

# Climate Change Adaptation Plan



## Statement from the Mayor

This plan starts with acknowledgment that climate change is happening and is highly likely to accelerate over the rest of the 21st century.

This has huge implications for an historic city like Fremantle whose fabulous built heritage remains vulnerable to rising sea levels, just as our enviable lifestyle and diverse infrastructure is vulnerable to the predicted higher temperatures, lower rainfall and more extreme storm events.

But as they say: in crisis is opportunity. The climate crisis gives the City of Fremantle the opportunity to focus on investing in more resilient and sustainable infrastructure over coming years. As one example; the plan demonstrates that we can still have a green city whilst using less water and using it more efficiently.



The City of Fremantle Climate Change Adaptation Plan sits alongside our ambitious Low Carbon City Plan 2011-2015, in which we seek to reduce both our local government and our community emissions radically over the next few decades.

This plan will ensure that Fremantle is prepared and ready to adapt to the climate change challenges that lie ahead. I hope you find the plan both useful and informative.

**Dr Brad Pettitt**  
Mayor

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# Background

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The City of Fremantle has been a climate change mitigation leader for some time. We became the first carbon neutral local government in WA in 2009, the first locality outside the Perth CBD to establish a CAT bus and we recently introduced a small secondary dwelling scheme amendment which will encourage more resource efficient infill development in our suburbs – something that is notoriously difficult to achieve.

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**40%**  
corporate greenhouse  
gas reduction by  
 **2020**

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In 2011 the City adopted the Low Carbon City Plan. This plan sets out the steps that the City will take to progress towards its 40% corporate greenhouse gas reduction targets by 2020, as well as how the City will support the community to take action to reduce emissions.

The next stage of the climate change journey is to begin adapting to both the existing and inevitable climate changes. This document sets out the scientific basis behind the key climate change impacts, the scenarios that have been considered when choosing our actions and a prioritised list of actions that the City will take to adapt to each impact.

Like the Low Carbon City Plan, the Climate Change Adaptation Plan is broken up into key themes and the actions are further prioritised into:

## Corporate actions

What the City will do with its own resources and assets

## Community actions

What the City will do to influence and support its residents' behaviour

## Advocacy and communication

An important action that is outside the City's jurisdiction to directly implement.



When deciding what the City should do, it also needs to understand what it can do. Parts of the storm water system, for example, are owned and operated by the Water Corporation, so the City only has minimal influence over it.

While the City of Fremantle acknowledges the need for further investigation and research, it also acknowledges the need to address promptly those risks which are known and which present immediate or pressing concern.

Thus this plan is not designed as a comprehensive risk assessment and action strategy, but as a live document which will evolve as new information becomes available and as new issues for the City and the community are identified.

The actions through this document have been prioritised as short, medium or long term. Short term is intended to be completed in the 2013/14 budget cycle. Medium term is intended to be completed by the end of the 2014/15 budget cycle and long term is beyond that but within a relevant timeframe. It should be noted that many of the short term actions proposed in this plan depend on the results of detailed sea level rise modelling that the City has commissioned as part of the Cockburn Sound Coastal Alliance. As such this document stands as a live document to be updated as more relevant data and modelling is applied through the completion of this process.





