City of Melville

Climate Vulnerability, Risks and Opportunity Assessment Report

FINAL

APRIL 2023

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Climate Vulnerability, Risks and Opportunity Assessment Report

City of Melville

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Approved by:	Alexandria Moore	18/04/2023	

WSP acknowledges that every project we work on takes place on First Peoples lands.
We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

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Glossary

Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects.[1]
Adaptive Capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.[1]
Climate Stressors	Changes in meteorological conditions such as temperature, precipitation, and wind, and causing changes in sea level, drought, flooding, or erosion.[2]
Ecosystem	A functional unit consisting of living organisms, their non-living environment and the interactions within and between them. The components included in a given ecosystem and its spatial boundaries depend on the purpose for which the ecosystem is defined: in some cases, they are relatively sharp, while in others they are diffuse. Ecosystem boundaries can change over time. Ecosystems are nested within other ecosystems and their scale can range from very small to the entire biosphere. In the current era, most ecosystems either contain people as key organisms, or are influenced by the effects of human activities in their environment.[3]
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.[1]
Mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases. Mitigation measures are technologies, processes or practices that contribute to mitigation, for example renewable energy technologies, waste minimisation processes, and public transport commuting practices.[1]
Non-Climate Stressors	Economic (rising prices), social (population growth, crime), physical (aging infrastructure), political (legal barriers, corruption, poor governance), environmental (deforestation, pollution, consumption of resources).[4]
Risk	The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic

1 IPCC. 2022. Annex VII: Glossary. Accessed 20 Oct 2022. <https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf>; City of Melville. 2022. RFQ212268 Contract for the Supply of Climate Vulnerability, Risk & Opportunity Assessment.

2 USAID. 2016. Climate Vulnerability Assessment. Accessed 20 Oct 2022. <https://www.climatelinks.org/sites/default/files/asset/document/USAID%20Vulnerability%20Assessment%20Annex.pdf>; City of Melville. 2022. RFQ212268 Contract for the Supply of Climate Vulnerability, Risk & Opportunity Assessment.

3 IPCC. 2022. Annex VII: Glossary. Accessed 26 Sept 2022. <https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf>.

4 City of Melville. 2022. RFQ212268 Contract for the Supply of Climate Vulnerability, Risk & Opportunity Assessment.

	changes and human decision-making. In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals. Risks can arise for example from uncertainty in implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions.[1]
Sensitivity	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.[1]
Shock	"An acute natural or human-made event or phenomenon threatening major loss of life, damage to assets and a city's ability to function and provide basic services, particularly for poor or vulnerable populations."[5]
Stressors	Events and trends, often not climate-related, that have an important effect on the system exposed and can increase vulnerability to climate-related events.[6]
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.[1]

[5] Resilience Tools. 2022. What is Resilience? – Definitions. Accessed 9 Dec 2022. <http://resiliencetools.net/node/14>.
[6] City of Melville. 2022. RFQ212268 Contract for the Supply of Climate Vulnerability, Risk & Opportunity Assessment. Accessed 21 Dec 2022.

Abbreviations

$	Dollars
%	Per cent
~	Approximately
>	Greater than
<	Less than
^{o}C	Degrees Celsius
ABS	Australian Bureau of Statistics
ACIS	Australian Cyclone Intensity Scale
AFDRS	Australian Fire Danger Rating System
AIHW	Australian Institute of Health and Welfare
B	Billion
BoM	Bureau of Meteorology
CARG	Climate Action Reference Group
City of Melville	The City
cm	Centimetre
COVID-19	Coronavirus pandemic
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cth	Commonwealth
e.g.,	For example,
FBI	Fire Behaviour Index
FFDI	Forest Fire Danger Index
GHG	Greenhouse gases
GIS	Geographic Information System
i.e.,	That is
IPCC	Intergovernmental Panel on Climate Change
km	Kilometres
km/h	Kilometres per hour
LGA	Local Government Area
m	Metres
m^3	Metres cubed

mm	Millimetres
n.d.	No date
NBS	Nature Based Solutions
RCP	Representative Concentration Pathways
SES	State Emergency Services
TCFD	Taskforce on Climate Financial Disclosures
TNDF	Taskforce on Nature-Related Financial Disclosures
UHI	Urban Heat Island
VRO	Vulnerability, Risk, and Opportunity
vs	Versus
WA	Western Australia
WHS	Work Health and Safety

1 Introduction

1.1 Purpose of the Document

In June 2021, the City of Melville (herein referenced as 'the City') declared a climate emergency and pledged to take actions to help mitigate against and adapt to the impacts of climate change. It aims to do so by establishing targets such as achieving carbon neutral at the Council operations level by 2030 and across the Local Government Area (LGA) by 2050. In April 2022, the City released a Climate Action Policy which details the Policy Objectives including "to demonstrate the City's leadership on Climate Action including climate change mitigation and adaptation" and "prioritising carbon neutral considerations in all aspects of the City's business practices in alignment with the Climate Emergency declaration". The City recognises the importance of embedding sustainability and environmental policies to develop resilient and prepared communities.

The City, together with the local community, are developing a Climate Action Plan which will be jointly owned and implemented. To support this effort, WSP has been engaged by the City to assess the vulnerabilities, risks, and opportunities their city may face against climate change and develop a Climate Action Plan. The Climate Action Plan will be informed by the findings of the Climate Vulnerability, Risk, and Opportunity (VRO) Assessment. The VRO Assessment will consider the City's assets, services, and climate impacts on the LGA's social, economic, and environmental adaptability. By assessing these considerations, the VRO Assessment will present the key findings from stakeholder engagement and prior research phases, offering implementable actions to be taken by the City, to best prepare for and address climate change.

1.2 How to Read the Document

The VRO Report is split out into four distinct parts. Part A focuses on the City context, previous disaster events and the shocks and stresses for the City. Part B details the stakeholder engagement activities and summary outcomes. Part C contains the Risk and Vulnerability Assessment, detailing the City's exposure to climate hazards, transitional risks and socio-demographics impacting the City's vulnerabilities. Part D establishes the risks and opportunities associated with climate change, providing recommended further actions the City can take in furthering their resilience.

PART A. Context Setting

- **Chapter 2:** City Context Overview. This chapter outlines a broad overview of the City, addressing administrative, geographic, environmental, urban development, demographic, social, economic, physical and social infrastructure aspects.
- **Chapter 3:** Previous Disaster Events. The occurrence and impact of previous disaster events across the City and greater Perth are considered within this chapter, particularly examining heatwaves, bushfires, floods, storms, and cyclones.
- **Chapter 4:** Key Shocks and Stresses for the City. Important acute shocks and chronic stressor events are addressed, including (but not limited to) extreme events, disease outbreaks, climate litigation, and reduced tourism.

PART B. Stakeholder Engagement

- **Chapter 5:** Stakeholder Engagement. Engagement workshops held across the City (internal staff and community workshops) are detailed with key risk themes and recommendations provided.

PART C. Vulnerability, Risk and Opportunity Assessment

- **Chapter 6:** Climate and Disaster Resilience. This chapter considers the impact of mitigation and adaptation efforts, with both contributing towards climate action.
- **Chapter 7:** Climate Hazards and Exposure. The impact of climate hazards is assessed against climate change projections and a summary of primary impacts provided within the chapter.
- **Chapter 8:** Climate Change Transitional Risks. The impacts of transitional risks across policy, social, technology, market, resources, and reputational aspects are addressed.
- **Chapter 9:** Vulnerability Risk Assessment. This chapter addresses the socio-demographic factors impacting the City, including economic, social, environmental, cultural, and built environment infrastructure.

PART D. Findings

- **Chapter 10:** Climate Vulnerabilities, Risks and Opportunities. A summary of the key risks is provided within this chapter with identification of level of likelihood, level of impact and quality of data.
- **Chapter 11:** Recommendations. This chapter offers recommendations towards climate action under several criteria including strengthening existing activities, additional action needed, building capacity and understanding, and new adaptation and mitigation actions needed.
- **Chapter 12:** Next Steps. This chapter provides final recommendations to the City on further actions with a particular focus on prioritisation and action development for their Climate Action Plan.

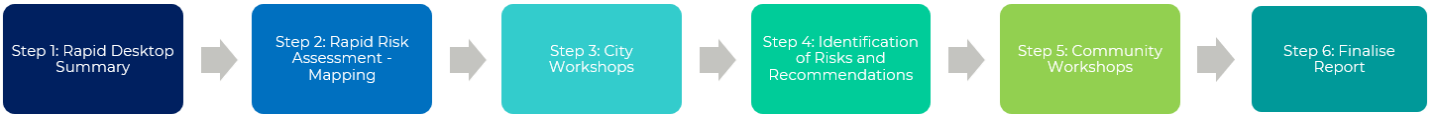
1.3 Risk Assessment Approach

There is no singular approach to conducting a city-wide climate risk assessment. Depending on the approach taken, different levels of analysis are possible from basic visual comparisons of base maps and hazard maps to more complex analyses that combine base maps into thematic composite maps and overlay these with hazard data.

In summary, the risk assessment was informed by the following key components (also see **Figure 1-1** for the stages of technical assistance provided):

- **Desktop research** of publicly available literature and other ‘grey’ sources (e.g., news articles) for contextual information on the study area;
- Obtaining, sorting, categorising, scoring, and mapping data in a geographic information system (GIS);
- **Stakeholder engagement** at the to obtain insights and first-hand information on the study area; and
- **Quantitative and qualitative analysis** of the above elements to arrive at this comprehensive VRO report.

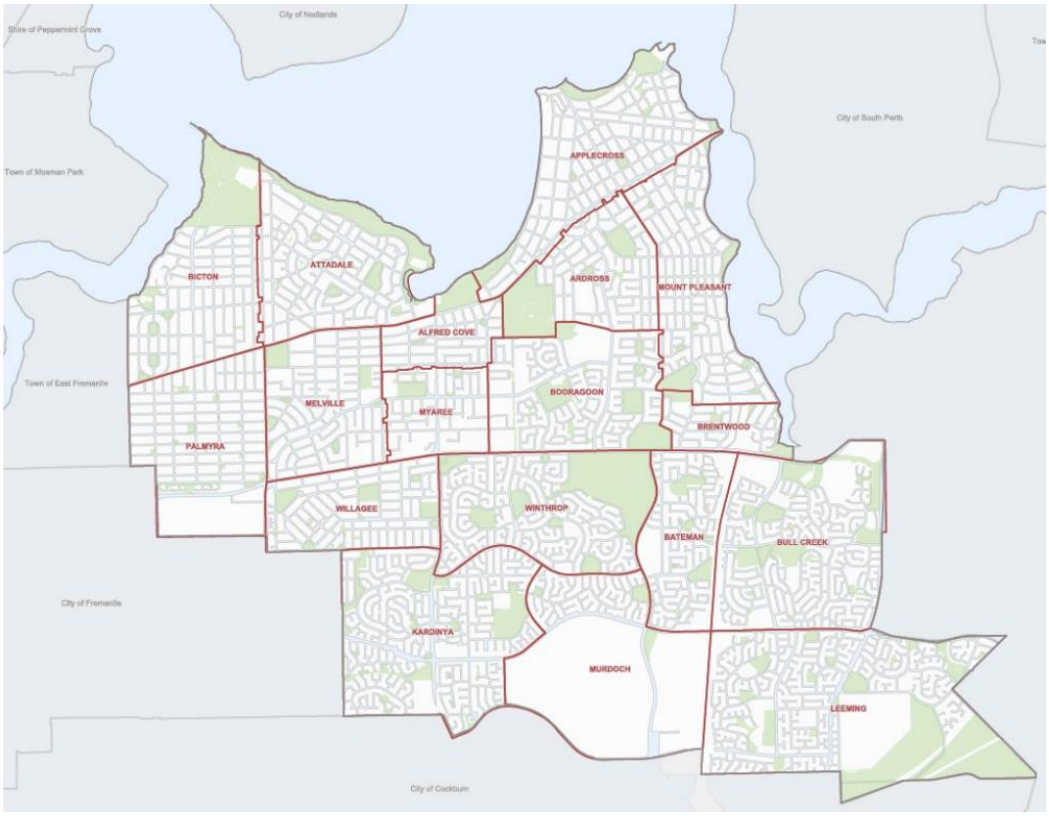
Figure 1-1. Technical Assessment Methodology



PART A.
CONTEXT SETTING

2 City Context Overview

Figure 2-1. The City's Suburbs



Source: City of Melville (2021)[7]

For the purpose of this report, we have provided a snapshot of the context overview that informed this VRO report in the Administration, Geography and Environment, Urban Development, Demographics and Social Aspects, Economy, Physical Infrastructure, and Social Infrastructure.

Administrative:

- The City is located in Perth, the state capital of WA, located 12 kilometres (km) south of Perth's CBD. It covers an area of 52.73km^2 which includes 18km of Swan River Coastline.
- The City consists of 18 suburbs and six wards (see **Figure 2-1** above).
- The City is home to 103,523 residents (2021) with a population density of 2,014 inhabitants per km^2.

Geography and Environment:

- The City is located on Whadjuk territory, home to the Bibbulmun people.
- Geographically, the City sits approximately 21m above sea level along the Swan River (north bound) and Canning River (east).[8] The City of Cockburn is found to the South, to the west is the City of

[7] City of Melville. 2021. *City of Melville Review of Local Planning Scheme No. 6 – Report of Review December 2021.* <https://www.melvillecity.com.au/our-city/our-council/agendas-and-minutes/ordinary-meeting-of-the-council/2021/december/minute-ordinary-meeting-of-the-council-14-december/3955-attachment-1-report-of-review>

[8] Worldwide Elevation Map Finder. 2023. Elevation and City of Melville, Melville, WA, Australia. Accessed 12 Jan 2023. <https://elevation.maplogs.com/poi/city_of_melville_melville_wa_australia.74691.html>.

Fremantle and the Town of East Fremantle.[9] The City is situated to the south and west of the Darling Range, east of coastal plains.

- The whole Perth region, including the City, is situated on mainly flat, undulating topography, largely attributable to the abundance of sandy soils and deep bedrock. Summers are hot, while winters are cool with temperatures ranging from 7-39°C.[10]

Urban Development:

- Suburban sprawl has been observed (particularly in southern regions) since the 1950s. However, following the 1980s, development has significantly slowed due to the consumption of green field opportunities.[11]
- The City consists of primarily residential housing, with a substantial amount of institutional land uses (including Murdoch University) and some employment districts. Due to the number of amenities found within the City, persistent demand for residential housing continues.

Demographics and Social Aspects:

- The City is expected to experience 14.55 per cent (%) population growth between 2022 and 2036, growing to 126,754 people by 2036.
- Of the 103,523 residents in 2021, there were 29,477 families and 43,811 private homes. A typical weekly household income was $2,096.
- The City has a portion of people born overseas (37.9%) and/or speaking another native language other than English at home (particularly Mandarin (4.7%) and Cantonese (2.0%)).

Economy:

- The City is economically well off, generating a Gross Regional Product of $6.45 million in the financial year ending 30th June 2021. This accounted for 2% of the States Gross State Product.
- The Health Care and Social Assistance Industry are the largest industry in the City, employing 13,208 people (29.6% of available local jobs in 2020/21), and generating $2,218 million. However, the Professions, Scientific and Technical Services industry accounts for the highest percentage of registered businesses (17.9%).
- In 2007, over half of the businesses in the City were self-employed, consisting of just the owner.

Physical Infrastructure:

- **Water supply:** The Perth area's primary water supply includes groundwater aquifers, desalinated water (two desalination plants) and catchment storage. However, aquifers and groundwater supplies are of limited availability, with diminishing supplies. Surface water is drawn from the Murray River catchment, Harvey River catchment and Swan-Canning River system. Potable drinking water is also supplied across the City.
- **Sanitation and wastewater:** The City has a network of water, drainage, and sewers connected to deep sewer. Wastewater is treated and recycled, being used for various purposes including irrigation and groundwater replenishment.

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9 Informed Decisions. N.d. City of Melville. Accessed 12 Jan 2023. <https://profile.id.com.au/melville/about#:~:text=The%20City%20of%20Melville%20is%20bounded%20in%20the%20north%20by,the%20Town%20of%20East%20Fremantle.>.

10 Weather Spark. N.d. Climate and Average Weather Year-Round in Melville Australia. Accessed 9 Nov 2022. <https://weatherspark.com/y/130043/Average-Weather-in-Melville-Australia-Year-Round>.

11 Informed Decisions (2017). *Drivers of population change*. Informed Decisions. Available at: https://forecast.id.com.au/melville/drivers-of-population-change?OverlayID=-1

- **Stormwater:** Stormwater is managed in various ways across the City, including on-site retention soil infiltration, underground or above ground water tank capture, and deep aquifer recharge.[12] Offsite disposal must be approved by the City.
- **Solid waste:** Waste from the City is transported to a waste transfer station in Bibra Lake before being landfilled at North Bannister to the south of Perth.
- **Energy:** Electricity accounts for 49% of the City's emissions (with 24% of this coming from commercial sources) and gas creates a further 6%.[13] Synergy is WA's largest energy provider (gas and electricity) across Perth.[14] The State Underground Power Program is run within the City.[15]
- **Transport:** The City has more than 1,300km of roads, with 92.9% of households able to access at least one car. The City has well established transport networks, with some cycle and pedestrian infrastructure. Major highways connect the City in all directions.

Social Infrastructure:

- There are several educational institutions across the City including Murdoch University, pre-schools, and primary/secondary education institutions.
- Fiona Stanley Hospital and St John of God Murdoch Hospital provide comprehensive healthcare services in the City with a 783 and 510 bed capacity respectively.
- Several emergency service associations reside within the City, including the Community Safety Service, police, fire brigade, and state emergency services (SES).
- Despite the City's overall affluence, low socioeconomic persons reside within the City. Social housing and social assistance services are available to assist those in need.

[12] City of Melville. 2022. Stormwater Drainage Information Sheet. Accessed 12 Jan 2022. <https://www.melvillecity.com.au/CityOfMelville/media/Documents-and-PDF-s/Stormwater-Drainage-Information-Sheet.pdf>.

[13] Snapshot. 2019. Melville. Accessed 7 Mar 2023. <https://snapshotclimate.com.au/locality/australia/western-australia/melville/>.

[14] Synergy. 2023. About Us. Accessed 7 Mar 2023. <https://www.synergy.net.au/About-us>.

[15] City of Melville. N.d. State Underground Power Program. Accessed 7 Mar 2023. <https://www.melvillecity.com.au/our-city/about-our-city/state-underground-power-program>.

3 Previous Disaster Events

This chapter examines the occurrence and impacts of previous disaster events across the City and greater Perth region. Previous heatwaves, bushfires, floods, storms, and cyclone events are examined. Historically, Melville experiences hot summers and cool winters, with temperatures ranging from 7-39ºC.[16] Temperature's average above 35 degrees (ºC) in summer, while winter averages a high below 23ºC. Rainfall usually occurs January to August, averaging 29mm monthly.

3.1 Heatwaves

Perth, and by extension the City, experiences extremely hot and dry weather due to easterly winds that move over the Great Victoria Desert. West coast troughs also influence the region's extensive hot and dry weather, blocking afternoon sea breezes when located offshore.[17] Additionally, the trough is known to cause warm north-easterly winds when it is stationary near the shore.[18]

A strong and stagnant anti-cyclone in the Great Australian Bight and a stationary "west coast trough" resulted in a record-breaking heatwave in January 2022 and the hottest summer on record. The Perth region sweltered through six days in a row over 40°C, bringing the total for the summer to 13 days at or above 40°C, with the 2021-22 summer smashing Perth's previous record (7 days during the 2015-16 summer).[19]

Temperature extremes have been recorded in **Table 3-1**. Fremantle weather station (Bureau of Meteorology (BoM) Station 009192; 3.6km away from the City; data only available for 1983-1985, 1991-1999) and Swanbourne (station 009215; 10.0km away) were selected as they are the closest stations to the City with sufficient data availability.

Table 3-1. Extreme Temperature Events Near the City

Station	Extreme Temperature Event
Fremantle	— 6-7 Jan and 8 Mar 1998: greater than (>) 40ºC. — 1997: 4 days >40ºC. — 1996: 2 days >40ºC. — 19 Dec 1993: 40.5ºC. — 1993: 3 days >40ºC. — 16 Dec 1991: 40.5ºC.[20]

16 Weather Spark. N.d. Climate and Average Weather Year-Round in Melville Australia. Accessed 9 Nov 2022. <https://weatherspark.com/y/130043/Average-Weather-in-Melville-Australia-Year-Round>.

17 Kala, P. 2022. What Drove Perth's Record-Smashing Heatwave – and Why it's a Taste of Things to Come. The Conversation. Accessed 7 Nov 2022. <https://theconversation.com/what-drove-perths-record-smashing-heatwave-and-why-its-a-taste-of-things-to-come-175516>.

18 Kala, P. 2022. What Drove Perth's Record-Smashing Heatwave – and Why it's a Taste of Things to Come. The Conversation. Accessed 7 Nov 2022. <https://theconversation.com/what-drove-perths-record-smashing-heatwave-and-why-its-a-taste-of-things-to-come-175516>.

19 Kala, P. 2022. What Drove Perth's Record-Smashing Heatwave – and Why it's a Taste of Things to Come. The Conversation. Accessed 7 Nov 2022. <https://theconversation.com/what-drove-perths-record-smashing-heatwave-and-why-its-a-taste-of-things-to-come-175516>; Karp, P. 2022. Perth Swelters Through Record Six Consecutive Days Over 40C Temperatures. The Guardian. Accessed 7 Nov 2022. <https://www.theguardian.com/australia-news/2022/jan/23/perth-swelters-through-record-five-consecutive-days-over-40c-temperatures#:~:text=Perth%20has%20registered%20a%20record,day%20above%2040C%20this%20summer.>.

20 Bureau of Meteorology. 2022. Daily Maximum Temperature Fremantle. Australian Government. Accessed 8 Nov 2022. <http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=122&p_display_type=dailyDataFile&p_startYear=1999&p_c=-17067190&p_stn_num=009192>.

Station	Extreme Temperature Event
Swanbourne	— 25-27 Dec 2021: 3 consecutive days >40°C. — 8 Feb and 21 Dec 2016: 42.8 and 42.0°C day (respectively). — Jan 2015: 43.2°C day. — 11 Jan 2014: 44.3°C. — 26 Jan 2012: 43.1°C. — 26-28 Jan, 5-7 Mar 2007: 3 consecutive days (each) >40°C. — 8-10 Mar 2003: 3 consecutive days >40°C.[21]

3.2 Bushfires

Due to the City's urban presence, bushfire risk will predominantly present itself through the impacts of smoke, impacts to transportation routes, and service provision such as an increase in local hospital admissions. Notwithstanding, thousands of homes in Western Australia (WA) are situated in at-risk suburbs that were constructed near bushland, according to data supplied by the consulting firm Risk Frontiers. The majority of homes destroyed in fires are within 500m of bushland, according to Risk Frontiers' analysis of significant historical bushfires, and distance from the bushland fringe is the single, most significant factor determining the probability of building destruction given an extreme fire in adjacent bushlands. Fires between 2005 and 2018 destroyed approximately 32ha of bushland and wetlands across the City (Booragoon Lake, Peter Ellis, Bull Creek, Blue Gum, Hatfield, Peter Bosci, Rob Weir, Wireless Hill, George Welby, Harry Sandon, Reg Bourke, Ron Carroll, Piney Lakes, and Richard Lewis Reserves impacted).[22]

Perth Hills bushfire, 2011: Perth's metropolitan area was impacted by two significant bushfires on the weekend of February 5 and 6, 2011. In the southeast suburbs of Perth, Roleystone and Kelmscott experienced one fire, and Red Hill, Herne Hill, Millendon, Baskerville, and Gidgegannup experienced the second. Before the start of the fires, the BoM had issued a Fire Weather Warning and a Total Fire Ban had been enacted for the whole fire-affected area. The Roleystone fire, which was unintentionally caused by sparks from an angle grinder, resulted in 71 homes being destroyed and an additional 39 homes sustained damage. The fire at Roleystone burned roughly 440ha, and the fire at Red Hill burned approximately 1,100ha. During both fires, at least 12 people were hospitalised and about 517 families were evacuated. Roleystone, Kelmscott, and Red Hill were proclaimed natural disaster zones on Monday, February 7, 2011, by the WA Premier and the preliminary damage was estimated at $35 million by the Insurance Council of Australia later that year.[23]

10 October 2022: A structure fire at Kardinya was recorded in the City.[24]

Overall, information on impacts and previous bushfire events is limited for the City. However, there are studies showing that Melville, alongside Rockingham, Canning, Armadale, Gosnells, and Cockburn City, are recorded to have the greatest number of non-deliberate child-ignited fires within Western Australia. With Melville being

[21] Bureau of Meteorology. 2022. Daily Maximum Temperature Swanbourne. Australian Government. Accessed 8 Nov 2022. <http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=122&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=009215>.

[22] City of Melville. 2019. Natural Areas Asset Management Plan. Accessed 8 Nov 2022. <https://www.melvillecity.com.au/CityOfMelville/media/Documents-and-PDF-s/Natural-Areas-Asset-Management-Plan.pdf>.

[23] Australian Institute for Disaster Resilience. n.d. Bushfire - Perth Hills, Western Australia 2011. Australian Disaster Resilience Knowledge Hub. Accessed 7 Nov 2022. <https://knowledge.aidr.org.au/resources/bushfire-perth-hills-western-australia-2011>.

[24] ABC. 2022. Structure Fire (Melville, City of Melville, Metro South Coastal, FCAD: 592321). Accessed 8 Nov 2022. <https://www.abc.net.au/emergency/warning/e132c8da-47f3-11ed-8f46-0a58012cdf60>.

identified as a high fire area.[25] However, despite this, there is limited fire data available providing information specific to the area.[26]

3.3 Flooding

Flooding is a naturally occurring event across WA. There are multiple types of flooding that affect the City including:

- Riverine flooding: occurs when riverbanks break and water covers surrounding land as a result of heavy rainfall, king tides, storm surges, or dam releases (slow onset flooding).[27]
- Flash flooding: occurs following heavy rainfall over a short period (less than six hours). This is often a result of poor drainage systems in urban areas (rapid onset flooding).[28]

Perth was established in 1829, almost 200 years ago, and during this time the Swan River colony has seen 7 major flood events. These major flood events took place in 1862, 1872, 1910, 1945, 1963, 1964, and 1983, with 1872 being regarded as the worst flood on record. Families left their homes in Guildford as the flood, which was 1.6km wide in places, engulfed Perth for days. The last major flood event of the Swan River occurred in 1983 when 100 millimetres (mm) of rain poured in 48 hours, flooding the upper Swan Valley and endangering Bassendean and Guildford houses. A minor flood occurred in February 2017 after a rain event saw 114mm fall in 24 hours across the region. However, the flood resulted in hundreds of millions of dollars in damages to repair roads, bridges, and farms, particularly in the Swan Valley, where it had a significant effect on grape growers.[29] The impact of these events on Melville is unknown due to lack of data.

3.4 Storms and Cyclones

For Storms and Cyclones events listed below the impact of these on Melville is unknown due to lack of data.

Cyclone Alby, 4 April 1978: Severe Tropical Cyclone Alby was thought to have been the worst tropical cyclone to ever hit southwestern WA. The storm rapidly grew stronger between April 1 and 2, when it peaked as a Category 5 cyclone according to the Australian cyclone intensity scale. Due to Alby's swift progress and hurricane-force gusts, extensive damage was caused across WA. Large swells along the coast caused flooding in low-lying regions, and strong winds caused many structures to lose their roofs. In Perth, the peak gust was reported at 130 kilometres per hour (km/h), the third highest in the city's recorded history and widespread structural, environmental, and agricultural damage was caused by these winds. The worst losses occurred in Albany, where the majority of residences experienced partial or total roof failure. During the storm, airborne debris also caused damage to buildings and in the Donnybrook-Manjimup region, 80% of the apple crop was lost. In total, 154,400metres cubed (m^3) of timber as well as the potential for 200,000m^3 of additional growth on mature trees was lost. Additionally, numerous dust storms destroyed crops and displaced valuable topsoil in many agricultural regions. Strong onshore winds and minimal rainfall during the cyclone combined to produce substantial inland sea spray close to the coast and due to the storm's winds and deposition of salt and dust, several electricity cables and stations failed. Cyclone Alby left a significant area of the South-West

[25] AIC. 2020. Understanding Bushfire: Trends in Deliberate Vegetation Fires in Australia (2020). Accessed 8 Nov 2022. <https://www.aic.gov.au/sites/default/files/2020-07/tbp027_05_wa.pdf>.
[26] AIC. 2020. Understanding Bushfire: Trends in Deliberate Vegetation Fires in Australia (2020). Accessed 8 Nov 2022. <https://www.aic.gov.au/sites/default/files/2020-07/tbp027_05_wa.pdf>.
[27] Bureau of Meteorology. 2022. Understanding Floods. Australian Government. Accessed 9 Nov 2022. <http://www.bom.gov.au/australia/flood/knowledge-centre/understanding.shtml>.
[28] Bureau of Meteorology. 2022. Understanding Floods. Australian Government. Accessed 9 Nov 2022. <http://www.bom.gov.au/australia/flood/knowledge-centre/understanding.shtml>.
[29] Brookes, S. 2022. 'Tsunamis from the sky': Perth Faces Swan River Flooding Threat. WA Today. Accessed 7 Nov 2022. <https://www.watoday.com.au/national/western>.

Land Division without electricity, and Perth's electrical infrastructure came dangerously close to collapse. This resulted in subsequent losses linked to the storm, such as manufacturing problems and production losses.[30]

Large swells caused by the storm along the coast led to major coastal and beach erosion with some areas losing 30 m of land and two fatalities in Albany Harbour. It was anticipated that the region's tides would rise, however, all anticipated figures were unexpectedly exceeded by at least 0.3m. In Busselton the highest storm tide was 2.5m, with an accompanying storm surge of 1.1m which penetrated approximately 200minland, requiring multiple evacuations. This caused considerable coastal flooding and damage to numerous buildings including the Busselton Jetty. A sea wall breach in Bunbury caused water to enter 100 homes, forcing 130 families to leave. Cyclone Alby caused $50 million (A$213 million in 2011) in damage and seven fatalities in WA.[13]

Perth hailstorm, 22 March 2010: The costliest natural disaster in WA to date was the devastating Perth hailstorm of 2010. The city was pummelled by hailstones that were the largest in recorded history, as well as 120km/hr winds, heavy rain, and flash flooding. There was extensive destruction to cars, houses, and other structures, including schools and hospitals, that was unparalleled, and the clean-up and repair took place over months after the event. A landslide in Kings Park resulted in more than 100 residents being evacuated from an apartment complex after houses were filled with a metre of dirt. According to the Insurance Council of Australia, it was the most expensive natural disaster in the state's history, resulting in claims totalling more than $1.3 billion (B).[31]

Severe Thunderstorm, 25 Feb 2020: Perth and the neighbouring regions were hit by a violent thunderstorm that moved in rapidly from the north and brought strong winds, copious amounts of rain, hail, and commotion during rush-hour traffic. During the approximately 30-minute-long storm, the ceiling of the Morley Galleria shopping centre collapsed, more than 18,000 buildings lost electricity, and several schools suffered damage. There were only reports of minor injuries even though the storm destroyed homes, toppled electrical lines, and uprooted trees, some of which fell on top of cars. The 14mm of rain that fell in 30 minutes caused flooding to Somerly Primary School and resulted in the removal of a floating vehicle from floodwaters in the outer suburb of Mindarie. The northern Perth suburb of Ocean Reef recorded the strongest wind gust in the city at 93km/hr.[32]

Ex-Tropical Cyclone Mangga, 25 May 2020: Thousands of homes lose power (65,000 properties), widespread property damage (more than 6,000 properties in Perth) and fallen trees across the southern coast (including Perth).[33] Wind gusts as high as 132km/hr near Cape Leeuwin. Very heavy rainfall also recorded, with tides higher than predicted.

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30 Department of Environment, Land, Water and Planning. 2015. The Economic Impact of Heatwaves on Victoria. Victoria State Government. Accessed 7 Nov 2022. <https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0011/413030/The-economic-impact-of-heatwaves-on-Victoria.pdf.>; Bureau of Meteorology. n.d. Past Tropical Cyclones. Australian Government. Accessed 8 Nov 2022. <http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/past-tropical-cyclones/.>; Attorney-General's Department. 2011. Event - South-Western, WA: Cyclone. Australian Government. Accessed 8 Nov 2022. <https://web.archive.org/web/20110706121800/http:/www.disasters.ema.gov.au/Browse%20Details/DisasterEventDetails.aspx?DisasterEventID=2726>.

31 Ceranic, I. 2020. It Started as a Warm and Sunny Autumn Day. But Then the Heavens Opened, and Perth was Forever Changed. ABC News. Accessed 8 Nov 2022. <https://www.abc.net.au/news/2020-03-22/ten-year-anniversary-perth-hail-storm-of-2010/12072760>.

32 ABC News. 2020. Perth Storm Damages Homes, Brings Down Trees and Causes Peak-Hour Traffic Chaos. Accessed 8 Nov 2022. <https://www.abc.net.au/news/2020-02-25/severe-thunderstorm-in-perth-damages-homes-brings-down-trees/12000534#:~:text=A%20severe%20thunderstorm%20has%20struck%20Perth%20and%20surrounding11>.

33 Kaur, H. 2020. Storm Hits Perth as Ex-Tropical Cyclone Mangga Delivers Wild Weather Across WA, Power Cut to Thousands. ABC News. Accessed 8 Nov 2022. <https://www.abc.net.au/news/2020-05-25/massive-storm-hits-perth-as-ex-tropical-cyclone-mangga-strikes/12281886>.

4 Key Shocks and Stresses for the City

Below are shocks and stresses expected to impact the City both imminently and by 2100.

4.1 Shocks

Table 4-1. Priority Shock Events Impacting the City

Shocks	Applicability to the City
More extreme events	Weather extremes (heatwaves, intense storms, winds) will intensify and increase in frequency (generally). The City should be prepared for such occurrences.
Floods	Climatic changes causing extreme rainfall events worsen flood impacts for the City.
Bushfires	Fire weather is expected to increase across WA, with catastrophic bushfires becoming more frequent and severe.[34]
Industrial closures	Global supply chain disruptions will continue to impact Australian businesses and services. Sea-level rise inundating ports and coastal infrastructure, supply chain disruptions due to floods, fires, and strong wind, and pandemics will increase disturbance and closures.[35] As the City shifts to net zero, fossil-fuel dependent industries will either adapt or close.
Disease outbreaks	Changes in prevalence and geographic distribution of infectious diseases will occur because of climate change (and as witnessed through the coronavirus (COVID-19) pandemic); for example, warming and precipitation changes associated with vector range expansion.[36]
Cyber attack	Poor weather increases cyber-attack surface, with more people working/studying or otherwise online and at risk of cybercrime.[37] Cyber security risks have significant economic cost, estimated as high as $29B each year.[38] The City should maximise technological innovation where possible, whilst preparing for greater cyber security and data transparency requirements.
Failure of critical infrastructure	Increasing disruptions of critical infrastructure due to increased operating costs, and climate related events such as heatwaves (causing power outages and increased degradation e.g., powerlines) and flooding must be planned for.[39]

[34] Climate Council. 2019. The Facts About Bushfires and Climate Change. Climate Council. Accessed 12 Dec 2022. <https://www.climatecouncil.org.au/not-normal-climate-change-bushfire-web/>.

[35] Leslie, J. 2022. How Climate Change is Disrupting the Global Supply Chain. Yale Environment 360. Accessed 12 Dec 2022. <https://e360.yale.edu/features/how-climate-change-is-disrupting-the-global-supply-chain>.

[36] Mora, C., McKenzie, T., Gaw, I.M., Dean, J.M., von Hammerstein, H., Knudson, T.A., Setter, R.O., Smith, C.Z., Webster, K.M., Patz, J.A. & Franklin, E.C. 2022. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change,* 12: 869-875.

[37] Brode, B. 2022. Unravelling the Climate Change and Cybersecurity Connection. AT&T Business. Accessed 12 Dec 2022. <https://cybersecurity.att.com/blogs/security-essentials/unraveling-the-climate-change-and-cybersecurity-connection>.

[38] Australian Government. 2021. Digital Economy Strategy 2030. Accessed 9 Dec 2022. <https://digitaleconomy.pmc.gov.au/sites/default/files/2021-07/digital-economy-strategy.pdf>.

[39] Mullan, M., Danielson, L., Lasfargues, B., Morgado, N.C. & Perry, E. 2018. Climate-Resilient Infrastructure. OECD. Accessed 12 Dec 2022. <https://www.oecd.org/environment/cc/policy-perspectives-climate-resilient-infrastructure.pdf>.

4.2 Stresses

Table 4-2. Priority Stresses Expected to Impact the City

Stresses	Applicability to the City
Hotter and drier (e.g., drought)	Water shortages, lowered precipitation (resulting in flora and fauna distribution/abundance changes), and increasing temperatures will impact all City residents, particularly affecting vulnerable populations such as the elderly.[40]
Climate risk disclosure and litigation	Climate litigation is increasing Australia-wide and internationally. Companies and governments are being found liable (duty of care, disclosure obligations, director duties etc) for lack of climate mitigation efforts. Mitigating greenwashing or failures to disclose climate impacts is important for the City.[41]
Coastal risks (storm surges, sea-level rise, erosion)	Due to the City's location less than 4km inland from the Indian Ocean, and proximity to both Swan and Canning River, with 18km of Swan-Canning Estuary Foreshore coastline, flooding will be extremely impactful. Sea-level rise will be an ongoing issue for the City.
Homelessness	Increased natural disaster incidents are displacing whole communities.[42] Forced migration may become an issue for coastal-dwelling residents. Homeless residents are extremely vulnerable to climate change events.[43]
Increasing unemployment	Approximately 1/3rd of jobs relies on the natural environment.[44] Heat stress reduces work productivity.[45] Although adaptation and mitigation measures can positively impact employment, many jobs will become redundant as a result of climate change. Jobs and the provision of safe work environments rely on healthy ecosystem services which are threatened by climate change.
Ageing population	Older residents of the City will be particularly vulnerable to the impacts of climate change for several reasons including limited mobility, medication and heat responsiveness, health conditions, health care dependence/assistance requirements, and compromised immune systems.[46]
Depleted or degraded natural resources	Material extraction is tightly linked to greenhouse gas (GHG) emissions.[47] Changes in agricultural and mineral extraction methods/quantities will impact the City. Altered population demographics may result as job markets alter in response to a transitioning energy market. This may also impact supply chains. Conflict arising from inequitable resource management may also arise.

40 Center for Climate and Energy Solutions. 2022. Drought and Climate Change. C2ES. Accessed 12 Dec 2022. <https://www.c2es.org/content/drought-and-climate-change/>.

41 Aushurst. 2022. Climate Change Litigation Risk in Australia. Accessed 12 Dec 2022. <https://www.ashurst.com/en/news-and-insights/legal-updates/climate-change-litigation-risk-in-australia/>.

42 Tondorf, C. 2022. Homelessness Conference Looks at Climate Change. Social Futures. Accessed 12 Dec 2022. <https://socialfutures.org.au/national-homelessness-conference-looks-at-the-impact-of-climate-change-on-homelessness/#:~:text='%20Climate%20change%20is%20generating%20new,thousands%20of%20people%20into%20homelessness.>.

43 Climate Reality Project. 2019. Homelessness and the Climate Crisis. Accessed 12 Dec 2022. <https://www.climaterealityproject.org/blog/homelessness-and-climate-crisis>.

44 International Labour Organisation. 2018. The Employment Impact of Climate Change Adaptation. Accessed 12 Dec 2022. <https://www.ilo.org/wcmsp5/groups/public/---ed_emp/documents/publication/wcms_645572.pdf>.

45 Schlein, L. 2019. ILO: Climate Change Will Lead to Huge Job, Economic Losses. VOA. Accessed 12 Dec 2022. <https://www.voanews.com/a/economy-business_ilo-climate-change-will-lead-huge-job-economic-losses/6170891.html>.

46 United States Environmental Protection Agency. 2022. Climate Change and the Health of Older Adults. EPA. Accessed 12 Dec 2022. <https://www.epa.gov/climate-change/climate-change-and-health-older-adults>.

47 United Nations Environment Programme. 2019. We're Gobbling Up the Earth's Resources at an Unsustainable Rate. UNEP. Accessed 12 Dec 2022. <https://www.unep.org/news-and-stories/story/were-gobbling-earths-resources-unsustainable-rate>.

Stresses	Applicability to the City
Reduced amentiy/tourism	Providing more than half a million jobs (5% of the workforce) across Australia, tourism is a multi-billion-dollar source of revenue.[48] Impacts to local tourism should be expected across the City due to decreased biodiversity (reducing natural attractions), changed tourism choices (when and where to travel) and a potential lack of climate-smart public infrastructure discouraging visitors.
Reduced water availability	Decreased annual rainfall is expected across the City in the future. Underground water aquifer supplies are also expected to decline. Combined with population increases and associated water consumption/usage this decline will result in overall reduced water availability. Reliance on desalination plants and other climate-resilient water sources will be important considerations for the City. Rainwater tanks are another important consideration.
Increased financial expenditure	Without suitable mitigation and adaptation measures put in place, increasing occurrence and severity of extreme weather and climate-related events will result in higher degrees of reactive responses to extreme events. This will place financial strain on the City, for example through public expenditure, reconstruction of infrastructure, and disaster relief funds.[49]
Urbanisation	Urbanisation feeds consumerism, commercialisation, and industrialisation.[50] Increasing population growth and urban sprawl will impact surrounding natural ecosystems. This could heighten climate change impacts. Further, urban activities are a significant contributor of GHG emissions (cities are estimated to produce 75% of global carbon dioxide emissions).[51,52] Coastal expansion also increases the City's exposure to sea level rise.
Rising prices	The combined, compounding effects of climate change, conflict, food shortages, and associated costs will increase as climate change worsens. Severe weather events (increasing in frequency, intensity, and duration) will further contribute to rising living costs.[53]
Substandard buildings	Building materials, quality, and infrastructure age are influenced by climate change. There will be increased risk of collapse, subsidence, water encroachment, declining indoor air quality, and reduced building lifetime vulnerabilities.[54] Flooding, coastal/riverine inundation, and severe storms (including hail) will disproportionately impact poorly built assets within the City, increasing their instability.
Pollution	Climate change is directly linked with the production of GHG emissions and carbon dioxide concentrations within the atmosphere. Increasing fossil fuel consumption will further GHG production, acting as a climate forcer, influencing pollution levels and the climate.[55] Deteriorating air quality will also influence human physical and mental

48 Hugh, L., Stock, P., Brailsford, L. & Alexander, D. 2018. Icons at Risk: Climate Change Threatening Australian Tourism. Climate Council. Accessed 23 Dec 2022. <https://www.climatecouncil.org.au/uploads/964cb874391d33dfd85ec959aa4141ff.pdf>.

49 Baur, M., Bruchez, P.A. & Nicol, S. 2021. Climate Change and Long-Term Fiscal Sustainability. OECD. Accessed 23 Dec 2022. <https://www.oecd.org/gov/budgeting/scoping-paper-on-fiscal-sustainability-and-climate-change.pdf>.

50 Shamasundari, R. 2017. Climate Change Dilemma Driven by Urbanisation. The ASEAN Post. Accessed 9 Jan 2023. <https://theaseanpost.com/article/climate-change-dilemma-driven-urbanisation>.

51 United Nations. 2017. Rapid Urbanization Increases Climate Risk for Billions of People. UNFCCC. Accessed 9 Jan 2023. <https://unfccc.int/news/rapid-urbanization-increases-climate-risk-for-billions-of-people>.

52 UNEP. N.d. Cities and Climate Change. Accessed 9 Jan 2023. <https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/cities-and-climate-change>.

53 King, H. 2022. Climate Change is a Secret Driver of Inflation. AXIOS. Accessed 9 Jan 2023. <https://www.axios.com/2022/08/18/inflation-climate-change-economy-extreme-weather>.

54 Klimatil Pasning. N.d. Climate Change Impact on Buildings and Construction. Accessed 9 Jan 2023. <https://en.klimatilpasning.dk/sectors/buildings/climate-change-impact-on-buildings/>.

55 US EPA. 2022. Air Quality and Climate Change Research. Accessed 9 Jan 2023. <https://www.epa.gov/air-research/air-quality-and-climate-change-research>.

Stresses	Applicability to the City
	health.[56] Solid waste and garbage disposal sites can also block sewerage systems, contributing to urban flooding during high rainfall events.[57]
Legal or regulatory barriers	Existing law and policies across the City, state, and nationally, will influence the City's capacity to enforce behavioural changes and practices. Legal and regulatory instruments influence strategy efficacy and may result in some divergence/inconsistencies (progressive vs conservative policies, regulations, or legislation).[58]

[56] Ju, K. et al. 2023. Casual effects of air pollution on mental health among adults – an exploration of susceptible populations and the role of physical activity based on a longitudinal nationwide cohort in China. *Environmental Research,* 217: https://doi.org/10.1016/j.envres.2022.114761.

[57] USAID. 2016. Climate Vulnerability Assessment. Accessed 10 Jan 2023. <https://www.climatelinks.org/sites/default/files/asset/document/USAID%20Vulnerability%20Assessment%20Annex.pdf>.

[58] Mackay, S., Hennessey, N. & Mackey, B. 2019. Barriers to the Implementation of Climate Change Adaptation Plans and Action: Considerations for Regional Victoria. Griffith University. Accessed 10 Jan 2023. < https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0038/489476/Policy-Brief-1-Barriers-to-the-implementation-of-climate-change-adaptation-plans-and-action.pdf>.

PART B.

STAKEHOLDER ENGAGEMENT

5 Stakeholder Engagement

5.1 City Staff Workshops

WSP undertook three workshops with three different groups within the City (workshop one: Environment and Infrastructure, workshop two: Urban Planning, and workshop three: Corporate Services and Community Development). These workshops were conducted late November/early December of 2022. Following a pre-briefing information booklet outlining the key findings from a rapid climate desktop study, City staff were briefed on the purpose of the project, WSP's role in undertaking the VRO Assessment, followed by an overview of the project itself. Participants then partook in two online activities utilised by WSP to understand the City's key concerns and perceived opportunities. The first activity explored physical and transitional risks impacting the City. The second examined possible opportunities. These risks and opportunities were used to prioritise the physical risk assessment and suggested actions.

