Attachment Z

Climate Adaptation Plan

BLOC

Former Brickworks Redevelopment, Yarralumla

Climate Adaptation Plan

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Climate change risk assessment spreadsheet

1 Introduction

This chapter introduces the proposal and proponent while describing the purpose and structure of this report.

1.1 Document purpose

The purpose of this document is to assist the Project understand and assess the implications of projected climate change on the design, construction and operations of the proposed Brickworks masterplan development.

The Climate Adaptation Plan (CAP) delivered in this document also meet the requirements of the Green Building Council of Australia's (GBCA) Green Star Adaptation and Resilience credit.

It reports on the outcomes of the Climate Risk Assessment (CRA) workshop held in June 2020 and identifies climate-related risks, their impacts and ratings, as well as proposed mitigations and revised ratings. The intention of the CAP is to:

- Inform the process of integrating climate change adaptation measures throughout the design, construction and operation of the Project;
- Contribute to achieving the Project's environmental approvals requirements (within the EIS); and
- Contribute towards attainment of GBCA's Adaptation and resilience credit under the Green Star Communities v1.1 rating tool.

1.2 Document approach

The following outlines specific requirements as part of the projects Scoping Report which must be addressed within the Environmental Impact Statement (EIS) document. Some of these items are being addressed in separate technical reports as referenced.

Table 1: EIS requirements cross reference

EIS requirements	Where addressed
Information on how the proposal will reduce the risks from climate change impacts and include proposed adaptation measures to reduce vulnerability and increase resilience of the community and the Territory, particularly to the extreme events of heatwaves, droughts, storms with flash flooding and bushfires	Sections 6 and 8
Address impacts on the local microclimate and how it will avoid contribution to urban heat and positively contribute to urban cooling measures	Section 4.2

EIS requirements	Where addressed
Address the contribution the proposal will make to reducing greenhouse gas emissions and meeting the legislated target for a net zero emissions Territory (by 2045 at the latest)	GHG technical paper
Consider the risks of extreme climatic events upon future residents and how the precinct has been designed to deal with climatic extremes	Section 6
Consider the likely increase in heat retention as a result of increased concrete and hard, landscaped areas. Provide mitigation measures to minimise increases in temperature and promote cooling through design and landscaping	Section 8.1
Investigate the impact of increasing residential and vehicular activities upon greenhouse gas emissions	GHG technical paper
Describe the design and layout of the site and provide details of building orientation and materials to achieve solar passive design. Provide details of mitigation methods to reduce reliance on mechanical heating and cooling	GHG technical paper
Outline proposed climate change adaption measures to reduce vulnerability and increase resilience of the community	Section 8.2
Describe how the site design and landscaping will contribute to the 30% Urban Environment target for coverage, in accordance with Canberra's Living Infrastructure Plan: Cooling the City	Section 8.1

2 Scope of Assessment

In the development of the CAP for the proposed masterplan development, Arup undertook climate risk and adaptation assessment in three stages: determining relevant scenarios of present and future climate change for use in risk assessment; a preliminary risk assessment; and stakeholder consultation and risk validation.

2.1 Stakeholder Consultation

This Climate Adaptation Plan was developed in collaboration with project stakeholders and included the following activities:

- Identifying key stakeholders and creating opportunities for them to input appropriately to the risk assessment process;
- Explaining the climate change scenarios for two time periods (2030; 2070) relevant to the project life cycle, and associated climate projections to the stakeholders;
- Mapping, in collaboration with the design team, climate variables relevant to each aspect of the design;
- Workshop with key stakeholders to identify potential design or operational activities impacted or at risk against relevant climate variables, along with a preliminary review of potential risk;
- Identifying and evaluating potential adaptation actions with the design team to manage unacceptable risks to the project;
- Run climate hazard scenarios, and determine the likelihood and consequences of potential impacts;
- Agreeing on the likelihood and consequence estimates and descriptions to produce a climate change risk register for the project.

2.2 Key Stakeholders

The key stakeholders involved in consultation are listed below:

- Project and construction managers
- Landscape Architect
- Utilities, energy and civils
- Architect
- Environmental consultant
- WSUD specialist
- Climate Change and ESD consultants

A climate change risk assessment workshop was held in June 2020 and was attended by the key stakeholders as noted above. The objective of the workshop was to provide background information on climate adaptation planning, present expected climate variability and change for the site, complete climate change scenarios for the masterplan and assets and undertake impact assessment and adaptation action planning exercises.

2.3 Project description

The Brickworks is a proposed low to medium density, residential development project at the former Canberra Brickworks at Yarralumla. The project will provide a maximum of 380 residential dwellings and recreational parkland around the re-purposed Brickworks heritage buildings. Given the heritage value of the site, the residential development will focus on maintaining the urban parkland that fits in with the existing landscape and surround urban areas.

The project will be divided into four distinct precincts, including:

- Low density dwelling houses to the east of the gravel pit
- Southern precinct which will include residential buildings including mix of houses, townhouses and apartment buildings
- Higher density, more urban residential setting to the west of the brickworks
- Brickwork heritage precinct including the repurposed buildings to allow for retail and commercial spaces

The site location is provided in Figure 1.

Figure 1 Site location

3 Context

3.1 Project Context

Arup was commissioned by Bloc to provide a high-level assessment of the current Yarralumla Brickworks Masterplan to achieve a 5 stars rating under Green Star Communities v1.1 rating tool. The Green Star Communities tool assesses the Communities scale development based on four categories, namely Governance, Liveability, Economic Prosperity and Environment. It also recognises and encourages the adoption of innovative technologies and programs that foster market transformation towards a sustainable building.

3.2 Statutory Context

3.2.1 Commonwealth

National Climate Resilience and Adaptation Strategy (2015)

This strategy articulates how Australia is managing the risks of a variable and changing climate. It identifies a set of principles to guide adaptation practices and the role of State and Territory Governments in delivering adaption responses for transport infrastructure and services.

Critical Infrastructures Resilience Strategy (2010)

This strategy aims to allow continuous operation of critical infrastructure in the face of all hazards. This strategy defines critical infrastructure as the “facilities, supply chains, information technologies and communication networks which, if unavailable, would significantly impact the wellbeing of Australians or their national security”. Resilience refers to coordinated planning across sectors and networks including responsive, flexible and timely recovery measures and an organisational culture that can give a minimum level of service during interruptions while quickly returning to full operation.

Smart Cities Plan (2016)

This plan sets out the vision for maximising the potential of our cities. This includes making smarter: infrastructure investments in accessibility, jobs, housing and healthy environments; developing policies that unlock public and private investment in main economic centres; and embracing new technologies that help define how cities are planned, function, and how economies grow. The Plan makes clear the Australian Government’s drive to use energy efficient technologies focussed on “innovations in climate change”.

3.2.2 Territory

ACT Climate Change Strategy 2019-25

The strategy outlines many actions regarding climate change and infrastructure adaptation including:

- Monitor climate change projections and ensure infrastructure and services are resilient to climate change impacts.
- Plan for efficient and sustainable urban land use to reduce emissions and maintain and enhance living infrastructure and biodiversity.
- Apply Canberra's Living Infrastructure Plan to work towards 30% urban canopy cover and 30% surface permeability, account for the value of living infrastructure and assess local needs for managing heat.
- Develop more climate-ready infrastructure that would help protect against future environmental threats.

Canberra's Living Infrastructure Plan: Cooling the City

Canberra's *Living infrastructure plan: cooling the city*, provides strategic direction to help the city's expanding and densifying metropolitan areas become better prepared for and more resilient to climate change. It identified options and opportunities provided by living infrastructure measures to enable residents and visitors to enjoy the benefits of climate resilience, amenities of nature, economic prosperity and health and wellbeing.

The Plan recognises the balance needed between urban density, with a growing population, and the natural environment, green spaces and trees. The actions in the Plan are to ensure appropriate planning, design, construction and managing the city in a way that values, incorporates and protects natural assets to strategically reduce climate vulnerability and safeguard the liveability of Canberra.

The Plan's success will rely on developments and local community taking collective action to enhance the natural environment, hence the importance of appropriate design considerations for the Brickworks project to contribute to this action.

3.3 Standards and credit requirements

The following standards and credit requirements have informed the structure of the Climate Change Risk Assessment carried out for the proposal.

Standards and requirements

The risk assessment method has been developed consistent with the following standards:

- AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines and ISO/IEC 31010 Risk Management – Risk assessment techniques
- AS 5334-2013 Climate change adaptation for settlements and infrastructure – A risk-based approach, which follows ISO 31000:2009 Risk Management – Principles and guidelines
- Green Star Communities v1.1 Submission Guidelines

Green Star Communities – Adaptation and Resilience

There are four points available for adaptation and resilience under GS Communities v1.1. This report aims to address 4.1 Climate Adaptation under the credit.

Process	4.1	**Climate Adaptation**	**2 points** are available where: • a **project-specific** Climate Adaptation Plan (CAP) has been developed in accordance with a recognised standard; and • ||Solutions have been included into the plan for development that specifically address the risk assessment component of the adaptation plan.||R1.04.01
Process	4.2	**Community Resilience**	**2 points** are available where, prior to the occupation of any habitable building on the project site, a **project-specific** Community Resilience Plan (CRP) has been developed that addresses preparation, during- and post-disaster communication, safety, and response.

A Community Resilience Plan is being developed and will be informed by outcomes of this assessment.

4 Historic and existing climate context

Canberra has a warm and temperate climate with hot summers, dry autumns and cool winters (ACT Climate Change Strategy, 2019-25). The following figures 2 - 4 illustrate the climate statistics from the Bureau of Meteorology (BoM) between 1996 and 2020 for Tuggeranong weather station, the closest weather station with long term climate statistics and similar climate conditions to the subject site, located approximately 10 km to the south of the site. The key observations are:

- Annual mean maximum and minimum temperatures are 20.9ºC and 7.0ºC respectively; the mean number of days per year above 35ºC is 9.1 days.
- The total annual mean rainfall is 607 mm, with mean rainfall higher in November through to February; the mean number of days per year with rainfall above 10mm is 20 days.
- Relative humidity (RH) at 9am typically ranges between 59-83%, and RH is generally greater in the winter months.