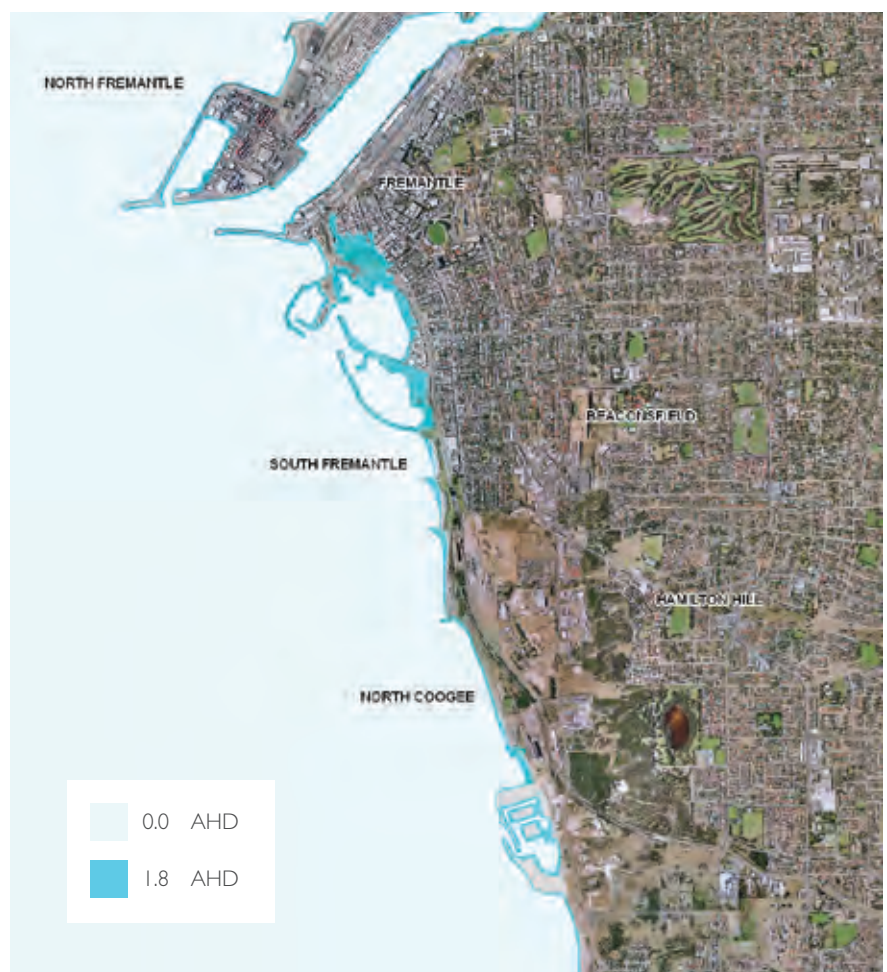
## Sea level rise

**18-59cm**  
increase in sea level  
indicated by  
**2100**

### Science and design scenarios

The latest Intergovernmental Panel on Climate Change (IPCC) modelling indicates the sea level will rise by 18-59 cm by 2100. Additionally sea level rise due to some types of ice flow / melt that have not yet been properly modelled can be expected to add to these projections.

The Australian government has released a 'bucket-fill' or 'bathtub' model, which shows how the shoreline would move if the sea level rose with no change to topography. This ignores accretion and erosion, which is likely to have a large impact on eventual shorelines. At this stage, in the absence of more rigorous data / research, the City has used this as an indicator of possible impacts. Further modelling is currently being conducted. The following images show selected changes to the City of Fremantle shoreline from this 'bucket-fill' model with a 1m projected sea level rise.



Publicly available source (with 1.2, 1.4 & 1.8m sea level rise scenarios):  
[www.ozcoasts.gov.au/climate/Map\\_images/Perth/mapLevel2\\_North.jsp](http://www.ozcoasts.gov.au/climate/Map_images/Perth/mapLevel2_North.jsp)

Until more detailed modelling is completed, these maps represent the best science currently available to the City, and therefore provide a notional basis for precautionary planning decisions.

More information:  
[www.realclimate.org/index.php/archives/2007/03/the-ipcc-sea-level-numbers/](http://www.realclimate.org/index.php/archives/2007/03/the-ipcc-sea-level-numbers/)