Key findings arising from the workshops has been provided below. The notes gathered can be found in **Appendix A**. Findings included:

- Concern regarding trees within the City and associated canopy cover.
- Risks associated with shifting to a circular economy and resource usage, including associated costs and resource availability.
    - Key opportunities include upcycling, recycling, community waste initiatives, harnessing waste energy, and worm farm initiatives.
- Transport, including high private vehicle dependence, issues associated with active transportation (such as heat waves), and free parking reducing incentives towards active or public transportation options.
    - Key opportunities include electrification, end of trip facilities, becoming a walking City, public transport upgrades, ticketed parking, and better connectivity.
- Financial concerns including increased insurance premiums, litigation, costs associated with service maintenance and upgrades, and increasing business operation costs.
    - Grants, sustainability expos, implementing smart technology, research, and investment were some of the suggested opportunities.
- Climate hazards such as fire, sea level rise, flash flooding, and disease require concerted efforts placing a climate lens on all that the City does going forward. Concerns regarding increasing temperatures and heatwave durations were also raised, particularly regarding staff's capacity to undertake their responsibilities safely under such conditions.
- Energy, including power loss due to grid overloading, increased energy demands, maladaptive design, fossil fuel reliance, and reliance on power for cooling/heating were raised by the City.
    - Efforts should aim to reduce carbon emissions associated with City activities. Key opportunities include renewable energy, community batteries, switching community centres to renewable energy sources, and establishing local micro-grids.
- Transitional risks were also of concern. These included:
    - Increased costs (insurance premiums will likely pressure the City's budget), supply chain demand issues, litigation and public liability arising when extreme events become more frequent, community backlash over what is/is not occurring within the City.

5.2 Community Workshops

WSP facilitated four community workshops with the City (the (1) Climate Action Reference Group (CARG)), (2) Community Groups, (3) Business and Stakeholders) and a (4) First Nations peoples. The First Nations Conversations were facilitated by an independent facilitator from Indigenous Economic Solutions.

The CARG consists of 24 local community representatives who regularly meet to discuss actions around reducing the community's carbon emissions and driving the development of a Community Climate Action Plan.[59] The Community Groups within the respective workshop were representative of sporting, “Friends of”, artistic, environmental, and sustainability groups, town teams, and youth groups. Finally, the business and stakeholder workshops included representatives of the Melville Cockburn Chamber of Commerce, State Government, utilities, healthcare, education, and other community groups (such as Melville SES).

For the four workshops two activities were undertaken. The first activity focused on climate risks faced by the community. Questions were addressed based on personal knowledge and local experience, considering questions such as:

- Looking forward, what do you see as the most significant risks arising from climate change?
- From your personal experience, what are the most significant risks arising from a changing climate?
- During previous extreme weather events, did your day-to-day activities change?

Activity two focused on recommendations to adapt and mitigate against the risks identified during the first activity (keeping it local). Questions considered included:

- What actions can be taken to assist in reducing the impacts of these risks?
- From your personal experience, do you have any recommendations on actions to mitigate against climate risks?
- What actions can be taken to assist in reducing the frequency of these risks?

Key findings arising from each activity are detailed below. Comprehensive notes from all four workshops can be found in **Appendix A**.

Activity 1. Focusing on key climate risks faced by the community.

- **Biodiversity loss**. Common concerns were held for the depletion of natural resources, with damage to biodiversity occurring as a result of climatic changes. The loss of vegetation and habitat was raised. As was extinctions and declining recreational appeal. Concerns were raised equally across all workshops. Business and stakeholder workshop participants were particularly concerned with vegetation loss in urban centres and loss of public open spaces. The impact of white colonialism and Nyittiyang (white) monopolisation of food, water, and energy have produced resource scarcities and ecosystem destabilisation.
- **Bushfires and increased fire weather**. The community group and CARG were concerned with bushfire weather, increased fire risks, and declining air quality (increasing risks to health sectors). Concern was also raised regarding emergency service access points and potential for increased fire-retardant use (a pollutant) as water availability declines. Poor fire management and controlled burns at the wrong time of year were noted by First Nations participants, alongside smoke and breathing issues such as asthma.

[59] City of Melville. 2022. City of Melville’s Inaugural Climate Action Reference Group Meets for the First Time. Accessed 6 Mar 2023. <https://www.melvillecity.com.au/our-city/news/latest-news/2022/november/city-of-melville%E2%80%99s-inaugural-climate-action-refere>.

- **Community tensions**. Increasing isolation, loss of social gatherings (either through community sport or farmers markets etc), and growing inequality across low socio-economic and vulnerable people were raised. The First Nations workshop raised particular issues with complete lack or poor communication resulting in anti-social behaviour.
- **Cost burdens.** CARG, First Nations, and business/stakeholder workshops raised concern around cost of living, increased maintenance costs, food costs, energy, the cost of keeping cool, and increased insurance costs or costs to businesses were also raised. First Nations people also raised the inequity they face. The monopolisation of food, water, and energy access by big businesses furthers this divide.
- **Disease.** The increasing likelihood of illnesses, pandemics, pathogens and parasites were raised by CARG and business/stakeholder groups. Bateman was specifically noted as an area of concern, particularly regarding insect abundance.
- **Education.** This theme was raised across the First Nations workshop, with concerns raised that community is not being prepared for a climate disaster and an overall distrust of cultural understanding (favouring western science) considered.
- **Energy.** Power grid outages, energy security and supply risks were key themes raised by the CARG and business and stakeholder group. Finding reliable and affordable renewable energy sources were also considered. White colonial impacts to resource scarcity and the rising price of energy were of concern. These costs are noted to be locking out First Nations people from the market (including renters). First Nations peoples have little say in clean energy or where it is built.
- **Food shortages.** This was a key stressor for Indigenous mob. There is also a perception among First Nations people that they are unwelcome in community gardens/wouldn't fit in. further, the cost of food and stress this holds for families were highlighted. Supply chain issues and increases in climate impacts were also problematic.
- **Health.** Increased emergency service pressures, demand on health services, increasing incidents of health problems, and declining mental health were considered. First Nations people were particularly concerned about medical gaslighting, misdiagnosed illnesses, or failure to provide adequate advice, particularly focussing on breathing and asthmatic illnesses. Costs of medication and the impacts of isolation/restrictions during future pandemics were noted. Importantly, the increased risk of disease among First Nations people were noted.
- **Infrastructure design.** Failures arising from poor house design, infrastructure damage as a result of climate change, and urban infill were flagged by across all workshops.
- **Policy.** First Nations participants were concerned with the impact of sub-divisions, leaving less space for gardens.
- **Sustainability.** Issues pertaining to the increase in waste going to landfill, noise pollution from cars increasing, past-tense conversations around the scarcity of resources as if it is no longer an issue were critical issues within the First Nations workshop.
- **Storms.** Increased instances of storms and extreme weather events causing damage to infrastructure and ecosystems were noted by participants.
- **Supply chain.** Disruption, food security, conflict, and material shortages were raised.
- **Temperature increases**. A common risk raised across the workshops was the impact of higher temperature on the elderly and general health concerns. It was also flagged that temperature increases would impact productivity, exercise, gardening, and would increase heat island impact. Increased heat may result in the derailment of Melville's future mobility plans as a result of heatstroke/discomfort. This was a particular issue for CARG participants. Restrictions to outside playtime and associated medical issues related to overheating were also flagged within the Indigenous workshop.

- **Transportation security**. Concerns were raised around heat and pedestrian amenity.
- **Tree loss**. Increasing tree death was of concern to CARG and community groups. The loss of shade and old tree growth were also noted. First Nations people were also concerned about tree stress resulting from heat and lower rainfall, resulting in changes to tree flowering patterns and broader ecosystem impacts. The loss of gum trees was also raised.
- **Waste supplies**. Increasing waste and associated pollution/contamination resulting in poor water quality were raised.
- **Water shortages**. Finally, water was a prominent issue across all workshops. General decreases in water resources, droughts, and increasing flood frequency were concerns. Salinisation of rivers and sea level rise causing inundation and damage to property were also key themes. Erosion was also of concern. Water quality and fish stocks were noted concerns for the First Nations community. Land is drying, water is increasing in locations where it shouldn't, and tide flows are changing. The availability of good quality water within restriction capacity is critical. Concerns around health impacts of chlorine in water were also raised. Impacts of ferries and boats on the river and wildlife is also of concern.

Activity 2. Key Recommendations from the community.

- **Biodiversity loss.** Community gardens, native plants/seedlings, improving urban 'greenscape', improving biodiversity corridors and pockets, maintaining local green spaces, tighter feral animal controls, participation in re-wild Perth, encouraging permaculture, enforcing native gardens, and increasing bird nesting were raised across workshops. Themes also identified the potential use of technology in measuring and modifying the environment. Closure of natural areas for revegetation and regenerative purposes, identifying polluters and rule breakers were recommended. Ensuring protection for local ecosystems, increasing habitat for animals within backyards are important. Equally, getting children involved in caring for Country through the adoption of a particular plant or animal were raised by First Nations people. Acknowledging the importance of climate change will impact First Nations people more heavily due to vulnerability factors and supporting them through grieving and protection efforts should occur.
- **Increased fire events such as bushfires.** Controlled burns and managing bushland in alignment with (or improving) planning code standards were raised within the CARG workshop. Recommended actions further included the implementation of cultural cool burns (away from waterways) and Indigenous ranger employment.
- **Community tensions.** This theme had several recommendations for all workshop groups. Many suggestions include the encouragement of local businesses and products, increased support for local groups, education and community-led solutions, increasing community development through workshops and training, supporting vulnerability-based insurance premiums to support equity, support vulnerable groups at a community level, expanding community gardens and growing food initiatives, resourcing hubs, maintaining an active and engaged volunteer emergency service base, increasing effective messaging, and asking First Nations people how to manage the land. Including action in the next Stretch (as part of RAP) alongside conversations around racism were raised. Letter drops, specifically targeting Aboriginal households were encouraged. Conducting neighbourhood drives to support the needy were also suggested.
- **Cost burdens.** This was of particular concern to the CARG and business/stakeholder groups. Food programs such as Food Cents were considered, bulk buying/zero packaging, funding mobility plans, increasing rates for houses without solar panels, increasing community grants, subsidising local manufacturing, and tiered payment structures for high usage groups on waste, water, and power. First Nations people suggested Council rates may be a suitable source of funding for grants etc.
- **Education.** More education, making cultural awareness and climate change necessary components of the curriculum is important. Different communication styles should be adopted for First Nations

people. Similarly, the re-education of the population that First Nations people have always cared for Country and peer learning is important. Council advocacy to state government regarding cultural education aspects is also key. Updating the Aboriginal 6 seasons to include climate change is also necessary.

- **Energy.** Renewable energy was a particular focus, including the use of solar panels, electric vehicles, community batteries, reducing council gas reliance, subsidies, and putting power underground. Solar panel incentives for Aboriginal and Torres Strait Islander peoples would encourage Indigenous uptake of renewable energy sources.
- **Food shortages.** Implementing community gardens to increase food security and costs, capability building, and educational exercises around food sovereignty, wastage, and maximising seasonal foods were noted. City assistance and subsidies were also suggested. Learning what foods were supported and found in the natural environment. The City should let the community know what is happening with recycled waste, Council should advocate for local food supplies, or local First Nations run food stores were suggested. Improved use of FOGO bins was also important. Education was also noted as key.
- **Health.** Maximising emergency service coordination, working with these groups to identify vulnerable groups and create action plans, implementing early warning systems, public health campaigns and establishing vulnerable registers to rapidly identify elderly/disabled were considered. Educating doctors, including Aboriginal doctor services and accessible bush medicine programs were strongly recommended.
- **Infrastructure design.** Improving building codes, maximising design and efficiency, improving town planning, ensuring builds comply with Green Star and ISC, utilising “eco guidelines” for new builds, restricting building sizes to provide more green space, supporting social housing, banning extra urban infill and addressing planning codes to improve social/low-cost housing were raised.
- **Policy.** First Nations participants raised suggestions relating to planning and programs. Rangers should be working to enforce lore (law), with more Council planning policies looking after the environment and recognising their connection to Country,
- **Reconciliation.** Actions promoting equality and inclusion were prominent within First Nations participants. First Nations peoples should be included in all consultations going forward, however further suggestions recommend the City stop consulting them, and rather providing them leadership positions and ability to instigate change within the City. Accurate education identifying the role of colonisation in ecosystem destabilisation were echoed throughout the workshop, demonstrating this need for Nyoongar leadership. Noongar voice should be given in the CARG and generally allowed more involvement. First Nations people should be employed as Council Staff, with higher positions (leading design and scheduling programs). The expansion of the First Nations’ Ranger program and support for cultural knowledge and living practices by local people, ensuring a focus on long-term job prospects for local rangers.
- **Sustainability.** Becoming self-sustainable, encouraging (or making compulsory) school gardening, support packages, recycling systems, census data measuring household waste, water, and electricity usage were noted by First Nations participants.
- **Storms.** Ensuring cyclone/storm ratings were implemented within structural designs would be of assistance to the City.
- **Supply chain.** Themes identified use of local suppliers, developing alternatives, and increasing stock held to cover possible delays. This was a particular issue for the business and stakeholder group.
- **Temperature increases.** The use of indoor sport centres (at a reduced cost with later hours) may become necessary. Identifying and mapping hot spots to mitigate heat stress was also recommended. The banning of artificial laws (increasing temperatures) was further noted.

- **Transportation security.** Utilising active transportation methods was recommended, increasing tree coverage along pathways, reducing road widths to increase space for active mobility, better end of trip facilities, solar panels within carparks, shaded bus shelters, electrification, minimising vehicle needs through increased footpaths, increased bus routes were suggested (particularly within CARG and the business/stakeholder group).
- **Tree loss.** A common theme among participants, trees should be native, increasing canopy cover, advocated for, updated urban forest plan, trees planted and subsidised, and shading bus stops, with more trees planted across the City. Smaller houses/blocks of land were also suggested as a measure to curb tree loss and increase green space (due to the availability of larger natural green space and park land controlled by Council, minimising the possibility of illegal tree removal on private property). First Nations people desired the inclusion of bush tucker and medicinal native trees for food and medicine, with plants on verges and local public open spaces were welcomed. “Plant a tree day” specifically targeting Aboriginal people, with assistance for older people to plant gardens were championed.
- **Waste supplies.** Increasing circular economy capacity through the use of toy/tool libraries, incentives to buy local (including seasonal foods/vegetation/vegan), the introduction of a landfill tax, soft plastic collection for reuse, improved recycling standards, mapping existing waste streams to identify opportunities, providing accessible waste disposal, education, and separate waste bins within all public spaces were raised.
- **Water shortages.** Water collection was recommended, recycled water, innovative foreshore erosion control techniques, advocacy for sensible risk-based land use and development in response to flash flooding, and rainfall capture suggestions were common. Voluntary waterway clean-ups, reclaiming grass foreshores into wetlands, conducting research, and implementing programs to protect waterways and reduce river activities were suggested. Promoting wetland and swamp restoration would be beneficial. Decreasing recreational river activity (particularly where animals breed) would encourage Indigenous people in their efforts to heal Country. Encouraging the use of waste and grey water were also recommended.

PART C.

VULNERABILITY, RISK, AND OPPORTUNITY ASSESSMENT

6 Climate and Disaster Resilience

Climate change falls into two categories: Climate Mitigation (emission reduction) and Climate Adaptation (managing risk). Whilst equally important, each category focusses on a different aspect of climate action. Mitigation aims to reduce and minimise GHG emissions entering the atmosphere.[60] This is attempting to reduce and prevent further global temperature increases. Actions include switching from fossil fuels to renewable energy, or carbon storage and capture technology.[61] Adaptation, on the other hand, addresses the impact of those heat-trapping emissions already locked-in to the system through a process of adjustment.[60,62] Adaptation aims to alter behaviour, and address the impacts observed (now and in the future) in the economic, social, environmental, and cultural sphere.[61] Adaptation measures can include diversifying crops to species capable of tolerating hotter and drier climates or ensuring infrastructure can tolerate extreme storms.[61] Some actions will overlap across both mitigation and adaptation spheres, such as tree planting. This is because tree planting encourages carbon capture through photosynthetic processes and creates cooling shade. Trees minimise carbon dioxide in the atmosphere and reduce urban heat island effects. As such, distinctions between the two categories can become blurred.

Whilst the City needs to continue to urgently cut emissions to reduce the effects of climate change, the city also needs to accelerate its adaptation planning to manage the changes that are already locked in. Adapting to climate change requires everyone to do things differently. It also involves making decisions that take a long view and involve complexity.

6.1 Climate Mitigation Profile

Climate mitigation is one method to address the effects of climate change and is the action of reducing emissions and stabilising levels of GHG in the atmosphere.[62] This can be done in two ways, either by reducing the sources of GHG (for example, through the use of renewable energy, or reducing private transport use) or by creating ‘sinks’ that absorb and store GHG (for example, oceans and forests).[62] The intention is to do this in a timeframe which allows ecosystems to adapt naturally to climate change.[63] To do this, GHG emissions must be understood using GHG accounting to establish a baseline.

The City has begun work in this area with organisational carbon emissions providing a baseline. This has allowed the City to establish a Carbon Budget in 2022-2023 to provide emission reduction targets for all service areas.[64] This includes both Scope 1 and Scope 2 emissions. Specifically, the City is committed to reducing carbon emissions by a minimum of 800 tonnes or 13% of annual emissions (within the aforementioned 2022-2023 Carbon Budget). The City has also adopted a Council-wide carbon neutral target for 2030 and community net zero target by 2050.[65]

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60 IPCC. 2021. Annex VII: Glossary. Accessed 7 Mar 2023. <https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_AnnexVII.pdf>.

61 World Wildlife Fund. 2023. What’s the Difference Between Climate Change Mitigation and Adaptation? Accessed 7 Mar 2023. <https://www.worldwildlife.org/stories/what-s-the-difference-between-climate-change-mitigation-and-adaptation>.

62 NASA. 2023. Responding to Climate Change. Accessed 7 Mar 2023. <https://climate.nasa.gov/solutions/adaptation-mitigation/>.

63 IPCC. 2014. Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. *Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press. Accessed 17 Jan 2023. <https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_summary-for-policymakers.pdf>

64 City of Melville. 2022. Budget Newsletter. Accessed 17 Jan 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/corporate-services/budget-newsletter-2022-2023>.

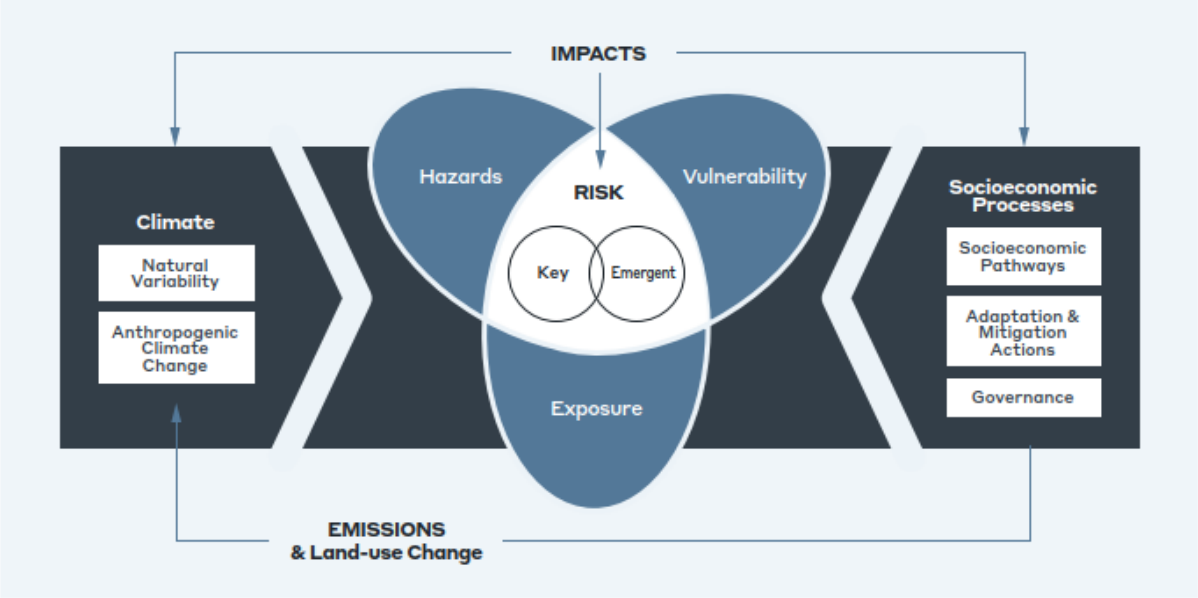
65 City of Melville. N.d. Our Climate Emergency Declaration. Accessed 21 March 2023. <https://www.melvillecity.com.au/waste-and-environment/environmental-sustainability/our-climate-emergency-declaration>.

6.2 Climate Risk Profile

Climate and disaster risks inform the resilience of infrastructure systems and communities. A risk is the potential for consequences where something of value (asset) is at stake and where the outcome is uncertain, recognising the diversity of values (i.e., stakeholder perceive and experience risks differently). Risk arrives from the interaction between a hazard, the exposure of people or assets to that hazard, as well as their vulnerability to be more or less susceptible to a hazard's impacts.

Climate and Disaster Risk is determined by **Hazards x Exposure x Vulnerability**.

Figure 6-1. Hazard, Exposure, and Vulnerability Risk Matrix



Climate resilience and disaster risk reduction are critical to protect lives, livelihoods, ecosystems, and development gains from increasingly frequent and severe climate change-related shocks (i.e., one-off or short-term extreme events) and stresses (i.e., chronic features), as well as disaster events (e.g., earthquakes, landslides, flooding). Implementing risk reduction measures by integrating resilience means not only reducing the likelihood of impact on infrastructure, or other assets, but also reducing vulnerability across numerous interconnected systems.

7 Climate Hazards and Exposure

A hazard is “a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation”.[66] Hazards may be characterised in terms of: **Exposure** – the physical area over which the potential impact of the hazard can be detected; **Intensity** – the level of impact likely to be felt within different parts of the exposed area; and **Probability** – the likelihood/frequency of the level of intensity within the area of exposure.

This chapter provides an overview of the key hazards that are considered to pose a threat to the people, infrastructure and economy of City.

1. Flooding
2. Rainfall
3. Sea level rise
4. Bushfires
5. Temperature
6. Riverine Erosion
7. Storms and Cyclones

Climate change is one of many factors influencing the City and the community it serves into the future. WSP situates its advice around climate change adaptation in the broader context through Future Ready™, WSP’s program allowing us to see the future more clearly and to work with clients to design for this future. These indictors have been incorporated into this analysis and a high-level summary of WSP’s Future Ready trends and insights can be found in **Appendix B.**

7.1 Climate Change Projections

Climate change projections are not precise predictions – rather, they present plausible future scenarios based on clearly defined assumptions. To enable consistency and comparability between different models, the Intergovernmental Panel on Climate Change (IPCC) publishes greenhouse gas concentration trajectories known as Representative Concentration Pathways (RCP). Produced as part of the IPCC’s Fifth Assessment Report, each RCP reflects different possible future scenarios around the rate at which efforts to reduce anthropogenic greenhouse gas emissions will proceed over coming decades. For the VRO assessment, the assessment has adopted an RCP 8.5 scenario. This scenario offers a conservative approach for climate change risk assessment and most closely represents the current trajectory of observed anthropogenic emissions (**Table 7-1**).

Table 7-1. Representative Concentration Pathways (RCPs) Background

Scenario		Global warming mean and likely range (°C)
RCP 8.5	**Limited efforts to curb emissions, which continue to rise throughout the 21st century. CO_2 concentration of 940ppm by 2100.**	**3.7°C (2.6 to 4.8)**

[66] UN SPIDER, 2019.

Summary of Major Changes

Climate change is already influencing the City and is expected to cause further disruptions in the future. Future trends suggest more extreme weather events (of increasing frequency and severity) should be expected. Negative emission processes locking up carbon should also be considered. The City is projected to experience significantly increasing temperatures, and declines in annual rainfall. An increase in mean and maximum temperatures and significant increases in the number of hot days above 35^{o}C is expected. Heatwaves are expected to be longer. The number of severe fire weather days is also expected. Decreases in annual rainfall (particularly winter and spring) will likely occur. Rainfall intensity will increase, with more frequent and severe storms. Cyclones will become less frequent, but likely more severe. Higher sea levels and more frequent sea level extremes with an increased risk of coastal erosion should be expected. However, it is important to note that climate change projections involve a level of uncertainty.

Climate hazards relevant to the City and their projected changes over time are explored in further detail in **Sections 7.2** to **7.8** below and the breakdown of the projections are in **Appendix C**.

7.2 Flooding

Broadly, a flood occurs when water overflows beyond the natural limits of a watercourse, over what is usually dry land.[67] There are several types of flooding, and it is important to distinguish between these. Although they are often linked, flood events can also occur independently of each other. Relevant to this context are:

- **Fluvial flooding** – Fluvial flooding occurs when the natural watercourse capacity is exceeded. This is linked to rainfall across the watercourse catchment, where all water is channelled into the watercourse. This can be particularly apparent in heavy rainfall events where water enters the catchment quickly, or prolonged rainfall that saturates permeable areas. Fluvial flooding may also be delayed after the main rainfall event as it can take some time for water falling within a catchment to reach the watercourse.
- **Pluvial flooding (surface flood)** – Occurs when water accumulation due to intense rainfall exceeds the urban drainage system and excess water cannot be absorbed. Heavy precipitation on impermeable surfaces results in water running over the ground and collecting in low points without adequate drainage. Due to the nature of these floods, they often occur with little warning.[68]
- **Groundwater flooding** – Occurs where the underground aquifer fills and rises above the surface.
- **Sewer overflows** – Although drainage might be present, very heavy rainfall may overwhelm the capacity of the drains. This often results in two processes: Firstly emergency ‘overflows’ will be opened, discharging potentially contaminated water into the natural environment, and secondly, the drain does not have the capacity to receive the volume of water, backing up and causing surface water flooding at the inlet.
- **Coastal/riverine flooding**[69] – A naturally occurring phenomenon in which coastal/riverine areas are temporarily inundated. Can occur as a result of interacting factors, including the prevailing tide, sea level and the occurrence of storms (which can cause storm surges). Climate change may increase risk of riverine flooding in some areas due to sea level rise and/or more severe storms.

The impact of flooding and inundation can cause damage and destruction to both the natural and built environments, creating health and safety hazards for affected communities. Within the Perth area, a minor

[67] Bureau of Meteorology. n.d. Understanding Floods. Accessed 13 January 2023. <http://www.bom.gov.au/australia/flood/knowledge-centre/understanding.shtml>.

[68] Houston et. al. 2011. Pluvial (rain-related) flooding in urban areas: the invisible hazard. Accessed 13 January 2023. <https://www.jrf.org.uk/report/pluvial-rain-related-flooding-urban-areas-invisible-hazard>.

[69] Refer to Chapter 6.3 Sea level rise.

flood in February 2017 caused hundreds of millions of dollars in damages to repair roads, bridges, and farms across the region.[70]

Flooding results from a range of different physical and hydrological factors derived from the intensity and duration of rainfall events and also hydrogeological conditions (surface treatment, sub-structure and elevation).[71] As such, site-specific flood risk assessments including computational modelling should be undertaken to measure flood hazards. Computational modelling provides details of the area of inundation in relation to the intensity of different rainfall conditions. These are based on time-series analyses to identify different 'return-periods' for the intensity of rainfall events and how these translate into spatial exposure of land cover. The measurement of flood hazards typically results in a snapshot of flood risk at a given point in time and help the user to understand the flood hazard in terms of expected extent and depths of the flood. This can be used to identify the areas at risk of flooding and prioritise mitigation and response efforts.[72]

As the measurement and mapping of flood hazards are typically considered for a specific period in time, in the context of climate change, it is important to consider external influences that may affect flood risk. Sea level rise, changes in storm intensity and shifts in rainfall patterns resulting from climate change will cause changes in the locations and severity of, and exposure to flooding.[73]

A floodplain mapping tool developed by the WA Department of Water and Environmental Regulation, is available for the community as a comprehensible way to learn about flood risk in the area. This visual tool largely considers 1% AEP flood events, displaying floodplain maps and flood levels where available (see **Figure 7-1**). The intention is for use for general interest and to guide land use planning and property. For site-specific flood advice, users are encouraged to contact the department.[74]

Figure 7-1 shows that the risk of riverine flooding in an 1% AEP event will have minimal impact in terms of extent, on foreshore areas of the City, including public parks, private property and businesses. There is little information regarding the level of exposure for impacted properties. This shows, however, that the City's location along the Swan and Canning River will create increased risks due to sea-level rise and its contribution to flooding impacts. With this, it is projected that the current day 1-in-100-year extreme sea level event could occur every five years by 2050 and 10 times per year by 2100 (high emissions scenario).

Through the Climate Council, hazard mapping is also available for riverine and surface water flooding, in addition to coastal inundation (see **Figure 7-2**). Using this tool, the suburbs with the highest proportion of properties at high risk of flooding include Attadale (34.4% of properties), Applecross (28.5% of properties), Alfred Cove (35% of properties) and Mount Pleasant (12% of properties).[75]

In tandem with flood hazard mapping, climate change projections developed show an increased intensity of extreme rainfall events which may contribute to a higher likelihood of floods.[76] State government mapping of 1% AEP flood events could cause the Swan River to rise by two meters between Fremantle and the city, and five meters around eastern suburbs.[77] In the context of flood insurance within the City, 2,286 properties (4.3%) are at high risk of insurance becoming unaffordable or unavailable in 2100 (**Figure 7-3**).

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[70] Brookes, S. 2022. 'Tsunamis from the sky': Perth Faces Swan River Flooding Threat. WA Today. Accessed 7 Nov 2022. <https://www.watoday.com.au/national/western-australia/tsunamis-from-the-sky-perth-faces-swan-river-flooding-threat-20220304-p5a1mp.html>.

[71] Office of the Queensland Chief Scientist. Updated May 2022. What factors contribute to floods? Queensland Government. Accessed 13 January 2023. < https://www.chiefscientist.qld.gov.au/publications/understanding-floods/what-factors-contribute>.

[72] UN Climate Technology Centre & Network. n.d. Flood hazard mapping. Accessed 13 January 2023. <https://www.ctc-n.org/technologies/flood-hazard-mapping>.

[73] UN Climate Technology Centre & Network. n.d. Flood hazard mapping. Accessed 13 January 2023. <https://www.ctc-n.org/technologies/flood-hazard-mapping>.

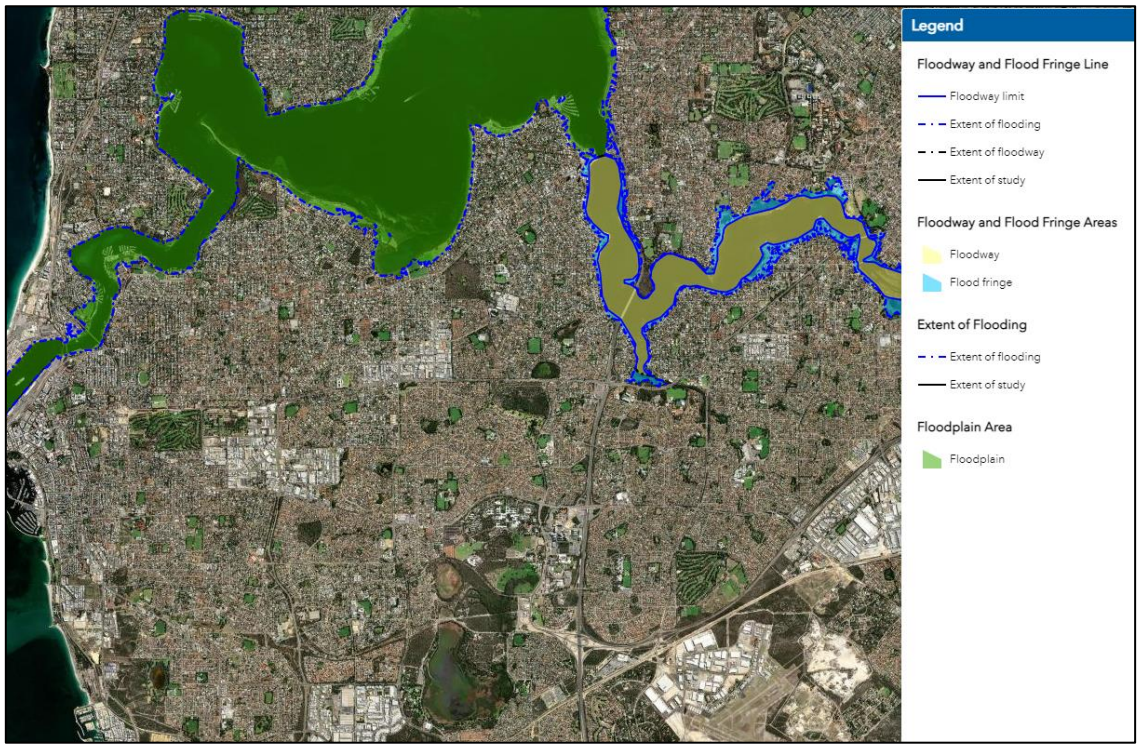
[74] Department of Water and Environmental Regulation. n.d. Floodplain management and development advice. Government of Western Australia. Accessed 13 January 2023. <https://www.water.wa.gov.au/planning-for-the-future/flood-planning-and-mapping/floodplain-development-advice>.

[75] Climate Council. n.d. Climate Risk Map of Australia. Accessed 12 January 2023. <https://www.climatecouncil.org.au/resources/climate-risk-map/>.

[76] Hope, P. *et, al*. (2015), *Southern and South-Western Flatlands Cluster Report*, Climate Change in Australia Projections for Australia's National Resource Management Regions: Cluster Reports, eds. Ekstrom, M. *et al*., CSIRO and Bureau of Meteorology, Australia

[77] Brookes, S. 2022. 'Tsunamis from the sky': Perth Faces Swan River Flooding Threat. WA Today. Accessed 7 Nov 2022. <https://www.watoday.com.au/national/western-australia/tsunamis-from-the-sky-perth-faces-swan-river-flooding-threat-20220304-p5a1mp.html>.

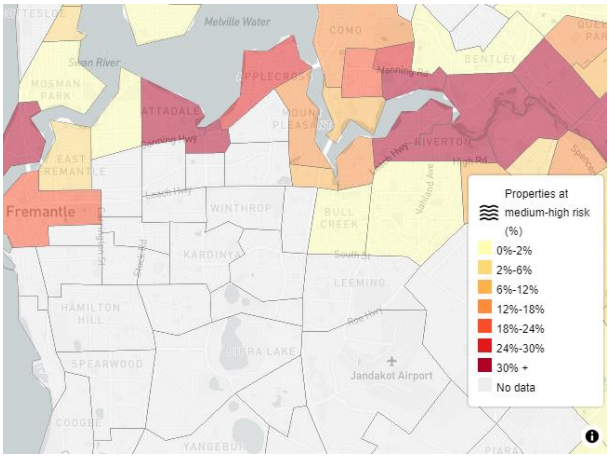
Figure 7-1. Floodplain Mapping for the City



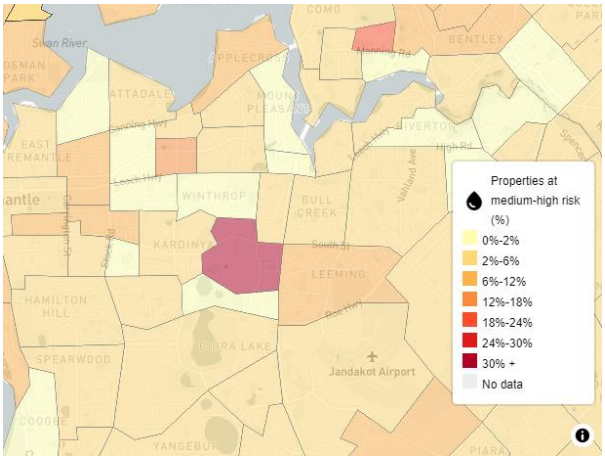
Source: Government of Western Australia (n.d.)[78]

[78] Department of Water and Environmental Regulation. n.d. Floodplain management and development advice. Government of Western Australia. Accessed 13 January 2023. <https://www.water.wa.gov.au/planning-for-the-future/flood-planning-and-mapping/floodplain-development-advice>.

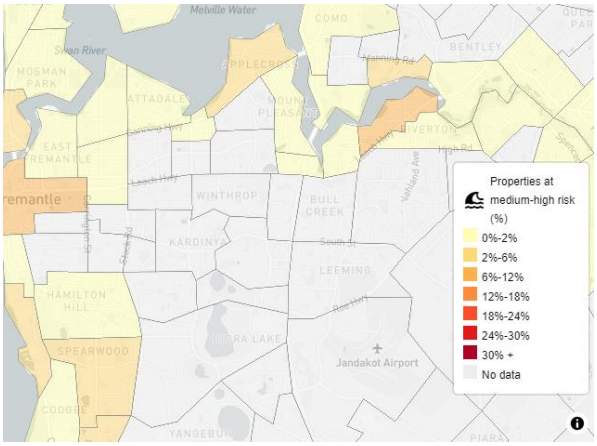
Figure 7-2. Flooding Risk Under High Emissions for 2100



Riverine flooding



Surface water flooding



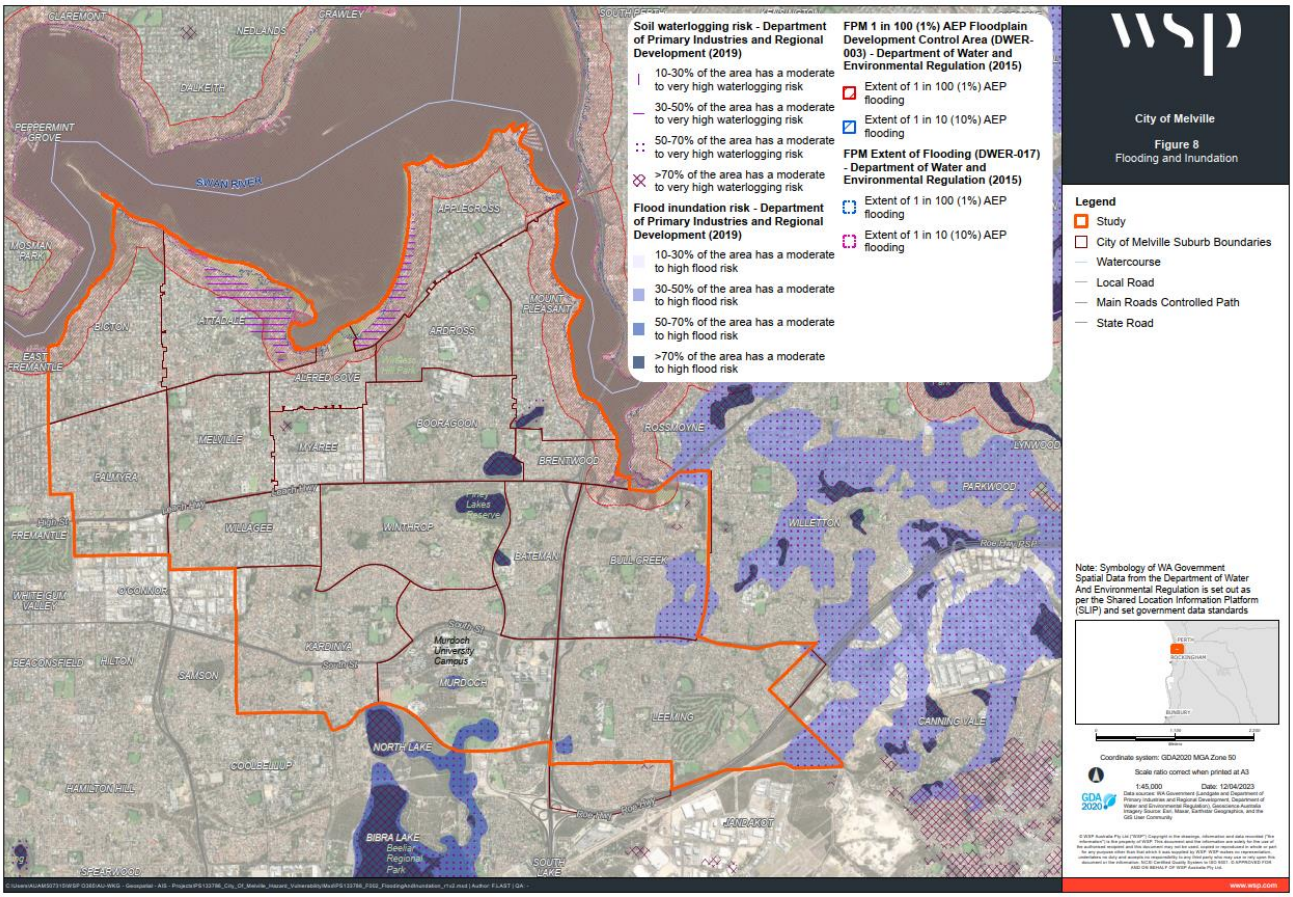
Coastal inundation

Source: Climate Council (n.d.) [79]

Figure 7-3 developed internally by WSP's GIS team uses data from the Department of Primary Industries and Regional Development and Department of Water and Environmental Regulation accessed from the DataWA portal and the Shared Location Information Platform to map the flooding and inundation risk from both riverine and non-riverine flooding. This displays the suburbs that have moderate to high flood risk, with waterlogging risk largely corresponding to flood and inundation risk. Again, the risks displayed by this map appear limited.

[79] Climate Council. n.d. Climate Risk Map of Australia. Accessed 12 January 2023. <https://www.climatecouncil.org.au/resources/climate-risk-map/>.

Figure 7-3. Flooding and Inundation Hazard for the City



Source: WSP (2023) - *Large version available in* ***Appendix D***

The data available for the City in regard to flood risk is good with generalised information available for flooding, with some limitations, particularly around lack of detail. While the State-wide mapping tool is useful for a general understanding of flood risk, it only considers riverine flood risk to the floodplain. Information is available via state government sources for current river levels and rainfall; however, this provides no contextualisation of flood risk.[80] Although **Figure 7-3** communicates further information about flood risk within the City, it is generally only accessible for those with some data background. Using the Climate Council dashboard, further information can be found for the City regarding flooding hazards and is a publicly accessible tool. It is still required that a user must navigate between several maps, with detail regarding which specific properties are at risk.

In this context, it is possible that the full extent of flood risk and the exposure of vulnerable communities in the City is not understood due to a lack of detailed data. There appears to be gaps in the comprehension of actual flood risk considering the influence of climate change, in addition to less explored groundwater flooding, sewer overflows and coastal flooding. As such, it will be difficult for the City to take targeted action for adaptation or preparation of response during hazards.

[80] Department of Water and Environmental Regulation. n.d. Floodplain management and development advice. Government of Western Australia. Accessed 13 January 2023. <https://www.water.wa.gov.au/planning-for-the-future/flood-planning-and-mapping/floodplain-development-advice>.

7.3 Rainfall

Rainfall, precipitated liquid water falling from the sky when clouds become saturated with water droplets, will be impacted by climate change.[81,82] There are three types of rainfall, convectional rainfall, orographic or relief rainfall, and cyclonic or frontal rainfall.[83]

- **Convectional rainfall:** forms convection currents and occurs when the earth's surface is warmer than the surrounds. Most often occurs in unstable, moist atmospheres.[83]
- **Orographic/relief rainfall:** occurs when moist air moves over a mountain range. This occurs in humid, mountainous areas.[83]
- **Cyclonic/frontal rainfall:** occurs when large air masses move along strong atmospheric pressure centres, producing cyclonic activity. This occurs at cyclone fronts.[83]

Rainfall is typically measured in rain gauges, a circular funnel 203mm in diameter. Rain falls into a measuring cylinder with precipitation manually recorded. Weather stations utilise modern Tipping Bucket Rain Gauges (TBRGs) with the same 203mm apparatus. However, TBRGs do not need emptying and provide automatic readings. Snow gauges also measure precipitation in locations across Australia where snow falls. These gauges contain antifreeze, causing the snow to melt and fluid levels measured (with 1 centimetre (cm) of snow approximate to 1mm of water).[84] The BoM take daily rainfall measurements at 9am and measurements are measured to the nearest 0.2mm.

Data available to the City assessing rainfall changes is extensive and of good quality. Baseline data is available on the BoM website for the years 1981 to 2010. However, some knowledge is needed to extract and manipulate available data. The closest BoM site to the City is Jandakot Aero (site 009172), approximately 6km from the City, and Fremantle WA (site 009192), approximately 7 km from the City. This is within an acceptable range, with data likely reflecting the City's actual rainfall. However, the City would benefit from direct records within their LGA boundary.

Average rainfall is expected to change globally and is highly variable across Australia. Rainfall is expected to decline, whilst heavy rainfall events will increase in intensity. Rainfall has declined in cooler months by 15% (April to October) and 19% (May to July) in the south-west of Australia since 1970.[85] These drying trends have been observed across southern Australia. Conversely, heavy rainfall events are becoming more intense, with a 10% increase since 1979.[86] These generalisations extend to the City. Data from the BoM shows a decline in annual average rainfall (as well as seasonally). However, rainfall intensity will likely increase by up to 25%.

Figure 7-4 shows the projected change in average rainfall to 2090. For the City, rainfall is projected to decrease gradually, with a maximum total decrease of 31.7% between the baseline and 2090 within the season of Spring. These changes will reduce community resilience and should be adequately prepared for by the City.

