised Adaptation Actions or as being of representative of good practice for Council to undertake as part of its existing operations. In particular, many of the Requisite Research and Management tasks contribute to adaptation to changes in natural hazards through their periodic review and updating. These included:

- Use of design standards that consider change in natural hazard: Update LEP and DCP with latest standards and best practice for bushfire resilience, heat, stormwater and other climate and natural hazard risks.
- Use of design standards that consider subsidence / heave in infrastructure foundation design.
- Shade audits of public areas: Conduct shade audits to determine the adequacy of existing shade, whether there is a need for more, if appropriately located and of appropriate size. This should be completed prior to the action to recommending the provision of shading.
- Develop inspection regimes for Council assets and infrastructure: This action may be undertaken in conjunction with the heritage management plan to assist Council in the early identification of cracking and structural distress and enable early intervention. This action also includes the inspection of other Council infrastructure, such as Council buildings, roads and pavements.

It is recommended that Council consider whether these tasks are currently undertaken or if there is a need for any such steps to be implemented.

4.8.3 Secondary Response Measures

A number of other measures were identified that were considered to have merit and correspond to the risks identified in the GHD (2012) report. These included:

- Review insurance on Council assets to ensure adequacy: Additional studies may be required to determine the risk to Council assets and the potential for insurance premiums to increase.
- Review emergency management fund based on disaster damages assessment: Assess feasibility of developing a readily accessible emergency management funds in order to have provision for clean-up and rebuild costs due to extreme weather events. Gather data and present the business case to increase Council resources to deal with natural disasters.
- Invest in R&D Projects: Investment in research and development projects to identify adaptive actions for use in Hawkesbury LGA.
- Shading: Shade provision policies for street furniture, shelters and awnings. Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres.

It is recommended that Council consider whether there are specific locations or areas where undertaking these measures may be of high value.

5 Recommendations and Next Steps

This report identifies 16 Adaptation Actions which it is recommended that Council consider undertaking in order to ameliorate the 27 natural hazard risks identified by GHD (2012) across the eight theme areas (**Table 5-1**). It is recommended that Council consider the extent to which these actions are practicable to site specific conditions in the LGA and whether similar actions or initiatives are already undertaken by Council or other organisations, either within the LGA or across the broader region. It is possible that unique characteristics of the LGA minimise the efficacy of the recommended actions.

Table 5-1 Actions

Sub Plan Theme	ID No.	Description	Time-frame	Council's Role	Key Performance Indicators
Building Resilience and Emergency Management	1	Provision of off-grid utilities at safe refuge areas and at key Council properties.	Short	Facilitator	Number and distribution of off-grid systems.
Building Resilience and Emergency Management	2	Business Continuity Plan	Short	Manager	Implementation of Business Continuity Plan.
Building Resilience and Emergency Management	3	Engineering Controls for Landslip	Medium	Manager	Reduction in frequency of landslip and associated damage / delays.
Building Resilience and Emergency Management Built Environment's Response	4	Retrofitting of existing buildings	Medium	Manager	Proportion of Council facilities with sustainable insulation and cooling.
Building Resilience and Emergency Management	5	Maintenance Support for Residents in High Risk Areas	Medium	Manager	Provision of services to at risk facilities. Reduction in average damage costs or insurance claims.
Managing Development to Consider Climate Changes in Growth Areas	6	Reduction in use of hard stand areas	Medium	Advisory / Manager	Reduction in proportionate presence of hard stand in new development design.
Managing Development to Consider Climate Changes in Growth Areas Built Environment's Response	7	Implementation of Water Sensitive Urban Design standards	Medium	Advisory / Manager	Number of WSUD systems developed; Measurable reduction in temperature; Increased water storage capacity.
Bushfire Risk Management	8	Establishment of Council disaster management fund	Medium	Manager	Costs associated with bushfire clean-up.
Bushfire Risk Management Built Environment's Response	9	Encourage adoption of fire resilient property standards and installations for residents	Medium	Facilitator	Number of properties compliant with AS3959 as a minimum. Reduction in fire damage costs.
Maintaining Roads and Bridges Built Environment's Response	10	Use of road materials to minimize maintenance costs	Short	Facilitator	Annual maintenance costs
Maintaining Roads and Bridges	11	Relocation of key asset crossing locations	Medium	Manager	Frequency of asset closure.
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes	12	Erosion control and rehabilitation of watercourses	Medium	Manager	Increase in number of watercourses in good condition. Overall improvement in watercourse condition.

Sub Plan Theme	ID No.	Description	Time-frame	Council's Role	Key Performance Indicators
Stormwater Drainage, Infrastructure and Water Quality					
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes Stormwater Drainage, Infrastructure and Water Quality	13	Water quality monitoring	Medium	Manager	Development of water quality database. Improvement in water quality.
Heritage and Community Infrastructure	14	Emergency response protection for key heritage assets	Medium	Facilitator	Lowered maintenance costs to heritage assets
Stormwater Drainage, Infrastructure and Water Quality	15	Utilisation of grey-water systems	Medium	Manager	Grey water recycling systems installed on Council assets
Stormwater Drainage, Infrastructure and Water Quality	16	Encourage the uptake of stormwater harvesting systems	Short	Facilitator	Number of stormwater harvesting systems installed on new developments.

In the process of identifying these actions, Cardno recognised that there a significant number associated studies and planning that may need to be undertaken to facilitate appropriate application of the recommended Adaptation Actions (Table 5-2). This is not intended to be an exhaustive list of such requisite research and management, but rather serve Council in highlighting key areas of investigation that may advance their understand of natural hazard risks and the most cost effective ways in which they may be addressed.

Table 5-2 Requisite Research

Sub Plan Theme	Description
Building Resilience and Emergency Management Maintaining Roads and Bridges Stormwater Drainage, Infrastructure and Water Quality	Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan
Building Resilience and Emergency Management	Review of emergency access routes
Building Resilience and Emergency Management	Mapping of static water supply
Building Resilience and Emergency Management Stormwater Drainage, Infrastructure and Water Quality	Monitoring performance of sewage and stormwater systems
Building Resilience and Emergency Management	Consideration of vegetation storm resilience around assets
Bushfire Risk Management	Review location of fire breaks
Bushfire Risk Management Maintaining Roads and Bridges	Review of emergency access routes
Bushfire Risk Management Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes	Mapping of fire tolerant and intolerant vegetation communities
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes	Undertake disaster risk assessment of natural assets and develop a Management Plan
Stormwater Drainage, Infrastructure and Water Quality	Model stormwater impact from increased storm activity and incorporate into design guidelines
Built Environment's Response	Shade audits of public areas
Built Environment's Response	Develop inspection regimes for Council assets and infrastructure

In addition, the nature of natural hazard risks and the timeframe over which they may change is such that a key component of any risk management strategy is implementation of effective management plans that address the existing conditions faced by Council (Table 5-3). On-going revision of these plans at intervals consistent with the rate of change of natural hazards (e.g. every five to ten years) will effectively ensure that any changes in conditions (including direct changes in risk through human activity, e.g. catchment clearance) are considered. Although not applicable in all scenarios, such progressive adaptation is often the most cost effective way for ensuring that all risks faced by Council are considered to be acceptable or, at worst, tolerable.

Table 5-3 Requisite Management

Sub Plan Theme	Description
Building Resilience and Emergency Management	On-going communication on environmental risks
Building Resilience and Emergency Management	Provision of an up-to-date DISPLAN that considers climate change risks – to be regularly updated
Building Resilience and Emergency Management	Utilisation of grey-water systems
Building Resilience and Emergency Management Bushfire Risk Management	Use of design standards that consider change in natural hazard
Building Resilience and Emergency Management	Heat emergency plans
Managing Development to Consider Climate Changes in Growth Areas Built Environment's Response	Use of design standards that consider change in natural hazard
Managing Development to Consider Climate Changes in Growth Areas	Strengthen DCP standards for ESD (particularly in growth areas)
Bushfire Risk Management	Installation of fire danger signage across the LGA
Bushfire Risk Management	Community engagement relating to fire safety
Bushfire Risk Management	Maintenance and upgrade of Council recreational and public vegetated space that minimises the risk of fires starting
Maintaining Roads and Bridges	Adoption and continuous review of the design standards to be applied
Natural Environment's Response to Temperature, Rainfall and Other Climatic Changes Stormwater Drainage, Infrastructure and Water Quality	Strengthen DCP standards for WSUD
Built Environment's Response	Use of design standards that consider subsidence / heave in infrastructure foundation design

There are a number of economic decision making tools available to Council to aid in selection of the optimal adaptation action strategy over time, including progressive adaptation approaches. Amongst others, these include:

- Multi-Criteria Assessment,
- Economic and Financial Cost Benefit Analysis and associated sensitivities; and
- Real Options Analysis.

Application of such analyses will aid Council in its selection and evaluation of adaptation actions that maintain acceptable risk levels while maximising value for money and return on investment. However, it is considered that Council may want to evaluate the Requisite Research and Management actions in advance (or parallel) of implementing the recommended Adaptation Actions.

Planning for Climate and Natural
Hazards

APPENDIX

A

RISK ASSESSMENT – GHD (2012)



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Hawkesbury City Council

Planning for Climate and Natural Hazards

Risk Assessment Report

May 2012



This report titled Planning for Climate and Natural Hazards: Risk Assessment ("Report"):

- 1. has been prepared by GHD Pty Ltd ("GHD") for Hawkesbury City Council;*
- 2. may only be used and relied on by Hawkesbury City Council;*
- 3. must not be copied to, used by, or relied on by any person other than Hawkesbury City Council without the prior written consent of GHD;*
- 4. may only be used for the purpose of preliminary risk assessment-based planning for climate change adaptation (and must not be used for any other purpose).*

GHD and its servants, employees and officers otherwise expressly disclaim responsibility to any person other than Hawkesbury City Council arising from or in connection with this Report.

To the maximum extent permitted by law, all implied warranties and conditions in relation to the services provided by GHD and the Report are excluded unless they are expressly stated to apply in this Report.

The services undertaken by GHD in connection with preparing this Report:

- Were limited to: the collation of climate change projections as reported by peak Australian scientific bodies and relevant to the Hawkesbury City local government area; facilitating a process whereby Hawkesbury City Council personnel provided inputs to the identification of community assets and values that may be sensitive to climate change, and an examination of risks to the community and Council that may arise; and the identification of broad adaptation planning options that Hawkesbury City Council may consider.*
- Did not include the preparation of climate change projection data or quantification of risks or adaptation management costs.*

The opinions, conclusions and any recommendations in this Report are based on assumptions made by GHD when undertaking services and preparing the Report ("Assumptions"), including (but not limited to):

- That the 'future' levels of risks to the Hawkesbury City Council and community were assessed based on the assumption that the projected climates as described in this report were overlaid onto the Hawkesbury City local government area as it currently exists and functions.*
- That the risks and climate adaptation planning options priorities were not measurable in absolute terms, but that the measures applied reflect the relative magnitude of risk and planning priority only.*

GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with any of the Assumptions being incorrect.

Subject to the paragraphs in this section of the Report, the opinions, conclusions and any recommendations in this Report are based on conditions encountered and information reviewed at the time of preparation and may be relied on until May 2013, after which time, GHD expressly disclaims responsibility for any error in, or omission from, this Report arising from or in connection with those opinions, conclusions and any recommendations.

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- A Hawkesbury City: Quick Facts
- B Risk Assessment Guidance
- C Risk Assessment Register
- D Risk Assessment Summary and Adaptation Themes
- E Adaptation Planning Principles

1. Introduction

Hawkesbury City Council has a vision to manage the future growth of the community and to be a vibrant and sustainable community. This vision is outlined in *Hawkesbury Community Strategic Plan 2010-30*. Council will play a primary role in undertaking the work and planning required to meet these visions.

In planning for its growth, and to develop appropriate strategies to deliver the infrastructure, facilities and services that will be required in a way that meets its community's needs and vision, Hawkesbury must also address the challenges that may be presented by a changing climate. There is a scientific consensus that human activities, including primarily through the burning of fossil fuels over the past century, is having an impact on the global climate (CSIRO and BoM, 2007). Global and regional changes in long-term patterns of temperature, rainfall, and other climate variables will have impacts on communities that require consideration, examination and planning. Local governments have a crucial role to play in developing and implementing climate adaptation plans.

Hawkesbury City Council has commissioned this study to:

1. Identify and assess the risks that a changing climate may pose to meeting the objectives and aspirations that are set out in the *Hawkesbury Community Strategic Plan 2010-30* and other key strategic plans; and
2. Determine the adaptation planning themes and approaches that may be adopted and implemented by Council so as to manage the risks that may arise in association with a changing climate.

The study approach, and a guide to navigating this report, is provided below:

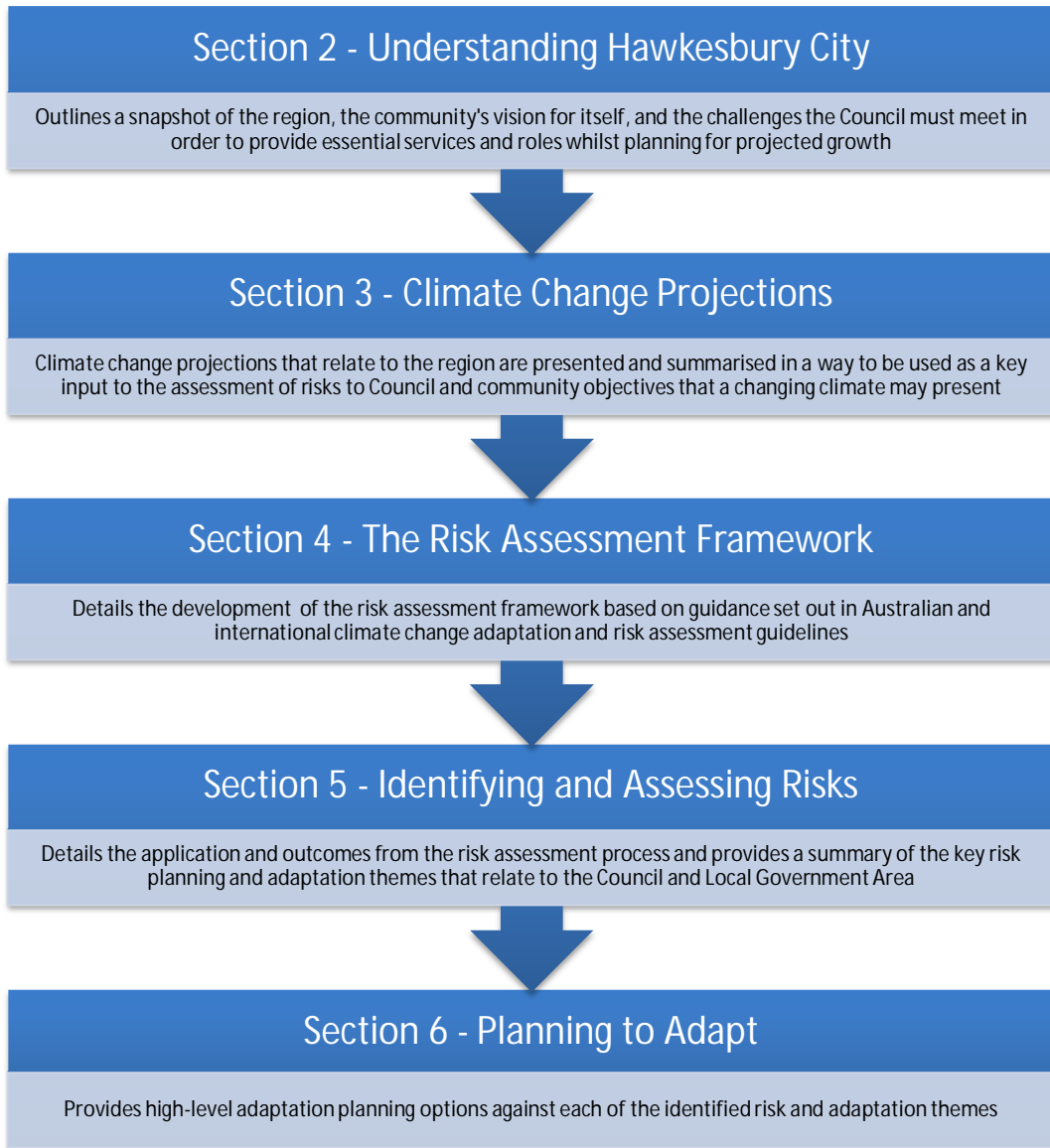


Figure 1 Study approach and report structure

2. Understanding Hawkesbury City

A series of 'quick facts' relating to Hawkesbury City Council, the community that it serves and the region that it covers is provided at Appendix A. Hawkesbury City's key attributes that are relevant to this study are summarised as follows:

The Hawkesbury region is home to a number of values and provides a number of services

The Hawkesbury LGA is home to a number of environmental and heritage sites, including early convict trails, many historic buildings, homesteads and parks, and the important river frontage and riparian areas of the Hawkesbury River and linked waterways. The community cherishes its proximity to bush and parklands and the rural lifestyle on Sydney's fringes. Council also provides services for a variety of urban and rural communities, caters for regional tourism and provides a home for local and Sydney-based workers. Council plays a role in the maintenance, enhancement and addition to each of these values.

Hawkesbury City is growing, and has a vision for the type of community it wants to be

The Hawkesbury region is experiencing a change in the composition of its population, primarily associated with an ageing population and declining household size. The next 20 years will see the Council adjusting to its changing demographic while seeking to maintain its present values, and to be a vibrant and sustainable community. Hawkesbury City Council will play a major role in laying the foundations to meet these visions, and it has outlined the supporting local services, programs and activities it intends to undertake via annual Management Plans.

