

# Climate Change Adaptation Plan: Preparing for and responding to climate risks in the City of Stirling

## 18 June 2013

This Climate Change Adaptation Plan has written in collaboration by the City of Stirling and Adaptive Futures.

Effort has been made to ensure that all content included in this report is correct and accurate at June 2013. For queries about this report and any other work occurring in the City of Stirling please don't hesitate to make contact:

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The City of Stirling adopted *Climate Change Adaptation Plan: Preparing for and responding to climate risks in the City of Stirling* on Tuesday 18 June 2013.

Adapt

# A Community Guide to the City of Stirling's Adaptation Plan

## Introduction

The City of Stirling has produced this Climate Change Adaptation Plan to begin assessing the potential impacts that projected climate change conditions could have on its essential services and operations. The main climatic changes likely to be of significance to the City are sea-level rise, increasing temperatures, reduced rainfall and infiltration, and increased frequency and intensity of storms.

Environmental impacts, built environment (infrastructure) and community impacts have been considered within this Adaptation Plan. These areas were chosen because they are most likely to affect the City's services and operations.

The City acknowledges that climate change planning is an important and long-term task and the development of this Adaptation Plan represents the first stage of many in helping the City build resilience.

After the City has increased its understanding and resilience around climate change it will be better placed to support its community with the challenges that it will face specifically in response to a changing climate.

## What's inside?



This summary provides an introduction to the City of Stirling's Climate Change Adaptation Plan. Key findings and results are summarised here. For further information, readers are directed to the full Adaptation Plan.

| impacts | natural | built | community |
|---|---|---|---|
| This table summarises key projected impacts to the natural environment, built environment and the community as a result of projected changes in climate. | **biodiversity**<br>Loss of biodiversity (including flora and fauna species such as the Carnaby's Black Cockatoo and the Graceful Sun Moth) | **buildings**<br>More severe storm damage, particularly from flooding | **social**<br>Indirect impacts, such as rising price of fuel, electricity and other services, exacerbate existing community vulnerabilities |
| | **bushland**<br>Drying of natural trees, increasing fuel loads | **assets**<br>Accelerated degradation of construction materials | **health**<br>Increase incidence of food and vector borne diseases and heat related illnesses |
| | **coasts**<br>Coastal erosion and decline in the condition of marine habitats | **infrastructure**<br>Increased run off from storm events resulting in overloading or failure of sewers and storm water systems | **values**<br>Community expectations and values challenged |

## Assessing the City's vulnerability to climate change

To help determine where the City is most vulnerable to climate change, a risk assessment was undertaken using research to-date about potential impacts from climate change and rating how much of a risk they are to City operations. Any risks that were rated medium or low did not require treatment (i.e. adaptation action) since the City already adequately manages them or are unlikely to impact upon the City's operations. The City will monitor and evaluate all of the risks identified in the risk assessment to help identify if additional action is required in the future.

The City considered the opportunities and challenges they would face when implementing each adaptation action. Some of the actions showed they face limited barriers while delivering multiple benefits to the community and the environment. The City can implement these types of actions readily. Other adaptation actions that may cost more to implement, or require partnerships between agencies to coordinate, or do not align to current community expectations, will mean more work is required before they can be implemented. By identifying these barriers to action, the City is now aware of what needs to be done before the adaptation action is undertaken. This supports forward planning meaning barriers are addressed so that adaptation takes effect before the risk occurs.

Representatives from relevant Business Units participated in the development of the Adaptation Plan. Climate Change Adaptation is a relatively new area for the City, so the participation of a cross-section of Council Officers on a Climate Change Adaptation Working Group helped raise awareness of the projected impacts and encouraged ownership of these issues across operations. This Adaptation Plan is the beginning of a resilience process that the City will continue, and involves sharing lessons learnt and improving the ability of the City to plan for and respond to the impacts of a changing climate. The science of climate change is always improving and this Adaptation Plan begins a learning process for the City and its community.

## Where is action required?

The outcomes of the climate change risk assessment and adaptation-planning process indicated that the City is already implementing many activities that will build its

resilience to climate change. For example, the Cities Water Smart Parks Initiative, which includes designing parks to reduce their watering requirements and a sophisticated control system that manages water use, ensures the City can efficiently respond to less rainfall. There are also policy documents being developed to address projected climate changes that will assist the City in its adaptation planning.

The outcomes of the risk assessment indicated that the City's risks are relatively low in comparison to other West Australian Local Governments that have worked on climate change adaptation. In the shorter term which is based around the year 2030, no 'extreme priority risks' and ten 'high priority risks' were identified. In the longer term, which is based around the year 2070, the effectiveness of existing controls (put in place by the City) is less certain due to uncertainties in the projected climate changes and difficulties in predicting how the City's operations will be affected. Therefore, the number of high and extreme risks increased for this period. The impacts from climate change are expected to deliver challenges for the City which will require additional resources, training, collaborative partnerships and uptake of new technologies. The adaptation planning process also highlighted some opportunities from the projected climate changes.

One such opportunity is an increase in tourism along the coastal strip as a result of prolonged warm seasons.

The following tables summarise short term (to be implemented in the next financial year) and medium term (to be implemented within four years) adaptation actions that were identified through the adaptation planning process. The complete Risk and Adaptation Register can be viewed in Annex 3.

## Strategic Community Plan

The adaptation actions identified in the risk assessment and adaptation-planning process help support the City meet the objectives of its Strategic Community Plan.

1. Liveable City and Thriving Neighbourhoods

Adaptation actions reflect the City's vision for beautiful streetscapes and green open spaces whilst also appreciating the challenge of maintaining such a vision under a changing climate. Strategies to improve emergency response to extreme events will contribute to a Safe City; while actions to maintain outdoor and indoor recreation areas will contribute to an Active City.

2. Sustainable Environment

Adaptation actions to maintain biodiversity despite a changing climate will be critical in ensuring long-term sustainability of the biodiversity values valued by the City.

3. Engaged Communities

Many of the programs currently delivered by the City will continue to play an important role in ensuring community vulnerability is effectively monitored and managed.

4. Accessible and Connected City

The City's Local Housing Strategy is being used to guide the development of planning documents, such as Local Area Plans. In addition to the Strategy, adaptation actions to improve accessibility, specifically in the coastal zone, have been identified.

5. Prosperous City

Implementing planning and development actions that enhance the tourist potential along West Coast Drive will support achievement of the vision for a Prosperous City.

| short term | risk | actions | risk 2030 | risk 2070 |
|---|---|---|---|---|
| In this table, the adaptation actions that will be implemented in the short term (within next financial year) are outlined. They are presented next to the risk that the action is intended to address as well as the risk priority level that was assigned during the risk assessment and adaptation planning process.<br><br>The level of risk was assessed at two future timeframes, 2030 and 2070. H indicates a high risk priority, M indicates a medium level risk priority. This risk priority level provides the City with insight into the priority of risk treatment. | Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | Review and report on the feasibility of altering timing of recreation use changes between seasons to avoid exposure to extreme heat | H | H |
| | Increase in heat island effect in built up areas | Undertake aerial imagery assessment of the City; and<br><br>Conduct a flyover to determine the baseline per cent (%) vegetation cover of the total City area. Subsequently, set annual targets for increase in urban tree establishment | M | H |
| | Loss and damage to street trees | Review and incorporate climate change projections in review of the Street Tree Policy | M | H |

## Conclusion

In summary, the risk assessment and adaptation planning process the City has undertaken indicates that it is well placed to respond to the impacts of climate change. The wealth of knowledge generated through existing management activities (such as coastal monitoring programs) and other programs in place sets a foundation for proactive management within the City. In combination with the detailed Adaptation Plan and the expertise gained through cross-Business Unit collaboration in climate change risk management, the City can respond adaptively to changes in climate, ensuring maintained service delivery and more importantly working towards the achievement of Community objectives.

# medium term

In this table, the adaptation actions that will be implemented in the medium term (within the next four years) are outlined. They are presented next to the risk that the action is intended to address as well as the risk priority level that was assigned during the risk assessment and adaptation planning process.

The level of risk was assessed at two future timeframes, 2030 and 2070. H indicates a high risk priority, M indicates a medium level risk priority. This risk priority level provides the City with insight into the priority of risk treatment.

| risk | action | risk 2030 | risk 2070 |
|---|---|---|---|
| Exceedance of drainage capacity | Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall and Runoff (ARR) guidelines in 2014 | H | H |
| Increased number of emergency response and recovery operations in response to floods and storm events | Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans | H | H |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | Investigate and report on improvements to irrigation technology; and<br>Implement soil conditioning for water retention | H | H |
| Increase in geographical range and/or incidence of vector-borne and water-borne diseases | Increase monitoring range and occurrence of vector borne/water borne diseases; and Develop a plan to respond to changes in vector-borne disease | H | H |
| Higher rates of building damage and deterioration (focus on council owned buildings) | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | M | H |
| Interruption of road traffic from extreme weather events and emergency transport routes disrupted | Include related risk (i.e. interruption of road traffic and emergency transport routes during extreme events) into reviews of emergency management plans; | M | H |
| Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies); and deliver community awareness campaign to raise awareness of projected risks | M | H |

## medium term

In this table, the additional adaptation actions that will be implemented in the medium term (within the next four years) are presented.

| risk | action | risk 2030 | risk 2070 |
|---|---|---|---|
| Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake; and Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report | M | H |
| Opportunity: The City has access to a wide range of spatial information, which if compiled within its central management system, would provide a useful tool to support risk assessment and adaptation planning | Investigate and compile a list of climate change adaptation data (natural environment and community) that is available within the City in various formats (Excel spread sheet, hard copy) and determine if it would be beneficial to future adaptation planning processes to convert some or all of these data into a spatial format to assist with vulnerability mapping and corporate knowledge of potential climate change impacts. | H | H |

Please note: Detailed descriptions of the methods adopted, scenario selection and other technical aspects of the study are presented in supplementary documents (Annex 1 to 3) to the Adaptation Plan.

## Contents

# 1 Introduction

Climate change represents a significant challenge for local governments, who will be at the forefront of managing the local response to its impacts. Climate change has the potential to directly (i.e. storm impact) and indirectly (i.e. policy changes at national levels) effect service provision. Local Governments need to prepare for climate change to protect assets, adapt to localised conditions and also to be part of the global solution (WALGA 2012).

This Climate Change Adaptation Plan (the 'Adaptation Plan') was developed in response to the recognised need by the City of Stirling (the City) to adopt a proactive and measured approach to respond to climate impacts. Through implementing the Adaptation Plan, the City will be supported to address climate risks, informed by an understanding of projected climate changes and associated impacts on the City's operations and the community.

## 1.1 Why an Adaptation Plan?

Local governments are the primary service providers for the community, responsible for many areas including planning (development assessment and land use planning), building regulation and environmental health. Climate change impacts may affect a broad range of services, from managing storm impacts on buildings, street trees and drainage; to ensuring the sustainability and longevity of coastal zones through proactive planning that takes account of projected changes in mean sea level. Planning for such activities ensures that local government can monitor change over time and take action to respond. This may involve establishing partnerships, working across borders and building capacity.

To develop the Adaptation Plan, a risk-based approach to climate change management was applied (Annex 2). A risk-based approach aids decision-making under uncertainty and has been widely adopted by Local Governments within Western Australia and nationally. The Australian Federal Government in their publication, *Climate Change Impacts and Risk Management: A guide for business and local government*, apply a risk-based approach.

The Adaptation Plan outlines strategies to respond to priority climate risks (Table 3), based on a consideration of projected changes in climate. The Adaptation Plan is a living document that establishes a foundation for regular review and performance assessment as new information comes to hand and/or circumstances change. Regular review and assessment is a critical element of adaptation, facilitating adaptive management of climate risks at the local scale.

## 1.2 Adaptation Plan Structure

The Adaptation Plan outlines the initial adaptive strategies identified through the City's first climate change risk assessment and adaptation workshop. The strategies will support continued adaptive action by the City in preparation for climate change. The plan is structured by theme, including: social environment, built environment, parks and recreation, natural environment and emergency management. The following is included within each theme (Figure 1):

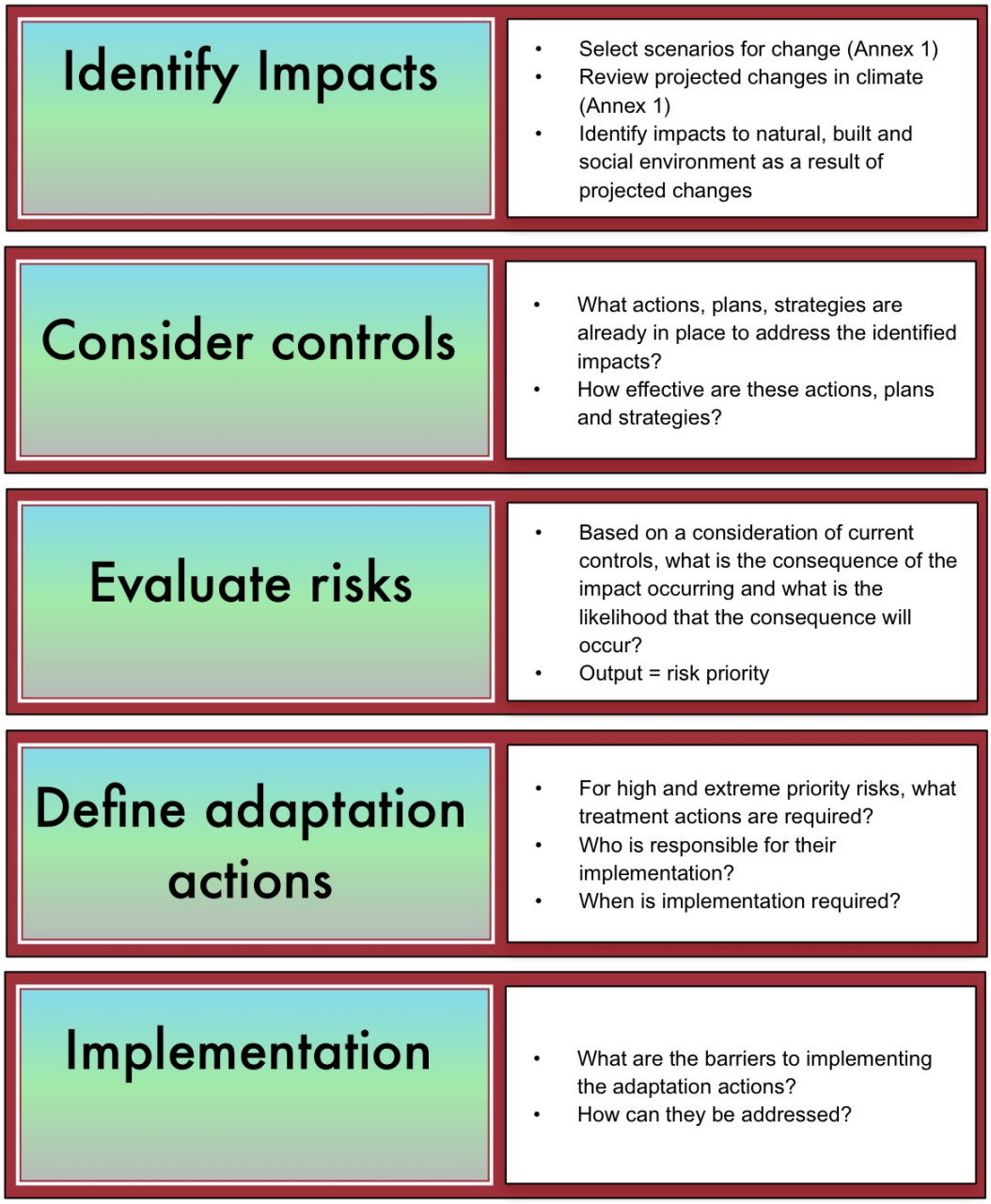



Figure 1: Steps in risk assessment and adaptation planning.

- Projected climate impacts
- Existing controls
- Priority risks
- Adaptation treatment options
- Barriers to implementation; and
- Implementation timeframes.

The themed approach aids the description of adaptive priorities in a way that is consistent with the City of Stirling's business structures; however, climate impacts will not occur in isolation. Direct and indirect impacts will occur across themed areas; for example, impacts to the natural and built environment will result in impacts to social environment. These relationships were considered in the plan's formulation and have informed the development of adaptation strategies.

## 1.3 Supporting Documentation

The Adaptation Plan is structured to deliver a concise summary of the priority risks and the recommended adaptation strategies that will reduce or treat the risks to a satisfactory level. Please refer to Annex 1 to 3 to obtain further important information about the methods adopted during the adaptation planning process, such as:

- How the climate has changed to date and projections for change in the future (Annex 1)
- The approach adopted to complete the risk assessment and adaptation planning (Annex 2)
- The full Adaptation and Risk Register, which contains all outputs of the Adaptation Planning workshop (Annex 3)

## 1.4 Adaptive Priorities for the City

The following table outlines actions to enable the City to respond to priority climate risks based on a consideration of projected changes in climate.

Table 1: Adaptation actions to address priority risks, by timeframe for implementation

| Risk Description | Adaptation Action | Lead Business Unit |
|---|---|---|
| **SHORT (within next financial year)** | | |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space, sports grounds and closure of ovals | Review and report on the feasibility of altering timing of recreation use changes between seasons to avoid exposure to extreme heat | Manager Recreation & Leisure Services |
| Increase in heat island effect in built up areas | Undertake aerial imagery assessment of the City of Stirling | Manager Parks & Reserves |
| | Conduct a flyover to determine the baseline per cent (%) vegetation cover of the total City area. Subsequently, set annual targets for increase in urban tree establishment. | Manager Parks & Reserves |
| Loss and damage to street trees | Review and incorporate climate change projections in review of the Street Tree Policy | Manager Parks & Reserves |
| **MEDIUM (within 4 years)** | | |
| Exceedance of drainage capacity | Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall and Runoff (ARR) guidelines in 2014 | Engineering Design |
| Increased number of emergency response and recovery operations in response to floods and storm events | Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans | Coordinator Emergency Management |
| Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | Managed retreat for Watermans Bay (infra-structure protection as determined by coastal sediment transport study and sand bag trial) | Manager Parks & Reserves |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | Investigate and report on improvements to irrigation technology | Manager Parks & Reserves |
| | Implement soil conditioning for water retention | Manager Parks & Reserves |
| Increase in geographical range and/or incidence of vector-borne and water-borne diseases | Increase monitoring range and occurrence of vector borne/water borne diseases | Manager Health & Compliance |
| | Develop a plan to respond to changes in vector-borne disease | Manager Health & Compliance |
| Higher rates of building damage and deterioration (focus on council owned buildings) | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | Manager City Buildings |
| Interruption of road traffic from extreme weather events and emergency transport routes disrupted | Include related risk (i.e. interruption of road traffic and emergency transport routes during extreme events) into reviews of emergency management plans | Coordinator Emergency Management |
| Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies) | Manager Engineering Design |
| | Deliver community education/awareness campaign to raise awareness of projected risks including loss of existing public space in coastal and estuarine areas and loss of coastal and estuarine recreational infrastructure | Manager Parks & Reserves |

| Risk Description | Adaptation Action | Lead Business Unit |
|---|---|---|
| Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake | Manager Parks & Reserves |
| | Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report | Manager Parks & Reserves |
| OPPORTUNITY: The City has access to a wide range of spatial information, which if compiled within its central management system, would provide a useful tool to support risk assessment and adaptation planning | Investigate and compile a list of climate change adaptation data (natural environment and community) that is available within the City in various formats (Excel spread sheet, hard copy) and determine if it would be beneficial to future adaptation planning processes to convert some or all of these data into a spatial format to assist with vulnerability mapping and corporate knowledge of potential climate change impacts. | City Buildings |
| **LONG (within 10 years)** | | |
| Erosion and/or exceedance of seawalls, jetties and other coastal defences | Asset planning to consider projections for change in climate and associated risks to erosion and/or exceedance of seawalls, jetties and other coastal defences | Engineering Operations |
| | Implement new measures noted in asset plans | Engineering Operations |
| | Remove non-essential vulnerable infrastructure from areas exposed to the impacts of erosion and inundation | Manager Parks and Reserves |
| Erosion and/or inundation in the coastal zone leading to damage to infrastructure (both private and council owned) situated in close proximity to the coast | Investigate and report on opportunities to change planning requirements e.g. limit infill development/ change setbacks/ change zoning | Planning & Development, with technical support from Engineering Design to determine appropriate set backs |
| Ground water bores increasingly saline | Investigate the feasibility of aquifer recharge to reduce salinization of ground water (the focus is on bore aquifer not drinking water) | Manager Parks & Reserves |
| | Investigate the feasibility of wet and dry detention basins as tools to reduce salinization of groundwater | Manager Parks & Reserves Manager Engineering & Design |
| | Implement waste water treatment and re-use in key precincts | Manager Parks & Reserves Manager City Planning |
| Inundation and/or erosion of roads in coastal areas | Undertake an integrated planning and engineering assessment of west coast drive and its future sustainability | Manager Parks & Reserves |
| Exceedance of drainage capacity | Implement drainage system improvements based upon catchment analysis program | Engineering Operations |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | Implement alternative surface coverings - e.g. more climate resilient species and reduced turf areas | Manager Parks & Reserves |
| | Set targets and a work plan to increase the number of indoor recreation areas within the City. There are six existing indoor facilities in the City. Construction new recreational areas would occur in the long term. | Manager Recreation & Leisure Services |
| Opportunity: Tourist numbers increase due to extended periods of warm weather providing more opportunities for coastal recreation | Undertake activities to improve the connectivity of business and services along the coastal drive. Increased shade structures and recreational areas | Manager Economic Development and Urban Regeneration |
| | Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area | Manager City Planning and Manager, Engineering Design |

| Risk Description | Adaptation Action | Lead Business Unit |
|---|---|---|
| Increase in geographical range and/or incidence of vector-borne and water-borne diseases | Implement education campaigns to raise awareness to mitigate the risk of vector-borne disease | Manager Health & Compliance |
| | Implement the plan to respond to changes in vector borne disease | Manager Health & Compliance |
| Change in building heating/cooling costs (can be either negative or positive) for council owned buildings | Monitor developments in building codes and best practice and adjust council building design standards accordingly | Planning Approvals and City Buildings Operations |
| Reduced resilience and increased costs for infrastructure (council owned) in regards to water use for buildings | Investigate the feasibility of policy changes that will increase the resilience and cost effectiveness of infrastructure (council owned) in regards to water use | Corporate |
| Increase in heat island effect in built up areas | Increase the number of shaded structures available in public spaces. | Manager Parks & Reserves |
| Loss and damage to street trees | Implement new measures developed in consideration of climate change as identified through the updated Street Tree Policy and research being conducted through street tree trials | Manager Parks & Reserves |
| Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | Mettams Pool, north - implement protective structures | Manager Parks and Reserves |
| Shift in distributions of plant and animal species; Increased risk of population extinctions; Ecological disturbances and reduced ecosystem resilience to stress; Change in distribution of invasive plant and animal species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity | Remove threats and disturbances as outlined in the Local Biodiversity Strategy | Manager Parks & Reserves |
| | Undertake land use planning and on-ground conservation measures | Manager Parks & Reserves Manager City Planning as support |
| | Implement natural and assisted regeneration through on ground conservation measures (monitoring, corridor planning and implementation) | Manager Parks & Reserves |
| Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | Aquifer recharge, shallow water recharge: Investigate opportunities to increase aquifer recharge. | Manager Parks & Reserves |
| Decline in outdoor working conditions leading to increased incidence of OSH issues for staff working outdoors - Rangers; Eng. Ops etc. | Investigate and report on the feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures | Manager Human Resources |
| | Implement active measures identified through the outdoor staff heat avoidance assessment | Manager Human Resources |

# 2 Context

## 2.1 The City and Adaptation

The City of Stirling (the City) is the largest local government in Western Australia, based on population. Geographically, the region has boundaries with the ocean to the west, the Cities of Joondalup and Wanneroo in the north, the Cities of Swan and Bayswater in the east, and the Towns of Vincent and Cambridge in the south. The coastal environment is characterised by a combination of rocky and sandy shores and includes renowned tourist beaches, Scarborough Beach, Watermans Bay, and Trigg Beach. Numerous local parks and reserves are located within the region, both in coastal and inland areas, including Star Swamp Bushland Reserve, Trigg Bushland Reserve, and Herdsman Lake.

The City has experienced moderate population growth over the last twenty five years, primarily as a result of residual greenfield opportunities and increasing redevelopment, offset by a decline in average household size as more areas are dominated by smaller households (City of Stirling 2008). The population is likely to continue to increase in the future as a result of continued growth in housing stock and a comparatively stable average household size (City of Stirling 2008). By the year 2031, population is projected to reach 232,446 residents, a 19 per cent increase from 2012.

The potential impacts of climate change will be overlaid upon existing social and environmental conditions, in which population growth, finite resources and change in global financial markets place pressure on managers to ensure high levels of service provision despite changing circumstances. The City has demonstrated foresight in a range of areas including its Water Smart Parks initiative, Local Housing Strategy and Oil Risk Strategy. These initiatives position the City to respond proactively to changes in social and environmental conditions.

Demonstrative of this foresight, the City made a commitment in its Strategic Plan 2009-2012 to address the potential impacts of climate change (Strategic Initiative 2.2.1: *Develop and implement a climate change adaptation strategy, action plan and community education program*). Completion of this Adaptation Plan in parallel with the transition to an Integrated Strategic Planning Framework, positions the City to proactively respond to climate risks – and to continue its best practice approach to service delivery for the Stirling community.

## 2.2 A Changing Climate

Over the past century, Perth has experienced a rise in mean annual temperature of approximately 0.8 degrees and significant declines in mean annual rainfall. These trends are consistent with projected changes of a warming and drying climate in the Perth metropolitan region. In addition, mean sea levels along the Western Australian coast have been rising at almost double the global average (Steffen and Hughes 2010).

## 2.3 Projections for Change

The climatic changes considered to be of significance to the City, with respect to its primary role of service delivery to the community, are sea-level rise, increasing temperature, reduced rainfall

and infiltration, and increased intensity of storms. Scenarios for change by 2030 and 2070 are summarised in Figure 2, which indicates a continued rise in mean annual temperature, declines in annual rainfall leading to significant decrease in annual water runoff, and an increase in the projected intensity of extreme events such as storms (refer to Annex 1 for full details).

The changes in climate may deliver a number of changes and associated challenges to the City. The anticipated challenges, and strategies to address them, are outlined in the remainder of this document. However, it is important to note that climate change science is continuously improving and the City will review both the science and the risks associated with projected impacts at regular intervals.

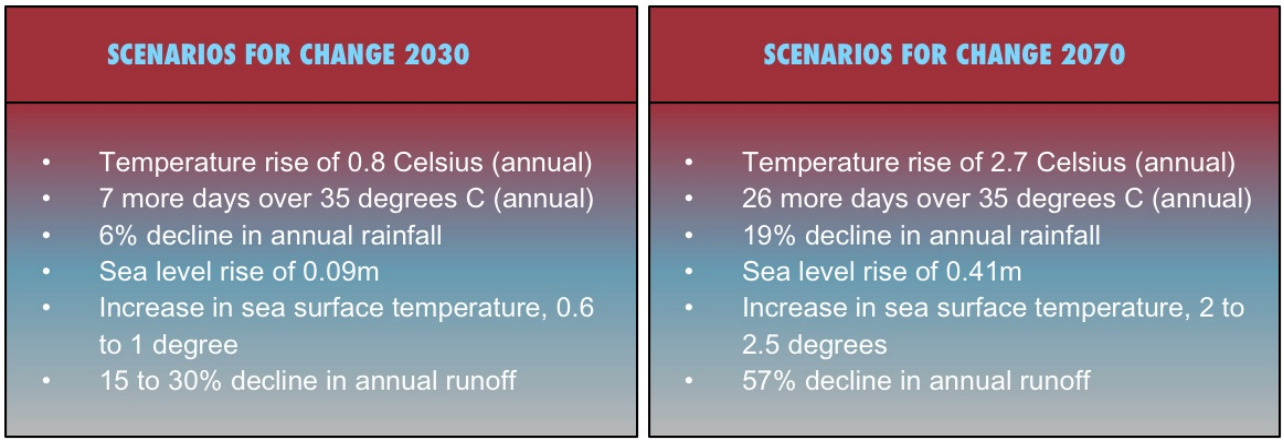



Figure 2: Projected changes in climate for 2030 and 2070 (modified from BOM/CSIRO 2007).

# 3 Social Environment

The social environment includes those residing within the City of Stirling and the City of Stirling's workforce. In this section you will find: (i) potential climate impacts to the Stirling community and workforce; (ii) the controls in place that build community resilience; (iii) priority risks; (iv) adaptation treatments to respond to priority risks; and (v) barriers to implementing adaptive treatments and timeframes for their implementation.