81 Dictionary.com. 2022. Rainfall. Accessed 13 Jan 2023. <https://www.dictionary.com/browse/rainfall>.

82 National Geographic. 2023. Rain. Accessed 13 Jan 2023. <https://education.nationalgeographic.org/resource/rain>.

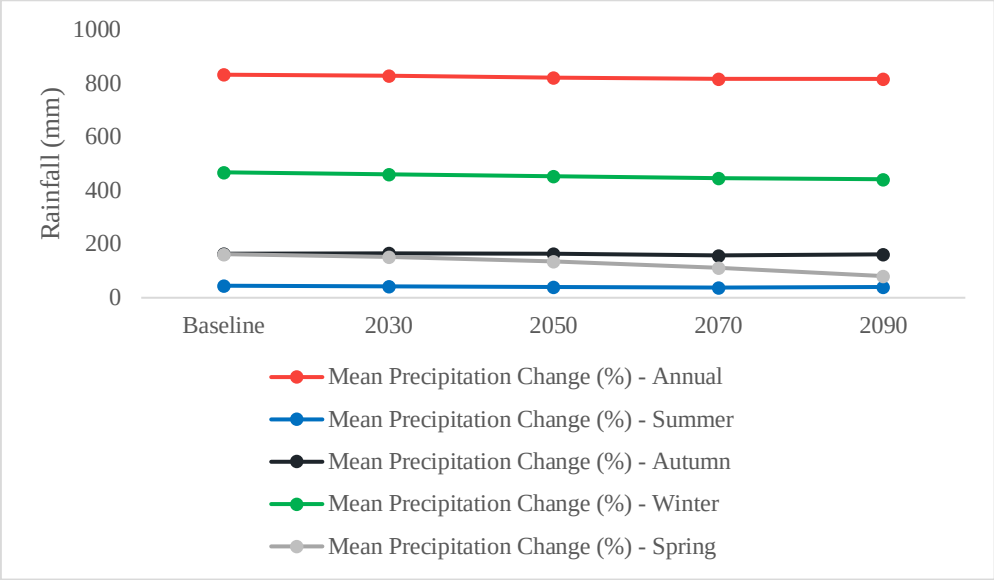
83 Unacademy. 2023. Types of Rainfall. Accessed 13 Jan 2023. <https://unacademy.com/content/cbse-class-11/study-material/geography/rainfall-types/>.

84 Bureau of Meteorology. 2022. Observation of Rainfall. Australian Government. Accessed 13 Jan 2023. <http://www.bom.gov.au/climate/cdo/about/rain-measure.shtml#:~:text=The%20standard%20instrument%20for%20the,up%20to%2025mm%20of%20precipitation.>.

85 Bureau of Meteorology. 2022. State of the Climate 2022. Australian Government. Accessed 13 Jan 2023. <http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml>.

86 AdaptNSW. 2023. Australian Climate Change Observations. NSW Government. Accessed 13 Jan 2023. <https://www.climatechange.environment.nsw.gov.au/australian-climate-change-observations#:~:text=the%20following%20changes.-,Changes%20to%20rainfall%20patterns,northern%20Australia%20since%20the%201970s.>.

Figure 7-4. Rainfall Projections



Source: Climate Change in Australia Website – Summary Data Explorer, Thresholds Calculator and Southern and South-Western Flatlands Cluster Report (2023)

7.4 Sea Level Rise

Rising sea levels are occurring globally as a result of ice melting and thermal expansion caused by increased global temperatures.[87] Warming temperatures mean land-based ice (mountain glaciers and polar ice sheets) are melting (e.g., Greenland and Antarctica).[87] Ice caps are melting at a disproportionate rate to the global replenishing that usually occurs during colder months.[87] This accelerated melt is currently the dominant contributing factor influencing sea level rise.[85]

However, warming global temperatures have also resulted in thermal expansion. As the burning of fossil fuel has contributed to increased global temperatures, oceans have absorbed most of the heat. However, as water warms, it expands, resulting in increased volume. Combined with ice melting, sea levels are expanding and increasing in volume, reflecting observed sea level rise.

The projected increases in sea levels resulting from climate change have varied impacts. Rising sea levels can result in permanent flooding and inundation of low-lying areas. Tidal inundation can occur more frequently at greater depths. Sandy coastlines and beaches are retreating and eroding, and coastal erosion causes damage to infrastructure, industries, and coastal ecosystems. Storm surges are also likely to intensify.[88] Saltwater intrusion alters freshwater ecosystems, affects groundwater systems, damages agricultural crops, amplifies erosion, and disturbs equilibriums.[89]

Using a combination of long-term tide gauge measurements and satellite data, scientists can determine the average absolute sea level change and height of the ocean surface. Global tide stations provide local data on

[87] National Geographic. N.d. Sea Level Rise. Accessed 13 Jan 2023. <https://education.nationalgeographic.org/resource/sea-level-rise>.

[88] AdaptNSW. 2023. Climate Change Impacts on Sea Level Rise. NSW Government. Accessed 13 Jan 2023. <https://www.climatechange.environment.nsw.gov.au/sea-level-rise#:~:text=The%20impacts%20of%20sea%20level,move%20further%20inland)%20and%20erode.>.

[89] Climate Change Knowledge Portal. 2021. Australia. Accessed 13 Dec 2023. <https://climateknowledgeportal.worldbank.org/country/australia/impacts-sea-level-rise>.

water height relative to a point on land by simply reading a gauge.[90,91] Alternatively, satellite laser altimeters measure the height of the ocean.[91] Together, these tools show the average global sea levels and can be used to show changes over time. Fossil, rock records can also tell scientists how sea levels have changed historically.[90]

Sea levels have risen by approximately 25 cm since 1880 across the globe.[85] Half of this increase has occurred since 1970. Within Australia, sea levels have risen approximately 1.4mm/year between 1966 and 2009.[92] Nationally, sea level rise varies, with the largest increases occurring in the north and south-east of the country. Within Western Australia, sea levels are expected to rise by 220-330mm within the next 20 years, 280-430mm by 2070, and 350-550mm by 2100.[92] $226B worth of infrastructure and homes Australia-wide are at risks from coastal inundation at a sea-level rise of 1.1m.[93] These projections show the impacts of increasing sea levels should be prepared for by the City.

The effect on coastal conditions have also been explored for the city. The projected range of sea level rise in Perth and Fremantle, WA is 0.4m to 0.85m by 2050 – these assumptions are assumed to be applicable to the City as well. It should, however, be noted that these projections are based on thermal expansion of the ocean. Due to the uncertainty of the rate of icecap melting. Therefore, if a collapse in the marine based sector of the Antarctic ice sheet occurred, these projections could be significantly higher.[94] **Figure 7-5** and **Figure 7-6** show the range of change expected for sea level rise and sea surface temperature respectively. Sea level rise is projected to increase between 2030 and 2090 due to climate change (see **Figure 7-5**), with a maximum increase of 0.85m in 2090, relative to the baseline. Similarly, an increase on baseline levels is expected for sea surface temperatures over 2030 and 2090 time slices, with a maximum projected increase of 3.3°C (see **Figure 7-6**). Given the City's LGA boundary is less than 15km from the coast, the City is at high risk of flooding, particularly along floodplains and the foreshore.

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90 Australian Academy of Science. 2018. How We Measure Global Sea-Level Changes. Accessed 13 Jan 2023. <https://www.science.org.au/curious/earth-environment/how-we-measure-global-sea-level-changes-0>.

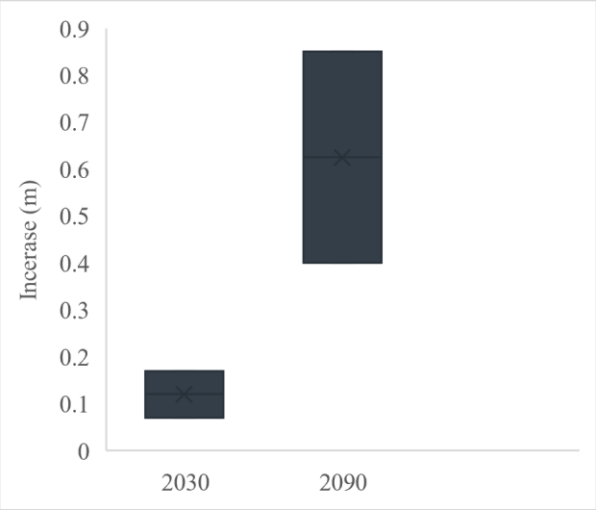
91 National Ocean Service. N.d. Is Sea Level Rising? National Oceanic and Atmospheric Administration. Accessed 13 Jan 2023. <https://oceanservice.noaa.gov/facts/sealevel.html#:~:text=Sea%20level%20is%20primarily%20measured,a%20specific%20point%20on%20land.>.

92 Main Roads Western Australia. 2020. Climate Change. Accessed 13 Jan 2023. <https://www.mainroads.wa.gov.au/technical-commercial/technical-library/road-traffic-engineering/climate-change/#:~:text=A%20study%20undertaken%20by%20the,the%20Year%202100%20(B1%20emmission>.

93 Steffen, W., Hunter, J. & Hughes, L. 2014. Counting the Costs: Climate Change and Coastal Flooding. Climate Council. Accessed 24 Oct 2022. <https://www.climatecouncil.org.au/uploads/56812f1261b168e02032126342619dad.pdf>.

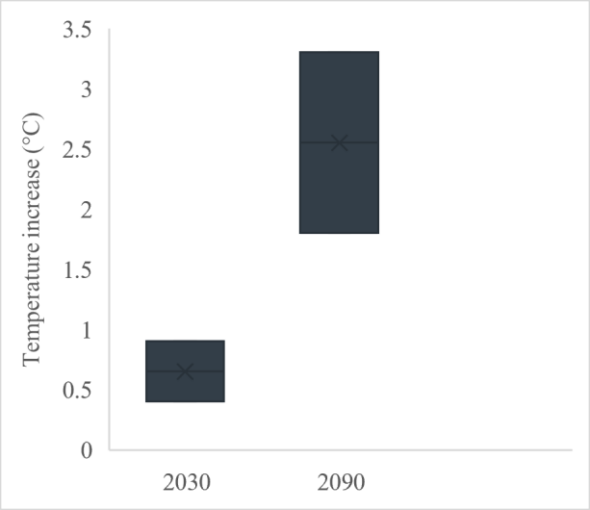
94 Hope, P. *et, al*. (2015), *Southern and South-Western Flatlands Cluster Report*, Climate Change in Australia Projections for Australia's National Resource Management Regions: Cluster Reports, eds. Ekstrom, M. *et al*., CSIRO and Bureau of Meteorology, Australia

Figure 7-5. Sea Level Rise Projections



Source: Climate Change in Australia Website – Summary Data Explorer, Thresholds Calculator and Southern and South-Western Flatlands Cluster Report (2023)

Figure 7-6. Sea Surface Temperature Projections



Source: Climate Change in Australia Website – Summary Data Explorer, Thresholds Calculator and Southern and South-Western Flatlands Cluster Report (2023)

However, projections and climate models carry inherent uncertainty. As such, the exact impacts and implications of sea level rise on the City remain largely unknown. The City's lack of data on sea level rise adds further uncertainty. There is a lack of tracked sea level changes, limiting tailored adaptation actions.

7.5 Bushfire

Bushfires are unplanned vegetation fires which can occur in grasslands, forests, scrubs, and agricultural areas. Although a significant hazard in Australia, they are considered a natural part of the Australian environment. They can be brought upon by several causes including lighting strikes and ignition (by people either accidentally or on purpose).[95]

Weather conditions play a major role in the size, intensity, speed, and predictability of a bushfire.[96] Factors like high temperatures, low humidity, dry conditions, and strong winds create ideal conditions for bushfires to start and rapidly spread.[97] As such, climate change can have a considerable influence on the occurrence of bushfires. The presence of fuel also contributes to fire risk and include materials such as leaf litter, dead and fallen vegetation, and grasses. [98]

Bushfires, when out of control, create significant risks to human and animal life, infrastructure, air quality, water resources and resultantly economies.[99] The impact of a bushfire can also cause wide-spread

[95] Australian Disaster Resilience Knowledge Hub. n.d. Bushfire. National Emergency Management Agency. Australian Government. Accessed 13 January 2023. <https://knowledge.aidr.org.au/resources/bushfire/>.

[96] Bureau of Meteorology. August 2019. Understanding Fire Weather. Australian Government. Accessed 13 January 2023. <https://media.bom.gov.au/social/blog/1538/understanding-fire-weather/>.

[97] Williams, L. November 2011. The worst bushfires in Australia's history. Australian Geographic. Accessed 13 January 2023. <https://www.australiangeographic.com.au/topics/science-environment/2011/11/the-worst-bushfires-in-australias-history/>.

[98] Australian Disaster Resilience Knowledge Hub. n.d. Bushfire. National Emergency Management Agency. Australian Government. Accessed 13 January 2023. <https://knowledge.aidr.org.au/resources/bushfire/>.

[99] Bushfire front. n.d. Impacts of Bushfires. Accessed 13 January 2023. <https://www.bushfirefront.org.au/home/fire-facts/impacts-of-bushfires/>.

consequences with fire embers travelling from the original location and causing smaller spot fires. Further, radiant heat from large bushfires has the potential to melt or fracture objects such as glass windows.[100]

To communicate bushfire hazards, the Australian Fire Danger Rating System (AFDRS) is used which indicates the danger should a fire start and actions to take to ensure safety.[101] Four levels make up this system; categories include moderate, high, extreme, and catastrophic.[102] This is determined based on a measurement of Fire Behaviour Index (FBI) which is on a scale of zero to 100 and indicates the scale of fire danger.

For the City, Summer is considered bushfire season. [103] Despite this, with climate change causing shifts in rainfall patterns, temperatures and wind, traditional periods of high fire risk may undergo changes in regard to duration and intensity. Significant changes towards more dangerous bushfire weather conditions which indicate more severe fire seasons, particularly in southern and eastern Australia, have been observed. [104] For example, days with a severe fire danger rating are projected to increase by 30-70% by 2030. For the City, increasing fire danger threatens community health, particularly vulnerable populations.

Figure 7-8 shows bushfire risk within the City as assessed by the Department of Fire and Emergency Services in 2014. This considers proximity to public assets including schools and government buildings. Hazard zones are similar to those mapped in **Figure 7-8** which were developed using DataWA and Geoscience Australia. **Figure 7-7** and **Figure 7-8** and show concentrated areas of bushfire risk in, most notably Murdoch, Leeming, Booragoon, and Bicton. These maps were developed using information on bushfire prone datasets which are defined by the presence of and proximity to bush fire prone vegetation. This includes the area containing the bush fire prone vegetation and a 100-metre buffer zone immediately surrounding it.[105] In terms of long-term projected fire risk,

Figure 7-9 shows an increase in forest fire danger index (FFDI) across 2030 and 2090 for the City. This accounts for the projected effects of climate change and their influence on ideal fire conditions.

Data for the City is also available based on the Cumulative McArthur Forest Fire Danger Index (ΣFFDI) which is the degree of danger of fires in Australian forests. This is calculated based on variables including temperature, relative humidity, wind speed, and drought factor (representing fuel availability).[106]

Figure 7-9 shows the projections developed based on this data.

For the City, the availability of data surrounding bushfire hazards is good, but appears limited in terms of accessibility. Real-time information reporting the AFDRS and FBI is available to the general public, however, data determining the risk of bushfire hazards to specific locations is largely only accessible to those with data modelling experience. While **Figure 7-7** and **Figure 7-8** is useful for depicting hazardous areas, these maps do not show the locations of the ancillary impacts of bushfire associated with travelling embers, radiative heat and smoke. As a result, understanding of the real risk of bushfire for the City is not comprehensive.

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100 Australian Disaster Resilience Knowledge Hub. n.d. Bushfire. National Emergency Management Agency. Australian Government. Accessed 13 January 2023. <https://knowledge.aidr.org.au/resources/bushfire/>.

101 Department of Fire and Emergency Services. n.d. Bushfire Overview. Government of Western Australia. Accessed 13 January 2023. <https://www.dfes.wa.gov.au/hazard-information/bushfire>.

102 Bureau of Meteorology. January 2023. Western Australia Fire Danger Ratings. Australian Government. Accessed 13 January 2023. <http://www.bom.gov.au/wa/forecasts/fire-danger-ratings.shtml>.

103 Australian Disaster Resilience Knowledge Hub. n.d. Bushfire. National Emergency Management Agency. Australian Government. Accessed on 13 January 2023. <https://knowledge.aidr.org.au/resources/bushfire/>.

104 Australian Disaster Resilience Knowledge Hub. n.d. Natural hazards and climate change. National Emergency Management Agency. Australian Government. Accessed 13 January 2023. <https://knowledge.aidr.org.au/resources/natural-hazards-and-climate-change/>.

105 DataWA. 2019. Bush Fire Prone Areas 2019 No2 (OBRM-015). Government of Western Australia. Accessed 16 January 2023. <https://catalogue.data.wa.gov.au/dataset/bush-fire-prone-areas-2019-no2-obrm-015>.

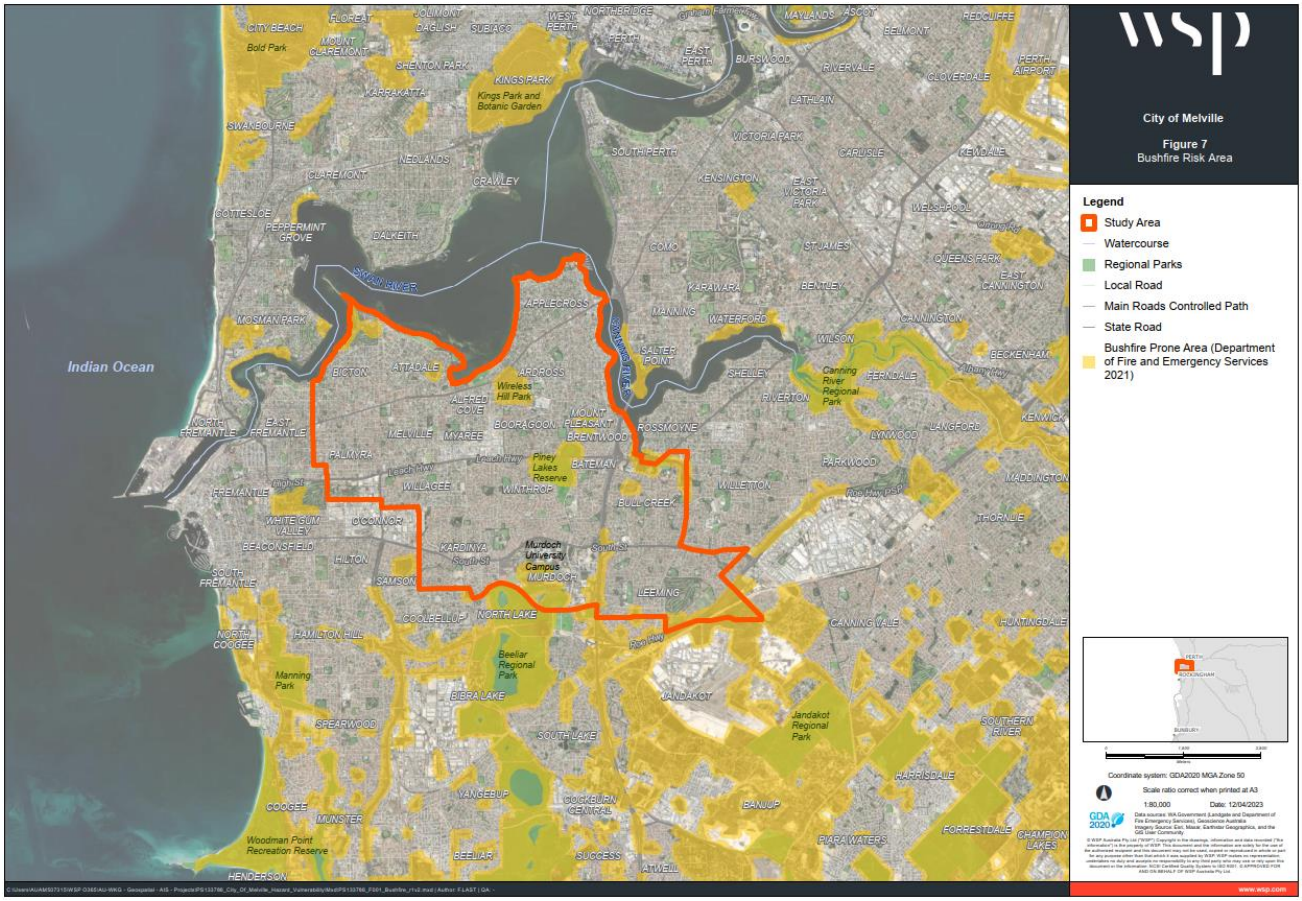
106 CSIRO. n.d. Forest Fire Danger Index. Accessed 13 January 2023. <https://research.csiro.au/bushfire/assessing-bushfire-hazards/hazard-identification/fire-danger-index/>.

Figure 7-7. Bushfire Prone Areas in the City

Source: City of Melville (2019)[107]

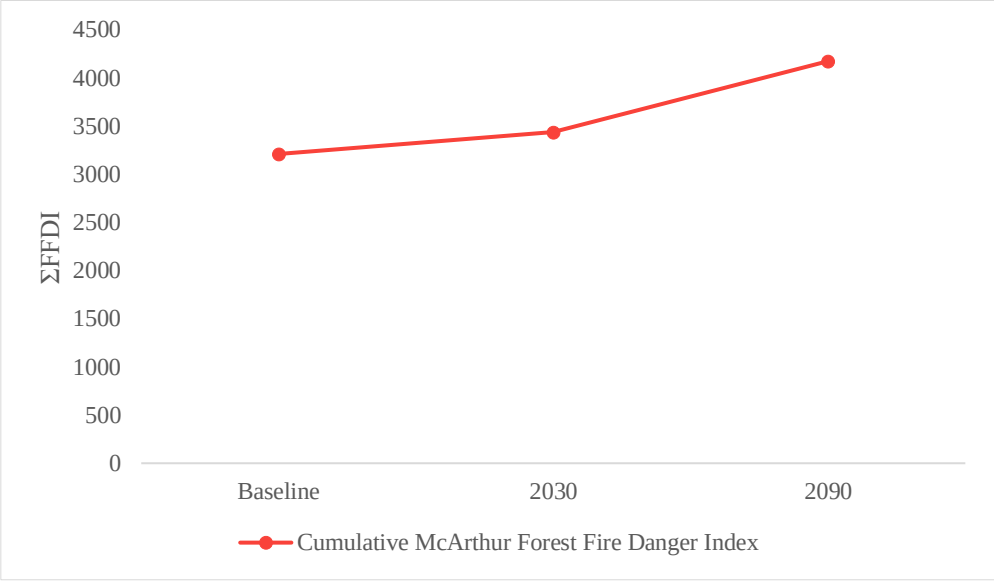
[107] CoM. February 2019. Bushfire Management Guidelines. Accessed 13 January 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/technical-services/bushfire-management-guidelines>.

Figure 7-8. Bushfire Risk Area for the City



Source: WSP (2023) - *Large version available in* ***Appendix D***

Figure 7-9. ΣFFDI for the City



Source: Climate Change in Australia Website – Summary Data Explorer,[108] Thresholds Calculator,[109] and Southern and South-Western Flatlands Cluster Report.[110]

While the maps in **Figure 7-7** and **Figure 7-8** are useful in understanding the extent of bushfire risk, there are gaps regarding the influence of shifts in environmental conditions due to climate change. As discussed, changes in wind speed, humidity, temperature, rainfall, and availability of fuel sources, increase the danger of bushfire. This can be determined based on the projections of ΣFFDI; however, without data literacy and modelling skills, these are not available in a visual format based on hazard location. As such, the ability to comprehend and communicate the real risk of bushfire considering climate change based on intensity, location, and extent may be missed. Further, the indirect risks to the community from smoke inhalation, exposure to spot fires, and impact of radiative heat is not clearly communicated. Without this information collated in a single source, there is a risk of misinformation and resultant health and safety implications.

7.6 Temperature

Shifts in temperatures is a primary impact of climate change across the globe. Increases in average temperatures, longer durations of hot weather, more frequent extreme temperature days and less cold nights are the most notable of these changes. According to the 2021 Global Climate Report from National Oceanic and Atmospheric Administration (NOAA) National Centres for Environmental Information, despite the influence of La Niña in the tropical Pacific providing cooling effects, each month of 2021 was warmer than average.[111] With communities experiencing broadly warmer weather, the resultant risks can include increased likelihood of heat-related illnesses and stresses.[112] Temperature can also be attributed as a contributor to many other climate hazards, including sea level rise, more severe storms, increased heatwaves and fire risk, and increased frequency and duration of droughts.[113]

It is important to note that depending on location, the recorded ambient temperatures may not reflect the true hazard. The relative humidity can affect the temperature felt, also called 'apparent' temperature or 'feels like' temperature.[114] This means the risks due to warmer temperatures are increased. Wind chill can also affect the apparent temperature, making conditions feel colder than the ambient temperature (actual temperature). For higher temperatures, our bodies sweat to cool us down, however, increased moisture in the air (in the instance of humidity), prevents sweat from being able to evaporate and cool the skin. [115]

Ambient temperature is measured using electronic thermometers, accurate within a fraction of a degree, using degrees Celsius within Australia (°C). These measure temperature by detecting changes in the resistance of electrical current flowing through a metal and allow information to be broadcast directly to meteorologists with instantaneous readings.[116] It is important that measurements of air temperature avoid the influence of other factors such a wind or solar radiation which can decrease or increase temperature readings respectively. To avoid this, the BoM measures ambient temperature using thermometers sheltered from sun and wind. [117]

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108 CSIRO and BOM (2019), 'Summary Data Explorer' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/summary-data-explorer/# (accessed 14 September 2022)

109 CSIRO and BOM (2019), 'Thresholds Calculator' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/threshold-calculator/ (accessed 14 September 2022)

110 Hope, P. *et, al*. (2015), *Southern and South-Western Flatlands Cluster Report*, Climate Change in Australia Projections for Australia's National Resource Management Regions: Cluster Reports, eds. Ekstrom, M. *et al*., CSIRO and Bureau of Meteorology, Australia

111 Lindsey & Dahlman. June 2022. Climate Change: Global Temperature. National Oceanic and Atmospheric Administration (NOAA). Accessed 16 January 2023. <https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature>.

112 World Wide Fund for Nature. n.d. Impacts of global warming. Accessed 16 January 2023. < https://www.wwf.org.au/what-we-do/climate/impacts-of-global-warming>.

113 United Nations. n.d. Causes and Effects of Climate Change. Accessed 17 January 2023. <https://www.un.org/en/climatechange/science/causes-effects-climate-change>.

114 Bureau of Meteorology. October 2016. Apparent ('feels like') temperature. Australian Government. <https://media.bom.gov.au/social/blog/1153/apparent-feels-like-temperature/>.

115 Bureau of Meteorology. October 2016. Apparent ('feels like') temperature. Australian Government. Accessed 16 January 2023. <https://media.bom.gov.au/social/blog/1153/apparent-feels-like-temperature/>.

116 National Institute of Standards and Technology. Updated April 2022. How Do You Measure Air Temperature Accurately? United States Government. Accessed 16 January 2023. <https://www.nist.gov/how-do-you-measure-it/how-do-you-measure-air-temperature-accurately>.

117 Bureau of Meteorology. October 2016. Apparent ('feels like') temperature. Australian Government. Accessed 16 January 2023. <https://media.bom.gov.au/social/blog/1153/apparent-feels-like-temperature/>.

The BoM estimates 'feels like' temperature using the Steadman Apparent Temperature model. This is defined as the temperature that (using a reference level of humidity and without wind) would produce the same level of discomfort in an adult as the current combination of ambient temperature, humidity, and wind chill. [118] This however does not consider the influence of direct sun on a person, which would impact the body's heat exposure.

Historic and current climate data for temperature is comprehensive across Australia and Western Australia via the BoM Climate Data Portal, with a number of stations bordering the City. Information available includes average temperatures and extreme temperatures readings. It is noted that, considering the standard baseline period for climate projections (1986 to 2005), specific data is not available for the City. Despite this, alternative time periods do provide comprehensive data to make accurate historic baselines. For climate projections, data is available for the City through the Climate Change in Australia Website – Summary Data Explorer,[119] Thresholds Calculator,[120] and Southern and South-Western Flatlands Cluster Report.[121]

[118] Bureau of Meteorology. October 2016. Apparent ('feels like') temperature. Australian Government. Accessed 16 January 2023. <https://media.bom.gov.au/social/blog/1153/apparent-feels-like-temperature/>.

[119] CSIRO and BOM (2019), 'Summary Data Explorer' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/summary-data-explorer/# (accessed 14 September 2022)

[120] CSIRO and BOM (2019), 'Thresholds Calculator' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/threshold-calculator/ (accessed 14 September 2022)

[121] Hope, P. *et, al*. (2015), *Southern and South-Western Flatlands Cluster Report*, Climate Change in Australia Projections for Australia's National Resource Management Regions: Cluster Reports, eds. Ekstrom, M. *et al*., CSIRO and Bureau of Meteorology, Australia

Figure 7-10 below shows the 50th percentile from associated model simulations associated with annual, summer season and winter season mean temperature change projected over four time slices. While the information displayed in

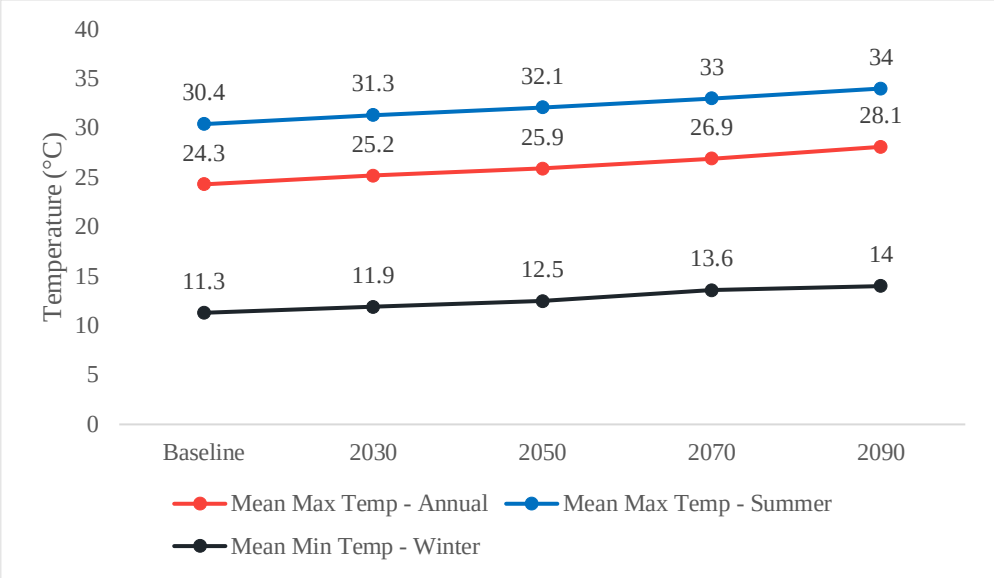
Figure 7-10 shows the average temperature increase projected, model outputs also include 10th percentile and 90th percentile outputs which illustrate the range of uncertainty associated with each climate change projection (see **Appendix C**).

For the City, average temperatures are expected to increase with a linear trend from the baseline to 2090 for all periods (see

Figure 7-10).

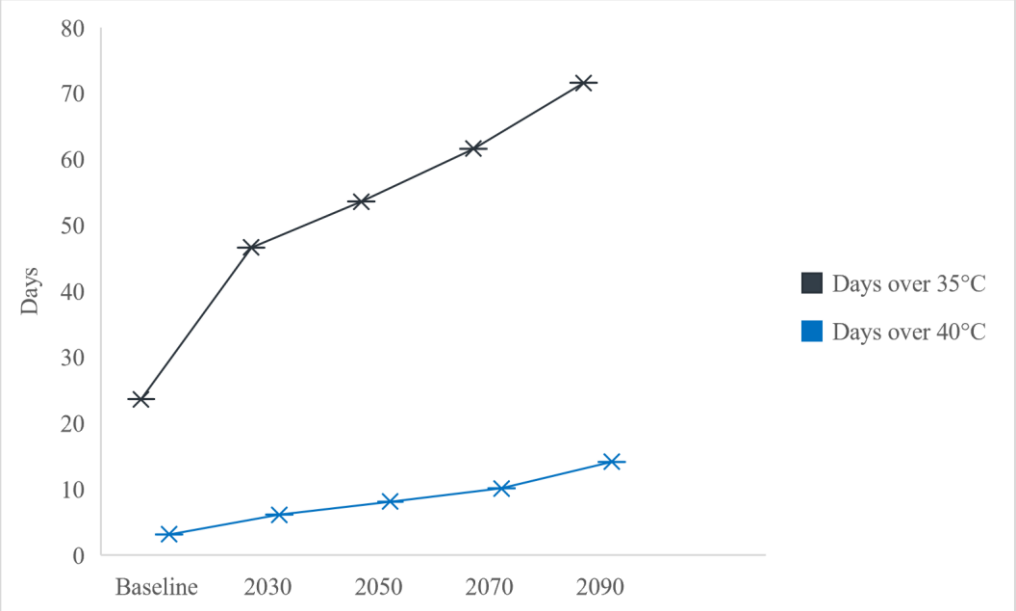
Figure 7-11 outlines the projected increase in extreme heat including days over 35°C and days over 40°C. For days over 35°C, a total increase of 48 days on the baseline of 23.6 days, is expected between 2030 and 2090. Days of 40°C are expected to increase by 11 days from the baseline of 3.1 days, by 2090.

Figure 7-10. Temperature Projections



Source: See **Appendix C.**

Figure 7-11. Extreme Heat Projections



Source: See **Appendix C**.

The data available for temperature within the City is comprehensive. Despite this, it is apparent that there are no public visual mapping tools associated with temperature hazards for the City. The information accessible assumes some experience with data comprehension and is otherwise not easily consumed. This is particularly the case for understanding historic temperatures. This limitation makes it difficult to communicate the severity of temperature hazards occurring within the City when accompanied by weather advice.

When considering specific risks associated with temperatures, available information also appears to lack communication of correlations with urban heat island (UHI) effects or heatwaves, particularly considering the urban context.

7.7 Riverine Erosion

Erosion is caused by the wear and transportation of earthen materials by elements such as wind, water, and ice.[122] Riverine erosion is the transportation of soil, sediment, and rock on riverbeds and banks by water within the catchment. Erosion is a natural occurrence within waterways and estuaries with their channels changing shape, size, vegetation density, and bed materials over time due to changes in water flow and sediment load.[123] Despite this, shifts in climate including increased rainfall intensity and vegetation loss can influence these natural processes and accelerate erosion.[124] When combined with the effects of climate change, inappropriate land-use management practices can further exacerbate the deterioration of rivers.[125] These potentially harmful practices include land clearing, grazing, channel works and water infrastructure such as dams and bridges.

Riparian vegetation has a particular role in stabilising sediments, slowing the flow of water into waterways and absorbing nutrients. As such the loss of this vegetation through land-use practices or drought can cause challenges. This is particularly notable when combined with increased intensity of rainfall and flash flooding.[126]

These factors can combine to cause complications with the health of the waterways. Erosion can increase suspended material in the water, limiting sunlight filtration and therefore restricting the ability of plants to photosynthesise. Sediment run off from adjacent areas, including agricultural land can also increase the nutrient and chemical load within the water. This results in water pollution and can often lead to algae blooms.[127]

Measuring riverine erosion can be complex; there are a number of methods that can help provide understanding of the changes in riverbanks and beds. Digital photogrammetry can be used to measure riverbank erosion through the extraction of high-resolution digital elevation models from terrestrial images of eroding riverbanks using specific commercial software.[128] This technology can allow for faster analysis, can be more accurate, and involve less ground disturbance than other methods of monitoring river channel change.[129]

LiDAR (light detection and ranging) technology is an airborne laser which provides high-resolution topographic data which can be gathered over large areas with both vertical and horizontal accuracy.[130] This can be useful in gaining a precise depiction of the conditions of riverbanks. Outputs can be compared over time to determine the occurrence of erosion.

Photo electric erosion pins (PEEP) can be used to directly measure the rate of erosion at a particular point. This method involves the installation and maintenance of pins at strategic locations along the waterway. This method can be expensive, and pins may be washed away when placed along a riverbank.[131]

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[122] National Geographic. n.d. Erosion. Accessed 16 January 2023. <https://education.nationalgeographic.org/resource/erosion>.

[123] Department of Water and Environmental Regulation. n.d. Erosion and Sedimentation. Government of Western Australia. Accessed 16 January 2023. <https://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/erosion-and-sedimentation>.

[124] Department of Water and Environmental Regulation. n.d. Erosion and Sedimentation. Government of Western Australia. Accessed 16 January 2023. <https://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/erosion-and-sedimentation>.

[125] Department of Water and Environmental Regulation. n.d. Erosion and Sedimentation. Government of Western Australia. Accessed 16 January 2023. <https://www.water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/erosion-and-sedimentation>.

[126] Department of Water and Environmental Regulation. n.d. Aquatic and riparian vegetation. Accessed 16 January 2023. <https://www.water.wa.gov.au/water-topics/waterways/values-of-our-waterways/aquatic-and-riparian-vegetation>.

[127] Healthy Land and Water. 2019. Erosion and Sediment Control Toolkit for House Builders. Accessed 16 January 2023. <https://hlw.org.au/download/erosion-and-sediment-control-toolkit-for-house-builders/>.

[128] Pyle, C, Richards, K., Chandler, J. February 2003. Digital Photogrammetric Monitoring of River Bank Erosion. Online Wiley Library. Accessed 16 January 2023. <https://onlinelibrary.wiley.com/doi/10.1111/0031-868X.00083>.

[129] Pyle, C, Richards, K., Chandler, J. February 2003. Digital Photogrammetric Monitoring of River Bank Erosion. Online Wiley Library. Accessed 16 January 2023. <https://onlinelibrary.wiley.com/doi/10.1111/0031-868X.00083>.

[130] Cavalli, M. January 2011. Application of LiDAR technology for rivers analysis. Italian National Research Council. Accessed 16 January 2023. <https://www.researchgate.net/publication/229429818_Application_of_LiDAR_technology_for_rivers_analysis>.

[131] Saadon, A., Abdulla, J., Muhammad, N., Ariffin, J., Julien, P. January 2021. Predictive models for the estimation of riverbank erosion rates. Science Direct. Accessed 16 January 2023. <https://www.sciencedirect.com/science/article/abs/pii/S0341816220304677>.

In terms of information available within the City, there appears to be no publicly accessible visual data marking the progress of river erosion. Despite this, it is clearly understood that erosion along the foreshore is occurring, as made clear by the City's Foreshore Restoration Strategy. [132] The City acknowledges that erosive processes are ongoing and may increase in intensity due to increased boat use and the impacts of climate change such as increased frequency and intensity of extreme events.[133] As such, the Foreshore Restoration Strategy does note that evidence of erosion was recorded, and locations provided to the City in the form of digital shapefiles at the time of development. Within this document, there are also historic assessments of the nature and rating of erosion along the foreshore using an erosion rating scale (prescribed by Natural Area Management and Services (NAMS) (2009)) (see **Figure 7-12** below). Broadly, these finding show an increase in erosion at most locations between 1997 and 2019. It is unclear whether evidence of erosion was provided to the City via shapefile for other time periods, as was the case with the latest (2019) assessment.

[132] GHD. March 2019. City of Melville Foreshore Restoration Strategy 2019. Accessed 16 January 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/technical-services/foreshore-restoration-strategy-review-and-final-re>.

[133] GHD. March 2019. City of Melville Foreshore Restoration Strategy 2019. Accessed 16 January 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/technical-services/foreshore-restoration-strategy-review-and-final-re>.

Figure 7-12. Nature and Rating of Erosion Along the Foreshore

Area	Nature	Rating				Comments (2019)
		1997[a]	2009	2014	2019	
Bull Creek	4,12	Not Rated	Negligible	Low	Medium	Coastline is exposed to energetic wave conditions and experiencing erosion leading to areas of unstable verges and movement (evidenced by observations such as cracked pipes).
Canning River	1,2,3,4,5 ,8,9, 10,12	4	High	High	Not rated	Not observed as part of the 2019 survey data.
South Perth Yacht Club to Canning Bridge	1, 4, 5	3	Negligible	Low	Not rated	This stretch of foreshore was part of the excluded zone.
Waylen Bay	1, 4, 9	2,3	Low	Med	Not rated	This stretch of foreshore has remained mostly stable, although there have been some instability issues at Pt Heathcote and verge erosion concerns along Jeff Joseph Reserve.
Melville Beach	4,9	1,2	Low	Low	High	This stretch of foreshore has been experiencing erosion from trampling and wave condition leading to undercutting of grass area leading to a drop of ground level.
Point Walter	1,2,3,4,5	Not Rated	Med	Low	High	There are erosion threats to trees.
Blackwall Reach	1,2,4,5,8 ,9,12	Not Rated	Low	High	Medium	The foreshore has been experiencing erosion from trampling, causing instability and trees under threat.

a: As rated by Tingay (1997); 1 (High): experiencing extensive seasonal soil loss and require significant remediation works; 2 (Medium): areas that require rehabilitation as a secondary consideration; 3 (Low): experiencing erosion but require only minor treatments; 4 (Interspersed patches): areas that have small sections (approximately 1 m wide) of erosion at inconsistent intervals.

Source: GHD (2019) [134]

For the City, quantifiable data on the presence and progression of riverine erosion appears limited and is likely unavailable. Although assessments have been made, as evident within the City's Foreshore Restoration Strategy (2019), visual data is missing. This makes it difficult to gain a comprehensive understanding of the extent and severity of erosion along the foreshore, particularly if external to the locations mentioned within the Foreshore Restoration Strategy. The lack of comprehensible information limits the ability to gauge particular zones more prone to erosion and the level of risk presented to vulnerable infrastructure or vegetation.

7.8 Storms and Cyclones

Thunderstorms are tall cumulonimbus clouds causing thunder, lightning, and turbulence. Storms are usually associated with warm, humid air that is forced upwards (often due to a cold front, sea-breeze moving inland, or wind moving over a mountain) due to surface winds, creating an unstable atmosphere with lots of energy.

[134] GHD. March 2019. City of Melville Foreshore Restoration Strategy 2019. Accessed 16 January 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/technical-services/foreshore-restoration-strategy-review-and-final-re>.

Storms consist of three parts, a core, anvil (cloud spreading out sideways at the top, with the flat cloud sheet usually consisting of ice crystals), and an inflow-outflow region where humid air supplies the storm with energy. The three types of storms are:

- **Single-cell thunderstorms:** a single updraught pulse is responsible for the storm. These likely occur mid-summer and do not last longer than one hour, rarely producing severe weather. These storms are rare.
- **Multicell thunderstorms:** the most common storm consists of successive, separate updraught pulses close together, resulting in stronger and weaker phases. These storms rarely cause tornadoes.
- **Supercell thunderstorms:** these storms are strong and long-lived, lasting several hours. Continuous large updraught occurs with cloud-scale circulation. These are usually classed as severe thunderstorms.[135]

The BoM classifies severe thunderstorms as those with large hail (≥2cm in diameter), damaging wind (speeds ≥90km/h), tornadoes, and heavy rainfall potentially leading to flash flooding. Most storms occur within Australia during the warmer months, particularly over summer. Cyclones (the term 'hurricane' is used in the North Atlantic and Northeast Pacific) are low-pressure systems forming over warm waters (usually over 26.5°C) with strong associated winds near the centre (10-minute mean wind speed ≥63km/h) persisting for at least six hours.[136] These spinning formations consist of multiple thunderstorms, following erratic paths.[137,138] Cyclones dissipate upon moving over land or cooler oceans.[138]

Storms are monitored via satellite and radar imagery, with early warning systems often in place. Anemometers measure wind speed, while rainfall is monitored via rain gauges.[139] The Australian Cyclone Intensity Scale (ACIS) categorises tropical cyclones into five categories measured by maximum mean wind speed.[140] The categories span from 1 (weak) to 5 (strongest) and are shown below in **Table 7-13**.

Table 7-13. ACIS Cyclone Categories, Associated Wind Speeds and Typical Effects

Category	Maximum Mean Wind (km/h)	Typical Strongest Gust (km/h)	Impact
1	63-88	Less than (<) 125	Damaging winds. Minimal damage to housing. Damage to crops, trees, and caravans. Marine craft may drag moorings.
2	89-117	125-164	Destructive winds. Minor house damage. Significant damage to signs, trees, and caravans. Power failure may occur. Small marine craft may break moorings.
3	118-159	165-224	Very destructive winds. Some roofing and structural damage. Some caravans are destroyed. Power failure is likely. E.g., Cyclone Olwyn.

135 Bureau of Meteorology. 2023. Severe Thunderstorms. Australian Government. Accessed 13 Jan 2021. <http://www.bom.gov.au/weather-services/severe-weather-knowledge-centre/severethunder.shtml>.

136 Australian Disaster Resilience Knowledge Hub. 2023. Cyclone. Australian Institute for Disaster Resilience. Accessed 13 Jan 2023. <https://knowledge.aidr.org.au/resources/cyclone/>.

137 Dictionary.com. 2021. Cyclone vs. Typhoon vs. Hurricane vs. Tornado: Are They All The Same? Accessed 13 Jan 2023. <https://www.dictionary.com/e/typhoons-hurricanes-cyclones/>.

138 Bureau of Meteorology. 2023. What is a Tropical Cyclone? Australian Government. Accessed 13 Jan 2023. <http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/understanding/tc-info/>.

139 Bureau of Meteorology. 2023. Storm Spotters' Handbook. Australian Government. Accessed 13 Jan 2023. <http://www.bom.gov.au/storm_spotters/handbook/what_to_report.shtml>.

140 QBE. 2017. Cyclone Ratings Explained. Accessed 13 Jan 2023. <https://www.qbe.com/au/news/cyclone-ratings-explained#:~:text=Cyclones%20that%20form%20in%20the,five%20distinct%20categories%20of%20cyclones.>.

Category	Maximum Mean Wind (km/h)	Typical Strongest Gust (km/h)	Impact
4	160-199	225-279	Significant roofing loss and structural damage. Many caravans destroyed/blown away. Dangerous airborne debris. Widespread power failure. E.g., Cyclone Tracy.
5	>200	>279	Extremely dangerous with widespread destruction. E.g., Cyclone Yasi.