The Hawkesbury City presents its 20-year vision through five key themes in its *Hawkesbury Community Strategic Plan 2010-30*, namely:

- ▶ Looking after people and place;
- ▶ Caring for our environment;
- ▶ Linking the Hawkesbury;
- ▶ Supporting business and local jobs;
- ▶ Shaping our future together.

Managing rapid growth in a future with an uncertain climate is a priority

The region comprised by The Hawkesbury will be challenged by the need to manage an increased population growth while maintaining a liveable region and economic, social and environmental stability. A changing climate provides additional challenges and perhaps opportunities. A priority for Council will be to continue to provide quality governance, services and facilities for a growing population in the face of climate change.



Source: http://www.hawkesbury.nsw.gov.au/_data/assets/pdf_file/0010/1225/web-map.pdf

Figure 2 Hawkesbury City Local Government Area

3. Climate Change Projections

3.1 Climate variability vs. change

Our climate weather patterns are already variable. Climate variability refers to the 'normal' day-to-day, seasonal and yearly variability in the components of climate (e.g. temperature, rainfall) that we commonly observe. This variability can result in extreme conditions such as flooding, heatwaves and hail, which require management. Local government have practices and strategies in place to deal with routine climate variability.

Climate change is likely to influence changes to average climate conditions and the frequency and severity of extreme events, rather than causing completely new climate-related risks. This progressive change has implications for sea levels, ocean temperatures and the functionality of natural ecosystems. Climate change also means that councils can no longer rely on prevailing assumptions that climate will be more or less the same as it was over the past 50 or 100 years.

3.2 Evidence and observations of change

The Intergovernmental Panel on Climate Change (IPCC) exists to provide decision-makers and others interested in climate change with an objective source of information about climate change. The world's leading climate scientists provide rigorous evidence demonstrating the current and projected impacts of human activity on the global climate in the IPCC *Fourth Assessment Report* (IPCC, 2007). Collaborations toward the IPCC's *Fifth Assessment Report* are underway, and it is due for release in 2013/14.

There is a wide body of evidence available to suggest that Australia's climate has already changed significantly, particularly over the last 50 years. Some of the key changes currently observed (CSIRO & BoM, 2007), at a national scale, are listed below:

Oceans

- Australian sea levels rose by 10 cm between 1920-2000; and
- Substantial warming has occurred in the three oceans surrounding Australia, particularly off the south-east coast and in the Indian Ocean.

Temperature

- Average Australian temperatures have increased 0.9 °C since 1950; and
- There are now more heatwaves and fewer frosts.

Rainfall

- Rainfall has declined substantially across most of eastern and south-western Australia since 1950; and
- Patterns of rainfall intensity and frequency have changed in the south-east, the south-west and along the central east coast of Australia.

3.3 Projections for Hawkesbury City LGA

3.3.1 Scenarios

The IPCC (2007) sets out a number of global climate projections that relate to how the world may respond to the challenge of climate changes, the need to continue to produce and use energy and resources, and the global greenhouse gas emissions that may occur (refer to Figure 3). The CSIRO & BoM (2007) provide climate change projections for Australia that relate to the IPCC scenarios.

The CSIRO & BoM (2007) provide climate change projections for Australia that relate to each of the IPCC greenhouse gas emissions scenarios.

The 'A1' storyline in the IPCC and CSIRO reports describes a future world of very rapid economic growth, a global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient energy technologies. The major underlying theme is a substantial reduction in regional differences in per capita income. It represents the storyline under which the greatest climate changes would likely occur. The 'A1' storyline develops into multiple scenario groups that describe alternative ways in which global energy needs would be met in the face of rapid global development.

Generally, under any scenario, the extent of climate change is projected to increase over time, and the projected changes are more uncertain for longer-term projections. As such it is useful to consider more than one climate scenario for undertaking a risk assessment. The scenarios adopted for Hawkesbury City's risk assessment were as outlined in Table 1. Climate change scenarios that relate to both a nearer-term (2030), moderate and a longer-term (2070), extreme extent of modelled changes were adopted. The 2030 scenario was adopted to relate to Hawkesbury City's current strategic planning horizon. While the period 2070 may be beyond the effective planning horizons for Council today, there is great uncertainty about the extent of climate changes that may ensue. The purpose of adopting the extreme case of change for assessment was to understand how resilient the community may be to such extremities, which can be useful for risk management, particularly for the purpose of filtering out some of the less material risks.

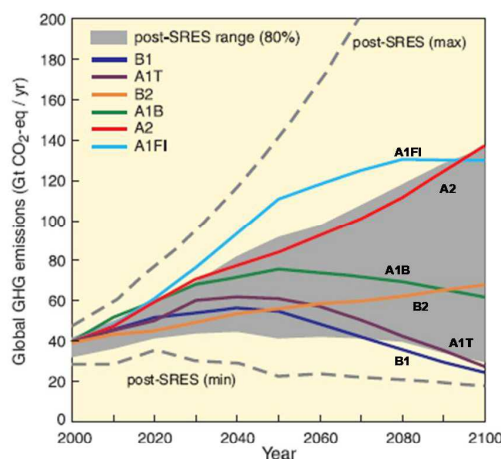


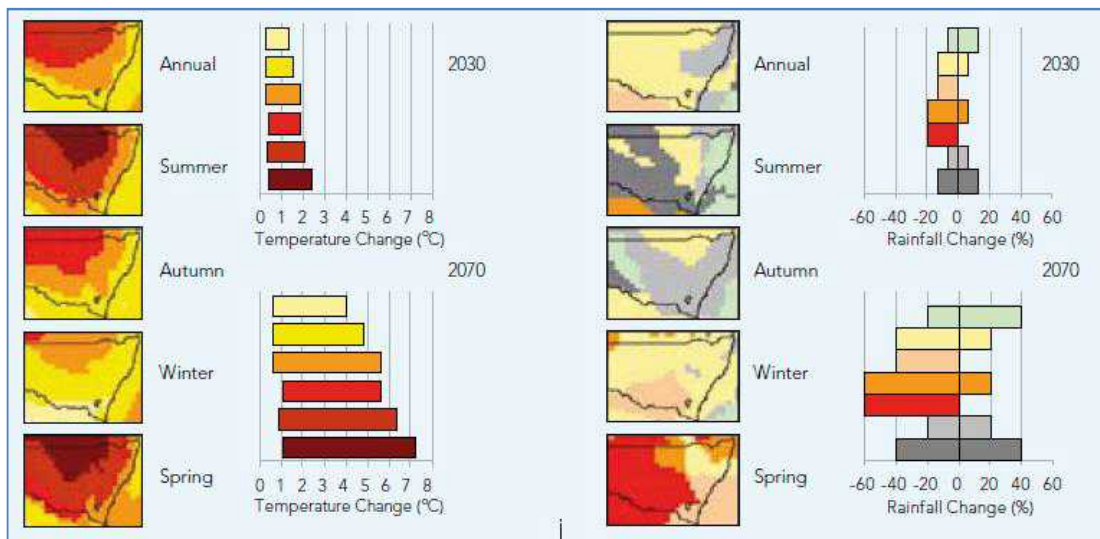
Figure 3 Greenhouse gas emissions scenarios (IPCC, 2007)

Table 1 Climate scenario storylines adopted for the Hawkesbury City climate change risk assessment

Scenario	IPCC scenario	Scenario description	Year	Rationale
Long-term, extreme change scenario	A1FI scenario	An extreme scenario; Outlines a future that remains largely fossil fuel intensive	2070	This would represent an extreme or near worst-case climate scenario, and will be useful to highlight the long term challenges and monitoring that may be useful for adaptation to meet the <i>Hawkesbury 2030</i> visions and beyond.
Near-term, moderate change scenario	A1B scenario	A moderate scenario; Outlines a balance across all energy sources, whereby there is no heavy reliance on one particular energy source, either renewables or fossil fuels	2030	This would be used to represent a more likely climate scenario that the Hawkesbury City may need to consider in its next series of five-year plans, and relates directly to the <i>Hawkesbury 2030</i> planning horizon.

3.3.2 Summary of projections

Climate change projections that relate to the adopted near and long-term climate change scenarios for the Hawkesbury City LGA are provided below (Figure 4, Table 2).



Source: Commonwealth Scientific and Industrial Research Organisation and Australian Bureau of Meteorology (CSIRO & BoM), 2007, *Climate Change in Australia: Technical Report 2007*, Australian Government, Canberra, Australia.

Figure 4 Climate change projections for New South Wales

Table 2 Climate change projections for Hawkesbury City

VARIABLE	CURRENT CLIMATE		CLIMATE CHANGE PROJECTIONS	Nearer-term, moderate scenario			Longer-term, upper range scenario			Source
	Season	Historic trend		Reported as	10th %ile	50th %ile	90th %ile	10th %ile	50th %ile	
Max. daily temperature (°C)	Annual	23.7 °C	Absolute change	+0.6	+0.9	+1.3	+2.1	+3.0	+4.3	1,2
	Summer	29.0 °C	Absolute change	+0.6	+1.0	+1.5	+2.1	+3.1	+4.7	1,2
	Autumn	23.7 °C	Absolute change	+0.6	+0.9	+1.4	+1.9	+3.0	+4.3	1,2
	Winter	17.9 °C	Absolute change	+0.6	+0.8	+1.2	+1.8	+2.6	+3.7	1,2
	Spring	24.3 °C	Absolute change	+0.7	+1.0	+1.5	+2.2	+3.3	+4.8	1,2
No. days over 35 °C	Annual	16.5 days p.a.	Absolute change	+4.1	+4.4	+5.1	+6.0	+8.2	+12.0	1,2
Rainfall (mm)	Annual	809 mm	Percentage change	-9	-3	+3	-25	-8	+10	1,2
	Summer	270 mm	Percentage change	-7	+1	+9	-21	+2	+28	1,2
	Autumn	221 mm	Percentage change	-10	-2	+6	-29	-6	+21	1,2
	Winter	138 mm	Percentage change	-15	-5	+4	-40	-16	+12	1,2
	Spring	180 mm	Percentage change	-16	-6	+4	-44	-17	+12	1,2
Storm intensity	Event	N/A	Percentage change	NSW planning advice is to assume intensity of rainfall events with some average recurrence interval (e.g. 1 in 10, 1 in 100 years, etc.) may increase by up to 30%. Also refer to Box 1.					3	
Potential Evaporation (%)	Annual	N/A	Percentage change	+2	+3	+5	+5	+9	+15	1,2
Ave. 3pm Wind Speed (km/h)	Annual	13.3 km/h	Percentage change	-5	0	+4	-15	-1	+12	1,2
Ave. 9am Relative Humidity (%)	Annual	75%	Percentage change	-1.3	-0.4	+0.4	-4	-1.2	+1.3	1,2
Solar Radiation (%)	Annual	N/A	Percentage change	-1	+0.3	+1.9	-3.2	+0.9	+6	1,2
High bushfire risk days	Annual	7.6 days p.a.	Absolute change	Modelling indicates the number of days will increase to within the range of 9.4-14.2 by year 2020					4	

1. Projection data sourced from CSIRO (2007) *Climate Change in Australia Technical Report*, Appendix B City Summaries and OzClim (www.ozclim.com.au)

2. Historical data from Bureau of Meteorology (www.bom.gov.au), Richmond RAAF Base, Hawkesbury monitoring station. Data downloaded 28 March 2012.

3. New South Wales Department of Environment, Climate Change and Water [DECCW] (2007) *New South Wales Floodplain Risk Management Guideline, Residential Flood Damages*. DECCW, Sydney, NSW. This document advises that climate change be accounted in flood damage management by assuming a 30% increase on storm intensities.

4. Lucas, C., Hennessy, K., Mills, G. & Bathols, J. (2007) *Bushfire Weather in South-eastern Australia: Recent Trends and Projected Climate Change Impacts*. Consultancy report prepared for the Climate Institute of Australia.

Box 1 – Impact of assuming a 30% increase to the intensity of a rainfall event on the estimation of its Average Recurrence Interval (ARI)

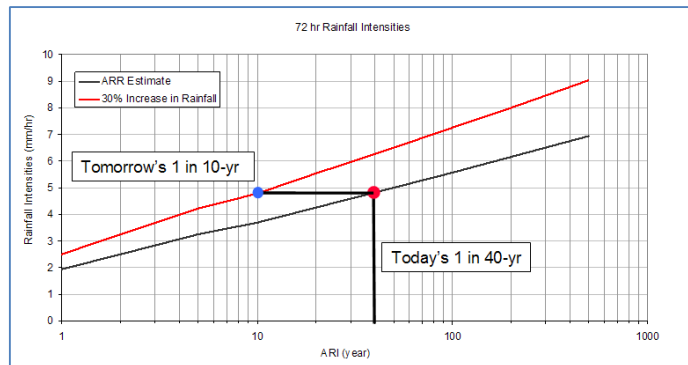
Rainfall events can be described in terms of:

- Intensity, *i.e.* how much rain is falling within a certain period of time;
- Duration, *i.e.* how long the event might last; and
- Frequency, *i.e.* how often on average might an event of this intensity and duration occur.

The *Australian Rainfall and Runoff (ARR)* (Engineers Australia, 1987) provides the methods and guidance for developing intensity-frequency-duration (IFD) rainfall profiles for any region in Australia. While it is currently under review, this guide does not yet account for the impacts of a changing climate on rainfall patterns.

The current advice relating to climate change in New South Wales from the Office of Environment & Heritage is that, for planning purposes, local councils and others may apply a 30% intensity increase factor to the IFD relationships that can currently be derived from *ARR*. The

implications of applying this concept is outlined in the figure below; for the hypothetical “72-hour duration rainfall event” shown, applying a 30% increase on the modelled rainfall intensities results in a storm intensity that currently occurs on average every 1 in 40 years (“today’s 1 in 40 year” event) would become a 1 in 10 year rainfall intensity event (*i.e.* “tomorrow’s 1 in 10 year”).



4. Risk Assessment Framework

A risk assessment and adaptation planning approach has been developed that is commensurate with the guidance in the following:

- Australian Greenhouse Office (AGO, 2006) *Guidelines for Climate Change Risk Management for Governments and Business*;
- Department of Climate Change and Energy Efficiency (DCCEE, 2007) *Climate Change Adaptation Options for Local Government*;
- ISO/ANZS 31000:2009 *Risk Management*; and
- The current draft AS 5334:2011 *Climate Change Adaptation for Settlements and Infrastructure*.

4.1 Focus: Hawkesbury City's values and what Council can do

Risk management is a process of setting objectives, developing an understanding of the events and uncertainties that might contribute to not meeting those objectives, and making priorities to manage or learn more about specific risks (ISO/ANZS 31000:2009).

In general, the role of local government is to provide and maintain a number of community assets and services, and to act as an advocate for the needs and desires of the community it represents. To be useful to Council, the assessment of risks as a result of climate change in Hawkesbury City needs to be framed within an understanding of:

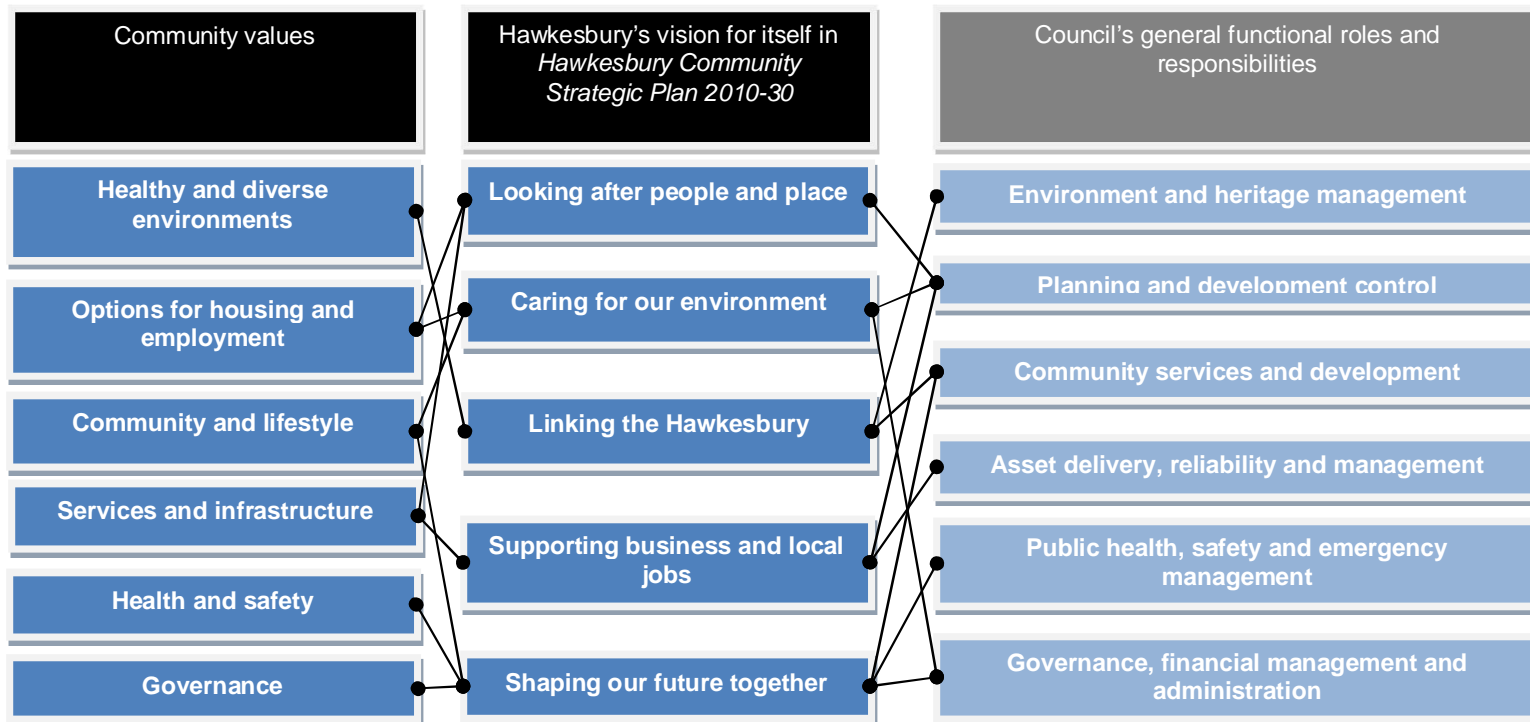
- What are the things that the Hawkesbury City community uniquely values, and
- The extents and limits to which Council can contribute to providing them.