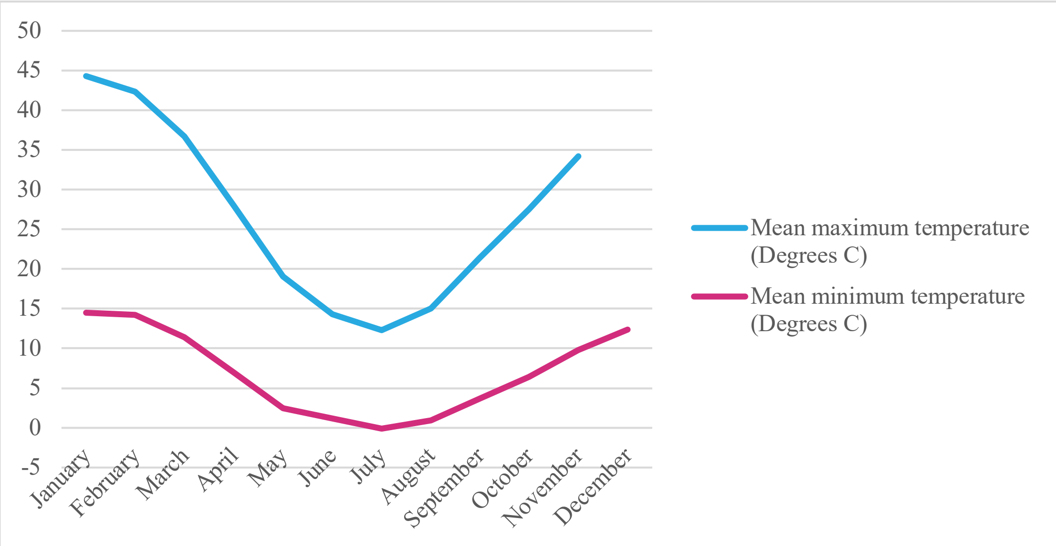


Figure 2 Historic annual mean maximum and minimum temperatures (1996 – 2020)

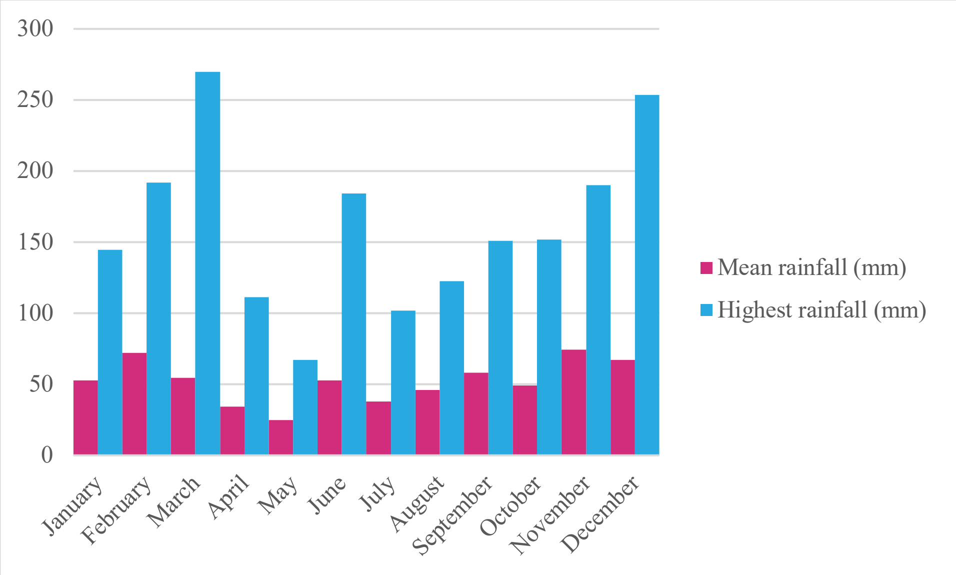


Figure 3 Historic annual mean rainfall (1996 – 2020)

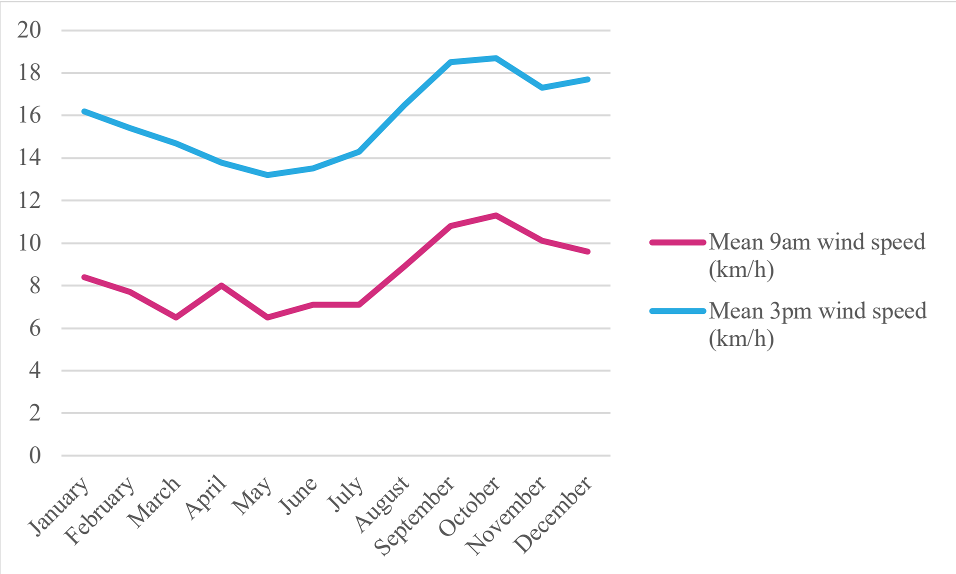
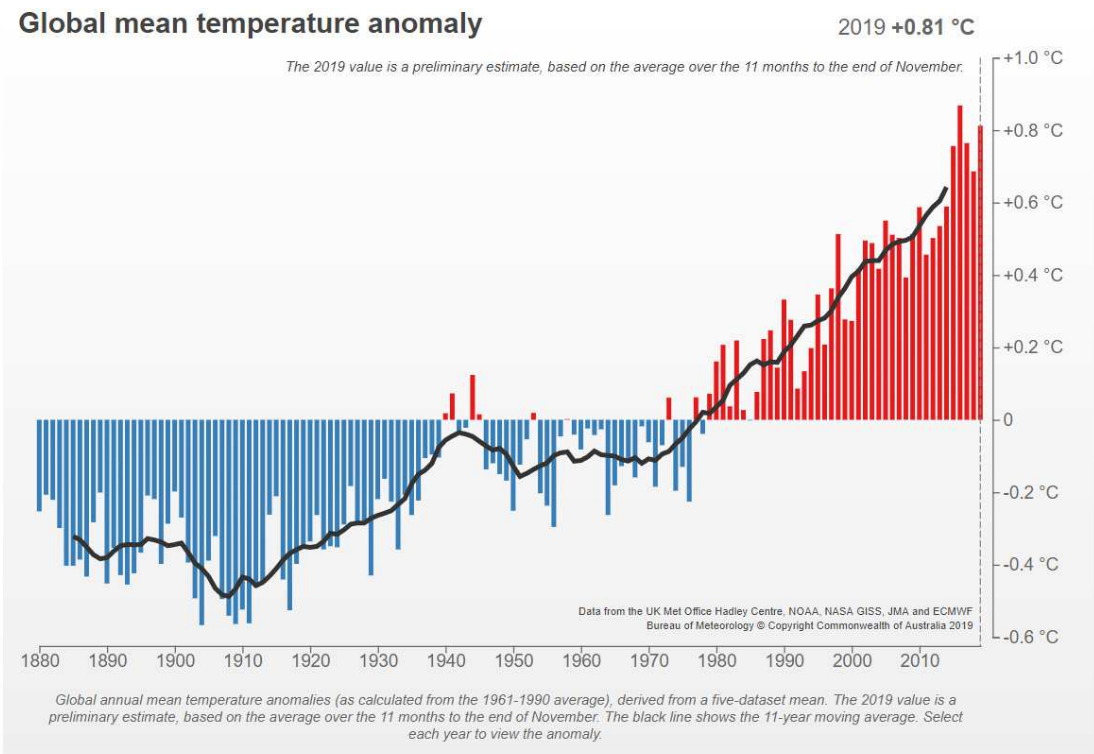


Figure 4 Historic mean wind speed (1996 – 2020)

4.1 Mean temperature anomalies

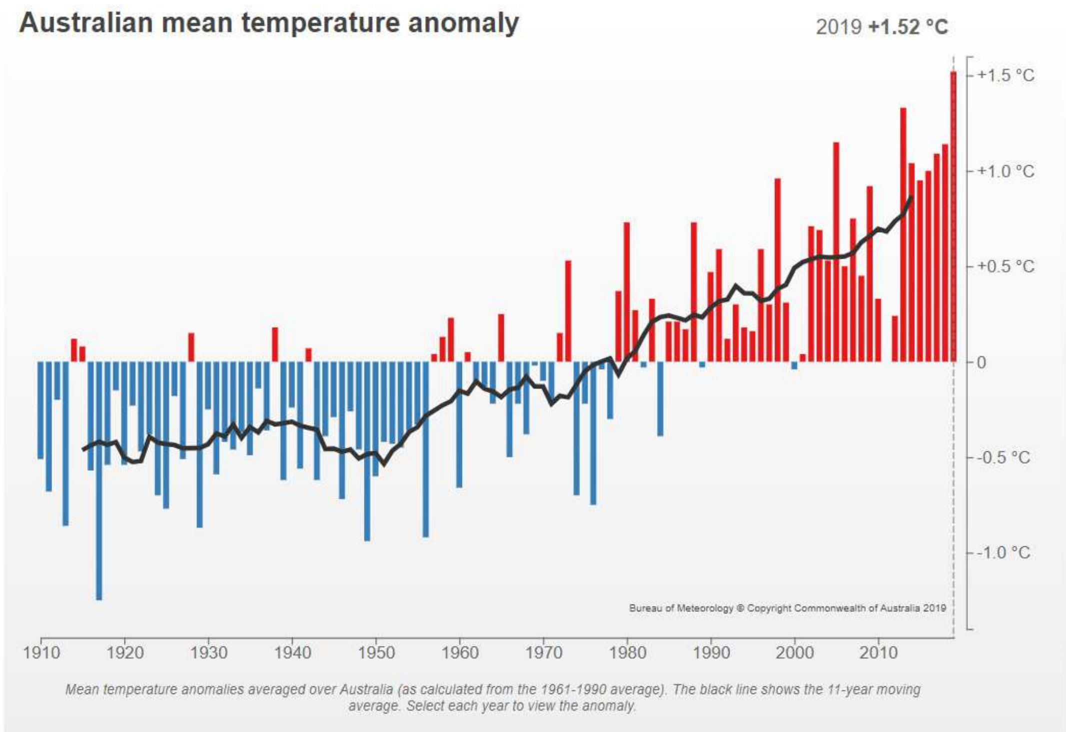
Australia's warmest year on record; 2019 had an annual national mean temperature 1.52 °C above average, surpassing the previous record of +1.33 °C in 2013. Warmth was widespread and persistent throughout 2019 — January, February, March, April, July, October, November, and December were all amongst the ten warmest on record for Australian mean temperature for their respective months. January, March, and December were the warmest on record, with January and December exceeding their previous records by a substantial 0.98 °C and 1.08 °C respectively.

The following charts are from global and national data which demonstrate mean temperature anomalies year on year.



Global mean temperatures were above average throughout 2019, with all months to November amongst the four warmest on record for their respective months.