## Consequences of sea level rise

| 01   | 02  | 03   | 04   |
|--|---|--|--|
| Primary impacts  | Secondary impacts   | Tertiary impacts   | Quaternary impacts   |
| <b>Sea level rise</b><br>Globally sea levels could rise 0.59m by 2100 on average. The degree of sea level rise is subjective to the geographic location.<br><br>(This does not include the volume of water from the melting of the ice sheet) (IPCC 2007, p. 45) | Modification of coastal ecosystems (IPCC 2007, p. 48).<br><br>Salt-water inundation in low-lying regions (IPCC 2007, p. 48, 53).<br><br>Coastal erosion and inundation in low-lying regions (IPCC 2007, p. 48). | Impact on the livelihood of coastal fisheries and productivity of marine ecosystems (IPCC 2007, p. 54).<br><br>Decline in natural biodiversity (Prato 2009, p. 923; IPCC 2007, p. 48)<br><br>Threat to the water supply of low-lying areas (IPCC 2007, p. 53).<br><br>Impacts on tourism and recreation activities along the coast (SMEC 2009, p. 10).<br><br>Damage to coastal infrastructure (specifically recreational infrastructure) (SMEC 2009, p. 10).<br><br>Loss of existing public space in coastal areas (SMEC 2009, p. 10).<br><br>Loss of beach width (SMEC 2009, p. 11).<br><br>Spread of water-borne disease (IPCC 2007, pp. 48, 53). | Economic loss (IPCC 2007, pp. 48, 53).<br><br>Impacts on tourism and recreation activities along the coast (SMEC 2009, p. 10).<br><br>Encourage competition with exotic species (Wilby and Perry 2006, p. 76).<br><br>Water shortages for irrigation and drinking purposes (IPCC 2007, p. 48).<br><br>Modifications in ecosystems and threat to biodiversity (Prato 2009, p. 923; IPCC 2007, p. 48).<br><br>Economic loss (IPCC 2007, pp. 48, 53).<br><br>Impacts on tourism and recreation activities along the coast (SMEC 2009, p. 10).<br><br>Pressures on health and emergency services (IPCC 2007, p. 48).<br><br>Beach closures, eg. Due to E.coli levels after storms (SMEC 2009 p. 10). |

Table 1: Synthesis of climate change impacts resulting from sea level rise.



## Sea level rise

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### Action to date

The City has commenced a detailed modelling exercise of sea level rise. This is being done through the Cockburn Sound Coastal Alliance which comprises of the local governments of Fremantle, Cockburn, Rockingham, Kwinana as well as the Department of Defence and the Cockburn Sound Management Council. The study aims to conduct detailed weather and sea level modelling to quantify the impact on the shorelines. It will also conduct a risk assessment and begin detailed adaptation planning. This is expected to be completed by mid-2013, which neatly aligns with the City's budget cycle and will allow further work to be completed by the City in 2013/14.

### Prioritised actions to adapt to sea level rise

As with any risk-based problem, the response to sea level rise will depend on the severity of the potential consequence.

The 'bucket-fill' mapping identifies that a sea level rise of 1m will result in localised flooding in North Fremantle along Johannah St and some inundation through Fishing Boat Harbour. The more rigorous modelling that is currently being undertaken by the Cockburn Sound Coastal Alliance may highlight more or less severe consequences, which would likewise affect the City's response. Until this is confirmed, actions will remain at a strategic level.





## CORPORATE ACTIONS

| Action   | Directorate        | Priority       |
|--|--------------------|----------------|
| Develop a planning policy dealing with sea level rise for existing development (ie where roads and infrastructure are already in place). This will need to consider conflicting priorities, such as streetscape impacts and heritage requirements. Prepare a town planning scheme amendment and/or a local law depending on the most appropriate means to implement this policy. | Planning           | Short term     |
| Develop a planning policy which ensures that proposed new development considers and mitigates the risks from projected sea level rise.   | Planning           | Short term     |
| Review level of risk to existing coastal infrastructure and prioritise protection/upgrades/relocation.   | Technical Services | Short term     |
| Review and implement options to address both sea water incursion and rising ground water salinity levels in the West End heritage precinct and the damage that is being done to these buildings.   | Planning           | Short term     |
| Review and amend standards to provide future protection of coastal infrastructure where appropriate.   | Technical Services | Long term      |
| Source funding including external opportunities to implement prioritised works and measures.   | Technical Services | As appropriate |