To assist with this understanding the Hawkesbury City Council and community values (*i.e.* the things that can be “at risk”) together with the functions and services that Council can provide to assist meeting those objectives, and how the two can interact, are mapped out (Figure 5). Also, this review of Hawkesbury City values and Council roles was used to develop the risk assessment criteria set out in Section 4.4, and served as a prompt for the types of influences that Council can have when developing adaptation options later in the study.

4.2 Differentiating between potential impacts and risks

Climate changes may have impacts on (*e.g.* damage) natural and infrastructure assets, but the risks actually relate to how these impacts may jeopardise Hawkesbury City Council's ability to meet its own objectives and the role it has in the community, and not necessarily to the assets themselves. Hence, the level of risk to Council and its community associated with a changing climate will not arise directly from the changes in the climate, but usually from a “cause-and-effect” chain whereby the change in the climate, the physical impacts on the local infrastructure and assets, and the risks to the community values that can eventuate are mapped out (*e.g.* Figure 6). Understanding this is critical to be able to properly identify the types of risks that may arise.

Figure 5 Community values and Hawkesbury City's vision (left), and relationships with Council and its role in the community (right)



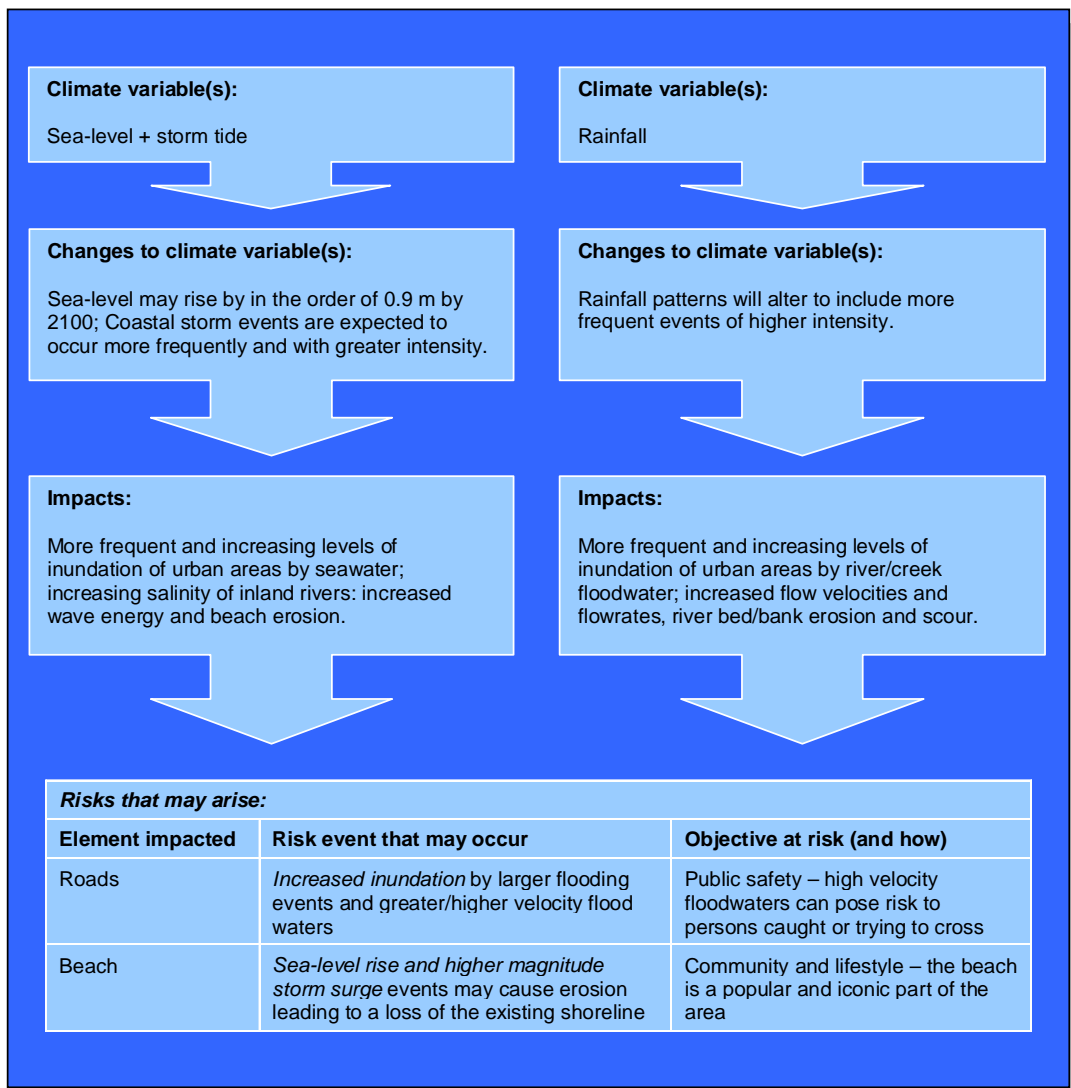


Figure 6 Example “cause and effect chain” where climate changes lead to risks

4.3 Climate variables, hazards, impacts and risks

Information relating to the types of climate variables and natural hazards that may have impacts on the natural and urban assets in the Hawkesbury City LGA is provided below (Table 3). An illustrative listing of the types of assets and values that may be vulnerable to a changing climate, and the community objectives that are potentially at risk in the Hawkesbury City LGA, are also provided (Figure 7).

Table 3 Relationships between climate variables and natural hazards of relevance to Hawkesbury City

Hazard type	Relevant climate variables (and for which climate change projections are available)							Notes
	Temperature	Rainfall	Evaporation	Wind speed	Humidity	High bushfire risk days	Sea-level rise	
Wildfire	X	X		X		X		<p>Higher temperatures and wind speeds heighten wildfire risks. Rainfall patterns can influence the amount of fuel available to perpetuate fire.</p> <p>This is relevant to the Hawkesbury, where bushfire hazard mapping indicates that the LGA is highly vulnerable to fire events</p>
Flooding		X					X	<p>Inland catchment rainfall patterns, particularly long term and event-based intensity patterns, can influence flooding risks. Sea-level rise may make some coastal catchment areas more vulnerable to flooding, with effects felt further inland.</p> <p>This is relevant to the Hawkesbury, including areas along the Hawkesbury River frontage, and known high risk areas.</p>
Landslide	X	X						<p>Rainfall (and associated hydro-geological responses) can be a trigger for landslides. Temperature changes may also impact soil properties and slip planes of landslides.</p>
Storms (rain, hail, wind, snow)	X	X		X				<p>Storm intensity and frequency changes may be related to changes in atmospheric temperature, humidity, wind and rainfall patterns.</p> <p>This is relevant to the Hawkesbury; storm damage is already Australia's most costly type of natural hazard.</p>
Heat wave	X							<p>Increases in average maximum temperatures will also impact the frequency and severity of extreme temperatures.</p>

Hazard type	Relevant climate variables (and for which climate change projections are available)							Notes
	Temperature	Rainfall	Evaporation	Wind speed	Humidity	High bushfire risk days	Sea-level rise	
								This is relevant to the Hawkesbury and its natural assets (and ecologies) that may be impacted by changes
Fog and frosts	X		X		X			<p>Fog frequency is related to humidity and temperature.</p> <p>This may be relevant to the Hawkesbury, where more frequent frosts and fogs could impact the local agricultural-based economy, or other natural & physical assets</p>
Drought		X						<p>Changes to rainfall patterns can influence the long-term inflows to catchments, reservoirs and other water users.</p> <p>This may not be relevant to the Hawkesbury, except for where strict water sharing or use rules place constraints on water use in the region.</p>
Salinity	X	X						<p>Environmental changes can impact on soil and water-table properties.</p> <p>This is relevant to the Hawkesbury, where a policy and building code already exists relating to development in saline soils.</p>



Figure 7 Elements and assets in Hawkesbury City that may be impacted by climate change processes (left) and the community values that may be placed at risk as a result (right)

4.4 Risk assessment approach and guiding materials

4.4.1 Identifying risks

The identification of risks consisted of facilitated brainstorming sessions with Hawkesbury City Council participants (at a workshop as described in further detail at Section 5.1) to:

- Identify and record details and locations of assets and values that may be vulnerable to climate changes; and
- Develop a number of risk statements through a brainstorming session which investigates the effects of the climate change impacts specified earlier in this paper. Each risk statement should be developed as a cause-effect statement which describes what may happen to specific services and assets as a result of climate change impacts.

4.4.2 Risk analysis

Each risk statement was analysed by estimating its likelihood and consequence of occurrence. The assigned 'level' of risk was based on a combination of the consequence and likelihood factors. To assist with evaluating and describing risk levels in a common way (to enable risk management priorities to be set), the numerical information and data available to describe risks were summarised in a qualitative way

by way of using the guidance at Appendix B. The likelihoods and consequences associated with each risk were informed by considering a range of information sources including detailed study and modelling outcomes (such as that available for Hawkesbury City on flood and bushfire risks) and the experiences and knowledge of Hawkesbury City Council personnel. Analysis of risks took into account any existing factors which are in place to control the risk.

Risk statements were evaluated for both the 'near-term, moderate' and 'long-term, extreme' climate change scenarios described at Section 3.3. This was useful to provide a rough indication of the possible timing associated with the elevation of a risk to a situation that may require more intensive monitoring or critical management.

4.4.3 Evaluate risks and determine priorities

Once qualitative likelihood and consequence ratings were assigned to each risk statement, the final risk evaluation (prioritisation) was completed using the risk matrix provided (Appendix B). The main objective of the risk evaluation stage is to ensure that the priority ratings are consistent, and that the relative risk ratings among the identified risk statements are well aligned. This key step involves reviewing and adjusting the risk assessment to ensure the final evaluation accurately reflects the relative risks of different climate impacts. Then, risk management needs can be prioritised based on the relative levels of assigned risk. As a guide, AGO (2006) suggests that the management priority levels for risks of various magnitudes can be interpreted as follows:

- 'Extreme' priority risks demand urgent attention at the most senior level and cannot be simply accepted as a part of routine operations without executive sanction;
- 'High' priority risks are the most severe that can be accepted as a part of routine operations without executive sanction but they will be the responsibility of the most senior operational management;
- 'Medium' priority risks can be expected to form part of routine operations but they will be explicitly assigned to relevant managers for action and maintained under review; and
- 'Low' priority risk will be maintained under review but it is expected that existing controls will be sufficient.

5. Identifying and Assessing Risks

5.1 Workshop

A risk identification and assessment workshop was held on 18 April 2012 at Hawkesbury City Council to:

- Identify potential risks to Hawkesbury City community values and Council service areas as a result of projected climate change;
- Analyse risk statements to assist with determining relative levels of risk for each of those identified;
- Evaluate the risk assessments to develop a list of priority risk management issues.

Workshop attendees from Hawkesbury City Council were:

- Dianne Tierney - Strategic Planner
- Matthew Owens - Director City Planning
- Prayog Pradhan - Strategic Planner
- Michael Laing - Strategic Planner
- Steven Kelly - Internal Auditor
- Greg Finnie - Risk Manager
- Shari Hussein - Manager Planning
- Chris Amit - Manager Design & Mapping
- Craig Johnson - Parks Project Officer
- Matthew Toriola - Construction Maintenance Engineer
- Hank Shollenberger - Trade Waste Technical Officer
- Lachlan McClure – Manager Building Services
- Sean Perry - Manager Parks and Recreation
- Richard Vaby – Manager Construction & Maintenance
- Ramiz Younan - Manager Waste Management

5.2 Risk assessment outcomes: Adaptation planning themes

A risk register record of the outcomes from the risk assessment is provided at Appendix C. A total of 27 risk descriptions were prepared and analysed during the workshop. An examination of the risk register resulted in the identification of nine 'adaptation planning themes' for Council. A detailed examination of the themes and the risk items that relate to each is presented at Appendix D. A 'risk profile' for each theme is presented in terms of: (i) the total number of risk items that relate to it; (ii) the proportion of those risks rated as 'low', 'moderate', 'high' or 'extreme' under current and the adopted future climate scenarios; and (iii) a summary of what is driving the risks and the changes to the risk profiles observed among the various climate scenarios.

Broadly, the level of priority that can be afforded to any theme can be determined based on a consideration of both the total number of risks that were identified and the relative magnitudes of current and projected future risks. The listing in Table 4 reflects a suggested ordered level of priority for each adaptation planning theme.

Table 4 Risk assessment summary and adaptation planning themes

Adaptation planning theme	Summary details
<i>PRIORITY 1 ADAPTATION PLANNING THEMES</i>	
Flooding of urban areas	<p>Significant high risks to property, community and people due to flooding of residential areas will be exacerbated by projected climate changes. The known problem areas are largely in the developed south east portion of the LGA, around Windsor, South Windsor, Bligh Park, McGrath Hill and Richmond Lowlands to Pitt Town Bottoms. Council is actively working to inform the community about flood risk and management and to understand further how to control development in the region in a way that is commensurate with good flood management and community needs.</p>
Building resilience and co-ordinated emergency management	<p>Higher risks may eventuate over time in regard to pressures placed on emergency resources and personnel to respond to natural hazard events (especially bushfires and floods) occurring more frequently or in greater magnitudes. The higher risk ratings align with the "high consequence, low probability" profiles of natural hazard emergency scenarios. The Council's Emergency Management Planning already includes monitoring, responsibilities and responsive provisions in the cases of emergency however it is uncertain how these may cope with events larger than what have been experienced previously. Some particular vulnerability at certain locations within the LGA was identified, including at Pitt Town, Colo, MacDonald and South Creek.</p> <p>Moderate risks were associated with the impacts of adverse temperature changes and the effects on community health and services. Heat wave periods are associated with spikes in hospital admissions and the region's proximity to waterways and wetlands exposes it to potential increases in vector (e.g. mosquito-borne) diseases.</p> <p>Moderate risks were associated with the impacts of adverse temperature changes and the effects on the local rural and agricultural aspects of the LGA. Impacts of temperature changes or from flood/bushfire events may test the region's resilience, especially in regard to the continued undertaking of valued rural and agricultural activities.</p> <p>Lower risks to the community are associated with urban water shortages and the need to restrict water use, though pressures on water resources are expected to increase over time and will require management. Periods of extreme water shortages leading to restrictions may occur more frequently, and this may be compounded by increased water demands associated with the growth areas.</p>
Managing development to consider climate changes in growth areas	<p>There is an opportunity to incorporate climate change resilience into new developments in the growth areas. Water Sensitive Urban Design principles and a review of development controls around flood risks in view of a changing climate, building codes for salinity and local soils issues and Asset Protection Zoning for bushfire control can all be considered during the planning and development phases of any new growth areas. In particular for flood and bushfire management, opportunities could be explored for good development practices that may even alleviate risks and exposure to natural hazards in other developed parts of the LGA.</p>
<i>PRIORITY 2 ADAPTATION PLANNING THEMES</i>	
Bushfire risk management	<p>Under extreme climate changes, the risks posed by bushfire to community property, health and safety may be heightened. Generally, higher bushfire risks are 'event-oriented' and can be considered as "low likelihood, high consequence". The increased build-up of dried fuels and increased number of extreme heat days projected under extreme change projections may exacerbate the risk from bushfire. However, fuel management (such as prescribed burning) can impact on the ecosystem of the Cumberland Woodlands and local riparian areas.</p>
Maintaining roads and bridges	<p>Higher risks primarily result due to pressures placed on Council's budget and resources available for infrastructure provision, in particular to address wear and tear of roads and bridges, which may eventuate if extreme climate changes are experienced. As well as disruptions to local traffic, it is anticipated that should the more extreme climate changes eventuate, the higher temperatures and rainfall intensities would see a need to significantly increase the roads and asset management plan maintenance budgets across the whole LGA.</p>

<p>The natural environment's response to temperature, rainfall and other climatic changes</p>	<p>Higher risks to local environment and water quality are associated with the extreme climate change projections. The Hawkesbury's bushland is part of the Cumberland Plain Woodland. Typically grey box, narrow leaved ironbark and forest red gums. Kangaroo grass is the main native ground cover. The Hawkesbury River runs through the area – high nutrient levels in the river have allowed exotic weeds to thrive. There are several bird species, molluscs, mammals and fish that have habitat in the area that are on the vulnerable endangered species list. A number of restoration activities for riparian, wetlands and land areas are underway. An increase in the mean maximum temperature by a few degrees would alter the ecosystem, the flora and fauna it can support, and alter a valued community asset (in particular the riparian areas).</p> <p>Moderate to high risks associated with changes to water quality and recreational use of the water may arise due to increased flow variability and temperatures. Weed infestations, increases in soil erosion and sediment and stormwater runoff can contribute to a degraded water quality and impacts on water users.</p>
<p>Protecting the region's heritage and community infrastructure, especially from storms</p>	<p>Moderate to high risks may arise and be exacerbated due to the exposure of the community's heritage and community facilities and Council buildings to storms and extreme weather conditions. Rain and hail storms are already the most costly natural hazard in Australia. In particular, Hawkesbury residents value the heritage fabric of the town, particularly in the town centres, and the community facilities provided and administered by Council.</p>
<p>Stormwater drainage, infrastructure and water quality</p>	<p>Moderate to high risks may arise and be exacerbated by Council's stormwater infrastructure being unable to cope with increases in storm intensities and having its capacity breached. In general, stormwater and drainage infrastructure may become undersized to cope with larger storm intensities, resulting in localised flooding and damages, particular in the residential and older built areas (including the town centres). Increased urban and other stormwater drainage can increase nutrient, microbial contaminant and heavy metals loads in urban waterways and creeks.</p>
<p><i>PRIORITY 3 ADAPTATION PLANNING THEMES</i></p>	
<p>The built environment's response to temperature, rainfall and other climatic changes</p>	<p>Lower to moderate risks may be brought about by the response of buildings and settlements to extreme changes in temperature and rainfall. Existing building codes for salinity and local soils issues may not be appropriate for future developments, and existing buildings and settlements may be exposed to the impacts of greater heat, temperature extremes and storm events.</p>

6. Planning to Adapt

6.1 On the roles and challenges for local governments

Providing some context on local government roles and challenges in adapting to climate change is useful to assist Hawkesbury City with understanding how it can and may be expected to play a role in the Hawkesbury City community. A changing climate will have a broad range of implications for local governments who will be charged with maintaining the provision of services into the future regardless of changing or increasing exposure to climate, weather and natural hazards. The Productivity Commission (PC, 2012) has recently reviewed the challenges at various levels of planning to adapt to climate changes and offers the following statement in regard to local government:

“A number of potential barriers exist that could be limiting local governments’ ability to plan for and implement adaptation measures. These are not unique to adaptation and are barriers to effective service delivery by local government in the current climate.