Figure 5: Global mean temperature anomalies (1880 – 2010) (BOM, 2019)



An extended period of heatwaves over much of Australia began in early December 2018 and continued into January 2019. The delayed northern Australian monsoon saw heat build over the north, which persisted through much of summer. January was an exceptional month: Australia's warmest month on record for any time of the year, with the monthly mean temperature 2.90 °C above average. It was the warmest January on record for New South Wales, Queensland, Victoria, Tasmania, and the Northern Territory.

Figure 6: Australian mean temperature anomalies (1910 – 2010) (BOM, 2019)

The ACT Government has recognised that the climate of Canberra is already changing and that extreme weather events will occur more frequently and with more intensity, particularly heatwaves, droughts, storms and bushfires.

Impacts of climate change are already being observed in the ACT. The ACT Climate Change Strategy 2019-25 outlines that more hot days (above 35 degrees Celsius) and fewer cold nights in the ACT region are already observed, with the hottest day recorded in history observed in January 2020 with 44 degrees Celsius recorded in the Canberra CBD

Since the 1950s, average temperatures in the ACT have increased by about 1° C and in the last 55 years, increases to all heatwave characteristics have been observed.

4.1.1 Precipitation

Rainfall is highly variable. Drier conditions were experienced in the first half of the 1900s, with more variability in rainfall then seen between 1950 and 2000. The Millennium Drought characterised the early part of the 21st century through below average rainfall (NSW OEH, ACT Gov, 2014).

The Murray Basin cluster within which the Canberra region is located, has experienced differing rainfall variability in the past 15 years, including the record-breaking Millennium drought, affecting the Murray Basin cluster region. This ended with two of the wettest years on record for Australia (2010-2011 – BOM, 2012)

4.2 Urban heat and mircoclimate

The urban heat island (UHI) effect is the elevated temperature experienced in urban areas compared to surrounding areas given the dynamic interplay between the urban fabric (urban materials and geometry, orientation and configuration), urban land cover (the ratio of natural and built environments) and the urban metabolism (anthropogenic effects). Each of these factors can shape the temperature of the urban environment and can lead to greater absorption of solar radiation, reduced convective cooling and lower water evaporation rates as shown in Figure 7.

Microclimate is the climate effects at the local precinct or street scale and can relate to the landscape and urban design that has a direct impact at the local scale on human and environmental comfort.

In Canberra’s Living Infrastructure Plan, the urban heat island effect showed up to a 10°C or more temperature difference between different parts of Canberra on a hot day. Other studies have shown that on average in different parts of Australia the difference in urban daytime temperatures can be 10-15°C greater than rural areas, with it being a 5-10°C temperature difference at night-time (EPSDD, 2019). The magnitude of these temperature differences varies with seasons, location and the layout of the urban environment.

Factors that influence the UHI effect need to be well understood to ensure appropriate and effective mitigation strategies are implemented. As population growth and urban expansion drive new infrastructure during a time of predicted extreme weather events, mitigating the effects of UHI is critical to human health and the functioning and productivity of a city.

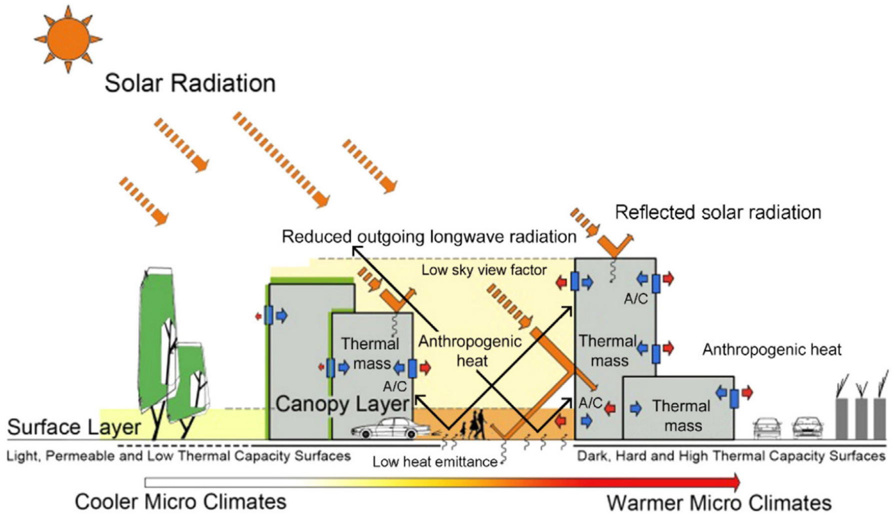


Figure 7- Urban Landscape and the UHI effect

Issues such as heat retention as a result of increased hardstand areas and materials with high thermal mass, such as concrete, bricks and tiles, act as a thermal battery. During summer they absorb heat during the day, and release heat during the evenings and nights, providing thermal comfort. In winter, the same mass can store heat from heaters or the sun, releasing it at night when temperatures are at their lowest.

The thermal comfort levels of an urban landscape are ultimately shaped by five fundamental processes; radiant heat from the sun, radiant heat reradiated from surfaces, air temperature and humidity, windspeed, direction and frequency, and anthropogenic effects (HVAC, transport, industry). Implementing proper design and integrating a variety of UHI mitigation strategies that deal with these factors can help cool the urban landscape, temper climate variances and improve thermal comfort levels. In turn, this can increase the value and productivity of the area, reduce incidents of heat stress and reduce energy consumption. Some of these design and mitigation strategies also offer additional benefits such as improving air quality, reducing stormwater runoff, reducing glare, dust mitigation, providing an acoustic barrier and improving the aesthetics of the space, which in turn improve the social and health outcomes for the region.

5 Climate change projections

5.1 Climate change scenarios

Climate projection data was sourced from the CSIRO's Australian Climate Futures (Climate Futures). Climate Futures is an interactive tool which references a range of global and regional climate models as well as statistically downscaled results to determine projection data for a range of climate variables as guided by the user.

Climate Futures uses the four Representative Concentration Pathways (RCPs) adopted in AR5 based on different greenhouse gas (GHG) scenarios. When applied, the RCPs describe four plausible climate futures for the project corridor, changing the levels of greenhouse gasses emissions that could be expected.

The RCPs are:

- RCP 2.6 – assumes global annual GHG emissions (measured in CO2-equivalents) peak between 2010-2020, and the decline substantially thereafter
- RCP 4.5 – assumes global annual GHG emissions peak around 2040, and then decline
- RCP 6 – assumes global annual GHG emissions peak around 2080, and then decline
- RCP 8.5 – assumes global annual GHG emissions continue to rise throughout the 21st century

Climate models suggest that global surface temperature change for the end of the 21st century is likely to exceed 1.5 degrees Celsius relative to 1850 to 1900 for all RCP scenarios except RCP2.6. Figure 8 displays the RCPs and corresponding carbon dioxide concentrations over time.

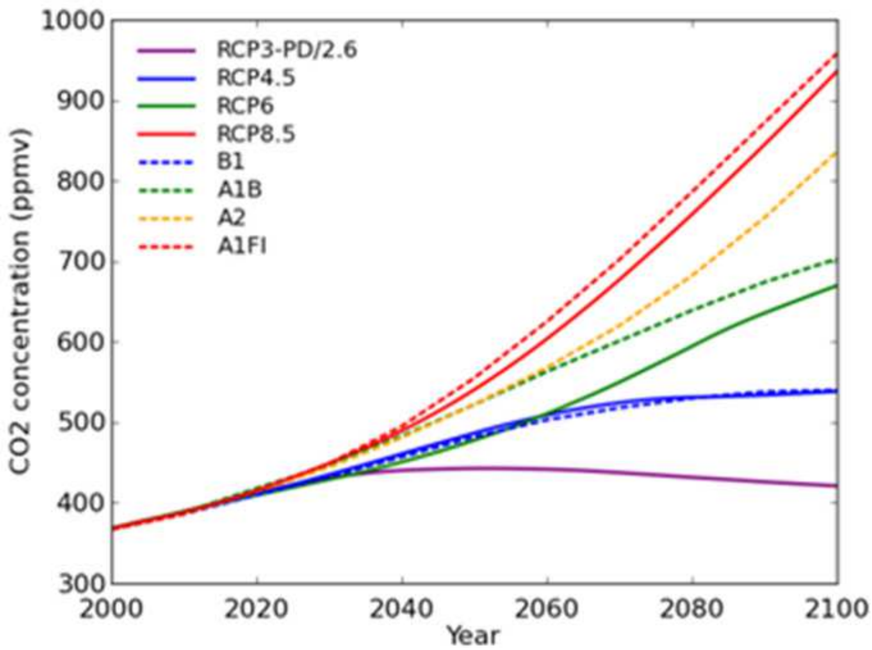


Figure 8: Comparison of Carbon dioxide concentrations for RCP scenarios (CSIRO and BOM, 2015)

For this project, RCP 8.5 has been considered in the climate projections. RCP8.5 corresponds to the pathway with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and GHG emissions with weak climate policy commitments in Australia (business as usual). RCP 8.5 is considered a worst case scenario, and has therefore been used to derive the corresponding climate projections.

5.2 Time scales

Two time periods, 2030 and 2070 were selected to establish climate scenarios that represent the near-term and long-term design life of the masterplan development and associated infrastructure components.

5.3 Projections

Across Australia, there has been almost a one degree increase (0.9°C) in the average surface temperature since 1910 (CSIRO & BoM, 2014). Based on long term observations (1910 – 2013), mean surface air temperatures has increased by 0.80C, with a substantial increase in the number and frequency of hot days. The region has experienced prolonged periods of extensive dry periods, with less rainfall particularly in the cooler seasons (Murray Basin Cluster Report, 2014).

Projected changes for each of the climate variables relevant for the Canberra region are presented in Table 2 below.

Future projections provided further below are soured from the Murray Basin cluster report (CSIRO, 2014) under which the Canberra region is located.