## ADVOCACY AND COMMUNICATION ACTIONS

| Action   | Directorate                        | Priority  |
|--|------------------------------------|-----------|
| Work with relevant state agencies to model impacts on marine environments and subsequent impacts on marine and tourist industries. | Economic Development and Marketing | Long term |



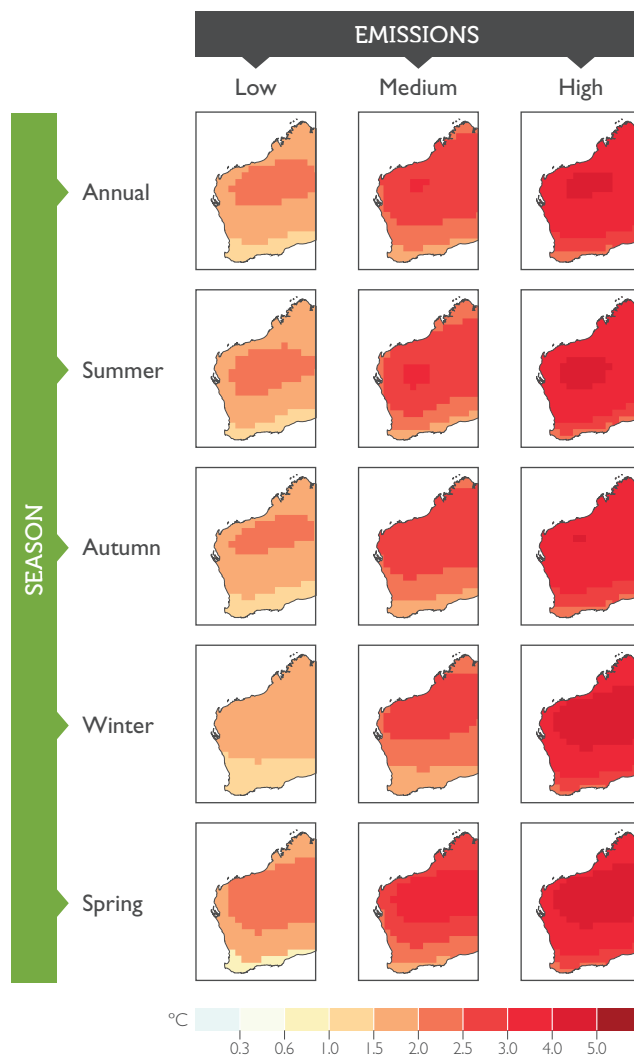
## Increased temperatures

**1-6.5%**  
increase in south west  
WA temperature by  
**+ 2070**

### Science and design scenarios

The IPCC AR4 is the latest source of information regarding temperature changes. As the figure below for expected temperature changes in 2070 shows, all emissions scenarios indicate that Perth will become a hotter place. The drying trend applies to all seasons, but more so the Spring and Summer months.

Depending on the emissions scenario applied, South West WA is likely to experience temperature increases of between 1 and 6.5°C by 2070.