- ▶ *There is a lack of clarity regarding the roles and responsibilities for adaptation of councils, including in the areas of land-use planning and emergency management.*
- ▶ *Legal liability concerns appear to be hindering adaptation for many councils. There is a case for state governments to clarify the legal liability of councils and the processes required to manage that liability.*
- ▶ *Many councils do not have the capacity to effectively plan for and implement adaptation responses - some face financial constraints and shortages of professional and technical expertise.”*

It is noted that at the risk workshops Council participants expressed the same concerns; particularly those surrounding an understanding of clarity of roles and legal liability, and other local councils have similar concerns (e.g. Booth & Cox, 2012). The Productivity Commission report only recommends that, among all tiers of government, the issue of roles and liability need to be addressed, but as yet there is no specific solution identified. Despite this, having undertaken the risk assessment component of the study, Council has an initial understanding of where its key vulnerabilities and exposures to a changing climate may reside. While the clarity of roles and liability still needs to be addressed, there are a number of principles that Council can readily adopt as it considers its approach to climate change adaptation. These principles are described at Appendix E.

In regard to this final point, on resources and capability, it is a routine part of planning at the local government level to prioritise works, further studies, or other planning and delivery needs to be met within their strategic plans and budgets. A comment on the considerations Council may wish to make when developing plans and prioritising adaptation planning activities is provided at Section 6.3.

. Options

Table 5 List of adaptation planning options

Adaptation planning theme	Adaptation planning options that may be considered
<i>PRIORITY 1 ADAPTATION PLANNING THEMES</i>	

<p>Flooding of urban and built areas</p>	<ul style="list-style-type: none"> • Understand extent of flood risk: Continue to undertake flood plain studies on the core drainage systems in the LGA and test sensitivity of 1% Annual Exceedance Probability flood levels to changes in assumptions about rainfall intensity (NB: The upcoming new addition of <i>Australian Rainfall and Runoff</i> will provide guidance on this); • Review Council positions and options for engineered solutions and/or transferring risk from the community via financial support for adaptation measures: House raising, purchase and property protection via levees or detention and/or raising of bridge levels; • Review development controls: Continue to apply development controls in flood affected areas and Council to review future Development Control Plan, particularly to assess whether flood planning levels are acceptable as a benchmark for future development. Liaise with State Government and lobby for resolution or guidance on this issue; • Educate: Increase awareness of the community about details related to flooding event management and community expectations and participation in flood risk management. Work with State Emergency Service and others to educate and equip property owners/occupiers in readiness for impacts. • Examine risks associated with wastewater treatment plants: at McGraths Hill and South Windsor, and understand contingencies for managing pollution and health risks in the event of inundation.
<p>Building resilience and co-ordinated emergency management</p>	<ul style="list-style-type: none"> • Educate: the general community and create awareness of the roles and responsibilities identified within the Emergency Management Plan and to encourage new members to volunteer emergency management organisations. To have a wider community and organisational understanding in relation to the role Council plays in assisting emergency services managing disasters. This could be achieved through internal policy development and wider community education programs; • Test and review Emergency Management Procedures: Implement a program of Emergency Management Drills to assess the capacity of emergency organisations to deal with heat, rain, storm events etc.; • Strategic Asset Management: Identify critical infrastructure and services and develop a plan to ensure these critical needs can be maintained during emergency scenarios; • Partnership: Work with State Emergency Services regarding preparedness for incidents and work through recovery plans, including allocation and confirmation of responsibilities. Similarly work with services regarding allocation of resources across the LGA, reflective of expected risks and responsiveness requirements; • Understand the economic drivers of the community and resilience to climate hazards: Map the dependency of the local economy to key industries and activities and develop a detailed understanding of how resilient or otherwise these key economic drivers may be to a changing climate.
<p>Managing development to consider climate changes in growth centres</p>	<ul style="list-style-type: none"> • Understand and educate: Develop and implement a policy on how to manage/integrate climate change impacts for growth centres. Communicate this to the community to enhance their understanding of the challenges/opportunities and how they're being met/realised; • Better understand climate projections: Facilitate formal down-scaled mapping and climate projection data for the LGA; • Match development controls to risk and consider climate effects: Continue to ensure that development is matched to risk and that development in floodplain and fire risk areas is strictly limited. Changes to Development Control Plans and Local Environment Plans to manage and mitigate against the future impacts of climate change risks. For example this could include: <ul style="list-style-type: none"> - Changes to flood detention systems - Changes to engineering specifications for the construction of storm water management infrastructure. - The widening of Asset Protection Zones to mitigate against the risk of bushfire; • Identify and adopt the latest codes, standards and guidelines: Design/construct all new buildings to the latest standards and engineering specifications that include

	<p>climate change considerations;</p> <ul style="list-style-type: none"> • Liaise with/lobby State Government: To identify the requirements for development controls, particularly for flood mitigation and liability issues, and introduce these into standards, planning controls, etc.
PRIORITY 2 ADAPTATION PLANNING THEMES	
Bushfire risk management	<ul style="list-style-type: none"> • Advocacy: Continue Council's involvement and input into regional bushfire hazard mapping and management initiatives. • Hazard Reduction: Review current processes around fuel reduction and evaluate current and future effectiveness given climate change projections. • Controlled Planning: Areas where significant populations are highly exposed to bushfire risk are limited. Planned growth will change this mix over time increasing primarily where there is an urban/bushland interface. Retain and strengthen current planning controls. Changes implemented in the design of new subdivision in relation to Asset Protection Zones, especially in risk areas surrounded by dense bush land or woodlands.
Maintaining roads and bridges	<ul style="list-style-type: none"> • Strategic Asset Management: Population growth within the local government area will increase Council's roads and bridge asset base. It is critical that appropriate increases to both Capital and Operation budgets are made to manage not only this growth but also the higher risk of extreme climate change on these assets; • Review: Upgrade design and construction specifications to reflect a changing climate and embed these into requirements consistently over time. Consider design life of pavement and assets and determine appropriate specifications that can be modified during routine maintenance to keep pace with altering temperature patterns or rainfall patterns. Upgrade asset management capability, including repeatable condition assessments to track over time, and ensure that roads are constructed in an adequate manner and minimise the likely risk of damage from flooding, but also extreme temperatures.
The natural environment's response to temperature, rainfall and other climatic changes	<ul style="list-style-type: none"> • Study and assess benefits and costs: Study changes to vegetation and water quality that may arise under drier and warmer conditions in the sensitive riparian corridors and bushland areas of the LGA. Undertake a benefit-cost assessment of management options. • Monitor water quality and warning/notification systems: Deteriorations in water quality will require increased surveillance for microbial pathogens and algae, and will require a review of effectiveness of current recreational water quality management strategies. • Continue invasive weed species management: Develop and implement a pest, weed and invasive species management policy/ strategy that take into account changed climatic conditions.
Protecting the region's heritage and community infrastructure, especially from storms	<ul style="list-style-type: none"> • Increase reliability of water supplies for parks: Four main options to consider in reducing irrigation mains water use – i). choosing areas to receive less irrigation, ii). efficient irrigation, iii). water efficient landscaping, iv). using alternative supplies of water such as rainwater tanks, aquifer storage and recovery, greywater and blackwater, reclaimed effluent and groundwater; • Audit: Understand the exposure and potential for storm damages to community heritage items and ensure sufficient protection/insurances are in place to protect or rebuild following damage; • Strategic Asset Management: Heritage items by default have higher lifecycle costs to manage (before even considering natural climatic events); as local and state governments become more aware of asset management planning and whole of life costs to managing and owning assets 'discourse' to the local community on costs of maintaining these assets will eventually become an issue.
Stormwater drainage, infrastructure and water	<ul style="list-style-type: none"> • Strategic Asset Management: Based on flooding and climate change data - stormwater management (design / construct and maintenance) will need to cater for more extreme patterns and have the ability to fully function to design intent - this may also require a redesign / upgrade of existing assets and higher operational budgets to maintain and

quality	<p>clean and upgrade assets to cater for higher storm intensities. Review the extent of impacts in the LGA under future climate scenarios/projections. Upgrading existing culverts, bridges, and other infrastructure to accommodate greater design flows may also provide benefits. A benefit-cost assessment should inform the need to undertake significant capital works;</p> <ul style="list-style-type: none"> • New systems to accommodate increased flows and changes to stormwater quality: Design wastewater systems to prevent overflow events from wetter than normal weather, based on climate change scenarios. Develop policies and design guidelines; • Consider stormwater harvesting options: Investigate flood management options whereby stormwater can be captured to reduce peak flows in creek/urban systems and stored for alternate uses following rainfall events.
PRIORITY 3 ADAPTATION PLANNING THEMES	
The built environment's response to temperature, rainfall and other climatic changes	<ul style="list-style-type: none"> • Further research: Further research into building codes and civil/structural engineering practices for salinity or soil (wetting, drying, subsistence risk) issues.

6.2 Considerations for prioritising adaptation planning activities

The risk assessment activities undertaken by Hawkesbury City Council have been useful to identify some relevant adaptation planning themes and to develop some broad options for adaptation planning. However when developing specific action items Council will need to consider the costs, feasibility, resource requirements, community acceptance and other stakeholder needs in combination with the type and relative level of risk it is trying to manage. A combined consideration of the adaptation theme priority together with the feasibility and costs of implementing the adaptation planning option will be useful to guide Council in making decisions about which options to prioritise and pursue. The following matrix illustrates the principle:

	Least feasible, higher cost adaptation option	Moderately feasible, moderate cost	Most feasible, lower cost
PRIORITY 1 ADAPTATION THEME	Implementation priority = "MEDIUM"	"HIGH"	"HIGHEST"
PRIORITY 2 ADAPTATION THEME	"LOW"	"MEDIUM"	"HIGH"
PRIORITY 3 ADAPTATION THEME	"LOWEST"	"LOW"	"MEDIUM"

7. Recommendations

This risk assessment and adaptation planning study was completed based on a desktop review of relevant climate change projections for the Hawkesbury City region and, more so, from the inputs provided by Hawkesbury City Council personnel. This study represents the first phase in a recommended routine and iterative component of Council business and community planning. The iterative climate change risk management process prescribed by AGO (2006) is outlined below:

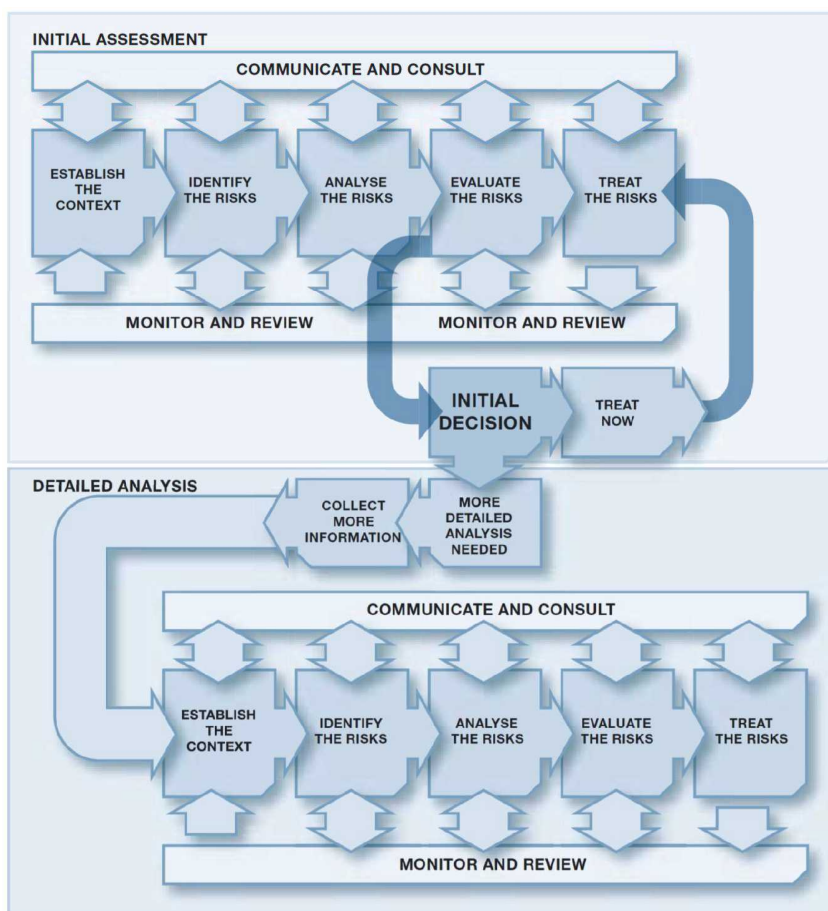


Figure 8 Continual climate risk management and adaptation process (AGO, 2006)

Given the initial nature of this risk assessment, it is important to note that of more significance than the absolute measure of risk or adaptation planning option priority that is allocated is in understanding the *relative* levels of risk and priority among those described. A key next step for Council is to reconcile how it will embed the outcomes from this study into its routine management, planning and risk management processes. It is recommended that Hawkesbury City Council:

- ▶ Is guided by this risk assessment study to implement more detailed climate adaptation planning and management activities (informed by the risk assessment and management details provided at Appendices C-E);

- ▶ Remains engaged and aware of developments in the allocated relationships, roles and responsibilities among federal, state and local governments in regard to managing a changing climate;
- ▶ Develops a policy position on climate change, how it is to be planned for and managed, and what components of the Council organisation will be responsible for implementing it;
- ▶ Reviews its strategic plans in light of the identified climate change risks and integrate potential controls and adaptation actions within them;
- ▶ Develops a plan that explicitly addresses the implementation of the adaptation planning options that Council determines as a priority, including the allocation of resources, funding and specifying the timeframes required;
- ▶ Further develops the collection and evaluation of climate change forecasts and local measurements, for the purposes of strategic planning and ongoing adaptation of community development and asset planning and operational procedures;
- ▶ Develops a “plan, monitor and respond” climate change adaptation process. This would involve: (i) a monitoring program of the local assets and values identified in this project that are sensitive to climate change; (ii) determining a set of thresholds related either to climate or weather patterns, or to asset or value functioning; and (iii) when monitoring determines that a threshold has been met, this could trigger the need to implement any of the “accommodate”, “retreat” or “protect” adaptation options that Council develops through its iterative climate change risk management approach;
- ▶ Ensures ongoing climate change risk assessment is incorporated into strategic planning and operational and other management plans.