Table 2: Climate projections - Brickworks

Climate variable	Specific climate variables for ACT	Current observations[1]	Main climate change impacts for ACT	
			By 2030	**By 2070**
Rainfall	Mean rainfall	607 mm	> Spring = decrease (-18% to -4%) > Summer = increase (-19% to +28%) > Autumn = increase (-12% to +48%) > Winter = decrease (-17% to +12%)	> Spring = decrease (-6% to -19%) > Summer = increase (-7% to +28%) > Autumn = increase (-9% to +54%) > Winter = decrease (-23% to +13%)
	Extreme rainfall	Not available	10% increase in rainfall intensity for every 1.0ºC increase	10% increase in rainfall intensity for every 1.0ºC increase
Temperature	Average daily maximum temperatures	20.9 ⁰C	Increase by 0.6 – 0.9ºC	Increase by 1.4 – 2.3ºC
	Average daily minimum temperatures	7 ºC in winter	Increase by 0.6ºC	Increase by 2.0ºC
	Temperature (heatwaves, for example the average number of days over 35ºC)	9.1	Increase in number of hot days (1-5 extra days per year for Canberra)	Increase in number of hot days (10-20 extra days per year for Canberra)
	Cold nights	Not available	Decrease in number of cold nights (10-17 per cold nights year)	Decrease in number of cold nights (32-53 fewer cold nights per year)

[1] Based on data sourced from BOM Tuggeranong AWS weather station #070339 based on average for years 1996 – 2020 http://www.bom.gov.au/climate/averages/tables/cw_070339_All.shtml

Climate variable	Specific climate variables for ACT	Current observations[1]	Main climate change impacts for ACT	
			By 2030	By 2070
Bushfire	Bushfire Risk – average FFDI	Annual Average FFDI = 6.9	Increase in average Forest Fire Danger Index (FFDI)* during spring and summer	Increase in average and severe Forest Fire Danger Index (FFDI)* during spring and summer
	Bushfire Risk – severe FFDI days	Severe FFDI days per year = 1.1 (for example FFDI>50)	Increase in severe Forest Fire Danger Index (FFDI)* during spring and summer	Increase in severe Forest Fire Danger Index (FFDI)* during spring and summer

5.3.1 Temperature

Under the RCP 8.5, daily temperature maximums in Canberra indicate projections of a marked increase by 2090, with predicted increase in warm spells of 75 days compared to 1986 – 2005 time period (CSIRO, 2014). The number of days above 35^0C is expected to more than double under the RCP 4.5 scenario by 2090, with number of days over 40^0C more than tripling in occurrence.

5.3.2 Precipitation

In the near future (2030), year to year changes in rainfall will dominate trends caused by greenhouse gases. By the middle of the century, and under high emissions, winter and spring rainfall reductions will become evident against natural variability. Projections indicate while mean rainfall is tending towards a decrease, the extremes are projected to increase.

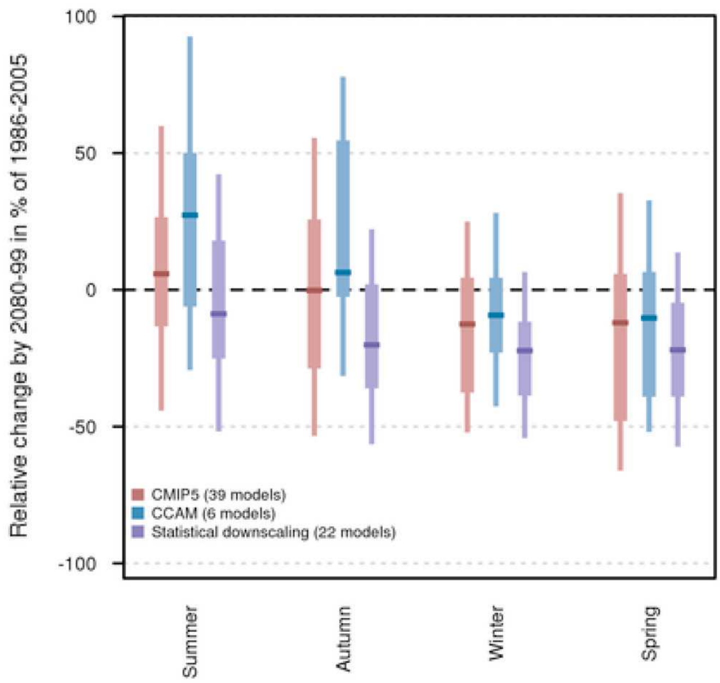


Figure 9 Projected near surface wind speed change between baseline period (19686-2005) and changes for 2090

5.3.3 Drought

In recent history, the Murray Basin cluster has been affected by three prolonged droughts. Projections indicate an increase in the percentage of time spent in drought and the frequency of extreme drought up to year 2090.

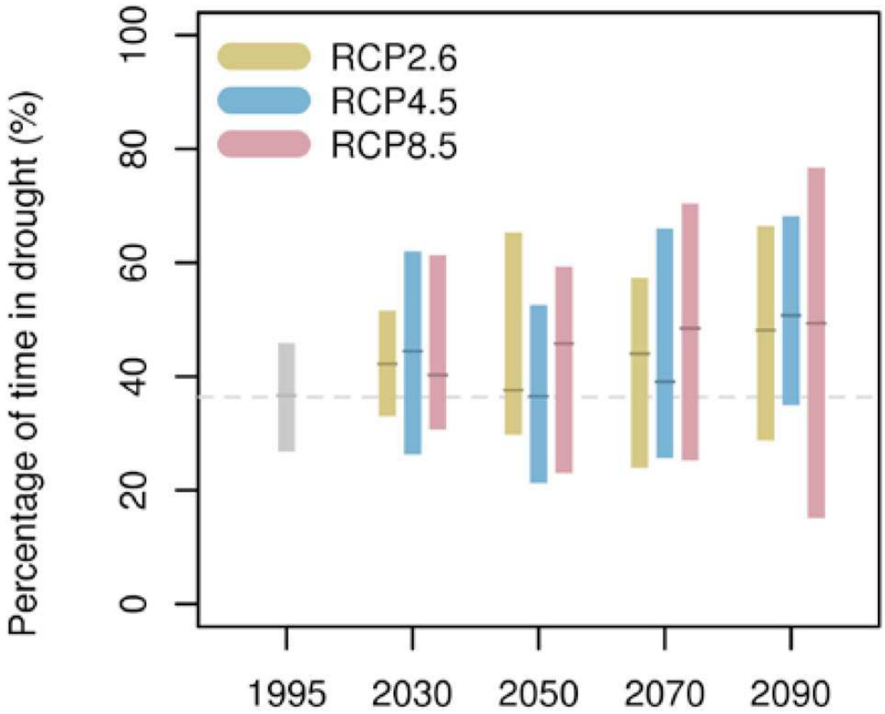


Figure 10 Projections of time spent in drought for Murray Basin region

5.3.4 Wind

Any notable projections changes to surface wind speed are expected during winter months, with indications that decreasing in wind speed will by more apparent during winter by 2090.

5.3.5 Fire weather

Fire weather is a measure of fuel dryness and abundance, as well a weather conditions i.e. hot, dry, and windy. CSIRO has estimated fire risk into the future based on the McArthur Forest Fire Danger Index (FFDI). This index uses ‘drought factor’ to estimate fuel dryness and inputs meteorological conditions. Modelling of climate change impacts on the fire regimes of the ACT landscapes predicts that a 20C increase in mean annual temperature would increase fire intensity by 25% and halve the mean interval between fires in the ACT (Department of Climate Change, 2009).

Focusing on the 2030 and 2090 timescales, the results indicate increased fire weather risk in the future, resulting from increased temperature combined with lower annual average rainfall.

6 Impact Assessment

Potential design or operational activities relevant to the Project and associated ancillary asset at risk or likely to be impacted were identified in a workshop with stakeholders. Impacts considered against respective climate variables identified in the workshop are outlined in Table 3.

Table 3: Potential climate impacts

Climate Variable	Direct/ Indirect impact	2030 – 2070 Potential Impact
Temperature	Direct	WSUD treatments more susceptible to extreme conditions Vegetation affected by temperature extremes leading to loss of trees/plants Health and safety of occupants, workers and visitors affected
Increase in extreme weather events – increased days >350C	Direct	Heat retention as a result of increased concrete, hard and landscaped areas Exposure of equipment/switchboards etc and potential for overheating Increased speed in degradation of building materials/facades or hardstand areas Heat retention in exposed metal contacts (handrails, children's playground etc) Increased temperatures affecting heat loads of buildings and occupants in particular on west facing facades
Bushfires	Indirect	Poor visibility, air quality and increased smoke resulting from nearby bushfires Bushfire risk and damage to infrastructure and utilities Restricted access to site due to bushfire threat
Increased precipitation	Direct	Flooding and subsequent damage to infrastructure and services Flow paths through the heritage areas resulting from increased wet weather Excess water loosening soils, in particular around heritage chimney Essential parts of site inundated Increased stormwater runoff from site Potential flooding of low level carparks
Drought	Direct	Reduction in water availability for irrigation
Wind	Direct	Increased structural load on buildings and infrastructure

7 Risk Assessment

Stakeholder engagement has been carried out to identify the potential impacts from the climate projections for 2030 and 2070. A risk assessment was then undertaken to assess the potential impacts identified for the development. The methodology and results of risk assessment are presented in this section.

7.1 Methodology

To evaluate the risks associated with impacts as a result of the projected climate change for 2030 and 2070 timescales, a qualitative risk assessment framework in line with the AS 5334 was undertaken. The risk management process is illustrated in Figure 11.

Risk is defined as the combination of consequences and likelihood. For each potential climate impact, the consequences and likelihood of occurrence were determined in accordance with Table 4 and Table 5. The risk rating for each combination of consequences and likelihood was outlined in Table 6.

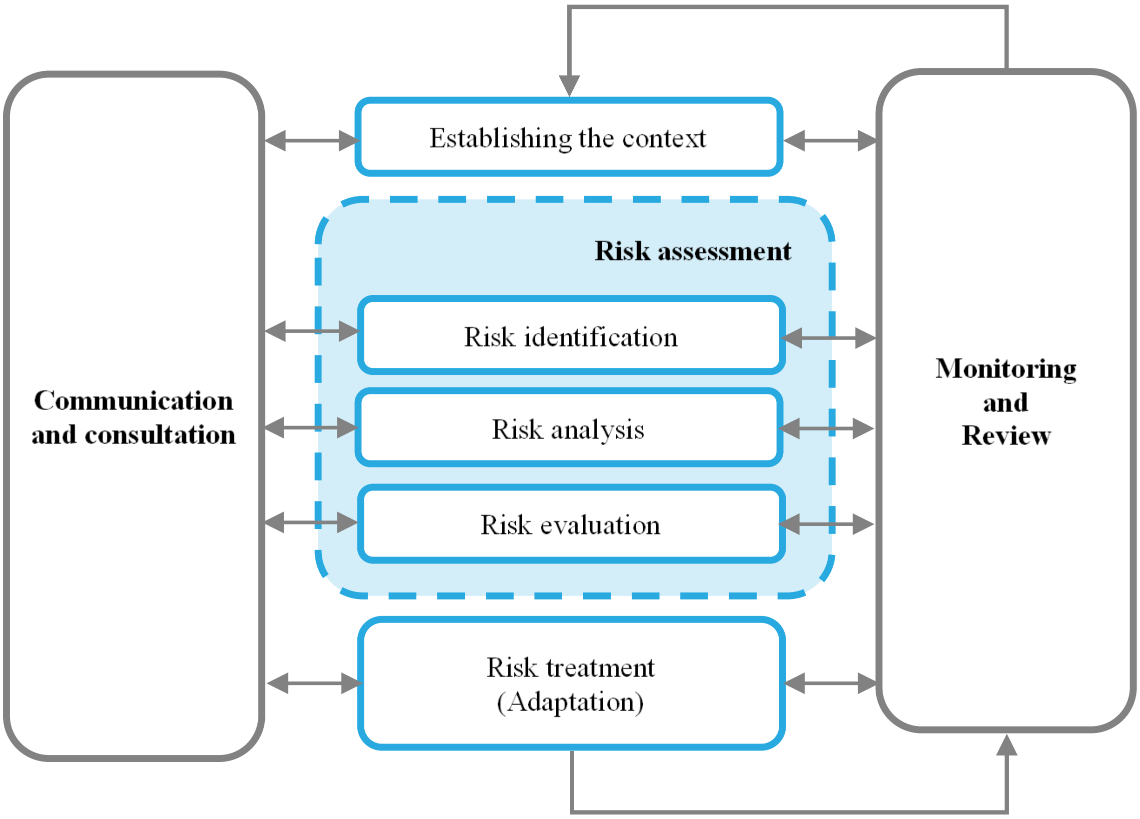


Figure 11: Risk management process (adapted from AS 5334-2013)