Source: <http://climatechangeinaustralia.com.au/watemp23.php>

## Consequences of higher temperatures

| 01   | 02  | 03   | 04   |
|--|---|--|--|
| Primary impacts  | Secondary impacts   | Tertiary impacts   | Quaternary impacts   |
| <b>Temperature increase</b><br>Global temperature is liable to increase by as much as 6.4°C by 2099 (Likely range between 2.4°C – 6.4°C) (IPCC 2007, p. 45). | Rise in the number of heatwaves (IPCC 2007, p. 46).<br><br>Bushfires will become more frequent and more intense (IPCC 2007, p. 48).<br><br>Increase in geographical range and seasonality of vector-borne diseases and the possibility for an expansion of receptive zones (IPCC 2007, p. 48).<br><br>Increasing incidence of food and water-borne diseases (IPCC 2007, pp. 48, 53).<br><br>Higher evaporation rates (IPCC 2007, p. 49).<br><br>Contribute to the Urban Heat Island Effect (Trenberth 2007, p. 244).<br><br>Decline in natural biodiversity (Prato 2009, p. 923).<br><br>88% of species risk extinction (Garnaut 2008, p. 102). | 88% of species risk extinction (Garnaut 2008, p. 102).<br><br>Decline in natural biodiversity (Prato 2009, p. 923; IPCC 2007, p. 48).<br><br>Threat to the water supply of low-lying areas (IPCC 2007, p. 53).<br><br>Impacts on tourism and recreation activities along the coast (SMEC 2009, p. 10).<br><br>Damage to coastal infrastructure (specifically recreational infrastructure) (SMEC 2009, p. 10).<br><br>Loss of existing public space in coastal areas (SMEC 2009, p. 10).<br><br>Loss of beach width (SMEC 2009, p. 11).<br><br>Spread of water-borne disease (IPCC 2007, pp. 48, 53). | Pressures on health and emergency services (IPCC 2007, p. 48).<br><br>Economic loss (IPCC 2007, pp. 48, 53).<br><br>Risks to public safety and tourism and longer term impacts on regional economies (SMEC 2009, p. 11; IPCC 2007, p. 53).<br><br>Water shortages (IPCC 2007, pp. 48-50).<br><br>Exacerbate health problems such as asthma (IPCC 2007, p. 48).<br><br>Reduced ecosystem resilience to stress (IPCC 2007, p. 48).<br><br>Further threat of the intensity of bushfires (IPCC 2007, p. 48).<br><br>Impact on the livelihood of coastal fisheries and productivity of marine ecosystems (IPCC 2007, pp. 48, 54). |

Table 2: Synthesis of climate change impacts resulting from temperature increase.

## Increased temperatures

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### Action to date

The following steps have been taken to adapt to increasing temperatures:

- Dramatically increased the City's tree planting program so that 1 000 new trees are planted each year.
- Installed several drinking fountains in public places, with a focus near bike parking.
- Including solar passive design principles in the local planning policy 2.2: Split Density Codes and Energy Efficiency, which allows increase density in some areas as a bonus for sustainability outcomes.
- Support for green wall research and a demonstration green wall installed on the City's administration building.





## Prioritised actions to adapt to increased temperatures

### CORPORATE ACTIONS


| Action  | Directorate        | Priority    |
|---|--------------------|-------------|
| Provide more outdoor drinking facilities.   | Technical Services | Medium term |
| Address the urban heat island effect by trialling the use of lighter and more heat reflective bitumen on roads and use permeable / vegetated surfaces where possible. Measure and report on the impact of this trial. | Technical Services | Short term  |
| Identify planning measures (possibly amendment to local planning scheme, or local planning policy) to limit heat absorption and energy consumption associated with new development including outdoor areas.           | Planning           | Short term  |

### COMMUNITY ACTIONS

| Action  | Directorate           | Priority  |
|---|-----------------------|-----------|
| Increase the availability of relevant City services to assist people to deal with increased temperatures. Consider discounting leisure centre access for vulnerable groups and extending opening hours of facilities such as the library and Hilton community centre. | Community Development | Long term |