8. References

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Appendix A

Hawkesbury City: Quick Facts

Topic	Notes
Agriculture	<p>Hawkesbury City LGA is part of the Sydney Basin which is a fertile agricultural area which produces two thirds of NSW's vegetable production by weight. The basin is strategically significant in providing food to the Sydney region and benefited by its proximity to this market, securing areas for food production within proximity to this market will become more significant as the cost of transportation increases.</p> <p>Hawkesbury City also has an extensive amount of agricultural land which provides a significant resource to the LGA and the Sydney Metropolitan Region. Rural landscapes contribute to the pastoral industry as well as the rural character of the LGA. Protection of these productive and landscape areas is essential to maintain a significant economic resource in terms of primary production as well as tourism. Hawkesbury City contains 16 % of vegetable and other crop establishments in the Sydney Basin. There has also been international demand for the Hawkesbury Harvest Farm Gate Trail and its products.</p>
Biodiversity	<p>Of the almost 2,800 km² of land within the Hawkesbury City LGA, 71% is contained within National Parks, Nature Reserves and State Recreation Areas. About 1.2% of the LGA is parkland managed by Hawkesbury City Council.</p> <p>With respect to vegetation in the Hawkesbury, this range is generally be categorised into three main groups:-</p> <ol style="list-style-type: none"> 1. Cumberland Plain and associated ecosystems 2. Hawkesbury-Nepean River floodplain and associated ecosystems 3. Hawkesbury sandstone and associated ecosystems. <p>Hawkesbury City LGA also includes a part of the Greater Blue Mountains World Heritage Area to the west containing a wide and balanced representation of eucalypt habitats as well as localised swamps, wetlands, and grassland.</p>
Bushfire	<p>Hawkesbury City LGA contains significant areas of bushland which serves to create a vulnerability to bushfire events. The vast majority of the LGA is categorised as vegetation 'Category 1 - High Risk' except for the urban areas which have been cleared of classified vegetation. 'Category 2' vegetation is found surrounding the outskirts of Wilberforce, North Richmond, Bligh Park and Vineyard.</p> <p>Bushfire prone maps have been prepared by the Hawkesbury City Council and certified by NSW Rural Fire Service. Future urban development areas must be avoided in areas of containing bushfire risk and must comply with the requirements of <i>Planning for Bushfire Protection</i> by the NSW Rural Fire Service.</p>
Catchments	<p>The Hawkesbury City LGA is dominated by several river systems associated with the Hawkesbury-Nepean Catchment and the sub catchments of:</p> <ul style="list-style-type: none"> • Hawkesbury River; • Cattai Creek; • South Creek; • MacDonald River • Grose River; and • Colo River.
Community	<p>Hawkesbury City LGA currently contains a large range of community facilities including</p>

wellbeing	<p>community centres, schools and tertiary institutions and facilities for young and older people. These facilities are primarily located in the southern part of the Hawkesbury City LGA which aligns with the key population centres where the majority of the population (94%) live. The remaining 6% of the population live in the more rural and remote parts of the LGA with more limited access to facilities and services.</p> <p>The LGA also offers a range of tertiary education opportunities including the University of Western Sydney Hawkesbury Campus, Richmond College of TAFE and a regional community college.</p>
Council revenue	Council's annual budget is over \$70 million. Revenue is primarily collected from rates, levies and grants.
Council roles	The Hawkesbury City Council provides: support services (including financial services, corporate services and governance, information services, cultural services and legal services), infrastructure services (including construction and maintenance, building services, parks and recreation, waste management, design and mapping), and city planning (including strategic planning, town planning, regulatory services, community services and customer services). All Council buildings, roads, footpaths and facilities must be maintained and upgraded as required to meet community needs. Numerous services and programs are provided by Council, including street lighting, garbage collection and recycling, pollution control, child care, aged and disability services, community development and recreational activities.
Demographics	The Hawkesbury City LGA is experiencing a change in the composition of its population, primarily associated with an ageing population and declining household size.
Economy	Hawkesbury City is well positioned for economic growth with an increasing population and strength in some key areas with export potential.
Emergency Management	Council has a role in working with other bodies such as the Rural Fire Service, State Emergency Service and state governments to prepare and plan for emergencies.
Flooding	<p>The Hawkesbury City LGA is dominated by several river systems, associated with the Hawkesbury and Nepean Rivers with the majority of the urban area of Hawkesbury City LGA prone to flooding within the 1% Annual Exceedance Probability flood event levels. Flooding is prevalent in areas around the North Richmond, Richmond, Windsor, Wilberforce and Pitt Town areas. Future urban development must address flood evacuation issues and must avoid high risk flood prone areas.</p> <p>Flooding is a significant issue in both established and undeveloped areas and effectively divides the LGA into 'north and south of the Hawkesbury River' vulnerability zones</p>
National Parks	Two thirds of the LGA is located in National Parks, including, Wollemi National Park, Parr State Conservation Area, Cattai and Scheyville National Parks, Yengo National Parks and Blue Mountains National Park. This provides a total of approximately 1,930 km ² of national park areas within the LGA.
Hawkesbury City Council Management Plan 2011-12	<p>Each year, Hawkesbury City Council outlines its activities for the coming year through its Management Plan which is divided into three volumes:</p> <p><i>Part 1 Strategic and Operational Plan</i> - This is the summary that outlines the different strategic goals Council will work toward in this financial year and, broadly, over the next</p>

	<p>three years.</p> <p><i>Part 2 Budget Estimates</i> - This document details the annual budget.</p> <p><i>Part 3 Revenue - Pricing Policy (with Fees and Charges)</i> - The Revenue Pricing Policy is a list of Council's fees and charges for 2011/2012 including all areas that support the production of Council's income from which Council provides its services. The revenue categories include rates, annual charges for services, fees for services, Federal and State government grants, borrowing and earnings from investments and entrepreneurial activities.</p>
Heritage	<p>The Hawkesbury City LGA is an area rich with heritage character, with over 500 items being identified as places of local heritage significance. The character of Hawkesbury has been influenced by its Indigenous, European and natural heritage. The future character of the Hawkesbury City LGA will need to build on these significant and unique elements that will contribute to this character and seek to create high quality urban development in both public spaces and urban design.</p> <p>Hawkesbury City Council has identified the following European heritage items situated within the LGA:</p> <ul style="list-style-type: none"> • 530 Local Sites; • 44 State Sites; • 139 on register of the National Estate; and • 1 listed place on Commonwealth heritage list.
Infrastructure assets and management	<p>Council have adopted an Asset Management Policy and an Asset Management Strategy, which together provide direction and supports the Council's asset management planning framework. These documents outline Council's asset management, principles, goals, strategies and describe current Council asset management practice, define desired future practice and identify key improvement actions.</p>
Land & land use	<p>Hawkesbury City LGA is influenced by the Blue Mountains and Great Dividing Range to the north west as well as some of Sydney's significant river systems. As a result, the topography varies widely from slopes of less than 1:20 (5% slope), increasing to 1:8 (12.5% slope).</p> <p>The built environment accounts for approximately 9% of the total land area uses in the Hawkesbury region, with nature conservation accounting for the largest portion of landuse (approximately 43%).</p>
Population growth	<p>The estimated population of the Hawkesbury City LGA is approximately 64,000 persons with the largest proportion of persons aged between 25 and 54 (42% of population). The average annual population growth has been around 2.2%.</p>
Power supply	<p>Council has no role, aside from planning and development inputs. Integral Energy serves all of the Hawkesbury area and connections to residential properties are carried out on application. It is noted that some outer lying rural areas of Hawkesbury City LGA may have no lines or have very old lines which may need additional supply.</p> <p>Solar power has been an option for houses in the LGA where it has been too expensive to connect to the power grid.</p>
Recreation sites	<p>There are 25 sports grounds and three sports complexes within the Hawkesbury City LGA and a range of formal recreation facilities, including:</p> <ul style="list-style-type: none"> • Swimming centres;

	<ul style="list-style-type: none"> • Clubs (including bowling clubs); • Community centres; • Golf courses; • Conference centres; and • Art schools <p>A Plan of Management has been developed which is designed to provide clear guidelines for the effective management of community land within the care and control of Council.</p>
Recycling	Sustainability trends in the 2011 State of Environment Report indicates an increase in recycled waste and household products over the last five years. Waste education programs which aim to drive waste avoidance and encourage recycling are part of Council's ongoing environmental strategy.
Roads	Council is responsible for the maintenance of 720 km of Sealed Roads and 305 km of Unsealed Roads within the Hawkesbury local government boundaries. In addition, the Council is responsible for 25 Timber Bridges and 46 Concrete/Steel Bridges.
Sewage	Sydney Water which is the water authority for the area and manages sewers within the LGA. Approximately 80% of Hawkesbury's residential areas have reticulated sewerage. Approximately 40% of the sewage generated is treated at McGraths Hill Treatment Plant and the remainder is treated at the South Windsor Treatment Plant. Both treatment plants are owned and operated by Council. The remaining premises are serviced by either onsite sewerage management facilities, septic pump out service, or connected to the Sydney Water sewerage systems.
Stormwater	The Environmental Stormwater Program was adopted by Council as part of an Environmental Levy in June 2002. In the 2007/2008 financial year, the Stormwater/Environmental Levy funding ceased with only maintenance of existing gross pollutant traps installed under that program and supplementing street sweeping activities to continue.
Strategic planning	Council have released a Strategic and Operations Plan which outlines strategies for the next four years for the people of the Hawkesbury. The strategies will be largely defined by what is important to preserve, protect and promote – such assets such as rural landscapes, the historical character of the towns and villages, and connections in neighbourhoods that support the needs of the people who reside there.
Tourism	<p>Besides the Hawkesbury River, 70% of the Hawkesbury Local Government Area is National Parks and Wilderness Areas and is home to a majority of the famous world-heritage listed Blue Mountains. Tourists can experience world heritage and villages nestled within a rural and natural setting.</p> <p>The rural character of Hawkesbury is seen as attractive to visitors and the local community. Best practice guidelines and performance standards have been implemented to protect the rural character of the area.</p>
Waste	The Hawkesbury City Waste Depot is operated by Council and is only available for use by residents of the Hawkesbury region. This landfill accepts domestic waste, including recyclables. Hawkesbury City Council provides a weekly household garbage collection service which is available to all residences within the Local Government Area.
Water supply	Hawkesbury City Council does not operate any water supply service as the City falls under

	the jurisdiction of Sydney Water.
Waterways and riparian areas	The Hawkesbury City LGA is dominated by several river systems, associated with the Hawkesbury and Nepean Rivers. There are a number of wetlands within the Hawkesbury City LGA including important and productive plant communities and bird habitats
Weeds	There are two different areas of responsibility with regard to weeds, in that noxious weeds are dealt with by the Hawkesbury River County Council and environmental weeds are dealt with by contractors or day labour. The Hawkesbury River County Council manages Noxious Weeds in the Hawkesbury City LGA.

Appendix B

Risk Assessment Guidance

Risk assessment matrix

LIKELIHOOD	CONSEQUENCE				
		Insignificant	Minor	Moderate	Major
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

Descriptors for the scales of likelihood of an event or risk arising

Likelihood rating	Recurrent Risks	Single Events
Almost Certain	Could occur several times per year	More likely than not – probability of occurring 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
Unlikely	May arise once in 10 years 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

Descriptors for the scales of consequences associated with a risk

CONSEQUENCE DESCRIPTORS	Health and safety	Natural and urban environmental health and safety	Diversity of options for housing and employment	Governance, financial management and administration	Sense of community and quality of lifestyle	Asset delivery, reliability and management
Insignificant	No known injuries or illnesses.	No or minimal impact on the environment - very limited direct damage to ecosystems or elements of place.	Minor financial loss that can be managed within standard financial provisions (e.g. insurance), inconsequential disruptions at business level.	Governing entities are able to manage the event within normal parameters, public administration functions without disturbances, public confidence in governance, no media attention.	Inconsequential short term reduction of services, no damages to objects of cultural significance, no adverse emotional and psychological impacts.	Inconsequential short term failure of infrastructure and service delivery, no disruption to the public services and utilities.
Minor	Minor injury/illness managed within existing resources (first aid personnel and readily available equipment).	Limited and/or localised impact on the environment that can be readily rectified but effort is still required to minimise. One off recovery effort is required.	Financial loss requiring activation of reserves to cover loss, disruptions at business level leading to isolated cases of loss of employment.	Governing entities manage the event under emergency arrangements, public administration functions with minimal disturbances, isolated expressions of public concern, media coverage within region.	Isolated and temporary cases of reduced services within community, repairable damage to objects of cultural significance, impacts within emotional and psychological capacity of the community.	Isolated cases of short- to mid-term failure of infrastructure and service delivery, localised inconvenience to the community and business anticipated to extend up to 72 hours. No long term impact on integrity or operation of the infrastructure.
Moderate	Single fatality or permanent incapacity. Multiple serious injury/illnesses requiring professional medical care and/or hospitalisation. Small number of people displaced for <24 hrs.	Isolated but significant cases of impairment or loss of ecosystem functions, intensive efforts for recovery required. Event can be managed under normal procedures.	Direct moderate financial loss in the region requiring adjustments to business strategy to cover loss, disruptions to selected industry sectors leading to isolated cases of business failure and multiple loss of employment.	Governing entities manage the event with considerable diversion from policy, public administration functions limited by focus on critical services, widespread public protests, media coverage within region.	Ongoing reduced services within community, permanent damage to objects of cultural significance, impacts beyond emotional and psychological capacity in some parts of the community.	Midterm failure of (significant) infrastructure and service delivery affecting some parts of the community, widespread inconveniences. Repair/replacement expected to take greater than 72 hours.

CONSEQUENCE DESCRIPTORS	Health and safety	Natural and urban environmental health and well-being	Diversity of options for housing and employment	Governance, financial management and administration	Sense of community and quality of lifestyle	Asset delivery, reliability and management
Major	Multiple fatalities or permanent incapacities (up to 1 per 100 000). Regional health care system stressed. External resources required to contain and resolve the incident. Large number of people displaced for >24 hours.	Severe impairment or loss of ecosystem functions affecting many species or landscapes, progressive environmental damage.	Significant financial loss requiring major changes in business strategy to (partly) cover loss, significant disruptions across industry sectors leading to multiple business failures and loss of employment.	Governing body absorbed with managing the event, public administration struggles to provide merely critical services, loss of public confidence in governance, national level media coverage. State level support required. Financial losses or impact on revenue that impairs Council's ability to provide even the most necessary functions without special federal or state intervention.	Reduced quality of life within community, significant loss or damage to objects of cultural significance, impacts beyond emotional and psychological capacity in large parts of the community. Majority of services unavailable to community.	Mid to long term failure of significant infrastructure and service delivery affecting large parts of the community, external support required.
Catastrophic	Widespread loss of lives (at least 1 per 10 000), regional health care system unable to cope, large displacement of people beyond regional capacity to manage.	Widespread severe impairment or loss of ecosystem functions across species and landscapes, irrecoverable environmental damage. Total incongruence with preferred elements of place.	Unrecoverable financial losses. Multiple major industries in the region seriously threatened or disrupted for foreseeable future. Asset destruction across industry sectors leading to widespread business failures and loss of employment.	Governing bodies unable to manage the event, ineffective public administration, loss of public order, widespread unrest and crime. State or national intervention required. Widespread international media coverage. Severe financial losses so that Council is unable to continue to operate.	Community unable to support itself, widespread loss of objects of cultural significance, impacts beyond emotional and psychological capacity in all parts of the community, long term denial of basic community services.	Long term failure of significant infrastructure and service delivery affecting all parts of the community, ongoing external support at large scale required.