Source: Bureau of Meteorology (2023).[138]

Although cyclones do not currently occur in Perth (usually ex-tropical), projections show tropical cyclones are likely to occur further south and be more damaging. [141] As such, it is assumed cyclonic winds and intense rainfall will likely begin impacting the City. There is currently limited data availability within the City, however this is assumed likely attributable to the lack of cyclone events. The BoM's Southern Hemisphere Tropical Cyclone Data Portal tracks cyclones across Australia, providing detailed information on cyclone pathways.[142] The BoM also measure wind speed, rain, and temperature for the City.[143] Detailed information on storms is also lacking across the State (beyond anecdotal news records). This information is widely accessible to the public but lacks scientific rigour.

Despite a lack of projections for WA and the City, it is expected tropical cyclones will occur less frequently (declining by 13%) but will likely be of greater intensity.[144] Extreme sea level rise and storm surges are expected alongside cyclonic events.[145] Increasing storm intensity and frequency are also expected. These changes should be accounted for by the City.

[141] CSIRO & Bureau of Meteorology. 2018. State of the Climate 2018. Australian Government. Accessed 24 Oct 2022. <http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf>.

[142] Bureau of Meteorology. 2023. Southern Hemisphere Tropical Cyclone Data Portal. Australian Government. Accessed 16 Jan 2023. <http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/tracks/>.

[143] Bureau of Meteorology. 2023. Latest Weather Observations for Western Australia. Australian Government. Accessed 16 Jan 2023. <http://www.bom.gov.au/wa/observations/waall.shtml?ref=hdr>.

[144] Tandon, A. 2022. Tropical Cyclones Now '13% Less Frequent' Due to Climate Change. Carbon Brief. Accessed 13 Jan 2023. <https://www.carbonbrief.org/tropical-cyclones-now-13-less-frequent-due-to-climate-change/>.

[145] Bureau of Meteorology. N.d. Tropical Cyclone Trends. Australian Government. Accessed 13 Jan 2023. <http://www.bom.gov.au/cyclone/climatology/trends.shtml>.

8 Climate Change Transitional Risks

Transitional risks can be broadly categorised as policy, social, technology, market, resources, and reputational risks, all of which have economic impacts across all levels of government. By default, these risks will also impact the Melville community. Although numerous and extensive, some examples are provided below:

- **Policy:** As the City transitions to a low-carbon economy, risks may ensue through various political and legislative controls. The City may become subject to carbon pricing and reporting obligations, may need to adopt policies and plans that encourage a circular economy, may be mandated to disclose risk (potentially heavily impacting large asset owners), and litigation may become a possibility for previous lack of action, certain development approvals, or failure to implement certain policies or plans. Climate risk disclosure and litigation should also be expected, with financial implications on asset valuation expected. Clear risk disclosure and reporting will further increase transparency. However, as climate emergencies and accelerated change become the norm, net zero commitments should be deepened.
- **Social**: Australia's social constructs are expected to change as a result of climate change and social advances. Analysis suggests local places and services will be of increasing demand as community cohesion is heightened (particularly as a result of frequent disaster events). Although we will be globally connected in the future more than ever, with increasing migration expected, greater polarisation and inequality will arise because of climate change. Ensuring adequate mental health providers are available to treat those affected by eco-anxiety, depression, and other mental health conditions resulting from frequent disasters should be prioritised. The City's health sector focus will be beneficial in maximising individual wellbeing. Indigenous influence should also be celebrated and recognised within the climate sphere.
- **Technology:** Technology development and uptake will also be particularly important in future years. Digital transformation will revolutionise society and change consumer expectations towards personalisation and instant services. Similarly, data transparency, cyber security, automation and digital augmentation, global technological connections, and increased mobility will influence our future society. Technological risks will ensue, particularly surrounding potentially risky investment in new climate technology and greener products such as electric vehicle charging infrastructure.
- **Market:** Major market risks exist concerning the changing of consumer sentiment. A shift in behaviour to climate-friendly consumption is necessary, with awareness and demand triggering and driving action. Increased price volatility of raw materials or commodities are a further market risk. Supply chain disruptions as a result of extreme weather events should also be expected.
- **Resources**: Resource constraints and booms are expected in the future. Constraints will occur as the City transitions to a circular economy. Designing out waste and pollution will maximise material exchange opportunities, aiding emission reductions. Similarly, transitions to a renewable energy sector will positively benefit the City. Decarbonising our energy sector will accelerate renewable energy uptake and reduce GHG emissions. Recognising and valuing the City's natural environments could assist both human and non-human adaptation to climatic changes. Ongoing biodiversity protection and management will also be required at a greater scale as pressures continue. Infrastructure shortages and increased demand will strain existing resources. Supply chains will also be stressed as a result of climate change. Water scarcity will be the norm in the future and shortages should be planned for.
- **Reputation:** Reputational risks exist for the City as they endeavour to address climate change. Direct reputation damage may result from specific actions or policies, while indirect risk results from public perception. Climate inaction can result in a poor reputation, damaging the existing regulatory environment and stakeholder relationships. The local government may also become less attractive. This may have flow-on effects for the community, as individuals move to other, more attractive, and favourable communities.

Transitional risks are considered in the next chapter in the Risk Assessment.

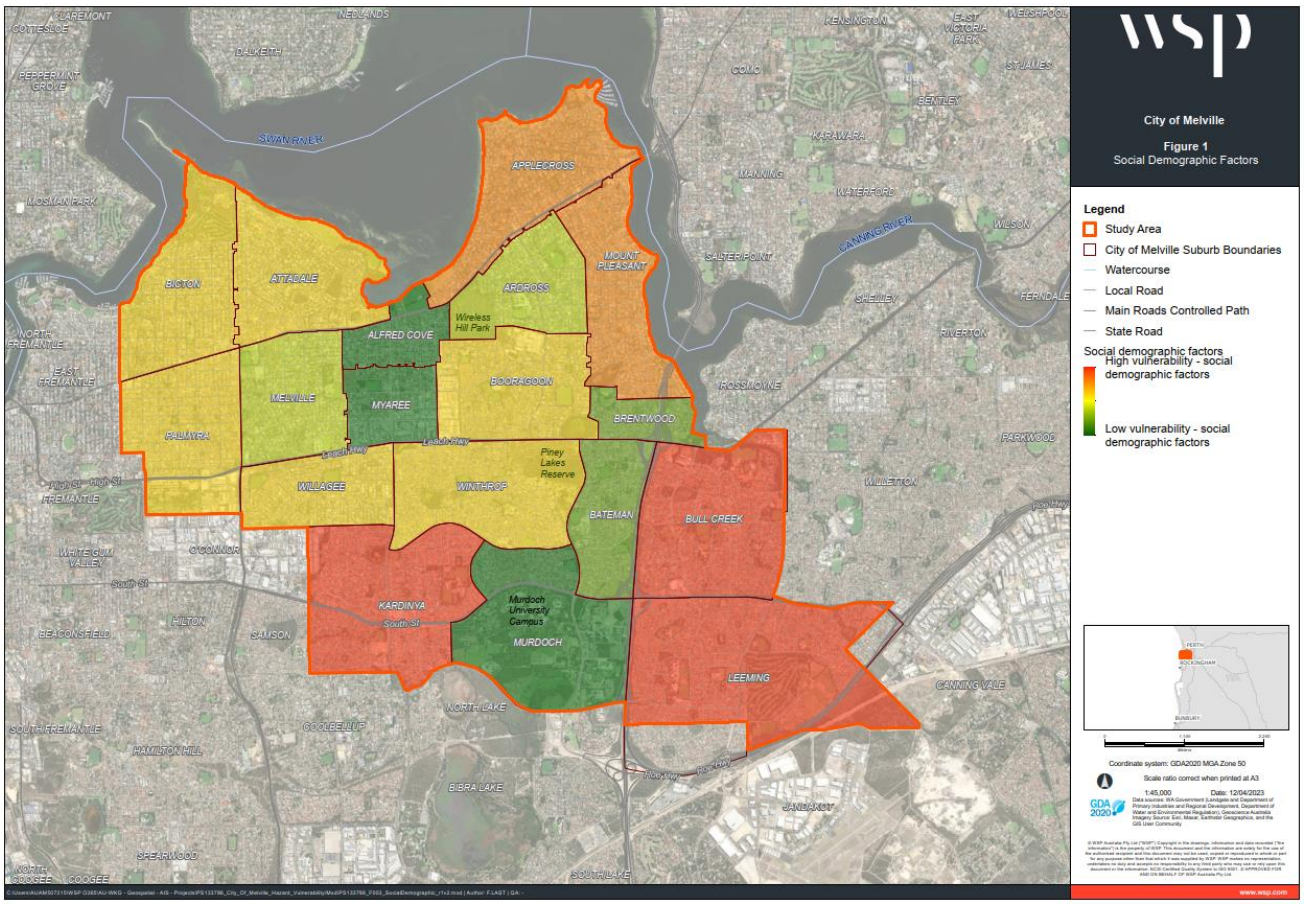
9 Vulnerability Risk Assessment

Vulnerabilities within a community interact with hazards to influence the magnitude of physical and transitional risks. To assess vulnerability, WSP analysed a multitude of data sources from the Australian Bureau of Statistics (ABS) which relate to demographic, social and economic factors. The suburb level denotes the smallest spatial scale in which this data is readily available. These data sets were weighted and combined to identify suburbs where levels of vulnerability were highest. The capacity of communities to cope with shocks and stresses is also related to the provision of services and access to cultural, social, environmental, health, educational and other support infrastructure. Using a variety of datasets including data held by Council, WSP analysed infrastructure and service provision across the City. This assists in identifying areas where provision of certain services is uneven, and where opportunities exist to improve services or target interventions. Environmental and cultural assets as well as critical assets, such as transport, utilities, and emergency services were mapped to identify where assets are exposed to hazards. This allows an assessment of physical or transitional risks, and what challenges and opportunities exist to mitigate these risks.

9.1 Socio Demographic Factors

This Socio-Demographic map (**Figure 9-1**) was developed by WSP using data from sources including the ABS, DataWA and Geoscience Australia. The map represents vulnerability of the community to various hazards within the City's suburbs (data sets used within mapping were drawn from the 2021 census data). A colour gradient is used to represent the least to most vulnerable suburbs, based on analysis of a range of demographic and social factors. The data is provided in **Appendix E.** The weighted assessment of the socio-demographic impacts across the suburbs in the City determined that Bull Creek, Leeming, and Kardinya are the most susceptible to socio-demographic variances.

Figure 9-1. Socio-Demographic Factors Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Physical Risk Analysis

Population Density

Suburbs with high population density including Mount Pleasant, Willagee and Alfred Cove are more susceptible to the physical risks posed by various hazards. Suburbs with high population density will require a greater level of response during a disaster event such as bushfire or flood which all three suburbs are noted as being as exposed to. This includes assistance from emergency services and urgent medical attention. These suburbs may also absorb resources from neighbouring suburbs such as Applecross, putting community members in this area at greater risk of injury or illness arising from a disaster event.

School Aged Population

Suburbs with a high population of school aged children including Bull Creek, Leeming and Attadale are more sensitive to the physical risks posed by hazards due to the level of dependence on caregivers. Children can pose a burden to their caregivers during a bushfire evacuation event for example due to limited mobility and level of care and support required. If separated from caregivers during a disaster, children are at greater risk of injury, illness and even death due to deficient decision-making skills, perception of risks and physical strength.

Elderly Population

Suburbs with a high population of elderly people including Bull Creek, Kardinya and Leeming are more sensitive to the physical risks posed by various hazards due to higher levels of dependence on external care, as well as increased isolation. Limited mobility and pre-existing health conditions can impact the elderly's ability to escape quickly during a hazard event such as rising flood waters. The elderly is also at greater risk of acquiring additional health complications, injury, and death during hazard events. Increased isolation can also

impact an elderly person's confidence in asking for assistance during an evacuation event for example, further increasing their risk of illness, injury, and death.

Disabilities

Suburbs with a high population of people with disabilities including Bull Creek, Leeming and Kardinya are sensitive to physical risks arising from hazards due to being less self-sufficient i.e., dependent on external social services and susceptibility to adverse health impacts. During a heatwave event for example, pre-existing health conditions may lead to additional health complications and potentially death. Cognitive impairments may also mean that those with disabilities cannot communicate that they are unwell and require medical attention. Limited access to resources including income, transport etc. may also mean that those with disabilities require extra support during an evacuation event. Social isolation may also increase for those with disabilities during a disaster event if access to social services is reduced or cut-off, causing impacts to mental health.

Adult Literacy

Suburbs with higher concentrations of poor adult literacy skills including Bull Creek, Kardinya and Leeming are more sensitive to the physical risks because of hazards due to inability to access necessary resources during a hazard event, increased reliance on external social services and inability to interpret hazard warnings and preparation information. Community members with reduced literacy skills may not feel confident to access medical attention for example during a bushfire event, due to poor income or inability to complete complex forms. External reliance on social services such as financial aid may limit a person's access to food, transport etc. during a disaster event putting them at greater risk of injury or illness. An inability to access resources or interpret disaster warning and preparation information due to poor reading skills may also increase a person's risk of injury or illness.

Non-English-Speaking Backgrounds

Suburbs with higher concentrations of people from non-English speaking backgrounds including Bull Creek, Kardinya and Leeming are more sensitive to the physical risks arising from hazards due to inability or resistance to accessing resources during a hazard event. During a heatwave event for example, community members who cannot speak or read English may find it difficult to seek out medical assistance or seek out resources such as free water stations and air-conditioned public buildings. Cultural barriers may arise among people from non-English speaking backgrounds causing resistance to accessing medical attention or support when it is required, increasing the likelihood of additional health complications.

Migration

Suburbs with a higher number of people who have re-located because of migration including Applecross, Leeming and Booragoon are more sensitive to physical risks because of hazards due to higher proportion of community members from non-English speaking backgrounds and being less established or comfortable within a given area. As noted previously, community members who cannot speak or read English may find it difficult to seek out medical assistance or seek out resources such as free water stations and air-conditioned public buildings during a heatwave event. Those who have recently moved to a new area may not be as well established and therefore could be more likely to be impacted by long-term displaced during an emergency event (such as a large bushfire). Those who have recently relocated will also likely have limited local support networks in place to assist them during and after a disaster or may be unsure of how to access necessary resources.

Aboriginal and Torres Strait Islander Peoples

Suburbs with a higher proportion of people that are Aboriginal, or Torres Strait Islander including Willagee, Palmyra and Brentwood can be more sensitive to the physical risks from hazards for a variety of reasons. Intergenerational trauma arising from colonisation of Australia lead to a variety of adverse outcomes among the Aboriginal and Torres Strait Islander community. This ranges from increased prevalence of health complications and diseases, poor mental health outcomes, substance abuse, as well as poorer literacy skills. These vulnerabilities increase the likelihood that Aboriginal and Torres Strait Islander community will suffer

injury, illness, or death during a hazard event. For example, an Aboriginal or Torres Strait Islander community member with a pre-existing heart condition and alcohol dependency may be more likely to suffer cardiac arrest from heat stress during extreme heat days or respiratory distress during a bushfire smoke haze event.[146]

Transitional Risk Analysis

Population Density

Transitional risks can have a greater impact to suburbs with high population densities including Mount Pleasant, Willagee, and Alfred Cove due to a greater number of people required to "transition", requiring my resources and attention from the relevant party. For example, the transition to renewable energy in medium and high-density suburbs would require more infrastructure, labourers/contractors, knowledge dissemination and political buy in. However, this also presents an opportunity in the sense that once suburbs with high population density have transitioned, it will make the transition in other suburbs more simple and fast track progress towards targets such as net-zero.

School Aged Population

Transitional risks are imposed on the school aged population primarily by their caregivers and political predecessors. Suburbs with a high proportion of school aged children including Bull Creek, Leeming and Attadale are more sensitive to the impacts arising from generational inequity. This includes the depletion of resources such as water, arable land, metals etc. and the inability to combat climate change by the current generation including governments and major corporations. For example, the transition from petrol to electric cars may become increasingly challenging for future generations due to over-mining of precious metals and the associated costs for these vehicles is also likely to increase.

Elderly Population

Transitional risks are more likely to impact the elderly population due their inability to adapt to changing social, political, and economic climates. This may be due to a lack of knowledge or active resistance to transitions. Bull Creek, Kardinya, and Leeming are most likely to be affected due to the high proportion of elderly people. For example, as advances in technology continue the elderly may become increasingly disconnected from society due to inability utilise technology but also from resistance to learning new technology-based skills.

Disabilities

Transitional risks will have a greater effect on suburbs with a high proportion of people with disabilities including Bull Creek, Leeming, and Kardinya due to pre-existing disadvantages and reliance on external services to function in society. For example, the increased frequency of hazards over time may increase the pressure on social services delivering support to people with disabilities, while funding may simultaneously decrease due to government spending elsewhere. This may impact the social, emotional, and financial wellbeing of people with disabilities.

Adult Literacy

Suburbs with higher concentrations of poor adult literacy skills including Bull Creek, Kardinya and Leeming are more sensitive to impacts from transitional risks due to a reduced uptake of current social, political, and economic news and events, as well as reliance on external social services. For example, the prevalence of community-led initiatives to improve resilience arising from increased frequency of disasters may not be known among those with poor literacy due to limited internet access and poor reading skills. These community members may miss out on vital educational opportunities and valuable resources to help them prepare for more frequent disasters putting them at a further disadvantage.

[146] Howitt, R., Havnen, O. & Veland, S. 2011. Natural and unnatural disasters: responding with respect for indigenous rights and knowledges, *Geographical Research,* 50(1): 47–59.

Non-English-Speaking Backgrounds

Suburbs with higher concentrations of people from non-English speaking backgrounds including Bull Creek, Kardinya and Leeming are more sensitive to impacts from transitional risks due inability to interpret Englished based news and events, as well as existing economic disadvantage. For example, the transition to working online due to increase spread in diseases such as COVID-19 may decrease the need for workers in face-to-face occupations such as accommodation and food services, social assistance, retail trade and manufacturing. These jobs are typically already low paying and occupied by people of non-English speaking backgrounds. This puts these community members at even further economic disadvantage.

Migration

Suburbs with a higher number of people who have re-located because of migration including Applecross, Leeming and Booragoon are more sensitive to transitional risks due to being less established within a given community and possible language and/or cultural barriers that may exist. Migrants may struggle to enter the workforce in a community that has transitioned from one primary industry to another. For example, a community that has a large mining industry may have less job opportunities available as society transitions to renewable energy and mines close, potentially locking migrants out of work in these areas. However, this presents an opportunity to developed targeted initiatives to attract migrants to jobs where workers are desperately needed i.e., healthcare, and social assistance.

Aboriginal and Torres Strait Islander People

Suburbs with a higher proportion of people that are Aboriginal, or Torres Strait Islander including Willagee, Palmyra and Brentwood can be more sensitive to transitional risks due to intergenerational trauma causing people to be resistant to change. For example, Aboriginal and Torres Strait Islander people may be resistant to European based climate science and may actively avoid contributing to Australia's transition to a more climate conscious society. For this reason, governments may miss out in vital knowledge of the land and its' processes provided by Aboriginal and Torres Islander people which could help to combat climate change.

Recommendations

Physical Risks

- As suburbs with higher population density (Mount Pleasant, Willagee, and Alfred Cove) require greater resources, the City should implement initiatives to ensure that existing services are adequately resourced, and new services be established where necessary. This includes auditing of emergency service centres, hospitals, and medical centres to ensure they are adequately staffed and have the appropriate equipment to manage in the case of a hazard related emergency. Smaller community health centres should be established where required to reduce reliance on major hospitals and emergency departments.
- Educational programs should be deployed among suburbs with a high proportion of school aged children (Bull Creek, Leeming, and Attadale) and elderly people (Bull Creek, Kardinya and Leeming) to increase awareness amongst children and the elderly of the physicals impacts that can arise from various hazards. This may be done through schools, aged care homes and among community groups. This will ensure they can help themselves to the extent possible should a hazard occur.
- In suburbs with a high proportion of people with disabilities (Bull Creek, Leeming, and Kardinya), training should be delivered to employees of disability/social services to ensure they can understand behavioural warning signs indicating someone may be unwell during heatwaves or bushfire smoke haze events and be able to provide adequate support during hazard events.
- In suburbs with a high proportion of people with disabilities (Bull Creek, Leeming, and Kardinya), hazard awareness resources should be deployed through community centres, public buildings and social services that cater to a range of abilities e.g., resourcing utilising braille or audio for vision impaired people, resources using simplistic language and graphics for those with cognitive impairments

- In suburbs with poorer adult literacy skills (Bull Creek, Kardinya and Leeming), deploy a community consultation officer or similar representative to host hazard awareness information sessions in a public building or space to cater to those with poor literacy skills to ensure they are educated via word of mouth.
- In suburbs with a high proportion of residents from a non-English speaking background (Bull Creek, Kardinya and Leeming), ensure that hazard awareness resources and community wayfinding are provided in other languages to ensure people of non-English speaking backgrounds can support themselves during a hazard and access vital necessities.
- In suburbs with a high proportion of Aboriginal and Torres Strait Islander people's (Willagee, Palmyra, and Brentwood), conduct targeted consultation to develop culturally sensitive programs and services that they feel are most needed to further protect them from hazards i.e., self-determination.

Transitional Risks

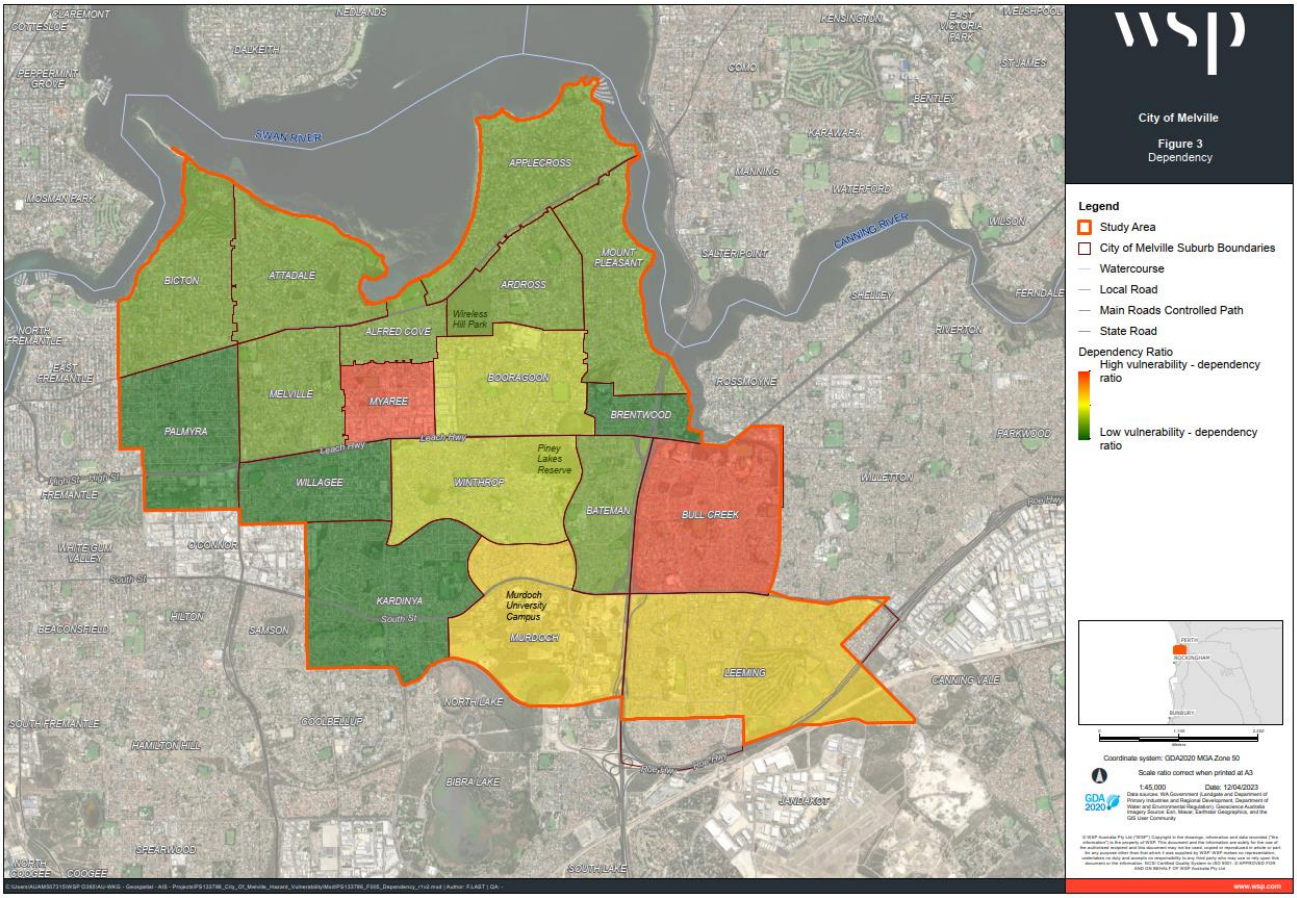
- In suburbs with a high proportion of school aged children (Bull Creek, Leeming, and Attadale), deploy educational programs to teach children how to live more sustainably e.g., growing their own food, minimising water consumption, re-using grey water, minimising energy consumption to reduce resource depletion and help combat climate change.
- In suburbs with high migration (Applecross, Leeming, and Booragoon), develop employment schemes to help people acquire work quickly, easily and in industries that will have a high demand for employees into the future.
- In suburbs with a high proportion of people from non-English speaking backgrounds (Bull Creek, Kardinya, and Leeming), develop permanent income protection schemes for industries that are highly casualised and/or require face-to-face services to ensure people have on-going income during a hazard event.
- In suburbs with a high proportion of adults with poor literacy and elderly people (Bull Creek, Kardinya and Leeming for both), ensure that public Wi-Fi is readily available and communal computers are available in public buildings to ensure these members of the community still have access to hazard awareness resources. Technology skills improvement programs should also be deployed through retirement villages to ensure that elderly can utilise technology to their benefit.
- Council could look into implementing EV charging infrastructure in publicly available areas (such as council sites). It is also suggested a feasibility study be undertaken to understand the demand and supply requirements.

9.2 Dependency Ratio

A dependency rate can be calculated as the number of non-working-age persons in a community dependent on working-age persons and can be expressed as a 'dependency ratio'—the number of persons aged less than 15 years and 65 years and over divided by the number of persons aged 15 to 64 years.[147] Using this equation **Figure 9-2** has been developed using the data provided in **Appendix E**. The weighted assessment shows that Bull Creek and Myaree are the most susceptible to dependency variances.

[147] Australian Institute of Health and Welfare. n.d. Dependency Ratio. Accessed 8 Feb 2023. <https://www.aihw.gov.au/getmedia/2d571fa2-afbb-47ae-9651-0b7370da52b7/11874-2-11.pdf.aspx>

Figure 9-2. Dependency Ratio Map



Source: WSP (2023) – *Large version available in* ***Appendix D***

In general, the younger and older populations are at high risk during an evacuation event. This can be due to a number of factors, such as the difficulty of getting dependent people out of harm's way because of limited mobility, dependence on care, and reliance on medication and other services. Additionally, the young and the elderly populations can increase the burden on families following a damaging flooding event (e.g., requiring additional care/support while the family is trying to recover from the event). The City should address mobility and the accessibility to transport links for dependent populations in their future planning to ensure vulnerability is reduced.

Increased rates of isolation among the elderly and place attachment can also mean they are more susceptible to physical risks during a disaster. A lack of connectedness and strong attachments to one's home may mean that the elderly does not have the confidence or willingness to call for assistance during a disaster. This can lead to them becoming stranded or cut-off during a bushfire event for example, putting them at much higher risk of injury, illness and death. On the other hand, young people and children are more susceptible to the physical risks from hazards due to deficient decision-making skills, perception of risks and physical strength. For example, a child may suffer heatstroke during a heatwave event due to over exertion and lack of hydration. This is likely due to limited cognitive development, resulting in a poor understanding of the health risks associated with extreme heat days and perception of their own physical abilities. The City should address such risks through implementation of awareness and educational programs among the elderly and young people, particularly school aged children to ensure they can care for themselves to the extent possible during a hazard event. For the elderly, community-based hazard awareness programs would also encourage connectedness and provide confidence and asking for assistance when required.

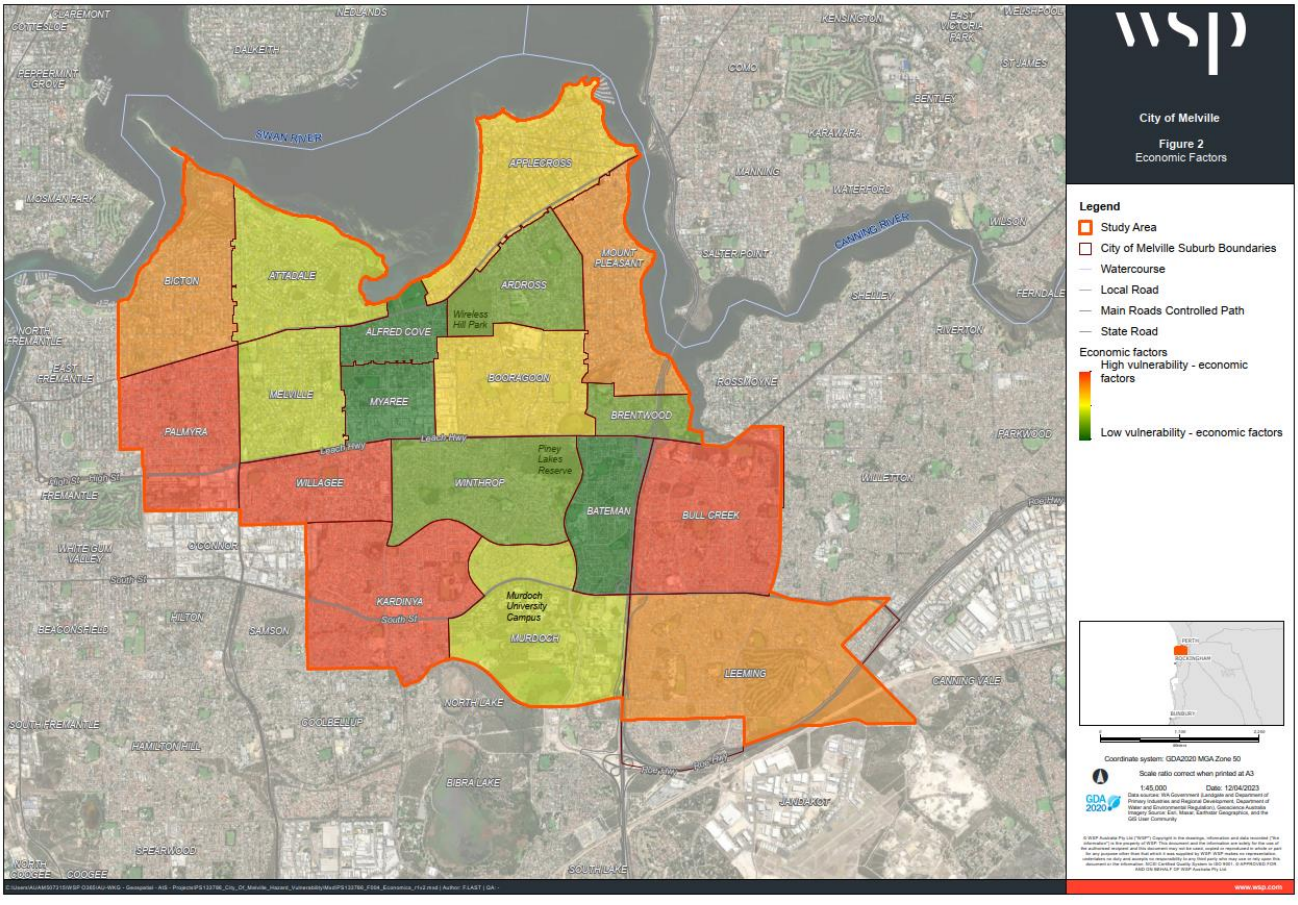
The Dependency Ratio will also exacerbate transitional risks due to the rampancy of generational inequity. The elderly is typically more resistant to social, political, economic ,and technological change. For example,

Bull Creek and Myaree may have a slower uptake of renewable energy by the elderly population during the energy transition. However, as the energy transition progresses, and young people become homeowners, this can cause perverse outcomes for them including high energy prices, less reliable energy and higher than necessary greenhouse gas emissions contributing to worsening climate change.

9.3 Economic Factors

This Economic Factors map (**Figure 9-3**) was developed by WSP using data from the ABS for unemployed (not in the labour force or unemployed), in rental accommodation, in social housing (either State or community housing provider), in a retirement village (self-contained), as well as where the household income was less than $1000 per week (See **Appendix E** for the data). Each of these indicators were first ranked across the Suburbs and then standardised and ranked across all the combined economic indicators. The resultant ranking across the indicators was utilised to develop the Economic Factors Map. The weighted assessment of the economic impacts across the suburbs in the City determined that Bull Creek, Palmyra, Willagee, and Kardinya are the most susceptible to economic variances.

Figure 9-3. Economic Factors Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Physical Risk Analysis

Overall, the City is an economically well off and affluent Local Government Area. As such, it is well placed with respect to economic buffers when faced with climatic hazards. However, with future climate projected to become harsher and more extreme, individuals, governments, and organisations are susceptible to the compounding effects of climate events. It is also important to consider the implications of climate hazards not only occurring within the City but also nationally and globally, as these may have significant influence on the economy of the City and its residents.

The City has relatively low rates of unemployment (under 2.5%) when compared to Western Australia which has an unemployment rate of 3.1%[148]. In the City, Leeming, Kardinya, and Bull Creek are the three suburbs identified as having the highest proportion of unemployment. During climatic hazards, such as extreme weather conditions, those that are unemployed are typically at heightened risk. Often when unemployed, individuals have reduced adaptability and increased vulnerability to these conditions as a result of their impaired financial status. For example, they may be unable to afford insurance due to increased premiums in the case of flooding events, or they may be unable to afford damage repairs post flood event. Accessibility is also a key issue for this demographic, as they are often reliant on public services including public transport, community centres, and libraries. During extreme weather events, such as bushfires or flooding, they may be unable to leave their home to access these services. Individuals who are unemployed may already be vulnerable with regard to mental and/or physical health. They may as a result have reduced mental and/or physical capacity to deal with various shocks and stressors arising from climate events. Many workplaces provide advise prior to or during extreme weather as well as additional support, thus enabling individuals to prepare and protect themselves sufficiently and appropriately. For example, workplaces also inherently provide a place of solace during periods of extreme temperatures as cooling systems are typically being run. Those that are unemployed and at home, may not have access to air conditioners increasing their vulnerability. Thus, additional support should be provided to the unemployed during these climatic hazardous events.

Like unemployment, there are also low levels of households renting across the City, indicating that the majority of residents own the property in which they reside. Applecross, Palmyra, Mount Pleasant, and Kardinya are the suburbs with the highest number of renting households within the City. Those in rental properties are also often more vulnerable to the impacts of extreme weather events. Rentals may be of lower quality and older which may make them more susceptible to certain hazards. Individuals often have limited capacity to modify the residence (beyond their contract) to increase resilience and reduce their vulnerability against climatic hazards. If a rental property gets damaged by flooding or fire, the residents are often displaced from their home creating housing insecurity. Similar to the effects felt by renters, those living in social housing and retirement villages also have limited capacity to adapt the place in which they reside to better protect themselves against extreme weather events. Willagee, Palmyra, and Brentwood have the highest number of social housing and the suburbs of Bull creek, Murdoch, and Booragoon have the highest number of persons living in Retirement villages. In particular, those that reside in retirement villages are often financially constrained with a fixed income and have limited opportunity and capacity to increase their incomes. This limits their ability to increase their resilience and better adapt to the changing conditions. However, in the case of social housing and retirement villages, the responsibility and duty of care lies with those managing the property. Often the older population are more susceptible and vulnerable to the effects of the various shocks and stressors resulting from climate hazards. They can often become more dependent on others to perform daily tasks, including transportation to medical and health services which they may be unable to access during certain extreme weather events such as extreme rainfall and flooding.

The number of households considered as having a low income is also relatively low in the City. Though the numbers are low, the suburbs of Palmyra, Kardinya, and Bull Creek have the highest number of low-income households. Low income has a systemic effect on an individual or households' vulnerability both by increasing their sensitivity to and reducing adaptive capacity from climatic hazards. As with those that are unemployed and the older population on fixed pensions, low-income earners have limited buffering capacity to absorb income loss, subsequently limiting their resilience both during and after hazardous events. For example, during extreme heat waves, households may have to reduce the use of air-conditioners in order to be able to afford food or rent.

[148] McGowan, M. 2022. Western Australia's Unemployment Rate the Lowest of the States. Government of Western Australia. Accessed 7 Mar 2023. <https://www.mediastatements.wa.gov.au/Pages/McGowan/2022/09/Western-Australias-unemployment-rate-the-lowest-of-the-States.aspx>.

Transitional Risk Analysis

With a National Policy in place to decarbonise the grid by 2050, an increased responsibility is placed on all levels of government. To achieve this target, all industries and businesses will be required to upgrade infrastructure, processes, and technologies. This would ultimately come at a cost which is mostly fed down to the consumers and taxpayers. Those that are low-income earners or the older population on a fixed pension would feel the effects of increased costs and will have limited financial buffering capacity to accommodate the increases. Likewise, if policy is brought in place to mandate the implementation of, for example solar energy generation on each household, then those that are low-income earners would again be impacted unless financial aid or incentives are provided. While these pose as a Policy Risk, they also subsequently generate a Market Risk, as increasing costs naturally impacts consumer behaviour within the broader economy. This would not only put those that are low-income earners in a more vulnerable position but also those that are unemployed, renting, living in social housing and in retirement villages. It is important to note that global markets would also be impacted by the shift towards decarbonised economies. This again impacts the global financial market and subsequently the cost of certain goods and services in Australia will also increase.

Recommendations

Physical Risks

- Implementation of support networks in relation to unemployment. These could be in the form of community groups, or online platforms. Leeming, Kardinya, and Bull Creek all have higher numbers of disabilities, lower levels of adult literacy, and a higher proportion of those who speak languages other than English. Additional services (including translators and educators) could be focused within these suburbs to aid those that are unemployed in finding and retaining jobs. It would also be essential to include information in other languages given the higher proportion of those that speak languages other than English.
- It would be imperative to understand the modes of transport used by those that are unemployed, are from a low-income household, residing in social housing and retirement villages. Often in climatic hazards access and connectivity can be an issue.
- Improve redundancy in transport infrastructure – alternate routes in and out of a suburb.
- The feasibility and accessibility to short term crisis housing should be investigated. In the event that renters are displaced from their homes as a result of climate hazards, a plan must be in place to assist in their relocation.
- Grants or Schemes could be investigated that encourage landlords to adapt and increase the resiliency of their property against climate hazards.
- Grants could be provided to renting households to assist in post disaster recovery.
- Climate risk assessments would be conducted on social housing. This could include working with agencies owning and managing social housing to improve resiliency of the dwellings subsequently reducing the resident's vulnerability to climate hazards.
- Investigate the retrofit of social housing to be more resilient e.g., installing solar panels and batteries.
- Climate risk assessments would be conducted on retirement villages. This could include working with agencies owning and managing retirement villages to improve resiliency of the dwellings subsequently reducing the resident's vulnerability to climate hazards.
- Conduct forums with the community to understand their views, including hesitations, to the transition of the grid and how the Council can aid in developing a more resilient system
- Grants could be provided to low-income households to recover from climate hazards. The assessments should also be done to determine how to embed resiliency into low-income households to better equip them for future extreme climate events.

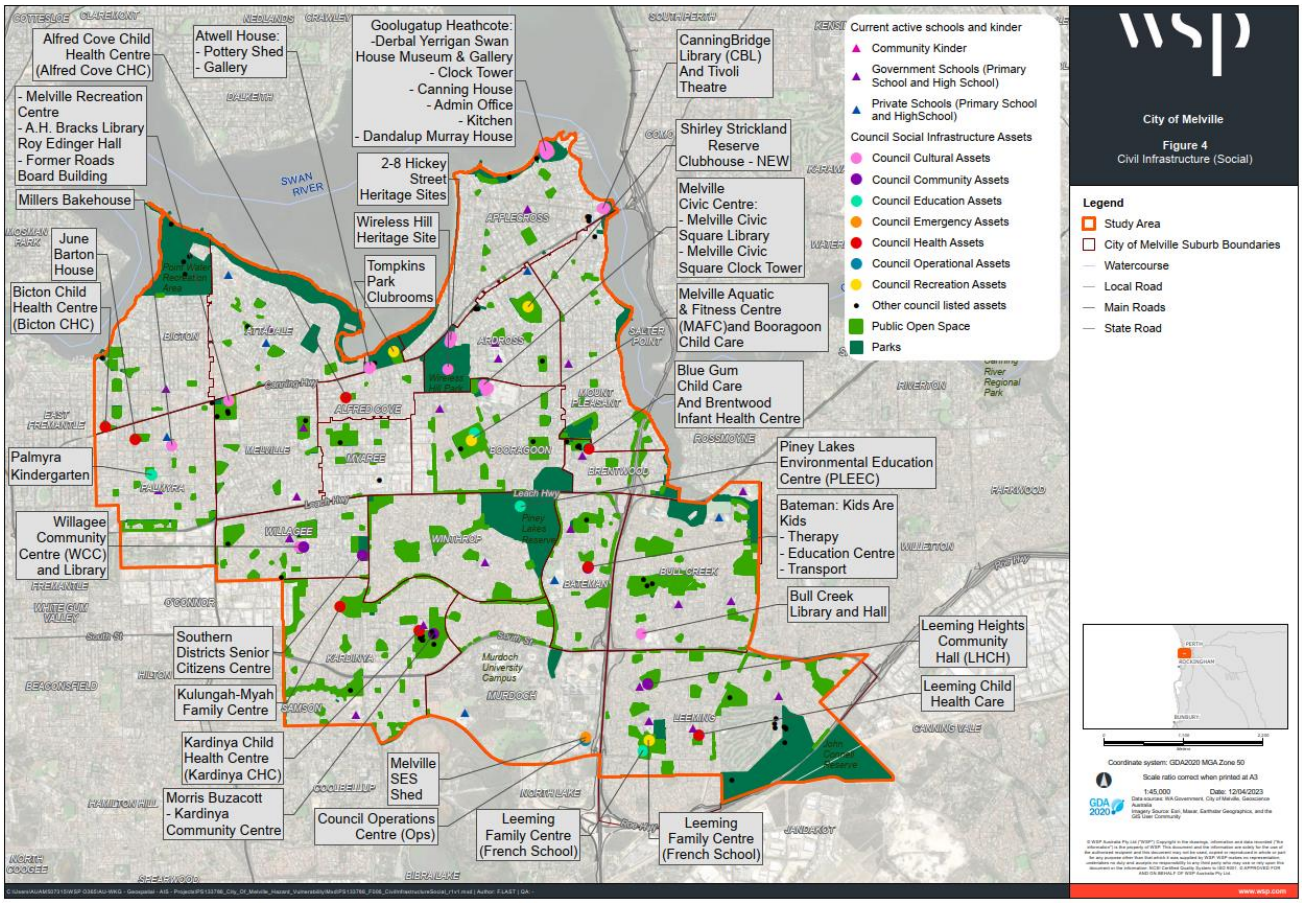
9.4 Social Infrastructure

Social infrastructure refers to infrastructure, facilities and natural areas supporting community life and underpinning non-critical infrastructure related aspects of the City's operations. The social infrastructure map, shown in **Figure 9-4**, identifies the types and the locations of social infrastructure across the City.

Data used to generate **Figure 9-4** include the City-provided spatial mapping of its built assets, zoning areas (public open spaces, recreation areas) and park locations. This dataset was augmented by feedback provided by the City Project Team which allowed the Council assets to be classified as cultural, community, education emergency, health, operation or recreational. The dataset provided by Council detailed every individual structure. To improve the readability of the map, ancillary assets such as pumps, toilets and sheds were not mapped. The remaining assets were classified as either primary or secondary assets by the City Project Team. Primary assets are those with intrinsic or financial value or whose loss would be particularly impactful on either the Community or the City's provision of services. These have been denoted by a coloured spot with the asset names detailed in call-out boxes. Secondary assets are represented by a smaller black dot, and frequently correspond with parks and public open spaces (with ancillary assets not included) which are mapped in various shades of green. The locations (street addresses) of specific social infrastructure such as community centres, administrative buildings as well as hospitals were added as points in the map. Finally, current active schools were sourced from the Data Western Australia website.[149] **Figure 9-4** was generated by WSP by combining these various sources of information and selecting relevant data for this theme.

[149] Borbely, S. & DataWA. 2021. Current Active Schools Semester 1 2021 – Public (DET-019). Department of Education. Accessed 7 Mar 2023. <https://catalogue.data.wa.gov.au/dataset/current-active-schools-semester-1-2021-public-det-019>.

Figure 9-4. Social Infrastructure Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Physical Risk Analysis

Social infrastructure comprises an array of facilities and areas including government buildings, nominated evacuation centres, parks, educational institutions, recreational assets, healthcare facilities as well as public open spaces and parks.

Physical climate change risks are analysed for key categories of social infrastructure.

Parks and Public Open Spaces

The City contains numerous public open spaces and parks which are well distributed throughout its territory. Recreation areas are also widely distributed throughout the City. These parks and areas of natural vegetation provide City communities with access to outdoor areas, natural environments and play an important role in community health and wellbeing[150]. Beyond areas to practice group activities and sport, these areas provide a range of important services to the community including stress reduction, improvements to psychological wellbeing, immunity and productivity and generally contribute to a better quality of life. The use of public spaces and recreation areas has likely increased across the City as a result of COVID-19. Increased use of these areas, buildings and assets may incur new pressures.

These areas are exposed to climate-related physical risks such as bushfires, storms, flooding associated with storm surges or riverine flooding. These events may result in the damage or destruction of these areas and assets (both built and natural). These areas' sensitivity to the effects of climate change are related to the types of vegetation and the nature of the landscaping. Natural environments may be more resilient to shocks and

[150] Maller, C., Townsend, M., Leger, L., Henderson-Wilson, C. Pryor, A., Prosser, L., Moore, M. 2008. Healthy parks, healthy people The health benefits of contact with nature in a park context. Deakin University School of Health and Social Development Faculty of Health, Medicine, Nursing and Behavioural Sciences. Accessed 7 Mar 2032. <https://www.deakin.edu.au/__data/assets/pdf_file/0016/310750/HPHP-2nd-Edition.pdf>.

stressors whilst highly modified environments (such as sports fields and other heavily maintained areas) which may require more management and maintenance. Alternatively, though requiring investment, these modified areas are more easily maintained and upgraded to account for climatic changes. Areas of native vegetation, such as Piney Lakes Reserve, Wireless Hill Park and Brentwood Park, may be affected by changing climatic conditions, altering the conditions under which existing ecosystems thrived, resulting in consequences which are less easily managed through routine maintenance.

