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Hawkesbury City Council

Planning for Climate and Natural Hazards

Risk Assessment Report

May 2012

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- 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.*

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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:

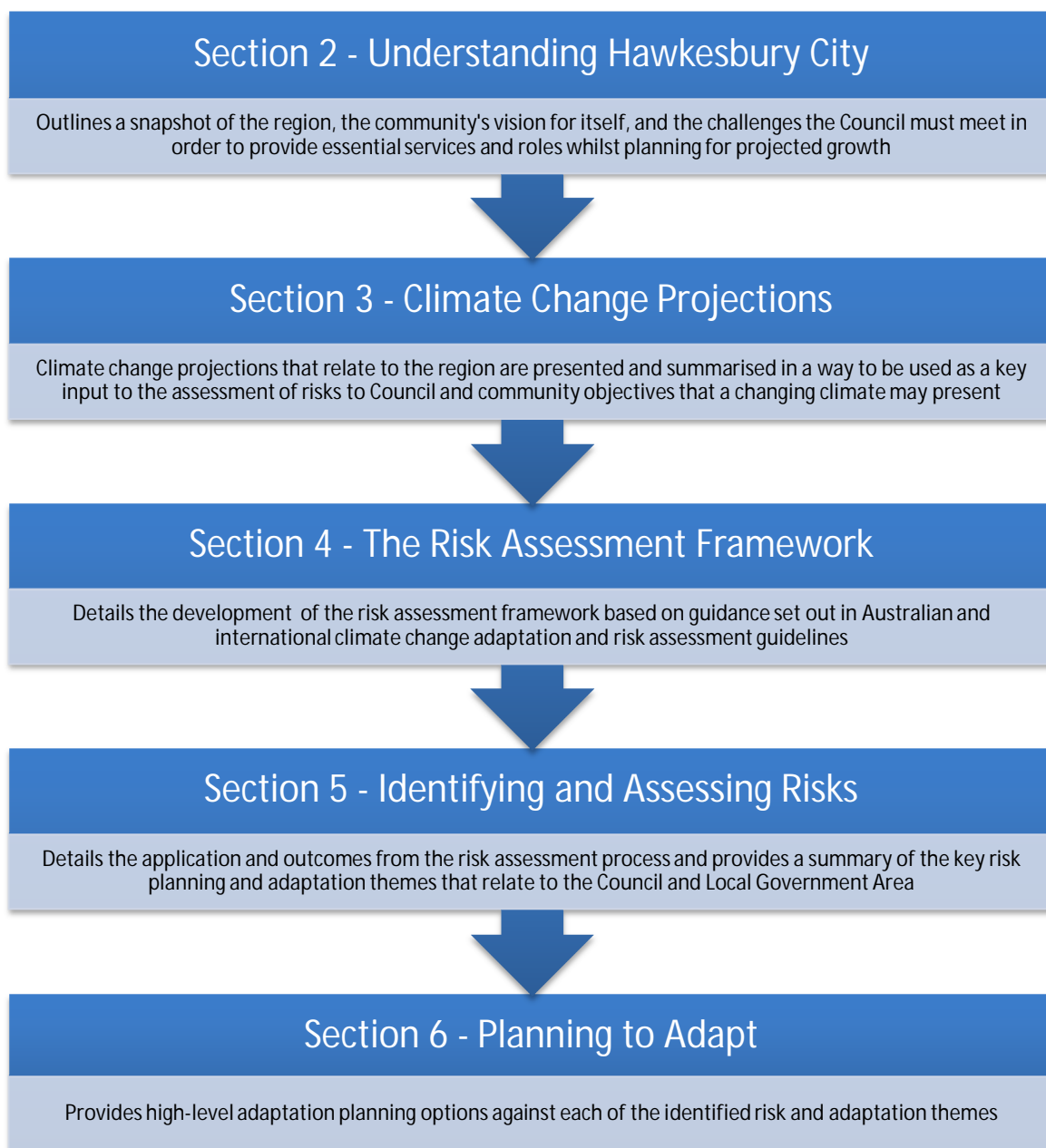


Figure 1 Study approach and report structure

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.