Appendix C
Risk Assessment Register

Risk description				Risk estimation for climate scenario...												Comments/rationale for risk assessments					
Hazard/s	Element/s at risk	Location and details	Pathways & impacts	What might be at risk due to the described impact?						Existing controls	Current			Near-term, moderate changes			Long-term, extreme changes				
				Health & safety	Environment	Economy	Governance	Community and lifestyle	Assets & services		C	L	R	C	L		R	C	L	R	
1 All hazards	Housing and urban areas: Growth centres	LGA wide	Failure to account for anticipated changes in natural hazard risk during development	x					x	Residents being placed at risk due to lack of awareness or accounting for climate change potential	Some state level guidance exists; Adaptation planning commencing at Council level	2	2	L	4	4	H	4	5	E	Failure to consider the most extreme levels of climate changes would exacerbate existing vulnerability to flood and heatwave hazards.
2 All hazards	Events	LGA wide	Adverse weather or natural hazards can impact on the ability to hold cultural and community events						x	For example, the closure of ferries or inability to host the Bridge to Bridge	Timing of holding events to limit exposure to hazards	3	1	L	4	1	L	4	2	M	Failure to consider the most extreme levels of climate changes would exacerbate existing vulnerability to flood and heatwave hazards.
3 Bushfire	Urban areas	Bushland areas - LGA wide	People and property in path of bushfire	x						Loss of life/property	Bushfire hazard reduction; Fire breaks; Rural Fire Service	5	2	M	5	3	H	5	4	E	Bushfire risks are expected to increase under a scenario of warmer temperatures, greater fuel build-ups, etc.
4 Bushfire	Roads, bridges and ferries	Thorley St Blacktown Rd (RMS) Londonderry Rd (RMS) Jim Anderson (RMS) Keith Richard (RMS) Windsor (RMS) Lower Portland Sackville (RMS) Wisemans Ferry (RMS)	Assets damaged and unusable due to bushfire event	x		x			x	Access is cut during events; risks to road users	Bushfire hazard reduction; Fire breaks; Rural Fire Service	3	2	L	3	3	M	3	4	H	Greater numbers of high bushfire risk days increases the risk under future scenarios - risks are higher when considering particularly valuable community assets and exposure to nearby bushlands
5 Bushfire	Bushland	Rural (Parks and Reserves)	Bushfire destroys property, bushland (Cumberland Woodland), loss of habitats and long regeneration times		x				x	Increased resources required to manage changes in species composition; Increased costs to respond to emergencies	Bushfire hazard reduction; Rural Fire Service	3	3	M	3	4	H	4	4	H	Greater numbers of high bushfire risk days increases the risk under future scenarios - risks are higher when considering particularly valuable community assets and exposure to nearby bushlands
6 Bushfire	Sewer and stormwater	McGraths Hill Treatment Plant, South Windsor Treatment Plant	Assets destroyed during bushfire	x	x				x	Loss of functions that are providing public health services, wastewater pollution on stormwater drains and exposure of public to pollutants	Asset Protection Zones; Bushfire hazard reduction	4	2	M	4	2	M	5	2	M	Greater numbers of high bushfire risk days increases the risk under future scenarios - risks are higher when considering particularly valuable community assets and exposure to nearby bushlands
7 Bushfire	Waste processing facilities	South Windsor	Assets destroyed during bushfire	x	x				x	Loss of functions that are providing public health services, wastewater pollution on stormwater drains and exposure of public to pollutants	Asset Protection Zones; Bushfire hazard reduction	4	2	M	4	2	M	5	2	M	Greater numbers of high bushfire risk days increases the risk under future scenarios - risks are higher when considering particularly valuable community assets and exposure to nearby bushlands
8 Drought	People	LGA wide	Reduced water availability will impact on the regional economy and lifestyle			x			x	Water shortages resulting in water restrictions and less available for non-potable users	Ability to enforce water restrictions	1	2	L	1	2	L	2	2	L	Council to work with Sydney Water on urban water management issues. Coped with most recent drought.
9 Landslide	Roads and bridges	Local roads, e.g. Gross Vale Rd, Nth Richmond	Road closure, damage to local roads	x		x				Costs to Council to remediate	Geotechnical design and engineering controls	3	1	L	3	2	L	3	3	M	Landslide potential can be related to rainfall, soil moisture/drying patterns. Higher intensity rainfall events may increase landslip potential in prone regions.
10 Salinity and temperature	Agriculture	LGA wide	Changes to groundwater recharge patterns result in increased salinity in western Sydney			x			x	Loss of productivity or changes in agricultural practices - impacts on economy	Nil	3	1	L	3	2	L	4	2	M	There is uncertainty as to how changes in groundwater recharge and sea-level rises may impact on groundwater and soil salinity over time. Western Sydney regions are already exposed to saline soils; targeted studies may be benefit the whole region.
11 Salinity	Roads, bridges, buildings	LGA wide	Changes to groundwater recharge patterns result in increased salinity in western Sydney			x			x	Asset and building degradation; loss of historic buildings	Salinity management building code policy	3	1	L	3	2	L	4	2	M	There is uncertainty as to how changes in groundwater recharge and sea-level rises may impact on groundwater and soil salinity over time. Western Sydney regions are already exposed to saline soils; targeted studies may be benefit the whole region.
12 Storms and flooding	Hawkesbury River and flood plain areas	Particular vulnerable areas of Colo, Macdonald, Gosse, Redbank, McKenzie, South Creek	Variable and intense rainfall and flooding patterns, higher intensity storms with increased runoff/flooding. Flood-prone built areas exist in LGA.	x		x			x	Damages to property, insurance payouts and losses; impacts on the community assets and services	Flood plain risk management plan; Development controls; Disaster plan	3	4	H	4	5	E	5	4	E	Projected increases in rainfall intensities would exacerbate an existing issue in the LGA
13 Storms and flooding	Hawkesbury River and flood plain areas	Riparian areas	Changes to water salinity, turbidity and other (e.g. microbial) characteristics due to altered flow/runoff and contaminant mobilisation patterns, leading to impacts on supported/endorsement eco-systems in the riparian and adjacent areas		x				x	Water quality deteriorates; Weed proliferation; Loss of diversity and habitat will impact on the natural environment; Loss of recreation opportunities due to poor water quality particularly following storm events, or, health risks to people who are exposed to the contaminants. The need to direct Council resources to adequately manage these impacts may impact on other areas of local service delivery.	Plans of Management; Development Control Plan 2011; Hawkesbury River Country Council; State and Federal Legislation (EPBC Act, Threatened Species Act, Weeds Act, NSW Minister's Guidelines for clearing waterways); Water quality monitoring and notification of poor quality periods	3	3	M	3	4	H	4	4	H	Changes in environmental flow regimes and the more concentrated mobilisation of surface contaminants (in runoff) during storm events that occur less frequently but with greater intensity
14 Storms and flooding	Community assets	Museum; Deerubbin Centre (Library/Gallery)	Power, water, sewage services and building fabric impacted through storm or flooding damage						x	The museum cannot operate, resulting in a loss of a community facility. The Deerubbin Centre being closed would impact tourism and loss of valuable community asset.	Passive solar controls; Cyclic maintenance; Building Code of Australia; Recently designed and built asset	3	3	M	3	4	H	4	4	H	Storms and hail are already the most costly natural hazard per annum in NSW. Risks to community buildings and assets may be heightened by a changing climate.
15 Storms and flooding	Roads, bridges and ferries	Thorley St Blacktown Rd (RMS) Londonderry Rd (RMS)	Surface water overflow during flooding events; abrasion and asset damages						x	Maintenance and construction access	Most assets are Roads and Maritime Services responsibility. Asset inspectors and control plans	3	3	M	3	4	H	4	4	H	More frequent sheet flows on roads will increase wear and tear
16 Storms and flooding	Roads, bridges and ferries	Jim Anderson (RMS) Keith Richard (RMS) Windsor (RMS)	Surface water overflow during flooding events; abrasion and asset damages						x	Access is cut during events	Flood risk management plan; Alternate routes during flooding event	3	3	M	3	4	H	4	4	H	More frequent sheet flows on roads will increase wear and tear
17 Storms and flooding	Sewer and stormwater	McGraths Hill/South Windsor Treatment Plants and CDS units	Inundation during flooding events	x	x				x	The flooding of these facilities could see untreated waste enter waterways posing a health and environment risk	Flood risk management planning; Facility-centred Business Continuity Plans	3	3	M	3	3	M	4	3	H	Forecasts for increased flood frequencies correlate to an increased risk of wet weather flows and wastewater treatment failures.
18 Storm and flooding	Heritage fabric of the LGA	All heritage-listed items	Damages from wind and hail					x	x	Increased maintenance; Loss of heritage fabric	Asset inspection and maintenance programmes	3	2	L	2	3	M	4	3	H	Storms and hail are already the most costly natural hazard per annum in NSW. Risks to community buildings and assets may be heightened by a changing climate.
19 Storms and flooding	Government buildings	Council administration centres	Power, water, sewage, building fabric impacted through storm or flooding damage						x	Buildings and facilities become closed for use for days or some time during/after an event. Council administration functions are affected.	Enable "work from home" for Council staff and other emergency personnel to provide continuation. Business Continuity Plan.	2	2	L	3	2	L	3	3	M	Storms and hail are already the most costly natural hazard per annum in NSW. Risks to community buildings and assets may be heightened by a changing climate.
20 Storms and flooding	Open space, bushland, recreation areas (inc. sportsgrounds)	LGA-wide	Flooding and inundation results in loss of access	x	x				x	Health and safety refers to people being exposed to elements while using the facilities, particularly vulnerable in flooding bushland areas. More commonly, grounds will be closed and inaccessible for periods	Flood plain risk management plan; Development controls; Disaster plan	2	3	M	2	3	M	3	3	M	Forecasts for increased flood frequencies correlate to an increased risk of waterlogged grounds and inaccessibility/lack of use for the community.

Risk description				Risk estimation for climate scenario									Comments/rationale for risk assessments								
Hazard/s	Element/s at risk	Location and details	Pathways & impacts	What might be at risk due to the described impact?						Specific consequences and further details	Existing controls	Current			Near-term, moderate changes			Long-term, extreme changes			
				Health & safety	Environment	Economic	Governance	Community well-being	Assets & services			C		L	R	C	L	R	C	L	R
21	Storms and flooding	Roads, bridges and ferries Lower Portland Sackville (RMS) Wisemans Ferry (RMS)	Surface water overflow during flooding events; abrasion and asset damages						x	Access maintenance and repairs	Most assets are Roads and Maritime Services' responsibility. Asset inspections and control plans	2	2	L	2	3	M	3	3	M	More frequent sheet flows on roads will increase wear and tear
22	Storms and flooding	Waste processing facilities	Inundation during flooding events	x	x				x	The flooding of these facilities could see untreated waste enter waterways posing a health and environment risk	Flood risk management planning, Facility-centred Business Continuity Plans	3	2	L	3	2	L	3	3	M	Forecasts for increased flood frequencies correlate to an increased risk of knock-on effects from the inundation of the waste facility.
23	Storms and floods	Stormwater assets	Gross Pollutant Traps - LGA wide Device will fail to work under storm stresses. Contents released downstream		x				x	Pollution and adverse effect on water quality	Stormwater drainage & Asset Management Plan	1	2	L	1	2	L	2	2	L	Flooding and intense rainfall/sheet flow from roads is projected to increase over time. Flooding events can impact on the water quality control functions, and result in more contaminants flowing downstream of the water bodies
24	Storms, bushfires, floods	Emergency management and community resilience: Service delivery	Access to services; allocation of resources; communications and decision-making ability	x			x	x		Ability and state of emergency following natural hazard event	Emergency Management Plan	4	2	M	4	3	H	4	5	E	Increased exposure to natural hazards due to a changing climate will increase the dependency and need to have a reliable emergency response process
25	Storms, bushfires, floods	Emergency management and community resilience: Communication	Towers Telecommunications and power supply infrastructure	x			x	x		Heightened risks to residents during emergency events due to loss of communications infrastructure	Emergency Management Plan	4	1	L	4	2	M	4	3	H	Increased exposure to natural hazards due to a changing climate will increase the dependency and need to have a reliable emergency response process
26	Temperature	Hawkesbury River	Water and riparian areas Temperature and climate conditions are primary drivers of potential for weed/pest and other undesirable species thriving		x					Increased temperatures and surface water temperatures impacts on oxygen in water, increases algal bloom risks, changes to fish and riparian corridor habitats	Riparian area plans of management	2	3	M	3	3	M	3	4	H	Increasing temperatures would alter the natural ecosystems and bushland/riparian areas
27	Temperature	Hawkesbury River/LGA-wide	Water and riparian areas Temperature and climate conditions are primary drivers of potential for weed/pest and other species thriving	x						Changes in prominence and risk of vector-borne disease (Ross River Fever) due to warmer/wetter environments and mosquito breeding grounds	Public health systems; Riparian areas plan of management	2	2	L	2	2	L	2	3	M	Increasing temperatures would alter the natural ecosystems and bushland/riparian areas

Appendix D

Risk Assessment Summary and Adaptation Themes

Risk profiles. NB: E = Extreme (Highest priority), H = Higher, M = Moderate, L = Lowest													Summary charts by climate scenario			Summary details
Theme	Relevant risk items (from register)	Total # risk items	Current			Near-term, mod.			Long-term, extreme			Summary charts by climate scenario			Summary details	
			E	H	M	L	E	H	M	L	E					H
A.	Flooding of urban and built areas	14	1	6	7	1	5	3	3	6	4	1	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</p>	<p>Significant high risks to property, community and people due to flooding of residential areas will be exacerbated by projected climate changes. The known problem areas are largely in the developed south east portion of the LGA, around Windsor, South Windsor, Bligh Park, McGrath Hill and Richmond Lowlands to Pitt Town Bottoms. Council is actively working to inform the community about flood risk and management and to understand further how to control development in the region in a way that is commensurate with good flood management and community needs.</p>
B.	Building resilience and co-ordinated emergency management	9		4	5		3	3	3	1	4	1	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</p>	<p>Higher risks may eventuate over time in regard to pressures placed on emergency resources and personnel to respond to natural hazard events (especially bushfires and floods) occurring more frequently or in greater magnitudes. The higher risk ratings align with the "high consequence, low probability" profiles of natural hazard emergency scenarios. The Council's Emergency Management Planning already includes monitoring, responsibilities and responsive provisions in the cases of emergency however it is uncertain how these may cope with events larger than what have been experienced previously. Some particular vulnerabilities at certain locations within the LGA were identified, including at Pitt Town, Colo, MacDonald and South Creek.</p> <p>Moderate risks were associated with the impacts of adverse temperature changes and the effects on community health and services. Heat wave periods are associated with spikes in hospital admissions and the region's proximity to waterways and wetlands exposes it to potential increases in vector (e.g. mosquito-borne) diseases.</p> <p>Moderate risks were associated with the impacts of adverse temperature changes and the effects on the local rural and agricultural aspects of the LGA. Impacts of temperature changes or from flood/bushfire events may test the region's resilience, especially in regard to the continued undertaking of valued rural and agricultural activities.</p> <p>Lower risks to the community are associated with urban water shortages and the need to restrict water use, though pressures on water resources are expected to increase over time and will require management. Periods of extreme water shortages leading to restrictions may occur more frequently, and this may be compounded by increased water demands associated with the growth centres.</p>
C.	Maintaining roads and bridges	6		2	4		2	1	3		3	3	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</p>	<p>Higher risks primarily result due to pressures placed on Council's budget and resources available for infrastructure provision, in particular to address wear and tear of roads and bridges, that may eventuate if extreme climate changes are experienced. As well as disruptions to local traffic, it is anticipated that should the more extreme climate changes eventuate, the higher temperatures and rainfall intensities would see a need to significantly increase the roads and asset management plan maintenance budgets across the whole LGA.</p>

Risk profiles. NB: E = Extreme (Highest priority), H = Higher, M = Moderate, L = Lowest

Theme	Relevant risk items (from register)	Total # risk items	Summary charts by climate scenario												Summary details		
			Current			Near-term, mod.			Long-term, extreme								
			E	M	L	E	M	L	E	M	L	E	M	L			
D.	The natural environment's response to temperature, rainfall and other climatic changes 5, 6, 7, 13, 17, 20, 22, 24, 26	9															<p>Current</p> <p>Near-term, moderate</p> <p>Long-term, extreme</p> <p>Higher risks to local environment and water quality are associated with the extreme climate change projections. The Hawkesbury's bushland is part of the Cumberland Plain Woodland. Typically grey box, narrow leaved ironbark and forest red gums. Kangaroo grass is the main native ground cover. The Hawkesbury River runs through the area – high nutrient levels in the river have allowed exotic weeds to thrive. There are several bird species, molluscs, mammals and fish that have habitat in the area that are on the vulnerable endangered species list. A number of restoration activities for riparian, wetlands and land areas are underway. An increase in the mean maximum temperature by a few degrees would alter the ecosystem, the flora and fauna it can support, and alter a valued community asset (in particular the riparian areas). Moderate to high risks associated with changes to water quality and recreational use of the water may arise due to increased flow variability and temperatures. Weed infestations, increases in soil erosion and sediment and stormwater runoff can contribute to a degraded water quality and impacts on water users.</p>
E.	Protecting the region's heritage and community infrastructure, especially from storms 2, 4, 5, 14, 20	5															<p>Current</p> <p>Near-term, moderate</p> <p>Long-term, extreme</p> <p>Moderate to high risks may arise and be exacerbated due to the exposure of the community's heritage and community facilities and Council buildings to storms and extreme weather conditions. Rain and hail storms are already the most costly natural hazard in Australia. In particular, Hawkesbury residents value the heritage fabric of the town, particularly in the town centres, and the community facilities provided and administered by Council.</p>
F.	Stormwater drainage, infrastructure and water quality 6, 17, 23, 25	4															<p>Current</p> <p>Near-term, moderate</p> <p>Long-term, extreme</p> <p>Moderate to high risks may arise and be exacerbated by Council's stormwater infrastructure being unable to cope with increases in storm intensities and having its capacity breached. In general, stormwater and drainage infrastructure may become undersized to cope with larger storm intensities, resulting in localised flooding and damages, particular in the residential and older built areas (including the town centres). Increased urban and other stormwater drainage can increase nutrient, microbial contaminant and heavy metals loads in urban waterways and creeks.</p>

Risk profiles. NB: E = Extreme (Highest priority), H = Higher, M = Moderate, L = Lowest

Theme	Relevant risk items (from register)	Total # risk items	Current									Near-term, mod.									Long-term, extreme									Summary charts by climate scenario	Summary details
			E			M			L			E			M			L			E			M			L				
G.	Bushfire risk management	1, 3, 4, 5, 6, 7	6				4	2					3	3					2	2	2		<p>Under extreme climate changes, the risks posed by bushfire to community property, health and safety may be heightened. Generally, higher bushfire risks are "event-oriented" and can be considered as "low likelihood, high consequence". The increased build-up of dried fuels and increased number of extreme heat days projected under extreme change projections may exacerbate the risk from bushfire. However, fuel management (such as prescribed burning) can impact on the ecosystem of the Cumberland Woodlands and local riparian areas.</p>								
H.	Managing development to consider climate changes in growth centres	1	1				1						1						1				<p>There is an opportunity to incorporate climate change resilience into new developments in the growth centres. Water Sensitive Urban Design principles and a review of development controls around flood risks in view of a changing climate, building codes for salinity and local soils issues and Asset Protection Zoning for bushfire control can all be considered during the planning and development phases of any new growth centres. In particular for flood and bushfire management, opportunities could be explored for good development practices that may even alleviate risks and exposure to natural hazards in other developed parts of the LGA.</p>								
I.	The built environment's response to temperature, rainfall and other climatic changes	11, 18	2				2						1	1					1	1			<p>Lower to moderate risks may be brought about by the response of buildings and settlements to extreme changes in temperature and rainfall. Existing building codes for salinity and local soils issues may not be appropriate for future developments, and existing buildings and settlements may be exposed to the impacts of greater heat, temperature extremes and storm events.</p>								

Appendix E
Adaptation Planning Principles

Principles for adapting

The AGO (2006) provides the following guiding principles for developing climate change risk adaptation and management measures:

- ▶ **Achieve balance with non-climate related risk management approaches adopted by Council** – Think about how climate change risk management can be integrated with Council's existing risk profile and appetite, and policies, processes and risk management approaches.
- ▶ **Identify Win-Win and No-Regrets options** – 'Win-Win' adaptation measures are those that have the desired result in terms of minimising the climate change related risks or exploiting potential opportunities but also have other social, environmental or economic benefits. 'No-regrets' measures are emergency or other planning measures that should be undertaken anyway, but that have the added benefit of addressing climate risks as well.
- ▶ **Implement flexible or adaptive management options** – involve putting in place incremental adaptation options, rather than undertaking large-scale adaptation in one instance. This approach minimises the chances of implementing ill-directed or over-compensatory measures in the face of uncertainty about future climate changes. The following process is in line with recommended practices for managing hazards in an uncertain future climate, and can be applied to general climate change adaptation planning:
 - Develop a monitoring program, or participate in an existing program, to gauge the weather and climate patterns that are occurring in vicinity of the infrastructure and assess the types of changes that might be occurring as compared to historical patterns;
 - Determine a set of thresholds (e.g. coastal still water levels, observed beach recession, statistical change in rainfall patterns or coastal storm patterns) that would trigger certain pre-emptive and incremental adaptation actions; and
 - Develop the series of actions that correspond to the thresholds that have been determined.
- ▶ **Adopt flexible strategies** - Avoid taking decisions that will make it more difficult to manage climate change risks in the future, an example of a constraining decision is allowing development to occur in land that is prone to flooding.