Along the coastline with the Swan River, much of the coastal area is parkland with at least some kind of vegetative or built area (beach, natural vegetation buffer, bike paths, parkland) buffer between the waterline and the road network and buildings which can act as a buffer for slight sea-level rise-induced elevations in the river. As shown in (**Figure 7-3.** Flooding and Inundation Hazard for the City), coastal flooding does not penetrate far beyond the existing coastline and remains contained in the coastal park areas. This being said, the majority of the built environment near the coastline is densely developed and offers little flexibility in development to account for significant sea-level rise-induced elevations in water levels.

For the City, the spatial distribution and high number of public open spaces, parks and facilities across the local government area provide service redundancy in the event of areas needing maintenance or repair in the event of climate-related impacts such as bushfire, flooding or changes in climatic conditions.

It is noted that for Melville, the definition of greenspace is: Public Open Space (POS) is an all-encompassing open area to which the public have free access. Within POS there are 3 areas: 1. Natural Areas (formerly called bushlands); 2. Parks and Reserves (interchangeable language); and 3. Streetscapes. Within Parks and Reserves there are 2 areas: Sporting, and Recreational. **The City operational assets**

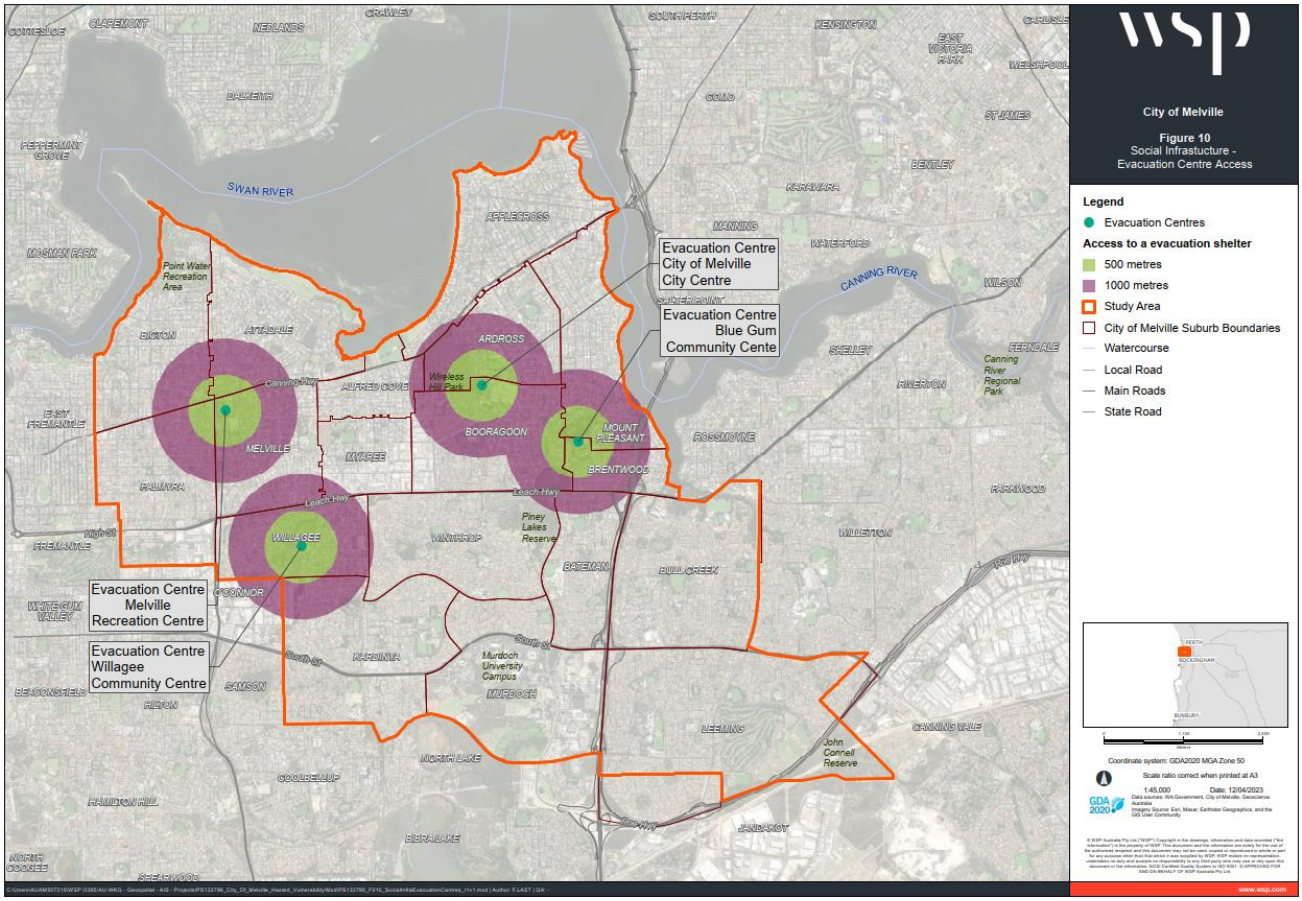
The City offices are located in Boorangoon, southeast of Wireless Hill Park. This is considered a bushfire prone area and the City office buildings are surrounded by some natural vegetation. The site is well connected to road networks in multiple directions, allowing for numerous access points in the case of emergency. The City offices are not located in a flood-prone area.

The Melville SES operational buildings are located in Murdoch in the southern portion of the City area. The City of Melville Operations Centre is used as a base for City staff and assets as well as the Melville SES. Therefore, a critical piece of infrastructure. As shown in (**Figure 7-8.** Bushfire Risk Area for the City), this site is located within an area which is susceptible to bushfires and contains multiple areas of natural bushland. The buildings are surrounded by a large parking area, which separates the building from the surrounding bushland. This limits the sensitivity of the site in the event of a bushfire by reducing the direct exposure of the building to flames. In terms of access, Bramanti road connects the site to the rest of City. This road is lined with bushfire prone vegetation in some locations. Bramanti road connects to Murdoch drive which connects with the rest of the City territory. This is a wide four-lane road which is not located in flood-prone areas.

Evacuation Centres

Evacuation centres play an important role in disaster and emergency responses but also provide a safe space for community members seeking heating, cooling, water or other services due to climate related impacts. As identified in **Figure 9-5**, four evacuation locations have been identified in the City. These are located in Brentwood, Willagee, Melville and Ardross. These evacuation locations are schools and libraries which have been nominated as evacuation points.

Figure 9-5. Evacuation Centre Access Map



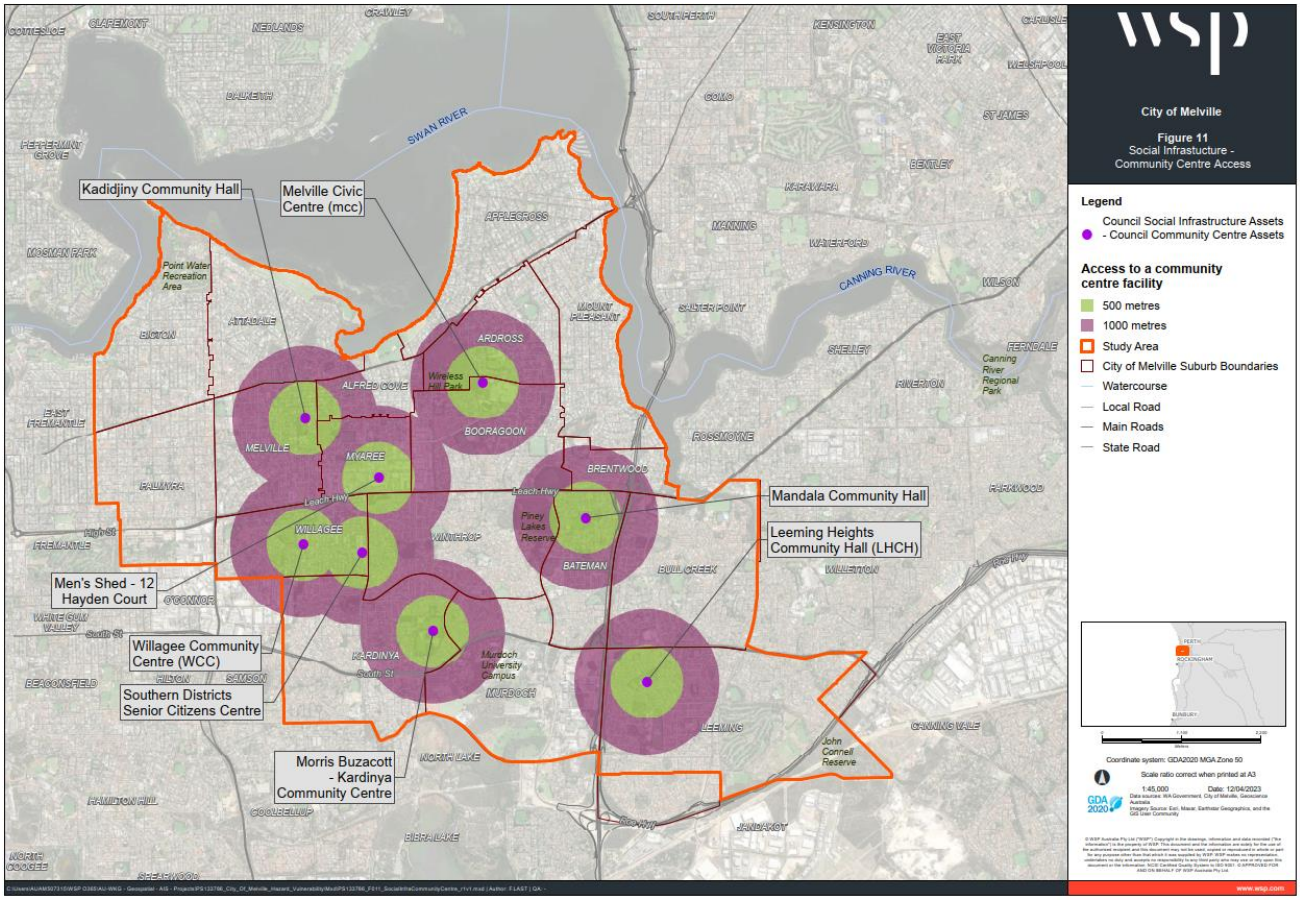
Source: WSP (2023) - *Large version available in* ***Appendix D***

In terms of exposure of these evacuation centres to physical climate change risks, the Brentwood evacuation centre is located in an area of waterlogging risk (**Figure 7-3.** Flooding and Inundation Hazard for the City) but all others are not located in flood-prone areas. The Brentwood and the Ardross locations are in areas susceptible to bushfire (**Figure 7-8.** Bushfire Risk Area for the City). The City has access to a number of evacuation centres which provide contingencies in the event one or two centres are not accessible.

In terms of the spatial distribution of evacuation centres, the southeast portion of the City area is devoid of nominated evacuation centres while this same area includes an important portion of the bushfire prone area as well as area with waterlogging risks. The lack of evacuation centres and the presence of bushfire prone areas and waterlogging risk areas is particularly notable in the Bull Creek and Leeming. The ability to adapt nominated evacuation centres is high, as the City area contains a number of facilities which could be used as effective evacuation centres (involving some planning and upgrading) but may require collaboration with non-City organisations.

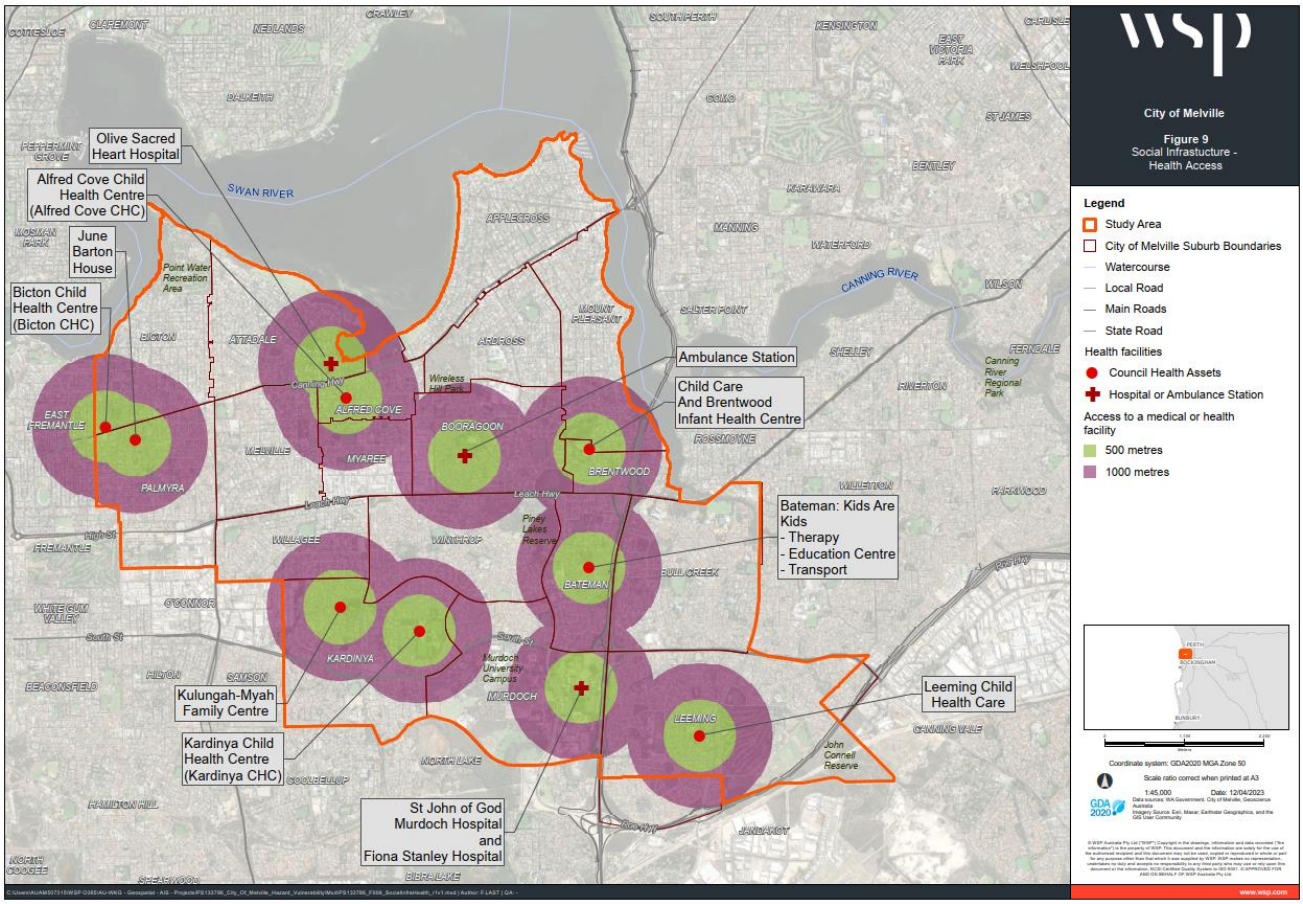
Furthermore, changes in the type of use of may occur generating a variety of challenges and opportunities for the City. For example, there may be an increased need for emergency evacuation locations, requiring schools or other City assets to develop appropriate planning and upgrades. As average temperatures increase, community members, especially in suburbs with a higher proportion of low-income earners, may seek out air-conditioned environments such as schools, malls, libraries, and other interior environments.

Figure 9-6. Community Centre Access Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Figure 9-7. Health Access Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Transitional Risk Analysis

As the transition to lower carbon economies and a more widespread consideration of the impact of climate change take place, social infrastructure will be confronted with a variety of transitional risks.

Changes in State or local government regulation in relation to water usage may alter the capacity for park and public space irrigation requiring the use of more drought-resistant species and, potentially, less vegetated public spaces. As discussed above, natural environments provide important benefits to communities, especially in highly urbanised environments. This could also involve changes in landscaping practices such as the use of pesticides and other chemicals used in maintenance activities. Changes to accepted maintenance practices may incur risks for the City through having to adapt technologies and assets to reach updated performance levels.

Regulation changes and community expectations may also drive the requirement for more energy and resource efficient buildings and community infrastructure. Though the City already possesses solar panels on some buildings, there could be a more widespread push for more widespread adoption of these systems as well as new for the adoption of new, innovative, technologies.

Changes in regulation as well as evolving community expectations could also include the need for social infrastructure and community emergency plans to fully account for climate risks such as bushfires, flooding, and storms. This could mean the need for a more holistic understanding of how climate change will impact specific areas, assets and buildings, especially those which are used by the community in the response to an emergency event.

Finally, the diverse and numerous impacts on existing City services generated through a transition to lower carbon economies and a more widespread consideration of the impact of climate change combined with the

need to adopt new strategies and practices may increase City financial expenditure. This could potentially result in some areas of City services being underfunded as well as the need for increased municipal taxes.

Recommendations

Physical Risk

- As they play an important role in community wellbeing, the protection and effective maintenance of the City natural environments, parks and public areas adapted to project changes in climate will be pertinent to ensure they continue providing the community the services they need. This is particularly applicable to Mount Pleasant and Willagee who have higher population densities.
- Ensure that emergency evacuation centres are appropriately distributed throughout the City territory and cater to all members of the community (non-native English speakers as well as Indigenous community members). This is particularly applicable to the suburbs of Bull Creek and Leeming as they are not near a nominated evacuation centre. Consideration of language is particularly applicable for Bull Creek and Kardinya.
- Undertake a climate change risk assessment for each nominated emergency evacuation centre and critical social infrastructure to identify key vulnerabilities and develop effective contingency plans.
- If not already undertaken, conduct an assessment of native ecosystem and vegetation health and understand how projected changes in climate may impact these environments. As applicable, manage these areas in order to bolster their resilience to projected changes in climate.

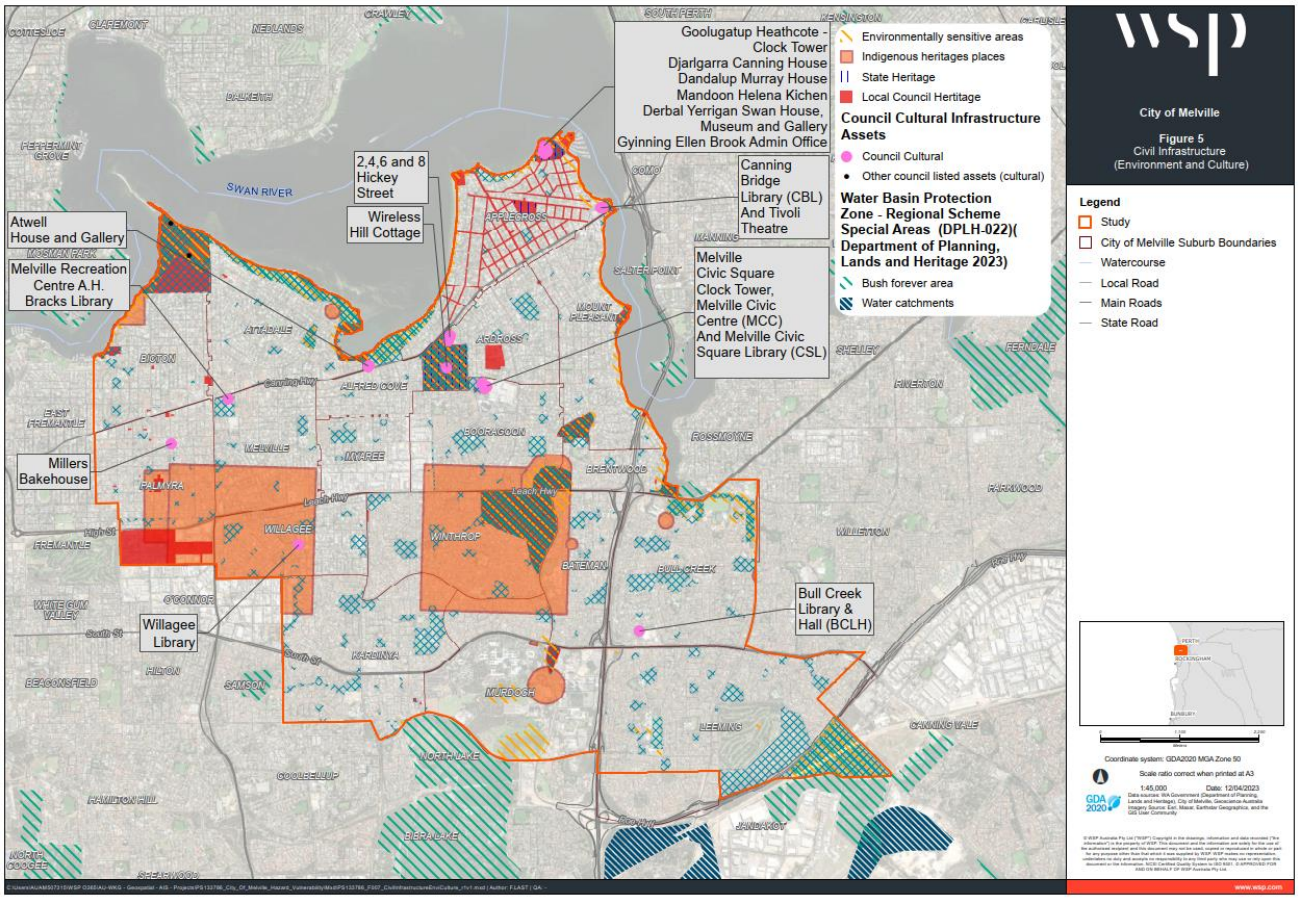
Transitional Risk

- Conduct studies to understand community sentiment regarding the transition to a lower carbon economy and the increased consideration of climate change and their perception of good local government management in this context. Proactively engaging with community members may help understand evolving expectations and increased preparedness.

9.5 Environment and Culture Infrastructure

The environment and culture infrastructure map (**Figure 9-8**) depicts environmental and cultural infrastructure within the City. These assets include places which are registered sites under the *Aboriginal Heritage Act 1972* or sites where applications have been lodged for assessment under this Act. Cultural assets listed on the State or City of Melville heritage register have been mapped, along with assets classified as ‘cultural’ by the City Project Team, such as libraries, galleries, and civic centres. Bush Forever Areas have also been included, with these areas being part of a State government initiative to preserve 10% of each vegetation complex on the Swan Coastal Plain within the Perth Metropolitan Area. This infrastructure may be at risk from one or more climate changes, require adaptive measures to maintain the environmental and cultural aspects or services and also are assets which create opportunities for improved resilience. The data used to develop this map was sourced from City of Melville Council and the Department of Planning, Lands and Heritage.

Figure 9-8. Environment and Culture Infrastructure Map



Source: WSP (2023) - *Large version available in* ***Appendix D***

Physical Risk Analysis

First Nations Heritage

Within the City's boundaries, there are a number of registered sites of Aboriginal cultural heritage. Where these sites coincide with the foreshore areas, there is a risk the cultural value will be affected by rising sea levels and inundation. For cultural sites which coincide with bushfire or flood-prone land, the presence of these hazards may be considered an intrinsic feature of these locations, with fire and/or flood contributing to how First Nations people interacted with the locations. The removal of these hazards, through hazard reduction burns or flood mitigation, may trigger a loss of cultural value. Conversely, adopting First Nations fire management techniques or indigenous flooding knowledge may be an opportunity to enhance First Nations cultural heritage within the City.

Environmental Assets

The City features numerous areas classified as environmentally sensitive, regional parks or bush-forever areas. These areas have an intrinsic value for their contribution to maintaining biodiversity and threatened species in this metropolitan area. At the same time, these areas provide visual amenity, spaces for passive recreation or shaded locations conducive to people movement. These spaces are at risk from multiple physical risks.

The City does not contain large continuous and extensive tracts of bushland connected with hinterland vegetation, meaning the risk of a bushfire spreading into the area is low. However, the multitude of regional parks and scattered patches of vegetation increases the vulnerability to bushfires from accidental ignition, discarded cigarettes, or arson. The presence of residential housing, Council assets or other structures in close

proximity to the City's natural assets can limit the carrying out of hazard reduction burns, leading to higher fuel loads.

Heatwaves increased average temperatures and lower rainfall are three climate-hazards which can act separately or in combination to decrease the health of existing vegetation. Heatwaves may result in tree, vegetation, or native animal mortality, altered reproductive patterns, or reduced recruitment of flora and fauna to an age where reproduction can occur. As temperature and rainfall patterns move further away from historical values, it is likely that the climate envelop will no longer be suited to certain species. With the vegetation occurring in isolated patches with a lack of land connectivity, there is a reduced ability for these natural areas to receive seeds or other reproductive material from species more suited to the changing climate. The cultural, recreational, and social utility of trees, shrubs, and groundcovers are also at risk from heatwaves, increase average temperatures, and reduced rainfall. For example, certain street trees may die during a heatwave, with replacement trees taking a decade or longer to reach maturity. Vegetation, particularly ornamental trees, and grass are likely to require increased levels of supplementary watering through ad-hoc or scheduled irrigation. However, this will pose a financial and infrastructure cost to residents and the Council. Further, water restrictions may prevent water applications to vegetation, leaving residents and the Council with limited options to maintain the current extent, quality and diversity of natural assets.

As sea-levels rise, the water depth and tidal zone will change. Prior to European settlements, marine, inter-tidal, and nearshore species would have slowly adapted their distribution in response to changing sea-levels, moving to higher or lower elevations as sea-levels rose or fell. With human settlement, roads, and other infrastructure abutting the Swan River fringe, these marine, inter-tidal and nearshore habitats are constrained, limiting their landward with rising water levels. The effects of rising sea levels will have elevated consequences for the heritage listed Alfred Cove Reserve and Swan Estuary Marine Park due to the natural elements being integral to their heritage listing.[151] Warming temperatures and a concomitant rise in water temperatures will also have deleterious impacts on certain species, such as sea grasses, whilst favouring other species, particularly introduced species.

Built Cultural Heritage

The suburb of Applecross contains a network of streetscapes featuring jacarandas and plane trees which are listed on the Council's cultural heritage list. It is considered likely that heatwaves, warming average temperatures and reduced rainfall has the potential to affect the growth, form, and flowering of these iconic trees. This risk extends to other heritage listed trees or vegetation located elsewhere in the council area. The City contains an extensive suite of heritage buildings. Depending on the layout, materials, and orientation of each individual building, the thermal comfort during heatwave or warm conditions will vary. In the absence of space cooling or mechanical ventilation, the occupants of these buildings are more likely to be susceptible to reduced thermal comfort and health impacts during extreme heat events. The ability of these buildings to remain in active use, particularly as public or cultural spaces may necessitate the installation of air-conditioning. However, this is likely to represent a compromise in retaining the heritage appearance, and the practicalities of installation. Similarly, these buildings may not be able to capitalise on building upgrades such as double-glazed windows or insulation which improve thermal efficiency.

Many of the City's cultural heritage items, such as the Swan River Rowing Clubhouse, Rookwood Street jetty and South of Perth Yacht Club are located adjacent to or within the Swan River. As sea-levels rise, these structures may be directly impacted by elevated sea levels preventing their use on an occasional or permanent basis. The intrusion of salt water, particularly during spring tides, may compromise the sub-structures or foundations, or the open space areas which separate the facilities from the water line.

Transitional Risk Analysis

First Nations Heritage poses a reputational risk to the Council where there is a real or perceived risk that adaptation measures, or actions such as hazard reduction burns will cause damage to First Nations cultural

[151] City of Melville. 2019. 2019 Local Heritage Survey and Heritage List. Accessed 7 Mar 2023. <https://www.melvillecity.com.au/our-city/publications-and-forms/building-and-development/city-of-melville-local-government-inventory-2014>.

heritage. Conversely, where adaptation or mitigation measures are proposed, such as enhancing natural assets, this may provide opportunities to improve the condition, appreciation or understanding of cultural sites. Utilising indigenous fire management techniques to manage bushfire risks represents an opportunity to improve bushfire management and empower indigenous residents and communities. There is also an opportunity for the council to incorporate indigenous knowledge into their land and natural asset management practices to improve the capacity of these assets to cope with a changing climate.

Insurance

Council has considerable roads, parks, and other assets located along the Swan River fringe. Their proximity to the river and susceptibility to rising sea levels may result in rising insurance premiums, insurance which is unaffordable, or a complete inability to obtain.

Council's public liability and workers compensation insurance is also an area where Council may experience rising premiums due to increased risks of heat-related claims. This may be in the context of Council's staff who work on roads, recreational facilities or other outdoor projects, from sporting bodies who use Council facilities, particularly those which operate in the summer months, or facilities which host children and the elderly.

Renewable Energy

As residents continue to embrace roof-top solar, there may be occasions where conflicts arise from installations being prevented due to heritage requirements. Conflict may also occur where trees planted in reserves, backyards or on verges shade rooftop solar panels. This may lead to some residents prioritising solar power and seeking to have trees trimmed or removed.

Recommendations

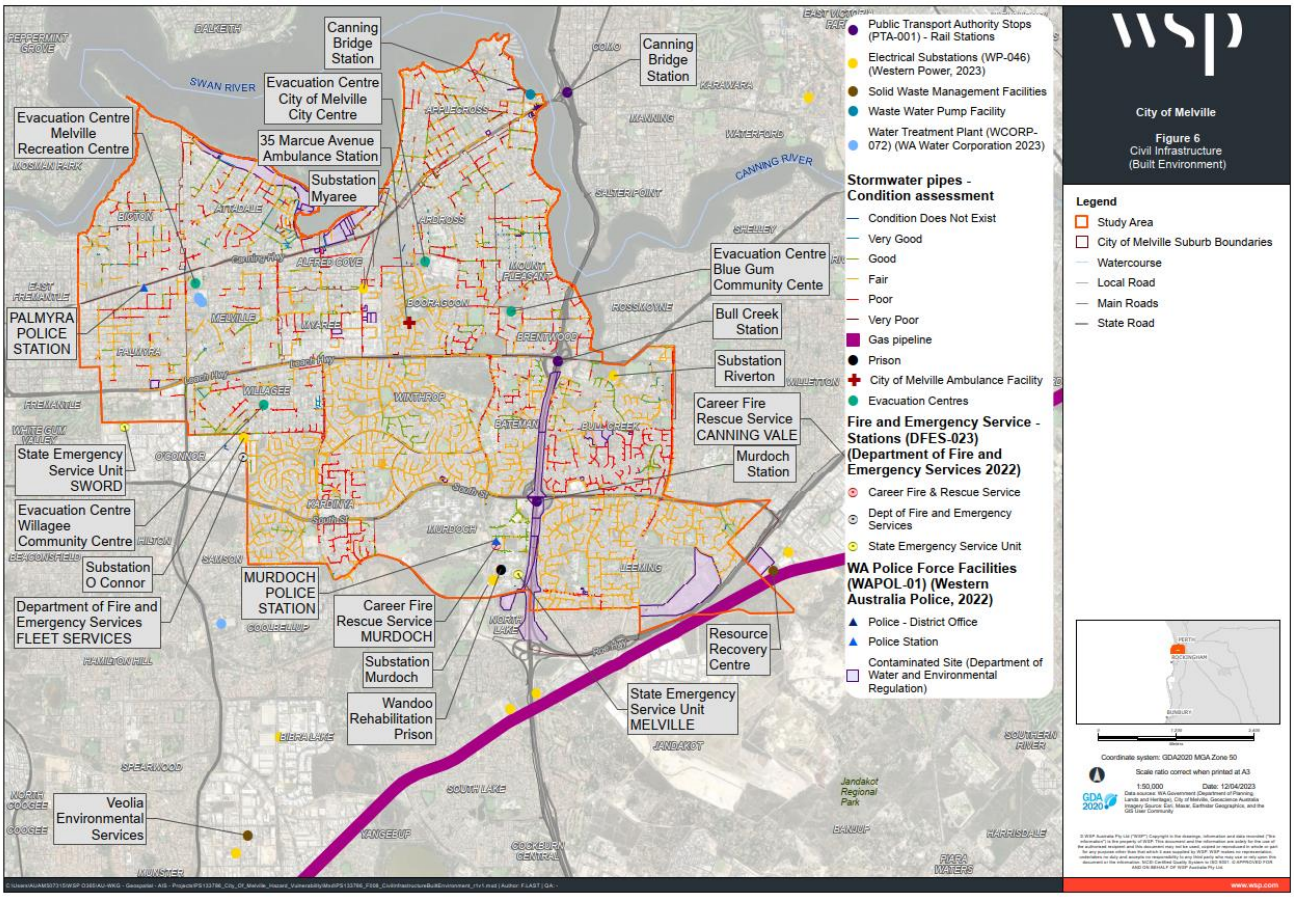
Physical Risks

- Audit Council's heritage-listed buildings for their thermal comfort and consider installation of fans, air-conditioning, shading, insulation, or other methods.
- Audit Council's heritage policies to consider updated amendments which remove barriers to thermal improvements, rooftop solar and other water, or energy efficiency measures.
- Create clear guidelines for dealing with conflicts between rooftop solar and trees.
- Conduct a climate-risk assessment on Council's heritage-listed vegetation assets and prepare management plans.
- Review and update Council's policies and procedures as they relate to outdoor workers, recreational sporting users, and other facility user groups to ensure heat-related risks are appropriately considered.
- Collaborate with indigenous groups to improve land and natural asset management regimes with a focus on fire management.
- Investigate the feasibility of facilitating the landward retreat of nearshore, intertidal and shallow water ecosystems adjacent to the Swan River.
- Prepare an updated list of native species suited to the future climate envelop and ensure future vegetation plantings are climate appropriate.

9.6 Built Environment Infrastructure

The built environment infrastructure map (**Figure 9-9**) includes locations of emergency services, utilities, transport infrastructure and contamination sites. The data used to develop this map was sourced from the City, DataWA, the Department of Fire and Emergency Services, the Western Australian Police, Western Power, St John WA, the Western Australian Public Transport Authority, the Water Corporation, the Department of Treasury and Geoscience Australia.

Figure 9-9. Built Environment Infrastructure Map



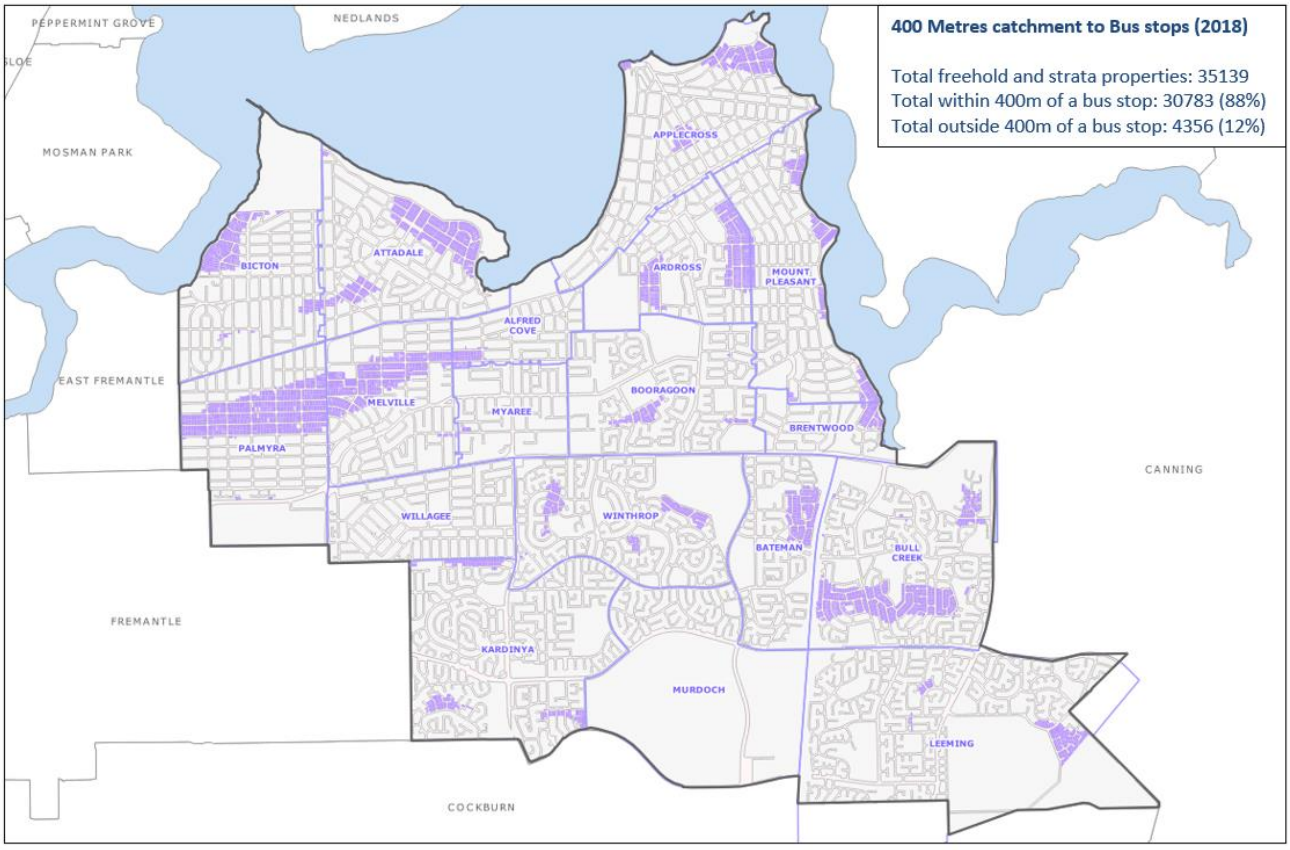
Source: WSP (2023) - *Large version available in* ***Appendix D***

Physical Risk Analysis

Transport

Transport infrastructure is critical in the response and recovery from climate disasters. As such, physical impacts to the transport system may increase the vulnerability of a population to climate risks. With two major access routes to and from the city, two train stations and a declining trend of households within 400m of a bus stop (88% in 2018 from 92% in 2011) (see **Figure 9-10**), the impact of climate hazards is a key consideration for the City.

Figure 9-10. Bus Stop Catchments Map



Source: City of Melville, (n.d).[152]

Projections of severe fire danger indicate a 30-70% increase by 2030. Bushfires may cause damage to transport infrastructure including destruction of asphalt pavements, transport stations and railway lines. This contributes to the challenge of hazard and emergency response, in addition to creating increased maintenance and repair costs. Particularly along the Kwinana Freeway, bushfire risk has been determined, placing one of the City's major transport corridors for private and public transport at risk. This will likely also impact the City's ability to respond to hazards in addition to the ability to evacuate at risk communities.

This is also the case in terms of flooding or inundation due to sea level rise. With the City's location along the Swan and Canning River, increases in sea-level rise and flooding impacts are projected. The current day 1-in-100-year extreme sea level event could occur every five years by 2050 and 10 times per year by 2100 (high emissions scenario). Risks to the Swan-Canning Estuary Foreshore and Attadale Alfred Cove Foreshore should be considered in addition to Point Heathcote Reserve and Bicton's Blackwell Reach Parade. This could comprise the foundations of transport infrastructure, while flooding of minor and feeder roads limit the ability of communities to evacuate. In this instance, the location of emergency responders such as the ambulance, fire and police also play an important role in their ability to respond.

The ability to adapt existing transport infrastructure to climate hazards is limited due to the significant costs required. Further, considering surrounding land uses, changes to major transport routes may cause further complications, such as an increased flooding risk to surrounding suburbs. Despite this, opportunities should be considered to reduce the exposure or vulnerability of transport infrastructure and communities to climate hazards. This could include creating fire buffer zones around critical transport infrastructure and preparing detour and evacuation routes during hazards. New infrastructure should consider projected climate changes and design accordingly.

[152] The catchment Bus Stop map was provided by City of Melville to WSP during the Assessment in 2023.

Electricity

Electricity supply is also key in the management and recovery from a disaster. Disruptions to the energy network can render numerous other systems non-functional unless decentralised back-up supply is available. Impacted services could include communication networks, healthcare and hospital facilities, food services and local businesses, and individual households.

Floods may damage electrical infrastructure at the household level, particularly in low lying areas where sub-standard electricity lines and sockets are more likely to be impacted. During storms, heavy impact waves and storm surges can destroy or displace electricity poles in coastal areas, leading to corresponding disruptions in specific areas. Broad disruptions to electricity supply may also occur if critical links of the network are cut. The combination of severe storms and flooding may also pose a safety risk to communities when damage is incurred in the form of fallen power lines, creating electrocution hazards. Rising sea levels may lead to increased soil salinity, which can pose challenges for the structural integrity of infrastructure such as electricity poles and distribution lines. For the City, suburbs including Bull Creek, Attadale, Applecross and Mount Pleasant may be impacted.

Fires present significant risk to electricity generation and supply infrastructure. Damage to vulnerable infrastructure such as distribution lines may also cause disruption of power supply. The impact of the electrical network is a consideration regarding climate change where structures with substandard electricity installations are more prone to catch fire. As fire weather days will increase across WA, making the City more vulnerable to bushfire disaster events, the state of infrastructure could exacerbate fire risk and the amount of damage. Opportunities existing in relocating critical electrical infrastructure from above-ground to under-ground services where possible. This must be considered alongside other climate hazards, such as flooding or sea level rise.

Heatwaves may also present a risk to electrical infrastructure. With a projected 55 days of temperatures over 35°C by 2090 in addition to increasing average temperatures, it is important that key infrastructure can cope with changes. The impacts of heat may cause sagging of distribution lines, an increased demand for cooling which may overload the energy network, and exceedances of mechanical infrastructure. This will cause increase costs for repairs and replacement. To address this, any infrastructure up for renewal could be replaced with products with higher maximum temperatures.

Transitional Risk Analysis

Transparency

With building risks of climate hazards, there is increasing use of litigation to compel governments and businesses to intensify their action on climate change (approximately (~) 1,800 cases filed world-wide as of July 2021, 115 cases in Australia). As trends towards climate litigation could impact the City, it is becoming crucial to be transparent about risks to communities. For example, the property risk of flooding or bushfire should be disclosed to people buying new property, in addition to surrounding risks to critical transport and electrical infrastructure. The need for transparency extends to the increased demand for accountability regarding duty of care to protect future generations from the effects of climate change.

Transparency also translates to the operation of companies in their disclosure of climate-related information surrounding their processes. Building on this, legislation prohibiting “greenwashing” advertising and activity may become a necessity in the future. The City must take legitimate and transparent actions to achieve their goal of carbon neutral emissions. This is particularly relevant for the operation of energy and transport services.

Low-Carbon Economy

The transition to a low-carbon economy relies heavily on the transport and energy sectors. The energy sector (comprising of stationary energy, transport, and fugitive emissions from fuels) continues to be the dominant source of Australia’s GHG emissions. This is followed by the transport and agriculture sectors. The City follows this trend with stationary energy the largest emission source for the City (48%), followed by transport (30%). The City should consider these high-emission source points when addressing emission cuts.

While clean electrification is the key to decarbonisation, clean energy and reduction of emissions will require significant investment to modernise transmission and distribution networks. By 2050, more than half of Australian houses are expected to have solar PV systems and about a third of residential buildings will have energy storage. With the City expected to follow these trends, this presents an opportunity to pre-emptively prepare the energy network to cope with future shifts.

Improving active and public transport options for the City will also play a significant role in the reduction of emissions. This will become increasingly important as road congestion is expected to increase with road congestion estimated to cost $31B by 2031. Again, the City is presented with the opportunity to respond to these changes and invest in the sustainability of the transport network.

Infrastructure tools

With damage caused by climate hazards increasing maintenance and repair costs of critical infrastructure, consideration should be given to alternative means of mitigation and adaptation. Nature-based solutions (NBS) for infrastructure are 50% cheaper than grey alternatives and deliver 28% greater added value in terms of direct and environmental benefits. In addition to mitigative effects, the implementation of NBS in replacement of, or combined with traditional infrastructure has the potential to reduce initial and ongoing costs to the City in response to climate change.

Recommendations

Physical

- Plan and communicate evacuation routes for flood events, particularly for vulnerable suburbs including Bull Creek, and river-side suburbs such as Attadale, Applecross and Mount Pleasant.
- Consider implementing additional stations for public transport access for communities with limited options.
- Plan and communicate detour routes during bushfire events considering the risk to the Kwinana Freeway.
- Implement standards for household electrical infrastructure for all new maintenance, repairs and renovations to gradually create better flood resilience for electricity supply.
- Investigate replacement of at-risk electrical infrastructure with marine-safe materials to reduce likelihood of degradation and damage.
- Investigate replacement of at-risk electrical infrastructure with fire-resistant materials to reduce likelihood of fire damage.
- Conduct audit and inspection of “old” electricity infrastructure to understand fire risk and schedule necessary replacements.
- Implement standards to increase maximum operational temperatures for critical infrastructure based on expected temperature increases, to supply key services, including mechanical and electrical infrastructure.
- It is noted that Western Power is currently transitioning suitable suburbs to underground power which will address some of the current and projected risk. It is recommended that this initiative is continued.

Transitional

- Increase transparency around climate risk to particular suburbs for existing and new community members
- Increased investment in renewable energy sector and incentives to adopt renewables
- Improvement of active and public transport opportunities for the community to reduce transport emissions.
- The City should consider the micro-mobility market and active transportation methods when updating city planning documents.
- Consider implementation of NBS in replacement of, or in combination with traditional infrastructure to mitigate impacts of climate change.

PART D.

FINDINGS

10 Climate Vulnerabilities, Risks, and Opportunities

The below table provides a summary of the climate vulnerabilities, risks and opportunities identified through this study. This includes cross-referencing those raised during workshops and meetings with the City of Melville staff and community members.