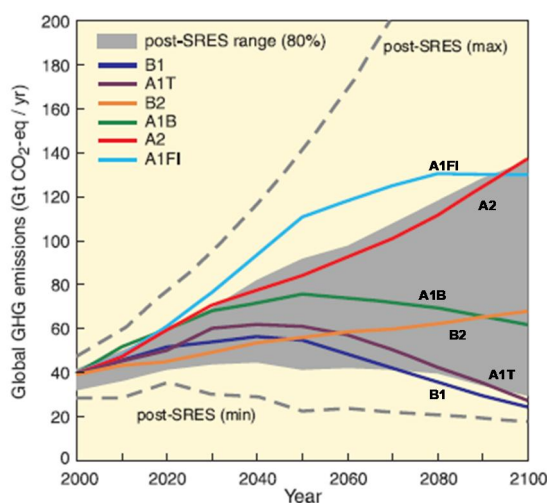


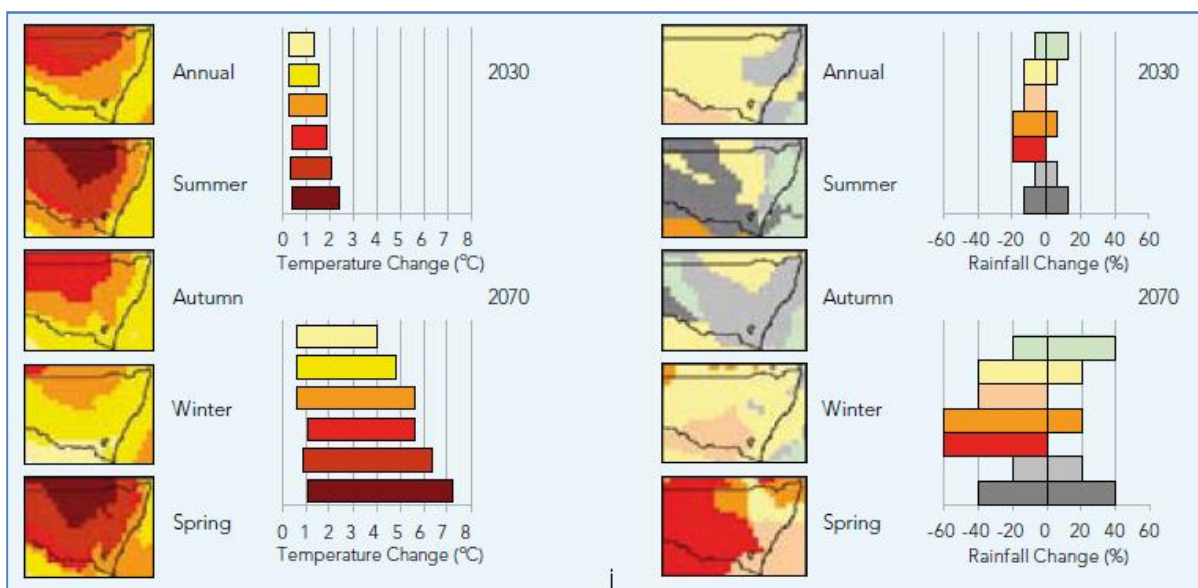
Figure 3 Greenhouse gas emissions scenarios (IPCC, 2007)

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)

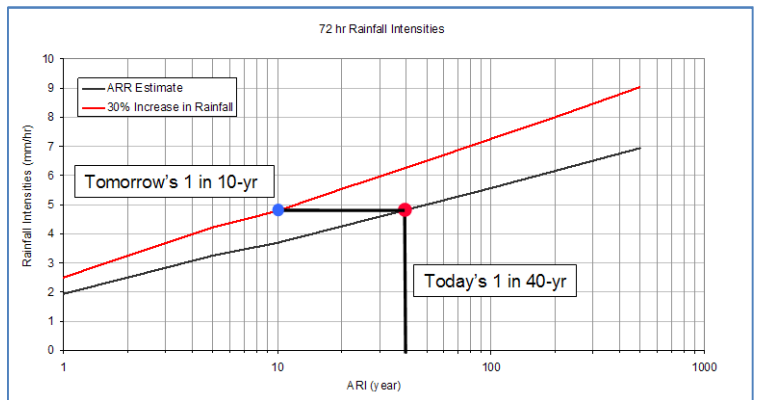
Rainfall events can be described in terms of:

- 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 10 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:

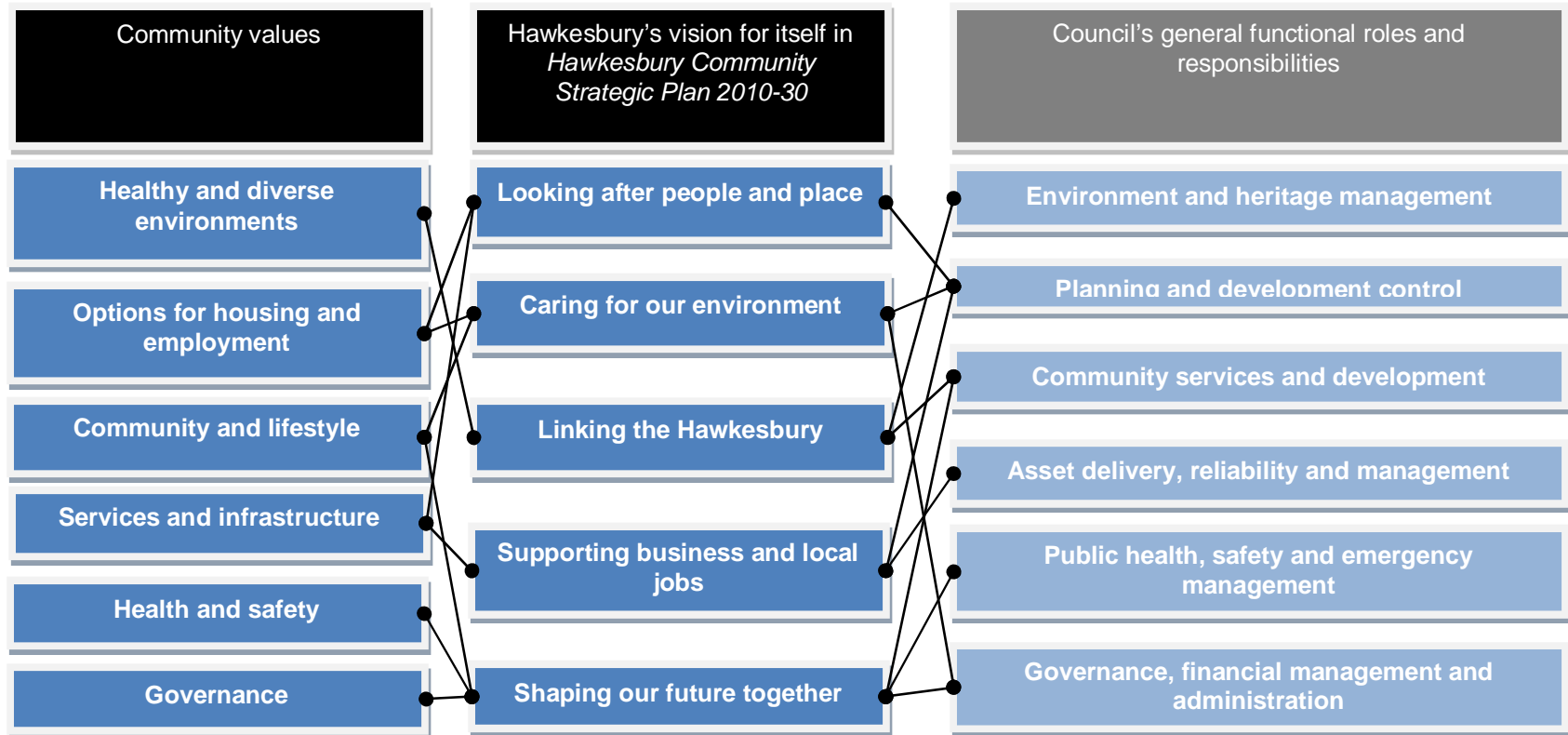
- What are the things that the Hawkesbury City community uniquely values, and
- The extents and limits to which Council can contribute to providing them.