Table 4: Consequence scale

Level	Descriptor	Consequence	Environmental	Social	Financial
1	Insignificant	No change, limited impacts	No adverse effect on natural environment	No adverse human health effects or complaints.	Insignificant financial loss
2	Minor	Localised service disruption. No permanent damage. Some minor restoration work required. Lifespan reduced by 10-20%	Minimal effects on the natural environment.	Short-term disruption to employees, residents or businesses. Slight adverse human health effects or general amenity issues. Negative reports in local media.	Additional operational costs. Minor financial loss
3	Moderate	Widespread damage. Damage recoverable by maintenance and minor repair. Partial loss of local infrastructure. Lifespan reduced by 20-50%.	Some damage to the environment, including local ecosystems. Some remedial action may be required	Frequent disruptions to employees, residents or businesses. Adverse human health effects. Negative reports in state media.	Moderate financial loss
4	Major	Extensive damage requiring extensive repair. Lifespan reduced by >50%.	Significant effect on the environmental and local ecosystems. Remedial action likely to be required.	Permanent physical injuries and fatalities may occur from an individual event. Negative reports in national media. Public debate about performance.	Major financial loss
5	Catastrophic	Permanent damage and/or loss of service Retreat and translocation of development.	Very significant loss to the environment. May include localised loss of species, habitats or ecosystems. Extensive remedial action essential to prevent further degradation. Restoration likely to be requirement.	Severe adverse human health effects – leading to multiple events of total disability or fatalities. Emergency response. Negative reports in international media.	Significantly high financial loss

Table 5: Likelihood scale

Level	Descriptor	Description	Recurrent risk
A	**Almost Certain**	Event is almost certain to occur (90% probability) within the next 12 months or is imminent.	May occur several times per year
B	**Likely**	Event is likely to occur within the next 12 months (greater than 60% probability).	May arise about once per year
C	**Possible**	Event is possible within the next 12 months (30% probability) OR, has a reasonable chance (more than 50% probability) of occurring in next 3 years.	May arise once in 10 years
D	**Unlikely**	Event is not likely to occur in a given year (less than 30% probability).	May arise once in 10 to 25 years
E	**Very Unlikely**	The event may occur in exceptional circumstances (less than 1% probability) within the next 3 years).	Unlikely during the next 25 years

Table 6: Risk matrix.

Likelihood		Consequence				
		1	**2**	**3**	**4**	**5**
		Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
A	**Almost Certain**	Low	Medium	High	Extreme	Extreme
B	**Likely**	Low	Medium	Medium	High	Extreme
C	**Possible**	Low	Low	Medium	High	High
D	**Unlikely**	Low	Low	Medium	Medium	High
E	**Very Unlikely**	Low	Low	Low	Medium	Medium
		Recurrent risk				

7.2 Risk analysis

Following the stakeholder workshop, climate risks were identified for associated impacts. This was undertaken as a first pass and discussed and agreed with the relevant technical leads to support the identification of relevant adaptation measures.

The following table presents the likelihood, consequences and resulting risks for the three timescales considered by the project team. The likelihood was largely determined by the climate data whilst the consequences were indicated by the project team. A full copy of the risk spreadsheet as informed by the workshop and subsequent outcomes is provided in Appendix A.

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
Change in average air temperature											
1	Prolonged periods of heat or drought	Death of fringing vegetation in wetland treatment system	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium
2	Extreme temperatures affecting vegetation	Leading to potential loss of trees/plants which aren't designed to withstand conditions	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium
3	Extreme temperatures affecting occupant and visitor comfort	Health and safety of occupants, workers and visitors - in particular pedestrian traffic to and from outdoor parking areas	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium
Increase in extreme weather events – increased days >35^{0}C											
4	Microclimate impacts	Heat retention as a result of increased concrete and hard, landscaped areas	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
5	Occupant comfort	Pedestrian comfort during extreme heat (Safety of users)	Possible	Moderate	Medium	Almost certain	Moderate	High	Almost certain	Moderate	High
6	Equipment design temperatures	Technology exposure / switchboards / cooling, equipment overheating	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
7	Exposure of building and facades to extreme heat conditions	Increased speed degradation of building materials/ facades/hardscaped areas	Possible	Minor	Low	Possible	Minor	Low	Likley	Minor	Medium
8	User safety	Heat retention in exposed metal contact (handrails, Kids playgrounds etc), exposed railroad tracks	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium
9	Increased temperatures affecting heat loads and resident comfort	West facing facades (considered in design), limited opportunity for heritage assets	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
10	Worker safety	construction delays due to prolonged periods of extreme temperature events	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low
Bushfires											
11	Smoke and visibility resulting from nearby bushfires	Bushfires within the proximity of the development may lead to smoke and limited visibility/poor air quality for occupants and residents.	Likely	Moderate	Medium	Likely	Moderate	Medium	Almost certain	Moderate	Medium
12	Bushfire threat to infrastructure	bushfire risk - damage to infrastructure (inner asset and outer asset protection zones)	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
13	Accessibility for emergency services	Restricted access during bushfire events for emergency services	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
Increased precipitation											
14	Increase extreme wet weather	Flooding and subsequent damage to infrastructure and services	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
15	Increased extreme wet weather	Resulting in flow paths through the heritage area - challenges of managing heritage levels due to restrictions on development	Possible	Minor	Low	Possible	Minor	Low	Likely	Minor	Medium
16	Excess water from flooding	Excess water ingress leading to loosening of soils and potentially affecting stability of heritage chimney	Possible	Moderate	Medium	Possible	Major	High	Possible	Major	High

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
17	Flooding risk	Increased stormwater runoff from the site – stormwater facilities not built for more frequent more intense storm events	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
18	Flooding risk	Essential parts of site inundated for the future scenario. Increase in frequency of damaging storms,	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium
19	Water ingress due to excess precipitation	potential flooding of low level carparks	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium
20	Increased severity of hail storms	Causing damage to property and personal injury	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium

Risk Number	Details of risk event	Impact of risk event	Present Risk			2030			2070		
			Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk	Likelihood	Consequence	Level or risk
Drought											
21	Reduced average rainfall events	Reduction in water supply to the wetland / pond treatment systems results in too little turnover and subsequent stagnation	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low
22	Prolonged dry periods	Reduction in water availability for irrigation	Possible	Minor	Low	Possible	Minor	Low	Likley	Minor	Medium
23	Increased wind loads	Increased structural load on buildings and infrastructure	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low

8 Adaptation responses

8.1 Urban heat and microclimate

There are a variety of ways UHI mitigation strategies can be incorporated into the urban landscape. Some methods involve new innovations and technology surrounding different compositions, types and colour of materials, while others use landscape design techniques to maximise the urban cooling effect.

The effectiveness of urban cooling strategies is heavily dependent on the local climate conditions and seasonal variabilities. Canberra experiences the range of seasons and is hot and dry in summer and cold in winter. Green infrastructure and shading can be used to combat high solar radiation intensity on hot summer days and choosing to use deciduous species on orientations that can help warm particular areas in the cold winter months. strategies in the Canberra's dry heat while high levels of annual rainfall means permeable paving can be utilised for additional cooling effects and stormwater management. The use of cool paving and structures to reflect away the urban heat can be effective, but the resulting glare that this can cause may limit its use in built up, high-traffic areas.

Integrating some of these design strategies and technologies can help reduce the UHI effect in Canberra and improve comfort levels immediately surrounding the Brickworks development. Combining a number of these strategies can have a cumulative effect and can often work better when employed together (e.g. canopy coverage, shading structures, high albedo surfaces). A summary of urban heat island mitigation strategies which have been considered in design of the masterplan development are presented in Table 7.

Table 7: UHI adaptation responses considered in design

UHI mitigation strategy	Design response	Design consideration
Urban green infrastructure	Tree canopy/planting – maximising canopy coverage where appropriate	Significant increase of tree canopy from exiting conditions and mature size on day of planting for immediate effect. New trees, including street trees and understory planting layer to be chosen from an appropriate species selection that are resilient to droughts and currently performing adequately within the local context
	Green roofs/green walls	To be further explored and implemented where possible

UHI mitigation strategy	Design response	Design consideration
Urban water	Active water features – old conveyor water feature	Water is an important element in the design and is the story telling element of the site past use A large water body located at Pittman Park collects all the water from site where is treated and then distributed to the site for many purposes such as irrigation or part of the design features.
	Permeable surfaces	To be further explored and implemented where possible
Materials	Solar reflective or light coloured paints/coatings and pavements	The paving and materials palette will take into account the heat mitigation by using light colours paving and implement permeable materials where possible
Shading structures	Solar radiation and reflection	Trees and vegetation will provide solar protection to the main gathering areas. The incorporation of shade structures and vegetated pergolas will be explored and implemented where possible

Implementation of the garden city design principles - to increase green space and canopy cover of the area, helps attribute to the cooling effects. Removal of the existing poor quality trees and vegetation, and replacement with higher quality vegetation which provides canopy cover and shading of exposed spaces. Establishment of green spaces, particularly at Pittman Park, where irrigated lawns and an ornamental lake will feature will help reduce temperature increases associated with the built surrounds. Extensive street planting along Quarry Drive will further provide shading and cooling effects along the site entrance.

The historic industrial nature of the site will also be maintained by retaining and reusing the concrete and other finish materials in the public domain areas. A water feature that brings water from the lake up via the historic conveyor belt to the old kiln site and public areas will also contribute cooling within the urban areas. The combination of the evaporation from the water feature and the shade from the tree canopy will assist in reducing the surface and air temperature providing a comfortable micro climate within the public domain area.

While the homage to the historic industrial nature of the site will retain concrete within some of the public domain areas, the water element which brings water from the lake up via the historic conveyor belt to the old kiln site and public areas will also allow cooling within the urban areas. Both the water feature and tree canopy from planted trees will assist in providing a comfortable micro climate within the public domain area.