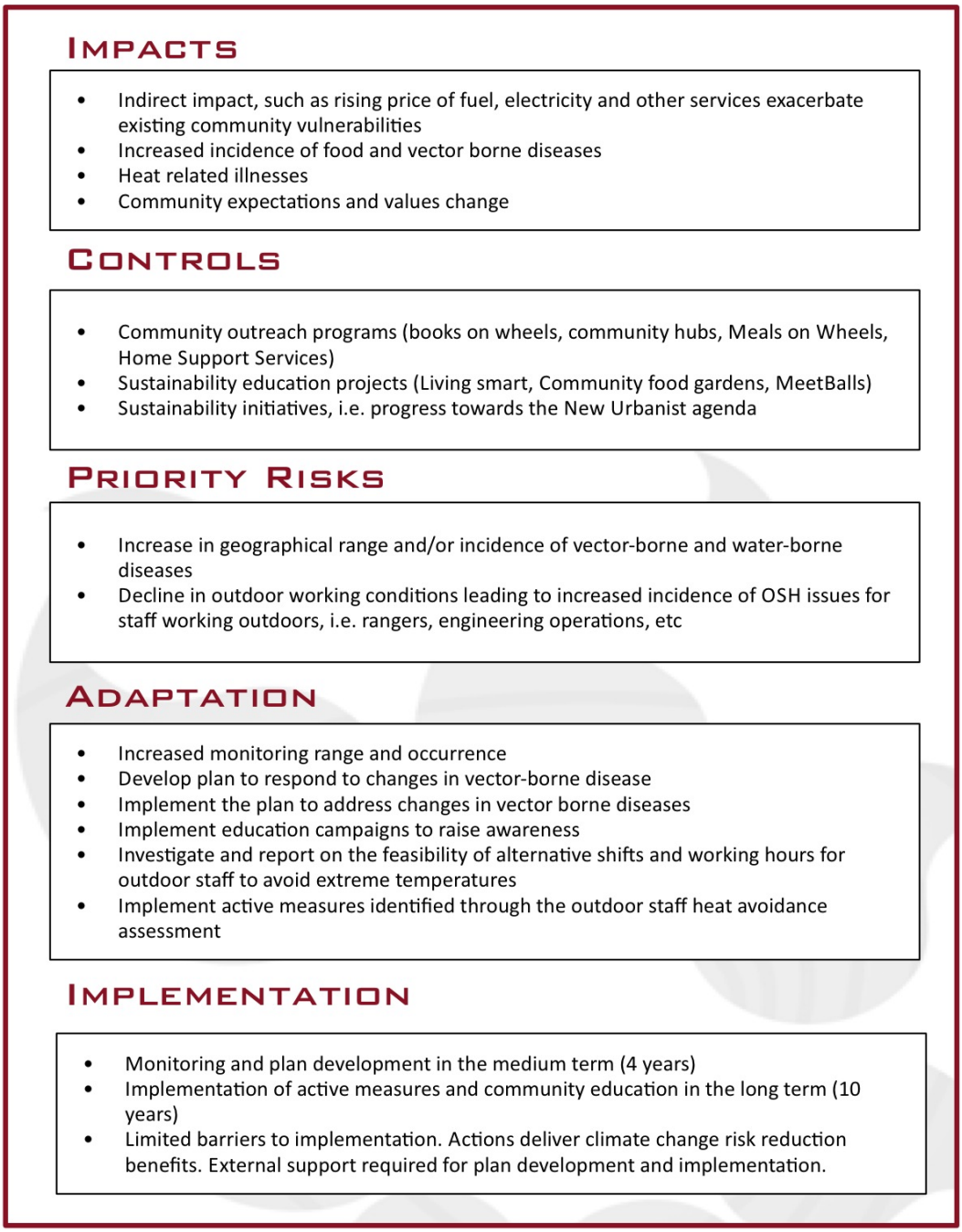



Figure 3: Summary of the impacts, controls, risks and adaptive priorities for the social environment

## 3.1 Potential Impacts to the City of Stirling Community

Changes in climate may deliver a range of impacts to the community, from direct impacts on human health that result from an increase in extreme heat events, to indirect impacts such as security of access and rising cost of water and electricity (VLGA 2009). These impacts will affect the community in different ways, with aged and low-socio-economic households most vulnerable to climate impacts.

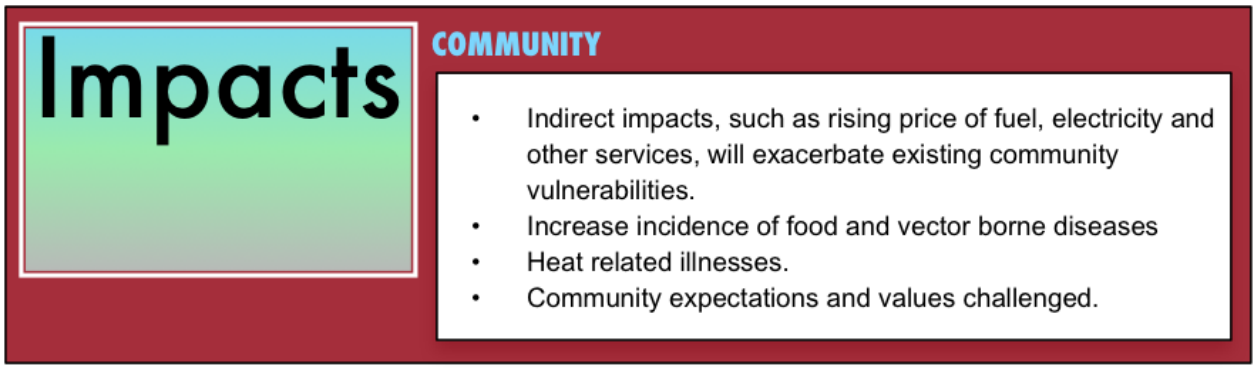
The City houses a higher proportion of aged residents, low-income households and non-English speaking residents than greater metropolitan Perth, and therefore contains a large proportion of households vulnerable to the direct and indirect impacts of climate change. Older people with reduced physical capacity are likely to experience higher levels of vulnerability to the impacts of extreme events. In addition, the social isolation of some aged residents can lead to a lack of access to information on emergency response measures and limited assistance from neighbours. Those in rental accommodation are also more limited in the strategies they can take to adapt, for example, through improving insulation or installing grey water systems.

Changes associated with moving to a low carbon economy and decline in the availability of resources, such as freshwater, may require communities to change their thinking about resource use, and the provision and maintenance of public facilities. For example, changes to more frequent use of native vegetation in landscaped and public areas to reduce water demand may challenge community expectations and values.

The projected changes in climate may also present increased health risks for vulnerable groups, particularly children and the elderly, including an increase in heat related deaths and increase in the annual rates of Ross River virus disease and other food-borne and water-borne diseases (Hennessy et al. 2007).

## 3.2 Potential Impacts to the City of Stirling's Workforce

Projected changes in climate, including rising mean annual temperatures and a higher number of extreme heat days (Annex 1), may negatively impact the City's workforce. A large number of the City's workforce spend a proportion of their working hours outdoors and consequently will be increasingly exposed to heat related illnesses. This could lead to reduced productivity and impacts upon service delivery, particularly in the service sectors of waste and environmental management.




## 3.3 Controls in Place to Build Resilience to the Community

The City currently provides a number of services that build community resilience. Support services are delivered to eligible residents. Workshops and events are also held that engage and connect the community while providing information about sustainability initiatives and the potential to adopt lifestyle choices that reduce impacts on the natural environment.

Systems are in place to monitor residents at home at a level that reflects their social networks and support; and the City plays a role in the delivery of services to seniors (such as Meals on Wheels; Home Support Services), in partnership with other Agencies.

Sustainability education projects, such as energy conservation workshops, community food gardens, waste recycling activities and the Living Smart program also provide mechanisms to bring the community together. The City is also taking action to build community networks through initiatives such as Adopt-a-Park; Follow My Lead; and proposed MeetBalls; as well as initiatives such as 'Going Green' (a sustainability initiative to improve water, power and water efficiency for clubhouses) and planning for tri-generation energy at aquatic centres. Such initiatives contribute to reduction in climate vulnerability and increase long-term sustainability.

Increasing the integration of transport and land-use, improving the pedestrian environment, reducing car dependent urban sprawl and increasing the role of alternative transport are long-term measures that deliver sustainability benefits and contribute to improvements in human well-being. The City's Local Housing Strategy outlines a recommended approach to providing mixed-use affordable housing. Smaller dwellings and sustainable design would reduce the need for electricity use and associated costs for air conditioning and heating. The Strategy has been adopted by Council and is being used to guide the development of planning documents, such as Local Area Plans. A Local Housing Strategy Implementation Plan is going to be developed to assist with uptake of these principles.

## 3.4 High Risks to the Community

Despite the existing community support programs and sustainability initiatives being delivered across the City, the risk assessment process identified climate change impacts that pose risks

to the City of Stirling's community that are likely to require additional services from Council. The priority risks identified were (Table 2):

- Increase in the geographical range and/or incidence of vector borne and water borne diseases; and
- Decline in outdoor working conditions leading to increased Occupational Safety and Health (OSH) issues.

The City contains a number of open water bodies that may harbour vector-borne hosts for diseases such as Ross River Virus. Rising temperature combined with decline in rainfall suggest that this issue will be a management challenge for the City's Health Services unit, particularly given the limited exposure to the risk to date. Continuing the testing that is regularly undertaken at two sites within the City will be important to monitor changes in the occurrence of vector-borne hosts.

Table 2: Priority risks to community health and well-being

| Risk ID | Description | 2030 | 2070 |
|---|---|---|---|
| 38 | Increase in geographical range and/or incidence of vector-borne and water-borne diseases | H | H |
| 47 | Decline in outdoor working conditions leading to increased incidence of OSH issues for staff working outdoors, i.e. Rangers; Engineering Operations etc. | M | H |

Further, in the longer term, managing health and safety risks, a productive outdoor workforce and effective service delivery may be challenging given the projected increase in the number of extreme heat days. Current mechanisms in place (i.e. provision of protective requirement, OSH training procedures and alternate shifts for staff during summer months) are adequate to manage the risk in the medium term; however, in the longer term (2070), additional measures may be required.

The City will be expected to play a critical role in addressing social vulnerability. While the existing mechanisms in place to respond to social vulnerabilities (including home support services and outreach programs) are sufficiently flexible to adjust to changing conditions; there will be a requirement to monitor capacity for service delivery to ensure a proactive approach to vulnerability reduction. For example, as the population profile changes (particularly in relation to an ageing population), additional actions may be required to enhance flexibility and capacity for service delivery.

## 3.5 Adaptation Treatments Identified for the Community

Four adaptive actions were identified to manage the risk of increased incidence of vector-borne or water-borne disease; including monitoring, awareness raising, plan development and implementation (Table 3).

To manage OSH risks associated with extreme temperatures in the long term, a study investigating feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures should be undertaken. In addition, increased monitoring of vector-borne diseases and awareness raising activities will reduce the City's risk exposure.

In addition, existing community outreach programs (such as 'Books on Wheels') are recommended for use to raise awareness about

the relevant risks from climate change to the aged and disadvantaged sections of the Stirling community. In addition, the provision of community 'hubs' to bring residents together to interact, learn and be engaged may also provide useful settings to raise awareness of relevant climate risks.

Table 3: Adaptation strategies to address priority risks to the social environment

| Risk Description | Action ID # | Risk Treatment Actions | Lead Business Unit | Timeframe |
|---|---|---|---|---|
| Increase in geographical range and/or incidence of vector-borne and water-borne diseases | **19** | Increase monitoring range and occurrence of vector borne/water borne diseases | Manager Health & Compliance | Medium |
| | **20** | Develop a plan to respond to changes in vector-borne disease | Manager Health & Compliance | Medium |
| | **21** | Implement education campaigns to raise awareness to mitigate the risk of vector-borne disease | Manager Health & Compliance | Long |
| | **22** | Implement the plan to respond to changes in vector borne disease | Manager Health & Compliance | Long |
| Decline in outdoor working conditions leading to increased incidence of OSH issues for staff working outdoors - Rangers; Eng. Ops etc. | **43** | Investigate and report on the feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures | Manager Human Resources | Long |
| | **44** | Implement active measures identified through the outdoor staff heat avoidance assessment | Manager Human Resources | Long |

## 3.6 Barriers and Timeframes for Implementation of Community Adaptation Actions

The City considered implementing adaptation measures against budgetary, community, and environmental pressures (Table 4). This process identified that there are minimal barriers to implement the adaptive actions that treat risks to the social environment. Budget was not considered a significant constraint, with all actions potentially covered through internal financing. The actions were also perceived to align to community values.

City staff currently have the capacity to implement the identified adaptive actions; however, external support would be required to undertake increased levels of monitoring and evaluation, planning and implementation. Consequently, capacity requirements should be regularly monitored to ensure adequate resourcing as circumstances change. The highest barrier to implementation is 'No regrets'. 'No regrets' indicates the extent to which an adaptive action provides opportunities or benefits regardless of the degree of climate change experienced. Simply put, even if the climate change impacts are not realised, implementing the adaptation actions would still be beneficial to the City's community. This suggests

that the adaptive actions deliver climate change benefits, with additional development benefits confined only to the action of *raising community awareness of vector and water-borne diseases*.

No actions are required for implementation within the immediate or short term. This is largely due to the effectiveness of the existing controls in place.

Table 4: Barrier analysis for adaptive actions that treat climate risks to the social environment

| Risk ID # | Risk Treatment Actions | No regrets | Community values | Environmental | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| **19** | Increase monitoring range and occurrence of vector borne/water borne diseases | | | | | | |
| **20** | Develop a plan to respond to changes in vector-borne disease | | | | | | |
| **21** | Implement education campaigns to raise awareness to mitigate the risk of vector-borne disease | | | | | | |
| **22** | Implement the plan to respond to changes in vector borne disease | | | | | | |
| **43** | Investigate and report on the feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures | | | | | | |
| **44** | Implement active measures identified through the outdoor staff heat avoidance assessment | | | | | | |

Note: Refer to Annex 2 for full details on barrier analysis criteria. Green = no barrier; Yellow = moderate barrier; Pink = high barrier

# 4 Built Environment

Projected increases in temperature and the severity of extreme weather events are likely to impact public and private infrastructure. This section contains: (i) potential impacts to the built environment, including buildings and infrastructure; (ii) the controls in place that build resilience to buildings and infrastructure; (iii) the high risks identified; (iv) adaptation treatments to respond to priority risks; and (v) a summary of the barriers to implementing adaptive treatments and timeframes for the implementation.

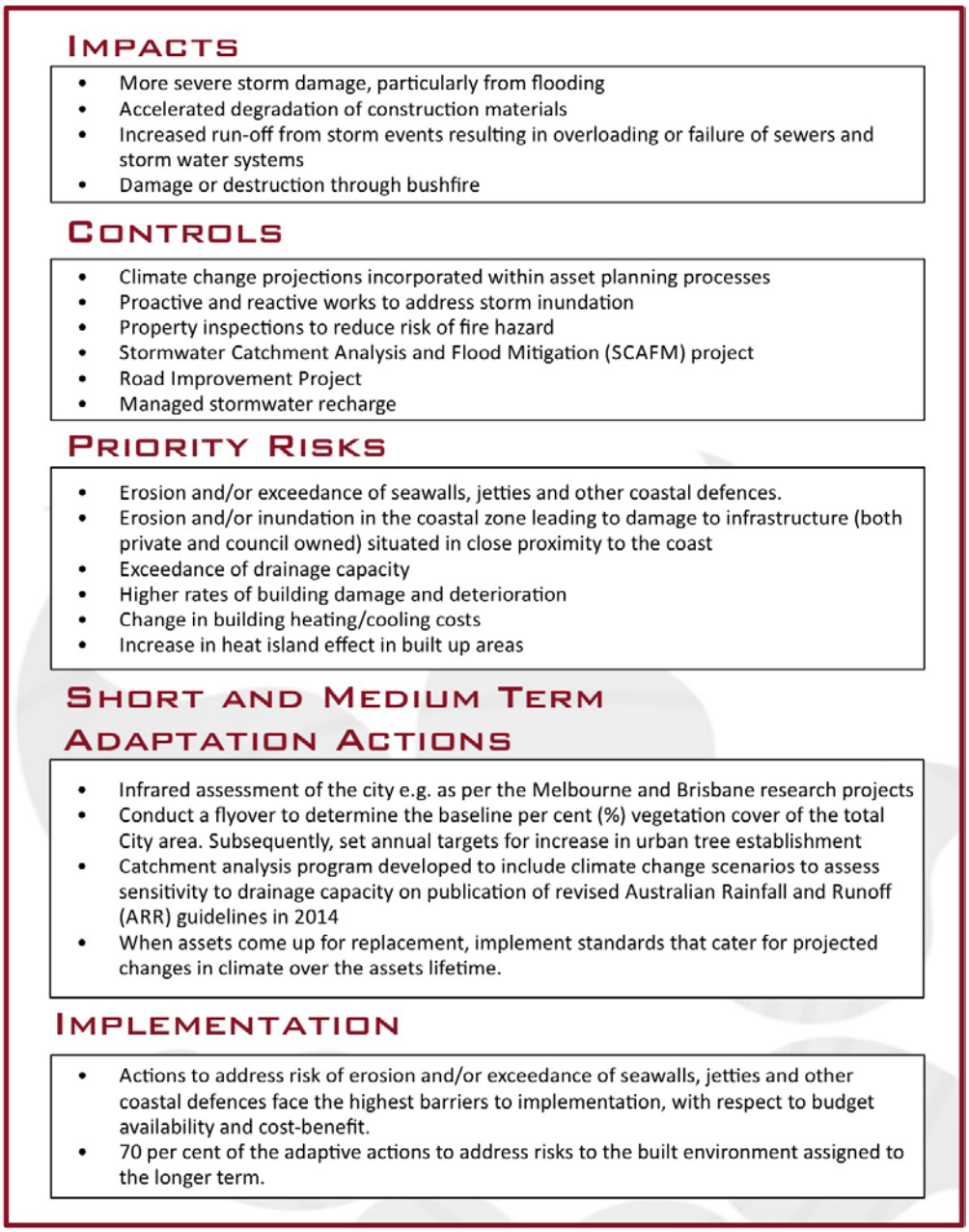



Figure 4: Summary of the impacts, controls, risks and adaptive priorities for the built environment

## 4.1 Potential Impacts to the Built Environment

Increased intensity in tropical cyclones in northern Western Australia is expected to have flow on impacts on local weather conditions in Perth and the City. BOM/CSIRO (2007) modelling suggests that potential changes in cyclone duration may mean they track further south, increasing associated extreme wind and rain events in these areas. Cyclonic wind and rain events could cause flooding and result in increased impacts on the coastal zone. Storms experienced in recent years have confirmed that the City's drainage and infrastructure is vulnerable to high intensity storm and rainfall events. In this section, impacts to the build environment are discussed in two parts: (i) impacts to buildings and (ii) impacts to infrastructure. Impacts to buildings include council, private and public buildings; while impacts to infrastructure include power, water, transport, sewerage, telecommunications, gas and waste management.

### 4.1.1 Impacts to Buildings

The impact of climate change on the built environment is a function of projected changes in key climate parameters as well as the characteristics of the building stock. In many instances, the characteristics of the building stock will play a larger role in vulnerability than projected changes in climate parameters (Figure 5). City buildings and community spaces may need to meet higher standards of thermal efficiency and consumption (water and electricity). This could have flow-on effects for the City in terms of costs to retrofit buildings or higher cost of construction and maintenance materials. In light of projected climate changes, revised planning and development approvals may need to be considered. Further, the impacts of climate change may indirectly expose the City to litigation and legal costs associated with planning decisions.

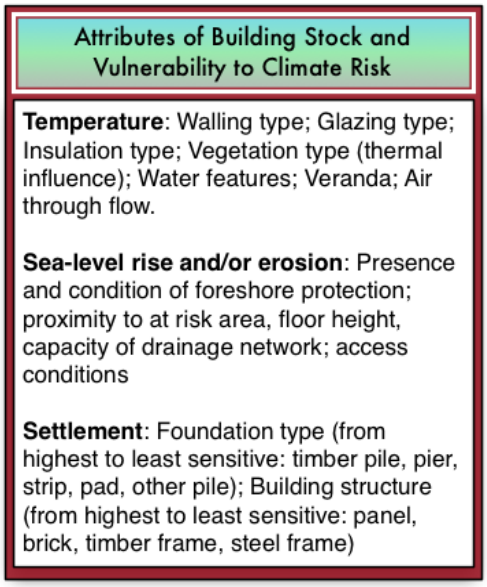



Figure 5: Attributes of buildings stock that influence vulnerability to climate risk

Coastal infrastructure may be impacted when storm surges combine with sea-level rise, resulting in temporary inundation of the coastal zone (CSIRO 2006). Further, increased coastal erosion may threaten private and public buildings located in close proximity to the coastal margin.

### 4.1.2 Impacts to infrastructure

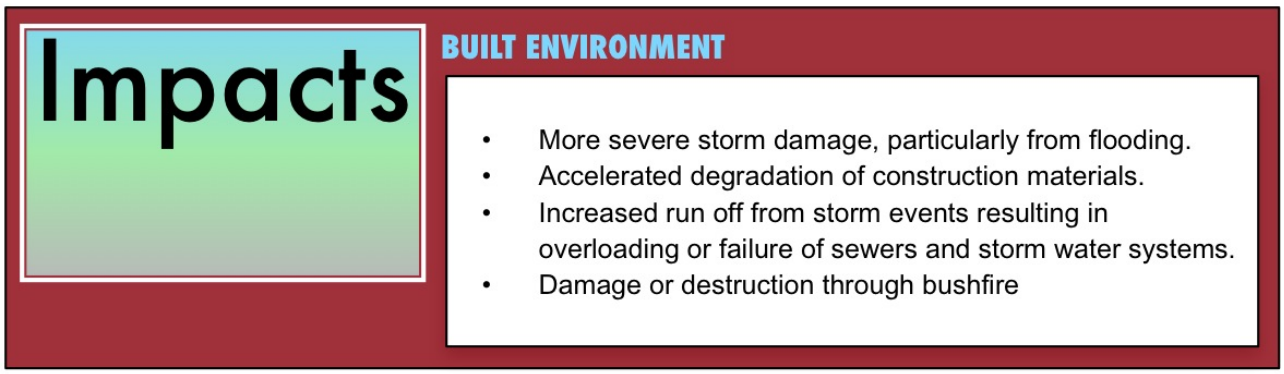
Water and electricity mains (particularly pipelines and overhead cables) are likely to be at high risk of damage from storms, flooding and/or fire. In addition, projected increase in the occurrence of extreme temperatures may reduce the life of asphalt on road surfaces and cause accelerated degradation of materials. Increased ground movement and changes in groundwater may also impact the foundations of transport infrastructure

(CSIRO 2006). While responsibility for managing impacts to transport infrastructure does not lie with the City, the City works in partnership with the Department of Transport to ensure continuity of service. Such partnerships will continue to be important into the future. Increased temperature also causes additional stresses to the steel in bridges and rail tracks through expansion and contraction (CSIRO 2006). Damage to infrastructure from extreme weather events such as flooding or bushfires would also be exacerbated.

The City of Stirling is responsible for maintaining drainage within its jurisdiction. During storm events, when rain water levels exceed the capacity of the stormwater network, drains are designed to accommodate runoff overflows. These drains can be inactive for large periods of time. When active, the effluent generated can be initially high in contaminants and contribute to elevated bacterial concentrations in nearshore coastal waters, impacting human health and the environment.

Projected declines in rainfall will result in reduced rates of groundwater recharge. In combination with increased reliance on groundwater resources for water supply, levels of saline intrusion into the groundwater aquifers may increase (Hassel 2010). In turn, the salinity of the water abstracted from groundwater bores will rise. Highly saline water can impact ecosystems. Therefore, while groundwater bores have been promoted as an alternate to potable supplies for garden watering in the Perth metropolitan region, as salinity increases, the adoption of bore water may reduce. This may place further pressure on potable freshwater resources.

In addition, waste collection and management issues could be exacerbated for the City due to projected increase in temperature and the occurrence of heat waves. Higher temperatures may give reason for more frequent rubbish collection to reduce impacts on community health and wellbeing.



## 4.2 Controls in Place that Build Resilience in the Built Environment

The City has a number of mechanisms in place that reduce exposure of the built environment to climate risks.

### 4.2.1 Buildings

Climate change projections are being incorporated within asset management planning processes. Climate change is one of the demand projections (in addition to population) adopted to project how the external world will impact service delivery. By projecting future changes in climate, assets can be planned to accommodate anticipated climate changes, thus reducing their exposure to climate impacts.

The City is working towards managing the life cycle of buildings (design/ development; maintain/ monitor/ review performance; lifecycle/ costs) so that strategic visioning and planning can occur. Such information is vital, not only in supporting forward planning, but also in providing access to up-to-date information on the characteristics of the built environment. This information can be adopted in future assessments of vulnerability to identify priority areas that (i) require retrofit or (ii) higher levels of monitoring, to reduce exposure to climate risks.

The City aims to develop an Energy Bureau to monitor and review building's performance. In addition, energy standards are being incorporated within the updated energy efficient legislation and energy efficiency information is available for the community on the City's website. The Energy Bureau will enable the City to monitor the energy performance of its own buildings. This may trigger planned improvements, such as thermal efficiency and other retrofitting activities, by the City.

The City is also undertaking proactive and reactive works to respond to storm inundation. Reactive stormwater drainage upgrades have commenced to address the impacts of major storm events experienced in the past three years. Three to four years of work has been scheduled to address private property flooding. Reports from storm events are evaluated to identify problem drains; the drains are then checked for blockages and drainage capacity is assessed.

### 4.2.2 Infrastructure

The existing controls in place to respond to impacts to infrastructure, such as power, water, transport, and gas, are outlined below.

The Stormwater Catchment Analysis and Flood Mitigation (SCAFM) Project is a proactive project implemented by the City to highlight capacity issues in drainage infrastructure. This project programs future drainage improvement activities and has been underway for two years.

A Road Improvement Project is underway to trial plantings and identify street trees that can tolerate heat stress conditions with low water requirements. Trees that perform well are incorporated in new capital projects to reduce the heat island effect. The heat island effect refers to the condition of higher temperatures in urban, densely developed areas comparative to areas that contain more green space. The heat island effect can result in increased summertime peak energy demand, higher air conditioning costs, air pollution and greenhouse gas emissions, and heat-related illness and mortality.

The City has budgeted (in the 2012/13 Budget) to commence micro-tunnelling from Scarborough Beach road to Scarborough Beach Reserve to address flooding. The works will increase the capacity of stormwater pipes; and stormwater will be piped to the Reserve into storage tanks, from which it will recharge into the aquifer. The works will be completed over a two-year period.

## 4.3 High Risks to the Built Environment Identified

The adaptation planning process highlighted erosion and inundation in the coastal zone as significant risks to the City's built environment (Table 5). It was recognised that the initial impacts will be on Council owned public assets and infrastructure due to the presence of existing foreshore reserves along the City of Stirling's coastal zone. The potential for long-term erosion and inundation impacts east of West Coast Drive were also considered; however it was recognised that this must be considered within the broader context of protection of West Coast Highway itself as a public asset. Consequently, the immediate threat was considered to be to council owned assets, including the dual use path and coastal recreational infrastructure (e.g. shade structures) (see Section 4.4 for further details).

Therefore, inundation or erosion of West Coast Drive was considered a priority risk for the City. While primary management responsibility for the road lies with the Department of Planning, responsibility for ongoing management of the recreation dual use path is vested with council. The importance of West Coast Drive in terms of transport flow, recreational amenity to the community and provision of access to abutting properties was recognised. Managing this risk will require ongoing partnerships between the Department of Transport and the City.

Waterman's Beach was identified as a priority area of concern due its history of chronic erosion. In contrast, a coastal vulnerability study completed at Scarborough beach confirmed its resilience to projected climate changes, as long as sediment supply, which is transported from the coast directly to the south of Scarborough beach, is maintained.

Drainage capacity has been exceeded in some areas within the City during extreme rainfall events over the last three years. This issue has been recognised and the City has enacted a program to strategically analyse all catchments at a high resolution (at the sub-catchment level, i.e. individual drains). However, this program, due to resourcing constraints, is scheduled for completion within eight years. Therefore, the risk level remains high given that the information that this analysis would yield will not be available for a period of time.

With respect to risks associated with building deterioration, damage or compliance (Table 5, Risk ID 4, 7), existing building designs were considered sufficient to cope with small changes in mean climate and the intensity of extreme events to 2030. However, the condition of these buildings is poorly understood with asset audits being out of date and resource capacity not being sufficient to answer questions regarding building age and maintenance requirements. In the longer term (to 2070), it was recognised that there may be a requirement to change designs. For example, guttering and rainwater runoff standards may not

be adequate for extreme rainfall events in the future, posing management and compliance risks to the City.

Table 5: Priority risks to the built environment

| Risk ID | Risk Description | Risk Level 2030 | Risk Level 2070 |
|---|---|---|---|
| 1 | Erosion and/or exceedance of seawalls, jetties and other coastal defences | H | E |
| 2 | Erosion and/or inundation in the coastal zone leading to damage to infrastructure (private and council owned) situated in close proximity to the coast | H | E |
| 3 | Inundation and/or erosion of roads in coastal areas | H | H |
| 10 | Exceedance of drainage capacity | H | H |
| 4 | Higher rates of building damage and deterioration (focus on council owned buildings) | M | H |
| 7 | Change in building heating/cooling costs (can be either negative or positive) for council owned buildings | M | H |
| 13 | Reduced resilience and increased costs for infrastructure (council owned) in regards to water use for buildings | M | H |
| 17 | Increase in heat island effect in built up areas | M | H |

The City's active sustainability and revegetation programs, including street scaping, contribute to mitigating future heat island effects resulting from climate change. Such programs are essential for the community to continue to enjoy the active outdoor lifestyle that is typical of most areas of the City. However, it was acknowledged that there may be potential limitations, particularly at a strategic level, in ensuring the scale of the current programs are sufficiently effective to mitigate future climate risks.

## 4.4 Adaptation Treatments Identified for the Built Environment

Thirteen adaptation actions were identified through the adaptation planning process (Table 6) to assist the City to minimize the impacts of climate change on its infrastructure.

To reduce risks to assets in the coastal zone, the focus was on public assets. Actions include exploring opportunities to change planning requirements and undertaking an integrated planning and engineering assessment of West Coast Drive. While private assets located east of West Coast Driver were also recognised as vulnerable (as discussed in Section 4.4), it was noted that any adaptation decisions applied to public assets, such as West Coast Drive, would have implications for the ongoing adaptation options available for private assets. As a result, the adaptation actions were prioritised to focus on council owned assets (which will initially bear the impacts), while being cognisant of potential long-term impacts and adaptation issues for private assets.

A strategic approach was recommended to adequately prepare for projected climate risks to infrastructure in the coastal zone. Such an approach would involve the integration of planning and engineering considerations, including assessments of land use planning and management issues (i.e. zoning, setbacks, building specifications, etc.), at all stages of the planning, development and asset management process.