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)



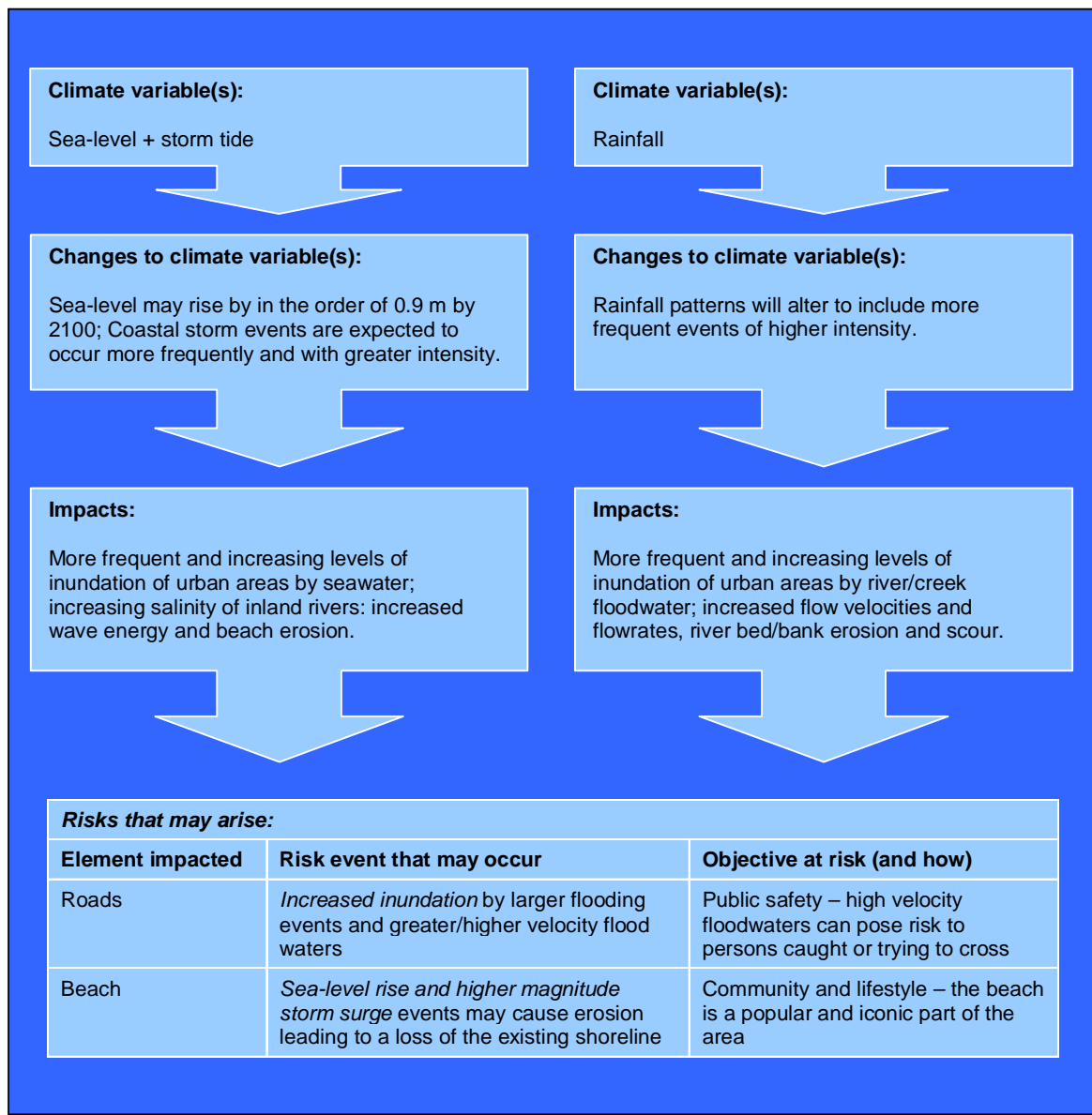


Figure 6 Example “cause and effect chain” where climate changes lead to risks

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	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.
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	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.
<i>PRIORITY 2 ADAPTATION PLANNING THEMES</i>	
Bushfire risk management	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.
Maintaining roads and bridges	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>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 <i>etc.</i>; • 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:

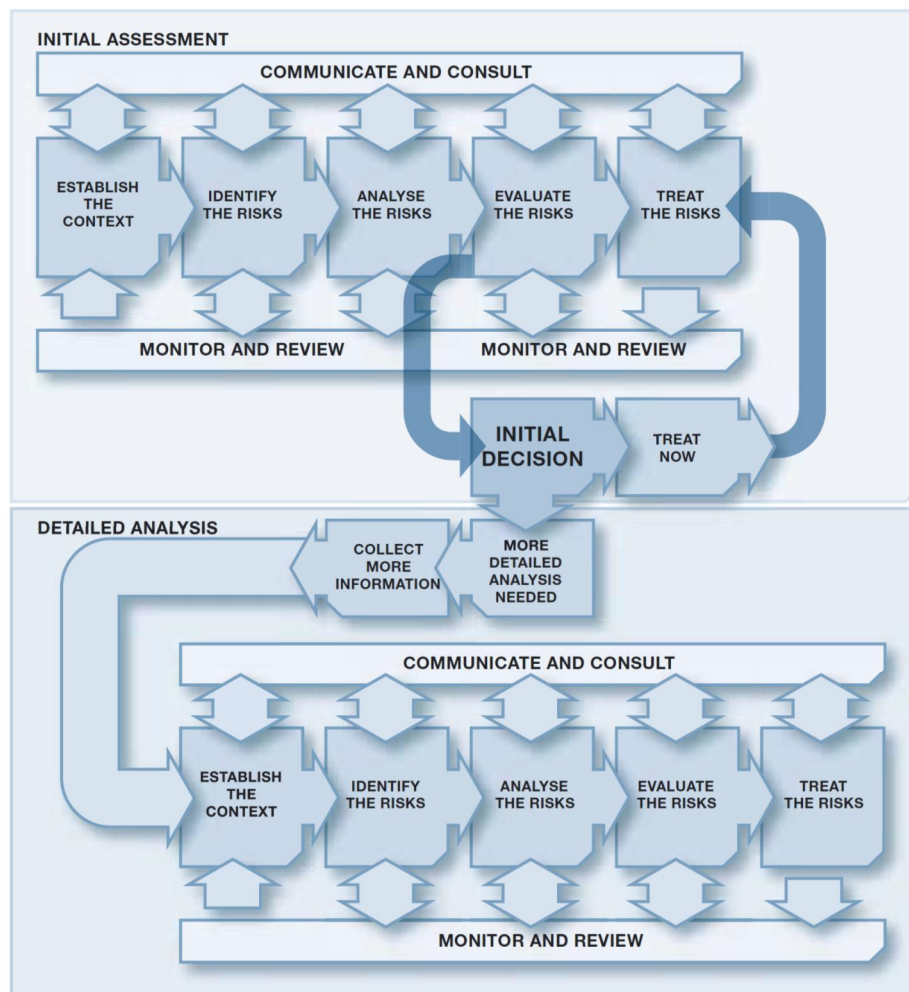


Figure 8 Continual climate risk management and adaptation process (AGO, 2006)

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.

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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	Catastrophic
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	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?						Specific consequences and further details	Existing controls	Current			Near-term, moderate changes			Long-term, extreme changes				
				Health & safety	Environment	Local 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	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	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			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 at Colo, MacDonald, Grose, 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		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 endangered 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 inspections 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	Local economy	Governance	Community and lifestyle	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	South Windsor	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	Access to services; allocation of resources; communications and decision-making ability tested due to clusters of emergency scenarios.	x			x	x		Anarchy 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