Table 10-1. Climate Vulnerabilities, Risks, and Opportunities – Business and Industry

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Broad decline in regional economic activity related to drought as well as flood-related impacts across the economy. Climate projections suggest an increase in the intensity of rainfall events as well as a decrease in annual average rainfall both of which impact the broader regional economy. Droughts and floods can cause widespread, systemic, impacts on the affected economies resulting in the loss of small/medium business and individual economic impacts.	High	High	Business and Industry	Medium
Widespread or locally concentrated impacts of drought and/or flooding impacting farms, crops, and livestock. Climate projections suggest an increase in the intensity of rainfall events as well as a decrease in annual average rainfall both of which impact the broader regional economy. Droughts can change bore water licenses due to reduced aquifer levels and floods can lead to the destruction of crops and the loss of livestock impacting the farming industry. For the City this will result in decreased food security and higher food costs for residents. It will also impact food service business due to higher input costs.	High	Moderate	Business and Industry	Medium
Impacts to the agricultural industry through the bushfire-related loss of crops, livestock, and assets. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season which affects the farming industry. Bushfires can lead to the destruction of crops and the loss of livestock impacting the farming industry. For the City this will result in decreased food security and higher food costs for residents. It will also impact food service business due to higher input costs.	High	Moderate	Business and Industry	Low
Riverine maritime services may be impacted by costal erosion and storm surges resulting in loss of production and widespread economic impacts. Climate projections suggest an increase in sea level rise which contributes to storm surges and highest astronomical tide levels causing coastal erosion. Damage to key maritime service infrastructure may lead to widespread logistical issues as well as economic impacts related to delayed deliveries.	Moderate	High	Business and Industry	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Employee productivity impacts in heatwaves. Projected temperature and precipitation changes will result in heatwaves and droughts, which are all likely to effect employee productivity. Health and well-being impacts and/or travel disruptions from heatwaves can decrease workforce productivity and result in increased staff absences.	Moderate	Moderate	Business and Industry	High
Impacts on the tourism industry in flood and drought affected areas. Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding. Floods can inhibit access or damage tourism attractions. Droughts and floods can cause widespread, systemic, impacts on the affected economies resulting in the loss of small/medium business and individual economic impacts.	Moderate	Moderate	Business and Industry	Medium
Impacts on the tourism industry in bushfire affected areas. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season impacting tourism attractions and activities. Bushfire environmental, infrastructure damage as well as related air pollution cause widespread, systemic, impacts on the affected economies resulting in the loss of small/medium business and individual economic impacts. Fewer tourists should be expected within the area during times of disaster.	Moderate	Moderate	Business and Industry	Low
Risks to business from disruption to supply chains. Global and national variations in temperature, precipitation and extreme weather may disrupt supply chains. Supply chain delays and disruptions are likely to delay or disrupt operations for local businesses.	Moderate	Moderate	Business and Industry	Medium
Weather-related shocks to global food production and trade. Global and national variations in temperature, precipitation and extreme weather may affect food production and trade. In some cases, residents may be unable to access favoured or necessary food items and businesses may be disrupted by trade issues.	Moderate	Moderate	Business and Industry	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Business risks/opportunities from changing demand for goods & services. Global and national variations in climate are likely to shift demand for particular goods and services, for example increase need for air conditioning units. Changing customer demand is likely to have minor negative or positive impacts on business within the City.	Moderate	Low	Business and Industry	Medium
Risks to business from reduced access to capital. Increases in global and national extreme weather events, may reduce businesses access to capital, however this is unlikely. Some businesses will experience financial implications if climatic events reduce access to this capital.	Low	Moderate	Business and Industry	Medium
Disruptions to air, road, and maritime transport logistics as well as resupply related to high winds and storm-related flooding. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms incurring impacts on transport systems. Storm and extreme weather-related disruptions to transport logistics can cause supply chain issues, widespread economic impacts as well as community isolation.	Low	Moderate	Business and Industry	Low
Impacts on the tourism industry in affected areas. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms impacting tourism activities. Acute impacts related to storms incurring the loss of small/medium business and individual economic impacts.	Low	Moderate	Business and Industry	Medium

Table 10-2. Climate Vulnerabilities, Risks, and Opportunities – Infrastructure

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Disruption of services and damage of infrastructure and property (e.g., roads, energy supply, water, sewerage and communications). Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding and impacts on infrastructure. Infrastructure and	High	High	Infrastructure	High

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
utilities can be affected by flooding which can lead to structural damage, increased maintenance costs as well as service interruptions.				
Disruption of services and damage of infrastructure and property (e.g., roads, energy supply, water, sewerage, and communications). Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season impacting infrastructure and properties. Impacted infrastructure and properties including roads, energy supply, water, sewerage, and communications lead to widespread disruptions in service and increased maintenance/replacement costs.	High	High	Infrastructure	Medium
Increased risk of sea level rise impacting transport infrastructure. Areas along the foreshore should consider risk of inundation due to combined effects of sea level rise, high tide, and storm surges. This may compromise the foundations of transport infrastructure, including roads, lighting, and signposting.	High	Moderate	Infrastructure	Medium
Changes to land uses exacerbating climate change effects. Changing urban landscape and resultant changes to transport networks due to increasing populations may exacerbate the effects of climate change (such as the effects of flooding), if not managed appropriately.	High	Moderate	Infrastructure	Medium
Flood damage to electrical infrastructure. Increased likelihood of flooding may cause damage to electrical infrastructure at a household level, particularly in low-lying areas, resulting in power-outages.	Moderate	High	Infrastructure	Medium
Extreme heat risks to road, and energy infrastructure. Climate projections suggest temperature changes and increased heatwave incidence which may expose infrastructure to heat stress. Overheating of energy, transport and ICT infrastructure is likely to cause disruptions to community services as well as incur increased maintenance costs.	Moderate	Moderate	Infrastructure	High
An increase in annual electricity and water costs to cool council owned buildings and irrigate public spaces. Climate projections suggest temperature changes and increased heatwave incidence. Supplementary energy and water requirements for cooling will incur supplementary costs to be considered in budget.	Moderate	Moderate	Infrastructure	High
Increased strain and potential failure of assets susceptible to temperature such as electrical equipment. Climate projections suggest temperature changes and increased heatwave incidence which may expose infrastructure to heat stress. Equipment temperature ratings exceeded, incurring increased maintenance costs or replacement costs as well as potential interruptions.	Moderate	Moderate	Infrastructure	High
Impacts on power and telecommunications lines caused by high winds combined with flooding inhibiting access. These lead to periods of disruption. Climate projections suggest fewer tropical cyclones and lows bringing rain. An increase in the proportion of these being considered extreme storms	Moderate	Moderate	Infrastructure	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
is likely, causing infrastructure damage. Storm-related impacts on infrastructure can cause interruptions in services isolating parts of the community. This hinders emergency response and resupply.				
Coastal erosion impacting essential infrastructure such as power, water, drainage, and communications resulting in increased maintenance costs and service disruptions. Climate projections suggest an increase in sea level rise which contributes to storm surges and highest astronomical tide levels causing coastal erosion. Exposed infrastructure may be damaged by coastal erosion and associated higher storm tides leading to interruptions in service as well as increased maintenance and replacement costs.	Moderate	Moderate	Infrastructure	Low
Increased extreme heat causing damage to electrical infrastructure. Projected increase in days of extreme heat may cause sagging of distribution lines, an increased demand for cooling which may overload the energy network, and exceedances of operational capacity with regards to heat.	Moderate	Moderate	Infrastructure	Medium
Increased demand on council facilities such as libraries as members of the community may use these as respite if they don't have adequate cooling at home. Climate projections suggest temperature changes and increased heatwave incidence requiring supplementary energy for cooling. Change in historical use and increase in usage of council facilities related to use as a cool area affecting normal service provisioning and operations.	Moderate	Low	Infrastructure	High
Increased demand on council facilities such as community halls as members of the community may use these as respite and shelter. Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding leading to community displacement. Change in historical use and increase in usage of council facilities related to use as a refuge impacting normal service provisioning and operations.	Moderate	Low	Infrastructure	High
Increased demand on council facilities such as City hall or libraries as members of the community may use these as respite and shelter. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season causing community displacement. Change in historical use and increase in usage of council facilities related to use as a refuge normal service provisioning and operations.	Moderate	Low	Infrastructure	Medium

Table 10-3. Climate Vulnerabilities, Risks, and Opportunities – Natural and Environmental Assets

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Significant impacts on the region's native fauna and flora. Climate projections suggest temperature changes and increased heatwave incidence. Increased surface and water temperatures incurring changes in species populations and distributions as well as the proliferation of invasive species. Heat related mortality and altered reproductive cycles could also occur. The timing of species flowering is also likely to be altered, leading to cascading impacts for dependent species.	High	High	Natural and Environmental Assets	Low
Reduction in average annual rainfall increases the frequency and severity of droughts impacting ecosystems. Climate projections suggest a decrease in average annual rainfall which contributes to the occurrence of drought. Droughts causing widespread damage on natural ecosystems including impacts on fauna and flora. Impacted ecosystems may see proliferation of invasive species as a result. Species distribution may occur, causing potential trophic cascades and influencing conservation management.	High	High	Natural and Environmental Assets	Medium
Foreshore damage as well as storm tides causing landslips in estuaries and inlets impacting coastal ecosystems and exposed species of fauna and flora. Climate projections suggest an increase in sea level rise which contributes to storm surges and highest astronomical tide levels causing coastal erosion. Coastal erosion may increase ocean encroachment onto land as well as erode previously higher and dryer land causing localised damage as well as widespread disruptions to ecosystems related to increased salinity and turbidity.	High	High	Natural and Environmental Assets	Medium
Increasing marine water temperatures altering natural processes and impacting marine flora and fauna. Climate projections suggest an increase in sea level rise as well as an increase in marine water temperatures impacting marine ecosystem health. Flooding-induced widespread damage on natural ecosystems including impacts on fauna and flora. Impacted ecosystems may see proliferation of invasive species as a result.	High	High	Natural and Environmental Assets	Low
Widespread or localised impacts on ecosystems or specific flora and fauna related to heavy rainfall. Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding. Flooding-induced widespread damage on natural ecosystems including impacts on fauna and flora. This could cause displacement, increase in invasive species proliferation, and mortality.	High	Moderate	Natural and Environmental Assets	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Damage to ecosystems and recognised species leading to loss of environmental value and services. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season impacting native ecosystems. Bushfires can impact native ecosystems, affecting species population and distribution. Invasive species may repopulate more aggressively and displace native flora/fauna. Fire mortality is often high, as is smoke-induced deaths. Altered species composition and abundance could occur, favouring fire-obligate species.	High	Moderate	Natural and Environmental Assets	Low
Widespread or localised impacts on ecosystems or specific flora and fauna related to strong winds and heavy rainfall. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms. Storm-related impacts on ecosystems flora and fauna affecting population numbers and distribution.	Low	High	Natural and Environmental Assets	Low

Table 10-4. Climate Vulnerabilities, Risks, and Opportunities – People and the Built Environment

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Health impacts related to widespread bushfire smoke air pollution. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season leading to increased potential for smoke related air pollution. Bushfire related air pollution can cause elevated levels of particulate matter in the air causing a range of health issues across the affected communities (e.g., asthmatics) as well as increased rates of mortality.	High	High	People and the Built Environment	Medium
Higher average and extreme temperatures potential, amplified by urban heat island effect, causing increased risk of heat stress and heat related illnesses for council staff who work outdoors. Climate projections suggest temperature changes and increased heatwave incidence which will incur health and safety considerations. High temperatures can cause heat-related illnesses and mortalities, particularly for vulnerable members of the community.	High	High	People and the Built Environment	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Flooding impacting transport infrastructure and road network access affecting community connectedness and morale. Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding. Flooding of isolated parts of the community may limit aid and the provisioning of supplies, as well as community support, disproportionally impacting vulnerable communities.	High	Moderate	People and the Built Environment	Medium
Urban heat island effect causing increased temperature hotspots in urban environments incurring impacts on public health and wellbeing from high temperatures. Climate projections suggest temperature changes and increased heatwave incidence amplified by urban heat island effect which are highly likely to impact public health and wellbeing. High temperatures can cause heat-related illnesses and mortalities, particularly for vulnerable members of the community	High	Moderate	People and the Built Environment	Low
Socio-economic risks of increasing insurance premiums. Unemployed and low-income earners are unlikely to be able to afford insurance due to increased premiums in the case of flooding events. Alternatively, they may be unable to afford damage repairs post flood event. Going forward middle-income earns are also unlikely to afford insurance premiums.	High	Moderate	People and the Built Environment	Medium
Risks to public health and wellbeing from higher average and extreme temperatures. Climate projections suggest temperature changes and increased heatwave incidence which are highly likely to impact public health and wellbeing. High temperatures can cause heat-related illnesses and mortalities, particularly for vulnerable members of the community	High	Moderate	People and the Built Environment	Medium
Decreasing rainfall. Drought conditions and declines in rainfall may cause increased stress for native vegetation and fauna, reducing visual amenity and increasing mental distress within the community.	High	Moderate	People and the Built Environment	Medium
Heatwaves. Increasing average temperatures and extreme heat events may result in increased usage and occupation of City owned/operated infrastructure such as libraries, leisure centres etc, resulting in increased resource strain on public assets.	High	Moderate	People and the Built Environment	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Socio-economic risks related to increased cost of mitigation. Industries and businesses will be required to upgrade infrastructure, processes, and technologies at a cost which is mostly fed down to consumers and taxpayers resulting in low-income earners or the older population on a fixed pension to feel the effects of and suffer from increased costs.	High	Moderate	People and the Built Environment	Medium
Heat related illness. Increased frequency of consecutive extreme heat days resulting in the elderly acquiring heat related illnesses, exacerbated by pre-existing health conditions and frailness causing increased hospital admissions and calls for medical assistance	High	Moderate	People and the Built Environment	Medium
Days with a severe fire danger rating are projected to increase by 30-70% by 2030. For the City, increasing fire danger threatens community health, particularly vulnerable populations.	Moderate	High	People and the Built Environment	Medium
Risk of public injury. Increase severity of storms and associated strong-wind events, or wave impacts can destroy or displace electricity poles, leading to corresponding disruptions and may damage over-head electrical infrastructure. This increases the risk of electrocution for public.	Moderate	High	People and the Built Environment	Medium
Impacts related to strong winds and storm-related flooding affecting social infrastructure including schools, hospitals, etc. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms and causing infrastructure damage. Storm-related impacts on social infrastructure can limit or eliminate the provision of essential community services during emergencies.	Low	High	People and the Built Environment	Medium
Impacts related to strong winds and storm-related flooding displacing community members. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms incurring community evacuation. Storms can cause property destruction or damage resulting in community displacement. Evacuation orders can impact community wellbeing.	Low	High	People and the Built Environment	Medium
Flooding damage to socially and culturally significant elements of the City. Climate projections suggest an increase in the intensity of rainfall events which are more likely to cause flooding. Floods damaging built or natural culturally significant elements may affect Indigenous, cultural and religious heritage sites, as well as community wellbeing.	Moderate	Moderate	People and the Built Environment	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Disruption to social connectedness related to communication services disruptions. Climate projections suggest an increase in the number of severe fire weather days especially in the peak fire season. Fire impacts can lead to power outages across large areas of the network. Leading to downstream impacts on telecommunication networks. These outages can frequently last longer than four hours, causing significant disruptions to study, business, and council operations.	Moderate	Moderate	People and the Built Environment	Low
Riverine erosion and storm tides impacting exposed residential dwellings, business, and community infrastructure through loss of land. Climate projections suggest an increase in sea level rise which contributes to storm surges and highest astronomical tide levels causing riverine erosion. Riverine erosion may increase ocean encroachment onto land resulting in areas being unusable and reducing public amenity.	Moderate	Moderate	People and the Built Environment	Medium
Risks from climate-related international human displacement. Global and national variations in temperature, precipitation and extreme weather is likely to lead to increased international human displacement. International or national climate refugees and migrants may move into the City, potentially putting strain on community resources, such as healthcare and schools.	Moderate	Moderate	People and the Built Environment	Medium
Imported food safety risks. Global and national climate variations may decrease food safety. Reduced food safety is likely to have health and well-being implications for local residents.	Moderate	Moderate	People and the Built Environment	Medium
Long-term changes in global food production. Global and national variations in temperature, precipitation and extreme weather may affect food production. In some cases, residents and food-related businesses may be unable to access favoured or necessary food items	Moderate	Moderate	People and the Built Environment	Medium
Risks to Australia from international violent conflict. Global and national climate variations may result in increased international violent conflict. Increased violent conflict, could result in global instabilities and increased numbers of refugees, which could have indirect impacts on the City.	Moderate	Moderate	People and the Built Environment	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Risks to international law and governance. Global and national climate variations may result in changes to international law and governance. Changes to international law and governance could result in global instabilities, which could have indirect impacts on the City.	Moderate	Moderate	People and the Built Environment	Medium
Socio-economic risk of resource absorption. Increased intensity of tropical cyclones and storms impacting suburbs with high population density, causing greater number of calls to SES and other emergency services, leading to absorption of resources from neighbouring suburbs creating extended waiting times and other perverse outcomes.	Moderate	Moderate	People and the Built Environment	Low
Loss of income. Increased frequency of climate hazards including flooding, bushfire, storms, and heatwaves causing shutdown of casualized, face-to-face employment industries and loss of income particularly to migrants who are more likely to be employed in these industries	Moderate	Moderate	People and the Built Environment	Low
Climate change-related disasters are p**rojected to cost Australia $73B a year by 2060**, even if action is taken to curb greenhouse gas emissions. Increasing sea-level rise, bushfire frequency/intensity, intense rainfall events, and drought will impact the City. The City's location along the Swan and Canning River will heighten sea-level rise and flooding impacts.	Moderate	Moderate	People and the Built Environment	Medium
Socio-economic risk of access to transport. Accessibility is a key issue for the unemployed and low-income earners, as they are often reliant on public services including public transport, community centres, and libraries. During extreme weather events, such as bushfires or flooding, they may be unable to leave their home to access these services.	Moderate	Low	People and the Built Environment	Medium
Damage to socially and culturally significant elements. Climate projections suggest fewer tropical cyclones and lows bringing rain but an increase in the proportion of these being considered extreme storms damaging significant elements. Storm-related impacts damaging built or natural culturally significant elements affecting Indigenous, cultural and religious heritage as well as community wellbeing.	Low	Moderate	People and the Built Environment	Medium

Climate Vulnerabilities, Risks, and Opportunities Scenarios	Likelihood of Risk	Impact of Risk	Impact Group / Sector	Level of Data Quality
Socio-economic risks related to increased cost of mitigation in homes. Policies should mandate the installation of new, more efficient, technologies or infrastructure affecting low-income earners.	Low	Low	People and the Built Environment	Medium

11 Recommendations

— The criteria used to filter and organise the **recommendations** is provided below in four types.

Strengthen existing activity – work to ensure current activities are supported and continue to address climate shocks and stressors alongside new proposed activities.

Additional action needed – new, stronger, or more tangible implementation activities or policies are needed. Those which are over and above what is already planned and need to be delivered in the next 5 years.

Building Capacity and Understanding – more work is needed to develop the City's ability to respond or manage this risk or opportunity including allocating more resources.

New adaptation, and mitigation action needed – areas where brand new efforts and actions need to be implemented to respond to existing or emerging challenges as a result of climate change.

— All recommendations need to be continually monitored, modified, and evaluated for efficiency. These should be revisited in the next VRO Assessment in 3-5 years.

— Each recommendation has been linked to the United Nations Sustainable Development Goals, see: https://www.undp.org/sustainable-development-goals. Additionally, for recommendations which were mentioned, raised, or commented on through the Community Workshops  or City of Melville Staff workshops  , a relevant icon has been included.

— For ease of presentation of the Recommendations – they have been grouped into the following themes: First Nations Engagement, Advocacy, Built Environment, Education and Awareness, Emissions Reduction, Financing, Habitat Protection (flora and fauna), Planning and Transport.

11.1 First Nations Engagement

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Work in partnership with local registered Aboriginal parties in the management of Council lands and explore avenues to hand back land for ownership.	SDG 13, SDG 16	
New adaptation, and mitigation action needed	Identify avenues to protect culturally significant sites on Council managed land under threat from climate change impacts.	SDG 13, SDG 16	
Building Capacity and Understanding	In suburbs with a high proportion of Aboriginal and Torres Strait Islander people's (Willagee, Palmyra, and Brentwood), conduct targeted consultation to develop culturally sensitive programs and services that they feel are most needed to further protect them from hazards i.e., self-determination.	SDG 10, SDG 16	
New adaptation, and mitigation action needed	Collaborate with indigenous groups to employ their services to improve land and natural asset management regimes.	SDG 14, SDG 15	

11.2 Advocacy

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Advocate for climate friendly tree policies at the regional, state, and national levels.	SDG 13, SDG 15	
Additional action needed	Advocate for flood modelling to be State responsibility, thereby ensuring consistency across local government areas.	SDG 13	
Building Capacity and Understanding	Improve climate disclosures to build social licence and enhance reputation.	SDG 13	
Strengthen existing activity	Advocate to the Western Australia Government to declare a climate emergency and act in accordance with climate science projections for RCP 8.5.	SDG 13, SDG 11, SDG 17	

Type	Recommendation	Link to SDGs	Workshops
Strengthen existing activity	Advocate for stronger sustainability legislation requirements. Start with listing priorities and avenues for advocacy (such as for tree protection, zero carbon building standards, green infrastructure, ecological connectivity, EV charging infrastructure, sustainable transport etc).	SDG 13, SDG 16	
Building Capacity and Understanding	Hold an urban resilience solutions Hackathon/Challenge Lab to support the development of innovative businesses and technologies.	SDG 9	
New adaptation, and mitigation action needed	Revisit working hours and schedules based on increase of heat stress. Conduct regular risk assessments and determine whether work should be conducted on a day-to-day basis (e.g., use heat stress calculator) and determine if work hours should be outside of traditional 9-5 work hours (e.g., working before 10am and midday heat). This would also include looking to schedule heavy/strenuous work for cooler times of the day/year.	SDG 3	
New adaptation, and mitigation action needed	Ensure staff are adequately trained for heat stress and have appropriate PPE as standard uniform/dress.	SDG 3, SDG 4	
New adaptation, and mitigation action needed	Avenues for cloud seeding.	SDG 9	
Building Capacity and Understanding	Educational programs should be deployed among suburbs with a high proportion of school aged children (Bull Creek, Leeming and Attadale) and elderly people (Bull Creek, Kardinya and Leeming) to increase awareness amongst children and the elderly of the physicals impacts that can arise from various hazards. This may be done through schools, aged care homes and among community groups. This will ensure they can help themselves to the extent possible should a hazard occur.	SDG 4, SDG 10	
Additional action needed	Review and update Council's policies and procedures as they relate to outdoor workers, recreational sporting users, and other facility user groups to ensure heat-related risks are appropriately considered.	SDG 3	
Building Capacity and Understanding Additional action needed	Increase transparency around climate risk to particular suburbs for existing and new community members. Advocate for sensible flood risk-based land use and development policies.	SDG 13 SDG 11	

11.3 Built Environment

Type	Recommendation	Link to SDGs	Workshops
Strengthen existing activity	Uptake of green building design principles. Increase awareness, implementation, and uptake of green building design principles. Especially the impacts of buildings on how they are currently affected by storms, wind moisture, and driving rain and the scale of possible overheating risk impact on vulnerable groups, such as elderly.	SDG 9, SDG 11	
Additional action needed	Build resilience principles and design into City of Melville's infrastructure and transport system by focusing on resilience in infrastructure and resilience through infrastructure principles. This could investigate developing a guideline for various resilient infrastructure treatment options for new builds and retrofitting (maintenance/operations) of existing buildings.	SDG 9, SDG 11	
Additional action needed	Develop a material identification manual looking at what materials should be used for various Council projects to reduce the impacts of climate change. For example, maximise the use of light-coloured surfaces to reduce UHI (pavement, roads, roofs).	SDG 11, SDG 9	
Additional action needed	Reinforce infrastructure to prevent/reduce extreme weather event disruptions. Decentralise generation, microgrids, battery storage.	SDG 7, SDG 13	
New adaptation, and mitigation action needed	Undertake an audit of council owned buildings and investigate options to provide adequately ventilated/cooled office spaces for use during the heat of the day.	SDG 7, SDG 13	
Additional action needed	Minimise radiant heat sources and reduce exposed metal surfaces.	SDG 11	
Additional action needed	Identify critical hot spot areas for heat stress and install automated equipment/processes in hot locations such as water facilitates, shade coverings, etc.	SDG 3	
Additional action needed	Upgrade stormwater drainage infrastructure to reduce flood impacts and increase stormwater reuse.	SDG 11	
Additional action needed	Retrofit buildings to improve overall design quality and ability to withstand extreme weather events looking at RCP8.5 and 2070 and 2090 projections.	SDG 13, SDG 10, SDG 11	
Strengthen existing activity	Review design specifications for engineering and civil projects to confirm if design parameters account for future climate change projections (e.g., increases in temperatures, extreme storms, increases to rainfall intensity etc).	SDG 11	

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	As suburbs with higher population density (Mount Pleasant, Willagee, and Alfred Cove) require greater resources, the City should implement initiatives to ensure that existing services are adequately resourced, and new services be established where necessary. This includes auditing of emergency service centres, hospitals, and medical centres to ensure they are adequately staffed and have the appropriate equipment to manage in the case of a hazard related emergency. Smaller community health centres should be established where required to reduce reliance on major hospitals and emergency departments.	SDG 10	
New adaptation, and mitigation action needed	Climate risk assessments would be conducted on social housing. This could include working with agencies owning and managing social housing to improve resiliency of the dwellings subsequently reducing the resident's vulnerability to climate hazards.	SDG 1, SDG 11/13	
New adaptation, and mitigation action needed	Investigate the retrofit of social housing to be more resilient e.g., installing solar panels and batteries.	SDG 7	
New adaptation, and mitigation action needed	Climate risk assessments would be conducted on retirement villages. This could include working with agencies owning and managing retirement villages to improve resiliency of the dwellings subsequently reducing the resident's vulnerability to climate hazards.	SDG 13, SDG 10	
New adaptation, and mitigation action needed	Audit Council's heritage-listed buildings for their thermal comfort and consider installation of fans, air-conditioning, shading, insulation or other methods.	SDG 11	
New adaptation, and mitigation action needed	Audit Council's heritage policies to consider updated amendments which remove barriers to thermal improvements, rooftop solar and other water, or energy efficiency measures.	SDG 11	
New adaptation, and mitigation action needed	Implement standards for household electrical infrastructure for all new maintenance, repairs and renovations to gradually create better flood resilience for electricity supply.	SDG 9	
New adaptation, and mitigation action needed	Investigate replacement of at-risk electrical infrastructure with marine-safe materials to reduce likelihood of degradation and damage.	SDG 9	
Building Capacity and Understanding	Investigate replacement of at-risk electrical infrastructure with fire-resistant materials to reduce likelihood of fire damage.	SDG 9	
Building Capacity and Understanding	Conduct audit and inspection of "old" electricity infrastructure to understand fire risk and schedule necessary replacements.	SDG 9, SDG 11	
New adaptation, and mitigation action needed	Drought resilient sport surfaces – investigate alternatives that aren't artificial turf for laws/parks/ovals.	SDG 11	
New adaptation, and mitigation action needed	Consider broad scale misting efforts to reduce UHI and temperatures.	SDG 3, SDG 11	

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Develop better end-of-trip facilities at Council buildings, add end-of-trip facilities to building codes (bike parking, showers, lockers).	SDG 3, SDG 6, SDG 13	
New adaptation, and mitigation action needed	Create subsidies for water harvesting (group water).	SDG 6, SDG 13	
Additional action needed	Increase stock held, depending on rate of use, to cover for “no incoming” to mitigate against supply chain interruptions.	SDG 12, SDG 9	

11.4 Education and Awareness

Type	Recommendation	Link to SDGs	Workshops
Building Capacity and Understanding	Introduce climate change education into staff/councillor induction training to support climate-positive decision-making. This should include local climate risks identified within this VRO.	SDG 4, SDG13	
Building Capacity and Understanding	Establish a climate program to allow community to act on the climate emergency.	SDG 13	
Building Capacity and Understanding	Engage with research institutes like Murdoch University, innovative technology groups, NGOs, climate emergency strategists, and other leaders to implement best practice climate responses.	SDG 17, SDG 13, SDG 9	
Building Capacity and Understanding	Develop local climate/environmental champions to foster leaders and support grassroot climate action.	SDG 13	
Building Capacity and Understanding	Implement a best-practice Community Engagement Plan for Climate Change.	SDG 13	
Building Capacity and Understanding	Support/employ two interns or volunteers in the Environmental Sustainability team to expand experience and build knowledge/skills to take climate action within the community.	SDG 4, SDG 13, SDG 8	
Building Capacity and Understanding	Support a youth climate summit to be held in City of Melville.	SDG 13	
Strengthen existing activity	Innovation Recommendation. Strengthen collaboration and dialogue between national and state authorities, local government, community, and civil society to promote climate change initiative.	SDG 17, SDG 13, SDG 9	
Building Capacity and Understanding	Public Service Climate Change Champions. Increase the capacity of public service personnel and institutions to become climate change champions not only within the Council but also within the community.	SDG 13	

Type	Recommendation	Link to SDGs	Workshops
Building Capacity and Understanding	Promote a community with low-waste plant-rich diets, supporting plant growing and sharing initiatives (community gardens, farmers markets, school growing programs/cooking programs).	SDG 3, SDG 2, SDG 13	
Building Capacity and Understanding	Target communication to support vulnerable residents to ensure they are prepared and cope with climate events such as storms, floods, and heatwaves.	SDG 4, SDG 13, SDG 10	
Building Capacity and Understanding	Help communities and organisations to work together to understand impacts of climate health and wellbeing, and to become more resilient in the face of climate change.	SDG 13, SDG 3	
Building Capacity and Understanding	Take advantage of mobile apps and web-based “systems of engagement” to disseminate information for disaster risk preparedness, early warnings, and response.	SDG 4	
New adaptation, and mitigation action needed	Promote a ‘Nature in the Neighbourhood’ initiative to encourage more retention of green spaces, especially trees, on private property.	SDG 15	
Building Capacity and Understanding	Host a Hackathon to support the development of innovative technologies supporting reduced marine water temperatures.	SDG 9, SDG 14	
Building Capacity and Understanding	In suburbs with a high proportion of people with disabilities (Bull Creek, Leeming, and Kardinya), training should be delivered to employees of disability/social services to ensure they can understand behavioural warning signs indicating someone may be unwell during heatwaves or bushfire soke haze events and be able to provide adequate support during hazard events.	SDG 10, SDG 4	
Building Capacity and Understanding	In suburbs with a high proportion of people with disabilities (Bull Creek, Leeming, and Kardinya), hazard awareness resources should be deployed through community centres, public buildings and social services that cater to a range of abilities e.g., resourcing utilising braille or audio for vision impaired people, resources using simplistic language and graphics for those with cognitive impairments.	SDG 10	
Building Capacity and Understanding	In suburbs with poorer adult literacy skills (Bull Creek, Kardinya, and Leeming), deploy a community consultation officer or similar representative to host hazard awareness information sessions in a public building or space to cater to those with poor literacy skills to ensure they are educated via word of mouth.	SDG 4, SDG 10	
Building Capacity and Understanding	In suburbs with a high proportion of residents from a non-English speaking background (Bull Creek, Kardinya, and Leeming), ensure that hazard awareness resources and community wayfinding are provided in other languages to ensure people of non-English speaking backgrounds can support themselves during a hazard and access vital necessities.	SDG 10	

Type	Recommendation	Link to SDGs	Workshops
Building Capacity and Understanding	In suburbs with a high proportion of school aged children (Bull Creek, Leeming, and Attadale), deploy educational programs to teach children how to live more sustainably e.g., growing their own food, minimising water consumption, re-using grey water, minimising energy consumption to reduce resource depletion and help combat climate change.	SDG 2, SDG 6, SDG 7, SDG 10, SDG 11, SDG 12, SDG 13	
Building Capacity and Understanding	In suburbs with high migration (Applecross, Leeming, and Booragoon), develop employment schemes to help people acquire work quickly, easily and in industries that will have a high demand for employees into the future.	SDG 8	
Building Capacity and Understanding	In suburbs with a high proportion of people from non-English speaking backgrounds (Bull Creek, Kardinya, and Leeming), develop permanent income protection schemes for industries that are highly casualised and/or require face-to-face services to ensure people have on-going income during a hazard event.	SDG 10	
Building Capacity and Understanding	In suburbs with a high proportion of adults with poor literacy and elderly people (Bull Creek, Kardinya, and Leeming for both), ensure that public Wi-Fi is readily available and communal computers are available in public buildings to ensure these members of the community still have access to hazard awareness resources. Technology skills improvement programs should also be deployed through retirement villages to ensure that elderly can utilise technology to their benefit.	SDG 10, SDG 9	
Building Capacity and Understanding	Implementation of support networks in relation to unemployment. These could be in the form of community groups, or online platforms. Leeming, Kardinya, and Bull Creek all have higher numbers of disabilities, lower levels of adult literacy, and a higher proportion of those who speak languages other than English. Additional services (including translators and educators) could be focused within these suburbs to aid those that are unemployed in finding and retaining jobs. It would also be essential to include information in other languages given the higher proportion of those that speak languages other than English.	SDG 8, SDG 10	
Building Capacity and Understanding	Conduct forums with the community to understand their views, including hesitations, to the transition of the grid and how the Council can aid in developing a more resilient system.	SDG 11	
New adaptation, and mitigation action needed	Transform Piney Lakes Education Centre into an Innovation Hub.	SDG 4	
Strengthen existing activity	Improve efforts to promote local circular economies to support supply chains. Waste reduction examples include (but are not limited to) toy and tool libraries, men's sheds.	SDG 12	
Additional action needed	Advocate for sensible risk-based land use and development policies.	SDG 16, SDG 11	

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Look into rising food costs caused by climate change and identify avenues to show how to stretch food budgets – could be linked to community food groups.	SDG 2, SDG 10, SDG 13	
New adaptation, and mitigation action needed	Develop a peer learning platform for Enterprise risk plans for local businesses.	SDG 4, SDG, 9	
Additional action needed	Adopt a participatory budgeting approach to which community members can vote on grants for projects.	SDG 11	
Building Capacity and Understanding	Work with emergency response services to identify vulnerable communities and action plans.	SDG 11, SDG 10	

11.5 Emissions Reduction

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Increase Council's renewable energy generation and storage capacity each year and create a pathway for Council to consume only renewable electricity and avoid consuming electricity and fuels from fossil fuel sources.	SDG 7, SDG 11, SDG 13	
Additional action needed	Update all street lighting to LED.	SDG 7, SDG 11, SDG 13	
Additional action needed	Measure CO2 emissions annually and monitor progress towards emissions reduction targets (measure both Council and Community Emissions Scope 1, 2 and (where possible) 3).	SDG 13	
Additional action needed	Integrate smart technologies (demand management tech) to manage electricity demand.	SDG 9, SDG 7	
Additional action needed	Eliminate the use of gas and map out a pathway for switching power of Council buildings with 100% renewable energy.	SDG 7, SDG 13	
Strengthen existing activity	Council should look into providing grants to leaseholders of buildings and facilities for energy efficiency upgrades and/or installation of solar generation.	SDG 7, SDG 13, SDG 11	
New adaptation, and mitigation action needed	Retrofit buildings to insulate and reduce radiant heat. Maximise good air flow (fans, windows, vents).	SDG 11	
New adaptation, and mitigation action needed	Energy efficient cooling devices installed within buildings (air conditioners, fans, ventilation) - start with council owned facilitates and then provide initiatives or grants for private and commercially owned assets.	SDG 7, SDG 11	

Type	Recommendation	Link to SDGs	Workshops
Strengthen existing activity	Develop a carbon neutral pathway that only uses offsets where remaining emissions cannot be mitigated.	SDG 13	
Additional action needed	Disclosing financial exposure to climate-related risks is likely to become mandatory for ASX-listed companies in the future (already occurring in NZ and UK). It is recommended the City disclose Scope 1, 2 (and where possible, 3) emissions to increase transparency.	SDG 10, SDG 8	
Additional action needed	Conduct studies to understand community sentiment regarding the transition to a lower carbon economy and the increased consideration of climate change and their perception of good local government management in this context. Proactively engaging with community members may help understand evolving expectations and increased preparedness.	SDG 11, SDG 13	
Strengthen existing activity	Increase Council's investment in renewable energy sector and incentives to adopt renewables and create clear KPI measures for Council to uphold.	SDG 7, SDG 8	

11.6 Financing

Type	Recommendation	Link to SDGs	Workshops
Strengthen existing activity	Climate and Green Finance opportunities. Increase climate considerations as part of grant application processes for a sector within City of Melville as a pilot and expand drawing on lessons from the pilot. Council should also look to scale up financial structures for grassroot community solutions for climate change.	SDG 13	
Building Capacity and Understanding	Identify more options to grow locally (roof gardens, community gardens, indoor gardens etc.) and support local initiatives through grant funding.	SDG 2	
New adaptation, and mitigation action needed	Reporting through Taskforce on Nature-Related Financial Disclosures (TNFDs). The City should address nature-based capital benefits through recognised disclosure methods such as TNFD. Our natural environment provides a range of ecosystem services (e.g., clean air, temperature regulation, improved mental health outcomes). Through initiatives such as the TNFD, Australia is part of the global push to quantify and incorporate these “natural capital” benefits into decision-making.	SDG 13, 14 and 15	
New adaptation, and mitigation action needed	Grants or Schemes could be investigated that encourage landlords to adapt and increase the resiliency of their property against climate hazards.	SDG 10, SDG 11	
New adaptation, and mitigation action needed	Grants could be provided to renting households to assist in post disaster recovery.	SDG 10	

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Grants could be provided to low-income households to recover from climate hazards. The assessments should also be done to determine how to embed resiliency into low-income households to better equip them for future extreme climate events.	SDG 8, SDG 13	
Strengthen existing activity	Create tiered payment structures for high usage groups such as waste, water, power, state government and the business community.	SDG 11, SDG 10	

11.7 Habitat Protection (flora and fauna)

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Planting to increase pedestrian pathway shade, particularly around school paths and local shopping precincts.	SDG 13, SDG 15	
Strengthen existing activity	Adapt tree selection and establishment based on health, lifespan, function, and adaptability in a changing climate.	SDG 13, SDG 15	
Strengthen existing activity	Enhance canopy cover, habitat, carbon drawdown potential, and ecological community connectivity. Engage with traditional cultures and knowledge to assist in managing land.	SDG 16	
Additional action needed	Expand Council's existing street tree program, particularly focussing on plants capable of tolerating Urban Heat Island Effect. Explore options to assist community members to plant native trees/plants on their nature strips.	SDG 15	
Additional action needed	Increase tree shading across the city – set targets and a pathway to achieve the goals.	SDG 13, SDG 15	
Additional action needed	Plant for a changing climate – Research future climate of Melville (using Climate Analogues) and match flora/fauna to species currently adapted to these areas (and plant/translocate). Such as prepare an updated list of native species suited to the future climate envelop and ensure future vegetation plantings are climate appropriate.	SDG 13, SDG 15, SDG 14	
Strengthen existing activity	Diversify species (to avoid homogenisation and extinction during a single shock event).	SDG 14, SDG 15	
Additional action needed	Restore and protect ecosystems (both terrestrial and aquatic).	SDG 14, SDG 15	
New adaptation, and mitigation action needed	Monitor emerging pest species (including diseases) and how they respond to climate change.	SDG 14, SDG 15	
New adaptation, and mitigation action needed	Explore options to implement nature-based solutions to serve as protective buffers against the impacts of disasters and climate change. Especially focusing on areas of flooding and riverine erosion.	SDG 11, SDG 15, SDG 13	

Type	Recommendation	Link to SDGs	Workshops
Building Capacity and Understanding	Explore options for carbon sequestration projects with local land, coastal/foreshore, and wetland sites with local Registered Aboriginal Parties, private landowners, community groups, and other councils/agencies.	SDG 13, SDG 9	
Additional action needed	Conduct a climate-risk assessment on Council's heritage-listed vegetation assets and prepare management plans.	SDG 13	
New adaptation, and mitigation action needed	Look into developing a pathway to transition to dry parks.	SDG 15	
New adaptation, and mitigation action needed	Creation of a council nursery for council, residents, and groups, supplying local natives (free or cheap), run by volunteers to create community cohesion.	SDG 13, SDG 15	
Strengthen existing activity	Implement tighter invasive species control measures (cats, foxes etc).	SDG 15, SDG 14	
Additional action needed	Increase the diversity and number of invertebrates that are indigenous plant pollinators (bee hotels, plant planters along streets).	SDG 15	
Strengthen existing activity	Develop community resilience to natural hazards through community development, workshops, and training.	SDG 14, SDG 15, SDG 13	
Additional action needed	Explore native based (wetland) mitigation options for flash flooding.	SDG 13, SDG 14, SDG 15	

11.8 Planning

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Air Quality Recommendation. Reduce the impacts of poor air quality on the population's health, especially focusing on areas with high elderly population and those who identify with medical health conditions (asthma, lung conditions, etc.) - with a focus to improve the public realm and housing quality to reduce the impact of increased air quality impacts especially during periods of bushfires.	SDG 3	
Additional action needed	Create an independent geographical database (online for everyone) that has all climate risk information.	SDG 13	
New adaptation, and mitigation action needed	Incorporate One Planet Living principles and the UN SDGs to Council projects and plans by setting up internal training and procedures for all staff to comply with.	SDG 17	

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Integrate climate emergency considerations into all Council decision making. Work with Climate Emergency Australia to identify gaps and develop procedures for all staff in Council to understand their role in reducing emissions and the impacts of climate events in their day-to-day lives as Council staff members.	SDG 13	
New adaptation, and mitigation action needed	Council's Internal Risk Register. Ensure climate risks are recorded with mitigation/adaptation strategies listed beside them in Council's internal Risk Register and identify key responsibilities and KPIs for measuring.	SDG 13	
Additional action needed	Set strong design standards in an ESD building policy ensuring buildings are demonstrating environmental and climate resilience through design, construction, and operation.	SDG 9, SDG 11	
Additional action needed	Integrate SuDS (Sustainable Drainage Systems) principles into land use planning and regulation.	SDG 11	
Building Capacity and Understanding	Pilot WSUD (water-sensitive urban design) and SuDS (sustainable urban drainage system) principles into a large-scale water sensitive project in the City.	SDG 11	
Strengthen existing activity	Allocate responsibility for water sensitive urban design in Council (a leadership role) (updates of guidelines, dissemination of practices and enforcement of requirements). This could include ensure gardens are water-sensitive, capable of withstanding significant dry periods (particularly given Melville's ongoing water restrictions).	SDG 11	
New adaptation, and mitigation action needed	Update Council's asset management plans to include climate change considerations including undertaking an adaptative pathways assessment to identify treatment options for operations and maintenance of the assets in the face of the changing climate.	SDG 13	
Strengthen existing activity	Review Council LSPS, LEP and DCP and incorporate resilience planning mechanisms and requirements. These should have particular focus on addressing the urban heat island effect, increases in extreme heat, increased rainfall intensity and sea level rise and storm surge. Some initiatives to address these risks have been identified through this risk assessment process.	SDG 17	
Additional action needed	Establish environmental management systems (EMS) to help understand resource consumption and areas where resources could be saved.	SDG 12	
Building Capacity and Understanding	Explore options to implement nature-based solutions to serve as protective buffers against the impacts of disasters and climate change.	SDG 13, SDG 14, SDG 15	
Building Capacity and Understanding	Promote and advocate for 'Aging in place' homes.	SDG 10	

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Develop a national best practice bushfire program.	SDG 13, SDG 15	
New adaptation, and mitigation action needed	Undertake more detailed flood modelling to manage flood risk from rivers, surface water and future sea level rise to homes and businesses based on the latest climate projections and build a strong framework for new development and inward investment which avoids or minimises future risk.	SDG 13, SDG 14, SDG 11	
New adaptation, and mitigation action needed	Consistently monitor sea level rise, erosion impacts to river front, and frequency of overtopping of the foreshore walls to determine when adaptation measures should be implemented as part of a pathways-based approach to foreshore management.	SDG 13, SDG 14	
New adaptation, and mitigation action needed	Integrate WSUD and enhance Melville as a water smart city. Intercept run-off, increase soil moisture, manage flood risk, enhance green spaces, improve waterway health.	SDG 14, SDG 11	
New adaptation, and mitigation action needed	Diversify job sector within the City to ensure there is diversity of employment.	SDG 8	
New adaptation, and mitigation action needed	Flood mapping. It is recommended that the City undertakes computational modelling to assess flood risk accounting for the projected effects of climate change. At a minimum, this should include the effects of pluvial and fluvial flooding, in addition to riverine foreshore flooding due to sea level rise and storm surges. This mapping exercise will equip the City with the understanding of where flooding is likely to impact communities to advise residents and plan accordingly. It will also provide sound information to help inform updates to future planning and building regulations, in addition to City-wide strategies and policies. This exercise should provide more targeted advice as to which properties are more impacted than others, rather than using larger ward areas as the context.	SDG 11, SDG 13, SDG 14	
New adaptation, and mitigation action needed	It may be useful for Council to monitor and document the impacts of flood hazards when they occur to track duration, extents, financial cost, response effort and time to rebuild.	SDG 11, SDG 10	
Strengthen existing activity	Continue to monitor water consumption and regulate during periods of drought. Look into climate changes and when these may need to be increased.	SDG 6, SDG 13, SDG 10	
New adaptation, and mitigation action needed	Explore avenues to move/relocate infrastructure inland and not approve any riverine foreshore development.	SDG 11, SDG 14	
New adaptation, and mitigation action needed	It is recommended that the City undertake a comprehensive mapping exercise to overlay FFDI (accounting for climate change projections) with bushfire risk. These should include indirect impacts of bushfires including travelling embers and radiant heat.	SDG 13	

Type	Recommendation	Link to SDGs	Workshops
New adaptation, and mitigation action needed	Heat Risk Map. It is recommended that visual maps be developed for the City to provide depicted of temperature hazards to be communicated easily to the public and decision-makers. Considering the availability of data, this should be a time-efficient exercise. This could be combined with overlays of communities that are more susceptible to heat exposure such as elderly populations and very young populations.	SDG 13	
New adaptation, and mitigation action needed	Further studies should include impacts on UHI and the ambient temperatures within built-up areas.	SDG 11	
Additional action needed	It is recommended that shapefiles provided in the 2019 version of the Foreshore Restoration Strategy be used to develop a visual map of the foreshore to provide a baseline for erosion monitoring. If data is available for previous years, the earliest date should be used as the baseline, and subsequent years overlayed to understand the extent of erosion.	SDG 13, SDG 14, SDG 15	
Strengthen existing activity	As they play an important role in community wellbeing, the protection and effective maintenance of the City natural environments, parks and public areas adapted to project changes in climate will be pertinent to ensure they continue providing the community the services they need. This is particularly applicable to Mount Pleasant and Willagee who have higher population densities.	SDG 15	
Additional action needed	Ensure that emergency evacuation centres are appropriately distributed throughout the City territory and cater to all members of the community (non-native English speakers as well as Indigenous community members). This is particularly applicable to the wards of Bull Creek and Leeming as they are not near a nominated evacuation centre. Consideration of language is particularly applicable for Bull Creek and Kardinya.	SDG 10	
Additional action needed	Undertake a climate change risk assessment for each nominated emergency evacuation centre and critical social infrastructure to identify key vulnerabilities and develop effective contingency plans.	SDG 13	
Additional action needed	If not already undertaken, conduct an assessment of native ecosystem and vegetation health and understand how projected changes in climate may impact these environments. As applicable, manage these areas in order to bolster their resilience to projected changes in climate.	SDG 15	
Additional action needed	Create clear guidelines for dealing with conflicts between rooftop solar and trees.	SDG 7, SDG 11	
New adaptation, and mitigation action needed	Investigate the feasibility of facilitating the landward retreat of nearshore, intertidal and shallow water ecosystems adjacent to the Swan River.	SDG 14, SDG 15	

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Plan and communicate evacuation routes for flood events, particularly for vulnerable wards including Bull Creek, and river-side wards such as Attadale, Applecross and Mount Pleasant.	SDG 10, SDG 11	
New adaptation, and mitigation action needed	Implement standards to increase maximum operational temperatures for critical infrastructure based on expected temperature increases, to supply key services, including mechanical and electrical infrastructure.	SDG 9, SDG 11	
Additional action needed	Consider implementation of nature-based solutions in replacement of, or in combination with traditional infrastructure to mitigate impacts of climate change.	SDG 13, SDG 14, SDG 15	
Additional action needed	Consider improving flood modelling and standards, including the possibility of building raised houses (on stilts).	SDG 11	
New adaptation, and mitigation action needed	Explore avenues to increase urban density (medium or high-rise) but not at the expense of open/green space.	SDG 15	
Strengthen existing activity	Work with state government to move power lines underground to reduce the outages caused by extreme weather events.	SDG 11, SDG 13	
Additional action needed	Establish public health programs that respond to the changing climate and look at key 'trigger' points for interventions.	SDG 3	
Strengthen existing activity	Employer-value proposition - There is an opportunity to become industry leading as a sustainable organisation (attracting talent to the Council).	SDG 11, SDG 8	

11.9 Transport

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Transition towards hybrid and electric vehicles, installing EV charging stations at Council-owned sites to encourage this transition.	SDG 7	
Strengthen existing activity	Promote active transport and embed climate considerations into road and pathway infrastructure planning. Including improving transportation to main hubs in the city and look into parking charges to provide more public transportation.	SDG 13, SDG 11	

Type	Recommendation	Link to SDGs	Workshops
Additional action needed	Active Transport Modes. Reallocate road and parking space to favour active transport modes – e.g., widen footpaths, public transport improvements, prioritising walking paths, promoting car sharing, restrict parking to maximise sustainable transport modes, reduce speed zones to encourage walking/cycling.	SDG 3, SDG 11, SDG 13	
New adaptation, and mitigation action needed	It would be imperative to understand the modes of transport used by those that are unemployed, are from a low-income household, residing in social housing and retirement villages. Often in climatic hazards access and connectivity can be an issue.	SDG 10, SDG 1, SDG 13	
New adaptation, and mitigation action needed	Improve redundancy in transport infrastructure – alternate routes in an out of each of the suburbs.	SDG 11	
Strengthen existing activity	Consider implementing additional stations for public transport access for communities with limited options.	SDG 11	
Building Capacity and Understanding	Plan and communicate detour routes during bushfire events considering the risk to the Kwinana Freeway.	SDG 4	
Strengthen existing activity	Improvement of active and public transport opportunities for the community to reduce transport emissions.	SDG 3, SDG 11	
Additional action needed	The City should consider the micro-mobility market and active transportation methods when updating city planning documents.	SDG 11	

12 Next Steps

This VRO report will be used to inform the development of a Climate Action Plan that is to be developed by the City. As direct next steps, WSP recommends:

- Major data gaps for various climate risks be filled
- A prioritisation process for the recommendations is undertaken with the community to identify priority actions
- A business case is prepared for each action (action owner, supporting stakeholders, costs, implementation steps, climate co-benefit, etc.).
- A pathways approach is adopted for the Climate Action Plan.