Assets are currently designed in accordance with relevant Australian standards and it is recognised that at present, climate change considerations are not part of the required design standards (with the exception of the State Government Policy SPP 2.6, where there is the requirement to consider sea-level rise projections). Consequently, in most instances it is discretionary to include projected climate changes in asset management; for example, to consider potential changes in flood risk away from the coast or building design to accommodate temperature increases. During the adaptation planning process the need to ensure projected climate changes are considered in asset management was discussed. A two-pronged approach for integration in the coastal zone was recommended:

1. Strategic assessment of the physical vulnerability and revised planning options for West Coast Drive, and the land surrounding, including its immediate landward side

2. Review ongoing management of individual assets, i.e. North Beach Jetty, to factor climate change into the upgrades at scheduled review periods.

It was confirmed that climate changes should be considered when there is sufficient justification to do so, either in terms of the level of criticality of the asset (based on consideration of its social and economic importance, i.e. emergency response shelter) and/or the assets projected lifetime. This recommendation was made whilst recognising that climate change considerations are not part of the current design codes and consequently there is a potential to over engineer assets. Managing future and current social, environmental and economic trade-offs within asset management and planning decision-making is a challenge for the City and other local governments throughout Australia. This challenge can be reduced by ensuring decisions are made through a process that engages with relevant stakeholders.

There may be a need in the future for the City to prioritise asset expenditure, taking potential climate change impacts into account, to ensure community values are met and the sustainability of financial investments is secured. Such a process may necessitate removal of assets that may be identified as either non-essential, overly expensive to maintain, or both.

It is recommended that drainage system improvements be undertaken to reduce flood risk. However, as a precursor to upgrading the City's drainage networks, it is important to accelerate the catchment analysis program to provide the information base for future upgrade decisions. The Australian Rainfall and Runoff (ARR) guidelines are currently under review and climate change is an important component of the review considerations. The ARR guidelines are due for release in 2014, and if resourcing is provided to accelerate completion of the catchment analysis program, this would enable the City to respond quickly to the new guidelines and amend operations proactively and accordingly.

Table 6: Adaptation actions to address priority risks to the built environment

| Risk Description | Action ID # | Risk Treatment Actions | Lead Business Unit | Timeframe |
|---|---|---|---|---|
| Increase in heat island effect in built up areas | **26** | Undertake aerial imagery assessment of the City of Stirling | Manager Parks & Reserves | Short |
| | **27** | Conduct a flyover to determine the baseline per cent (%) vegetation cover of the total City area. Subsequently, set annual targets for increase in urban tree establishment. | Manager Parks & Reserves | Short |
| Exceedance of drainage capacity | **9** | Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall and Runoff (ARR) guidelines in 2014 | Engineering Design | Medium |
| Higher rates of building damage and deterioration (focus on council owned buildings) | **23** | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | Manager City Buildings | Medium |
| Erosion and/or exceedance of seawalls, jetties and other coastal defences | **1** | Asset planning to consider projections for change in climate and associated risks to erosion and/or exceedance of seawalls, jetties and other coastal defences | Engineering Operations | Long |
| | **2** | Implement new measures noted in asset plans | Engineering Operations | Long |
| | **3** | Remove non-essential vulnerable infrastructure from areas exposed to the impacts of erosion and inundation | Parks and Reserves | Long |
| Erosion and/or inundation in the coastal zone leading to damage to infrastructure (private and council owned) situated in close proximity to the coast | **4** | Investigate and report on opportunities to change planning requirements e.g. limit infill development/ change setbacks/ change zoning | Planning & Development | Long |
| Inundation and/or erosion of roads in coastal areas | **8** | Undertake an integrated planning and engineering assessment of West Coast Drive and its future sustainability | Manager Parks & Reserves | Long |
| Exceedance of drainage capacity | **10** | Implement drainage system improvements based upon catchment analysis program | Engineering Operations | Long |
| Change in building heating/cooling costs (can be either negative or positive) for council owned buildings | **24** | Monitor developments in building codes and best practice and adjust council building design standards accordingly | Approvals and City Buildings Operations | Long |
| Reduced resilience and increased costs for infrastructure (council owned) in regards to water use for buildings | **25** | Investigate the feasibility of policy changes that will increase the resilience and cost effectiveness of infrastructure (council owned) in regards to water use | Corporate | Long |
| Increase in heat island effect in built up areas | **28** | Increase the number of shaded structures/trees available in public spaces. | Manager Parks & Reserves | Long |

## 4.5 Barriers and Timeframes for Implementation of Built Environment Treatments

Actions to address risk of erosion and/or exceedance of seawalls, jetties and other coastal defences face the highest barriers to implementation, with respect to budget availability and cost-benefit (Table 7).

As a Council adjacent to coastal areas, the City of Stirling will be adversely affected by sea-level rise in vulnerable areas. The question of who pays for adaptive action to reduce the impacts of sea-level rise remains unclear. All tiers of government will need to work together to manage this issue and the City of Stirling would require financial assistance if it is expected to manage the response.

Taking action when opportunities present, for example, ensuring climate change resilient standards are implemented when assets are scheduled for replacement, was noted as a key strategy to facilitate implementation.

Two actions are assigned to the short term (Table 6), with the remainder of the adaptive actions to address risks to the built environment assigned to the medium or longer term. This provides a significant opportunity to ensure climate risks are captured within long-term business planning.

Table 7: Barrier analysis for adaptive actions that address climate risks to the built environment

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| 23 | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | | | | | | |
| 2 | Implement new measures noted in asset plans | | | | | | |
| 3 | Remove non-essential vulnerable infrastructure from areas exposed to the impacts of erosion and inundation | | | | | | |
| 4 | Investigate and report on opportunities to change planning requirements e.g. limit infill development/ change setbacks/ change zoning | | | | | | |
| 8 | Undertake an integrated planning and engineering assessment of west coast drive and its future sustainability | | | | | | |
| 9 | Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall | | | | | | |

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| | and Runoff guidelines in 2014 | | | | | | |
| **10** | Implement drainage system improvements based upon catchment analysis program | | | | | | |
| **23** | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | | | | | | |
| **24** | Monitor developments in building codes and best practice and adjust council building design standards accordingly | | | | | | |
| **25** | Investigate the feasibility of policy changes that will increase the resilience and cost effectiveness of infrastructure (council owned) in regards to water use | | | | | | |
| **26** | Undertake infrared assessment of the City of Stirling | | | | | | |
| **27** | Conduct a flyover to determine the baseline per cent vegetation cover of the total City area. Subsequently, set annual targets for increase in urban tree establishment. | | | | | | |
| **28** | Increase the number of shaded structures/trees available in public spaces. | | | | | | |

Note: Refer to Annex 2 for full details on barrier analysis criteria. Green = no barrier; Yellow = moderate barrier; Pink = high barrier

# 5 Parks and Recreation

Parks and recreation services provide opportunities for outdoor recreation, increase the visual amenity of the City and provide broader human health and ecological services. Rising mean annual temperatures and declines in freshwater availability may impact parks and reserves, streetscapes, and associated community facilities. In this section you will find: (i) potential impacts to parks and reserves; (ii) the controls in place that build resilience; (iii) high risks identified; (iv) adaptation treatments to respond to priority risks; and (v) a summary of the barriers to implementing adaptive treatments and timeframes for the implementation.

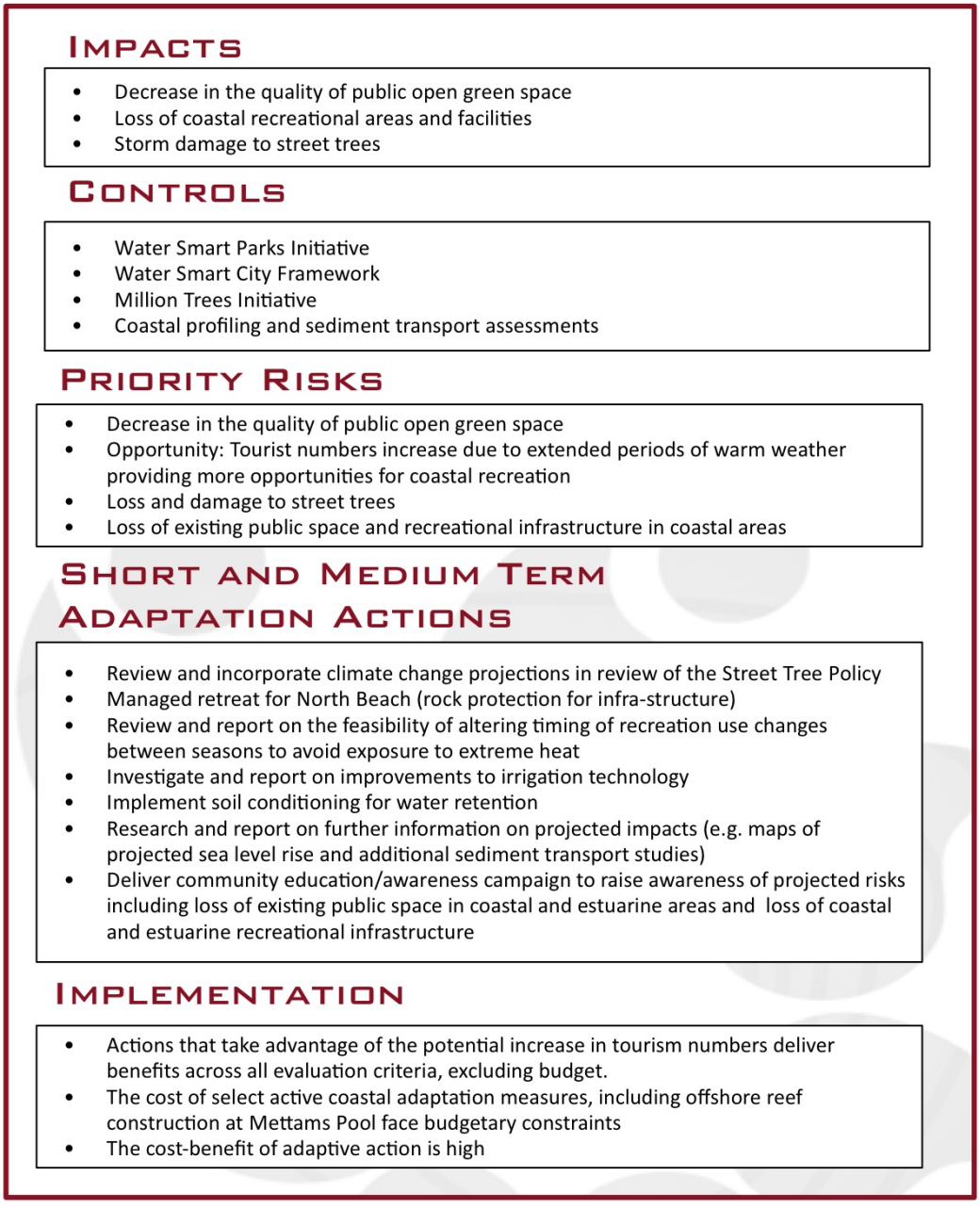



Figure 6: Summary of the impacts, controls, risks and adaptive priorities for parks and recreation

## 5.1 Potential Impacts to Recreation

### 5.1.1 Impacts to Parks and Reserves

Increasing mean annual temperatures combined with decline in annual rainfall and annual runoff has significant implications for the availability of freshwater across the Perth metropolitan region. Impacts to the City may include increased water restrictions, water costs and a potential decline in the quality of green open space.

These impacts are likely to extend to street trees, which provide important shading and visual amenity to the City. The Stirling community has provided feedback to the City through the Strategic Planning process that green and attractive streetscapes are considered a high priority. As such, species selection trials (mentioned in Section 4.2.2) are important to assist the City to select more suitable, water wise species that will be more tolerant of increasingly hot and dry conditions.

The projected increase in the intensity of extreme events is expected to result in an increase in the occurrence of storm damage to street trees. Over the last eight years the City's annual expenditure on storm maintenance for parks and reserves has risen by over $100,000 (Figure 7). These costs are projected to continue to increase as storm intensity increases.

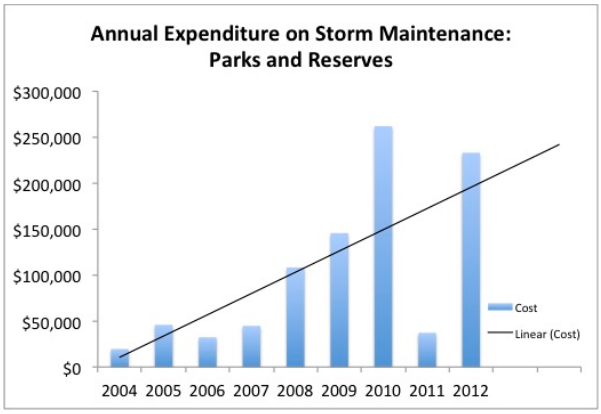



Figure 7: Trend indicating rising expenditure for storm maintenance

The coastal foreshore reserve provides recreational and economic benefits to the City and its community. Sea-level rise and erosion could severely impact vulnerable areas of the coastal zone, particularly the northern coastal beaches, including Watermans Bay, Watermans Beach, North Beach, and Mettams Pool.

Increased temperatures may result in increased visitation, by both residents and tourists, to the City's coastal foreshore for longer periods during the year. This could have positive flow-on benefits to the City's local business community. Conversely, rising ocean temperatures may result in marine ecosystem changes that impact negatively on tourism and recreation, with subsequent economic ramifications to the City's business community. For example, jellyfish population numbers and distribution may increase.

Strategies to take advantage of the identified opportunities, whilst also addressing negative impacts are outlined in Section 5.4.

### 5.1.2 Impacts to Community Facilities

In addition to buildings and infrastructure services, the City provides a range of facilities to its community that support recreation, including equipment, waste services and shade structures. These facilities are particularly prevalent in the coastal zone. The impacts of climate change in the coastal zone, including inundation and erosion may affect these infrastructure services resulting in increased management and repair costs for the City.

## 5.2 Controls in Place that Build Resilience in Recreation

The City has a number of strategies in place that reduce the vulnerability of parks and recreational facilities to the impacts of climate change. The Water Smart Parks initiative has concentrated vegetation plantings in groupings to manage water use (high water demanding plants like grass are planted in high recreational use zones and low water demanding vegetation is planted in low recreational use zones), whilst maintaining biodiversity and recreational values. To build on the Water Smart Parks initiative, Engineering Design is developing a Water Smart City Framework that considers council initiatives and community support to develop a holistic water management approach for scheme, groundwater and storm water within the City. Furthermore, the Framework considers the natural landscape within the City and opportunities to increase water retention, improve storage and help to manage problems such as acid sulphate soils and water pollution.

The City's Million Trees initiative aims to improve urban landscape aesthetics, reduce 'urban heat island' effects, aid carbon sequestration and increase green-links and biodiversity corridors across the City of Stirling. This program is currently being implemented.

Finally, the City is leading activities in the coastal zone to collect information that will support adaptive planning, for example, sediment transport assessments and on-going beach monitoring. This information provides a vital foundation to support coastal management activities, based on a detailed understanding of the nature and rate of change in the coastal zone.

## 5.3 High Risks to Recreation Identified

As mentioned, recreation is important in the City, with the Strategic Community Plan identifying community led priorities of a *Liveable City and Neighbourhood* and *Beautiful Streetscapes and Open Spaces*. The Water Smart Parks initiative positions the City to respond to changes in water availability and the associated impacts on public open green space. However, the historic and projected declines in rainfall signify that despite these controls, the risk of loss in green space remains a significant issue for the City both in the immediate (2030) and longer (2070) term (Table 8).

Climate change brings not only risks but also opportunities. One such opportunity is an increase in tourism along the coastal strip as a result of prolonged warm seasons. Recognising this as an opportunity will ensure that the City can position itself to take advantage of the opportunity through forward planning.

Table 8: Priority risks to recreation

| Risk ID | Description | 2030 | 2070 |
|---|---|---|---|
| 23 | Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | H | H |
| 29 | Opportunity: Tourist numbers increase due to extended periods of warm weather providing more opportunities for coastal recreation | H | H |
| 22 | Loss and damage to street trees | M | H |
| 25 | Loss of existing public space in coastal and estuarine areas | M | H |
| 26 | Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | M | H |

## 5.4 Adaptation Treatments Identified for Recreation

Actions to address the projected decline in green space from climate change are recommended to include a combination of modifying behaviours and providing alternate recreational areas. Changes in behaviour would be achieved by altering the timing of recreational use around the hottest part of the day; while altered recreational areas may include changed surface coverings (more resilient turf species) installed at outdoor recreational spaces to reduce water consumption. It is likely that the City will need to provide more indoor recreation areas. The City is developing an out of season policy for sports clubs and is aware of turf research for climate resilient species. However, resources to progress these initiates are limited, and without prioritisation, may become a significant issue for the City.

Actions to enhance the tourism potential of the coastal zone, as a key asset of the City, were identified (Table 9). A significant amount of work has been undertaken in Scarborough (i.e. SEAS strategy); however there are opportunities along the coastal drive nodes of Trigg Beach and Mettams Pool to improve connectivity of business and services, increase shade structures and recreational areas, and improve transport planning.

Current research on coastal change in priority areas, such as Mettams Pool and Watermans Bay, provides a foundation for responding to projected changes in an informed and proactive manner. A range of active coastal management options for the northern beaches may be considered, including:

- Managed retreat[1] (suitable for North Beach due to the existing rock protection afforded to infrastructure)
- Ocean pool and/or offshore reef construction (i.e. Watermans Bay)
- Protective structures (i.e. for the beaches north of Mettams Pool).

Such options will need to be considered and compared based upon local issues and environmental factors. The feasibility of such options will be defined based on the outcomes of coastal research currently underway and local community consultation.

[1] Managed retreat is a management policy that refers to the relocation of homes and infrastructure under threat from coastal flooding.

Table 9: Adaptation actions to address priority risks to parks and recreation

| Risk Description | Action ID # | Risk Treatment Actions | Lead Business Unit | Timeframe |
|---|---|---|---|---|
| Loss and damage to street trees | **30** | Review and incorporate climate change projections in review of the Street Tree Policy | Manager Parks & Reserves | Short |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | **14** | Review and report on the feasibility of altering timing of recreation use changes between seasons to avoid exposure to extreme heat | Manager Recreation & Leisure Services | Short |
| | **15** | Investigate and report on improvements to irrigation technology | Manager Parks & Reserves | Medium |
| | **16** | Implement soil conditioning for water retention | Manager Parks & Reserves | Medium |
| Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | **32** | Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies) | Manager Engineering Design | Medium |
| | **33** | Managed retreat for Watermans Bay (infra-structure protection as determined by coastal sediment transport study and sand bag trial) | Manager Parks & Reserves | Medium |
| | **36** | Deliver community education/awareness campaign to raise awareness of projected risks including loss of existing public space in coastal and estuarine areas and loss of coastal and estuarine recreational infrastructure | Manager Parks & Reserves | Medium |
| | **35** | Mettams Pool, north - implement protective structures | Manager Parks and Reserves | Long |
| Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | **12** | Implement alternative surface coverings - e.g. more climate resilient species and reduced turf areas | Manager Parks & Reserves | Long |
| | **13** | Set targets and a work plan to increase the number of indoor recreation areas within the City. There are six existing indoor facilities in the City. Construction new recreational areas would occur in the long term. | Manager Recreation & Leisure Services | Long |
| Opportunity: Tourist numbers increase due to extended periods of warm weather providing more opportunities for coastal recreation | **17** | Undertake activities to improve the connectivity of business and services along the coastal drive. Increased shade structures and recreational areas | Manager Economic Development and Urban Regeneration | Long |
| | **18** | Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area | Manager City Planning | Long |
| Loss and damage to street trees | **31** | Implement new measures developed in consideration of climate change as identified through the updated Street Tree Policy and research being conducted through street tree trials | Manager Parks & Reserves | Long |

## 5.5 Barriers and Timelines for Implementation of Recreation Treatments

Most of the adaptive actions that would increase resilience of parks and reserves face few barriers to implementation. In particular, the actions that take advantage of the potential increase in tourism numbers, such as improving the connectively of business and services along West Coast Drive. Also, transport planning to enhance coastal recreation is expected to deliver benefits across all evaluation criteria, excluding budget.

Budget is a common barrier to many of the recommended active coastal adaptation measures being implemented.

Table 10: Barrier analysis for adaptive actions that treat climate risks to parks and reserves

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| **12** | Implement alternative surface coverings - e.g. more climate resilient species and reduced turf areas | | | | | | |
| **13** | Set targets and a work plan to increase the number of indoor recreation areas within the City. There are six existing indoor facilities in the City. Construction of new recreational areas in the long term. | | | | | | |
| **14** | Review and report on the feasibility of altering timing of recreation use changes between seasons to avoid exposure to extreme heat | | | | | | |
| **15** | Investigate and report on improvements to irrigation technology | | | | | | |
| **16** | Implement soil conditioning for water retention | | | | | | |
| **17** | Undertake activities to improve the connectivity of business and services along the | | | | | | |

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| | coastal drive. Increased shade structures and recreational areas | | | | | | |
| **18** | Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area | | | | | | |
| **30** | Review and incorporate climate change projections in review of the Street Tree Policy | | | | | | |
| **31** | Implement new measures developed in consideration of climate change as identified through the updated Street Tree Policy and research being conducted through street tree trials | | | | | | |
| **32** | Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies) | | | | | | |
| **33** | Managed retreat for Watermans Bay (infra-structure protection as determined by coastal sediment transport study and sand bag trial) | | | | | | |
| **35** | Mettams Pool, north - implement protective structures | | | | | | |
| **36** | Deliver community education/awareness campaign to raise awareness of projected risks including loss of existing public space in coastal and estuarine areas and loss of recreational infrastructure | | | | | | |
| **15** | Investigate and report on improvements to | | | | | | |

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| | irrigation technology | | | | | | |

Note: Refer to Annex 2 for full details on barrier analysis criteria. Green = no barrier; Yellow = moderate barrier; Pink = high barrier

# 6 Natural Environment

The City of Stirling falls within the Swan Coastal Plain sub-region of the Swan Coastal Plain Biogeographic Region. It contains diverse natural areas including 616 hectares of bushland, 33 wetland sites and 6.5 kilometres of coastal dunes and beaches. This section contains: (i) potential impacts to the natural environment; (ii) the controls in place that build resilience to the natural environment; (iii) high risks identified; (iv) adaptation treatments to respond to priority risks; and (v) a summary of the barriers to implementing adaptive treatments and timeframes for their implementation.

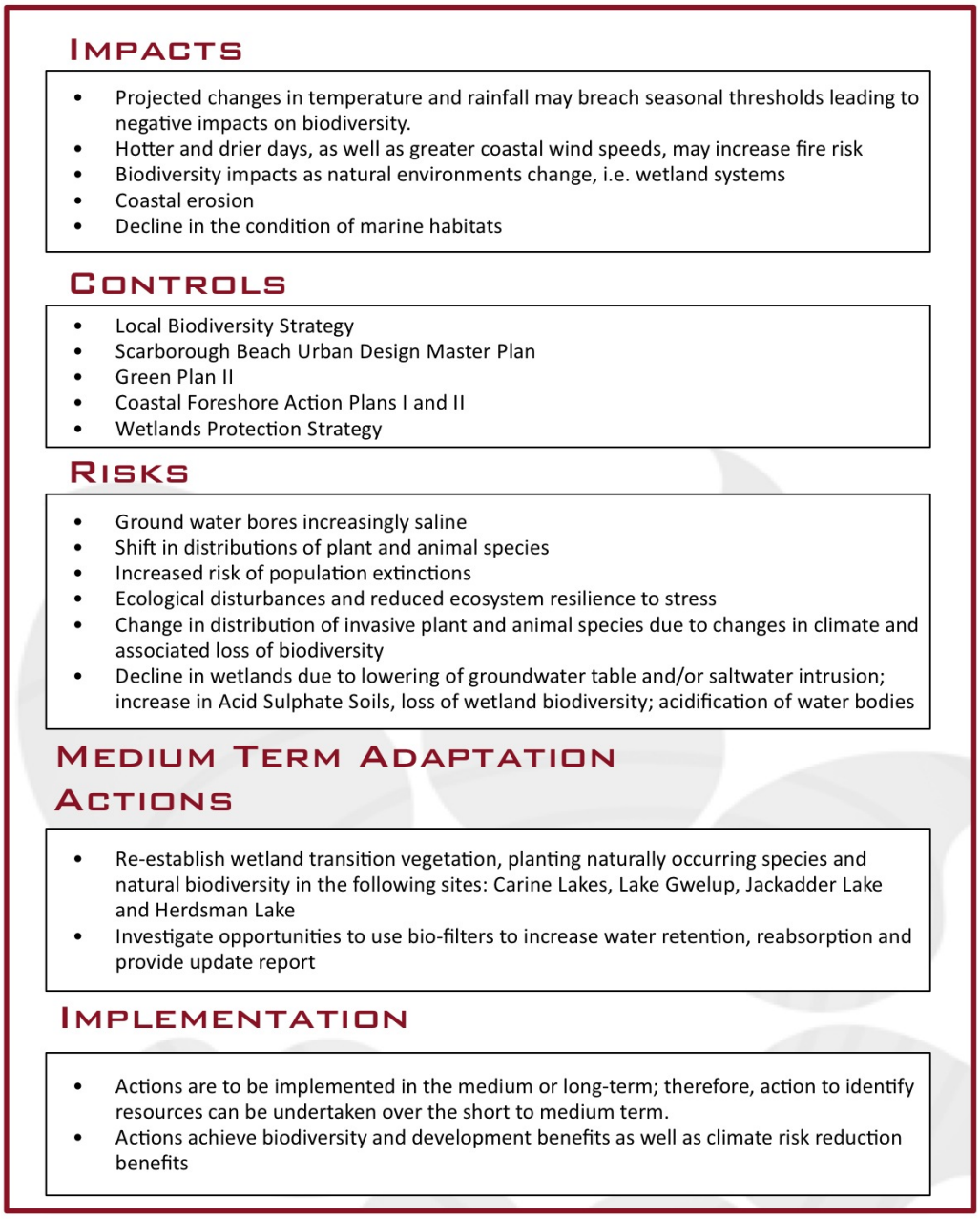



Figure 8: Summary of the impacts, controls, risks and adaptive priorities for the natural environment

## 6.1 Potential Impacts to the Natural Environment

Local flora and fauna species may be negatively affected by increasing heat, water stress and changes in bushfire frequency and/or extremity. The loss of vegetation corridors due to environmental degradation limits the ability of species to migrate to suitable areas. Two species found within the City of Stirling that are vulnerable to such changes, already listed as endangered under the Commonwealth Environment Protection and Biodiversity Conservation Act (1999), include the Carnaby's Black Cockatoo (*Calytorhynchus latirostris*) and the Graceful Sun Moth (*Synemon gratiosa*) (City of Stirling 2010a).

### 6.1.1 Bushland and Remnant Vegetation

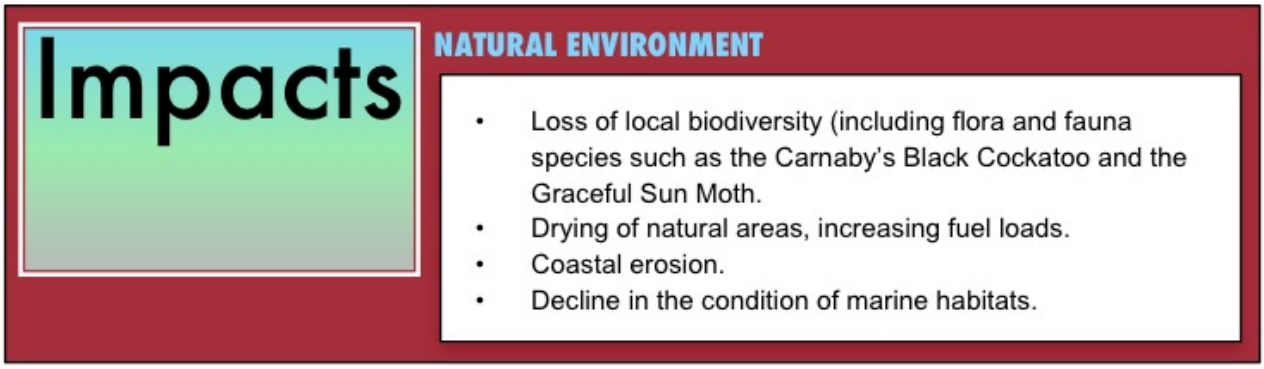
The City's bushland areas, ranging in size from 0.2 to 100 hectares, include eight bush forever sites and 21 sites recognised as regionally significant. Projected changes in temperature and rainfall may impact biodiversity, particularly as dry periods are further prolonged. Whilst seasonal drying may enhance biodiversity, projected changes in temperature and rainfall may breach seasonal thresholds leading to negative impacts on biodiversity.

Natural vegetation complexes within the City have experienced extensive loss since European settlement and are well below the 30 per cent National threshold level for retention targets (City of Stirling 2010a). As population continues to grow, promoting expansion of urban development, the natural vegetation complexes are exposed to increased pressure and currently require active management to improve extent and condition. Changes in ground water quality (increasing salinity) and increased weed species may impact such natural areas. In addition, introduced flora may be more resilient to climate changes, placing further pressure on natural biodiversity.

Hotter and drier days may increase fire risk, with the potential for more intense fires. This would be an issue throughout the City given the significant amount of remnant bushland as well as parks and reserves.

### 6.1.2 Wetlands

The City of Stirling has 37 wetland sites, 24 of which are naturally occurring wetlands, while the remaining 13 are artificially constructed. Both are important for biodiversity conservation because they provide habitat for a wide range of species including wetland and terrestrial birds. Natural wetlands are dynamic systems influenced by geography and climate. The lakes and wetlands in the City form part of a 'chain of wetlands', which run north-south and include Carine Lakes, Lake Gwelup, Jackadder Lake, and Herdsman Lake. Wetlands suffer degradation as a result of altered hydrological regimes, land use change, nutrient enrichment, acidification and fire. Changes in climate may result in changes to hydrological regimes, indirectly influencing fire incidence, nutrient enrichment and acidification. These changes may have important implications for natural biodiversity as changes in species composition occur.




### 6.1.3 Coastal Zone

The City's coastline stretches from the Peasholm Street Dog Beach northwards to Watermans Bay. South of Trigg Island, the coastline consists of sandy beaches and dunes. North of Trigg Island, coastal limestone reefs, rock platforms and cliffs result in a rocky coastline interspersed with small bay beaches (City of Stirling 1984). The variations in coastal landform determine the vegetation types and habitats, as well as differential vulnerability to the projected impacts of climate change.