The residential zones will sit amongst garden settings in contrast to the dominantly brick material used in construction, providing cooling and further minimising increases in temperature around the built up areas.

8.2 Climate change adaptation responses

As a result of the risk assessment and stakeholder consultation, the following adaptation options has been considered and included in the design and operational intent of the Project to improve the climate resilience – noting adaptation responses are not proposed for items identified as ‘low’ risk.

Where risks have been highlighted as 'high', mitigation measures have been implemented to reduce these risks to medium or lower. Intervention measures which are subsequently incorporated within design have also been considered for at least two of risks identified, in line with GS Communities requirements.

Table 8: Project Mitigation responses

Risk ID	Description of Impact	Initial Risk rating			Measures implemented	Residual risk rating		
		Present	2030	2070		Likelihood	Consequence	Risk
1	Prolonged periods of heat or drought	Medium	Medium	Medium	Wetland water levels monitored during heatwaves and adjusted as required to keep plants alive. Replanting program for any plants lost during extreme events	Likely	Minor	Medium
2	Extreme temperatures affecting vegetation	Medium	Medium	Medium	Planting of native species that are resilient to droughts - minimising erosion and degradation of soil	Possible	Minor	Low
3	Extreme temperatures affecting occupant and visitor comfort	Medium	Medium	Medium	Consideration of covered walkways, design considers wayfinding through site links and shared paths to minimise walking distances	Possible	Moderate	Medium
4	Microclimate impacts	Medium	Medium	Medium	No further mitigation measures proposed as impact not considered high risk	Likely	Minor	Medium

Risk ID	Description of Impact	Initial Risk rating			Measures implemented	Residual risk rating		
		Present	2030	2070		Likelihood	Consequence	Risk
5	Occupant comfort	Medium	High	High	Outdoor parking under cover or underground Appropriate design of wayfinding to minimise pedestrian exposure Implementation of garden city design principle to increase green space and canopy cover of the area through removal of existing poor quality trees and replacement with better quality vegetation Provision of water drinking fountains in public areas	Possible	Moderate	Medium
6	Equipment design temperatures	Medium	Medium	Medium	Locate systems appropriately. Providing shelter for equipment will reduce the impact of UV radiation and weather and increased temperature.	Unlikely	Minor	Low
8	User safety – heat retention on exposed metal	Medium	Medium	Medium	Consideration of shade structures for playgrounds Canopy coverage from replacement trees and vegetation to provide shading Use of alternative materials for playground equipment to be investigated to minimise heat retention	Likely	Minor	Medium

Risk ID	Description of Impact	Initial Risk rating			Measures implemented	Residual risk rating		
		Present	2030	2070		Likelihood	Consequence	Risk
9	Increased temperatures affecting heat loads and resident comfort	Medium	Medium	Medium	Deeper balconies proposed for western facing apartments, consideration of shading structures for afternoon sun, appropriate glazing selection to reduce solar heat penetration Look at maximising passive shading for residential buildings	Likely	Minor	Medium
11	Smoke and visibility resulting from nearby bushfires	Medium	Medium	Medium	100% recycled air in majority of apartments	Possible	Moderate	Medium
12	Bushfire threat to infrastructure	Medium	Medium	Medium	power and comms infrastructure u/ground Bushfire report been completed - inner and outer impact - existing APZ and possible amplification, lower fire potential plantings, maintained trees in park like fashion (reducing fuel loading)	Possible	Minor	Low
13	Accessibility for emergency services	Medium	Medium	Medium	Use of designated access/street for emergency service vehicles	Possible	Moderate	Medium
14	Increase extreme wet weather leading to flooding	Medium	Medium	Medium	No further mitigation measures proposed as impact not considered high risk	Medium	Medium	Medium

Risk ID	Description of Impact	Initial Risk rating			Measures implemented	Residual risk rating		
		Present	2030	2070		Likelihood	Consequence	Risk
16	Excess water from flooding loosening soil around heritage chimney	High	High	High	Chimney stacks currently structurally sound - continue to monitor as part of ongoing mgt, monitor structural performance. Assumed level of degradation within design, with structures to be retained water proofed etc	Possible	Moderate	Medium
17	Flooding risk affecting stormwater infrastructure ability to cope	Medium	Medium	Medium	No further mitigation measures proposed as impact not considered high risk	Medium	Medium	Medium
18	Flooding risk – inundation of site access	Medium	Medium	Medium	No further mitigation measures proposed as impact not considered high risk	Medium	Medium	Medium
19	Water ingress due to excess precipitation – flooding risk to lower carparks	Medium	Medium	Medium	Assess parking access road levels to minimise water ingress and provide strategies to manage excess water flow	Possible	Minor	Low
20	Increased severity of hail storms	Medium	Medium	Medium	Specify impact resistant building materials as required	Possible	Moderate	Medium

9 Next steps

This climate change risk assessment has been developed for the proposed Brickworks masterplan development, and the following actions would be undertaken as design progresses to ensure that relevant climate risks are considered at each stage of design. This will ensure the project has considered the future occupied environment along with relevant climate factors or variables which may impact the asset.

The following items are noted as the next steps following design progression and detailed design:

- Further develop and consider the work undertaken to date, in conjunction with relevant literature and data to identify and prioritise the key climate impacts and potential urban heat impacts likely to impact the functionality of the masterplan development and its impact on both the local and wider regional community
- Work with relevant stakeholders, including external stakeholder organisations to enable aligned approach to adaptation and response to climate change impacts and urban heat impacts across the broader region
- Collaborate with relevant stakeholders to develop and implement site specific Community Resilience Plan (CRP).

10 Conclusions

This report summarises the outcomes of potential climate change and urban heat impacts on the Brickworks masterplan development through completion of a climate change risk assessment. The report demonstrates a rise in climate uncertainty, affecting the future masterplan whereby considerations to be made through the design stage need to take into account rise in temperatures, the increase in the number of heatwaves per year and the potential for flooding.

Both direct climate change impacts (such as change in average temperatures) and indirect climate change impacts (such as reduced bushfires resulting in flow on impacts to service requirements) need to be taken into consideration when carrying out future climate change risk assessments.

Current weather conditions that lead to flooding and heatwaves, are predicted to increase in intensity over the coming years within the region due to an increase in temperatures and the number and intensity of storms. Through appropriate design and construction, future climate change assessments will assist in protecting the masterplan development from future extreme weather conditions.

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Appendix A

Climate change risk assessment spreadsheet

Climate Change Risk Workshop				9/6/2020	Brickworks Masterplan												
					Present Risk			2030			2070						
								RCP 8.5 (2030)			RCP 8.5 (2070)				Residual Risk		
Item Number	Climate Variable	Direct / Indirect	Details of Risk Event	Impact of the risk event	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Adaptation/Mitigation Strategy	Likelihood	Consequence	Level of Risk
1	Change in average air temperature	Direct	Prolonged periods of heat or drought	WSUD treatments more susceptible to extreme conditions	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Wetland water levels monitored during heatwaves and adjusted as required to keep plants alive. Replanting program for any plants lost during extreme events	Likely	Minor	Medium
2	Change in average air temperature	Direct	Extreme temperatures affecting vegetation	Leading to potoential loss of trees/plants which aren't designed to withstand conditions	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Planting of native species that are resilient to droughts - minimising erosion and degradation of soil	Possible	Minor	Low
3	Change in average air temperature	Direct	Extreme temperatures affecting occupant and visitor comfort	Health and safety of occupants, workers and visitors - in particular pedestrian traffic to and from outdoor parking areas	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Consideration of covered walkways, design considers wayfinding through site links and shared paths to minimise walking distances	Possible	Moderate	Medium
4	Increase in extreme weather events – increased days >350C	Direct	Microclimate impacts	Heat retention as a result of increased concrete and hard, landscaped areas	Likely	Minor	Medium	Likely	Minor	Medium	Likely	Minor	Medium	Use of light coloured surfaces for light reflection and reducing heat retention Implementation of garden city design principles to increase green space and canopy cover	Likely	Minor	Medium
5	Increase in extreme weather events – increased days >35^{0}C	Direct	Occupant comfort	Pedestrian comfort during extreme heat (Safety of users)	Possible	Moderate	Medium	Almost certain	Moderate	High	Almost certain	Moderate	High	Outdoor parking under cover or underground Appropriate design of wayfinding to minimise pedestrian exposure Implementation of garden city design principle to increase green space and canopy cover of the area through removal of existing poor quality trees and replacement with better quatity vegetation Provision of water drinking fountains in public areas	Possible	Moderate	Medium
6	Increase in extreme weather events – increased days >35^{0}C	Direct	Equipment design temperatures	Technology exposure / switchboards / cooling, equipment overheating	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Locate systems appropriately. Providing shelter for equipment will reduce the impact of UV radiation and weather and increased temperature.	Unlikely	Minor	Low
7	Increase in extreme weather events – increased days >35^{0}C	Direct	Exposure of building and facades to extreme heat conditions	Increased speed degradation of building materials/ facades/hardscaped areas	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Specificiation of durable materials to maximise lifespan of building components			
8	Increase in extreme weather events – increased days >35^{0}C	Direct	User safety	Heat retention in exposed metal contact (handrails, Kids playgrounds etc), exposed railroad tracks	Likely	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Consideration of shade structures for playgrounds Canopy coverage from replacement trees and vegetation to provide shading Use of alternative materials for playground equipment to be investigated to minimise heat retention	Likely	Minor	Medium
9	Increase in extreme weather events – increased days >35^{0}C	Direct	Increased temperatures affecting heat loads and resident comfort	West facing facades (considered in design), limited opportunity for heritage assets,	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Almost certain	Minor	Medium	Deeper balconies proposed for western facing apartments, consideration of shading structures for afternoon sun, appropriate glazing selection to reduce solar heat penetration	Likely	Minor	Medium