Adaptation planning options

Often, adaptation options are presented as belonging to one of the following categories (DCCEE, 2007):

- ▶ **Protect** - Which is providing a means to eliminate that impact from affecting the identified infrastructure components (e.g. building sea walls to accommodate sea-level rises);
- ▶ **Accommodate** - Which is allowing the impact to affect the infrastructure components, but making this impact acceptable by either increasing the resilience of the component or by allowing the impact to occur in a controlled way (e.g. increasing the maintenance and re-paving schedule on a road);
- ▶ **Retreat** - This is planning for moving the impacted elements or the services that they provide to an area that is at lower risk of being impacted by changes in climate.

However, there are a series of planning steps that may need to be made before a decision can be made in regard to adopting any one of those options (AGO, 2006). Hence, for Hawkesbury City Council, a more appropriate set of adaptation planning option categories were considered that reflected this, comprising:

- ▶ **Accept** risk and continue to manage and budget for it;

- ▶ **Spread** or share risk (e.g. insurance, diversify options for service delivery);
- ▶ **Engineered** or technical solutions (particularly aligned with accommodating projected changes);
- ▶ **Planning** and development controls;
- ▶ **Further studies** and research to better understand risks, costs and benefits to inform decisions;
- ▶ **Education**, awareness and advocacy programs;
- ▶ **Changes** to internal systems and procedures.

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
DRAFT	R Signor	S Thompson		S Thompson		15.5.12
FINAL	R Signor	S Thompson		S Thompson		25.5.12

Planning for Climate and Natural
Hazards

APPENDIX

B

ACTION LONG LIST

Option #	Name	Action Type	Action	Theme*	Risks
1			Actions will be derived from the outcomes of the Flood Taskforce findings	A	12,14,15,16,17,19,20,21,22,23,24,25
2	On-going communication on environmental risks	Requisite Research and Management	Provide education of preventative practices prior to and during extreme events, e.g. clearing gutters and drains. Distribute community educative information through rates notices.	B	1
3	Refer No. 4		Minimise hard surfaces, such as pavements.		
4	Reduction in use of hard stand	Adaptation	Development controls to promote soft surfaces external to the building footprint.	C	1, 12
5	Provision of an up-to-date DISPLAN that considers climate change risks – to be regularly updated	Requisite Research and Management	Ensure emergency procedures and equipment are in line with currently available information on local flooding, bushfire and other emergency risks.	B	3,24
6		Avoided	Provide educational materials and strengthen provisions for green roofs and green walls in the Development Control Plan (influence design within the community more generally through their role of building approver and setting examples with demonstration houses to demonstrate potential adaptation measures).	C	1
7	Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan.	Requisite Research and Management	Produce a prioritised list of infrastructure items that are at risk of damage as a result of sea-level rise, flooding, bushfire, and salinity. [Follows on from 58]	B, E	
8	Provision of an up-to-date DISPLAN that considers climate change risks – to be regularly updated	Requisite Research and Management	Review Council's DISPLAN and include climate change risks. Does the DISPLAN include provisions for flood, fire, drought, severe storm, landslide, communication disruption? Ensure emergency procedures and equipment are in line with currently available information on local flooding, bushfire and other emergency risks.	B	24,25
9		Avoided	Educate the community about the DISPLAN outlining responsibility of residents, Council and emergency response agencies - letterbox drop, community newsletter, workshops etc.	B	1,24
10	Review of emergency access routes	Requisite Research and Management	Identify emergency access/evacuation routes - implement a study to review risks, limitations	B, E	
11	Use of design standards that consider change in natural hazard	Requisite Research and Management	Review DCP and LEP to ensure natural hazards and climate risks are addressed and mitigation measures included. Ensure that the DCP is updated periodically and advocate for continuous improvement in the Building Code. Are stormwater management infrastructure specifications adequate for intense storms projections? Are asset protection zones adequate for bushfire risk?	C	
12	Council to develop its own social media network separate to the DISPLAN	Avoided	Council to develop a Facebook page/email/ SMS service to disseminate information to locals in case of an emergency - e.g. can post updates from RFS, SES, RMS about road closures, risk areas etc.	B	1,24,25
13	Review insurance on Council assets to ensure adequacy	Secondary Response Measures	Ensure adequate insurance for assets deemed at risk (through preliminary or detailed studies)	A, C, D, G, H, I	
14	Refer No. 138		Gather data and present the business case to increase Council resources to deal with natural disasters		
15	Implementation of Water Sensitive Urban Design standards	Adaptation	Implement water sensitive urban design standards into development assessment criteria. The purpose of this is to reduce heat particularly in Richmond, Windsor and other town centres.	C, F, H	1, 12, 17
16	Encourage adoption of fire resilient property standards and installations for residents	Adaptation	Encourage changes to existing developments, to include improved protection and adaptations to increased bushfire risk (bushfire management strategies are largely available). Note that the DCP requires new development in within bushfire prone land to be compliant with AS3959.	B, D, I	1,3, 5
17	Use of design standards that consider change in natural hazard	Requisite Research and Management	Adopt latest codes, standards and guideline for new buildings with respect to climate projections. Where practicable, adopt climate sensitive building design that considers local cooling and heating requirements e.g. inclusion of natural ventilation cooling, consideration of building orientation and low energy consumption. Design buildings to allow for consideration of future climate change impacts and incorporation of future adaptation (noting that the Building Code of Australia sets minimum standards, and it can be difficult for local governments to justify setting more stringent requirements).	C, I	
18	Use of design standards that consider change in natural hazard	Requisite Research and Management	Prepare master plans/development plans, which take into account projected climate change, to guide long term use and development of areas that will experience population growth and areas that are expected to be significantly impacted by climate change	C	
19		Avoided	Identify which areas will be more vulnerable to bushfire. For new development, conduct a risk assessment to ensure new infrastructure is not placed in fire-prone areas. For infrastructure where location is not flexible, investigate standards of construction that reduce their sensitivity to bushfire.	B, D, I	3
20	Refer No. 16		Increase percentage of existing and new homes compliant with AS3959		
21	Encourage adoption of fire resilient property standards and installations for residents	Secondary Response Measures	Discount or rebate on fire resilient installations in homes		
22	Increase number of prescribed burns	Avoided	Increased number of prescribed burns and undertake selective removal of mid-story vegetation.	B, D, I	3,4
23	Invest in R&D Projects	Secondary Response Measures	Invest in R&D Projects, e.g.. selective weeding, identification of sections of corridor that can be cleared in an emergency, fast decomposing bacteria to reduce fuel - carbon sequestration, or mechanical removal, pre-curing process prior to hazard reduction burns in Asset Protection Zones for hotter burns support natives plants	B, D, F, I	3,4
24	Mapping of fire tolerant and intolerant vegetation communities	Requisite Research and Management	Map areas of non fire tolerant vegetation communities, phytophthora locations, wildlife refuges	D, F	5
25	Mapping of static water supply	Requisite Research and Management	Map areas with static water supply and make information available to RFS and SES. Prepare a GIS map of surface and arterial water supply and catchments within the LGA (a GIS map of surface and arterial water supply would show the location and quantity of water resources and assist in protection of water supplies and catchments, particularly open catchments where stock graze).	B	
26		Avoided	Fire mapping through GIS technology.	D	
27	Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan	Requisite Research and Management	Detailed mapping of roads and access routes affected by sea level rise, storms / flooding, bushfire risk, landslide. Undertake a feasibility study for engineering solutions for assets, roads, buildings, and other infrastructure or areas at risk	B, E	4,9
28	Undertake disaster risk assessment of natural assets and develop a Management Plan	Requisite Research and Management	Produce maps indicating potential natural asset loss and gain	F	

Option #	Name	Action Type	Action	Theme*	Risks
29	Maintenance support residents in high risk areas	Adaptation	Identify and support residents requiring property maintenance assistance in high risk areas. For example: Council bulk green waste removal and chipping service (subsidised) in high risk areas.	B, D	1, 3
30	Increase static water supply	Secondary Response Measures	Increase static water supply volume (e.g. tanks) on council owned assets (e.g. stormwater harvesting on Council owned buildings) and provide strategic water supply points for emergency purposes and re-supply by tankers. Refer to 144	B	
31	Additional RFS facilities	Secondary Response Measures	New RFS station, or increased supply of RFS resources (e.g. train more Community Fire Units)	B, D	3
32	Compulsory High Risk property acquisition	Avoided	Compulsory high risk property acquisition.	B	3
33	Installation of fire danger signage	Requisite Research and Management	Install fire danger signs, evacuation route signage, and early alert fire warning system.	D	3,4
34	Establishment of safe refuge areas	Secondary Response Measures	Provision of safe refuge areas for people and pets [this information is in the DISPLAN for flooding][link to Action b - heatwave - evacuation centres will require off grid electricity and water supplies]	B	3
35	Establishment of new access roads	Secondary Response Measures	Consider potential for new roads to reduce evacuation risk (Bells Line of Road extension and M9 orbital).	B, E	3,4
36	Community engagement relating to fire safety	Requisite Research and Management	Undertake community engagement to inform the community of their responsibilities and options for implementing alternative fire fighting capability, i.e. on site water reserves and RFS's limited capabilities if there is no water	D	
37	Review location of fire breaks	Requisite Research and Management	Review locations of fire breaks	D	3,4,5
38	Review of emergency access routes	Requisite Research and Management	Review access arrangements and resource provision for firefighting (Strategic review of capability to react to fires, in terms of available resources and access to bushfire prone areas, in liaison with RFS). Construct new fire trails where appropriate	D	3,4
39	Review of emergency access routes	Requisite Research and Management	Audit and assure compliance for key fire evacuation routes and asset protection zones, and develop minimum standard or code.	D, E	3,4
40	Use of design standards that consider change in natural hazard	Requisite Research and Management	Review bushfire management provisions in LEPs and DCPs taking into account: (1) Long term climate change projections. (2) Any changes to State planning bush fire management provisions and Planning for Bushfire Protection Guide. Require appropriate bush fire prevention and response in relation to new developments (planning policy). Planning provisions for private land may include: increase minimum lot sizes and/or setbacks to bushland in bushfire prone areas, restrict type of development, enforce fire retardant landscape design, provision of water storages such as tanks, dams, pools etc. Refer 17	C, D	3
41	Update road design standards	Requisite Research and Management	Update road design standards (Council road infrastructure design standards require regular updating in response to climate change to ensure that materials and designs respond to climate change risks). Guidelines should be developed for incorporating climate change adaptation into design criteria for new roads and bridges, and for the retrofitting of existing assets (e.g. take into account changes in rainfall and runoff, consider appropriate designs, materials and construction methods).	E	
42	Engineering Controls for Landslip	Adaptation	Engineering controls for landslide risk focusing on access/evacuation routes - geotechnical studies to evaluate risk. Risk in itself and evacuation risk.	B, E	9
43	Refer No. 7	Requisite Research and Management	Prepare and review road asset management plan/s every five years. Plans should consider the projected long term impacts of climate change and include: - Increased frequency of road surface and bridge condition inspections (regular, repeatable condition assessments of critical roads and bridges (e.g. access/evacuation routes) - Increased scheduled maintenance of sealed and unsealed roads including provision for increased surface maintenance. - Increased scheduled bridge repair, strengthening and replacement including consideration of removing or relocating bridge placement and materials with those more suited to anticipated conditions. - Consideration of revised service and design standards for bridges including consideration of overtoppable bridges and removal of some bridges. - Emergency repairs to road surface and bridges. (This will fit inside the Asset Management Plan)	E	4,9,15,16
44	Advocate for additional funding from State agencies	Avoided	Advocate to RMS for increased funding and resources, including changes in methodology for funding allocation, for asset management planning, monitoring, capital works, road maintenance and repair to the regional and local road network and bridges.	E	
45	Undertake disaster risk assessment of natural assets and develop a Management Plan	Requisite Research and Management	Implement conservation management plans for local reserves and other local government lands.	F	
46	Encourage private land conservation	Avoided	Encourage private land conservation, e.g. through incentives.	F	
47	City Atlas of values	Avoided	Develop a City Atlas of Values that presents known environmental, recreational, cultural and land-use values and issues. (e.g. Darwin City Council - The Darwin Environmental Atlas is based on the city's 24 identified hydrological sub catchment boundaries, referred to as Catchment Management Units. The Atlas provides residents with a summary of their living and built environment.)	F	5
48	Develop pest, weed and invasive species management strategy	Secondary Response Measures	Develop and implement a pest, weed and invasive species management policy/strategy that takes into account changed climatic conditions. Revisions to mowing and weed control schedules to take into account changed climatic conditions that affect growth and dispersion.	F	26
49	Education relating to weed risks	Avoided	Promote awareness to local communities of potential weed risks resulting from climate change in the local area (incorporate into existing awareness programmes if appropriate).	F	26
50	Erosion control and rehabilitation of watercourses	Adaptation	Implement erosion control and rehabilitation works on creek lines and seek external funding partnerships.	F, H	26
51	Water quality monitoring	Adaptation	Monitor water quality in recreational waterways	F, H	13
52	Refer No. 23	Secondary Response Measures	Explore climate change impacts to agriculture - risks and management options	F, G	10
53	Shading	Secondary Response Measures	Develop shade provision policies. Review/prepare design guidelines for street furniture, shelters and awnings, and infrastructure to provide protection, e.g. development of a shade and sun protection policy. Ensure sufficient shade, either natural or built, is available or planned for when developing new recreational facilities or centres and in any development plans for picnic areas, playgrounds etc.	I	2