Coastal dunes are constantly impacted by wind, rainfall, sea level and temperature conditions. As mean sea level increases, so too will the exposure of flora and fauna to the erosive forces. In addition, sediment transport processes may alter, modifying erosion and accretion along the coast. The protection currently afforded by the reef system, buffering wave impact in the nearshore zone, is likely to decrease as sea levels rise.

In addition, reef organisms have a narrow temperature range tolerance and increased sea temperatures can be associated with decline in the condition of marine habitats. This in turn impacts fish and other marine species due to decline in their principal food sources. Changes in other weather variables such as rainfall, cloud cover and water circulation all affect the growth, reproduction and distribution of marine organisms. This has implications for marine biodiversity throughout the City's coastal zone and in particular at Mettams Pool, which is recognised for its snorkelling and recreational activities.

## 6.2 Controls in Place that Build Resilience in the Natural Environment

The City's Local Biodiversity Strategy recommends actions to maintain and enhance natural areas; with a focus on meeting national targets and preserving endangered species. The Strategy promotes the inclusion of representational targets within the City's land zoning system to ensure natural areas of significant value are monitored and protected. Implementation of the plan will enhance the resilience of biodiversity to the impacts of climate change. In addition, the City is currently implementing strategies and plans to respond to impacts to local biodiversity, including the Local Biodiversity Strategy, Green Plan II, Coastal Foreshore Action Plans I and II, the Wetlands Protection Strategy, and the Million Trees Initiative.

A study undertaken to inform the Scarborough Beach Urban Design Master Plan (SEAS), outlined recommendations to the City to respond to changes in the dune system and fluctuations in ground water and associated impacts of coastal flora, as a result of changes in climate. The recommendations align to the SEAS study area (north to Reserve Street and south to the parkland near Brighton Beach and Brighton Road) and have been incorporated into the design stage of the SEAS re-development. The City is aware that these risks extend beyond the SEAS study area; however further technical studies would be required (e.g. groundwater analysis; bore analysis, etc) to determine if the recommendations are directly applicable beyond the SEAS study site.

Additional actions currently underway that contribute to the resilience of the City's coastal zone include ongoing monitoring, sediment transport studies, beach access rationalisation and dune protection.

## 6.3 High Risks to the Natural Environment Identified

Risks to ecosystems and ecological resilience are significant risks for the City in the longer term (2070) (Table 11). The strategies and plans currently implemented by the City (see Section 6.2) provide a foundation to respond to risks to local biodiversity by 2030; however, additional resourcing is required to implement active adaptation measures to manage sustainability in the longer term (2070).

Table 11: Priority risks to natural environment

| Risk ID | Risk Description | Risk Level 2030 | Risk Level 2070 |
|---|---|---|---|
| 34 | Ground water bores increasingly saline | H | E |
| 30 | Shift in distributions of plant and animal species | M | H |
| 31 | Increased risk of population extinctions | M | H |
| 32 | Ecological disturbances and reduced ecosystem resilience to stress | M | H |
| 33 | Change in distribution of invasive plant and animal species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity | M | H |
| 35 | Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | M | H |

Increasing salinity of ground water bores was recognised as a significant risk to the City, given the interrelationships between bore salinity and other priority health, community and well-being risks, including the maintenance of recreational parks and reserves and biodiversity conservation. Similarly, groundwater decline, saltwater intrusion and acid sulphate soils are considered a high priority risk to wetlands in the longer term. This has implications for the chain of wetlands in the City, which includes, among others, Carine Lakes, Lake Gwelup, Jackadder Lake, and Herdsman Lake.

Street trees provide important amenity and passive cooling properties. There are a number of existing policies relating to street trees and their management that are considered to take important steps towards reducing the projected impacts of climate change. However, the selection of tree species and establishment procedures do

not explicitly factor in climate changes and therefore, residual risk remains, although predominantly in the longer term.

## 6.4 Adaptation Treatments Identified for the Natural Environment

Additional resourcing to implement large-scale actions would be required to increase the resilience of natural areas (Table 12). Such actions include the removal of threats and disturbances (for example, broad scale weeding), protection from further degradation through land use planning; and natural and assisted regeneration through on ground conservation measures. Further detail on these actions is provided in the City's Local Biodiversity Strategy. Many of these actions would require partnerships between Parks and Reserves Business Unit and City Planning, to progress the initiatives. For example, City Planning can support the objectives of environmental management in combination with social and economic development, through its role in strategic planning.

Increased salinity of ground water bores and flooding may be managed through active measures, including Managed Aquifer Recharge, wet and dry detention basins and waste water treatment. Managed Aquifer Recharge has been recommended as a strategy to address long-term sustainability issues associated with a drying climate (Hassel 2011). It involves adding a water source such as recycled water to underground aquifers under controlled conditions to increase groundwater reserves. Increased levels of freshwater can reduce saline intrusion. Wet and dry detention basins are a storm water management tool designed to protect against flooding by managing excess runoff.

## 6.5 Barriers and Timelines for Implementation of Adaptation Treatments for the Natural Environment

Financial and human capacities were identified as the primary barriers to implementing the adaptation measures that treat climate risks to the natural environment (Table 13). The recommended actions will be implemented in the medium (within 5 years) and long term (within 10 years). This provides an opportunity for the City to address the financial and human resource constraints (Table 13) prior to the implementation.

The actions would achieve biodiversity and development benefits as well as climate risk reduction benefits. Organisation capacity is available to implement a number of the assigned actions; yet external support will also be required, for example, in investigating the use of bio-filters and implementing waste water treatment and reuse in key precincts.

Importantly, plans are available to support delivery of active adaptation measures that will build resilience; and the environmental and social benefits will be significant. Activities should focus on ensuring the budgetary allocations are in place through integration with Corporate Business Planning and the Strategic Community Planning.

Table 12: Adaptation actions to address priority risks to the natural environment

| Risk Description | Action ID # | Risk Treatment Actions | Lead Business Unit | Timeframe |
|---|---|---|---|---|
| Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | **41** | Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake | Manager Parks & Reserves | Medium |
| | **42** | Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report | Manager Parks & Reserves | Medium |
| | **40** | Aquifer recharge, shallow water recharge: Investigate opportunities to increase aquifer recharge. | Manager Parks & Reserves | Long |
| Ground water bores increasingly saline | **5** | Investigate the feasibility of aquifer recharge to reduce salinization of ground water (the focus is on bore aquifer not drinking water) | Manager Parks & Reserves | Long |
| | **6** | Investigate the feasibility of wet and dry detention basins as tools to reduce salinization of groundwater | Manager Parks & Reserves Manager | Long |
| | **7** | Implement waste water treatment and re-use in key precincts | Manager Parks & Reserves | Long |
| Shift in distributions of plant and animal species; Increased risk of population extinctions; Ecological disturbances and reduced ecosystem resilience to stress; and Change in distribution of invasive plant and animal species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity | **37** | Remove threats and disturbances as outlined in the Local Biodiversity Strategy | Manager Parks & Reserves | Long |
| | **38** | Undertake land use planning and on-ground conservation measures | Manager Parks & Reserves | Long |
| | **39** | Implement natural and assisted regeneration through on ground conservation measures (monitoring, corridor planning and implementation) | Manager Parks & Reserves | Long |

Table 13: Barrier analysis for adaptive actions that treat climate risks to the natural environment

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environmental | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| **5** | Investigate the feasibility of aquifer recharge to reduce salinization of ground water (the focus is on bore aquifer not drinking water) | | | | | | |
| **6** | Investigate the feasibility of wet and dry detention basins as tools to reduce salinization of groundwater | | | | | | |
| **7** | Implement waste water treatment and re-use in key precincts | | | | | | |
| **37** | Remove threats and disturbances as outlined in the Local Biodiversity Strategy | | | | | | |
| **38** | Undertake land use planning and on-ground conservation measures | | | | | | |
| **39** | Implement natural and assisted regeneration through on ground conservation measures (monitoring, corridor planning and implementation) | | | | | | |
| **40** | Aquifer recharge, shallow water recharge: Investigate opportunities to increase aquifer recharge. | | | | | | |
| **41** | Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake | | | | | | |
| **42** | Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report | | | | | | |

Note: Refer to Annex 2 for full details on barrier analysis criteria. Green = no barrier; Yellow = moderate barrier; Pink = high barrier

# 7 Emergency Management

Emergency management plays a leading role in responding to the impacts of climate extremes, such as storm damage, inland and coastal flooding. This section contains: (i) potential climate impacts on emergency management services; (ii) the controls in place that build resilience to such impacts; (iii) the high risks identified; (iv) adaptation treatments to respond to priority risks; and (v) a summary of the barriers to implementing adaptive treatments and timeframes for their implementation.

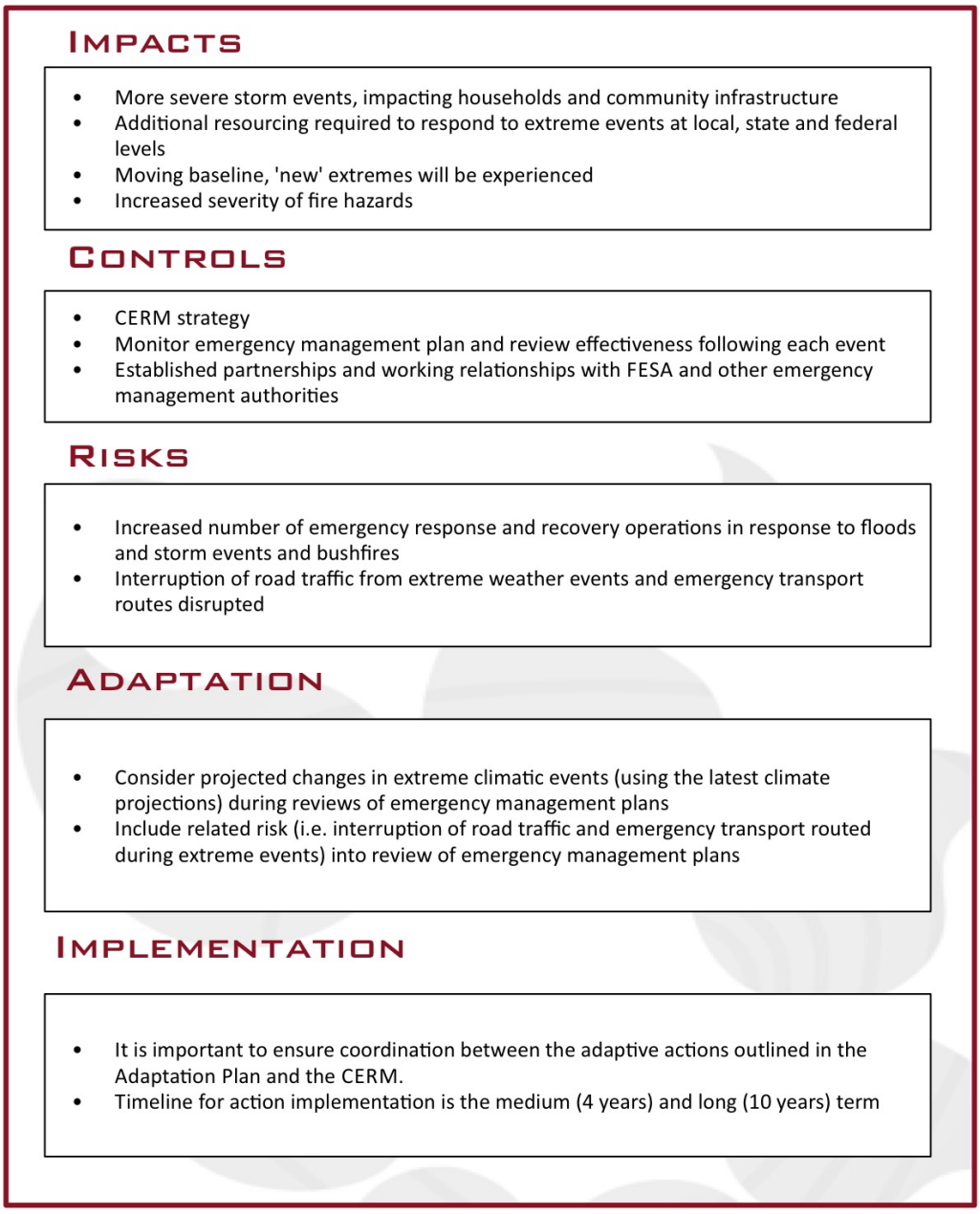



Figure 9: Summary of the impacts, controls, risks and adaptive priorities for emergency management

## 7.1 Potential Impacts to Emergency Management

Projected changes in climate include altered mean annual temperatures and annual rainfall; however, changes to extreme events, such as storms and heatwaves, are also expected (CSIRO/BOM 2007; 2012). As events become more intense, the number of emergency response events and the spatial distribution of response activities may increase. This may place pressure on emergency response providers, including local, state and federal governments. Emergency management is undertaken by the City of Stirling in partnership with State and Federal departments, such as the Fire and Emergency Services Authority of Western Australia (FESA). As conditions change, the role and responsibilities of all parties' delivering emergency response actions may require clarification.

## 7.2 Controls in Place to Build Resilience in Emergency Management

The City plays an important role in the effective planning and delivery of emergency response. The City actively monitors its Emergency Management Plan and reviews its effectiveness following each event. For example, in responding to the recent 'mini tornado' in Dianella/Morley (7 June 2012), the City worked closely with FESA and other state emergency response agencies. Such arrangements are likely to continue into the future, mitigating the severity of risks.

There is a strong practice of Emergency Management within the City. Partnerships with State and local organisations (i.e. FESA) are well established and effectively support emergency management. The Community Emergency Risk Management (CERM) plan specifies external and internal responsibilities for emergency risk management.

## 7.3 High Risks to Emergency Management Identified

There is a recognised element of uncertainty with how climate change will affect emergencies in the City, for example, bushfires, extreme heat events, flooding (rainwater) and storm surge. The City annually clears firebreaks on City land and performs inspections on approximately 2,800 private properties (as per requirement of State Bushfires Act) to reduce the risk of fire hazard. Consequently, fire was not considered a major risk in the City. Priority risks include increased emergency response during extreme weather events, such as storms, as outlined in Table 14.

Table 14: Priority risks to emergency management

| Risk ID | Risk Description | 2030 | 2070 |
|---|---|---|---|
| 19 | Increased number of emergency response and recovery operations in response to floods and storm events | H | H |
| 18 | Interruption of road traffic from extreme weather events and emergency transport routes disrupted | M | H |

At the time of assessment, the City was finalising its Community Emergency Risk Management Plan (CERM). The CERM identifies emergency risks that may affect the City and is conducted, at a minimum, every five years (in accordance with the Emergency Management Act 2005). Climate change was one of the important issues considered in the development of the CERM and there is alignment between the draft CERM and risks identified in this assessment (in particular Risk IDs 1, 2, 3, 10, 19, 20, 23, 38, 4, 17, 18, 22,

26, 47, 36, 44, 39 and 40 – Refer to Risk and Adaptation Register, Annex 3, for Action IDs).

## 7.4 Adaptation Treatments Identified for Emergency Management

The adaptation planning process identified two adaptation actions to address risks associated with extreme weather events in the City (Table 15). These include incorporating climate projections in the regular CERM risk assessment process and specifically focusing on potential disruption to emergency transport routes during extreme events.

Table 15: Adaptation actions to treat priority risks to emergency management

| Risk Description | Action ID # | Risk Treatment Actions | Lead Business Unit | Timeframe |
|---|---|---|---|---|
| Increased number of emergency response and recovery operations in response to floods and storm events | **11** | Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans | Coordinator Emergency Management | Medium |
| Interruption of road traffic from extreme weather events and emergency transport routes disrupted | **29** | Include related risk (i.e. interruption of road traffic and emergency transport routes during extreme events) into reviews of emergency management plans | Coordinator Emergency Management | Medium |

## 7.5 Barriers and Timelines for Implementation of Adaptation Treatments for the Natural Environment

No barriers to implementing the adaptation measures were identified during the adaptation-planning process (Table 16).

Importantly, the CERM treatment strategies were not available at the time of producing the Adaptation Plan. Therefore, it will be important to ensure coordination between the adaptive actions for emergency management risks as outlined in Table 15 and the adaptive actions for other risks that may be classified as emergency management but are covered here under built environment, natural environment and community (i.e. Risk IDs 1, 2, 3, 10, 19, 20, 23, 38, 4, 17, 18, 22, 26, 47, 36, 44, 39 and 40 – Refer to Risk and Adaptation Register, Annex 3, for Action IDs).

The timeline for implementing the adaptive measures is the medium (4 years) and long term (10 years), which aligns to the timeframes for Corporate Business Plans and the Strategic Community Plan.

Table 16: Barrier analysis for adaptive actions that treat climate risks to emergency management

| Action ID # | Risk Treatment Actions | No regrets | Community values | Environment | Budget | Cost Benefit | Organisational capacity |
|---|---|---|---|---|---|---|---|
| **11** | Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans | | | | | | |
| **29** | Include related risk (i.e. interruption of road traffic and emergency transport routes during extreme events) into reviews of emergency management plans | | | | | | |

Note: Refer to Annex 2 for full details on barrier analysis criteria. Green = no barrier; Yellow = moderate barrier; Pink = high barrier

# 8 Monitoring Risks into the Future

Adaptation strategies to address the climate risks have been outlined. In this section, the approach to monitor and evaluate progress in adaptation is discussed.

## 8.1 Introduction

Adaptive management is widely advocated in the field of climate change adaptation. It provides a mechanism to address the inherent uncertainties in climate projections and acknowledges that systems change over time, thus requiring flexible management approaches.

Adaptive management is facilitated through ongoing monitoring and review. The Adaptation Plan will be regularly reviewed and updated, particularly as climate change information (projections) changes. The purpose of review is to (NSW Government 2011):

- Incorporate new climate change information as it becomes available
- Check that risk controls in place remain effective
- Include new information gained from hazard events
- Account for any changes in context; and
- Identify any new risks.

Similarly, the effectiveness of the adaptation measures in achieving their objective will be analysed. Therefore, actions include:

- Review and update the risk assessment to increase certainty and modify/adapt adaptation actions in light of new information.
- Monitor effectiveness of adaptation actions in treating identified risks. It is possible that risks may become more or less significant over time depending on (i) the success of various adaptation actions, (ii) improved understanding of the risk and its consequences, or (iii) a change in the perceived values under threat from climate change.

Monitoring and review occurs most efficiently and effectively when it is integrated within existing risk management processes. Such a mainstreamed approach to climate adaptation is widely advocated (Olhoff & Schaer 2010; UNDP, 2010; IDS 2006; Dalal-Clayton & Bass 2009); yet, demonstrated good practice in achieving such integration is in its infancy (Gero et al., 2012). Challenges faced include:

- Poor clarity around the role of local government in addressing climate change
- Absence of effective mechanisms for cross-scale coordination of adaptation planning, particularly within coastal zones
- Ingrained values and beliefs that shape how people perceive, interpret and think about climatic risks and their management
- Lack of experience in the selection of indicators to measure and monitor success; and

- On a practical level, potential incompatibility of performance management, risk management and other management tools and software.

Therefore, this is a recognised challenge; but one that if proactively addressed by the City, will facilitate adaptive climate risk management into the future.

## 8.2 An approach to integrate climate change risk management in the City

Monitoring and evaluation of climate change risks and adaptation effectiveness in the City of Stirling will be undertaken through strategic planning and in operations. These two facets of integration are discussed in turn.

### 8.2.1 Monitoring and Evaluation: Strategic Planning

In accordance with the Local Government Act, the City is transitioning towards an Integrated Planning Framework that will improve strategic planning. The Framework (Department of Local Government 2010):

- Recognises that planning for a local government is holistic in nature and driven by the community
- Builds organisational and resource capability to meet community need
- Optimises success by understanding the integration and interdependencies between the components; and
- Emphasises performance monitoring so that local governments can adapt and respond to changes in community needs and the business environment.

The transition to an Integrated Planning Framework in parallel with action on climate change adaptation provides a unique opportunity to integrate the outcomes of the Adaptation Plan with the City's long-term view of planning and management. Such integration supports monitoring and reporting of climate risks and the evaluation of performance in risk management.

The Integrated Planning Framework consists of a Strategic Community Plan, Corporate Business Plans, and Informing Strategies (Figure 10). The Strategic Community Plan, with its 10-year vision, is delivered through 4-5 year rolling Corporate Business Plans that address core themes, i.e. Liveable City and Thriving Neighbourhoods. The Corporate Business Plans are updated annually.

The Strategic Community Plan will highlight the inter-relationships between theme objectives and managing the impacts of climate change. In turn, the long-term adaptation actions (allocated for implementation within 10 years) can be embedded with relevant sub-themes. Business Unit managers will then examine the Adaptation Risk Register to identify adaptation strategies allocated to the medium term (within 4 years), which contribute to meeting the highlighted adaptation goals/priorities as captured within the Strategic Community Plan. In turn, these measures may be incorporated within Corporate Business Plans. The adaptive actions that align to themed areas in the Medium and Long term are summarised in Table 17.

The City also maintains a Corporate Risk Register, which operates at a strategic level, capturing priority risks across the organisation. The City has previously identified climate change as a strategic risk that requires treatment. While the Corporate Risk Register does not provide the level of detail for risk assessment and treatment as delivered through individual operational risk assessments (including climate change risk assessment), it does provide strategic direction for climate change risk management. The Corporate Risk Register is reviewed and updated at least annually or when there is a change in circumstances (e.g. completion of the climate change risk assessment and adaptation plan). Existing controls and new actions are updated in this review. Therefore, the strategic treatment actions in this adaptation plan will be included in the next review, i.e. 'Regular (e.g. annual) update of the Climate Change Risk Assessment and Adaptation Planning'.

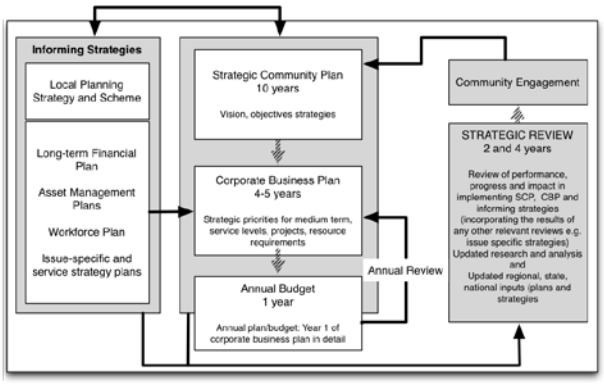



Figure 10: Integrated Planning Framework and associated elements

Table 17: Adaptation actions aligned to the themes of the Strategic Community Plan

| Description | Links to Adaptation | Relevant Adaptive Actions and Specified Timeframe |
|---|---|---|
| **Liveable City and Thriving Neighbourhoods Theme** | | |
| This element of the Strategic Community Plan aims to contribute to the community's vision of vibrant City Centre complemented by attractive local neighbourhoods. The objectives include: a strong sense of place; housing choice; beautiful streetscapes and open spaces; a safer City; health and wellbeing; and an active City | A majority of the adaptation actions assigned to Parks and Reserves reflects the City's vision for beautiful streetscapes and green open spaces whilst also appreciating the challenge of maintaining such a vision despite a changing climate. Declines in rainfall, runoff and increasing mean annual temperatures will have a significant impact on the quality of green space. The City has shown leadership in establishing mechanisms that enable it to effectively manage the distribution of water across green areas; however, there will remain a challenge in raising awareness within the community of alternate visions of 'beautiful streetscapes' that are less water reliant. Strategies to improve emergency response to extreme events will contribute to a Safe City; in combination with the CERM; while the current programs delivered through the Community Services Directorate contribute to community health and well-being. Actions to monitor the continued effectiveness of these strategies will be an important aspect of ensuring high levels of well-being are maintained despite a changing climate.<br>Actions to increase the availability of outdoor and indoor recreation areas support an active City; as too do the adaptive actions presented under the Sustainability and Prosperous City themes.<br>Adaptation actions that enhance the resilience of the built environment will contribute to a strong sense of place; for example, those actions outlined within the Built Environment section of this Adaptation Plan. A sample of these actions is provided here. | 15. Investigate and report on improvements to irrigation technology: **Medium**<br>16. Implement soil conditioning for water retention: **Medium**<br>31: Implement new measures developed in consideration of climate change as identified through the updated Street Tree Policy and research being conducted through street tree trials: **Long**<br>11. Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans: **Medium**<br>19: Increase monitoring for the range and occurrence of vector borne/water borne diseases: **Medium**<br>20: Develop a plan to respond to changes in vector-borne disease: **Medium**<br>21: Implement education campaigns to raise awareness to mitigate the risk of vector-borne disease: **Long**<br>22: Implement the plan to respond to changes in vector borne disease: **Long**<br>43: Investigate and report on the feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures: **Long**<br>44: Implement active measures identified through the outdoor staff heat avoidance assessment: **Long**<br>12. Implement alternative surface coverings - e.g. more climate resilient species and reduced turf areas: **Long**<br>13. Set targets and a work plan to increase the number of indoor recreation areas within the City. There are six existing indoor facilities in the City. Construction new recreational areas in the long term: **Long**<br>9: Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall and Runoff (ARR) guidelines in 2014: **Medium**<br>23: When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime: **Medium**<br>1: Asset planning to consider projections for change in climate and associated risks to erosion and/or exceedance of seawalls, jetties and other coastal defences: **Long**<br>4: Investigate and report on opportunities to change planning requirements e.g. limit infill development/ change setbacks/ change zoning: **Long** |

| Description | Links to Adaptation | Relevant Adaptive Actions and Specified Timeframe |
|---|---|---|
| **Sustainable Environment Theme** | | |
| The City will value, protect and improve the environment by using natural resources wisely, reducing the impact of its activities on the environment and protecting wildlife and natural habitats. The City will support and encourage everyone in the community to work for a sustainable environment. The objectives include: a clean and waste wise city; energy efficiency, water wise, wildlife and natural habitat | A Water Smart City will support adaptation to declines in freshwater availability, whilst also contributing to the ability to maintain beautiful streetscapes and green space. Adaptation actions to maintain biodiversity despite a changing climate will be critical in ensuring long-term sustainability of the biodiversity values valued by the City.<br>Energy efficiency and a waste wise city align to mitigating the impacts of climate change. Improving energy efficiency across the city, from households to business and local government operations, will reduce greenhouse gas emissions – which in doing so contributes to reducing the long-term impacts of climate change on the City. In addition, adequate waste management reduces the carbon footprint of landfill sites. The City is currently undertaken actions, such as development of an Energy Bureau, which will support achievement of these objectives. | 37. Remove threats and disturbances as outlined in the Local Biodiversity Strategy: **Long**<br>38. Undertake land use planning and on-ground conservation measures: **Long**<br>39. Implement natural and assisted regeneration through on ground conservation measures (monitoring, corridor planning and implementation): **Long**<br>40. Aquifer recharge, shallow water recharge: Investigate opportunities to increase aquifer recharge.: **Long**<br>41. Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake: **Medium**<br>42. Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report: **Medium** |
| **Engaged Communities Theme** | | |
| An inclusive city, volunteering and good communication are viewed as important aspects contributing to an engaged community. The objectives include: a harmonious and inclusive city; active participation and volunteering; and two way dialogue between the City and the community. | Many of the programs currently delivered by the City contribute to the objective of an engaged community (for example, MeetBalls, Meals on Wheels, Men's Shed, among others). These programs will play an important role in ensuring vulnerabilities occurring as a result of climate change are effectively monitored and managed. While such programs target areas of existing social and cultural vulnerability within the City, climate impacts are likely to expand the spread of vulnerabilities across the City. | Actions to monitor the continued effectiveness of strategies delivered by Community Services Directorate will be important in ensuring maintenance of this objective despite a changing climate. |
| **Accessible and Connected City Theme** | | |
| Getting around the City of Stirling will be convenient, safe and affordable whether by foot, cycle, public transport or car. The City will provide quality and easily accessible services to all its customers. The objectives include: planning for accessibility; walking and cycle friendly; improved access to and use of public transport; safer road; smart parking; and connected City. | The City's Local Housing Strategy outlines a recommended approach to providing mixed-use affordable housing, and discusses principles that support planning for accessibility. The Strategy has been adopted by Council and is being used to guide the development of planning documents, such as Local Area Plans. A Local Housing Strategy Implementation Plan is going to be developed to assist with uptake of these principles. | In addition to the actions and principles outlined in the City's Local Housing Strategy, adaptation actions to improve accessibility, specifically in the coastal zone, were identified.<br>18. Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area: **Long**<br>Also see Prosperous City Theme for further details. |

| Description | Links to Adaptation | Relevant Adaptive Actions and Specified Timeframe |
|---|---|---|
| **Prosperous City Theme** | | |
| The City of Stirling will be recognised as a great place to invest and do business. It will offer lots of jobs locally. The City of Stirling will make the most of its great tourism potential. The objectives include: a great place to invest and do business; lots of diverse jobs locally; and destination city. | The tourism potential of West Coast Drive, in combination with its recognised vulnerability to sea-level rise and change in the intensity of storm events, are high adaptive priorities. Implementing the planning and development actions that enhance the tourist potential along West Coast Drive, for example, by increasing business and service connectivity, will support achievement of the vision for a Prosperous City. Ensuring maintenance and protection of such assets via continued investigations into shoreline change and strategies to maintain the northern beaches in the long-term, will ensure that the attributes of the coastal zone that contribute to the both local and international tourist value are maintained. | 17. Undertake activities to improve the connectivity of business and services along the coastal drive. Increased shade structures and recreational area: **Long**<br>18. Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area: **Long**<br>32. Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies): **Medium**<br>34. Watermans - undertake ocean pool and offshore reef construction and/or managed retreat. The business case for both options should be considered: **Medium**<br>35. Mettams Pool, north – implement protective structures: **Long**<br>36. Deliver community education/awareness campaign to rasie awareness of projected risks including loss of existing public space in coastal and estuarine areas and loss of coastal and estuarine recreational infrastructure: **Medium** |

## 8.3 Monitoring and Evaluation: Operational planning

Integrating climate change risks within strategic planning (Strategic Corporate Planning and Corporate Business Plans) and reporting processes (Corporate Risk Register) in isolation will not deliver an integrated approach to climate risk management and treatment across the City, as it: (i) may exclude some treatment strategies for priority risks that do not directly align to the Strategic Corporate Planning; and (ii) there remains the requirement for a centrally managed tool that will allow all risks and treatment strategies to be reported upon across Business Units (climate and non-climate risks).