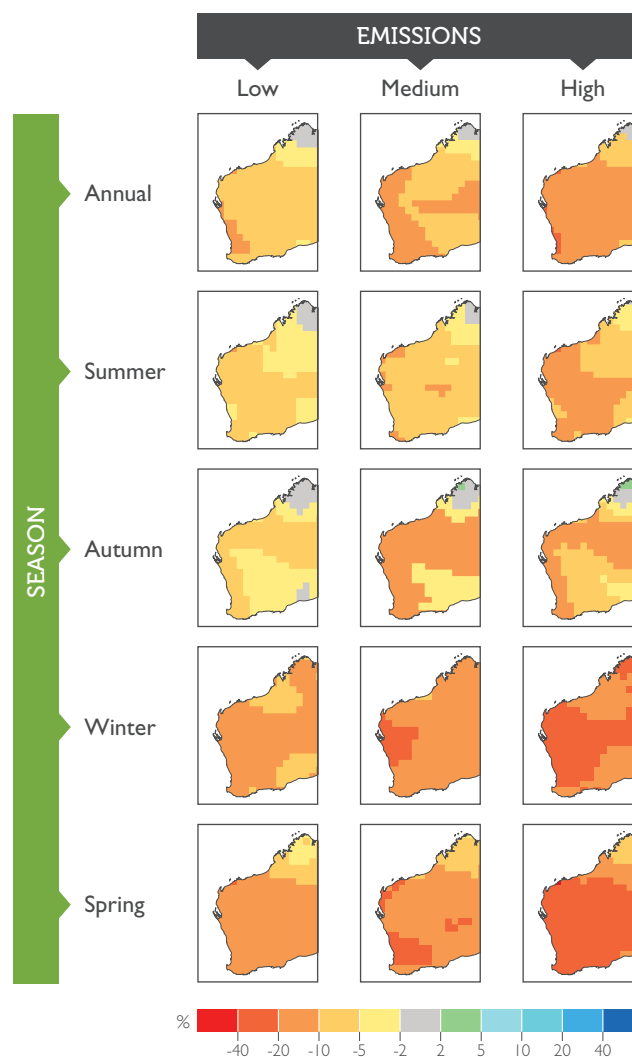


## Decreased rainfall

**5-60%**  
decrease in south west  
WA rainfall by  
—  **2070**

### Science and design scenarios

The IPCC AR4 indicates that rainfall in the Southwest of WA will decrease dramatically. Depending on the emissions scenario applied, South West WA likely to experience rainfall decreasing by between 5 and 60% by 2070.



This shows that the greatest relative decrease is in Winter and Spring, which is when most of Perth's rain falls. As such ground and surface sources of water are expected to become even scarcer:

## Consequences of reduced rainfall

| 01   | 02  | 03   | 04   |
|--|---|--|--|
| Primary impacts  | Secondary impacts   | Tertiary impacts   | Quaternary impacts   |
| <b>Changes in precipitation</b><br>Precipitation levels will increase at high-latitude and decrease in subtropical areas by as much as 20% by 2100 (IPCC 2007, p. 30). | Increase the intensity of rainfall events (IPCC 2007, pp. 48-49).<br><br>Changes to ground water recharge and flow Loáiciga 2003).<br><br>More frequent and severe droughts (IPCC 2009, pp. 48-49). | Increase extreme and flash flooding events (IPCC 2007, pp. 48-50).<br><br>Impacts of water supply for irrigated agriculture (IPCC 2007, pp. 48-50).<br><br>Water shortages (IPCC 2007, pp. 48-50).<br><br>Increase in the threat of bushfires (IPCC 2007, p. 48).<br><br>Impacts on water supply for irrigated agriculture (IPCC 2007, p. 48). | Exceedence of existing flood defences (SMEC 2009, p. 10).<br><br>Exceedence in drainage capacity (SMEC 2009, p. 10).<br><br>Transporting contaminants into waterways (SMEC 2009, p. 11).<br><br>Changes in flood plains (SMEC 2009, p. 12).<br><br>Further changes in ecosystems and threat to biodiversity (Prato 2009, p. 923; IPCC 2007, p. 48).<br><br>Food shortages (IPCC 2007, pp. 48, 50).<br><br>Reduced water quality and quantity resulting in less watering and irrigation of open space and sports grounds and closure of ovals (SMEC 2009, p. 10).<br><br>Limited water for swimming pools, etc (SMEC 2009, p. 10).<br><br>Risks to public safety and tourism and longer term impacts on regional economies (SMEC 2009, p. 11; IPCC 2007, p. 53).<br><br>Food shortages (IPCC 2007, pp. 48, 50). |

Table 3: Synthesis of climate change impacts resulting from changes in precipitation