Option #	Name	Action Type	Action	Theme*	Risks
54	Shade audits of public areas	Requisite Research and Management	Conduct shade audits to determine the adequacy of existing shade, whether there is a need for more, if appropriately located and of appropriate size.	I	2
55	Provision of additional public shading	Secondary Response Measures	Include provision of shade structures in design of new council recreational facilities.		
56	Heat emergency plans	Requisite Research and Management	Adopt heat-emergency contingency plans for recreational/tourism events held within local council area (these plans are generally developed by state/territory governments).	B, G	2
57		Avoided	Encourage scheduling recreational and sporting events and activities to avoid the hottest part of the day and at shady locations where possible. Education for recreational park users such as schools.	B, G	1,2
58	Undertake disaster risk assessment of key infrastructure and determine an Asset Management Plan	Requisite Research and Management	Undertake disaster risk assessments of key infrastructure. Precedes No. 7.	B	
59	Refer No. 127	Requisite Research and Management	Identify and manage drainage around vulnerable trees		
60	Consideration of vegetation storm resilience around assets	Secondary Response Measures	Replace canopy trees with appropriate trees to withstand high velocity winds. Refer No. 127.	B, G	14,18,19
61	Consideration of vegetation storm resilience around assets	Secondary Response Measures	Decrease tree canopy. Refer No. 127.	G	14,18,19
62	Encourage adoption of storm resilient installations on properties	Secondary Response Measures	Discounts or rebates provided for storm resilient installations (e.g., window shutters, corrugated roofing)	G	
63	Train staff in disaster management	Avoided	Train staff in disaster management (i.e., chainsaw operation)	B	
64	Undercover parking for Council fleet	Secondary Response Measures	Identify areas to provide undercover parking for Council owned vehicles. Warn staff to put Council owned vehicles undercover when storms are forecast.	G	19
65	Installation of subsurface irrigation and drought tolerant landscaping	Avoided	Install subsurface irrigation where required (sporting grounds, ovals, parks). Refer No. 106.	H	
66	Installation of subsurface irrigation and drought tolerant landscaping	Avoided	Install drought tolerant landscaping at Council facilities Refer No. 106.	H	
67	Refer No. 80 and 102	Avoided	Insulate Council buildings including windows, walls and roof. Refer No. 80 and 102	B, I	
68	Management plan for core heritage areas	Requisite Research and Management	Develop management plan for heritage protection zones in core heritage areas (e.g. Macquarie Towns and Hawkesbury-Nepean River locations)	G	14,18
69	Refer No. 5 and 8	Requisite Research and Management	Review of DISPLAN on regular basis – to be amended if necessary. Refer No. 8.	B	
70	Regular system reviews of wastewater and sewage systems	Avoided	Design wastewater systems to prevent overflow events from wetter than normal weather, based on climate change scenarios. If costs are prohibitive, plan for regular system reviews to consider climate change effects.	B, H	23
71	Utilisation of grey-water systems	Adaptation	Introduce requirements for greywater recycling as part of development approval, and incorporate greywater recycling in public infrastructure. Develop water strategies that incorporate greywater reuse.	B, H	8,24,25
72	Community education: water efficient landscaping	Avoided	Community education on water efficient garden planting and watering.	H	1,8
73	Refer No. 15		Promotion of use of WSUD and water efficient installations into new developments. Identification of opportunities to include WSUD in existing developments/infrastructure.	C, F, H	8
74	Encourage uptake of stormwater harvesting	Adaptation	Prepare or review policies to incorporate demand management strategies such as roof water harvesting in residential areas.	B, H	8
75	Refer No. 7		Development of a stormwater management plan that addresses potential locally-appropriate alternative uses of stormwater and includes measures to reduce peak flows during wet weather, e.g. increased use of stormwater by capturing (such as developing wetlands and aquifer storage and recovery). Develop urban drainage management plans that optimise active storage capacity to alleviate flood peaks. Urban based drainage system should be linked to catchment based flood management to avoid impacting on other areas in the catchment.	B, H	23
76	Regular system reviews of wastewater and sewage systems	Avoided	Ongoing and periodic review of sewerage system strategies and operations to address hydraulic constraints and overflow risks, and sewer rehabilitation and cleaning regimes.	B, H	17
77		Avoided	Limit growth expansion and/or connections to parts of the sewerage system where there are potential capacity constraints.	B, H	17
78	Community education: greywater use	Avoided	Develop a Community Engagement Strategy to ensure that guidelines for grey water use are well known throughout the community. Consult with EPA to implement strategies and guidelines.	B, H	
79	Encourage uptake of stormwater harvesting	Adaptation	Explore grants for stormwater harvesting for residents/businesses	B, H	8,23
80	Retrofitting of existing buildings	Adaptation	Review of schools and community centres to ensure they are built to withstand high temperatures and extreme storms. Install storm resilient installations and insulate schools and community centres	G	1, 24, 25
81	Increase asset protection zones	Avoided	Two sewage treatment plants owned by Council and one waste processing facility - increase asset protection zone for bushfire risk.	G	6,7
82	Model stormwater impact from increased storm activity and incorporate into design guidelines	Requisite Research and Management	Modelling of impact to stormwater from increased storm activity.	H	23
83	Model stormwater impact from increased storm activity and incorporate into design guidelines	Requisite Research and Management	Incorporate climate change requirements into design guidelines for stormwater. Update infrastructure design standards for stormwater.	B, H	23
84	Refer No. 7 and 58	Requisite Research and Management	Prepare/review and implement Council stormwater management plans to reduce the impacts of sediment and diffuse sources of water pollution entering waterways under a climate changed future.	H	23
85	Work collaboratively with the Local Land Services to monitor water pollution	Avoided	Work collaboratively with the Local Land Services to monitor role of effluent disposal and diffuse sources of water pollution in affecting aquatic ecosystems.	H	
86		Avoided	Support and publicise initiatives to improve health of waterways and aquatic ecosystem services.	F, H	27

Option #	Name	Action Type	Action	Theme*	Risks
87	Water Security storage and access plans	Secondary Response Measures	Develop/ implement a water security strategy and public health plan/s which include: - Review/ increased water monitoring program to detect and report algal blooms, water borne diseases and other potential contaminants. - Identification of methods to control diseases and disease vectors and improve alert systems for potential outbreaks. - Awareness/ education campaign including risks and impacts of water borne diseases and other potential contaminants. - Alternative water supply/emergency storage. - Enhance infectious disease and food safety programs.	B, H	1
88	Refer No. 7 and 58	Requisite Research and Management	Prepare and review strategic business plans and asset management plan/s for the piped water supply network every five years. Plans should consider the projected long term impacts of climate change and include: - Proposed monitoring of pipe condition. - Proposed maintenance and replacement of the network including; replacing pipes with pipes made of more resilient materials (appropriate to area) and improved construction techniques with improved bedding and backfill materials. Implement asset management plans for the water supply network.	B	
89	Refer No. 7 and 58	Requisite Research and Management	Implement asset management plans for the water supply network.		8
90	Refer No. 7 and 58	Requisite Research and Management	Prepare and review strategic business plans and asset management plan/s for the sewerage network every five years. Plans should consider the projected long term impacts of climate change and include: - Proposed monitoring of stormwater infiltration and pipe condition. - Proposed maintenance and replacement of the network including replacing pipes with pipes made of more resilient materials (appropriate to area) and improved construction techniques with improved bedding and backfill materials. Implement asset management plans for the sewerage network.	B, H	17,27
91	Refer No. 7 and 58	Requisite Research and Management	Implement asset management plans for the sewerage network.		17
92			Update infrastructure design standards for stormwater.		
93	Monitoring performance of sewage and stormwater systems	Requisite Research and Management	Monitor system performance of reticulated sewerage infrastructure including: - Sewerage treatment plant/s. - Performance of sewerage infrastructure in preventing infiltration (including lid selection, seals in access chambers and lids). - Responding to complaints about illegal connections to the sewerage system.	B, H	23
94	Refer No. 7 and 58	Requisite Research and Management	Prepare and review asset management plan/s for the stormwater network and stormwater management plan/s every five years. Plans should consider the projected long term impacts of climate change and include: - Proposed monitoring of pipe condition. - Staged extensions to the pipe stormwater network, duplication of stormwater system and targeting high risk areas. - Proposed maintenance and replacement of the network including replacing pipes with pipes made of more resilient materials (appropriate to area) and improved construction techniques with improved bedding and backfill materials. - Options for increased stormwater harvesting for use as recycled water. - Diffuse source water pollution management principles. - Review design and implement stormwater drainage systems to be capable of handling greater flows (including retention basins) for new and existing drainage systems (Increase capacity of stormwater infrastructure). Implement asset management plans for the stormwater network and stormwater management plan.	H	
95	Refer No. 7 and 58	Requisite Research and Management	Implement asset management plans for the stormwater network and stormwater management plan.		23
96	Refer No. 51	Adaptation	Develop a strategy to manage water quality issues in recreation areas in response to extreme rainfall events. Establish event based water quality monitoring program to inform the water quality strategy.	B, H	23
97	Refer No. 82		Identify the resource implications of increased extreme rainfall intensity events and prioritisation of complaints. Review options to disseminate results of information to residents.	A	
98	Refer No. 102	Adaptation	Design Council buildings to allow for ease of future adaptation, e.g. have the ability for significant amounts of shade to be added or removed from a facade. Relevant guidelines could be included in council specific design manuals.	G, I	
99	Use of design standards that consider subsidence / heave in infrastructure foundation design	Requisite Research and Management	Consider potential for subsidence/heave in the design of infrastructure foundations. Relevant guidelines could be included in council specific design manuals.	I	
100	Refer No. 1		Flood-proof or re-site infrastructure and plan transport routes and roads to avoid disruption by flooding activities. Relevant guidelines could be included in council specific design manuals and asset management plans.	A, E	
101	Increase use of insulation	Avoided	Increase use of insulation in new buildings.	B, I	
102	Retrofitting of existing buildings	Adaptation	Retrofitting existing buildings with addition of insulation materials and effective and efficient cooling systems (encourage retrofitting actions through marketing and incentives and by setting an example with public buildings).	B, I	1, 24, 25
103	Reduce lighting and equipment loads	Avoided	Reduce lighting and equipment loads to reduce overheating.	I	
104	Refer No. 102	Adaptation	Optimise design of cooling systems to provide the best energy efficiency under higher temperature operating loads, i.e. use of passive cooling systems, improved use of thermal properties of building materials, reduce solar heating using recessed windows, roof overhangs and shades. Assess cooling systems as part of building approval role.	B, I	
105	Refer No. 144	Adaptation	Promote micro power initiatives.	B	

Option #	Name	Action Type	Action	Theme*	Risks
106	Development of an irrigation plan	Secondary Response Measures	Develop an irrigation plan to identify and reduce existing mains water irrigation levels where possible: - Reduce mains water irrigation by choosing areas to receive less irrigation. - Water efficient landscaping (drought tolerant landscaping) - subsurface irrigation at sporting ovals and parks (reduces evaporation rates) - Alternative supplies of water such as rainwater tanks, greywater, reclaimed effluent and groundwater - Increase mowing height of lawns (reduces evaporation rates and requires less water) - Increase application of mulches	B, H	8
107	Refer No. 106	Secondary Response Measures	Reduce mains water irrigation by efficient irrigation.	B, H	8
108	Refer No. 106	Secondary Response Measures	Reduce mains water irrigation by creating water efficient landscaping	B, H	8
109	Refer No. 106	Secondary Response Measures	Reduce mains water irrigation by using alternative supplies of water such as rainwater tanks, aquifer storage and recovery, greywater and blackwater, reclaimed effluent and groundwater.	B, H	8
110	Refer No. 106	Secondary Response Measures	Train staff on irrigation system auditing and scheduling.	H	
111		Avoided	Set aside areas for community gardens to trial plants local to the council area and their ability to adapt to use in gardens.	H	
112	Refer No. 106	Secondary Response Measures	Increase mowing heights of lawns to decrease lawn water use and stress.	B, H	
113	Refer No. 106	Secondary Response Measures	Increase application of mulches	B, H	8
114	Refer No. 4	Adaptation	Use pervious paving materials	A, E	
115	Underground living areas	Avoided	Install underground living areas that are cool in extreme heat	B, I	
116	Use of road materials to minimize maintenance costs and heat absorption	Adaptation	Use road and footpath surface material to minimise maintenance and be less heat absorbent	I	
117	Plant more trees in public areas	Avoided	Plant more trees in streets, parks and public domain areas - use species indigenous to the local area. Use of fire adapted vegetation in parks and recreation areas.	F	
118	Review of recreational space and consolidation	Secondary Response Measures	Ovals and parks - Identify a 'trigger' that ovals, playing fields and parks are becoming unusable - Identify fields that may need to close permanently (too expensive to keep up to standard) and those that need to be upgraded. - Install synthetic playing surface on council owned ovals/fields/parks to reduce heat and water consumption. - Consideration of a regional complex to replace several small grounds	B, H	8
119	House Buddy Program	Secondary Response Measures	Develop a 'House Buddy' program to assist neighbourhoods to monitor vulnerable residents in time of extreme risks (heat, flood, bushfire). Utilise existing council facilities to monitor at risk members of the community e.g. Meals on Wheels	B	
120		Avoided	Conduct community education program to increase awareness of heat risk and response	B	1
121	Shading of pools	Avoided	Shade pools to protect from UV radiation exposure in summer months	B, I	8,24,25
122	Public drinking fountains	Secondary Response Measures	Ready access to water in public places for pets and people. Install drinking fountains and taps in public places.	B	
123	Provision of transport options in extreme conditions	Secondary Response Measures	Provide a shuttle bus to vulnerable residents in time of extreme heat.	B	8
124	Develop inspection regimes for Council assets and infrastructure	Requisite Research and Management	Regularly monitor, record and repair footpath hazards and use footpath materials and techniques that minimise cracking (e.g.. Flexible materials)	G, I	
125	Develop inspection regimes for Council assets and infrastructure	Requisite Research and Management	Review inspection regimes for Council-owned buildings to enable early identification of cracking and structural distress and enable intervention.	G, I	
126	Relocation of community infrastructure away from trees	Avoided	Relocate park seating from under trees at risk of limb drop, and ensure appropriate placement and selection of tree species to avoid limb drop in resting areas.	G	24
127	Consideration of vegetation storm resilience around assets	Requisite Research and Management	Conduct regular surveys to identify trees that present a high risk of collapse or limb drop and remove trees or limbs as appropriate, particularly trees in high risk areas (e.g. high value infrastructure or for public safety). Decrease tree canopy near public infrastructure. Replace canopy trees with tree species that can withstand high velocity winds.	G	
128	Strengthen DCP standards for ESD (particularly in growth areas)	Requisite Research and Management	Design new/upgraded buildings to include: - Ecologically sustainable design features which consider the impacts of projected climate change including passive heating and cooling, solar or wind generated energy and appropriate solar orientation and recycled water. - Use appropriate designs to minimise lifecycle costs and maximise building performance. Designs for new Council buildings should take into account climate change projections and the design should take into account ESD principles. Overall building design should minimise lifecycle costs and maximise building performance.	C	
129		Avoided	Review Buffer zones which already exist around sewage treatment plants. Continue to investigate new technology which will minimise likelihood of odour problems.	B, G, H, I	
130	Review of recreational space and consolidation	Secondary Response Measures	Consider alternative maintenance measures for ovals, playing fields and parks based on climatic conditions • Increase irrigation installation programme • Investigate bore water in key areas • Increase aeration programme • Increase sand surface for cushioning	B, H	8
131	Refer No. 118		Identify a 'trigger' that ovals, playing fields and parks are becoming unusable	B, H	
132	Refer No. 118		Identify fields that may need to close permanently (too expensive to keep up to standard) and those that need to be upgraded	B, H	
133	Refer No. 118		Consideration of a regional complex to replace several small grounds.	B, H	
134	Invest in R&D Projects		Engagement with universities to improve research (targeted monitoring program, vulnerability study to identify trigger points) and knowledge (formalise and grow)		10,11
135	Refer No. 11	Requisite Research and Management	Improvements in future town planning to improve safety (with mandated setback requirements for life and property or alternative safety systems in place)	C	
136		Avoided	Improved health warnings (such as advertising in conjunction with other councils).	B	27
137	Review insurance on Council assets to ensure adequacy	Secondary Response Measures	Budget for potential increase of public liability insurance premiums.	A, C, D, G, H, I	

Option #	Name	Action Type	Action	Theme*	Risks
138	Review emergency management fund based on disaster damages assessment	Secondary Response Measures	Assess feasibility of developing a readily accessible emergency management funds in order to have provision for clean-up and rebuild costs due to extreme weather events (potential rate increases). Gather data and present the business case to increase Council resources to deal with natural disasters. For minor events (storm, flood, fire), increase operational budget by 5% to accommodate increased clean up costs.	A, C, D, E, G, H, I	
139	Refer No. 11	Requisite Research and Management	Assess, review and alter Councils' engineering standards to allow for change in severity/frequency of storm events.	C, I, H	
140	Refer No. 7 and 58	Requisite Research and Management	Revisit existing high risk infrastructure and develop and implement priority/ strategic mitigation strategies		
141	Refer No. 11	Requisite Research and Management	Progressively incorporate higher design standards into asset management plans and rolling capital works programmes.	C, E, H, I	
142	Refer No. 143	Adaptation	Fire protection and reduction programs; physical security measures; property insurance; proactive maintenance programs; flood mitigation strategies; coastal protection measures; Local Area Disaster Plan(DISPLAN); Council's Business Continuity Plan Develop Business Continuity Plans. Development of Recovery Plans for critical business functions. Continue to increase emergency management networking and capability through working with other agencies on increased community awareness and preparedness programs	B	6,7,17,22
143	Business Continuity Plan	Adaptation	Council to have a Business Continuity Plan	B	1, 6, 8, 19, 24
144	Provision of off-grid utilities (including static water supply)	Adaptation	Off grid utilities supply (electricity, water). Consistent with Strategic Plan emphasising sustainability.	B	1, 3, 5, 6, 7, 8, 22, 24, 25
145	Emergency response protection for key heritage assets	Adaptation	Where unique heritage items have been identified which have maintenance costs and potential high costs following emergency events (e.g. through hail/ tree/wind/flood damage) installation of site specific emergency response measures may be appropriate (e.g. Dutchdam barriers, deployable protective roofing). The potential for subsidence due to alterations in ground conditions may also need to be considered and reinforcement of heritage assets applied.	G	1, 24, 25
146	Bushfire Neighbourhood Watch	Secondary Response Measures	Establishment of Bushfire Neighbourhood Watch systems to encourage local responsibility for bushfires and prevention of anti-social behaviour that may increase bushfire risk	D	
147	Coordination of land care activities	Secondary Response Measures	Council co-ordination and co-operation within and between local and regional Landcare / gardening associations to promoted integration of bushfire management practices (e.g. selection of species than minimise ground fuel)	D	
148	Maintenance of Council parks and BBQ facilities	Requisite Research and Management	Maintenance and upgrade of Council recreational and public vegetated space that minimises the risk of fires starting	D	
149	Relocation of key asset crossing locations	Adaptation	Relocation of road and bridge infrastructure to elevate it flood frequent flood events and reduce fire damage. This may also be expanded to utility provision. The reduction in maintenance may offset the capital costs. Assets to be replaced would need to be identified through an Asset Management Plan	E	15, 16
150	Replacement of high maintenance cost assets	Secondary Response Measures	Where environmental conditions are anticipated to significantly increase asset (e.g. bridges) maintenance costs into the future, Council may want to consider the feasibility of upgrading existing assets to lower maintenance cost options	E	
151	Condition assessment of watercourses within the LGA	Requisite Research and Management	Condition assessment of watercourses within the LGA to determine high priority areas for rehabilitation	F	

*Themes

A	Flooding of Urban and Built Areas
B	Building Resilience and Coordinated Emergency Management
C	Managing Development to Consider Climate Changes in Growth Centres
D	Bushfire Risk Management
E	Maintaining Roads and Bridges
F	The Natural Environment Response to Temperature, Rainfall and Other Climatic Changes
G	Protecting the Region's Heritage and Community Infrastructure, especially From Storms
H	Stormwater Drainage, Infrastructure and Water Quality
I	The Built Environment's Response to Temperature, Rainfall and Other Climatic Changes