Risk assessments are currently carried out across a range of themes (including climate change); however, the lack of a central system impedes risk reporting across the City. While medium, low and very low risks are managed through regular (annual) completion of risk assessments that involve re-evaluation of the effectiveness of existing controls; regular reporting on the implementation of treatment strategies for high and extreme risks is not undertaken in a systematic manner. In turn, the effectiveness of adaptive actions and treatment strategies in treating the identified risks is not evaluated. In short, the lack of a central monitoring system impedes the ability to monitor the implementation of actions and/or the performance of the actions implemented.

The City is currently working to develop a dedicated central risk management system with a number of options being considered.

# 9 Conclusion

This Adaptation Plan provides a summary of the outcomes of a risk assessment and adaptation planning assessment conducted by the City in 2012, to contribute to Strategic Initiative 2.2.1. *Develop and implement a climate change adaptation strategy, action plan and community education program.* It sets a basis for ongoing adaptation and adaptive management by the City, to respond to the impacts of climate change in coordination with other important management priorities.

Implementation of the detailed adaptation recommendations will be supported through the selection and implementation of a dedicated central risk management system. This will enable officers to monitor progress in implementation and report on the effectiveness of adaptation measures in achieving their risk reduction objectives. The medium (4 years) and long-term (10 years) actions align to the City's Corporate Business Plans and Strategic Community Plan, ensuring that the actions can be integrated within the operational planning and reporting process of the City.

In many instances, the climate risks identified are not confined to the City's boundaries. Therefore, opportunities to partner with neighbouring local councils to consolidate resources, or to promote a regional approach led by the State Government or the West Australian Local Government Association (WALGA), should be considered.

Risk assessment is not a one-off exercise, rather, it is a tool for ongoing reflection and management that ensures changing circumstances are captured and inform ongoing management. Risk assessments will be undertaken by each Business Unit annually as part of the risk management component of the Performance Planning process. All climate risks identified will be added to the relevant lead business units risk register.

The Adaptation Plan will be reviewed every five years or as significant changes to climate change research becomes available. Lessons from implementation of this assessment can be drawn on to guide subsequent analyses, as an ongoing process of improvement in climate change risk assessment (Box 1).

***Box 1: Opportunities for improvement***

In this assessment the spatial prioritisation of risks was confined to a qualitative assessment. The City has a spatial information system that may be used to assess differential risk priorities throughout the City in future assessments. However, the system must be populated with information that is currently managed and stored in different forms (hard copy, excel, etc.). Completing such a conversion process would require significant human and financial investment, in combination with awareness-raising on the importance of spatial consolidation of information across the City. Despite the challenges, the benefits derived through utilisation of such a system would be great. It would facilitate spatially refined prioritisation of assets and locations to implement adaptation strategies, increasing efficiency in adaptation expenditure and providing quantitative evidence to seek external assistance in implementing adaptation actions. The Risk and Adaptation Register contains an adaptation action to respond to this opportunity (Annex 3).

The City is well placed to respond to the impacts of climate change. The wealth of knowledge generated through management activities (such as coastal monitoring programs) and the current controls in place set a foundation for proactive management within the City. In combination with the detailed Adaptation Plan and the expertise gained through cross-Business Unit collaboration in climate change risk management, the City is better placed to respond adaptively to changes in climate, ensuring maintained service delivery and achievement of Community objectives

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# Annex 1: Projections for Change in Climate and Climate Scenarios


## Climate Change Adaptation Plan: Preparing for and responding to climate risks in the City of Stirling

# Table of Contents

# Introduction

This Annex provides an overview of how the climate has changed to date and how it is projected to change in the future. In addition, the scenarios for change that were adopted within the City's Climate Change Risk Assessment and Adaptation Planning Project are presented.

# How has the climate changed?

Perth is characterised by a warm Mediterranean climate with cool wet winters and hot dry summers. Recent climate trends indicate a warming and drying climate for metropolitan Perth. These trends are briefly examined, prior to exploring projected future changes in key climate drivers for the Perth metropolitan region.

## 1.1. Temperature, Rainfall and Runoff

There has been a strong rise in average temperature across Western Australia by approximately 0.8 degrees over the past century (Steffen and Hughes, 2010) (Figure 1). In addition, rainfall patterns have changed over the last 40 years, with significant evidence that climate change has contributed to the drying trend in the southwest of Western Australia (Steffen and Hughes, 2010). Rainfall decline is linked to rising temperatures and an overall drying trend. Rain is brought through rain bearing fronts that pass across southwestern Australia from the Southern Ocean during autumn and winter. Over the last 40 years, these fronts have moved southwest, driven by the warming climate, resulting in a reduction in annual rainfall (Steffen and Hughes, 2010) (Figure 3). Declines in rainfall have significant impacts on water inflow into the state's dams, with implications for freshwater availability (Figure 2).

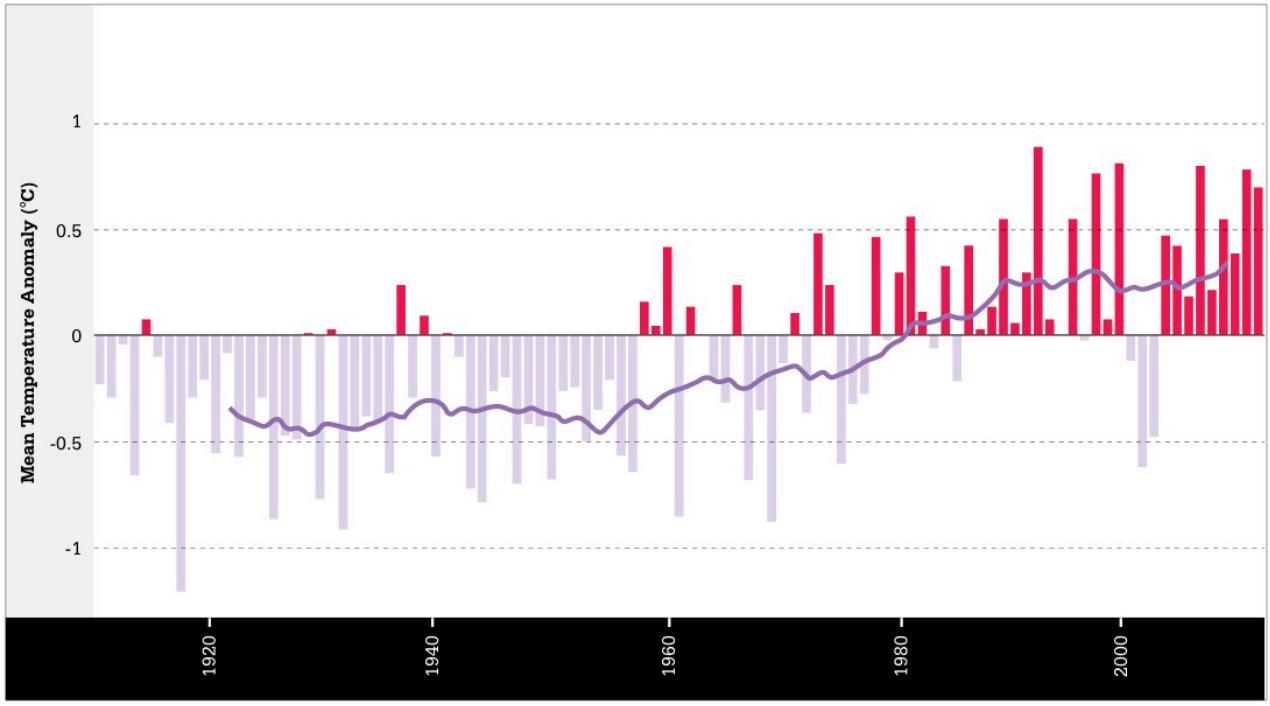



**Figure 1: Long-term trend in average temperature for Western Australia, 1961 – 1990 average (source: Steffen and Hughes 2010; pg. 4).**

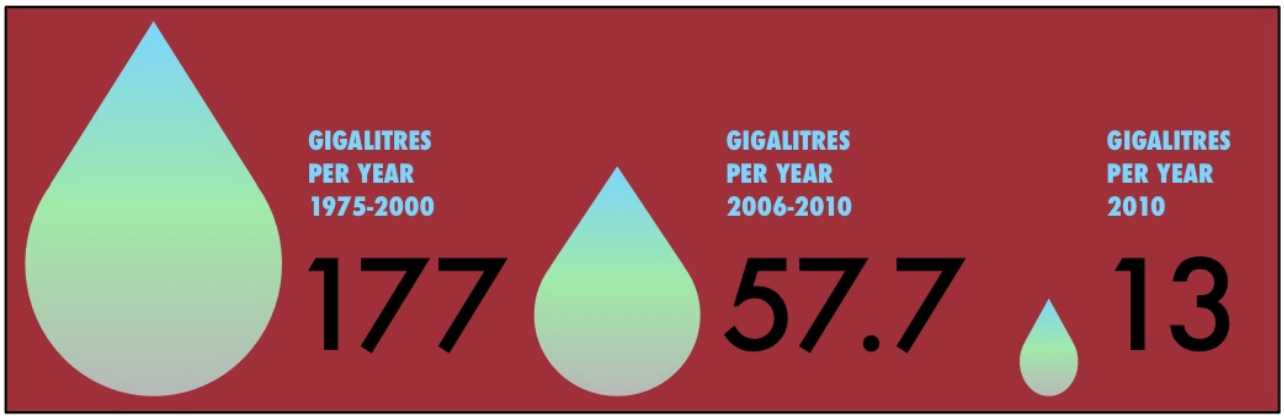



**Figure 2: Change in water inflow into Perth dams (source: Steffen and Hughes 2010; pg. 5).**

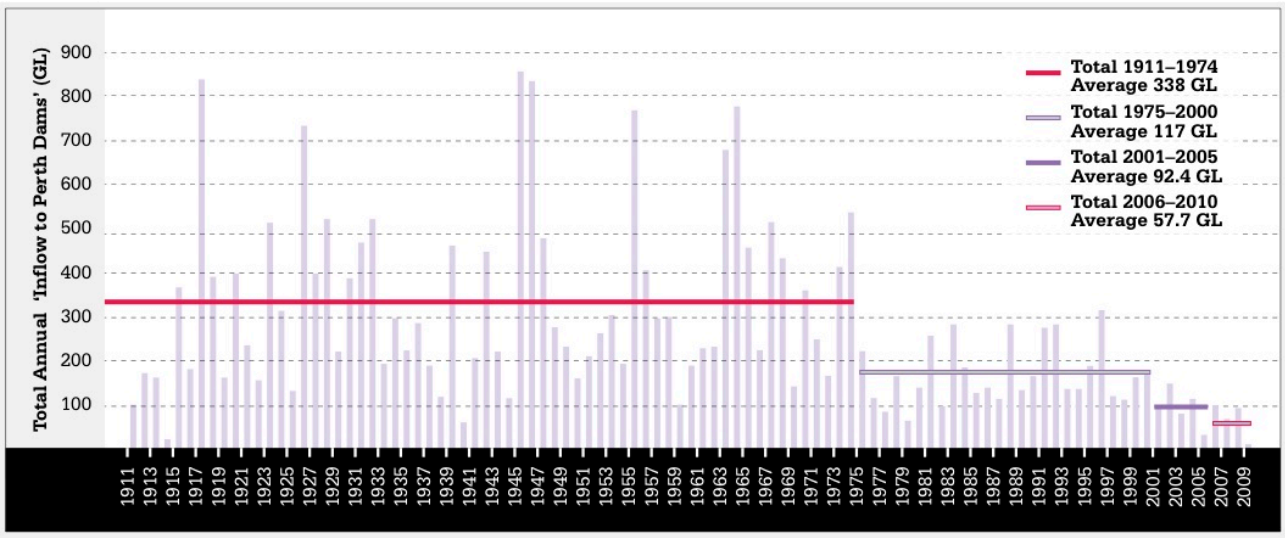



**Figure 3: Trend in total annual stream flow into Perth dams, 1911 – 2010 (source: Steffen and Hughes 2010; pg. 5).**

## 1.2. Sea-level Rise

Trends in global mean sea-level rise are shown in Figure 4. The thin red line depicts the trend, while projections for change in mean-sea level proposed by the Intergovernmental Panel on Climate Change (IPCC) scenarios are shaded in grey. Current mean sea levels are rising at a faster rate than projected under the highest scenarios for change produced by the IPCC in their Fourth Assessment Report (Parry et al., 2007). Further, sea levels along the west coast of Australia have been rising at more than double the global average (Steffen and Hughes, 2010).

## 1.3. Sea-surface Temperatures

The rate of temperature rise in Australian waters has accelerated since the mid-20th century (Poloczanska et al 2012) (Figure 5). In early 2011, sea temperatures along most of Western Australia's coast were 2 to 4°C warmer than usual. As a result, changes in the local abundance and distribution of seaweeds, invertebrates such as abalone, demersal[1] and pelagic fish were reported, with a shift towards a more tropical fish community (Poloczanska et al 2012).

[1] This difference between demersal and pelagic fish is that demersal fish live and feed close to the sea floor while pelagic fish live near the sea surface on in the water column.

## 1.4. Extreme Events

Many of the impacts of climate change are due to extreme weather events rather than changes in average values of climatic parameters. The most important of these are high temperature-related events, such as heat waves and bushfires; heavy precipitation events; and storms, such as tropical cyclones and hailstorms (Climate Commission 2010).

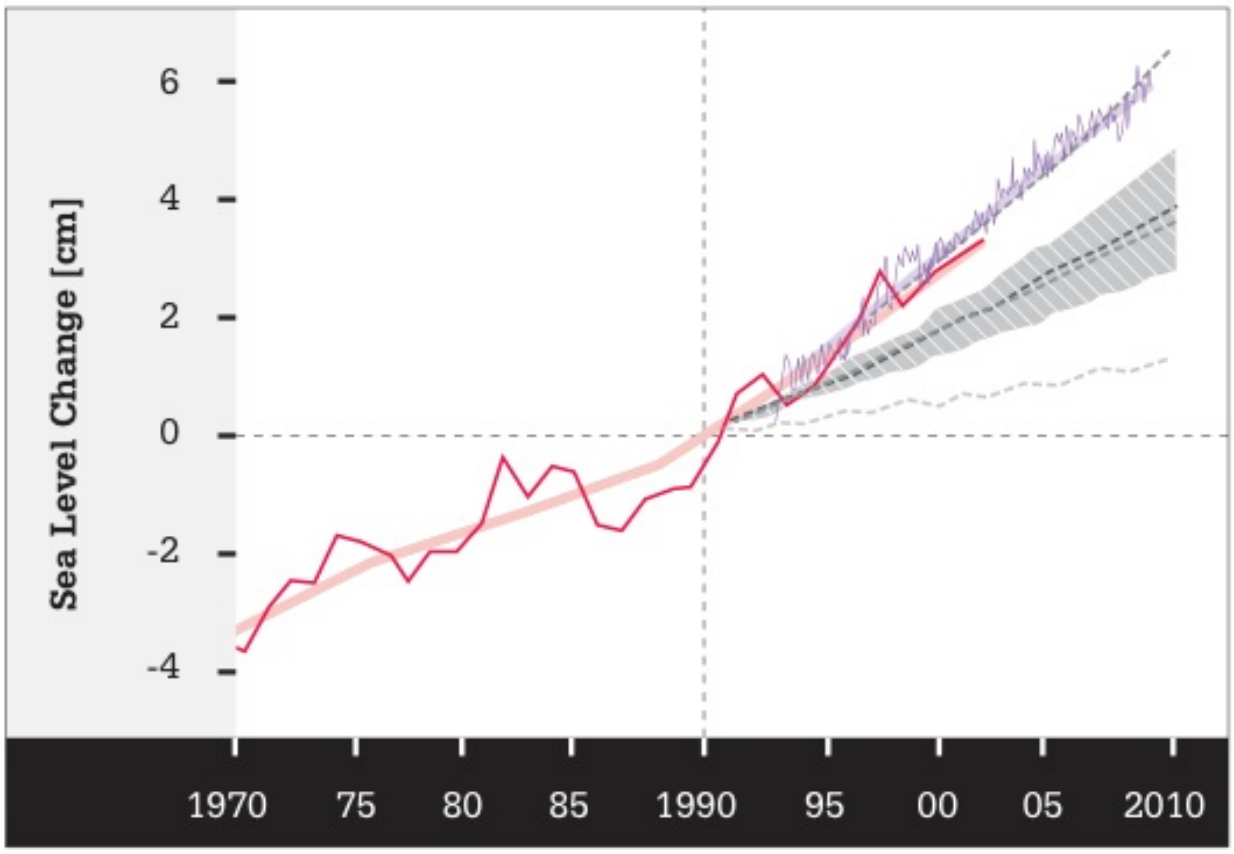



**Figure 4: Global Sea-level change from 1970 to 2008 (source: Climate Commission 2010)**

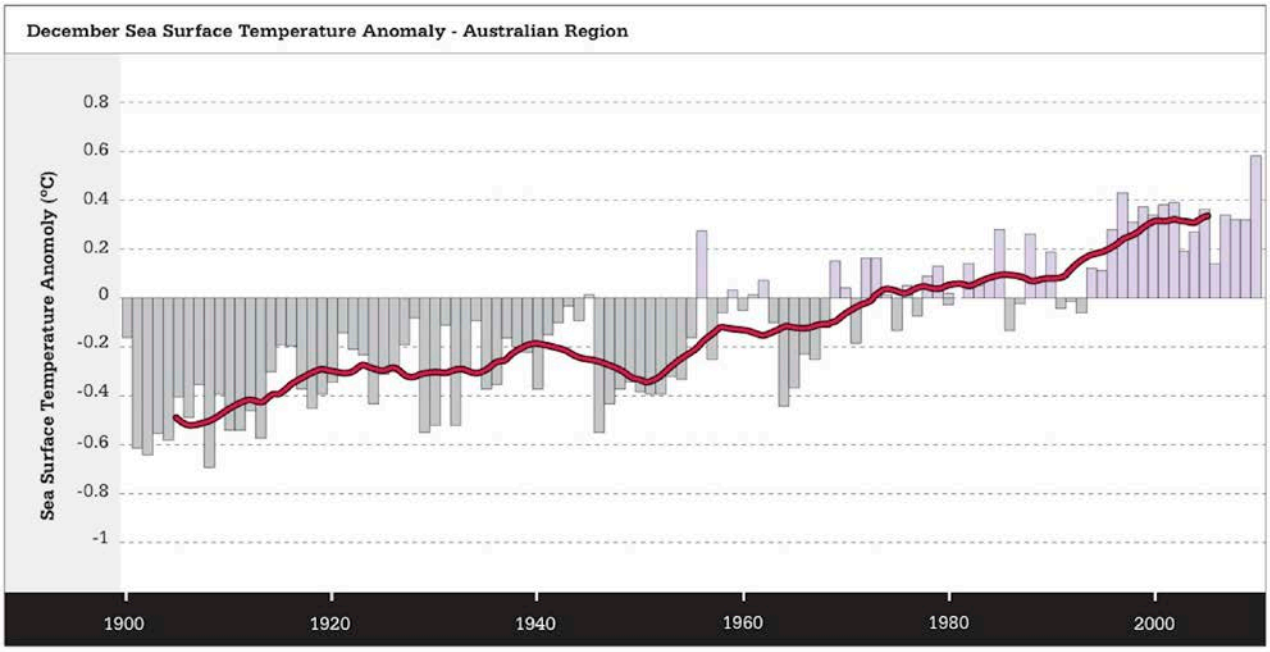



**Figure 5: Sea surface temperature time series for the month of December from 1990 to 2010 for the oceanic region around Australian (source: Climate Commission 2010).**

## How will the climate change in the future?

Scenarios are applied to project future climate conditions. Importantly, scenarios are not predictions. The value of scenario planning is the ability to explore a range of possibilities and make 'robust' decisions that recognise future uncertainties (Biggs et al 2011). Relatively simple scenarios about future climate change are all that is needed when considering implications for the local context, as more detailed simulations of the climate are often less important than developing a deeper understanding of local vulnerability and opportunities to reduce it (Biggs et al 2011).

The City of Stirling Climate Change Adaptation Working Group (CCAWG) considered scenario application adopted by other local governments across Australia, and the primary goals of the current assessment to define scenarios for change. A mid-level scenario and high-end scenario[2] was adopted for 2030 and 2070 respectively. The selection is reflective of the strategic nature of the assessment and the need to consider both short-term and longer-term climate risks to the City.

### 1.5. Temperature, Rainfall and Runoff

Projected climate changes, drawing on the selected scenarios, suggest an increase in seasonal and annual temperature, decline in rainfall, increase in humidity and increase in solar radiation that will have associated significant impacts for ecosystems, economic growth and human settlements (BOM/CSIRO 2007) (Figure 6). Importantly, annual run-off is projected to decline significantly (over 50 per cent reduction), resulting in further projected declines in dam inflow.

### 1.6. Sea-level Rise

Average global sea level is projected to increase by between 0.5 m to 1.0 m this century. Drawing on the scenario adopted in the City's risk assessment, this equates to a rise of 10 cm by 2030 and 40 cm by 2070[3]. Importantly, these values align to the values adopted by the Department of Planning (2012) in the State Coastal Planning Policy: SPP 2.6.

A sea-level rise of 50 cm will lead to increases in the frequency of coastal flooding. For example, flooding that is currently considered a 1-in-100 year event would occur every year in most parts of Western Australia and even more frequently in Perth (Steffen and Hughes, 2010).

### 1.7. Sea-surface Temperatures

The increase in sea-surface temperature experienced in 2011, is expected to become the normality off the Western Australian coast by 2070, with a projected increase of 2 to 2.5°C. Rising mean temperatures have implications for fish species composition of the Western Australian coast and it is anticipated that trends observed in 2011, including changes in the local abundance and distribution of seaweeds, invertebrates, demersal and pelagic fish, will continue.

### 1.8. Extreme Events

The connection between long-term, human-driven climate change and the nature of extreme events is both complex and controversial, leading to intense debate in the scientific community and heated discussion in the public and political arenas (Climate Commission 2010). Extreme events can include high temperature-related events, such as heat waves and bushfires; heavy precipitation events; and storms, such as tropical cyclones and hailstorms.

Projections for change in the number of hot days (defined as days with a temperature over 35°C) suggest an average of seven more extreme hot days per year by 2030 and 26 more extreme hot days by 2070 (BOM/CSIRO 2007). Projections for change in extreme precipitation events and storms are less clear. The consensus is that the frequency of storm events in metropolitan Perth will decrease, however, when they do occur, the intensity of such events will be higher (BOM/CSIRO 2007).

[2] The A1B scenario 2030; A1FI scenario for 2070 . Refer to Annex 2 for details on climate change scenarios.
[3] The projected increase is taken from the baseline at 1990.

## 1.9. Uncertainties in Climate Projections

All existing climate change science has an element of uncertainty regarding regional impacts. These uncertainties remain given the complexity of the climate system and the inability to predict future pathways of human political, social and technological changes (Climate Commission 2010).

Despite uncertainties there is strong international consensus that the climate is changing and will continue to change in the future. Regardless of efforts to reduce greenhouse gas emissions, we are globally committed to a degree of change. As such, impacts will be inevitable. Planning for such change through scenario approaches provides the foundation for adaptive management of climate risks.

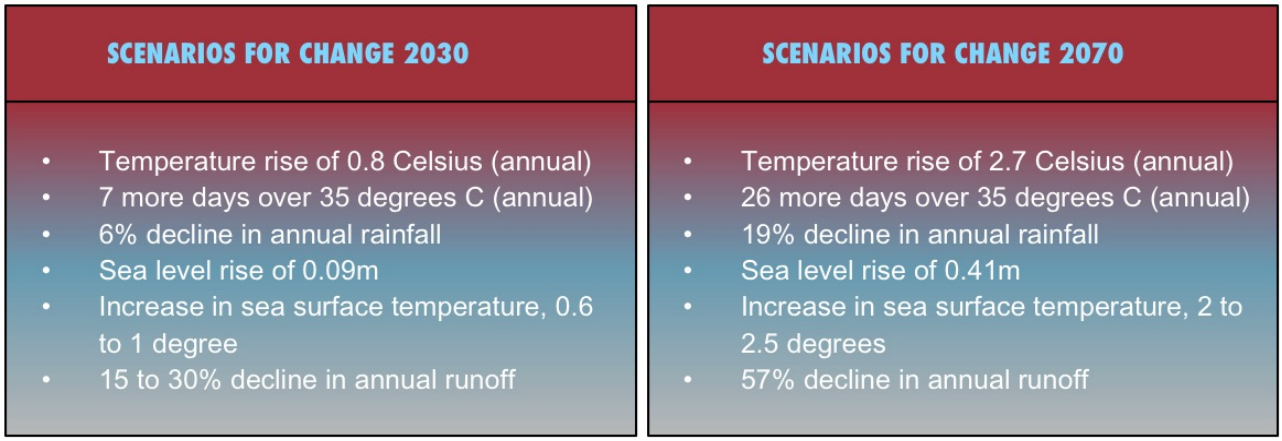



**Figure 6: Projected changes in key climate parameters for 2030 and 2070, A1FI climate scenario (modified from BOM/CSIRO 2007).**

## Climate scenarios

Scenarios for change are an important input into climate change risk assessments. Scenarios are applied to project future climate conditions. Importantly, scenarios are not predictions. The value of scenario planning is the ability to explore a range of possibilities and make 'robust' decisions that recognise future uncertainties (Biggs et al 2011). This section commences with a brief overview of climate scenarios, followed by a discussion on selecting climate scenario's for use in the City's Climate Change Risk Assessment. This is followed by a brief summary of the projections for change in key climate drivers that align to the selected scenarios.

The Intergovernmental Panel on Climate Change (IPCC) has historically produced a number of scenarios of future changes in climate. The scenarios are based on alternate patterns in global social and economic development called 'storylines' (Box 1 and Box 2) and have been applied to explore trends in future Australian climate by BoM/CSIRO (2007). The projections for change in Australian climate are published in the *Climate Change in Australia* report (BoM/CSIRO).

**Box 1: IPCC Climate Change Scenarios**

The **A1 storyline** and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

The **A2 storyline** and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

The **B1 storyline** and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The **B2 storyline** and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Since 2007 there has been rapid development in the generation and application of climate scenarios for adaptation planning. The CSIRO has updated the scenario planning tools available to decision makers through the delivery of the OzClim website; and are currently trialling the *Climate Futures* tool within the Pacific[4]. OzClim allows users to explore projections of change in a range of climate variables, including temperature and rainfall, based on select timeframes, scenarios (low, medium or high) and climate models. Similarly, the Climate Futures tool seeks to combine climate models into particular 'storylines' as a way of exploring different futures. The IPCC is also transitioning from the provision of scenarios (i.e. A1B, A1FI) to the generation of Representative Concentration Pathways (RCPs). This transition, while in its infancy, is intended to heighten collaboration between impacts, adaptation and vulnerability research as well as climate and integrated assessment modelling (Moss et al 2010). Importantly, the climate change modelling community is now using the RCP paradigm to develop the scenarios to be used in the IPCC Fifth Assessment Report, due for completion in 2014.

These advances are intended to support adaptive decision making, providing decision makers with more direction in the creation of scenarios and associated projections of change (or alternate futures). However, the numerous options for application in climate change vulnerability and adaptation assessments may appear daunting. Particularly as many decision makers prefer predictive

[4] http://www.pacificclimatefutures.net/

approaches to more open-ended scenario planning processes. Yet, placing too much emphasis on prediction can lead to choices that do not consider all potential outcomes and increase the potential impacts of climate change or reduce capacity to adapt to different types of events (Gibbs et al 2010). Using scenario approaches provides an opportunity to discuss underlying assumptions and to consider opportunities for more innovative, far-reaching and positive change.

**Box 2: IPCC Climate Change Scenarios Summary for Policy Makers**

The IPCC developed four different narrative storylines to describe consistently the relationships between emission driving forces and their evolution and add context for scenario quantification. Each storyline represents different demographic, social, economic, technological, and environmental developments, which may be viewed positively by some people and negatively by others.

The scenarios cover a wide range of the main demographic, economic, and technological driving forces of GHG and sulphur emissions. Each scenario represents a specific quantitative interpretation of one of four storylines. All the scenarios based on the same storyline constitute a scenario "family" (figure below).

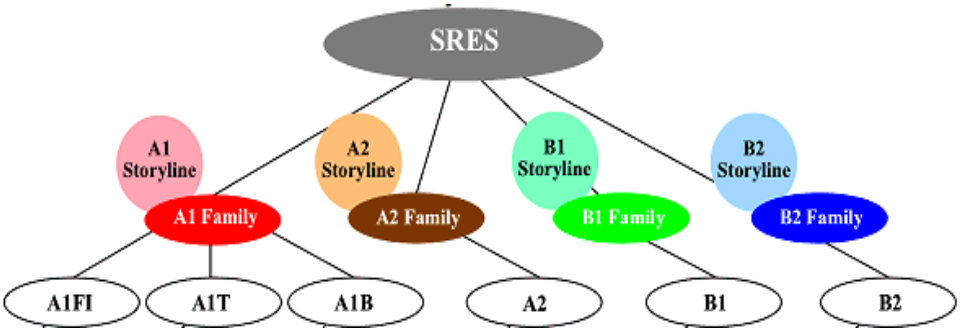



**Figure 7: Six scenario groups developed by the IPCC (2007)**

The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). Within each family and group of scenarios, some share "harmonized" assumptions on global population, gross world product, and final energy.