## Decreased rainfall

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### Action to date

The following steps have already been taken to adapt to decreasing rainfall:

- Participating in the ICLEI Water Campaign and committing to an ambitious Water Conservation Plan. The Water Conservation Plan lists many actions, including establishing targets on ground water extraction, hydrozoning and reviewing alternative water supplies.
- Funding a project to hydrozone Fremantle Park, will be modelled to illustrate reduction in water demand.
- Installing low flow shower heads at the leisure centre, which use 45% less water.
- Retrofitting The Meeting Place as a sustainable demonstration home, including a rain water tank and low flow plumbing fittings.
- Subsidising native plants for all residents and schools each year, as well as providing additional incentives to install native verges.
- Created a school garden at Winterfold Primary School, which stores storm water for use as reticulation.
- Increased the use of permeable surfaces around street trees to allow more rain water to be captured by these trees.
- Including Water Sensitive Urban Design considerations at structure planning stages – for example the Lefroy Road Quarry site.





## Prioritised actions to adapt to decreased rainfall

### CORPORATE ACTIONS

| Action   | Directorate        | Priority           |
|--|--------------------|--------------------|
| Plant trees based on future climate – e.g. drought tolerant indigenous species   | Technical Services | Short term         |
| Develop an action plan to divert storm water from the ocean to freshwater aquifer recharge. Consider bioretention swales and other passive means of achieving this within the limits of the City's jurisdiction. | Technical Services | Short term         |
| Implement the above plan to divert storm water from the oceans to freshwater aquifer recharge.   | Technical Services | Medium – long term |
| Reuse water from outdoor / public showers at beaches for grass reticulation (starting with pilot at Leighton Beach)  | Technical Services | Short term         |

### ADVOCACY AND COMMUNICATION

| Action   | Directorate        | Priority  |
|--|--------------------|-----------|
| Partner with the Water Corp and Department of Water for aquifer recharge and alternative supply technologies | Technical Services | Long term |
| Consider forming ground water management programs with other councils, such as through the South West Group  | Technical Services | Long term |

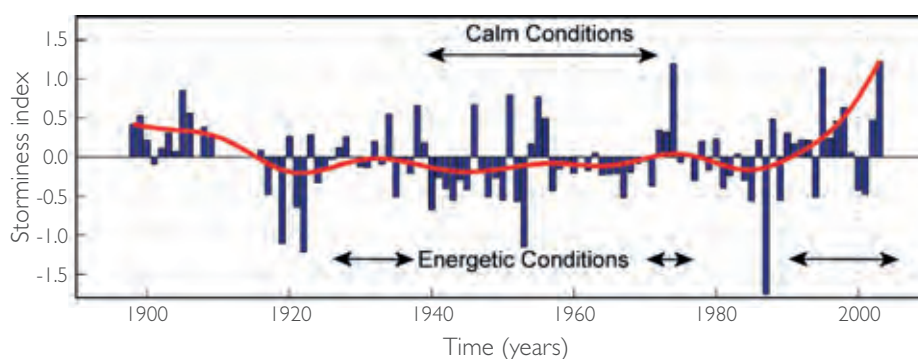


## Increased storm intensity

**18-59<sup>cm</sup>**  
**increase in sea level**  
**indicated by**  
**2100**

### Science and design scenarios

The science regarding how climate change will impact on storm intensity is less well understood than other climate variables included in this report. When allowing for long term tidal effects however storminess in Fremantle has increased rapidly in the last 10-15 years.