					Present Risk			2030			2070						
								RCP 8.5 (2030)			RCP 8.5 (2070)				Residual Risk		
Item Number	**Climate Variable**	**Direct / Indirect**	**Details of Risk Event**	**Impact of the risk event**	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	Likelihood	Consequence	Level of Risk	**Adaptation/Mitigation Strategy**	Likelihood	Consequence	Level of Risk
10	Increase in extreme weather events – increased days >35^{0}C	Indirect	Worker safety	construction delays due to prolonged periods of extreme temperature events	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Appropriate health and safety management plans and adherence to industry regulations around work conditions			
11	Bushfires	Indirect	Smoke and visbility resulting from nearby bushfires	Bushfires within the proximity of the development may lead to smoke and limited visibility/poor air quality for occupants and residents.	Likely	Moderate	Medium	Likely	Moderate	Medium	Almost certain	Moderate	High	100% recycled air in majority of apartments	Possible	Moderate	Medium
12	Bushfires	Direct	Bushfire threat to infrastructure	bushfire risk - damage to infrastructure (inner asset and outer asset protection zones)	Possible	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	power and comms infrastructure u/ground Bushfire report been completed - inner and outer impact - existing APZ and possible amplifcation, lower fire potential plantings, maintained trees in park like fashion (reducing fuel loading)	Possible	Minor	Low
13	Bushfires	Direct	Accessibility for emergency services	Restricted access during bushfire events for emergency services	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Use of designated access/street for emergency service vehicles	Possible	Moderate	Medium
14	Increased precipitation	Direct	Increase extreme wet weather	Flooding and subsequent damage to infrastructure and services	Possible	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium				
15	Increased precipitation	Direct	Increased extreme wet weather	Resulting in flow paths through the heritage area - challenges of managing heritage levels due to restrictions on development	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low				
16	Increased precipitation	Direct	Excess water from flooding	Excess water ingress leading to loosening of soils and potentially affecting stability of heritage chimney	Possible	Major	High	Possible	Major	High	Possible	Major	High	Chimney stacks currently structurally sound - continue to monitor as part of ongoing mgt, monitor structural performance. Assumed level of degredation within design, with structures to be retained water proofed etc	Possible	Moderate	Medium
17	Increased precipitation	Direct	Flooding risk	Increased stormwater runoff from the site – stormwater facilities not built for more frequent more intense storm events	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium				
18	Increased precipitation	Direct	Flooding risk	Essential parts of site inundated for the future scenario. Increase in frequency of damaging storms,	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium				
19	Increased precipitation	Direct	Water ingress due to excess precipitation	potential flooding of low level carparks	Likely	Moderate	Medium	Likely	Moderate	Medium	Likely	Moderate	Medium	Assess parking access road levels to minimise water ingress and provide strategies to manage excess water flow	Possible	Minor	Low
20	Increased precipitation	Direct	Increased severity of hail storms	Causing damage to property and personal injury	Possible	Moderate	Medium	Possible	Moderate	Medium	Possible	Moderate	Medium	Specify impact resistant building materials as required	Possible	Moderate	Medium
21	Drought	Indirect	Reduced rainfall events	Reduction in water supply to the wetland / pond treatment systems results in too little turnover and subsequent stagnation	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	Water availability in a drying climate for wetland/pond could be enhanced by connecting to the stormwater system in the surrounding suburban areas. Could also be enhanced by connecting into the potable mains system.			
22	Drought	Direct	Prolonged dry periods	Reduction in water availability for irrigation	Possible	Minor	Low	Possible	Minor	Low	Possible	Minor	Low	70% irrigation demand - design looking at ability to expand tanks to store more water for contingency?			
23	Wind	Direct	Increased wind loads	Increased structural load on buildings and infrastructure	Unlikely	Minor	Low	Unlikely	Minor	Low	Unlikely	Minor	Low	structure of bldg designed to meet current codes			

Memorandum

ARUP

To	EIS Input - Umwelt	Date	7 April 2021
Copies	Bloc, Doma	Reference number	Click here to enter text.
From	Arup	File reference	276789-00
Subject	Brickworks Redevelopment, Yarralumla - GHG technical input for EIS		

1 Introduction

This technical memo outlines specific requirements relating to greenhouse gas and carbon mitigation required as part of the projects Scoping Report which must be addressed within the Environmental Impact Statement (EIS) document. This memo just includes those that relate to greenhouse gas contribution and response.

Table 1 EIS requirements cross reference

EIS requirements	Where addressed
Address the contribution the proposal will make to reducing greenhouse gas emissions and meeting the legislated target for a net zero emissions Territory (by 2045 at the latest)	*GHG technical memo section 1.1*
Investigate the impact of increasing residential and vehicular activities upon greenhouse gas emissions	*GHG technical memo section 2.5*
Describe the design and layout of the site and provide details of building orientation and materials to achieve solar passive design. Provide details of mitigation methods to reduce reliance on mechanical heating and cooling	*GHG technical memo sections 2.2 and 2.3*

Memorandum

1.1 Approach

Overall, the design principles guiding the development for Brickworks precinct considers strategies which aim to reduce reliance on mechanical heating and cooling, using the existing building design and orientation to achieve solar passive design.

The Project is also undertaking a climate risk assessment process that examines impacts of a changing climate in terms of microclimate and urban heat. Building resilient communities which take into consideration construction and design impacts and how these can reduce the carbon foot will also assist in reducing greenhouse gas emissions and contribute towards meeting the legislated target for a net zero emissions Territory.

The general approach is to prioritise initiatives which sit higher in the energy hierarchy Figure 2, where:

- Load reduction – means limiting the amount of energy used, while maintaining amenity
- Passive systems – uses systems driven by natural means to achieve outcomes that would otherwise have used energy e.g. orientation
- Active systems- where energy is used, providing systems that utilise energy more efficiently e.g LED lighting that gives the same amount of light for less input energy
- Energy recovery – where energy has been spent, recovering it before it is released into the environment
- Renewable energy – application of renewable energy close to the use of energy e.g. solar PV panels for core heritage precinct
- Offsets – where the above cannot be achieved, the final step is to offset the energy impact by the purchase or development of off-site, carbon-free energy generation.

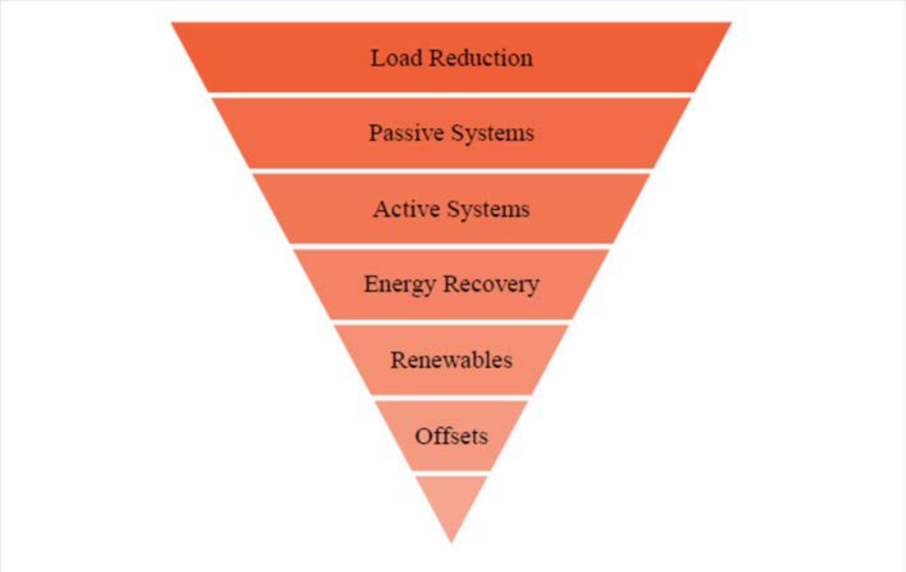

Figure 1 Energy approach hierarchy

The overall strategy for operational emissions reduction is to follow a 'Lean, Clean, Green' approach, balancing immediate environmental and economic performance with longer term reduction in GHG emissions. This approach delivers opportunities to maximise development opportunity while minimising the carbon footprint of the precinct:

- Lean – prioritising passive design to mitigate the demand for resources through design of natural and passive lighting and ventilation. The design concept follows the energy hierarchy by utilising world class passive design principles to reduce the energy demand in the first instance
- Clean – selection of efficient equipment to deliver further improvements – in the form of highly efficient mechanical and lighting design to further reduce energy consumption
- Green – selection of green technology to reduce remaining carbon emissions where possible. For example, the roofs of the kiln building within the heritage core provides an excellent opportunity for onsite renewable energy generation using solar panels.

1.2 Impact

According to Architecture Australia (2019), approximately 25% of greenhouse gas emissions in Australia is produced by the construction, operation and maintenance of buildings[1]. Hence, it is important to consider the whole of lifecycle of planning, design, construction and operations of buildings, to produce structures that are less resource intensive with less carbon emissions throughout the process.

[1] https://architectureau.com/articles/buildings-produce-25-of-australias-emissions-what-will-it-take-to-make-them-green-and-wholl-pay/

Reducing greenhouse gas emissions on the project and hence contributing towards the Territory's ultimate net zero target, will result from reducing consumption through energy efficient passive design. Passive design involves the designing of a building or structure and surrounds which requires little heating and cooling requirements. Apartments and dwellings which are appropriately passively designed will take advantage of the natural climate to maintain and improve thermal comfort.

2 GHG actions

2.1 NatHERS

The majority of GHG emissions are attributed to the operational phase, specifically the Heating Ventilation and Cooling (HVAC). The design aims to optimise orientation, materials and passive design features to increase the energy efficiency of the buildings and minimise the heating and cooling demand. The resultant building performance will be measurable, and it is anticipated that the National House Energy Rating Scheme (NatHERS) will be used to target a high level of building performance. Through the targeted NatHERS rating and on-site generation of green power, GHG savings of 68.4-84% compared to a BAU reference development will be targeted. The details of this will be outlined in the Green Star Communities Submission, credit 25A.

2.2 Orientation

The proposed Brickworks development layout consists of a mixture of apartment and terrace building typologies, as well as single dwelling lots and the existing heritage precinct. All buildings are accessible by public roads and footpaths with green space concentrated within the north west region of the site. Optimum solar orientation of the apartment buildings and townhomes in response to both the site topography and north orientation will allow passive heating and cooling – see site layout in **Error! Reference source not found.**.

Figure 2 Site layout plan

North facing units will be maximised with appropriate cross ventilation, optimisting the orientation to catch the sun and breezes consitent with improved solar passive design. Responding to the solar orientation of the site also ensures adequate sunlight is provided to the public open space areas as well as to the café and restaurant spaces. The use of deciduous trees to provide appropriate shading through varied seasons is considered within the public realms and parkland areas, providing further cooling effects to mitigate urban heating.

Limiting the level of sun exposure directly or indirectly into a buildings core structure is a logical way of mitigating and reducing heat generation particularly during summer months. Utilising window shading structures or eaves will be considered to reduce mean radiant heat temperature (heat gain) within apartments and dwellings, improving the overall thermal comfort levels within the building interior. In Canberra, north orientation is desirable as it's a region which requires winter heating and summer cooling. By utilising the seasonal variation of the angle of the sun and incorporating simple design features such as shading, the dwellings and apartment buildings can be protected from the summer sun while providing full penetration during winter months.