By 2100 the world will have changed in ways that are difficult to imagine - as difficult as it would have been at the end of the 19th century to imagine the changes of the 100 years since. Each storyline assumes a distinctly different direction for future developments, such that the four storylines differ in increasingly irreversible ways. Together they describe divergent futures that encompass a significant portion of the underlying uncertainties in the main driving forces. They cover a wide range of key "future" characteristics such as demographic change, economic development, and technological change. For this reason, their plausibility or feasibility should not be considered solely on the basis of an extrapolation of current economic, technological, and social trends (Box 1).

There are six scenario groups that should be considered equally sound that span a wide range of uncertainty.

Available from: http://www.ipcc.ch/

## 1.10. Scenario selection for the City of Stirling

When applying scenarios to inform decision making, the type or number of scenarios applied will vary depending on the decision-making context. Biggs et al (2011) note that relatively simple scenarios about future climate change may be all that is needed when considering implications for the local context, as more detailed simulations of the climate are often less important than developing a deeper understanding of local vulnerability and opportunities to reduce it. Further, Biggs et al (2011) align applications of scenarios to different adaptation decision-making contexts (Table 1). The adoption of multiple scenarios is important when planning investment decisions, to ensure the range of uncertainties are considered and planned for as appropriate.

**Table 1: Ways scenario planning can assist in meeting key climate adaptation challenges (Biggs et al 2011)**

| Key Policy and Research Questions | Types of scenarios and ways in which they can be used to answer questions and meet challenges |
|---|---|
| Understanding | |
| Do we need to adapt to climate change?<br>What climate trends and impacts do we need to adapt to?<br>What climate change risks do we face?<br>How do these climatic risks interact with other non-climatic trends, drivers, stressors and risks?<br>Who or what needs to adapt? Who or what is most vulnerable?<br>How do we raise awareness about climate adaptation risks?<br>How do we engage key stakeholders? | Using down-scaled global and national climate change scenarios to identify possible local and regional climatic changes.<br>Using climate change scenarios as inputs to social and economic impact, risk and vulnerability assessments.<br>Developing 'tailored' local and regional scenarios to explore interactions between climate change and other local and regional drivers.<br>Developing local impact scenarios to identify vulnerable people and places.<br>Using or developing local impact scenarios to strengthen shared understanding of need for adaptation.<br>Developing local impact scenarios as a means of engaging citizens and stakeholders in consideration of risks and current vulnerabilities. |
| Planning | |
| What kind of future do we want to create?<br>What actions are needed to create this future?<br>What climate adaptation options are available?<br>What criteria should we use to assess various climate adaptation options?<br>How do we engage key stakeholders in identifying, assessing and selecting climate adaptation options? | Using local impact scenarios to stimulate creative thinking about possible adaptation options.<br>Developing and using local impact or climate adaptation response scenarios to assist communities and stakeholders identify possible and desirable futures.<br>Development of climate adaptation scenarios to show what might happen if different adaptation options are enacted.<br>Using climate adaptation scenarios to test the robustness of different policy options or adaptation measures under different plausible futures.<br>Developing impact or climate adaptation scenarios with a range of stakeholders to build shared understanding of adaptation priorities. |
| Implementing | |
| What is the most effective way of implementing the chosen climate adaptation option?<br>What actions can be taken to improve the capability of organisations and communities to implement climate adaptation policies and programs? | Using scenarios to test and evaluate the ongoing effectiveness and robustness of climate adaptation policies and plans.<br>Using scenarios to improve social learning/reflexive organisations. |

During the Set the Context meeting, the City of Stirling Climate Change Adaptation Working Group (CCAWG) considered different approaches to scenario application adopted by local governments across Australia, and the primary goals of the risk, vulnerability and adaptation assessment conducted by the City. The selected scenarios and timeframes for change are reflective of the strategic nature of the current assessment and the need to consider both more immediate (short-term) and longer-term vulnerabilities and climate risks to the City.

The timeframes adopted for the study are: 2030 and 2070. These timeframes align to those adopted by other local governments in Western Australia and provide a more immediate (short-term) and longer term planning horizon.

The climate change projections adopted in the study at 2030 are based on the IPCC A1B climate change scenario (50$^{th}$ percentile), while the IPCC A1FI climate change scenario is adopted for 2070 (50$^{th}$ percentile). The A1B climate scenario represents the mid-range of scenarios produced by the IPCC. In the near term (i.e. 2030), the variation in emissions of greenhouse gases and aerosols represented by the IPCC Special Report on Emission Scenarios (SRES) (IPCC, 2000) makes only a small contribution to uncertainty in global warming given historic emissions; whereas climate changes later in the century are more dependent on the particular pattern of greenhouse gas emissions that occur through the century (CSIRO 2007; pg. 49). Consequently, the *Climate Change in Australia Report* only outline projections for multiple scenarios for timeframes post 2030 (i.e. 2050 and 2070).

The A1FI scenario is the most pessimistic climate change scenario developed through the IPCC SRES. While the A1FI scenario is the upper limit of climate change projections, recent measurements of the global climate from 1990 (the baseline from which climate change scenarios are calculated) have suggested that global climate change is currently tracking to this upper scenario (UCH, 2009; Hennessey 2008). Further, this scenario is consistent with those used by other local governments in Western Australia that have undertaken similar strategic climate change risk assessments.

The decision not to explore projections for multiple scenarios at 2070 was deemed appropriate as the assessment represents the first stage in planning and responding to climate change for the City. Consequently, it was deemed appropriate to adopt a simple approach that incorporated the range of projected change for the City.

## 1.11. Climate projections

Perth is currently characterised by a warm Mediterranean climate with cool wet winters and hot dry summers. Meteorological data collected from Perth Regional Office station indicates an average[5] annual maximum temperature of 23.9$^{o}$C; average annual minimum temperature of 14.0$^{o}$C and an average annual rainfall of 819.4mm (BoM 2009).

Projected climate changes, drawing on the selected scenarios, suggest an increase in seasonal and annual temperature, decline in rainfall, increase in humidity and increase in solar radiation that will have associated significant impacts for ecosystems, economic growth and human settlements across the region (CSIRO 2007). The projections in Table 2 are not presented for all climate variables and are based on the results of multiple climate models and do not account for local topographical effects. However, they are considered to be sufficiently reliable from which to draw inferences on potential changes in climate that will likely affect the City of Stirling up to 2070.

Several climate variables required to assess climate change risk in coastal environments are not incorporated within Table 2. For example, projections for change in mean sea level. Consequently, the methodology described by the National Committee on Coastal and Ocean Engineering (NCCOE) (2004) was applied to ensure the suite of variables for the Study area, which includes coastal environments, was available. The NCCOE (2004) framework considers ocean water levels, winds, wave conditions, coastal currents, sediment transport patterns and ocean nutrients for assessing risk of climate change in the coastal zone (NCCOE 2004). Information in Table 3 is drawn primarily from CSIRO (2007), and supplemented with information drawn from the IPCC Fourth Assessment Report (IPCC 2007), Indian Ocean Climate Initiative (IOCI) documents and other recent scientific publications, where appropriate.

[5] Average climatic conditions are based on the 1961 – 1990 baseline, following CSIRO (2007).

It is useful to note that there are a number of outstanding information gaps. For example, changes to wave climate, wind speed and extreme water levels are not adequately addressed by existing information. This is largely due to the fact that a detailed understanding of how these environmental variables respond to climate change at the local scale is lacking and predictive models are unable to interpret response with any certainty at this stage. However, due to the strategic nature of the current assessment, these information gaps will not significantly influence the assessment outputs.

**Table 2: Climate change projections for key climate variables for Perth (CSIRO 2007).**

| Variable | Season | 2030 | 2030 | 2030 | 2070 | 2070 | 2070 |
|---|---|---|---|---|---|---|---|
| | | A1B | A1B | A1B | A1FI | A1FI | A1FI |
| | | 10p | 50p | 90p | 10p | 50p | 90p |
| Temperature (°C) | Annual | 0.6 | 0.8 | 1.2 | 1.9 | 2.7 | 3.8 |
| | Summer | 0.6 | 0.9 | 1.3 | 1.9 | 2.9 | 4.2 |
| | Autumn | 0.6 | 0.8 | 1.2 | 1.6 | 2.7 | 3.9 |
| | Winter | 0.5 | 0.7 | 1 | 1.6 | 2.3 | 3.3 |
| | Spring | 0.6 | 0.9 | 1.3 | 1.9 | 2.9 | 4.1 |
| No. of days over 35°C. (current 28.1) | Annual | 33.1 | 35.1 | 36.7 | 44.1 | 53.8 | 67.4 |
| No. of days over 40°C. (current 4.13)[6] | Annual | 5.8 to 7.4 (across four climate models) | | | 11.5 to 21 (across four climate models) | | |
| Rainfall (%) | Annual | -13 | -6 | +1 | -37 | -19 | +2 |
| | Summer | -16 | -4 | +9 | -43 | -12 | +28 |
| | Autumn | -15 | -4 | +8 | -41 | -12 | +26 |
| | Winter | -14 | -7 | -1 | -39 | -22 | -2 |
| | Spring | -18 | -9 | -2 | -48 | -27 | -7 |
| Potential Evaporation (%) | Annual | +1 | +2 | +4 | +4 | +7 | +12 |
| | Summer | +1 | +2 | +3 | +2 | +6 | +11 |
| | Autumn | +1 | +3 | +5 | +4 | +9 | +17 |
| | Winter | +2 | +5 | +9 | +7 | +16 | +28 |
| | Spring | 0 | +2 | +4 | +1 | +6 | +13 |
| Wind-speed (%) | Annual | -3 | 0 | +2 | -9 | -1 | +7 |
| | Summer | -1 | +2 | +7 | -5 | +8 | +24 |
| | Autumn | -2 | +2 | +7 | -7 | +6 | +21 |
| | Winter | -10 | -4 | +1 | -34 | -14 | +4 |
| | Spring | -5 | -1 | +3 | -17 | -3 | +10 |
| Relative humidity (%) | Annual | -1.3 | -0.6 | +0.0 | -4.0 | -2.0 | -0.3 |
| Solar radiation | Annual | -0.1 | +0.4 | +1.0 | -0.3 | +1.4 | +3.3 |

[6] Extreme Temperature exceedance based on Hennessey et al. (2011) “Methods for producing extreme temperature projections for Australia” http://www.climatechangeinaustralia.gov.au/resources.php

**Table 3: Perth region coastal climate change scenarios**

| Key Variable | Code | Perth Regional Coastal Scenario | Comment |
|---|---|---|---|
| Mean Sea Level | K1 | Projected range of sea level rise (m) relative to 1990 baseline has been produced by Hunter (in press) (who analyzed the AR4 outputs in combination with the TAR outputs to establish time series data[7]), and was adopted by State Coastal Planning Policy: SPP 2.6 (2010). In projections are normalized to 2010.<br>SPP 2.6 (normalised to 2010)<br>2030 2070<br>**0.09m 0.41** | Importantly, these values align to the 0.9m rise in mean sea-level by 2110, as adopted by the Department of Transport (2010) for application to the State Coastal Planning Policy: SPP 2.6. |
| Ocean Currents and Temperature | K2 | Median values of sea surface temperature for the A1FI scenario (50%) (fig 5.49, CSIRO 2007):<br>• 0.6 to 1.0 (2030) and<br>• 2.0 to 2.5 (2070) | It is not clear at present, how potential climate-change driven changes to SSTs will affect the Leeuwin Current. As such, this has implications for SSTs immediately offshore of Perth, with implications for foreshore vulnerability (direct sea-level impact) and also primary productivity with potential implications for sediment supply. |
| Wind Climate | K3 | See Table 2.<br>These scenarios suggest an overall very small reduction in mean annual wind speed, with disproportionate seasonal changes – a reduction in winter/spring, and increase in summer/autumn. | Perth regional winds are highly event driven and influenced by local land sea-breeze cells (Pattiaratchi et al., 1996). Mean wind predictions will not represent these processes.<br>Extreme winter wind projections are expected to reduce in a similar proportion to mean winter wind speeds. It is less certain whether extreme summer winds will, or are likely to, increase corresponding to mean summer winds. |
| Wave Climate | K4 | No recent scenarios of the implications of climate change on local or swell-driven waves. Inferring wave climate from the wind climate projections (local wind wave component only) suggests a lower proportion of local wind-waves. Climate change scenarios move the swell-wave generation zone further south. At present the mean sea-wave is 2.5 m off the SW Capes and 1.5m off Shark Bay. Assuming that this North-South gradient of swell-wave energy is maintained in the future, it may be inferred that mean swell waves will decrease, and that greater decreases will occur under the higher emission scenarios. | These are initial interpretations only. The recent analysis of Hemer et al (2008) analysed historical wave climates for all Australian waters. This study is expected to form the basis of future studies that link measured historic wave climate variability with climate change models. |
| Rainfall / Runoff | K5 | See Table 2<br>Runoff changes:<br>2030 A1FI (%): Annual; -15 to -30<br>2070 A1FI (%): Annual, -57 | While changes in the frequency of occurrence of high intensity precipitation events are possible, the current understanding of climate change in SW WA precludes any conclusions being drawn in this regard (Berti et al, 2004, Pearcey, Department of Water, pers comm., Nov 2008). |

[7] See http://www.cmar.csiro.au/sealevel/sl_proj_21st.html#21C_ts

| Key Variable | Code | Perth Regional Coastal Scenario | Comment |
|---|---|---|---|
| | | | The work of the Department of Water with CSIRO (Berti et al, 2004), including work soon to be published on the Serpentine catchment (Pearcey, pers comm.) has developed a 'rule of thumb' of a three times multiplier of mean annual rainfall to the resulting changes in annual runoff. These multipliers have been applied here. |
| Air Temperature | K6 | See Table 2 | Increases are possible in the frequency of occurrence of extremely high temperatures with reductions in the frequency of very low temperatures. |
| Extreme Water Levels | K7 | Analysis of historic extreme water levels at Fremantle show that there is a direct relationship between extreme event levels and mean sea-level changes. The frequency of high water level events on a decadal time scale is strongly modulated by tidal cycles and inter-annual mean sea level variations associated with ENSO. A recent analysis of potential extreme water levels in the Peel-Harvey system (M. P. Rogers & Associates, 2008) concluded that "Limited information exists as to the change in frequency and intensity of extreme sea level events due to climate change, so the probability of the 1 in 100 year event occurring in 2008 is assumed to be the same as it occurring in 2100". In the lack of information applicable to the Swan-Canning estuary, this conclusion is considered valid for the current assessment. | |

# Annex 2: Risk Assessment and Adaptation Planning: Approach

## Climate Change Adaptation Plan: Preparing for and responding to climate risks in the City of Stirling

# Table of Contents

# 1. Introduction

This Annex details the approach adopted to complete Risk Assessment and Adaptation Planning for the City of Stirling in 2012. An overview of the risk management framework adopted is provided. In addition, the evaluation framework used to assess risks is presented. The evaluation framework draws on the City of Stirling's Risk Management Framework (City of Stirling 2011a).

The City promotes a flexible approach to risk management, and as such, endorses the modification of the framework to ensure that it is fit-for-purpose for the select decision-making context. The consultants worked in partnership with the Coordinator of Risk Management and the Climate Change Adaptation Working Group (CCAWG) to construct an evaluation framework to assess climate risk to the City. The resultant framework primarily draws on the existing risk management framework of the City, while the rationale for modifications, where made, are presented.

# 2. Introduction to Risk Assessment

Risk management is the process of defining and analysing risks to facilitate subsequent decision making on the appropriate course of action to minimise these risks. The Risk Assessment Framework applied in this assessment is one recommended by the Australian Government. The Australian Greenhouse Office (AGO, now the Department of Climate Change and Energy Efficiency (DCCEE)) publication, '*Climate Change Impacts and Risk Management: A guide to business and government*' (referred to herein as the AGO Risk Framework) outlines a methodology to conduct climate change risk assessment and risk treatment (adaptation planning) based on the Australian/ New Zealand Standard Risk Management framework (AS/NZS 4360:2004)[1].

There are five core phases to this framework (Table 1 and Figure 2):

- Set the context
- Identify the risks
- Analyse the risks
- Evaluate the risks
- Treat the risks.

**Table 1: Phases in the risk assessment framework (AGO 2007)**

| Phase | Description |
|---|---|
| Set the Context | Defining the business or organisation to be assessed and the scope of the assessment<br>Clarify the objectives of the organisation<br>Identify stakeholders and their objectives and concerns<br>Establish success criteria<br>Develop key elements<br>Determine relevant climate change scenarios for the assessment |
| Identify the Risks | Describe and list how climate changes impact each of the key elements of the organisation |
| Analyse the Risks | Review the controls, management regimes and responses already in place to deal with each specific risk<br>Assess the consequences of each risk against the organisations objectives and success criteria<br>Form a judgement about the likelihood of each identified consequence<br>Determine the level of risks to the organisation for each of the climate change scenarios used in the analysis |

[1] The updated ISO 31000 Risk Management framework has since replaced this standard; however the stages within the framework remain consistent. The updated framework will guide the risk assessment process as relevant. The terms and assessment approach, as advocated in the ISO 31000 are applied herein.

| Phase | Description |
|---|---|
| Evaluate the Risk | Re-affirm the judgements and estimates<br>Ranking the risks in terms of their severity<br>Screening out minor risks that can be set aside and which otherwise distract attention of management<br>Identify those risks for which more detailed analysis is recommended |
| Treat the Risk | Identify relevant options to manage or adapt to the risks and their consequences<br>Select the best options incorporating these into forwards plans and implementing them |

The overarching role of the risk assessment framework is to enable a systematic and defendable approach to risk management and treatment. The approach is focused on treating organisational risks. The link between climate change and organisational risks is shown in Figure 1.

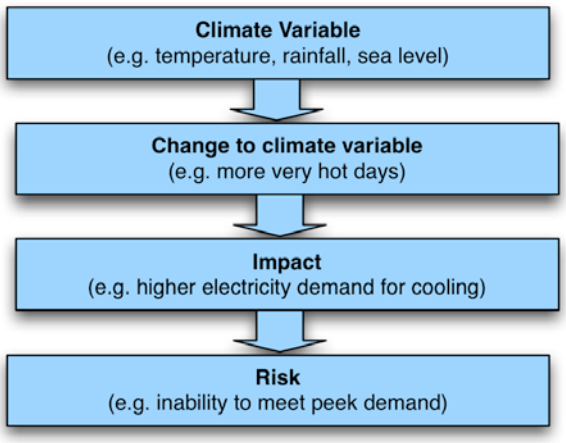



**Figure 1: Link between climate change and risk (AGO 2007)**

The impacts of climate change on an organisation can be identified and subsequently treated by working through the chain of consequences. It is important to note that the outcome is a strategic risk assessment and treatment plan, which is not designed to deliver spatially refined treatment recommendations.

The five phases of the risk assessment framework are detailed below.


**Figure 2: The AGO risk assessment process**

# 3. WORKSHOP ONE: Setting the Context

The Set the Context phase of the risk assessment establishes the boundaries and scope of the assessment, the evaluation framework and specifies the stakeholder engagement strategy. The key activities completed within the context-setting phase include:

- Set the scope of assessment
- Define the objectives of the organisation (objectives of the assessment)
- Establish success criteria against which risks to organisation's objectives can be evaluated
- Define likelihood scales
- Identify key elements as a means of restructuring the process
- Select relevant climate change scenarios for the assessment
- Complete stakeholder identification.

Risk assessment terminology is also defined to ensure clear understanding of the language that will be used to evaluate and describe climate change risks (Table 2).

The Set the Context phase was undertaken through a workshop process with the CCAWG at the outset of the Project. The outputs of this step guide subsequent phases of the risk assessment, through production of an evaluation framework. The outcomes of the Set the Context activities are summarised below and presented in the *Set the Context Report* (an internal project deliverable to the City of Stirling). For further information about any stage of the framework, refer to the *Climate Change Impacts and Risk Management: A Guide to Business and Government* (AGO 2007).

**Table 2 Key risk assessment terminology**

| *Term* | *Definition* |
|---|---|
| Success Criteria | The goals and objectives of an organisation |
| Consequence Scales | Describes the level of consequence to an organisation of a climate change risk, should it occur |
| Likelihood | The probability of an event arising |
| Risk Priority | The level of priority associated with each combination of consequence and likelihood |

## 3.1. Project Scope

The Project was limited in geographical extent to the City of Stirling local government boundaries. The assessment examined potential climate change risks to the City, resulting from change in key climate variables (refer to Annex 2 for details on scenarios).

The assessment was a 'first pass' strategic assessment of climate risk to the City. AGO (2007) recommends a two-stage approach to risk assessment to allow effort to be directed towards the highest priority issues. The initial assessment (also termed 'first pass') identifies and reviews risks quickly, followed by treatment planning and implementation for those risks that require it. In the second phase, detailed analysis is undertaken where additional information is needed to determine whether treatment is required or what form of treatment to adopt (Figure 3).

The initial assessment is a rigorous method of identifying and appraising risks that allows:

- Immediate treatment of risks that can be identified through simple analysis;
- Issues that do not require further consideration to be set immediately aside;
- More detailed technical analysis to be focused on priority issues (AGO 2007).

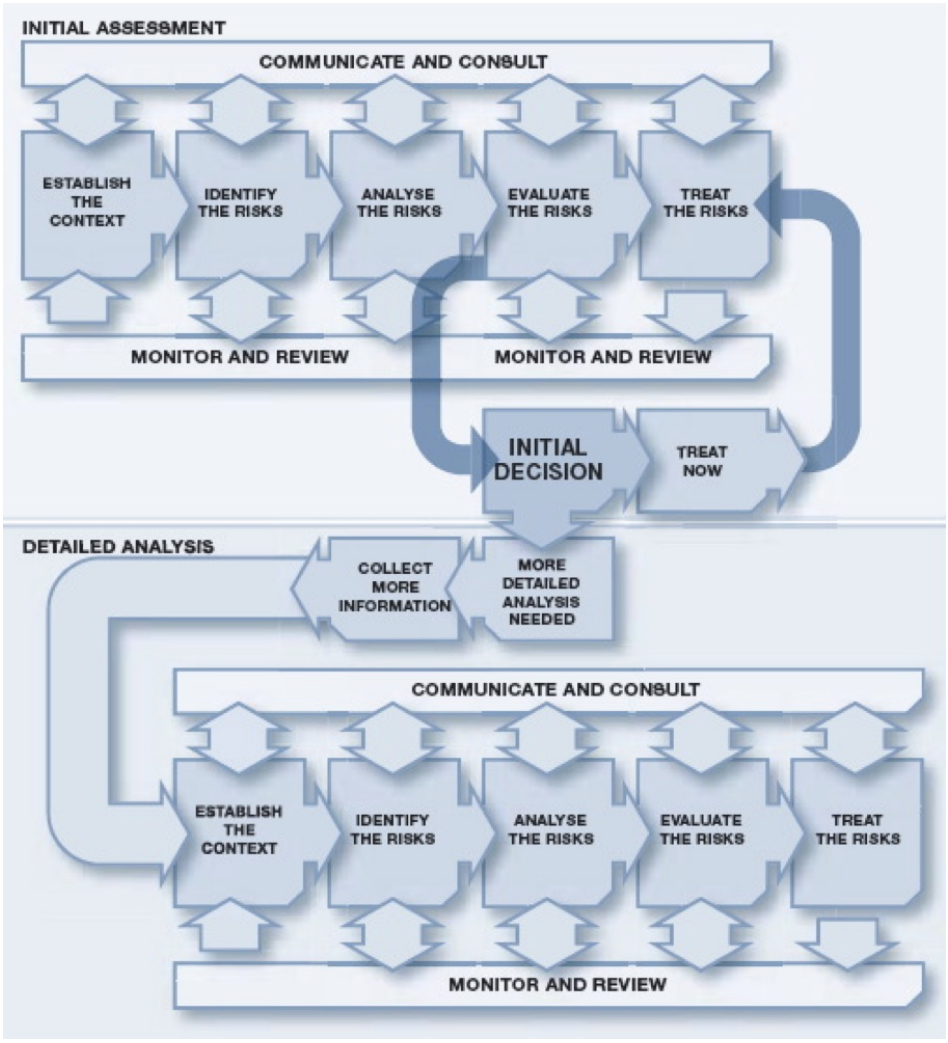



**Figure 3: Two phased approach to risk assessment (AGO 2007)**

## 3.2. Climate Change Scenarios and Timeframes

Full details on the climate change scenarios and timeframes adopted in the assessment is presented in Annex 1. The CCAWG considered the range of scenarios available and the purpose of the current assessment, to inform the selection of the A1B 50$^{th}$ Percentile for 2030 and the 50$^{th}$ Percentile A1FI Scenario for 2070 (see Annex 1 for projections of change in climate drivers for these timeframes). This was considered appropriate as best practice among other local governments has been to use the A1FI 2070 scenario in strategic climate change risk assessments (for example, WESROC, EMRC, Mandurah, Murchison, Mid West Regional Council).

## 3.3. Evaluation Framework

Setting the evaluation framework for application in the risk assessment entails:

- Defining the objectives of the organisation (objectives of the assessment);
- Establishing success criteria against which risks to the organisations objectives can be evaluated; and
- Defining likelihood scales.

An evaluation matrix is required for each component, to ensure a consistent and transparent approach to risk evaluation. The components of the evaluation framework applied in the current assessment follow the City of Stirling's Risk Management Framework (2011) and are presented in Table 3 to Table 5 and discussed briefly below.

### 3.3.1. Organisational Objectives

The City's vision is to deliver responsive, sustainable services to its diverse community (City of Stirling 2009). In doing this, the City seeks to preserve and enhance its environment and lifestyle, now and into the future. The core values of the city are: integrity, diversity, environment, respect, community participation and accountability.

### 3.3.2. Success Criteria

Success criteria are essentially a summary of the organisations long-term objectives (AGO 2007). By combining success criteria with a consequence scale, it is possible to describe the level of consequence of a risk associated with climate change. Drawing on the City of Stirling's Risk Management Framework (RMF) (2011), the success criteria for the City can be summarised as:

- To meet strategic performance objectives.
- Ensure sound public administration and governance (financial, legislative, reputation and OHS).
- Sustain and enhance the natural environment.
- Protect existing community services and the lifestyle enjoyed by the people of the region.

These four broad criteria were captured under six distinct success criteria for application in the climate change risk assessment:

- Provision of service/performance (including reputation impacts)
- Property (degree of damage)
- Financial (Revenue and costs)
- Environment
- People (Health & safety to public and employees)
- Social Value & Community Lifestyle

The success criteria adopted are modified from those outlined in the City's Risk Management Framework. The primary changes to the success criteria in the City's RMF include:

- 'Legislation' was removed as a stand-alone category of consequence (or success criteria) to be captured under 'Provision of service/performance (including reputation impacts)';
- Property damage was noted as a key consequence of relevance to climate change that was not adequately captured within the existing consequence scale. This was added as a stand-alone category.
- Financial and Environment remained consistent across frameworks.
- 'People' was added to capture both consequences for council staff and the broader community.
- Social Value and Community lifestyle was added, as social elements were not captured in the original framework.

The modified consequence scale was reviewed by the CCAWG during the Set the Context phase of the project. Participants discussed opportunities to enhance the clarity of terms adopted in the consequence matrix, particularly under 'Environment' and 'Community'. Post the Set the Context Meeting, the City's Coordinator of Risk Management worked to refine the Consequence scale to ensure it was fit for purpose.

Risk Management within the City of Stirling follows a flexible ethos, where the consequence and likelihood evaluation scales can be modified[2] to ensure they are relevant to the assessment context. This flexible approach ensures those involved can apply meaningful scales (and associated

[2] Modification of the evaluation scales (i.e. 5 point scale) is not supported.

descriptions) of analysis that have been generated through a collaborative approach. The consequence scale adopted is presented in Table 5.

### 3.3.3. Likelihood Scales

Risk is often expressed in terms of the (ISO 31000:2009):

- Consequence of an event; and
- Likelihood of the consequence.

The likelihood of the consequence occurring is rated based on a five-point scale (Table 3).