WSP also recommends that the City undertakes a Climate Vulnerability, Risk and Opportunity Assessment every 3-5 years as new climate data becomes available.

12.1 Limitations

The key limitations relevant to this assessment are as follows:

- Uncertainty is an inherent element of risk and risk assessments. This should be considered when interpreting the findings of this report.
- The climate change projections adopted are based on publicly available data (from the Commonwealth Scientific and Industrial Research Organisation (CSIRO)'s Climate Change in Australia Website – Summary Data Explorer, Extremes Data Explorer, and Threshold Calculator, East Coast Cluster Report, and BoM). All climate projections involve a degree of uncertainty; if climate change projections change throughout the life of the project this assessment should be revisited.
- Information and data used throughout this assessment assumes a degree of quality and availability. It is possible that some information used may be limited which can affect the accuracy and reliability of aspects of the assessment.
- Analysis by third parties has informed this risk assessment (e.g., flood modelling). No effort has been made to validate the accuracy of analysis undertaken by third parties.
- Despite the advice provided within this VRO, the implementation of actions resultant of the Climate Action Plan may incur challenges due to a number of factors, including political will, funding constraints and limitations associated with the capacity of government and community organisations responsible for implementation. It is the responsibility of the City to conduct proper feasibility assessment of any actions carried through.
- In addition to the information provided within this VRO assessment, it is also important to consider the interdependencies of different systems such as transport, communications and social infrastructure when considering impact of climate change
- External factors may also create limitations for this assessment. Changes in policies, economic conditions and technological advancements may impact the effectiveness of recommendations or actions and must be evaluated in this scenario

APPENDIX

Appendix A

Workshop Notes

Table A-1. Risks and Opportunities Identified During Workshops with the City in December 2022

Theme	Risk	Opportunity
Circular economy	— Reusing asset increases cost and the resources used in storing such assets, along with the skills required — Food wastage and loss of agricultural farming land (to hardstand)	— Upcycle — Recycle — Reduce waste initiatives — Community initiatives reducing waste in homes — Worm farm initiative — Harness waste energy
Transport	— Free parking reduces uptake of active/public transport — High private vehicle reliance — Active transport in hot weather	— Sustainable transport options — Move away from petrol machinery — Focus on community centres and connected public transport — Ticketed parking with revenue subsidising buses — New technology for electric waste truck — Electrify fleet — Fast charging stations — Become a walkable/walking City — End of trip facilities — More public transport within the region — Opportunity to become industry leading — Electric vehicles/hybrids, e-bikes (could be part of salary packaging) — Reduce car parking — More cycle lands — Better connectivity — Design roads to focus on people not cars — Use of one vehicle for bushfire and compliance monitoring undertaken by the City — Shaded, walkable streets — Driverless bus — Monorail

Theme	Risk	Opportunity
		— Bus rapid transit system
Finance	— Increased insurance premiums — Increased service maintenance costs — Material supply — Resourcing – funding the right areas? — Litigation — Cost of sustainable materials — Increased business operation costs — Asset value and management — Financial risk — Venue insurance costs	— Smart technology that provides useful data to change behaviours and make different decisions. — Sustainability expos — Innovation and research grant funding — Investment support — Grants supporting vulnerable populations
Climate hazards	— Fire (including dust and smoke hazards) — Sea level rise — Disease/pandemics — Flash flooding — Estuarine flooding	— Put a climate lens on all that we do
Energy	— Loss of power due to grid overload — Increased energy demands — Power outages during hotter climates — Poorly designed buildings for hotter climates — Reliance on power to cool, heat and grow food — Transition to electric	— Establish local micro-grids for energy sustainability — Street lighting scheme — Renewable energy — Community batteries — Switch all community centres off gas
Change Management	— Organisational (City) buy-in — Community backlash (doing too much (push back) or not enough)	— Employer-value proposition - opportunity to become industry leading as a sustainable organisation (attracting talent) — Transform Piney Lakes Education Centre into an Innovation Hub — Community education

Theme	Risk	Opportunity
	— Conflict between Council's traditional roles and working as a leader in net-zero/resilience — Working in silos — Organisational capability and expertise	— Internal alignment — Consistent messaging — Activity centres — Work with existing working groups — Think global, act local — Find easy solutions to existing barriers — Equity – a socially just transition
Engagement and education	— SMS notification systems — People leave Melville for work/education — Resource availability — Placemaking is different when it occurs inside	— Local champions — Co-designed solutions — Facilitate education and awareness — Engage First Nations people — Technology solutions — Hackathon — Education and alignment between staff — Industry partnerships with local businesses to supply technology/infrastructure needed, including First Nations people — Build community skills and connections — Partner with Murdoch University and Curtin University e.g., Carnaby habitat and water quality — Cross Council collaboration — Continue and strengthen cross-service areas collaboration — Grants/funding — Create partnerships to create more local resilience — Create new jobs — Incentives to stay in the area — Business owner education — Show best practice — Understand what is happening regionally – connectivity, sustainability, supply chain — Internal capacity building and dissemination of information — Reconnect community with local suppliers and businesses

Theme	Risk	Opportunity
Politics	— Behaviour changes around controversial topics — Conservative mindset — Community mistrust — Time sensitivity — Political environment — Reputational risks — Public liability — Bureaucracy	— Advocacy — Prioritisation (impact, resourcing, cost) — Follow through with action (do what we say we will) — Local Planning Scheme and policies to require tree retention or more tree planting — Culture can lead legislation
Heat	— Increased heat — Heatstroke — Increased public air conditioning demands due to cost of home cooling — Outdoor parking hot due to concrete — Building heat during summer months — Ops Centre Workshop is in the heat — Working in extreme heat conditions — Public water availability and spaces to cool down — Cooling systems ability to cope — Reduced number of outdoor events	— Space redesign: change the use of spaces to encourage night-time usage (outside high heat periods) — Split shifts/flexible work hours to avoid working in extreme heat or work later in the day/at night — Education and communication — Collect temperature and air quality data — New technology to manage site visits for the Community Safety Services (CSS) team — Longer opening hours — Refurbish buildings to be more comfortable and resilient with a reduced heat, ventilation, and air conditioning energy demand
Infrastructure design	— Destruction due to vulnerable location — Inadequate stormwater infrastructure — Change in the look and feel of the City during transitional period — Poor drainage infrastructure — Limited building design guidance	— Redesign spaces for heat — Retrofit — Erosion control structures — Smart, carbon neutral buildings and street lighting — Proactive design for the new norm — Advocate to State Government around changes to Building Code to improve climate resilience — Review design standards and planning controls

Theme	Risk	Opportunity
	— Fit for purpose — Shared paths lost during extreme storms — Urban development — Building proximity to bushfire risk areas	— Strategic development in key locations (ensuring centres and corridors) — Awnings — Streetscape enhancements — Urban open space and tree canopy responses — Educate around planning changes e.g., R Code splits — Corridor planning approach — New Library and Culture Centre (LCC) design — Create climate friendly places/hubs — Green Star for future development – integration into local planning scheme — Smart City Strategy — House on stilts
Recreation	— Reduced outdoor recreation space — Flooding of sports fields — Artificial turf and urban heat island (UHI) effect — UHI — Hot water demands at community facilities	— LeisureFit Aquatic facility upgrade to reduce carbon footprint – carbon neutral — Drought resilient sport surfaces – investigate alternatives that aren't artificial turf for laws/parks/ovals — Misting to reduce temperature — Shading

Theme	Risk	Opportunity
Natural environments	— Land use — Foreshore inundation — Quality of open space impacted — Increased usage of public spaces — Impact to vegetation, fauna, insect, etc. — Weed increase and control — Fire risks — Increased estuarine salinity — Reduced amenity/services/tree canopy — Tension between urban and natural environments — Erosion impacting drainage and property values	— Water dry parks — Salt tolerant species — Consider a transition to dry parks — Prioritise park assets — Install shade in open spaces — Encourage species adaptation — Reduce bushland clearing
Trees	— Watering — Loss of canopy — Impact on groundwater — Changes in species — Misalignment between state and community expectations — Reduced water table and lower rainfall impacting trees	— Research WA plants and materials/techniques that will be more at risk — Tree canopy mapping — Birch trees — Proactive monitoring — Behaviour change/education alongside policy/regulation changes around private property tree retention — Lobby government for legislative changes — Nature-based solutions — Tree retention and protection — Significant trees register

Theme	Risk	Opportunity
Water	— Hot water demands require gas — Stormwater network — Rowing club flooding — Water scarcity — Increased salinity — Declining bore water allocation for watering parks/laws — Diminishing aquifers and recharge — Tree planting and water requirements — Impacts to leisure activities — Algal blooms — Sea walls for asset protection – expensive — Raw sewage in waterways	— Transition to alternative heating methods such as heat exchanges — Incorporate WSUD — Education — Nature pool — Work with other LGAs and State government regarding foreshore erosion and action
Work health and safety (WHS)	— Changing WHS procedures — Increased number of no outside workdays — Increased personal protection equipment requirements — Working hours — Extreme events — Drinking water — Heat related illness/death — Heat stress — Staff safety during site visits — Mental/emotional wellbeing — Impact on community health — Climate anxiety (especially in young people)	— City training to manage community encounters who require medical help — Support the health industry through facilitation/education/awareness raising

Theme	Risk	Opportunity
Housing	—	— Affordable housing and diversity — Social housing — Advocate for public and social housing with access to renewable energy (solar, wind, batteries)
Vulnerable groups (older people, young people, Aboriginal and Torres Strait Islander peoples, people with chronic health issues)	— Aging community — Access to services — Awareness of the issue — Often located in at risk locations — Social isolation — People sleeping rough exposed to extreme weather — Lost social connections	— ‘Aging in place’ homes — Melville aged care bus (already exists) — Offer additional health services and support — Engage with Traditional Owners — Emergency management and strategies to support vulnerable groups (training) — Subsidies to electrify house, insulate, solar, batteries, air conditioning — Facility opening hours for vulnerable people — Homelessness services and support — Home delivery services

Community Workshops

Table A-2. Risks and Opportunities Identified During Workshops with the Community in February 2023

Theme	Risk	Recommendations
Biodiversity	— Decrease in/lower biodiversity — Biodiversity loss/extinction risk — Parks + gardens + bushland – weeds + pests increase — Recreation areas less appealing — Heat – biodiversity affected — Lakes + wetlands can be damaged — Less beauty – plants dying — Migration problems of animals and people — Decrease in biodiversity — Impact on local wildlife — Ecological impact à drying lakes à decrease/dying vegetation à loss of habitat and decreased biodiversity — Air quality decline — Natural resources diminished – biodiversity risk — Loss of vegetation in urban centres, developments – urban infill creating heat/lack of green capes clean air! — Loss of fringing vegetation and habitat — Public open space monopolised by adaptation (drainage) — Loss of vegetation – urban infill — Increased bush fire risk – threat to biodiversity — Decreasing biodiversity — Death/loss of trees and wildlife and people — Increasing temperature flora/fauna impact compounding on biodiversity and ecosystems — Loss of biodiversity — Loss of species – birds, reptiles — Loss of insects affects whole food chain including food	— Community gardens everywhere. Lots of families in the area. – Rick Vosper Reserve also part of the Mt Pleasant bowling club – not used for competitions — Design and incentivise more green spaces and private gardens — More free/cheap local native seedlings and in parks — Keep wetlands. Council groups — Get rid of home lawns — Council and community plant local natives more biodiversity — Insect hotels in community, perks and complimentary plant planters — Man-made habitats/wires/shelters for local (endemic) species — Use technology to measure and modify the environment – measure impacts/change — Use technology to monitor to identify heat stress in bushland – City of Melville — Create /retain larger areas of ‘greenscape’ in urban centres/developments – planning implementation — Plant natives – City — Biodiversity corridors and pockets – State Gov/Melville City — Develop drainage and other “lost” space for canopy, POS, water quality improvement, biodiversity – Melville City — Increased green canopy/landscape – Melville City — Create and maintain local green spaces – keep trees in local developments — Biodiversity protocols – increased tree canopy – council laws to enforce — Encourage replacement on lawn with native verges encourage and rewild (local fauna/flora) – council and community

Theme	Risk	Recommendations
		— Council to acquire land between high rise building and create open, green space (council will be greeting increased revenue from increased rates so can afford to buy land) — Enforce more native gardens as opposed to introduced species (re-wild Melville) fill unused spaces in native gardens — Council – More wild spaces on the edges of existing recreation spaces — Tighter control of cats, foxes, etc — Increased diversity and number of invertebrates that are pollinators of indigenous plants, i.e., moths, bees, native bees — Participation in re-wild Perth initiative by Perth NRM to 'Bring Nature Home' — Increase bird nesting – community, birds — Encourage permaculture – increasing diversity of plants, suitable plants
Bushfire	— Fire — Extreme weather — Increased fire risk — Neighbours to bushland — Fires – smoke – lung health — Bushfires and smoke haze and air quality — Bushfire risk — Biodiversity threat — Air quality decline — Increasing demand on health sector — Need for greater fire control due to accidental/set fires — Risks of no/little access to parkland for fire trucks when fire occurs (deliberately at times) — Increasing fire risks — Air quality — Vulnerability — Demographics	— Controlled burns — Manage bushland building codes

Theme	Risk	Recommendations
	— Register/emergency response — Increase in fire coupled with less water available means greater use of polluting fire retardant — Fires in parks especially wireless hill park	
Climate	— Unpredictability of climate	— N/A
Community	— Community isolation — Fewer outdoor places — No farmers market — Outdoor community sports — Risk of increase in homelessness — Inequity in coping — Politics – conflict from different ideas – move to radical views — Human response to climate change – we may get it wrong — Volunteer burnout/reduced service provision — Further inequity in social systems — Breakdown of social cohesion — People focused on traditional suburbs – vegetation/housing — Over reliance on mitigation rather than change — Have/have not – bridging low socio-economic/vulnerable — Impact on community groups/business = collapse — Equity — Outdoor lifestyle activities — Division between have and have nots — Increased domestic violence	— Healthier lifestyles — Weight loss — Leisure centres — Reducing costs — More leisure centres — Encourage more local business – so more local made products – City of Melville — Increase availability and accessibility of public climate-controlled facilities — Community to take care of the bush around Forrington Rd — Council supporting local and care groups — Educate — Education re why less lawn, water — Community education on resources available community hub/connect communities app — Food growing as a social enterprise like North Freo social farm — Expanding and making more accessible community gardens — Focus on how we support vulnerable people at a community level — Targeted re-vege and community gardens in high concreted heat island areas — Community infiltration and permeability of infrastructure (at source) — Education and info on growing your own food — Create community gardens to increase food security and increased social interaction – City of Melville — Identify and support anchor institutes and support community engagement for sustainability – City of Melville

Theme	Risk	Recommendations
		— Community-led solutions – liaise with communities to support in activities and actions – City of Melville — Educate community to better service/save their environments – Vice Local Council — Develop community resilience to natural hazards through community development and workshops and training – City of Melville/State gov/community — Vulnerability – based insurance premiums (equity?) business community — Education à circular economy à wastage à greening value — Embed to build practices — Love the togo tags! – City of Melville — Community resilience to natural hazards – state gov, Melville City, community — Maintain an active and engaged volunteer emergency service base that adapts to emerging risks – state gov — Educate the residents of Me need to attain 350ppm goal — Areas of Aboriginal significant protected and education shared on specific land management – Council and local groups — Community — Reduce grass — Adopt permaculture principles in gardens and parks — Community education about climate change — Workshops leading discussion — Council — Ban council Astro turf — Education — Effective messages — Schools — Council — City of Melville – plot ratios are too big – reduce them — Undertake large scale education programme including billboards – education

Theme	Risk	Recommendations
		— Melville Planning Dept work to create environment development — Community education – incentives to plant trees — Ask 1st nation people how to manage land — Support for comm groups to operate in and governance of groups
Cost burdens	— Cost of living etc cooling house — Cost factors, ability to adapt — Food costs going up — Energy costs increase — Water costs and use increase — Increase in rates to fund mitigation — Electricity bills increasing – equity — Cost of living affordability and air conditioning. Infrastructure maintenance — Higher insurance premiums — Increased cost of waste management — Increasing costs to keep cool in summer and warm in winter (household and business) — Less patronage for business in extreme weather – particularly rain — Increased costs to business — Reporting — Stranded assets — Rising insurance costs — Increase cost – business and households — Increased cost of insurance — Rising costs of insurance — Widening inequalities — Electricity — Water	— The Dept of Health used to run a fantastic program called Food Cents. It would be a great one for the City to implement in the context of rising food costs caused by climate change. i.e., how to stretch food budgets – could be linked to community good groups. — Bulk buying/zero packaging — Fund/implement mobility plan — Put up rates if no solar panels, so landlords have to. For renters — Expanding APACE subsidy initiatives and making it more accessible and known of — Grants for community — Home sustainability audits — Insulation — Rain tanks — Waterwise gardens — Enterprise risk plans for local businesses – peer learning (city of Melville) — Subsidise manufacturing – keeping it local — Tiered payment structures for high usage groups and waste, water, power, state gov and business community — COM voting for grants shouldn't be only by public vote – good projects don't always get up
Disease	— Mosquito breeding groups increased — Bateman see more of insects – virus — Diseases — Parasites do well in lukewarm weather	— N/A

Theme	Risk	Recommendations
	— Pathogens — Another pandemic — Increase vector disease — Respiratory illnesses — Injury and illness from extreme events	
Energy	— Power grid outages due to A/C demand spikes — Energy security – risk of blackouts — Power outages from severe weather events — Power supply risk for business continuity — Reliance on power to fix things (air con, desal, transport) — Energy sources à finding more renewable, affordable, reliable sources	— Require businesses to have solar panels/energy efficiency — Grid stability coordination – batteries — Solar panels on buses — Underground power à increased canopy cover — Subsidise solar — Encourage solar power and electric vehicle use — Community batteries — Renters — Low income — Community batteries for solar – City of Melville — Use sources of 'renewable energy' – State Government — Underground power – loss of outages in extreme weather events – state gov — State community solar battery — Get off gas – electrify every home – council incentive
Health	— Pressure on emergency services and health care system during heatwave/fire — Heat health — Increased mortality from more intense events — Health risk/emergency presentations from heat/dehydration — Overwhelmed emergency services capacity — Mental health impact due to reduced social connectedness from isolation from weather events — Increased demand on health services — Mental health — Social unrest — Isolation	— Emergency services coordination — More SES volunteers for accident – emergency — Work with emergency response services to identify vulnerable communities + action plans – City of Melville — Early warning systems for air quality/water quality – City of Melville — Public health campaign to link climate health to human health – City of Melville — City of Melville to have optional register of where vulnerable elderly and disabled live so emergency service can rescue them

Theme	Risk	Recommendations
	— Domestic violence increased — Health impacts due to power outages during extreme heat or storm events — Decreased air quality causing decreased health — Increased demand on health services — Residence health problem — Increasing hospital visitations response Murdoch Fiona Stanley — Mental health à support groups — Death rates/chronic diseases increase	
Infrastructure	— Home design not coping (equity again) — Infrastructure failures — Impact on City of Melville facilities as people seek shelter/cooling centres — Damage to infrastructure — Urban infill not designed for hotter climate and lower temp – sick. Increased death rates. — Location choices	— Building codes — Drainage — Stormwater ways — More efficient housing design – insulation — Lower rates for better designs — Good town planning – (net zero Perth) Scott Ludlum and Brad Pettitt plan — Council regulate and promote better house design — Policies for buildings including roof colour to reflect light/heat in community — New builds to include Green Star and Infrastructure to be ISC rated — Land use and building policies and local resilience in housing builds — New buildings (MSDs) must have an — “eco guideline” — No gas, solar etc — Restrictions — Block size to house size = more green space – state and council — City of Melville planning codes support sustainable social housing – local and state govt — Ban extra urban infill (protect all current green spaces) even turn housing into parks – state govt — Planning codes – support social/low-cost housing – low cost, more sustainable buildings

Theme	Risk	Recommendations
Mitigation	— Net zero risk — Decreasing 350 — Illusion of net zero – need to consider a lot more, do job properly (not credits) – down to 350 parts per million — Develop alternative carbon capture systems	— Opportunity of developing tech solutions and be a leader – business community — Data based mitigation strategy (weather, air, water quality) – state gov
Storms	— Extreme storms – damages to houses and infrastructure — Extreme storm/rain – house and infrastructure damage — Storms – weather damage, accidents — Increased storm related damage to households — Increasing storms — Water quality and force of nature and underground power — Infrastructure response of Government Emergency — Impact of more cyclones	— Introduce cyclone/storm rating to structure design – state government
Supply chain	— Supply chain and food security — Supply chain disruption — Supply chain disruption – food security — Food security/availability locally and globally — Conflict/fighting over food/water — Supply chain disruption — Food insecurity for vulnerable people — Material shortages/supply chains — Supply chain disruption – business/community — Food shortages security — Ability to grow food decreases – food insecurity — Growing enough food for all	— Possible solution – increase stock held, depending on rate of use, to cover for “no incoming” for extreme length of time — Increase the use of local suppliers – City of Melville — Identifying at risk supplies and create local suppliers where possible or alternatives — Increased use of local suppliers – buy local (community/businesses)
Temperature increases	— Rising temperatures à impact on elderly — Heat effecting health (working out) — Productivity shutting down (more hot days) — Increase risk of heat stroke — Increased use of electricity – hot — Increased demand for public climate-controlled facilities — Exercise outdoors becomes difficult/impossible in hotter months	— Use technology to measure/modify heat stress — Indoor sports more cheaper leisure centres later hours — Cheaper leisure centres — Identification and mapping of hot spots to plant heat stress mitigation – state gov and Melville City — Ban of artificial lawn on verges due to temperature and insurance – council

Theme	Risk	Recommendations
	— Heat stress — Mortality rates up — - injury — Heat — School – business shut-down shopping centres — Productivity/construction activity slows due to heat — Heat à local sports impacted — Increase in food waste due to increased heat — Local leisure centres busier/at capacity — Rising temps' impact on elderly – my Dad — Concrete jungle – heat/areas in Melville — More reliance on industrial farming and inorganic foods due to heat and insect proliferation — Rising temps' impact on my vege and fruit garden. Growing my food. — Not being able to go outside and enjoy my environment - too hot or too cold — Less greening à urban heat island effect. Increased individual risk and health impacts. — Extreme heat events — Decrease greening, heat, mental health, stay at home — Increased number of days with temp >37^{o}C — Too hot to go out à more isolation à loneliness/depression — Attadale reserve is a heat island — Increasing temp = less use of active transport e.g., bikes, walking, bus/public — Increase in heat island – Attadale reserve. Kids affected by heat – heat risks — Number of days of high temps – less trees — Hotter temps – lose amenity — Risk of depopulation if temp gets too hot	
Transportation	— City of Melville plans à mobility	— More public transport or walking/cycling — Mobility plans

Theme	Risk	Recommendations
	— Derailment of Melville's future mobility, plans (cycling, walking, public transit) due to heatstroke/discomfort — Less walking à more cars à more accidents (cycle continues) — Transport security – pedestrian amenity	— Increase tree cover along paths — Reduce road widths to increase space + efficiency for active mobility — Better end-of-trip facilities at CoM buildings, add end-of-trip facilities to building codes (bike parking, showers, lockers) — Carpark solar panels — Rebate for install solar panel — Bus shelters – shade — Better local public transport and shaded bus — Electrification of City facilities/services, businesses — Rebates for businesses in transition — Advocate for better public transport — Increase density along transport routes to minimise vehicle needs — Footpaths — Local bus routes — (council more) — Increased density along transport routes to decrease car use – minimum densities — Heat and transport – shelters at all public transport depots (esp. for vulnerable) and natural shade reassessment – transparency — Shelters at all bus stops – natural or made
Trees	— Increase in tree death — Increased risk of tree death — Less grass — Decreasing number of trees as houses get bigger and do not plant trees — Old growth trees falling over in wetlands — Less shade — Lack of shade areas in parks — Urban infill – density decreasing trees	— Council supplied NATIVE trees — Increased rates for new development with less than 15% canopy cover — Watering street trees during heat waves to maintain cooling capacity — Australian plants in gardens — More trees in parking areas due to increased heat on cars — Rules resubdivision and keeping trees — Discounts on rates if you have verge trees — More tree canopy on council land — Street trees - safe, maintenance (storms) — A council nursery: for council and residents and groups, local natives, free or cheap seedlings. Volunteers – I'd volunteer!

Theme	Risk	Recommendations
		— Council à to change verges – mulch plant — Cooling suburb – tree canopy less strain on house to keep cool — More shelters at parks — Planting more trees and providing shade on street scape (native/endemic) — Cooler/shaded bus stops and trees etc — Accelerated tree planting program – City of Melville — By laws to protect trees canopy from infill – City of Melville — Increased tree planting program – native trees, resilient plants — Compulsory trees for verges/number council — Development sites min retention of green – council — Plant trees — Subsidy to carpark — Plant more trees to decrease temperature, council land, government land, more wild species on edge of recreate – state, fed, local — To rethink the type of lawn planted in public parks and public ovals — Plant trees – joint — Community and city — More shade — Start with artificial to start with as trees grow — Decreased number of trees as houses get bigger and do not plant trees — Lack of shade areas in parks – trees — All street trees on house verges to be native trees — Plant more trees – everywhere to decrease temp — Smaller houses so space to plant trees (re-wild Perth website)
Waste	— Uncover old rubbish tips — Unusable water ways due to pollution and contamination	— Circular economy — Toy libraries — Tool libraries — Men sheds — Incentives to buy local — Encourage seasonal foods

Theme	Risk	Recommendations
		— Vegetarian and vegan — Land fill tax — Landfill production tax — Regional soft plastics collection for reuse — Better recycle program – like Japan. Whole government — Promote local circular economy to support supply chain — Map local business waste stream to identify opportunities — Provide more accessible waste disposal within the city — Waste education/advertising — Separated waste bins in all public spaces (general waste, local, and recycling in all parks, shops, etc).
Water	— Less water available — Overuse of water resources — Displacement from droughts and flooding — Another public swimming pool needed due to increased demand for and safer swim — Flood erosion — Salinisation of river – ecosystem issues — Localised flooding impact houses or infrastructure — SLR – infrastructure impacted — SLR – relocation of people in low-lying areas — Less water — Sea level rise decreasing inundation – market gardens — Localised flooding – drains not coping — Sea level rise damaging public and private property — Gardens, water use will have to change — Depleted ground water reserves due to increased water demand = bad for wetlands (+ nutrients) increased temps = hypoxic and anoxic events in the river = bad for wildlife — Droughts and less water = dead gardens and lawns (aesthetic) — Erosion along the river — Emerging flash flood risk	— Build a giant sea wall — Water collection and water tanks — More recycled water à less “quality” water — Subsidies for water harvesting (group water) — Rainwater tanks in homes — Innovative foreshore erosion control techniques – City of Melville/DBCA — Flash flood risk: advocate for sensible risk-based land use and development policies – State gov — Flash flood risk: native based (wetland) mitigation – Melville City / State gov — Rainfall capture of stormwater management — Initiatives for households — Water runoff from roads should be diverted into soak wells for each street tree – Council — Plant rushes along riverbank – Council — Increased intensity of rain when it falls à more erosion — Wave and tidal readings to flooding – already happening on the Attadale Reserve Foreshore – washing the path away – erosion — Program to address foreshore erosion — Capture rain/storm water – tanks for homes

Theme	Risk	Recommendations
	— Erosion and flooding along Melville Beach Road (Swan River) — Water quality and Supply — Flooding — Flooding of property — Uncontrollable erosion of shorelines — Flash flooding, along river flooding — Erosion — Flooding — Flat — Rising water levels — Loss of homes and roads — More erosion — Rising tidal readings to flooding – already happening on the Attadale Reserve Foreshore – washing the path away — More intense rain and high tides causing flooding. Drain systems carrying pollution into river systems require “living streams” to clean water prior to entering rivers — Increasing water low lying impact areas — Infrastructure, mains, comms, roads — Erosion — Swimming pools lawns water rationing bath, gardens, toilets, car — Impact on low lying areas – floods along rivers — Loss of water — Drinking water	

Table A.4 Risks and Opportunities Identified During Workshops with First Nationals People in February 2023

Theme	Risk	Recommendation
Financial burdens	— Inflation rates — Costs going up — Food/petrol — Inequity — Big businesses have monopolised food, water and energy access in society	— Funding — Capital in initial stages — Use rates to fund recommended actions
Ecosystems / natural environment	— Nyittiyang (white) monopolisation of food, water, energy because of scarcity arising from ecosystem destabilisation — Scarcity of public open space in the region — Culture is based on abundance of natural resources which are becoming scarcer	— Rubbish clean-ups (voluntary) — Closure of nature areas for revegetation and marine life — Identify polluters/rule breakers regarding water/rubbish — have green spaces for fruit, veg, bush tucker and medicine. Bring more into the community — want more community gardens to grow food and self-sufficiency. Help people to grow food at home. Have Council guide re soil building, mulches, providing food plants, run workshops in the community. — Protect snakes and local ecosystems more — Increase protection or erosion — Acknowledgement that climate change will impact First Nations people more heavily due to vulnerability factors and support for them to adapt to this — Increase habitat for animals in our backyards — Get children to be responsible for a particular plant or animal that they will take notice of at their homes – children should be caring for Country

Theme	Risk	Recommendation
Education	— Concern that community is not being prepared for a climate disaster — Distrust of cultural understanding of climate change – risk not learning from their knowledge and only focusing on western science — Schools need to be more self-sustainable	— More education (across government and personal) — Aboriginal 6 seasons need to be updated to include all climate changes. This will require informational help from the University — CoM organise people to come to homes of people who want to grow fruit and vegies and help establish and educate — Compulsory education in schools about waste, energy, Aboriginal cultural awareness, climate change. Get LGA to talk to education department about it. — First Nations people learning and teaching kids and other people around native food sources — Communicate differently/more broadly with all community, but particularly First Nation residents what the City is doing around sustainability and climate change as they want to know what is happening and have opportunities for involvement — Re-education of population that First Nations people have always cared for Country and peer-learning can occur. — Council advocacy to state government on school curriculum regarding the introduction of more sustainability, waste, environmental, and cultural education aspects
Energy	— Nyittiyang (white) monopolisation of food, water, energy because of scarcity arising from ecosystem destabilisation — Solar PV systems – cost of energy is high and no way to reduce cost — Energy cost for renters — First Nations people have little say in clean energy and where it is built — Large electricity bills for big families	— Solar panels need to be “incentives” for ATSI people (alternatives) — Need big systems to provide energy for large families — More clean energy — Affordable solar panel options for Aboriginal families and renters

Theme	Risk	Recommendation
Fire	— Controlled burns at the wrong time of year — Smoke and asthma/other breathing issues	— Controlled burning — More rangers employed — Cool burns away from waterways (smoke pollutes)
Food shortages	— Food shortage for our mob — Cost of food is difficult for Indigenous and non-Indigenous families (protein, veg) – many are struggling — Nyittiyang (white) monopolisation of food, water, energy because of scarcity arising from ecosystem destabilisation — Perception that they are unwelcome in community gardens/don't fit in/would be viewed negatively going there — Increasing reliance on food bank and support services to access cheap food (too expensive in store) — Supply chain issues can impact food bank food, leaving large families unable to feed their household — Increases in storms, bushfires, COVID have impacted food supply chain – during emergency rush for food meaning some people cannot access everything	— Community gardens for food to increase food security and reduce associated costs (also could become a great resource to access natural medicines) — Capacity building towards food sovereignty — Education around how to reuse produce — Education on how to store staples and seasonal foods naturally in your own home — Education on what can be grown in your area (seasonally) — The City to provide more assistance around pricing, quality, size of food produce — Grow your own food/veg — Need warning to be prepared — Food sovereignty and Noongars having ownership over this — Learn what food is in the natural environment and plant more for food supply — Educate Council and neighbours what food/seeds are in nature — Improve use of FOGO bins, including working with local companies — City to let us know what is happening with the recycled waste by Council — Council to advocate for local food supplies or local First Nations run food stores

Theme	Risk	Recommendation
Health risks	— COVID (has shown us that life can change. Climate change pollution will affect health – skin problems, renal dialysis, asthma) — Lack of proper medical attention from doctors not diagnosing treating and guiding adequate advice regarding breathing/asthma problems — Cost of medication — Being believed by medical professionals — Late onset asthma (confusion around what it is and adequate treatment) — Future pandemics and the impact of isolation/restrictions on First Nations people and communities — Increasing risk of disease in First Nations people e.g., skin cancers	— Education for doctors (including around the effects of fire on health) — Aboriginal doctors service — Bush medicine program accessible for all
Heat	— Resulting in no outside play — Having to stay indoors when it is very hot — Overheating, struggling to function and breathe in the heat already causing medical issues — Dryness after the heat of, and use of heaters, dryers etc — Summer feels more humid/tropical (can make it hard to breath/general unwell feeling) — Hard to function in the heat (both physically and emotionally)	— N/A

Theme	Risk	Recommendation
Policy	— Too much sub-dividing and less space for gardens (too much density)	— Planning and programs (at government and personal level) — Rangers – enforce laws/lore — More Council planning policies looking after the environment — Policies that support people's connection to Country and protect the environment (local and state level)
Reconciliation	— N/A	— First Nations people included in all consultations moving forward — Accurate education that identifies colonisation as root of ecosystem destabilisation. Educates how nyoongars are the answer. Illustrates a future of abundance with nyoongar leadership at force — Would like Noongar voice into CARG and more involvement generally — Aboriginal people employed as Council staff — Have more Aboriginal people higher in the Council's hierarchy – lead design and scheduling of programs (like up North) — Expansion of First Nations' Rangers program and support cultural knowledge and living practices by local people. Should also focus on long-term job prospects for local rangers
Social cohesion	— No communication — Anti-social behaviour	— RAP (including actions in next Stretch) — Conversations around racism (also linked to climate change education and awareness) — Letter drops (not just social media) – specifically target Aboriginal households (about 600 people in the City) — People having a say and everyone listening — Neighbours taking collections to share with the needy — Increase community spirit

Theme	Risk	Recommendation
Sustainability	— Increase in waste going to landfill — Noise pollution from cars increasing — Talk about scarcity as if it is in the past – we need to be able to participate and have abundance of water/energy/food available	— Become self-sustainable — Make garden care compulsory in schools — Have suburb support packages for self-sustainability — Correct recycling system — Re-use non-biodegradable — A yearly census sent to house to show waste/water/electricity usage — Workshops for gardening — Promote self-environmental awareness (government and personal level) — Burning of some waste supports soil quality
Trees and community gardens	— Lack of access to native trees/plants — Trees stressed by heat and less rainfall — Changing tree flowering and ecosystem impacts — Loss of gum trees	— Planting more native trees (and knowing their medicinal uses) — Free trees for all residents (more information from Council about this) — Council to start giving free native plants for food and medicine — More trees and plants on verges (including those that can be used in daily life – e.g., some native grasses are superfoods – City of Cockburn mows them without realising their benefit) — Work with neighbours to revegetate verges and local public open spaces — Verge vegie gardens and register for community watering — “Plant a tree day” – specifically target Aboriginal people (letterbox drop/supply with trees/help plant) — Assistance for older people to plant gardens, making it easy to maintain — Assistance in landscaping through Murdoch University or other local companies for all residents to have a sustainable garden

Theme	Risk	Recommendation
Water	— Nyittiyang (white) monopolisation of food, water, energy because of scarcity arising from ecosystem destabilisation — Water quality — Fish stock — Land is drying up and then everything else is at risk — Availability in the future, quality, where it will come from, is it drinking quality? — Worry not enough drinkable water — Food stock in driver is changing (e.g., crab movements are already changing and these effects locals being able to catch crabs for food – impacts cultural practices) — Rivers/waterways warming — Tide flows changing — Freshwater access — Water restrictions and strong reliance on mains water — Concerns around health impacts of chlorine in water — Increase in water where we don't need it — Impact of more ferries and boats on the river and on wildlife	— Fish traps — Volunteer waterway clean-ups — Grass reclaimed foreshore into wetlands — Research — Programs — Reduced activity in areas of river — Promote wetland and swamp restoration — Monitor mussel numbers (indicators of clean water and river filtration) — Recreational activities will need to change as a result of water warming and tide flow changes — More household water tanks to water home gardens (Council mandated in new builds and retrofitting) – grants and support — Water filters on taps for possible drop in water quality if pollutants increase and/or chemicals added to purify water — Develop the City's ranger program to examine river/foreshore water. Include Aboriginal people — Put drains around properties to capture water — Encourage use of waste and grey water — Give Rangers more power to check for breaches of water quality, e.g., pollutants from households — Having Aboriginal people reclaim the wetlands and have more Aboriginal Rangers to look after it — Having a specific team of Rangers for foreshore and waterways — Decrease recreational river activity (use of boats) where crab/fish breeding areas are — Build "fish traps" in sections of the river to help people fish sustainability

Appendix B

Future Ready Trends

Climate change is one of many factors influencing the City and the community it serves into the future. WSP situates its advice around climate change adaptation in the broader context through Future Ready™, WSP's program allowing us to see the future more clearly and to work with clients to design for this future. Below is a high-level summary of WSP's Future Ready trends and insights, with applicable links drawn to the City during this analysis. A rigorous analysis will be performed during the later risk analysis phase.

Climate

Future trends suggest climate change will result in a warmer atmosphere, higher sea levels, and significantly altered precipitation patterns. Key trends have been assessed alongside the expected impact this will hold for the City in **Table A-5**.

Table A-5. Future Climatic Trends

	WSP Future Ready™ trend
	More Extreme Events
	Driven by changes in climate, extreme weather events such as cyclones, strong storms, intense rainfall, heatwaves, droughts, and catastrophic bushfires, are becoming more frequent and severe.
	— More extreme weather events will mean 1 in every 19 property owners in Australia face the prospect of insurance premiums that will be effectively unaffordable by 2030 costing 1% or more of the property value per year.[153] **It is assumed the City will follow the Australia-wide trend, meaning housing affordability will continue to pressure individuals as the cost of living continues to increase.** — Days with a severe fire danger rating are projected to increase by 30-70% by 2030.[154] **For the City, increasing fire danger threatens community health, particularly vulnerable populations.** — Natural disasters cost Australia $9B a year on average. Costs could reach $27B a year by 2050 if no action is taken.[155] Climate change-related disasters are projected to cost Australia $73B a year by 2060, even if action is taken to curb greenhouse gas emissions.[156] Increasing sea-level rise, bushfire frequency/intensity, intense rainfall events, and drought

153 Steffen, W., Rice, M., Dean, A., Kompas, T. & Mallon, K. 2019. Compound Costs: How Climate Change is Damaging Australia's Economy. Climate Council. Accessed 24 Oct 2022. <https://www.climatecouncil.org.au/resources/compound-costs-how-climate-change-damages-australias-economy/>.

154 Climate Council. 2019. The Facts About Bushfires and Climate Change. Accessed 24 Oct 2022. <https://www.climatecouncil.org.au/not-normal-climate-change-bushfire-web/>.

155 Deloitte Access Economics. 2017. Building Resilience to Natural Disasters in our States and Territories. Accessed 24 Oct 2022. <http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf>.

156 Deloitte. 2021. Special Report: Update to the Economic Costs of Natural Disasters in Australia. Accessed 24 Oct 2022. <http://australianbusinessroundtable.com.au/assets/documents/Special%20report%3A%20Update%20to%20the%20economic%20costs%20of%20natural%20disasters%20in%20Australia/Special%20report%20_Update%20to%20the%20economic%20costs%20of%20natural%20disasters%20in%20Australia.pdf>.