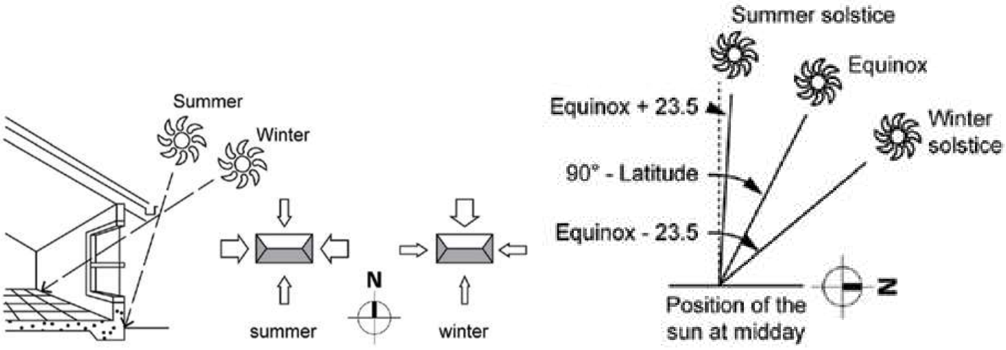

Figure 3 Solar solstice angles and example of standard eaves shading[2]

Incorporation of extensive shading in the form of balconies in addition to eaves and window overhangs for apartment buildings will also be considered, allowing low-angle winter sun into the interiors while reducing high angle summer sun and maintaining ample daylight. This will act to reduce the need and reliance on mechanical heating during the cooler seasons.

Cool breezes are a cost free and effective means of cooling where the climate provides it. Buildings can utilise these breezes by adopting a narrow or open plan layout. Cross ventilation within apartments and dwellings will allow for breezes, with the proposed building design providing opportunities for natural ventilation and/or mixed mode in certain buildings to reduce reliance on mechanical ventilation.

As outlined in the Climate Adaptation Plan, urban cooling strategies have the potential to be effective in the outdoor spaces, which can lead to flow on positive effects to the common accessible areas and cafés and indoor/outdoor spaces. Evaporative cooling strategies, in particular with the importance of water in the design and the presence of large water body at Pittman Park conveying water up to the public spaces, helps reduce excessive heat in the hotter months within the shared spaces, leading to potentially cooler indoor spaces. Green infrastructure and appropriately designed shading will be considered to combat high solar radiation intensity on hot summer days, with selection of deciduous tree species, particularly on orientations that can help warm areas in the cold months and provide shading in the warmer months. These passive design features help to reduce the heating effect around the urban areas and improve comfort levels within the indoor spaces.

2.3 Building materials

As is the case with any development, there is an inevitable impact on GHG emissions. Embodied emissions in materials, transportation and construction account for approximately 11% of the total GHG emissions across the whole life cycle of a development[3]. Recent advances in technology now enable engineers and architects to quickly assess how their design decisions impact on the total embodied carbon of the development. These carbon tools can be used to aid the option appraisal and design iterations as the development progresses to realise reductions in embodied carbon. This has the potential to save thousands of tonnes of carbon at little to no cost.

[2] https://www.yourhome.gov.au/passive-design/orientation
[3] https://architecture2030.org/new-buildings-embodied/

The manufacture of materials commonly used in building construction, such as steel, concrete, aluminium and glass, accounts for 11% of global carbon dioxide emissions[4]. Specification of the use of sustainable natural materials in construction thereby provides opportunities for reduction in embodied energy of a structure and subsequent GHG emissions.

Design opportunities being considered in material choice include low embodied energy and low life cycle impact such as timber, recycled steel, aluminium and glass products which will be considered across the design.

Materials with high thermal mass, such as concrete, bricks and tiles, act as a thermal battery. During summer they absorb heat during the day, and release heat during the evenings and nights, providing thermal comfort. In winter, the same mass can store heat from heaters or the sun, releasing it at night when temperatures are at their lowest. Thermal mass is most effective where diurnal ranges (difference between day and night temperature) exceed 10 degrees. Canberra has a high seasonal diurnal temperature range with a mean high of 27.7 degrees in January and a mean low of 11.1 in July. It is therefore an optimum climate for the use of thermal mass to aide comfort and reduce reliance on mechanical heating and cooling.

The use of brick as a dominant material in building structure for the new terraces, apartments and houses will increase the thermal value, contributing towards energy efficiency and lower heating and cooling demand. High performance facades combined with high levels of insulation to external walls, floors and roofs will also enhance thermal mass to minimise impacts of external temperature fluctuations.

Low emissivity, high albedo materials will be considered in particular for the open space areas where appropriate, to increase albedo and solar reflectance.

2.4 Reducing Building Green House Gas (GHG) emissions

The two most common sources of greenhouse gas emissions for buildings are purchased electricity and direct consumption of natural gas for heating and cooking.

The design is currently exploring options of introducing a rooftop photovoltaic system integrated with battery storage to the core heritage buildings, the aim being for a central heritage precinct that is ‘net electricity neutral’. This initiative would provide the precincts energy usage, thereby contributing to overall reduction in GHG emissions.

In common areas where energy is used, systems which utilise energy more efficiently, such as LED lighting (common areas, street lighting and public areas) will be mandated where possible. Low energy lighting in the car park would also be considered, with variable speed drives linked to CO sensors for occupant detection and subsequent energy saving benefits. Energy efficient lift systems would also be considered, along with provision of a staircase to access floors as an alternative to using the lifts. In private dwellings where active systems can not be directly controlled, consideration of incentives for the purchase of more energy efficient appliances, in the form of residential incentive discounts may be applied, reducing overall site energy consumption and associated GHG emissions.

[4] UIN Environment Program, 2018 *Global Alliance for Buildings and Construction*

Highly efficient mechanical ventilation systems with variable speed drives responsive to occupation through CO2 or CO sensors will be considered, along with high efficiency chillers and plant systems.

2.5 Increased vehicular Activity

As with residential activity, there will be an increase in GHG emissions during the construction phase, however most vehicular emissions will occur during the operational phase from the use of private vehicles. This impact is difficult to quantify as the majority of new residents may already have private vehicles. From a local perspective, it is true that an increased number of vehicles will be detrimental to air quality. However, for GHG emissions the point of source is largely irrelevant; CO_{2e} that is released in north west Canberra has the same global warming potential than CO_{2e} that's released in south east Canberra. Therefore, the question that remains is how many additional vehicles on the road will occur as a result of the development.

Since this cannot be estimated with any real certainty, a series of scenarios have been modelled to assist in determining the plausible range of impact. Firstly, the total CO_{2e} released from the expected number of cars was calculated, which equates to approximately 666,000 kgCO_{2e} assuming that each of the 200 carpark lots is occupied, and each car travels the average number of kms per year. Secondly, by assuming a range of scenarios for the % of cars that are new to the road, the impact of the development was estimated. Three scenarios in total were modelled; 5, 10 & 15%, resulting in additional emissions of approximately 33,000, 67,000 & 100,000 kgCO_{2e} per year. It is expected that the actual figure will be towards the lower range of this estimate. The calculation methodology and assumptions can be found in Attachment A.

However, given the proximity to public transport, and the emerging market for Electric Vehicles there is the opportunity to encourage a transition away from Internal Combustion private vehicle use and enabling a transition towards public transport or electric vehicle choice. The design facilitates easy and direct access to public transport and light rail and will provide conduits throughout the carpark to enable owners to fit EV charging stations in bays to enable EV choice.

ARUP

Vehicle Use Inputs

Brickworks

Methodology

The total distance travelled by all vehicles within the development was based on expected number of cars and the average distance travelled per car per year.

Scenarios 1-3 represent the plausible range of the % of total cars that are new to the road, and therefore result in a net increase in CO_2e emissions.

Distance travelled and scenario inputs

Total distance travelled

	Value	Unit	Source	Comment
Average distance per car	13400	km/year	https://www.abs.gov.au/ausstats/ab	Based on length of journey to and from work for ACT (14.4 km x2)
Number of cars	200		Site masterplan	Assumed that each parking lot contains a car
Total km	2,680,000	km/year		

New cars on the road

	Value	Unit	Source	Comment
Scenario 1	5.0%	%	Assumed value	% of cars that were not on the road prior to the development
Scenario 2	10.0%	%	Assumed value	% of cars that were not on the road prior to the development
Scenario 3	15.0%	%	Assumed value	% of cars that were not on the road prior to the development

ARUP

Carbon Intesity Inputs

Brickworks

Methodology

The split of petrol and diesel vehicles was based on 2016 data, assuming a worst case scenario with no electric vehicles.

Fuel efficiency was also found for 2016 as this was the most recent and robust data source.

Emissions factors were taken from the National Greenhouse Accounts

Carbon intensity inputs

Vehicle fleet split

	Value	Units	Source	Comment
% of cars that are Petrol	87%	%	https://www.bitre.gov.au/sites/defa	
% of cars that are Diesel	13%	%	https://www.bitre.gov.au/sites/defa	Assuming no LPG/CNG/dual fuel/hybrid and other

Fuel efficiency

	Value	Units	Source	Comment
Passenger Vehicle (Petrol)	0.11	l/km	https://www.bitre.gov.au/sites/defa	Based on 2016 car fleet as most recent data available
Passenger Vehicle (Diesel)	0.10	l/km	https://www.bitre.gov.au/sites/defa	Based on 2016 car fleet as most recent data available

Energy content factor

	Value	Units	Source	Comment
Petrol	34.20	GJ/kL	https://www.environment.gov.au/sy	
Diesel	38.60	GJ/kL	https://www.environment.gov.au/sy	

Emission factors

		Value	Units	Source	Comment
Petrol	CO_2	67.40	kgCO2e/GJ	https://www.environment.gov.au/sy	
	CH_4	0.02	kgCO2e/GJ	https://www.environment.gov.au/sy	
	N_2O	0.20	kgCO2e/GJ	https://www.environment.gov.au/sy	
Diesel	CO_2	69.90	kgCO2e/GJ	https://www.environment.gov.au/sy	
	CH_4	0.01	kgCO2e/GJ	https://www.environment.gov.au/sy	
	N_2O	0.60	kgCO2e/GJ	https://www.environment.gov.au/sy	

ARUP

Emission Calculations

Brickworks

Methodology

Based on the total number of km travelled per year, the fleet split and the fuel efficiency for petrol and diesel cars, the fuel consumption per year was estimated in Litres.

Litres were then converted to GJ using the energy content values from the National Greenhouse Accounts Factors.

Similarly, GJ was converted to kgCO2e using the emissions factors for petrol and diesel.

The additional kgCO2e was then calculated for scenarios 1 - 3.

CO_{2e} Calculations

Emissions

		Value	Units	Source	Comment
Fuel consumption	Petrol	247,150	L/year		
	Diesel	34,840	L/year		
Energy content	Petrol	8,453	GJ/year		
	Diesel	1,345	GJ/year		
Emission factors	**Petrol**				
	CO_2	569,700	kgCO2e/year		
	CH_4	169	kgCO2e/year		
	N_2O	1,691	kgCO2e/year		
	Diesel				
	CO_2	94,003	kgCO2e/year		
	CH_4	13	kgCO2e/year		
	N_2O	807	kgCO2e/year		
	Total	666,383	kgCO2e/year		

Additional Emissions

		Value	Units	Source	Comment
Scenario 1	5% new cars	33,319	kgCO2e/year		
Scenario 2	10% new cars	66,638	kgCO2e/year		
Scenario 3	15% new cars	99,957	kgCO2e/year		