**Table 3: Likelihood scale (City of Stirling 2011a)**

| Level | Description |
|---|---|
| Almost certain | Occurs regularly or is almost certain to occur.<br>A clear opportunity already apparent, which can easily be achieved |
| Likely | Occurrence is noticeable or is likely to occur.<br>An opportunity that has been explored and may be achievable |
| Possible | Occurs occasionally or may occur.<br>Possible opportunity identified |
| Unlikely | Occurs infrequently or not likely to occur.<br>Opportunity that is fairly unlikely to happen. |
| Rare | Only occurs in exceptional circumstances. Opportunity that is very unlikely to happen. |

**Table 4: Risk matrix (City of Stirling 2011a)**

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

**Table 5: Success/Consequence scale**

| | Provision of service / performance (including reputation impacts) | Property (degree of damage) | Financial (Revenue and costs) | Environment | People (Health &safety to public and employees) | Social Value & Community Lifestyle |
|---|---|---|---|---|---|---|
| **Catastrophic** | Long term/irreversible impact on ability to provide services<br><br>Significant long term damage to public confidence in the City<br><br>Exceptional improvement on the ability to provide services and public confidence in the City | Total and permanent loss or damage, replacement required<br><br>Significant improvement in the condition, characteristics and value of property in the City | Adverse impact on annual revenues and costs<br>>15% deviation from budget<br>Increase in asset value of >15%.<br>Positive impact on annual revenues with >15% rise in revenue | Major widespread loss of environmental amenity and progressive irrecoverable environmental damage<br><br>Exceptional improvement to local environment | Death<br><br>Exceptional improvement in the health and safety of the public and employees | Permanent loss of access, amenity, aesthetics and/or cultural value of asset/infrastructure<br><br>Permanent decline in the quality of life<br>Exceptional improvement to community services, well-being and safety |
| **Major** | Major, long-term disruption to services<br><br>Adverse local publicity of a major and persistent nature/affects the perception/standing of the City within the community<br>Improvement on the ability to provide services and public confidence in the City | Major damage of the asset/infrastructure, significant repairs required<br><br>Major improvement in the condition, characteristics and value of property in the City | Adverse impact on revenue and costs<br>5%→15% deviation from budget<br>Increase in asset value of 5-15%.<br>Positive impact on annual revenues with 5-15% rise in revenue | Severe loss of environmental amenity and a danger of continuing environmental damage<br><br>Major improvement to local environment | Multiple serious injuries and/or major OS&H and WC incident/issue<br><br>Major improvement in the health and safety of the public and employees | Long term loss of access, amenity, aesthetics and/or cultural value of asset/infrastructure<br><br>Evident decline in the quality of life<br>Major improvement to community services, well-being and safety |
| **Moderate** | Disruption to an important service area for a short period<br><br>Negative publicity or damage to reputation to a specific audience which may not have significant long-term community effects<br>Improvement in an important service area for a limited period and limited improvement in select audiences confidence in the City | Moderate damage of the asset/infrastructure, repairs required<br><br>Moderate improvement in the condition, characteristics and value of property in the City | Adverse impact on revenue and costs<br>2%→5% deviation from budget<br>Increase in asset value of 5-15%.<br>Positive impact on annual revenues with 5-15% rise in revenue | Isolated but significant instance of environmental damage that might be reversed with intensive efforts<br><br>Moderate improvement to local environment | Serious injury and/or illness<br><br>Moderate improvement in the health and safety of the public and employees | Short term loss of access, amenity, aesthetics and/or culture value of asset/infrastructure associated with regular activities<br>Short term decline in the quality of life<br>Moderate improvements to community services, well-being and safety |

| | Provision of service/performance (including reputation impacts) | Property (degree of damage) | Financial (Revenue and costs) | Environment | People (Health &safety to public and employees) | Social Value & Community Lifestyle |
|---|---|---|---|---|---|---|
| **Minor** | Brief disruption of an important service area<br><br>Minor negative publicity or damage to reputation to an insignificant audience (complaint from a group of people)<br>Minor improvement in service delivery in one service area and minor positive publicity from an insignificant audience | Minor damage to asset/infrastructure, monitoring required to ensure it does not worsen<br><br>Minor improvement in the condition, characteristics and value of property in the City | Adverse impact on revenues and costs <2% deviation from budget<br>Increase in asset value of <2%<br>Positive impact on annual revenues with <2% rise in revenue | Minor transient environmental damage that could be reversed<br><br>Minor improvement to local environment | First aid or minor lost time injury and/or minor OS&H liability incident/issue<br><br>Minor improvement in the health and safety of the public and employees | Short term loss of access, amenity, aesthetics and/or cultural value of asset/infrastructure associated with occasional activities<br><br>Brief decline in the quality of life<br>Minor improvements to community services, well-being and safety |
| **Insignificant** | Brief disruption of non-crucial service area<br><br>Minor unsubstantiated negative publicity or damage to reputation to an insignificant audience<br>Maintained service delivery and public confidence in the City | Negligible damage<br><br>Negligible improvement in the condition, characteristics and value of property in the City | Insignificant adverse impact on annual revenue or costs<br>Insignificant rise in value of asset based or revenue | Negligible environmental damage requiring no restoration<br><br>Negligible improvement to local environment | Incident with or without minor injury<br><br>Insignificant improvement in the health and safety of the public and employees | Short term difficulty/decrease in access, amenity, aesthetics and/or cultural value of asset/infrastructure<br>Little to no improvement to community services, well-being and safety |

## 3.4. Key Elements

Key elements provide a framework that assist in identifying risks by breaking down concerns into a number of areas of focus and relating them to climate scenarios (AGO 2007). For the purpose of this assessment, themed areas of risk were selected as key elements, including:

- Built environment
- Natural environment
- Emergency Management
- Recreation; and
- Community

Business units across the City were assigned actions across each key element. The risk assessment and adaptation planning was undertaken with an explicit focus on integrating outcomes with existing systems and processes within the City. Integration is facilitated through ownership of risks and adaptation outcomes by organisational business units. The City is made up of 20 individual business units, operating under five Directorates (Table 6 and Figure 4).

**Table 6: Directorates and business units within the City of Stirling**

| No | Description |
|---|---|
| 1 | CEO<br>a. Governance and Council Support<br>b. Executive Services |
| 2. | Planning and Development<br>a. Economic Redevelopment and Urban Regeneration<br>b. City Planning<br>c. Approvals<br>d. Health and Compliance |
| 3. | Infrastructure<br>a. Engineering Design<br>b. Engineering Operations<br>c. Parks and Reserves<br>d. Waste and Fleet<br>e. City Building Operations |
| 4. | Corporate Services<br>a. Finance<br>b. Corporate Information Services<br>c. Asset Management<br>d. Human Resources |
| 5. | Community Development<br>a. Marketing and Communications<br>b. Library Services<br>c. Recreation and Leisure Services<br>d. Community Services<br>e. Community Safety |

In addition, a spatial prioritisation of risks was considered. A preliminary review of the available spatial information held by the City to inform risk assessment was undertaken during the Set the Context phase. This involved distribution of a data collection information sheet to all CCWAG members for population and discussions with staff. It was the intention to review spatial information that may be populated within the City's spatial information system, for example, spatial information indicating

shoreline change or vulnerability of the coastal zone, biodiversity hotspots or areas of known flood risk. Following extensive consultations with the Project Manager and staff across business units, it was clear that limited spatial information existed in a form readily compatible with the City's spatial information system. It was noted that compiling such information will be a valuable resource in future risk assessments, but this activity was beyond the scope of the current assessment.

As an alternate approach, hotspots of risks were identified during the risk assessment, drawing on participant's knowledge of the study area. The allocated hotspots (recorded in the Risk and Adaptation Register) will guide implementation of adaptive actions. Applying the City's spatial information system, hotspots may be aggregated to meaningful spatial units depending on the decision context. For instance, spatial units may include 'suburbs', 'local area planning zones', 'wards', or 'coastal zones' etc, as relevant to the decision context.

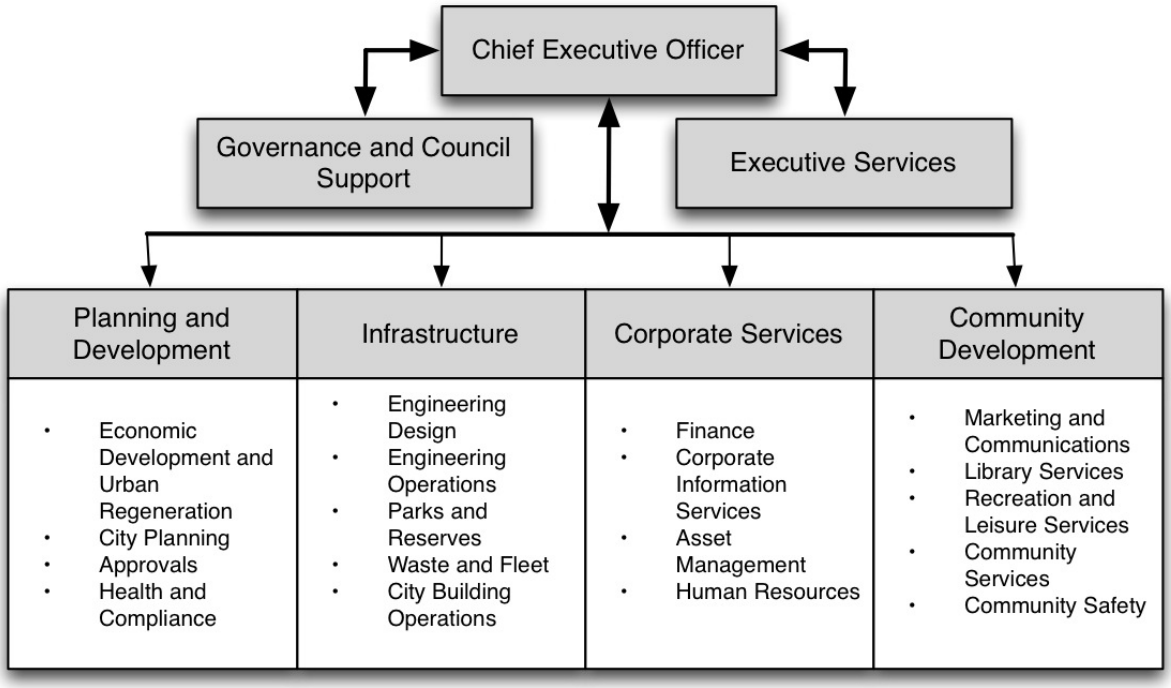



**Figure 4: Organisational structure, City of Stirling**

## 3.5. Stakeholder Identification

The Climate Change Adaptation Working Group (CCAWG) was established to lead the risk assessment and adaptation planning activities. The CCAWG is represented by staff from across Business Units that have a role or experience in managing and responding to climate risks. In addition, it was agreed that the risk assessment and adaptation planning outputs would be communicated internally (via presentations to Council and the Leadership Team) and externally (via Community Conversations and online and library feedback processes). The objectives of the consultation were to affirm the outputs of the risk assessment, and enhance ownership and awareness.

# 4. WORKSHOP TWO: Risk Assessment and Adaptation Planning

Risk assessment and adaptation planning (phases 2 to 5 of the risk assessment process) were implemented during a full-day workshop with CCAWG members. The CCAWG members were separated into two groups, one covering risks to the built environment and emergency management; the other covering risks to natural environment, recreation and community. The groups completed:

- Risk identification

- Risk analysis
- Risk evaluation
- Risk Treatment

## 4.1. Identify the Risks

Risk identification involves review of the projected impacts of climate change and the associated risks for the City. An initial identification of risks was undertaken in consultation with the CCAWG, drawing on the outcomes of an Internal Discussion Paper prepared by the City and extensive document review. The information collected was summarised into (i) Impact and Adaptation Summary Sheets (see Section 6); and (ii) the draft Risk and Adaptation Register. These tools were adopted during the risk assessment workshop to ascertain the potential risks of climate change to local government operations.

The risks compiled within the Risk and Adaptation Register were considered as 'thought-starter risks'. They were organised by theme (built environment, emergency management, recreational services, community health and well-being and natural environment) and aligned to climate drivers. During the workshop, participants had the opportunity to modify, add and/or eliminate thought-starter risks to ensure applicability to the City. In doing so, they considered the climate projections and the risk categories in the City's Risk Management Framework.

## 4.2. Analyse the Risks

This stage of the Risk Assessment involves establishing the consequences of a risk occurring, and the likelihood that the consequence will occur. Workshop participants adopted the evaluation matrixes defined during the 'Set the Context' phase to analyse the risks. In-depth discussions were held to assign a consequence and likelihood rating for each risk.

### 4.2.1. Consequence

Consequence was determined by assessing the impact of projected climate change on Council organisational objectives (or Success Criteria). During the workshop, participants applied the consequence scale (Table 5) to assign a level of consequence to each identified risk. The consequence scale was originally developed drawing on the City's Risk Management Framework (RMF), which was modified to capture strategic and operational risks[3].

### 4.2.2. Likelihood

The likelihood of a consequence occurring was determined based on understanding of the history of occurrence and associated impacts, as well as an appreciation of the current controls in place to manage the impact (Table 7). Likelihood was assigned following a five-point scale and ranged from Rare to Almost Certain (Table 3). To identify existing controls in place, the participants reviewed the Summary Sheets and considered a range of general management controls, including (City of Stirling 2011):

- Management systems and structures
- Reporting
- Delegations
- Audit plans and/or periodic (formal) reviews
- Insurance
- Policies
- Training
- Procedures
- Contract conditions

[3] The City's RMF contains two consequence scales, one for strategic risk, the other for operational risk.

- Design specifications
- Supervision/testing
- Monitoring/ quality assurance
- Segregation of duties

**Table 7: Control effectiveness rating table (City of Stirling 2011a)**

| Rating | Description |
|---|---|
| Excessive | Controls in place may be excessive and a poor use of resources |
| Satisfactory | Most controls are designed correctly and are in place and effective. |
| Some weaknesses | While the design of the controls may be largely correct, they are not currently very effective or some of the controls do not seem correctly designed |
| Poor | No controls in place or significant control gaps i.e. controls are ineffective in design and do not operate effectively |

### 4.2.3. Risk Prioritisation

In order to establish a risk prioritisation level for each identified climate change risk, consequence and likelihood are evaluated in the Risk Matrix (Table 4). The outputs of the risk prioritisation provide guidance on the importance of treating an identified risk, and the overall approach to risk treatment (i.e. existing controls are sufficient to managed versus urgent attention is required at the most senior level). The acceptability and associated management actions for each risk level are outlined below (drawn from the City's Risk Management Framework). In general, extreme and high priority risks need to be treated immediately or subject to more detailed analysis. Medium and low priority risks are acceptable with existing controls and can be set aside with no further action to treat them, apart from routine reviews to ensure that there has been no change that would make them more severe.

**Table 8: Management actions and responses to risk/opportunity levels (City of Stirling 2011a)**

| Risk Level | Acceptability | Management Action |
|---|---|---|
| **EXTREME** | Unacceptable with existing controls (save in extraordinary circumstances) | • Risk escalated to business unit manager/director<br>• Select and implement treatment option immediately<br>• Assign management responsibility for treatment<br>• Supervision of treatment by business unit manager/director<br>The opportunity should be pursued. A detailed implementation plan should be developed and regular monitoring on the implementation progress conducted |
| **HIGH** | Unacceptable with existing controls (save in extraordinary circumstances) | • Risk escalated to business unit manager/director<br>• Select and implement treatment option<br>• Assign management responsibility for treatment<br>• Oversight of treatment by business unit manager<br>The opportunity should be pursued. A detailed implementation plan should be developed and regular monitoring on the implementation progress conducted |
| **MEDIUM** | Acceptable with existing controls | • Document existing treatment plan or select a treatment plan for ongoing risk management<br>• Assign management responsibility for monitoring<br>• Ensure that existing controls, consequences and likelihood do not substantially change<br>A cost/benefit exercise should be presented to determine |

| Risk Level | Acceptability | Management Action |
|---|---|---|
| | | whether the opportunity should be pursued |
| LOW | Acceptable with existing controls | Risk is tolerable. Manage by well established, routine processes/procedures and be mindful of changes to the nature of risks<br><br>Consideration should be given to pursuing the opportunity |
| VERY LOW | Acceptable with existing controls | Unlikely to require allocation of resources |

## 4.3. Evaluate the Risks

Once risks were prioritised, the risk levels assigned were evaluated to ensure consistency. This stage generally involves reviewing the combination of consequence and likelihood to re-affirm the judgements and estimates and ensure consistency across the analysis. The final output was a risk prioritisation rating for all identified risks. Based on the outcomes of the risk analysis and evaluation, the risks requiring treatment were identified – leading to the final stage in the Risk Framework, Risk Treatment.

## 4.4. Treat the Risks

Adaptation planning was undertaken during the risk assessment workshop. This enabled an end-to-end evaluation of risks. The automated Risk Management Template adopted by the City of Stirling facilitated this process. Participants were provided with instructions to complete the adaptation planning (within the Participants Handouts) and 'thought starter' adaptation options were presented in the Summary Sheets.

Following the assignment of adaptation measures to each risk, participants re-evaluated the risk priority for 2030 and 2070, indicating the degree to which the options treated the identified risk. While it is recognised that treatments will change over time, as risk and adaptation planning continues, the re-assessment of risk at both timeframes highlighted the potential need for additional measures in the longer-term. Participants in Workshop Group 2 found rating residual risk difficult, given the inherent uncertainty in the effectiveness of different adaptive measures in treating the risks and the uncertainty in expected degree of change. In many cases, the risk was slightly reduced or maintained, given that the actions would be implemented in the short term to control what would be a long-term risk.

While residual risk is extremely useful when considering effectiveness of actions to treat immediate risks, it appears the utility of this activity is lessened when considering the effectiveness of immediate actions on future risks. The certainty of effectiveness can only be increased via monitoring and evaluating actions to inform future adaptive planning. This should remain the focus.

During the Set the Context meeting, the CCAWG considered evaluative criteria to be applied in adaptation planning (

Table 9) as well as timeframes for implementation to assign to adaptive actions (Table 10). The criteria were assigned values of 1, 3 and 5 to enhance separation between low and high barriers (and opportunities) to adaptive action. The values follow those adopted by the Shires Association of NSW in their Climate Change Adaptation Planning Package.

The output was Climate Change Risk and Adaptation Register, containing the priority rating of all risks and adaptation actions to treat high and extreme priority risks. The register specifies responsibility for implementation and anticipated implementation timeframes.

**Table 9: Criteria to evaluate adaptation actions**

| Criteria | Description | 1 = high barrier | 3 = moderate barrier | 5 = no barrier |
|---|---|---|---|---|
| **No regrets** | The extent to which the action provides opportunities or benefits regardless of the degree of climate change. | The option only contributes to climate change adaptation | Contributes in part to development as well as climate change | Will greatly contribute to development in addition to climate change adaptation |
| **Community values** | The extent to which the action aligns to community values, as captured by the City to date. | The option does not align to community values and will not be amenable to community members | The option aligns in part to community values and should be amendable to community members | The option completely aligns to community values will be amendable to community members |
| **Environment** | The extent to which the action can be implemented without detrimental impact on the environment. | Potential for high impact on the natural environment | Minor impact on the natural environment | No impact on the natural environment |
| **Financial** | The extent to which implementing the action can be accommodated within existing financial resources. | The option would require major inclusion in budget: > 1 year to receive funding | May be covered by next financial year budget | Can be covered under existing financial budgets |
| **Cost benefit** | The extent to which the long-term benefits of the adaptive action exceed the upfront costs (strategic estimate only). | The upfront costs exceed the future benefits | The upfront coasts are equal to the future benefits | The future benefits exceed the upfront costs |
| **Organisational capacity** | The extent to which the action can be implemented by staff, without the need for additional training, external support, or policy or legislative change. | Staff do not have the capacity to implement the action. Others must lead/implement. Council can play an influencing role (Influence). | Staff have some ability to implement the action, but may require limited external support. Partnerships required for implementation (Collaborate). | Staff have the capacity to take implement the action and can lead implementation (Lead). |

**Table 10: Implementation timeframes**

| Timeframe | Description |
|---|---|
| Immediate | This financial year, i.e. can be implemented within existing resource environment, no additional funding allocation required. |
| Short term | Next financial year, i.e. existing resources will not cover activity and therefore will need to be budgeted for in next financial year. |
| Medium term | Within 4 years (business plans) |
| Long term | Within 10 years (strategic plans) |

## 4.5. Implementation

A session was held at the end of the climate change risk assessment and adaptation-planning workshop to explore approaches to integrate the outcomes of the adaptation planning into the City's operational processes. Termed mainstreaming, integration of outcomes ensures that climate change adaptation actions are couched within the existing management processes of the City, reducing duplication of effort and ensuring a coordinated approach to climate risk management across the City.

Participants were asked to consider how the actions identified during the workshop may integrate into the current operational and/or future planning frameworks for each business unit. An open-floor discussion was held to identify connections between departments that may be relevant for select risks. The discussion focused on answering the following questions:

- What actions/activities need to occur to facilitate implementation of management of this risk?
- Are there any perceived barriers to integration?
- How can barriers be addressed?

The outcome was a list of preliminary approaches to integration, which were further analysed and developed as a component of the adaptation strategy.

# 5. Post Workshop Compilation and Review

The outputs of the workshop processes were analysed to compile priority risks and key adaptive strategies. Further, outputs of the integration session were synthesised and presented back to CCAWG representatives to develop preliminary recommendations for integration for presentation to the Leadership Team. The outcomes were presented to the Councillors and the Leadership Team, prior to drafting the Adaptation Plan. Council endorsed the final Adaptation Plan prior to its release for community consultation. The outputs gathered during Community Consultation will be compiled and integrated into the Adaptation Plan, as required.

## 6. Summary Sheets

### QUICK NOTES: ENVIRONMENT

**SITUATION**

- Priority flora species
- Wetland systems
- Reef and coastal dune systems buffering the coastal zone
- Bush Forever Sites and Locally Significant Natural Areas

**SCENARIOS FOR CHANGE**

| 2030 | 2070 |
|---|---|
| • Temperature rise of 0.8 degrees C (annual)<br>• 7 more days over 35 degrees C (annual)<br>• 6% decline in annual rainfall<br>• Sea level rise of 0.09m<br>• Increase in sea surface temperature, 0.6 to 1 degree C<br>• 15 to 30% decline in annual runoff | • Temperature rise of 2.7 degrees C (annual)<br>• 26 more days over 35 degrees C (annual)<br>• 19% decline in annual rainfall<br>• Sea level rise of 0.41m<br>• Increase in sea surface temperature, 2 to 2.5 degrees C<br>• 57% decline in annual runoff |

**POTENTIAL IMPACTS**

- Loss of species and damage to ecosystem services
- Changes in the sea surface temperature may see a movement of fish species impacting recreational fishing
- Increased fire risk
- Increase risk of acid sulphate soils

**SAMPLE ADAPTATION STRATEGIES**

- Abandon: allow natural processes to continue unabated
- Protect: shield areas from relevant climate change impacts and identified hazards
- Accomodate: formulate measures that allow continued or extended use of vulnerable land and resources
- Retreat: instigate measures to minimise the costs of changing land-use once threatened by coastal hazards and climate change impacts
- Do nothing

**EXAMPLE CURRENT CONTROLS**

- Million Trees Initiative
- Biodiversity Strategy
- Scarborough Beach Urban Design Master Plan (ground water and flora recommendations)

# QUICK NOTES: WATER AND WASTE

## SITUATION

- Areas prone to flooding during high-intensity rainfall events
- No landfill sites in project area, one transfer landfill site
- Central control management system for irrigation of parks and reserves across three zones

## SCENARIOS FOR CHANGE

| 2030 | 2070 |
|---|---|
| • Temperature rise of 0.8 degrees C (annual)<br>• 7 more days over 35 degrees C (annual)<br>• 6% decline in annual rainfall<br>• Sea level rise of 0.09m<br>• Increase in sea surface temperature, 0.6 to 1 degree C<br>• 15 to 30% decline in annual runoff | • Temperature rise of 2.7 degrees C (annual)<br>• 26 more days over 35 degrees C (annual)<br>• 19% decline in annual rainfall<br>• Sea level rise of 0.41m<br>• Increase in sea surface temperature, 2 to 2.5 degrees C<br>• 57% decline in annual runoff |

## POTENTIAL IMPACTS

- Increased run-off from storm events resulting in overloading or failure of sewers and storm water systems
- Decline in availability of freshwater
- Increased salinity of groundwater bores
- Policy mechanisms (such as Clean Energy Act 2011) place increased financial burden on waste management (land fill)
- Health risks resulting from storm water contaminants entering the coastal zone

## SAMPLE ADAPTATION STRATEGIES

WATER

- Water efficient urban design and housing standards
- Water efficient garden planting and watering
- Supplementing supplies with recycled water
- Restrictions and pricing mechanisms
- Detection and control of leaks including water pressure management

WASTE

- Design waste water systems to prevent overflow events based on climate scenarios
- Urban drainage management plans that optimise active storage capacity to alleviate flood peaks
- Link urban drainage to catchment flood management

## EXAMPLE CURRENT CONTROLS

- Water Smart Parks (hydro and eco zoning)
- Stormwater Catchment Analysis and Flood Mitigation (SCAFM) project
- Education programs and waste recycling activities delivered by Waste and Fleet Business Unit

# QUICK NOTES: ASSET MAINTENANCE

## SITUATION

- Development within the coastal zone
- Areas identified as prone to flood risk
- Building standards accommodate for past climate

## SCENARIOS FOR CHANGE

| 2030 | 2070 |
|---|---|
| • Temperature rise of 0.8 degrees C (annual)<br>• 7 more days over 35 degrees C (annual)<br>• 6% decline in annual rainfall<br>• Sea level rise of 0.09m<br>• Increase in sea surface temperature, 0.6 to 1 degree C<br>• 15 to 30% decline in annual runoff | • Temperature rise of 2.7 degrees C (annual)<br>• 26 more days over 35 degrees C (annual)<br>• 19% decline in annual rainfall<br>• Sea level rise of 0.41m<br>• Increase in sea surface temperature, 2 to 2.5 degrees C<br>• 57% decline in annual runoff |

## POTENTIAL IMPACTS

- More frequent and severe storm damage, particularly from flooding
- Accelerated degradation of construction materials and subsidence risk
- Inundation and/or erosion of the coastal zone damaging shorefront infrastructure
- Changing regulations leave assets stranded
- Inefficient assets (water and energy use) resulting in reduced liveability within buildings and financial burden to instal water and energy efficient items

## SAMPLE ADAPTATION STRATEGIES

- On-going monitoring programme to proactively plan for change in beach form
- Update coastal management plans to align to new WA State set-back policy (SPP 2.6)
- Incorporate climate relevant criteria within asset maintenance programs to identify areas most vulnerable
- Plan for (and construct evidence base of) increased expenditure for asset maintenance and repair

## EXAMPLE CURRENT CONTROLS

- City Buildings Energy Bureau
- The existing works to respond to storm inundation undertaken by Engineering and Design Business Unit
- Five year monitoring program to monitor beach change in Watermans Bay, Mettams Pool, Scarborough Beach and Trigg Beach

# QUICK NOTES: COMMUNITY SERVICES

## SITUATIO

- Socio-economically and demographically diverse population
- Projections for 20% growth in population by 2031
- Varying capacity of community to manage climate risks, for example, vulnerable community members include the elderly, low socio-economic, non-english speaking, and those in rental accommodation

## SCENARIOS FOR CHANGE

### 2030

- Temperature rise of 0.8 degrees C (annual)
- 7 more days over 35 degrees C (annual)
- 6% decline in annual rainfall
- Sea level rise of 0.09m
- Increase in sea surface temperature, 0.6 to 1 degree C
- 15 to 30% decline in annual runoff

### 2070

- Temperature rise of 2.7 degrees C (annual)
- 26 more days over 35 degrees C (annual)
- 19% decline in annual rainfall
- Sea level rise of 0.41m
- Increase in sea surface temperature, 2 to 2.5 degrees C
- 57% decline in annual runoff

## POTENTIAL IMPACTS

- Increased pressure on community services for the elderly and socially disadvantaged, as households are impacted by the direct and indirect impacts of climate change
- Increased demand on local medical facilities and other community services (e.g. local pools or recreational areas)
- Increase workload and scope for environmental health officers
- Change demands and use patterns of recreational facilities (e.g. additional shelters in public areas and along bike and foot paths)

## SAMPLE ADAPTATION STRATEGIES

- Short term strategies include actions to reduce vulnerabilities to specific events and emergencies such as heat waves, storms and floods. Longer term strategies include policies and programs designed to strengthen resilience and reduce overall social disadvantage
- Trial programs to increase water and energy efficiency of residential housing (for example, BASIX)
- Promote sustainability retrofits to residential housing via policies, codes for development, applications for renovation/extension or at the point of sale
- Investigate incentive or rebate schemes, i.e. levy to households/developments with a larger than average ecological footprint
- Progress towards the 'New Urbanist' agenda (enhancing sustainability through modifications to transport, land use and development)

## EXAMPLE CURRENT CONTROLS

- Existing community outreach programs
- Emergency management program and welfare points
- Community sustainability education projects (i.e. great gardens and energy conservation workshops)
- Actions to build community networks (i.e. MeetBalls)

# QUICK NOTES: STRATEGIC PLANNING

## SITUATION

- Transition to new Integrated Planning Framework
- Future long term planning is based on past climate (?)
- Need to reduce uncertainty with respect to zoning and landuse

## SCENARIOS FOR CHANGE

| 2030 | 2070 |
|---|---|
| • Temperature rise of 0.8 degrees C (annual)<br>• 7 more days over 35 degrees C (annual)<br>• 6% decline in annual rainfall<br>• Sea level rise of 0.09m<br>• Increase in sea surface temperature, 0.6 to 1 degree C<br>• 15 to 30% decline in annual runoff | • Temperature rise of 2.7 degrees C (annual)<br>• 26 more days over 35 degrees C (annual)<br>• 19% decline in annual rainfall<br>• Sea level rise of 0.41m<br>• Increase in sea surface temperature, 2 to 2.5 degrees C<br>• 57% decline in annual runoff |

## POTENTIAL IMPACTS

- Policy and regulation changes increasing financial burden on council, for example, in-direct impacts on automotive fuel costs, stationary energy costs and construction costs
- Litigation risks for approving developments in 'at-risk' areas
- Stranded assets no longer viable for development due to change in building code standards or planning policies
- Increased likelihood of illness or injury from extreme weather events and heat waves, and associated Occupational Health and Safety costs

## SAMPLE ADAPTATION STRATEGIES

- Monitoring programme to proactively plan for change in beach form
- Promote sustainability retrofits to residential housing via policies, codes for development, applications for renovation/extension or at the point of sale
- Investigate incentive or rebate schemes, i.e. levy to households/developments with a larger than average ecological footprint
- Incorporate climate change considerations into planning processes
- Plan for opportunistic upgrades of key assets, i.e. at point of replacement and/or maintenance, to climate proof assets

## EXAMPLE CURRENT CONTROLS

- Climate projections incorporated within the planning processes of the Asset Management Business Unit
- Long-term asset management plans (as a component of the Integrated Planning Frameworks that council is transitioning towards)
- Road Improvement Project to incorporate street trees into capital improvement projects
- Integrating sustainable purchasing practices into council operations, led by Economic Development and Urban Regeneration Unit

# QUICK NOTES: PARKS AND RECREATION

## SITUATION

- Tourist and community use of foreshores and beaches
- Parks and reserves provide social amenity
- Trend of increasing expenditure to respond to storm impacts
- No State or Federal support for storm clean-up expenditure
- National awards for Water Smart Parks Strategy

## SCENARIOS FOR CHANGE

| 2030 | 2070 |
|---|---|
| • Temperature rise of 0.8 degrees C (annual)<br>• 7 more days over 35 degrees C (annual)<br>• 6% decline in annual rainfall<br>• Sea level rise of 0.09m<br>• Increase in sea surface temperature, 0.6 to 1 degree C<br>• 15 to 30% decline in annual runoff | • Temperature rise of 2.7 degrees C (annual)<br>• 26 more days over 35 degrees C (annual)<br>• 19% decline in annual rainfall<br>• Sea level rise of 0.41m<br>• Increase in sea surface temperature, 2 to 2.5 degrees C<br>• 57% decline in annual runoff |

## POTENTIAL IMPACTS

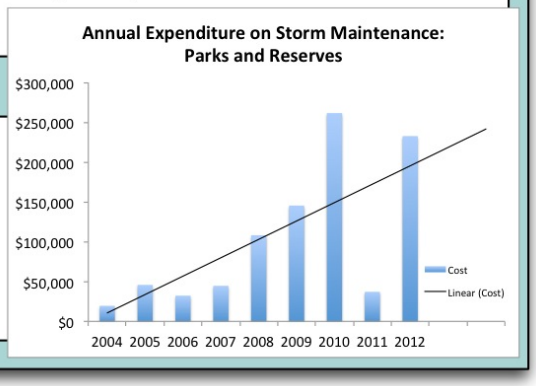
- Threat to scenic amenity with potential tourism ramifications
- Changes in jellyfish abundance have potential ramifications for tourism and local recreation
- Community discontent, i.e. changes to landscaped and public areas to reduce water demand may challenge community expectations and values

## SAMPLE ADAPTATION STRATEGIES

- Adopt emergency (heat, storm) contingency plans for recreational/tourism events in local area
- Use of plants that are indigenous to local area
- Education programs to help citizens understand what climate change means for them and the local area
- Plan for increased investments (human and financial) to respond to extreme events and long-term changes in climate

## EXAMPLE CURRENT CONTROLS

- Water Smart Parks
- Data collection on storm clean-up expenditure
- Community education programs



# Annex 3

# City of Stirling Climate Change Adaptation and Risk Register

This file contans the outputs of a risk assessment and adaptation planning workshop in September 2012.