The red line shows the interannual variability in the record obtained by running a 19 year Hanning window to remove the long-term tidal effects. Source: Technical Advisory Panel 2007.<sup>1</sup>

<sup>1</sup> Swan River Trust Technical Advisory Panel, above no. 5, pg 25

## Consequences of increased storm intensity

| 01  | 02   | 03   | 04   |
|---|--|--|--|
| Primary impacts   | Secondary impacts  | Tertiary impacts   | Quaternary impacts   |
| <p><b>Extreme weather events</b><br/>Extreme weather events (including typhoons, cyclones and hurricanes) will become more frequent (IPCC 2007, p. 30).</p> <p>High likelihood of a gradual pole-ward progression of tropical storms (p. 46).</p> | <p>Increase in extreme winds, flooding and erosion (IPCC 2007, pp. 48-50).</p> | <p>Disrupt electricity services with more frequent and severe blackouts (CSIRO 2006, p. 22).</p> <p>Increased pressure on dune systems (SMEC 2009, p. 11).</p> <p>Damage to development and infrastructure (IPCC 2007, p. 48; SMEC 2009, pp. 11-13).</p> <p>Encourage outbreaks of water-borne disease, especially in low-lying regions susceptible to coastal inundation (IPCC 2007, pp. 48, 53).</p> <p>Increase the risk of bushfires from lightning strikes (SMEC 2009, p. 8).</p> | <p>Risks to public safety and tourism and longer term impacts on regional economies (SMEC 2009, p. 11; IPCC 2007, p. 53).</p> <p>Modifications in insurance policies and costs (IPCC 2007, p. 53).</p> <p>Increased costs associated with operation and maintenance costs of public amenities recreational sites due to storm damage (SMEC 2009, p. 10).</p> <p>Pressures on health and emergency services (IPCC 2007, p. 48).</p> |

Table 4: Synthesis of climate change impacts resulting from increase in extreme weather events.

## Action to date

The following steps have been taken to adapt to increasing storm intensity:

- Conducted a drainage review and continuing to install gross pollutant traps where necessary.
- Increased the use of permeable surfaces around street trees to allow faster dispersal of storm water.
- Upgrading the storm water system to comply with Department of Water best practice storm water management whenever changes are made. More information on best practice stormwater management can be found here:

<http://www.publish.csiro.au/pid/2190.htm> and here:

<http://www.water.wa.gov.au/Managing+water/Urban+water/Stormwater/Stormwater+management+manual/default.aspx>

## Increased storm intensity

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### Prioritised actions to adapt to decreased rainfall

#### CORPORATE ACTIONS

| Action  | Directorate        | Priority    |
|---|--------------------|-------------|
| Review and where necessary update emergency response plans and infrastructure to deal with severe storm events  | Corporate Services | Short term  |
| Investigate whether the costs associated with disaster recovery can and should be insured against   | Corporate Services | Short term  |
| Ensure the City's insurance policies adequately treat climate change risks  | Corporate Services | Short term  |
| Review the storm water system for adequacy. Consider ways to maximise storm water diversion to the water table, or to directly productive uses such as irrigation or swimming pool top up | Technical Services | Short term  |
| Assess and manage trees in high storm risk areas  | Technical Services | Medium term |

#### ADVOCACY AND COMMUNICATION

| Action  | Directorate        | Priority  |
|---|--------------------|-----------|
| Request that building codes be updated to accommodate high risk storms and flooding zones | Planning           | Long term |
| Research modelling that identifies impacts of severe storms through Fremantle.            | Technical Services | Long term |



# Education

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The City will use its unique position to inform local residents about climate change adaptation issues. In particular the City is the planning regulator; so is involved in the building and renovation of buildings throughout Fremantle. It is also informed every time that a house is sold. The City will prepare information suitable for prospective builders or renovators as well as new residents and provide this information to each of these groups. This information may be provided as fact sheets, policy or planning recommendations. This is a medium term action.

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## Acknowledgements

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It is acknowledged that this report has relied heavily on work by others. A broad literature review of both the science and potential adaptation options was conducted by one of Mayor Brad Pettitt's Murdoch University Honours students – Lauren Mackaway. Jessica Lisle also adapted her Master's thesis to present the cascade of impacts from each climate change theme. The City also acknowledges the work of other local governments which is informing the broader discussion about how to adapt to Climate Change – in particular the City of Mandurah and the Town of Cottesloe, who have been leaders in WA local government adaptation research, planning and action.