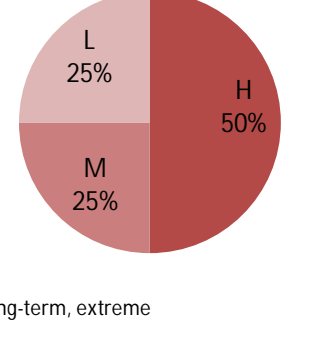
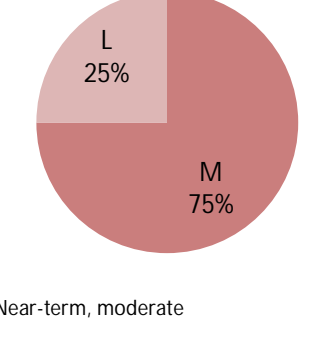
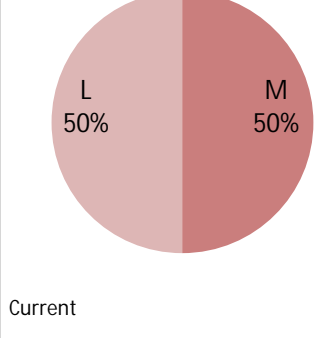
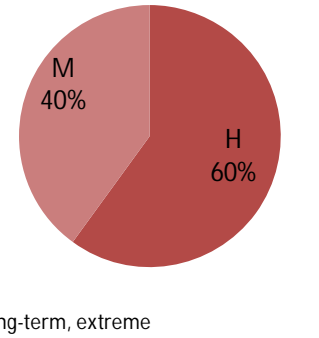
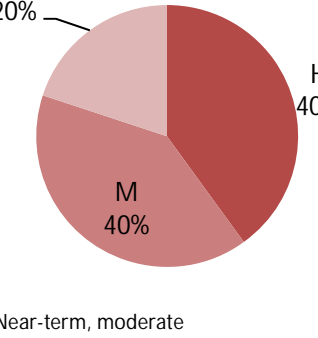
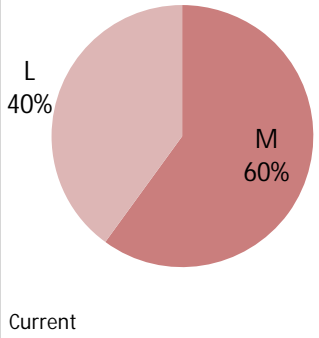
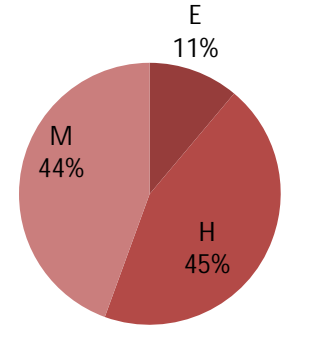
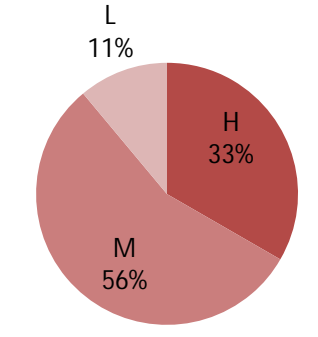
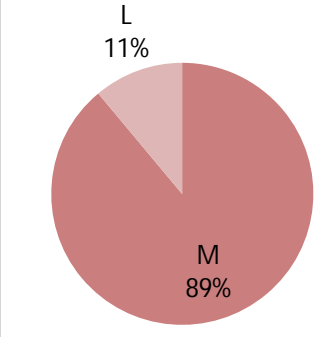
Risk Assessment Summary and Adaptation Themes

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

Theme	Relevant risk items (from register)	Total # risk items	Summary charts by climate scenario												Summary details			
			Current				Near-term, mod.				Long-term, extreme							
			E	H	M	L	E	H	M	L	E	H	M	L				
A.	Flooding of urban and built areas 1, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	14	1	6	7	1	5	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 1, 3, 6, 7, 8, 22, 24, 25, 27	9		4	5		3	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 4, 9, 10, 11, 14, 15, 15	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	Current			Near-term, mod.			Long-term, extreme			Summary charts by climate scenario	Summary details		
			E	H	M	L	E	H	M	L	E			H	M
D.	The natural environment's response to temperature, rainfall and other climatic changes 5, 6, 7, 13, 17, 20, 22, 24, 26	9													<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>
E.	Protecting the region's heritage and community infrastructure, especially from storms 2, 4, 5, 14, 20	5													<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>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	Summary charts by climate scenario												Summary details		
			Current				Near-term, mod.				Long-term, extreme						
			E	H	M	L	E	H	M	L	E	H	M	L			
G.	Bushfire risk management	1, 3, 4, 5, 6, 7	6	4	2	3	3	2	2	2	2	2	2	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</p>	<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	1	1	1	1	1	1	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</p>	<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	1	1	1	1	<p>Current</p>	<p>Near-term, moderate</p>	<p>Long-term, extreme</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>	

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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