	WSP Future Ready™ trend
	will impact the City. **The City's location along the Swan and Canning River will heighten sea-level rise and flooding impacts.** — Projections show that tropical cyclones are likely to occur further south and be more damaging.[157] It is assumed these events will become more costly as the impacts of climate change come to full fruition. **It is assumed cyclonic winds and intense rainfall will likely begin impacting the City.** — Extreme weather events represent a huge threat to life. Heatwaves kill more Australians than all other natural disasters combined.[158] **Assumptions suggest heatwaves will be the deadliest threat to the City.** — The frequency of the most dangerous 10% of fire weather days has increased significantly in recent decades across many regions of Australia, especially in the south and east.[159] **Fire weather days will increase across WA, meaning the City will be more vulnerable to bushfire disaster events.**
	Hotter and Drier
	As Australia gets hotter and drier, the adaptive capacity of our people, infrastructure, environment, and economy will be severely tested.
	— By 2090, Perth could experience 55 days over 35°C.[160] **Heatwaves may be the deadliest threat to the City. As the median age of the City's population is 41, the City will be particularly vulnerable to heatwaves and hot weather days.[161]** — Average temperatures in Australia have increased by more than 1°C in the past century.[162] **Temperatures are equally assumed to have increased across the City.** — Under a high emissions scenario, temperatures can warm by as much as 5°C by 2090.[163] **High emission scenarios Australia-wide are assumed to negatively impact the City irrespective of the City's response to climate change.** — In 2021, both mean annual maximum and minimum temperatures were above average for most of northern Australia, Tasmania, and parts of the west coast, but below average for parts of inland New South Wales.[164] The mean temperature for the 10 years from 2012 to 2021 was the highest on record, at 0.99 °C above the 1961–1990 average, and 0.38 °C warmer than the ten years 2001–2010.[165]**The City is assumed to be increasing in annual temperatures.**
	Climate Risk Disclosure and Litigation
	Climate change has and will continue to have significant financial implications on asset valuation in global markets across various asset classes, in the short and long term. Additionally, there is a growing responsibility for companies, governments, and businesses

157 CSIRO & Bureau of Meteorology. 2018. State of the Climate 2018. Australian Government. Accessed 24 Oct 2022. <http://australianbusinessroundtable.com.au/assets/documents/ABR_building-resilience-in-our-states-and-territories.pdf>.
158 Coates, L., Haynes, K., O'Brien, J., McAneney, J. & Dimer de Oliveira, J. 2014. Exploring 167 years of vulnerability: an examination of extreme heat events in Australia 1844-2010. *Environmental Science & Policy, 42*, 33-44.
159 Bureau of Meteorology. 2020. State of the Climate 2020: Australia's Changing Climate. Australian Government. Accessed 24 Oct 2021. <http://www.bom.gov.au/state-of-the-climate/australias-changing-climate.shtml>.
160 Earth Systems and Climate Change Hub. 2020. Accessed 25 Oct 2022. <https://www.cmsi.org.au/reports>.
161 Australian Bureau of Statistics. 2016. Melville (C). Accessed 25 Oct 2022. <https://abs.gov.au/census/find-census-data/quickstats/2016/LGA55320>; Wilson, L., Black, D. & Veitch, C. 2011. Heatwaves and the elderly. *Australian Family Physician,* 40(6): 637-640.
162 CSIRO. 2018. Australia's Changing Climate. Accessed 24 Oct 2022. <https://www.csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/previous/state-of-the-climate-2018/australias-changing-climate>.
163 IPCC. 2018. Global Climate Projections. Accessed 24 Oct 2022. <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter10-1.pdf>.
164 Bureau of Meteorology. 2022. Annual Climate Statement 2021. Australian Government. Accessed 24 Oct 2022. <http://www.bom.gov.au/climate/current/annual/aus/?utm_source=special-climate-statement&utm_medium=email&utm_campaign=climate>.
165 Bureau of Meteorology. 2022. Annual Climate Statement 2021. Australian Government. Accessed 24 Oct 2022. <http://www.bom.gov.au/climate/current/annual/aus/?utm_source=special-climate-statement&utm_medium=email&utm_campaign=climate>.

	WSP Future Ready™ trend
	to clearly disclose climate-related risks and opportunities through their existing reporting processes.
	— Disclosing financial exposure to climate-related risks is likely to become mandatory for ASX-listed companies in the future (already occurring in NZ and UK). **It is recommended the City disclose Scope 1, 2 (and where possible, 3) emissions to increase transparency.** — There is increasing use of litigation to compel governments and businesses to increase their action on climate change (~1,800 cases filed world-wide as of July 2021, 115 cases in Australia). **Trends towards climate litigation could impact the City, meaning climate action should be taken seriously. Ambitious actions should be implemented where possible.** — In May 2021, the Federal Court of Australia found that the Commonwealth Environment Minister has a duty of care to protect future generations from the effects of climate change.[166] Although subsequently overturned on appeal, cases imposing ministerial duties of care are likely to increase in frequency.[167] **This duty of care may extend to the City in the future should another case successfully raise this argument. This means the City should act for the good of future generations.** — In 2022 ASIC reiterated the need for listed companies to specifically report in respect of climate related matters to comply with their disclosure obligations and to also disclose relevant and useful climate related information to investors.[168] **Climate-related disclosures may become obligatory. The City can proactively act here by implementing disclosure processes across operations.** — The pressure on companies to disclose information is placing scrutiny on "greenwashing". In August 2021, the Australasian Centre for Corporate Responsibility sued Australian oil and gas company Santos over its claims that it provides clean energy natural gas and has a plan for net zero emissions by 2040.[169] **Legislation prohibiting "greenwashing" advertising and activity may become a necessity in the future. The City must take legitimate and transparent actions to achieve their goal of net zero emissions.** — *Mark McVeigh v Retail Employees Superannuation Pty Ltd* considered the adequacy of disclosures to investors. In this case, the Australian pension fund agreed to incorporate metrics to assess climate change financial risks in its investment strategy and implement a net zero by 2050 carbon footprint goal.[170] **Incorporating climate financial risks within council strategies and net zero ambitions is recommended.**
	Net Zero and Beyond
	Climate emergencies, new government commitments and COVID-19 are accelerating change, putting climate at the forefront. Net Zero refers to the balance between the amount of greenhouse gas produced and the amount removed from the atmosphere.
	— Transitioning to a low-carbon economy could grow Australia's GDP by 2.7% by 2070 adding over 250,000 jobs.[171]

166 *Sharma by her litigation representative Sister Marie Brigid Arthur v Minister for the Environment* [2021] FCA 560.
167 Sinclair, A. & Simington, S. 2022. The Landmark Decision of Sharma v Minister for the Environment is Overturned. Lindsay Taylor Lawyers. Accessed 8 Dec 2022. <https://www.lindsaytaylorlawyers.com.au/in_focus/the-landmark-decision-of-sharma-v-minister-for-the-environment-is-overturned/>.
168 Clyde & Co. 2022. Year in Review – Climate Change and the Construction Industry. Accessed 24 Oct 2022. <https://www.clydeco.com/en/insights/2022/01/climate-change-and-the-construction-industry>.
169 *Sharma by her litigation representative Sister Marie Brigid Arthur v Minister for the Environment* [2021] FCA 560.
170 *Sharma by her litigation representative Sister Marie Brigid Arthur v Minister for the Environment* [2021] FCA 560.
171 Deloitte. 2020. A New Choice Australia's Climate for Growth. Accessed 24 Oct 2022. <https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-dae-new-choice-climate-growth-051120.pdf?nc=1>.

	WSP Future Ready™ trend
	— **A low-carbon economy should be pursued by the City, assisting Australia in reaching their NDC and Paris Agreement obligations. It is assumed the City will gain jobs as a result of this transition, meaning such changes should be embraced where possible.** — To keep the Paris Agreement goal of limiting warming to 1.5ºC within reach, global CO_2 emissions need to decline by approximately 45% from 2010 levels by 2030. Failing to rapidly cut emissions is forecast to lead to exponential increases in the cost of climate change for Australia - about $129B per year.[172] **It is assumed the City will experience increases in disaster costs and costs associated with adapting to climate change irrespective of carbon emission cuts. However, should the City fail to adopt a low-carbon economy, these costs are expected to be exponentially higher. Some costs will likely be incurred irrespective of the City's actions due to national and global inactivity.** — A cut in emissions is required for Australia to meet its Net Zero goal for 2050. **Deep, ambitious emission cuts should be made by the City as a part of achieving 43% reductions by 2030 and net zero by 2050.** — Australia is the world's 14th largest emitter. We contribute 1% of total global emissions, while our per capita emission level is ranked 8th.[173] **As a large global polluter, Australia (and therefore the City) has a myriad of opportunities to address emission cuts**. — The energy sector (comprising of stationary energy, transport, and fugitive emissions from fuels) continues to be the dominant source of Australia's GHG emissions. This is followed by the transport and agriculture sectors.[174] **The City follows this trend. Stationary energy is the largest emission source for the City (48%), followed by transport (30%).[175] The City should consider these high-emission source points when addressing emission cuts. Clean electrification is therefore key to decarbonisation.** — Australian industries must decarbonise, but some hard-to-abate sectors will require negative emissions processes such as locking up carbon through biological processes in forests, soils and new agricultural practices.[176] **The City's key industries (health, education, professional, retail, and construction) should be targeted when seeking to reduce emissions.[177] Carbon-negative practices should also be considered in agricultural practices despite only accounting for 0.5% of the City's employment.[178]**
	Coastal Risks
	Rising sea levels and storm surges are contributing to coastal erosion and inundation as well as impacting ecosystems, water resources, and human settlement activities.
	— The current day 1-in-100-year extreme sea level event could occur every five years by 2050 and 10 times per year by 2100 (high emissions scenario).[179] **Risks to the Swan-Canning Estuary Foreshore and Attadale Alfred Cove Foreshore should be considered. Point**

172 Climate Council. 2021. Markets are Moving: the Economic Costs of Australia's Climate Inaction. Accessed 24 Oct 2022. <https://www.climatecouncil.org.au/resources/markets-moving-economic-costs-australias-climate-inaction/>.
173 Climate Change Authority. 2020. Prospering in a Low-Emissions World: an Updated Climate Policy Toolkit for Australia. Australian Government. Accessed 24 Oct 2022. <https://www.climatechangeauthority.gov.au/sites/default/files/2020-09/Prospering%20in%20a%20low-emissions%20world.pdf>.
174 Australian Government. 2021. Australia State of the Environment 2021. Accessed 24 Oct 2022. <https://soe.dcceew.gov.au/>.
175 City of Melville. N.d. Response to Climate Change at the City of Melville. Accessed 25 Oct 2022. <https://www.melvillecity.com.au/getdoc/6bd1e91a-9e4e-4ddc-b820-1c4026e2e8d4/5843-response-to-climate-change-at-the-city-of-mel.aspx>.
176 CSIRO. 2021. How Can Australian Industries Meet Their Emission Targets? Accessed 24 Oct 2022. < https://www.csiro.au/en/work-with-us/industries/mining-resources/Resourceful-magazine/Issue-21/Meeting-emissions-targets>.
177 .idcommunity. n.d. City of Melville Industry Sector of Employment. Accessed 25 Oct 2022. <https://profile.id.com.au/melville/industries>.
178 .idcommunity. n.d. City of Melville Industry Sector of Employment. Accessed 25 Oct 2022. <https://profile.id.com.au/melville/industries>.
179 Vousdoukas, M.I. et al. 2018. 2018. Global probabilistic projections of extreme sea levels show intensification of coastal flood hazard. *Nature Communications,* 9:2360.

	WSP Future Ready™ trend
	Heathcote Reserve and Bicton's Blackwell Reach Parade are also likely to be impacted. — Sea levels have risen in Australia at an average rate of 2.1mm/year over the past half-century. The likely estimate of sea-level rise in Australia by 2090 is about 45-82cm higher than 1986-2005 levels.[180] **Sea-level rise will impact the City. Exact increases are unknown but assumed to follow the national trend.** — 85% of Australians live within 50km of the coast; 1 in 10 homes are located in a flood risk area.[181] **The City's LGA boundary is roughly 15km or less from the coast. Consequently, there is a higher flood risk, particularly along floodplains and the foreshore.** — $226B worth of infrastructure and homes are at risks from coastal inundation at a sea-level rise of 1.1m.[182] **Sea-level rise and increasing storm surges should be expected by the City. Infrastructure developments and planning policies should consider this future risk.** — Globally, seawater could increase its acidity by 170% by the end of the century if the RCP8.5 concentration scenario is followed.[183] **Increasing atmospheric carbon dioxide is dissolving within the ocean, resulting in decreasing pH. Impacts to Swan Estuary Marine Park and biodiversity should be expected. Acidity can also impact infrastructural integrity.**

12.2 Society

Australia's social constructs are also expected to change as a result of climate change and social advances. Social trends are elicited in **Table A-6**.

Table A-6. Future Social Trends

	WSP Future Ready™ trend
	Local Places
	Internationally there is an increasing focus on local places as critical city fabric. Demand for services and infrastructure will continue to change in response to population densities and community expectations.

[180] Coast Adapt. 2018. Climate Change and Sea-level Rise in the Australian Region. Accessed 24 Oct 2022. <https://coastadapt.com.au/climate-change-and-sea-level-rise-australian-region>.

[181] Australian Bureau of Statistics. 2004. 1310.0 – Year Book Australia, 2004. Accessed 24 Oct 2022. <https://www.abs.gov.au/ausstats/abs@.nsf/previousproducts/1301.0feature%20article32004>; IAG. 2020. Fact Sheet Flooding in Australia 2020. Accessed 24 Oct 2022. <https://www.iag.com.au/sites/default/files/Documents/Climate%20action/IAG-Flood-Fact-Sheet.pdf>.

[182] Steffen, W., Hunter, J. & Hughes, L. 2014. Counting the Costs: Climate Change and Coastal Flooding. Climate Council. Accessed 24 Oct 2022. <https://www.climatecouncil.org.au/uploads/56812f1261b168e02032126342619dad.pdf>.

[183] Clyde & Co. 2022. Year in Review – Climate Change and the Construction Industry. Accessed 24 Oct 2022. <https://www.clydeco.com/en/insights/2022/01/climate-change-and-the-construction-industry>.

	WSP Future Ready™ trend
	— Since COVID-19, people use public space more often, including their local streets and parks. — 76% of people use their local parks — 70% of people use their local streets — 49% people walk more, and 56% cycle more — Public space is strongly used for personal exercise (81%) at least once a week. — ~40% use their local high streets, bushland walking tracks, off-leash dog parks.[184] — **The use of public spaces has likely increased across the City as a result of COVID-19. Protection of these ecosystems will be pertinent.** — The swell of community cohesion after more frequent disasters has also spawned a movement toward community-driven, place-tailored planning for the future. Disaster survivors, as an indicator, "shared information with their communities about local... initiatives more regularly (61% versus 49%)," which is something planners can leverage.[185] **Community cohesion will be high within the City after natural disasters. However, increasing disaster frequency may reduce morale.**
	**Diverse and Divided**
	Net overseas migration is expected to increase to around 74% of total population growth by 2060-61, further increasing Australia's cultural diversity. Alongside greater acceptance of diversity, we are seeing greater polarisation and inequality of opportunity in our society.[186]
	— Up to 40% of Australians used Facebook for news between 2018 and 2020; social media platforms increasingly dictate what news and information we see.[187] **Community education will be critical in communicating climate disaster risks. It will also encourage community-led initiatives and actions to climate change.**
	**Access for All**
	We increasingly understand the importance of designing places to cater for the 18% of all Australians with a disability. However, we also need to design for inclusiveness along other lines, such as age, ethnicity, religion, and gender.

184 Department of Planning and Environment. 2022. Listening to the Community. NSW Government. Accessed 25 Oct 2022. <https://www.dpie.nsw.gov.au/premiers-priorities/great-public-spaces/streets/have-your-say>.
185 Monash University. 2022. Fire to Flourish. Accessed 25 Oct 2022. <https://www.monash.edu/msdi/initiatives/fire-to-flourish>.
186 Treasury. 2021. 2021 Intergenerational Report. Australian Government. Accessed 24 Oct 2022. <https://treasury.gov.au/publication/2021-intergenerational-report>.
187 Reuters Institute. 2020. Digital News Report 2020. University of Oxford. Accessed 25 Oct 2022. <https://reutersinstitute.politics.ox.ac.uk/sites/default/files/2020-06/DNR_2020_FINAL.pdf>.

	WSP Future Ready™ trend
	— 45 per cent of Australians will experience a mental health condition in their lifetime; and in any one year around 1 million Australian adults have depression; over 2 million have anxiety.[188] **This is a significant risk for the City, with eco-anxiety, depression, and solastalgia impacting those affected by increasingly frequent natural disasters.** — Just under one in five people (4.2 million people or 18.5% of Australians) live with a disability in Australia.[189] **Melville LGA has 4,947 people requiring assistance with core activities (4.66% of the City's population, with Willagee, Bull Creek, and Kardinya having the highest number of individuals), and 27,456 people recording one or more long-term health conditions (~25.87% of the LGA, with Leeming, Kardinya, and Bull Creek as the highest contributing suburbs). Those community members impacted by ill-health or disability will be disproportionately impacted by climate change.**
	A Focus on Health
	Increasingly, we are striving to design our infrastructure, cities, and communities in a way that generates far-reaching outcomes beyond those being delivered directly by the asset or initiative.
	— As of 2018, 47% of Australians had one or more chronic diseases.[190] **Those experiencing long-term chronic illness will be more susceptible to climatic changes such as heatwaves.** — In 2017 – 2018, Australia spent $185B on health goods and services (Australian Institute of Health and Welfare (AIHW) 2020), a figure that continues to rise on average at 4.3% each year.[191] **Healthcare burdens are expected to proportionately impact the City. This increasing cost averts money otherwise available for climate adaptation/mitigation efforts.** — Individual health and economic growth are interlinked. The Productivity Commission estimates that GDP could be enhanced by $4B per annum through improved health.[192] **As health is a large industry sector for the City, Melville may be able to gain significant GDP through healthcare provision. This could be used to fund climate action.**
	Indigenous Influence
	There is a growing need for Indigenous knowledge holders and traditional custodians of Country to influence the changing social, economic, and environmental fabric of Australia to improve outcomes for all people.

12.3 Resources

Resourcing constraints and booms are also expected in the future. Shifts to a circular economy are expected to be particularly beneficial. These trends are delineated in **Table A-6** below.

188 Beyond Blue. 2022. Learn About Mental Health. Accessed 25 Oct 2022. <https://www.beyondblue.org.au/the-facts>.
189 Australian Bureau of Statistics. 2019. Disability, Ageing and Carers, Australia: Summary of Findings. Accessed 25 Oct 2022. <https://www.abs.gov.au/statistics/health/disability/disability-ageing-and-carers-australia-summary-findings/latest-release>.
190 Australian Bureau of Statistics. 2018. Chronic Conditions. Accessed 25 Oct 2022. <https://www.abs.gov.au/statistics/health/health-conditions-and-risks/chronic-conditions/latest-release>.
191 AIHW. 2022. Health Expenditure. Australian Government. Accessed 25 Oct 2022. <https://www.aihw.gov.au/reports/health-welfare-expenditure/health-expenditure>.
192 Productivity Commission. 2017. 5 Year Productivity Review Supporting Paper No. 6: Impacts of Health Recommendations. Australian Government. Accessed 25 Oct 2022. <https://www.pc.gov.au/inquiries/completed/productivity-review/report/productivity-review-supporting6.pdf>.

Table A-7. Future Resource Trends

	WSP Future Ready™ trend
	Circular Economy
	A Circular Economy is based on the principles of designing out waste and pollution, keeping products and materials in use at their highest possible value, and regenerating natural systems. It maximises the synergy opportunities of material exchange, with the waste stream from one development potentially serving as the input for another.
	— According to the Ellen McArthur Foundation, the route to Net Zero is 55% from energy reduction; 45% from the way we manage resources (circular economy).[193] **The energy sector (the City's largest sector) should aim for rapid emission reductions.** — Australia is investing over A$1B to turbocharge our waste and recycling industries.[194] **The City could benefit from funding and grant availability in this space.** — It is estimated that a circular economy could give Australia a $23B GDP boost.[195] **It is assumed movements towards a circular economy would likewise benefit the city economically.** — Australia offers nearly A$70B in grants, incentives, and funding pools to Australian-based companies across priority sectors: — Built environment — Mobility — Consumables.[196] — **The City may be able to capitalise on such grants, incentives, funds etc.** — Australia generates 76 million tonnes of waste annually.[197] This is approximately 540kg of household waste per year, 10kg per week.[198] **With ongoing shifts to a circular economy, the City should aim to reduce waste consumption, aligning with both local and national strategies.**
	Water Scarcity
	Water scarcity is continuing to accelerate in Australia and will be at the core of short and long-term infrastructure planning and investment. Water shortages and worsening conditions are now the norm.
	— Three quarters of hydrologic reference stations around Australia show a declining trend in streamflow. Rainfall in southern Australia is very likely to continue decreasing under all future scenarios.[199] **Wungong Brook (one of the closest hydrologic reference stations to the City) shows a declining streamflow trend.[200] It is assumed the City will experience similar rainfall declines across future emission scenarios.**

193 Ellen Macarthur Foundation. N.d. Completing the Picture: How the Circular Economy Tackles Climate Change. Accessed 24 Oct 2022. <https://ellenmacarthurfoundation.org/completing-the-picture>.

194 Global Business & Talent Attraction Taskforce Australia. 2021. The Circular Economy. Australian Government. Accessed 24 Oct 2022. <https://www.globalaustralia.gov.au/sites/default/files/2021-07/GBTAT_Circular_Economy_Factsheet.pdf>.

195 Rynne, B. n.d. Potential Economic Pay-Off of a Circular Economy for Australia. KMPG. Accessed 24 Oct 2022. <https://home.kpmg/au/en/home/insights/2020/05/potential-economic-pay-off-circular-economy-australia.html>.

196 Global Australia. N.d. Circular Economy. Australian Government. Accessed 24 Oct 2022. <https://www.globalaustralia.gov.au/industries/circular-economy>.

197 Australian Bureau of Statistics. 2020. Waste Account, Australia, Experimental Estimates. Accessed 8 Dec 2022. <https://www.abs.gov.au/statistics/environment/environmental-management/waste-account-australia-experimental-estimates/latest-release>.

198 Clean Up Australia. 2022. Clean Up Our Waste. Accessed 8 Dec 2022. <https://www.cleanup.org.au/clean-up-our-waste>.

199 CSIRO. N.d. Australia's Changing Climate. Accessed 11 Nov 2022. <csiro.au/en/research/environmental-impacts/climate-change/state-of-the-climate/australias-changing-climate>.

200 Bureau of Meteorology. 2022. Hydrologic Reference Stations. Australian Government. Accessed 25 Oct 2022. <http://www.bom.gov.au/water/hrs/#id=616041>.

	WSP Future Ready™ trend
	— Australia's total annual rainfall in 2019-2020 was approx. 24% lower than the mean value from 1900-2020.[201] **Rainfall declines are therefore expected for the City.** — Dry conditions over much of Australia have led to below average streamflow across the whole country, some the lowest on record.[31] **It is assumed streamflow is at a record low for the City. This will impact threatened biodiversity living within aquatic ecosystems.** — Industry accounts for 16% of the water footprint with water-heavy industries such as mining increasing their consumption.[202] **Water-heavy industries have a smaller impact across the City (e.g., mining accounting for 6.0% of employment, manufacturing 4.6%, construction 7.3%).[203] However, efforts in water reduction should occur as water scarcity intensifies.** — Urban centres across Australia face the challenge of increasing water needs, due to population growth, and often also a declining reliability of existing water resources. **The City is forecast to grow to 126,754 by 2036 (23.8% growth between 2016 and 2036, or 1.07% annually).[204] This growth will strain water resources.**
	The Energy Transition
	The imperative to decarbonise our energy sector has led to an accelerating transition to renewable energy sources. In 2020 Australia had the highest GHG emissions from coal power in the world on a per capita basis and fossil fuels contributed 76% of electricity generation conveying the immensity of the challenge.
	— Australia's main grid is projected to reach 50% renewables by 2025, growing to 69% by 2030. When coupled with major advances in battery storage and e-mobility, massive investment will be required to modernise our transmission and distribution networks.[205] **Renewable energy sector growth is likewise expected for the City. Better active transport options should also be considered.** — By 2050, more than half of Australian houses are expected to have solar PV systems and about a third of residential buildings will have energy storage. To date, Australia has the highest penetration of residential rooftop solar in the world.[206] **Rooftop solar is expected to follow this trend across the City.** — Demand for hydrogen exported from Australia could be over 3 million tonnes each year by 2040, which could be worth up to $10B each year to the economy by that time.[207] **Hydrogen demands could have a high impact to the City, with possibilities for renewable hydrogen a focus across WA.[208]**

201 Bureau of Meteorology. 2022. Water in Australia. Australian Government. Accessed 24 Oct 2022. <http://www.bom.gov.au/water/waterinaustralia/>.
202 Rynne, B. 2020. Potential Economic Pay-off of a Circular Economy for Australia. KPMG. Accessed 11 Nov 2022. <https://home.kpmg/au/en/home/insights/2020/05/potential-economic-pay-off-circular-economy-australia.html>.
203 .idcommunity. n.d. City of Melville Industry Sector of Employment. Accessed 25 Oct 2022. <https://profile.id.com.au/melville/industries>.
204 .idcommunity. n.d. City of Melville Population Summary. Accessed 25 Oct 2022. <https://forecast.id.com.au/melville/population-summary>.
205 ANU. 2018. At Its Current Rate, Australia is on Track for 50% Renewable Electricity in 2025. Accessed 25 Oct 2022. <https://science.anu.edu.au/news-events/news/its-current-rate-australia-track-50-renewable-electricity-2025>.
206 Clean Energy Council. 2019. The Distribution Energy Resources Revolution A Roadmap for Australia's Enormous Rooftop Solar and Battery Potential. Accessed 24 Oct 2022. <https://assets.cleanenergycouncil.org.au/documents/advocacy-initiatives/the-distributed-energy-resources-revolution-paper.pdf>.
207 ARENA. 2022. Opportunities for Australia from Hydrogen Exports. Australian Government. Accessed 24 Oct 2022. <https://arena.gov.au/knowledge-bank/opportunities-for-australia-from-hydrogen-exports/>.
208 Department of Jobs, Tourism, Science and Innovation. 2020. Western Australian Renewable Hydrogen Roadmap. Government of Western Australia. Accessed 25 Oct 2022. <https://www.wa.gov.au/system/files/2020-12/Western%20Australian%20Renewable%20Hydrogen%20Roadmap%20-%20November%202020.pdf>.

	WSP Future Ready™ trend
	— Australia is likely to see between 61% and 90% of its electricity sourced from renewable generation by 2040.[209] **Renewable electricity generation could positively impact the City and their ambitions to reach net zero.** — If by 2040, Australia has a 90% renewable power system, it would add $15B to GDP and enable increased spending by Australians of $11B. **This would positively assist the City, offering economic prosperity.**
	Valuing Natural Capital
	Australia's biodiversity is under increased threat and has, overall, continued to decline. Our current investments in biodiversity management are not keeping pace with the scale and magnitude of current pressures.
	— Nature-based solutions for infrastructure are 50% cheaper than grey alternatives and deliver 28% greater added value in terms of direct and environmental benefits. Economic investment opportunity could reach $133B annually in 2030.[210] **Nature-based solutions offer the City significant economic opportunities.** — Bioregions in QLD, SA, and in southwest WA have lost more than 50% of their pre-1760 vegetation.[211] **The extent of cleared vegetation across the City is high (max 6.3% within Bushland Reserves).[212] This degrades overall ecosystem health, increasing climate change vulnerability.** — Limiting global warming to 1.5ºC or below is essential to meeting ambitious biodiversity goals, especially for 2050 and beyond.[213] **The City must work towards this global ambition.** — More than 50 animal and 60 plant species have been lost, with Australia recording the highest rate of mammalian extinction in the world over the last 200 years. Projections suggest that 3 million hectares of untouched forest will have been bulldozed in eastern Australia by 2030.[214] **The City is assumed to have experienced species loss. Ecosystem loss is also expected to continue into the future.** — Our natural environment provides a range of ecosystem services (e.g., clean air, temperature regulation, improved mental health outcomes). Through initiatives such as the TNFD, Australia is part of the global push to quantify and incorporate these "natural capital" benefits into decision-making.[215] **The City should address nature-based capital benefits through recognised disclosure methods such as TNFD.**
	Human Capital and Skills
	Rapid expansion in the infrastructure sector is testing the limits of existing capacity and capability, with workforce shortages and demand anticipated to reach unprecedented levels.
	— About two thirds of key occupations are likely or potentially in shortage. Shortages amongst engineers, scientists, and architects, are most acute with these occupations estimated to be

209 PWC & Jacobs. N.d. The Future of Energy Australia's Energy Choice. Accessed 24 Oct 2022. <https://www.pwc.com.au/power-utilities/future-of-energy/future-of-energy.pdf>.
210 World Economic Forum. 2022. BiodiverCities by 2030: Transforming Cities' Relationship with Nature. Accessed 25 Oct 2022. <https://www3.weforum.org/docs/WEF_BiodiverCities_by_2030_2022.pdf>.
211 Yeates, D.K., Metcalfe, D.J., Westcott, D.A. & Butler, A. n.d. Australia's Biodiversity: Status and Trends. Accessed 25 Oct 2022. <https://www.publish.csiro.au/ebook/chapter/9781486302062_Chapter_3>.
212 City of Melville. 2019. City of Melville Natural Areas Asset Management Plan 2019. Accessed 25 Oct 2022. <https://www.melvillecity.com.au/CityOfMelville/media/Documents-and-PDF-s/Natural-Areas-Asset-Management-Plan.pdf>.
213 UNEP. 2022. Convention on Biological Diversity. Accessed 25 Oct 2022. <https://www.cbd.int/doc/c/16b6/e126/9d46160048cfcf74cadcf46d/wg2020-03-inf-11-en.pdf>.
214 Spring, A. & Earl, C. 2019. Australia's Biodiversity at Breaking Point – A Picture Essay. The Guardian. Accessed 25 Oct 2022. <https://www.theguardian.com/environment/2019/may/15/australias-biodiversity-at-breaking-point-a-picture-essay>.
215 TNDF. N.d. Introducing the TNDF Framework. Accessed 25 Oct 2022. <Tnfd.global/>.

	WSP Future Ready™ trend
	70,000 people short of demand in late 2021.[216] **This trend is assumed to apply to the City. As education is a key sector for the City, shortages could be addressed through incentive programs.** — The infrastructure workforce is ageing, with over 40% of current workers likely to retire over the next 15 years.[217] **The City has a higher median age than Australia nationally. As populations continue to age, this increases burdens to healthcare systems etc across Australia. This will be particularly significant within the City as elderly populations are particularly climate vulnerable.**
	Supply Chains Under Stress
	Recent events have highlighted Australia's vulnerability to global supply chain disruptions. Future shocks to supply chains will continue to impact Australian businesses and services.
	— The transport and logistics sector has an estimated revenue of $101.50B adding $39.9B to the Australian economy.[218] **Transport is a significant sector for the City. This added revenue could support climate adaptation and mitigation efforts.**

12.4 Technology

Finally, trends suggest the technology sector will be heavily impacted and change in future years. Key themes have been discussed below in **Table A-8.**

Table A-8. Future Technology Trends

	WSP Future Ready™ trend
	Digital Expectations
	A widespread digital transformation of our society is driving in consumer expectations for personalised and instantaneous services.
	— The COVID-19 pandemic has accelerated adoption of digital solutions. 75% of customers expect companies to use new technologies to create better experiences.[236] Digital solutions will become increasingly available and accessible. It is assumed they will be a key aspect in addressing climate change. **The City may struggle with digital uptake given their median population age is 41 (reflecting an aging population).**
	A Networked World
	Connectivity is the defining technology of the 21st century, transforming the way we interact with the world and enabling a wealth of innovation across every industry.

[216] Infrastructure Australia. 2021. Infrastructure Workforce and Skills Supply. Australian Government. Accessed 25 Oct 2022. <https://www.infrastructureaustralia.gov.au/sites/default/files/2021-10/Infrastructure%20Workforce%20and%20Skills%20Supply%20report%20211013.pdf>.

[217] Department of Jobs, Tourism, Science and Innovation. 2020. Western Australian Renewable Hydrogen Roadmap. Government of Western Australia. Accessed 25 Oct 2022. <https://www.wa.gov.au/system/files/2020-12/Western%20Australian%20Renewable%20Hydrogen%20Roadmap%20-%20November%202020.pdf>.

[218] AISC. N.d. Transport and Logistics. Accessed 25 Oct 2022. <https://nationalindustryinsights.aisc.net.au/industries/transport/transport-and-logistics>.

	WSP Future Ready™ trend
	— Networks increasingly underpin how we engage with each other and the world. The average Australian household is expected to have 50 connected devices by 2026.[237] Increasing internet connectivity and phone use may result in increased CO_2 generation, increasing emissions.[238] **This is a risk for the City as increased automation and technology uptake continues across the country. This would counter positive emission advances.**
	New Mobility
	The transport sector is on the verge of significant technology change. New mobility provides a bundle of transport, technology and mobility changes that will become the bedrock of future transport systems.
	— Australian future transport market industry is expected to generate more than $16B in revenue by 2025.[219] **Transportation market revenue may increase across the City, offering funding potentials for further green actions. Opportunities for carbon neutral transport may offer economic boosts to the City.** — New mobility is expected to increase Australian economy GDP by $30B AUD by 2050.[220] **Greater connectivity opportunities within the City and nationally provide greater connection points for infrastructure such as EV chargers.** — Australian micro-mobility market revenue is estimated to be $19M by 2030.[221] **The City should consider this market and active transportation methods when updating city planning documents.** — Road congestion is estimated to cost $31B by 2031. The cost of crowding on public transport is expected to rise to $837M by 2030.[222] **The City should implement good public transport infrastructure in response to increased road congestion costs (assumed based on this future trend).**

[219] ATIC. 2018. Industry Overview. Australia Unlimited. Accessed 25 Oct 2022. <https://www.austrade.gov.au/future-transport/industry-overview/>.
[220] Streeting, M. n.d. The economic benefits of new mobility for Australia. *LEK,* XXI(49), <https://www.lek.com/sites/default/files/insights/pdf-attachments/2149_Economic-Benefits-New-Mobility-Australia.pdf>.
[221] P&S Intelligence. 2021. Australia Micromobility Market to Reach $19,185.6 Million by 2030, says P&S Intelligence. Accessed 25 Oct 2022. <https://www.prnewswire.com/news-releases/australia-micromobility-market-to-reach-19-185-6-million-by-2030--says-ps-intelligence-301421887.html>.
[222] Transurban. 2021. Industry Report Urban Mobility Trends from Covid-19. Accessed 25 Oct 2022. <https://www.transurban.com/content/dam/transurban-pdfs/03/Mobility-Trends-Report-1H21.pdf>.

Appendix C

Climate Change Projections

Climate change projections will also vary depending on the future 'time slices' chosen. Time slices refer to a period over which projections are averaged in order to reduce the influence of natural variability between years. This desktop report provides projections for the following time slices:

- 2020 – 2039 (referred to as 2030)
- 2040 – 2059 (referred to as 2050)
- 2060 – 2079 (referred to as 2070)
- 2080 – 2099 (referred to as 2090).

The projections (see **Table 7.1**) have been adopted from the Climate Change in Australia Website – Summary Data Explorer[223], Thresholds Calculator[224] and Southern and South-Western Flatlands Cluster Report.[225] The 50th percentile from the associated model simulations are shown in bold, with the 10th and 90th percentile shown in brackets to illustrate the range of uncertainty associated with each climate change projection.

The baseline climate data has been obtained from the BoM Climate Data Portal and represents data from an average of 30 years between 1981-2010. This timescale was adopted for this desktop report as it was the closest time period where reliable historic climate change data was available for this region to align with the IPCC's Fifth Assessment Report baseline period of 1985-2005 that the below projections are baselined from. Data from the Jandakot Aero Weather Station has been used as the representative baseline location for the City. This weather station is located approximately 10km south-west of the City and is the closest weather station with best long term historic climate data collation.

Table A-9. The City's Climate Change Projections (High Emission Scenario RCP 8.5)

Climate variable	Baseline	2030	2050	2070	2090
Temperature					
Mean Max Temperature (ºC) – Annual	24.3ºC	**+0.9** (0.6 to 1.2)	**+1.6** (`1.4 to 2.1)	**+2.6** (2.0 to 3.1)	**+3.8** (2.7 to 4.3)
Mean Max Temperature (ºC) – Summer	30.4ºC	**+0.9** (0.6 to 1.3)	**+1.7** (1.2 to 2.3)	**+2.6** (1.9 to 3.4)	**+3.6** (2.5 to 4.4)
Mean Minimum Temperature (ºC) – Winter	11.3ºC	**+0.6** (0.5-0.9)	**+1.2** (0.9 to 1.6)	**+2.3** (1.9 to 2.8)	**+2.7** (2.2 to 3.5)

223 CSIRO and BOM (2019), 'Summary Data Explorer' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/summary-data-explorer/# (accessed 14 September 2022)

224 CSIRO and BOM (2019), 'Thresholds Calculator' Available at: https://www.climatechangeinaustralia.gov.au/en/projections-tools/threshold-calculator/ (accessed 14 September 2022)

225 Hope, P. *et, al*. (2015), *Southern and South-Western Flatlands Cluster Report*, Climate Change in Australia Projections for Australia's National Resource Management Regions: Cluster Reports, eds. Ekstrom, M. *et al*., CSIRO and Bureau of Meteorology, Australia

Climate variable	Baseline	2030	2050	2070	2090
Days over 35ºC	23.6	+23	+30	+38	+48
Days over 40 ºC	3.1	+3	+5	7	+11
Hottest recorded temperature ºC	46.6ºC (23 Feb 1991)				
Rainfall					
Mean Precipitation Change (%) – Annual	831.8mm	**-3.9** (-14.1 to 2.3)	**-10.7** (-20.7 to 1.2)	**-15.4** (-28.5 to -3.4)	**-14.6** (-36.2 to -2.5)
Mean Precipitation Change (%) – Summer	44.9mm	**-1.5** (-20.1 to 17.7)	**-5.3** (-28.7 to 11.5)	**-6.9** (24.8 to 14.9)	**-4.2** (-26.1 to 27.7)
Mean Precipitation Change (%) – Autumn	165.3mm	**+0.3** (-21.8 to 12.5)	**-1.9** (-25.1 to 13.4)	**-7.3** (-24.6 to 10.4)	**-2.3** (-32.9 to 14.3)
Mean Precipitation Change (%) – Winter	467.8mm	**-8.5** (-14.7 to 1.1)	**-14.8** (-22.7 to -2.3)	**-21.6** (-35.6 to -10.3)	**-25.8** (-44.2 to -12.9)
Mean Precipitation Change (%) – Spring	162.6mm	**-9.4** (-21.6 to 2.5)	**-16.5** (-34.7 to 2.6)	**-24.1** (-42.4 to -3.3)	**-31.7** (-51.5 to -5)
Extreme Rainfall Events		Increase in rainfall intensity, low confidence in the magnitude of change (Max 1-day rainfall change of -4 to 25%)			
Bushfire Fire					
Cumulative McArthur Forest Fire Danger Index (ΣFFDI) (%)	3,211 FFDI	+7%	Unavailable	Unavailable	+30%
Extreme Weather					
Maximum Daily Wind Speed (%)	113km/hr	Unavailable	Unavailable	Unavailable	-0.6 (-3.5 to 4.5)
Extreme Storms		Fewer tropical cyclones and lows that bring rain to southwest WA; however, an increase in the proportion of these being considered extreme storms			
Coastal conditions					
Sea Level Rise (m)	-	0.07 to 0.17	Unavailable	Unavailable	0.4 to 0.85
Sea Surface Temperature (ºC)	-	0.4 to 0.9	Unavailable	Unavailable	1.8 to 3.3

Appendix D

Maps

Appendix E

Data

Figure	Title	Data Sources[226]
1	Social Demographic Factors	2021 ABS Census Statistics by Suburb[227] — Population (Gender data total) — Population Density (Population divided by suburb area) — School Aged Population (Age in 1-year bracket from 5 to 18 years inclusive) — Elderly Population (Age in 5-year brackets, all brackets from 70 years and above) — Aboriginal or Torres Strait Islander (Aboriginal, Torres Strait Islander or both Aboriginal and Torres Strait Islander) — Disabilities (Long-Term Health Condition – Three or more + Two conditions + One condition) — Adult Literacy (Highest Year of Schooling – Did not go to school + Year 8 or below) — Non-English-Speaking Background (English Proficiency – Uses other language and speaks English: Not well + Not at all) — Migration (Arrived 2011-2020 + Arrived 1 January 2021-10 August 2021)
2	Economic Factors	2021 ABS Census Statistics by Suburb — Employment (Not in the labour force + Unemployed, looking for part-time work + Unemployed, looking for full-time work) — Renting (Building Occupancy: Landlord real estate agent + Landlord person not in the same household) — Social Housing (Building Occupancy: Social Housing - State, territory or community housing provider) — Retirement Village (Building Occupancy: Retirement Village - Self Contained) — Household Income (all brackets where income was reported between $1 and $999)
3	Dependency	2021 ABS Census Statistics by Suburb — Age (Age in 5 years, for all ages up to and including 14 years) — Age (Age in 5 years, for all ages from 65 years or above)

[226] All data sources are from DataWA unless indicated otherwise.

[227] For those suburbs where the boundaries do not align with the LGA boundaries, the entire suburb population has been taken to be residing within the City of Melville LGA. Population density is based on the population of the suburb divided by the suburb's total area (inclusive of areas outside of the City of Melville LGA).

Figure	Title	Data Sources[226]
4	Civil Infrastructure (Social)	Schools - Current Active Schools Semester 1 2021 - Public (DET-019) Council Cultural, Community, Education, Emergency, Health, Operation and Recreational Assets – City of Melville 'Asset Buildings.shp' Council Public Open Space – City of Melville 'LP6_zoning.shp' Council Parks – City of Melville 'Parks.shp'
5	Civil Infrastructure (Environment and Culture)	Environmentally Sensitive Areas - Clearing Regulations - Environmentally Sensitive Areas (DWER-046) Indigenous Heritage Places - Aboriginal Heritage Places (DPLH-001) State Heritage - Heritage Council WA - State Register (DPLH-006) Local Council Heritage - Heritage Council WA - Local Heritage Survey (DPLH-008) Council Cultural Assets (identified by City of Melville Project staff within City of Melville 'Asset Buildings.shp' Bush Forever Areas – Region Scheme - Special Areas (DPLH-022) Water Catchments - Region Scheme - Special Areas (DPLH-022)
6	Civil Infrastructure (Built Environment)	Train Stations - Public Transport Authority Stops (PTA-001) Electrical Substations - Substations/Terminals/Power Stations (WP-046) Solid Waste Management Facilities – Council waste webpage Wastewater Pump Facility – 'Public Purposes: Infrastructure" category within City of Melville 'LPS6_zoning.shp' Water Treatment Plant - Water Treatment Plant (WCORP-072) Stormwater Pipes – City of Melville 'Asset Stormwater Lines.shp' Gas Pipeline - https://energymaps.dmp.wa.gov.au/energymaps/ Prison – 'Public Purposes: Prison" category within City of Melville 'LPS6_zoning.shp' City of Melville Ambulance Facility – Address from Google Search Evacuation centres - City of Melville Local Emergency Management Arrangements 2018 document Fire Service Facilities – Fire and Emergency Service – Stations (DFES-023) State SES – from City of Melville 'Asset Buildings.dbf' Police Stations – WA Police Force Facilities (WAPOL-01) Contaminated Sites - Contaminated Sites Database (DWER-059)
9	Social Infrastructure – Health Access	Assets identified by City of Melville Project staff within City of Melville 'Asset Buildings.shp' which provide community health services. Hospital or Ambulance Station (identified via Google search)
10	Social Infrastructure – Evacuation Centre Access	City of Melville Local Emergency Management Arrangements 2018 document

Figure	Title	Data Sources[226]
11	Social Infrastructure – Community Centre Access	Select Council Cultural, Community and Library Assets within – City of Melville 'Asset Buildings.shp' identified by City of Melville Project staff as having the potential to operate as a community refuge.

Appendix F

Legal Framework

Regulations/Policies/Strategies to be Considered by the VRO:

International:

- United Nations Framework Convention on Climate Change 1992
- Paris Agreement 2015
- United Nations Sustainable Development Goals 2015
- IPCC Assessment Report 6 2022
- C40 Climate Action Planning Framework and Cities Climate Change Risk Assessment Guidance
- C40 Cities Inclusive Community Engagement Executive Guide
- UN Habitat Climate Change Vulnerability and Risk – A Guide for Community Assessments, Action Planning and Implementation 2020
- Vienna Convention on the Protection of the Ozone Layer 1985, Montreal Protocol on Substances that Deplete the Ozone Layer 1987, and Kyoto Protocol 1997

National:

- Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth (Cth))
- National Greenhouse and Energy Reporting Act 2007 (Cth)
- Renewable Energy (Electricity) Act 2000 (Cth)
- Climate Change Bill 2022 (Cth)
- Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 (Cth), Carbon Credits (Carbon Farming Initiative) Act 2011 (Cth), and the Australian National Registry of Emissions Units Act 2011 (Cth)
- Australia's Long-Term Emissions Reduction Plan
- Australia's International Climate Change Action Strategy
- National Climate Resilience and Adaptation Strategy 2021-2025
- National Waste Policy: Less Waste, More Resources 2018 and National Waste Action Plan 2019
- Future Fuels and Vehicles Strategy 2021
- Bioenergy Roadmap
- National Energy Productivity Plan 2015-2030
- 2010 Intergenerational Report
- National Food Waste Strategy 2017 and Australia's Strategy for Nature 2019-2030

State:

- Environmental Protection Act 1986
- Local Government Act 1995 (WA)

- National Environment Protection Council (Western Australia) Act 1996
- Emergency Management Act 2005
- Waterways Conservation Act 1976
- Waste Avoidance and Resource Recovery Act 2007
- Conservation and Land Management Act 1984
- Biodiversity Conservation Act 2016
- Western Australian Climate Policy 2020
- Western Australian Climate Change Risk Management Guide (Interim)
- Waste Avoidance and Resource Recovery Strategy 2030
- Future Battery Industry Strategy
- Renewable Hydrogen Strategy
- Greenhouse Gas Emissions Policy for Major Projects
- Energy Transformation Strategy
- Distributed Energy Resources Roadmap
- Electric Vehicle Strategy
- Sectoral Emissions Reduction Strategies
- Waterwise Perth Action Plan
- WA Recovery Plan 2020
- Western Australia's Plan for Plastics

Local:

- Climate Action Policy
- Corporate Business Plan 2020-2024
- Strategic Community Plan 2020-2030
- Sustainability Policy 2018
- Environmental Policy 2018
- Climate Emergency Declaration 2021
- Urban Forest and Green Space Policy 2022
- Tree Policy 2022
- Natural Areas Asset Management Plan 2019
- Corporate Environmental Strategic Plan 2016-2025
- Foreshore Restoration Strategy Review
- Risk Management Policy
- Improving Public Spaces Policy 2019
- Resource Recovery and Waste Minimisation Policy 2022
- Cultural Awareness Policy 2019
- Residential Development Policy 2021

- Energy Efficiency in Building Design Policy
- Local Planning Strategy 2016
- People Places Participation: A Strategic Community Plan for the City of Melville 2016-2016
- Bike Plan 2012
- Car Parking Strategy 2014
- Feral Animal Management Guidelines 2015
- Canning Highway Precinct Design Guidelines 2016
- Acid Sulfate Soils Guidelines 2016
- Public Spaces Strategy 2017
- Disease and Pathogen Management Guidelines 2018
- Response to Homeless People Policy 2019
- Stormwater Quality Management Guidelines 2019
- Bushfire Management Guidelines 2019
- Revegetation Management Guidelines 2020
- Small Business Friendly Approvals Program Action Plan 2021
- Asset Management Policy 2022.