The Workshop was conducted as a component of the Climate Change Risk Assessment and Adaptation project, which was commissioned to meet the City's Strategic Objective 2.2.1:

*Develop and implement a climate change adaptation strategy, action plan and community education program*

The Adaptation and Risk Register details the risk priority of all identified climate risks, together with recommended adaptation strategies to treat high and extreme priority risks, and responsibility and timeframes for implementation.

In addition, barriers to implementation across six critieria are evaluated per action, which may direct precurser activities to support implementation of each selected action.

The City is currently working towards an approach to integrate the outputs of the Adaptation and Risk Register within the organisation wide risk reporting frameworks.

This register should be considered in conjunction with the City of Stirling's Adaptation Plan, produced as an output of this project.

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUILT ENV (coastal) | Sea level rise | 1 | Erosion and/or exceedance of seawalls, jetties and other coastal defences | • Pressure on public administration (human and financial) to maintain and repair coastal infrastructure following disturbance or damage | Interim works at Watermans Bay - giant sandbanks / study into permanent engineering solution/ sand dunes at Scarborough/ plantings on coastal strip/ fencing and dune management | Satisfactory | 4 | 3 | High | YES | 5 | 4 | Extreme | YES |
| BUILT ENV (coastal) | Sea level rise | 2 | Erosion and/or inundation in the coastal zone leading to damage to infrastructure (both private and council owned) situated in close proximity to the coast | • Increased need in human and financial resources to monitor and repair<br>• Disruption to the delivery of services<br>• Increased liability for death and injury<br>• Pressure on public administration (human and financial) to reduce coastal erosion and inhibit inundation<br>• Potential liability resulting from planning decisions allowing construction in potential erosion or flood risk areas<br>• Changing insurance premium costs – or potential loss of insurability | As above | Satisfactory | 4 | 3 | High | YES | 5 | 4 | Extreme | YES |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 34 | Ground water bores increasingly saline | • Decline in visual amenity of parks and reserves<br>• Increased pressure to find alternate water sources and use water sensitive urban design | Water Smart Parks Program, Million Trees, Public Open Space (POS) strategy, turf research for climate resilient species, out of season policy for sports clubs (in development) | Satisfactory | 4 | 3 | High | YES | 4 | 5 | Extreme | YES |
| BUILT ENV (coastal) | Sea level rise | 3 | Inundation and/or erosion of roads in coastal areas | • Increased pressure on public administration (human and financial) to maintain and repair roads<br>• Disruption to the delivery of services<br>• Change in insurance costs – or potential loss of insurability | As above for Watermans plus other coastal protection works | Satisfactory | 5 | 2 | High | YES | 5 | 3 | High | YES |
| BUILT ENV (asset management) | Extreme events (increase in | 10 | Exceedance of drainage capacity | • Pressure on public administration to manage and repair storm/water drainage | Existing maintenance program / ongoing reactive capital works / | Satisfactory | 4 | 3 | High | YES | 4 | 4 | High | YES |
| EMERGENCY MANAGEMENT | Extreme events (increase in intensity and number) | 19 | Increased number of emergency response and recovery operations in response to floods and storm events | • Increased pressure (human and financial) to monitor and manage flood risks, i.e. completion of an asset audit to determine capacity of current infrastructure to cope with current and projected flood frequency<br>• Increased community pressure to respond to impacts of storm events<br>• Increased cost to increase emergency response mechanisms | Stirling emergency management plan / protocols in place with State Government/FESA | Satisfactory | 4 | 3 | High | YES | 4 | 4 | High | YES |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RECREATION (parks and gardens) | Increase in temperature & decrease in rainfall | 23 | Decrease in the quality of public open green space; reduced water quality and quantity | • Increased need for community consultation and education regarding changing environmental conditions and the resultant Council management strategies | Water Smart Parks Program Adopt-a-park, Follow my lead programs, Million Trees, Public Open Space (POS) strategy, turf research for climate resilient | Satisfactory | 4 | 3 | High | YES | 4 | 3 | High | YES |
| RECREATION (general) | All | 29 | Opportunity: Tourist numbers increase due to extended periods of warm weather providing more opportunities | • Increased investment in the local economy<br>• Increased local revenue | SEAS, Trigg Master is a planning document in place but not implemented due to lack of funding | Satisfactory | 3 | 4 | High | YES | 3 | 4 | High | YES |
| COMMUNITY (health and well-being) | Increase in temperature & decrease in rainfall | 38 | Increase in geographical range and/or incidence of vector-borne and | • Decline in public safety<br>• Decreased aesthetic value of the region<br>• Increased inspection and control program workload and costs | Information provided, testing in isolation locations | Some Weakness | 3 | 4 | High | YES | 3 | 5 | High | YES |
| BUILT ENV (asset management) | Extreme events plus storms (increase in intensity and number) | 4 | Higher rates of building damage and deterioration (focus on council owned buildings) | • Increased human and financial resources to monitor and repair<br>• Disruption to delivery of services due to building maintenance and repair activities<br>• Existing buildings not being compliant with best practice leading to increased vulnerability<br>• Increased insurance premiums<br>• Pressure on public administration (human and financial) to maintain and repair buildings following disturbance or damage | Buildings comply with legislative standards<br>Facility Risk Management Plans | Some Weakness | 4 | 2 | Medium | NO | 4 | 3 | High | YES |
| BUILT ENV (asset management) | Increased Temperature | 7 | Change in building heating/cooling costs (can be either negative or positive) for council owned buildings | • Higher costs for service delivery, i.e. increased cooling costs<br>• Increased maintenance and upgrade of temperature controlling devices | Energy efficiency measures | Some Weakness | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| BUILT ENV (planning) | Reduced rainfall | 13 | Reduced resilience and increased costs for infrastructure (council owned) in regards to water use for buildings | • High costs of retrofitting of systems to align to introduced standards<br>• Discrepancies between planning policy and standards that align to best practice and controls to maintain the unique character of the region | Water Smart City Framework | Some Weakness | 3 | 3 | Medium | NO | 3 | 4 | High | YES |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BUILT ENV (planning) | Increase Temperature | 17 | Increase in heat island effect in built up areas | • Re-design costs to reduce heat island effect (i.e. tree planting, inclusion of shade features, green roofs, etc.)<br>• Increased incidence of heat-related | Existing million trees program / policy provisions - draft policy on retention of trees on private property / draft verge and | Some Weakness | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| EMERGENCY MANAGEMENT | Extreme events (increase in intensity and number) | 18 | Interruption of road traffic from extreme weather events and emergency transport routes disrupted | • Pressure on public administration (human and financial) to maintain and repair roads following extreme events<br>• Decline in public safety | Stirling emergency management plan / protocols in place with State Government/FESA | Satisfactory | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| RECREATION (parks and gardens) | Extreme events (increase in | 22 | Loss and damage to street trees | • Decline in residential watering of verges, leading to decreased amenity | Draft Verge Policy, Street Tree Policy, Verge Bonds, Adopt-a-Park | Some Weakness | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| RECREATION (coastal) | Sea level rise | 25 | Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of | • Decline in revenue through loss of tourism and local use of open space<br>• Community discontent over loss of valuable natural assets<br>• Increased pressure (financial and human) to maintain public open space in coastal and estuarine areas and | Monitoring at identified locations; coastal studies to survey beaches (focus on sediment transport); beach access rationalisation , dune protection | Satisfactory | 3 | 3 | Medium | NO | 4 | 4 | High | YES |
| RECREATION (coastal) | Extreme events (increase in intensity and number) and SLR | 26 | Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | • Community discontent over loss of public amenities/recreation sites<br>• Increased costs to repair or rebuild recreational infrastructure | Monitoring at identified locations; coastal studies to survey beaches (focus on sediment transport); beach access rationalisation , dune protection | Satisfactory | 3 | 3 | Medium | NO | 4 | 4 | High | YES |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in | 30 | Shift in distributions of plant and animal species | • Loss of habitat and fragmentation of habitat resulting in increased resource requirements to maintain vegetation | Local biodiversity strategy, Green Plan 2, Coastal Foreshore Action Plans 1 and 2, Wetlands Protection | Satisfactory | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 31 | Increased risk of population extinctions - AS PER 30 | • Community discontent over loss of biodiversity<br>• Increased pressure (financial and human) to monitor and manage species at high risk<br>• Increased research requirement and liaison to support the identification and management of species at risk | Reserve Plans | Satisfactory | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 32 | Ecological disturbances and reduced ecosystem resilience to stress - AS PER 30 | • Community discontent over loss of biodiversity<br>• Increased pressure (financial and human) to monitor and manage ecological disturbance and to increase ecosystem resilience<br>• Increased need for communication and consultation to reduce habitat destruction | | Satisfactory | 3 | 3 | Medium | NO | 3 | 4 | High | YES |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 33 | Change in distribution of invasive plant and animal species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity - AS PER 30 | • Increased pressure (financial and human) to manage invasive species<br>• Increased feral animal management works | | Satisfactory | 3 | 3 | Medium | NO | 3 | 4 | High | YES |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in | 35 | Decline in wetlands due to lowering of groundwater table | • Managing community concerns<br>• Increased management efforts required | Water Smart Parks | Satisfactory | 3 | 3 | Medium | NO | 3 | 5 | High | YES |
| COMMUNITY (health and well-being) | Increase Temperature | 47 | Decline in outdoor working conditions leading to increased incidence of OSH | • OHS - heat stroke, dehydration<br>• Decline in staff productivity | Provision of protective equipment (PPE), OHS training and procedures, in summer shifts start earlier | Satisfactory | 3 | 3 | Medium | NO | 4 | 3 | High | YES |
| LESSONS LEARNED | Risk Assessment and Adaptation Planning | P1 | OPPORTUNITY: The City has access to a wide range of spatial information, which if compiled within its central management system, would provide a useful tool to support risk assessment and adaptation planning | • Improvements in the efficiency and spatial resolution of risk assessment and adaptation planning for the City | | Poor | 4 | 3 | High | YES | 4 | 4 | High | YES |
| BUILT ENV (asset management) | Extreme events (increase in intensity and number) | 9 | Potential for flooding as a result of increased leaf litter and debris build up on roads and grates from extended dry spells | • Higher repair and maintenance costs (increased street sweeping and inspection of drains) | Drainage standards / strategic asset management processes / proactive maintenance | Some Weakness | 3 | 3 | Medium | NO | 3 | 3 | Medium | NO |
| RECREATION (parks and gardens) | Extreme events (increase in intensity and number) and SLR | 21 | saltwater intrusion to groundwater sources (irrigation bores) | • Increased watering costs<br>• Increased repair and maintenance costs for reticulation; may include relocating reticulation | Water Smart Parks Program | Satisfactory | 3 | 3 | Medium | NO | 3 | 3 | Medium | NO |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMMUNITY (health and well-being) | All | 36 | Increased vulnerability of elderly and low socio-economic households to secondary impacts (policy change, rising prices of electricity and water etc.) | • Increased pressure on community services for the elderly and socially disadvantaged, as households are impacted by the indirect impacts of climate change.<br>• Demand for additional council services<br>• Expectation to provide air-conditioned halls<br>• Higher number of community enquiries to direct to service providers<br>• Requirement to coordinate help for the sick and elderly, rather than give phone number and leave to them to organise | Meals on Wheels, Books on Wheels, Home Support Services Heat wave plan | Satisfactory | 2 | 3 | Medium | NO | 3 | 3 | Medium | NO |
| COMMUNITY (health and well-being) | All | 37 | Growing population, pressure to provide services and changing climate interact resulting in a decline in community well-being | • Pressure on council to deliver strategies that enhance community resilience<br>• Decline in rates base as residents migrate to areas with better service provision or planning mechanisms that have catered for future social and environmental changes | | | 2 | 3 | Medium | NO | 3 | 3 | Medium | NO |
| COMMUNITY (health and well-being) | All | 41 | Policy change leading to greater emphasis on recording emissions | • Increased costs associated with possible recording and auditing of GHG emissions recording<br>• Increased costs associated with energy costs (without adaptive measures) | Carbon inventory of operations and services provided by the City (CCAP modelling tool; Energy Efficiency Working Group) | Some Weakness | 2 | 4 | Medium | NO | 2 | 4 | Medium | NO |
| COMMUNITY (health and well-being) | Increase in temperature & decrease in rainfall | 42a | Increased pressure on drinking water supplies | • Cost to the City to implement education programs promoting water efficiency of City operations | Water wise Council;<br>ICLEI Water Campaign | Poor | 2 | 3 | Medium | NO | 3 | 3 | Medium | NO |
| BUILT ENVIRONMENT | Increase in temperature & decrease in rainfall | 42b | Increased costs for provision and use of water | • Financial and technical resources required to reduce corporate use of scheme water | Waterwise Council;<br>ICLEI Water Campaign | Poor | 2 | 3 | Medium | NO | 3 | 3 | Medium | NO |
| COMMUNITY (health and well-being) | Reduced rainfall | 43 | Reduced air quality and increased pollution | • Increased pressure on Environmental Health Officers to investigate health and other complaints<br>• Increased demand on local medical facilities and other community services (e.g. local pools or recreational areas) | Travelsmart; Aquatic Facilities Community Recreation Centres Public Open Space | Satisfactory | 2 | 3 | Medium | NO | 2 | 3 | Medium | NO |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMERGENCY MANAGEMENT | Increase in temperature & decrease in rainfall | 20 | Increased number of emergency response and recovery operations in response to bushfires | • Increased pressure (human and financial) to ensure best practice policy and knowledge on bushfire risk management , research, construction techniques; and to improve integration of bushfire risk assessment into planning and development, need for policy and information support from State Government<br>• Increased pressure on volunteers – including Council staff directly and Council support for volunteers<br>• Increased pressure on dedicated disaster management and response staff<br>• Increased cost to increase emergency response mechanisms<br>• loss of natural vegetation<br>loss of buildings/assets within reserves<br>• Liability issues - from spread to surrounding areas<br>Waste Management | Stirling emergency management plan, Protocols in place with State Government/FESA, Community Safety inspections | Satisfactory | 3 | 2 | Medium | NO | 3 | 3 | Medium | NO |
| BUILT ENV (planning) | All | 16 | Changes to State and Federal building code standards and planning policies impact the council with compliance and/or retrofitting costs | • Stranded existing assets (e.g. land no longer viable for development) | Current compliant rating processes | Satisfactory | 1 | 2 | Low | NO | 2 | 3 | Medium | NO |
| RECREATION (parks and gardens) | Increased Temperature | 24 | Change in demands and use patterns of recreational facilities (e.g. additional shelters in public areas and along bike and foot paths) | • Increased demand on local facilities and other community services (e.g. local pools) | Urban regeneration planning; SEAS; POS, Coastal Foreshore Action Plans 1 and 2, POS amenity policies, shading around play areas | Satisfactory | 2 | 2 | Low | NO | 3 | 3 | Medium | NO |
| COMMUNITY (health and well-being) | Sea level rise | 44 | Loss of areas of heritage or indigenous importance - coastal zone only | • Decline in community and lifestyle characteristics<br>• Community discontent over loss of culturally significant sites and assets<br>• Increased need for Council to ensure that community expectations and management practices are aligned | Community networks in place/being developed | Some Weakness | 3 | 1 | Low | NO | 4 | 2 | Medium | NO |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Consequences | Existing Controls in place/ Actions | Control Ratings | Consequence 2030 | Likelihood 2030 | Risk Level 2030 | Risk Treatment Actions Required 2030 | Consequence 2070 | Likelihood 2070 | Risk Level 2070 | Risk Treatment Actions Required 2070 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COMMUNITY (health and well-being) | All | 46 | Impact on outdoor events (e.g. Somerset festival, farmers markets etc.) due to less predictable climatic conditions | • Decline in community and lifestyle characteristics<br>• Increased need for Council to ensure that community expectations and management practices are aligned | | Satisfactory | 1 | 3 | Low | NO | 1 | 4 | Medium | NO |
| BUILT ENV (asset management) | Increased Temperature | 6 | Deterioration of Council roads and other paved surfaces from higher temperatures and increased solar radiation | • Increased human resources to monitor and repair<br>• Higher repair and maintenance costs | Good design standards and engineering practice/ good maintenance schedule / asset management | Satisfactory | 3 | 1 | Low | NO | 3 | 1 | Low | NO |
| COMMUNITY (health and well-being) | Extreme events (increase in intensity and number) | 39 | Extreme rainfall events transporting contaminants into waterways (including ocean) | • Decline in public health<br>• Adverse publicity and community concern<br>• Increased pressure (financial and human) to monitor and manage contamination | Information provided (Health) | Satisfactory | 2 | 1 | Low | NO | 2 | 2 | Low | NO |
| COMMUNITY (health and well-being) | Increased Temperature | 40 | Increased odour nuisance from deteriorating household waste Disease/health issues that could arise from deteriorating waste | • Pressure to increase the frequency of collections (and associated pressure on human and financial resources) | | Satisfactory | 2 | 2 | Low | NO | 2 | 2 | Low | NO |
| BUILT ENV (asset management) | Increase in temperature & decrease in rainfall | 5 | Ground subsidence impacting buildings and transport networks | • Increased insurance premium costs<br>• Reduced rates base/income for Council<br>• Exposure to legal liability on planning decisions<br>• Disruption to delivery of services leading to community discontent<br>• Increased financial and human resources to respond and repair following extreme events | Existing building standards | Satisfactory | 1 | 1 | Very Low | NO | 1 | 1 | Very Low | NO |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| BUILT ENV (coastal) | Sea level rise | 1 | Erosion and/or exceedance of seawalls, jetties and other coastal defences | **1** | Asset planning to consider projections for change in climate and associated risks to erosion and/or exceedance of seawalls, jetties and other coastal defences | Engineering Operations | Long | **Low** | **Low** |
| | | | | **2** | Implement new measures noted in asset plans | Engineering Operations | Long | | |
| | | | | **3** | Remove non-essential vulnerable infrastructure from areas exposed to the impacts of erosion and inundation | Parks and Reserves (lead); Engineering Operations (support) | Long | | |
| BUILT ENV (coastal) | Sea level rise | 2 | Erosion and/or inundation in the coastal zone leading to damage to infrastructure (both private and council owned) situated in close proximity to the coast | **4** | Investigate and report on opportunities to change planning requirements e.g. limit infill development/ change setbacks/ change zoning | Planning & Development, with technical support from Engineering Design to determine appropriate set backs | Long | **Low** | **Low** |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 34 | Ground water bores increasingly saline | **5** | Investigate the feasibility of aquifer recharge to reduce salinization of ground water (the focus is on bore aquifer not drinking water) | Manager Parks & Reserves | Long | **High** | **High** |
| | | | | **6** | Investigate the feasibility of wet and dry detention basins as tools to reduce salinization of groundwater | Manager Parks & Reserves Manager Engineering & Design | Long | | |
| | | | | **7** | Implement waste water treatment and re-use in key precincts | Manager Parks & Reserves Manager City Planning | Long | | |
| BUILT ENV (coastal) | Sea level rise | 3 | Inundation and/or erosion of roads in coastal areas | **8** | Undertake an integrated planning and engineering assessment of west coast drive and its future sustainability | Manager Parks & Reserves | Long | **Low** | **Low** |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| BUILT ENV (asset management) | Extreme events (increase in intensity and number) and SLR | 10 | Exceedance of drainage capacity | **9** | Catchment analysis program developed to include climate change scenarios to assess sensitivity to drainage capacity on publication of revised Australian Rainfall and Runoff (ARR) guidelines in 2014 | Manager Engineering Design | Medium | **High** | **High** |
| | | | | **10** | Implement drainage system improvements based upon catchment analysis program | Engineering Operations | Long | **Medium** | **Medium** |
| EMERGENCY MANAGEMENT | Extreme events (increase in intensity and number) | 19 | Increased number of emergency response and recovery operations in response to floods and storm events | **11** | Consider projected changes in extreme climatic events (using the latest climate projections) during reviews of emergency management plans | Coordinator Emergency Management | Medium | **High** | **High** |
| RECREATION (parks and gardens) | Increase in temperature & decrease in rainfall | 23 | Decrease in the quality of public open green space; reduced water quality and quantity resulting in less watering/irrigation of open space and sports grounds and closure of ovals | **12** | Implement alternative surface coverings - e.g. more climate resilient species and reduced turf areas | Manager Parks & Reserves | Long | **Medium** | **medium** |
| | | | | **13** | Set targets and a work plan to increase the number of indoor recreation areas within the City. There are six existing indoor facilities in the City. Construction new recreational areas would occur in the long term. | Manager Recreation & Leisure Services | Long | | |
| | | | | **14** | Review and report on the feasibility of altering timing of recreation use changes between seasons to avoid exposure to extreme heat | Manager Recreation & Leisure Services | Short | | |
| | | | | **15** | Investigate and report on improvements to irrigation technology | Manager Parks & Reserves | Medium | | |
| | | | | **16** | Implement soil conditioning for water retention | Manager Parks & Reserves | Medium | | |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| RECREATION (general) | All | 29 | Opportunity: Tourist numbers increase due to extended periods of warm weather providing more opportunities for coastal recreation | **17** | Undertake activities to improve the connectivity of business and services along the coastal drive. Increased shade structures and recreational areas | Manager Economic Development and Urban Regeneration | Long | **High** | **High** |
| | | | | **18** | Undertake transport planning for coastal recreational use (increase bike use and access, public car parking) in areas beyond SEAS focus area | Manager City Planning and Manager, Engineering Design | Long | | |
| COMMUNITY (health and well-being) | Increase in temperature & decrease in rainfall | 38 | Increase in geographical range and/or incidence of vector-borne and water-borne diseases | **19** | Increase monitoring of the range and occurrence of vector borne/water borne diseases | Manager Health & Compliance | Medium | **Medium** | **Medium** |
| | | | | **20** | Develop a plan to respond to changes in vector-borne disease | Manager Health & Compliance | Medium | | |
| | | | | **21** | Implement education campaigns to raise awareness to mitigate the risk of vector-borne disease | Manager Health & Compliance | Long | | |
| | | | | **22** | Implement the plan to respond to changes in vector borne disease | Manager Health & Compliance | Long | | |
| BUILT ENV (asset management) | Extreme events plus storms (increase in intensity and number) | 4 | Higher rates of building damage and deterioration (focus on council owned buildings) | **23** | When assets come up for replacement, implement standards that cater for projected changes in climate over the assets lifetime. | Manager City Buildings | Medium | **NA** | **Low** |
| BUILT ENV (asset management) | Increased Temperature | 7 | Change in building heating/cooling costs (can be either negative or positive) for council owned buildings | **24** | Monitor developments in building codes and best practice and adjust council building design standards accordingly | Planning Approvals and City Buildings | Long | **NA** | **Very Low** |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| BUILT ENV (planning) | Reduced rainfall | 13 | Reduced resilience and increased costs for infrastructure (council owned) in regards to water use for buildings | **25** | Investigate the feasibility of policy changes that will increase the resilience and cost effectiveness of infrastructure (council owned) in regards to water use | Corporate | Long | **NA** | **High** |
| BUILT ENV (planning) | Increase Temperature | 17 | Increase in heat island effect in built up areas | **26** | Undertake aerial imagery assessment of the City of Stirling | Manager Parks & Reserves | Short | **NA** | **High** |
| | | | | **27** | Conduct a flyover to determine the baseline per cent (%) vegetation cover of the total City area. Subsequently, set annual targets for increase in urban tree establishment. | Manager Parks & Reserves | Short | | |
| | | | | **28** | Increase the number of shaded structures/trees available in public spaces. | Manager Parks & Reserves | Long | | |
| EMERGENCY MANAGEMENT | Extreme events (increase in intensity and number) | 18 | Interruption of road traffic from extreme weather events and emergency transport routes disrupted | **29** | Include related risk (i.e. interruption of road traffic and emergency transport routes during extreme events) into reviews of emergency management plans | Coordinator Emergency Management | Medium | **NA** | **High** |
| RECREATION (parks and gardens) | Extreme events (increase in intensity and number) and Reduced rainfall | 22 | Loss and damage to street trees | **30** | Review and incorporate climate change projections in review of the Street Tree Policy | Manager Parks & Reserves | Short | **NA** | **High** |
| | | | | **31** | Implement new measures developed in consideration of climate change as identified through the updated Street Tree Policy and research being conducted through street tree trials | Manager Parks & Reserves | Long | | |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| RECREATION (coastal) | Sea level rise | 25 | Loss of existing public space in coastal and estuarine areas and Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | **32** | Research and report on further information on projected impacts (e.g. maps of projected sea level rise and additional sediment transport studies) | Manager Engineering Design | Medium | **NA** | **High** |
| | | | | **33** | Managed retreat for Watermans Bay (infra-structure protection as determined by coastal sediment transport study and sand bag trial) | Manager Parks & Reserves (lead), Manager Engineering Design (support) | Medium | | |
| | | | | **35** | Mettams Pool, north - implement protective structures | Manager Parks and Reserves | Long | | |
| | | | | **36** | Deliver community education/awareness campaign to raise awareness of projected risks including loss of existing public space in coastal and estuarine areas and loss of coastal and estuarine recreational infrastructure | Manager Parks & Reserves | Medium | | |
| RECREATION (coastal) | Extreme events (increase in intensity and number) and SLR | 26 | Erosion, inundation and storm damage leading to loss of coastal and estuarine recreational infrastructure | | Adaptation Actions and Ratings as per Risk ID 25 (Action ID 32, 33, 34, 35 and 36) | | | | |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 30 | Shift in distributions of plant and animal species | **37** | Remove threats and disturbances as outlined in the Local Biodiversity Strategy | Manager Parks & Reserves Manager City Planning as support | Long | **NA** | **Medium** |
| | | | | **38** | Undertake land use planning and on-ground conservation measures | Manager Parks & Reserves Manager City Planning as support | Long | | |
| | | | | **39** | Implement natural and assisted regeneration through on ground conservation measures (monitoring, corridor planning and implementation) | Manager Parks & Reserves Manager City Planning as support | Long | | |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 31 | Increased risk of population extinctions - AS PER 30 | | Adaptation Actions and Ratings as per Risk ID 30 (Adaptation ID 37, 38 and 39) | | | | |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 32 | Ecological disturbances and reduced ecosystem resilience to stress - AS PER 30 | | Adaptation Actions and Ratings as per Risk ID 30 (Adaptation ID 37, 38 and 39) | | | | |
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 33 | Change in distribution of invasive plant and animal species due to changes in climate and associated loss of biodiversity and changes to bushfire intensity - AS PER 30 | | Adaptation Actions and Ratings as per Risk ID 30 (Adaptation ID 37, 38 and 39) | | | | |

| Ref | Climate Variable (Driver) | Risk ID | Risk Description | Action ID # | Risk Treatment Actions (i.e. what is to be done) | Accountability/ Risk treatment Owner | Implementation Timeframe | If actions implemented Risk Level 2030 | If actions implemented Risk Level 2070 |
|---|---|---|---|---|---|---|---|---|---|
| NATURAL ENVIRONMENT | Increase in temperature & decrease in rainfall | 35 | Decline in wetlands due to lowering of groundwater table and/or saltwater intrusion; increase in Acid Sulphate Soils, loss in wetland biodiversity; acidification of water bodies | **40** | Aquifer recharge, shallow water recharge: Investigate opportunities to increase aquifer recharge. | Manager Parks & Reserves | Long | **NA** | **High** |
| | | | | **41** | Re-establish wetland transition vegetation, planting naturally occurring species and natural biodiversity in the following sites: Carine Lakes, Lake Gwelup, Jackadder Lake, Herdsman Lake | Manager Parks & Reserves | Medium | | |
| | | | | **42** | Investigate opportunities to use biofilters to increase water retention, reabsorption and provide update report | Manager Parks & Reserves, Manager City Planning | Medium | | |
| COMMUNITY (health and well-being) | Increase Temperature | 47 | Decline in outdoor working conditions leading to increased incidence of OSH issues for staff | **43** | Investigate and report on the feasibility of alternative shifts and working hours for outdoor staff to avoid extreme temperatures | Manager Human Resources | Long | **NA** | **Medium** |
| | | | | **44** | Implement active measures identified through the outdoor staff heat avoidance assessment | Manager Human Resources | Long | | |
| LESSONS LEARNED | Risk Assessment and Adaptation Planning | P1 | OPPORTUNITY: The City has access to a wide range of spatial information, which if compiled within its central management system, would provide a useful tool to support risk assessment and adaptation planning | **45** | Investigate and compile a list of climate change adaptation data (natural environment and community) that is available within the City in various formats (Excel spread sheet, hard copy) and determine if it would be beneficial to future adaptation planning processes to convert some or all of these data into a spatial format to assist with vulnerability mapping and corporate knowledge of potential climate change impacts. | Manager City Buildings | Medium | | |
| | | | | | | | | | |