Landcom

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Climate Resilience Assessment

Cherrybrook State Significant Precinct

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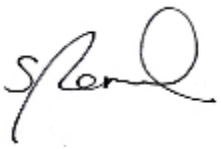
3	07-Oct-2020	SSP Final	Suzanna Remmerswaal Associate Director, Sustainability & Resilience	
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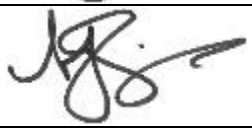
6	01-Apr-2022	Final	Adam Davis Project Director	

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Summary

Site	**Cherrybrook Station Government Land State Significant Precinct**
Address	Estate bounded by Castle Hill Road (south), Bradfield Parade (west), and Franklin Rd (east), Cherrybrook, NSW 2126
Location	Cherrybrook in Northwest Sydney, approximately 20km from the Sydney CBD
Site Overview	Landcom's Cherrybrook Station Government Land State Significant Precinct is a developable government land parcel located immediately adjacent to the corresponding Sydney Metro North West Cherrybrook Station. As a State Significant Precinct (SSP), the Minister for Planning and Public Spaces has determined that it is of State planning significance and as such, has issued Study Requirements which were prepared in collaboration with Hornsby Shire Council, The Hills Shire Council and Transport for NSW. Requirements fulfilled by this report include items 11.2 and 11.3 Climate Change Mitigation and Adaptation: • *11.2 Provide a Climate Change Adaptation Report which details how the proposal will address temperature increases from climate change (see NSW and ACT Regional Climate Modelling: NARCLIM), including the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features into the design of the development.* • *11.3 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and increase of rainfall intensity integrated with the Water Quality, Flooding and Stormwater Study.* The precinct is bounded by Castle Hill Road (to the south), Bradfield Parade (to the west), Franklin Rd (to the east), while the northern side is bounded by existing private property. Neighbouring suburbs are predominantly developed low-density residential land. The Cherrybrook site encompasses 3.5ha of developable land and is planned to accommodate high density residential (approximately 390 new dwellings), a provision for public open space (12,945m^2 as per the reference scheme), a proportion of ground level retail space, and a community facility. The development site currently remains vacant, adjacent to the completed Cherrybrook Station and attached multi-storey commuter carpark. Landcom is delivering the land development for the station precinct on behalf of Sydney Metro.
Initial climate risk screening and priority rating (Portfolio-wide assessment)	**Priority rating:** Medium **Initial screening of key climate risks:** • Extreme Heat (days over 35ºC) • Extreme rainfall and flooding • Extreme storms (including wind and hail)
Site assessment and consultation with project stakeholders	A briefing and site visit were conducted on the 5th November 2018 to discuss and inspect key community aspects and the community context. The attendees included: • Alex Sommer, Sustainability & Research Manager, Landcom • Smita Sundarjee, Development Manager, Landcom • Harley Lewington, Sustainability & Resilience Consultant, AECOM

Summary of key findings	A total of 37 climate risks were identified for the community. Based on the location and local modelling it was determined that extreme heat, extreme rainfall and flooding, and storm events are the key climatic variables relevant for the project. Given these key climatic variables and the undesirable nature of high risks, all seven 'high' and 'extreme' climate risks were extracted from the risk register for consideration. It is worth noting that no extreme climate risks were identified for the time period of 2030, while one extreme climate risk was identified for the time period of 2090. Adaptation actions have been developed to strengthen the community's resilience to these climate risks.

1.0 Study Context

1.1 Overview

This study relates to a proposal to develop land called the 'Cherrybrook Station Government Land State Significant Precinct' (the State Significant Precinct) by Landcom on behalf of the landowner, Sydney Metro. The State Significant Precinct is centred around Cherrybrook Station on the Metro North West Line. The Metro North West Line delivers a direct connection with the strategic centres of Castle Hill, Norwest, Macquarie Park and Chatswood. It covers 7.7 hectares of government-owned land that comprises the Cherrybrook Station, commuter carpark and station access road (Bradfield Parade) and vacant land to the east of the station (referred to as the Developable Government Land) (DGL). It is bound by Castle Hill Road (south), Franklin Road (south east) and Robert Road (north west).

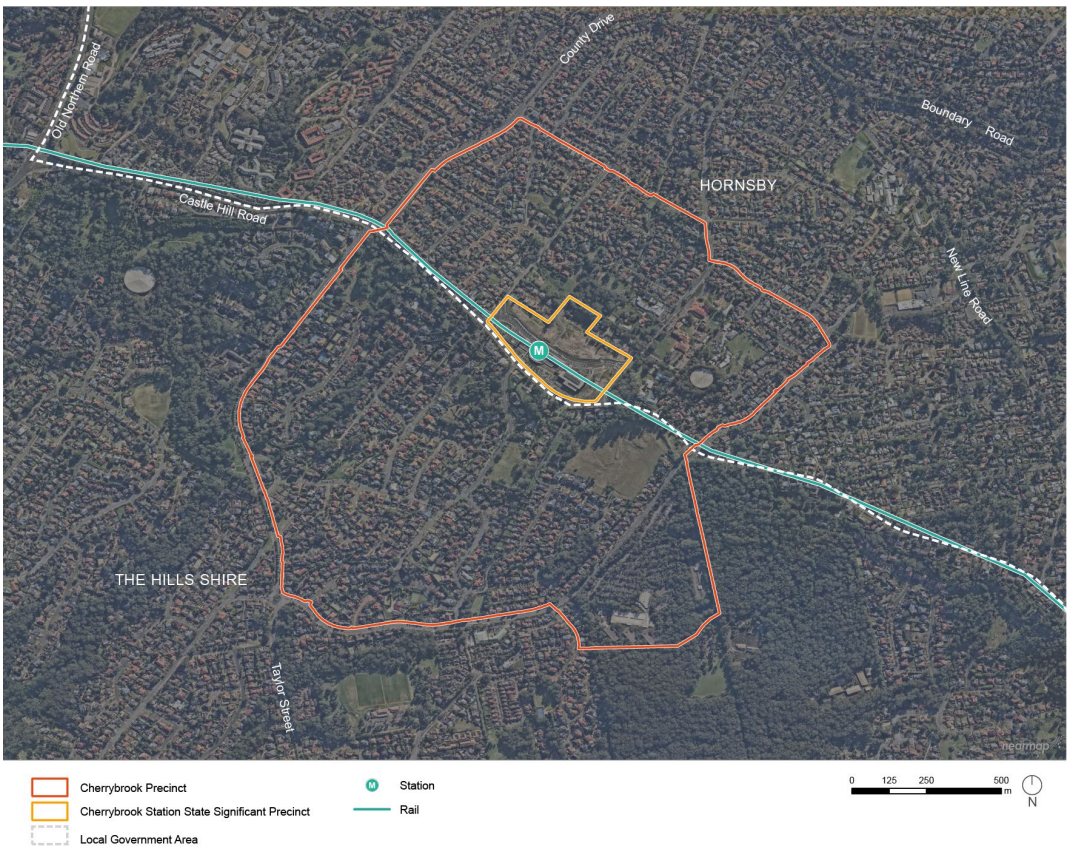
As a State Significant Precinct, the Minister for Planning and Public Spaces (the Minister) has determined that it is of State planning significance and should be investigated for rezoning. This investigation will be carried out in accordance with study requirements issued by the NSW Department of Planning, Industry and Environment (now Department of Planning and Environment (DPE)) in May 2020. These study requirements were prepared in collaboration with Hornsby Shire Council and The Hills Shire Council.

The outcome of the State Significant Precinct process will be new planning controls. This will enable the making of development applications to create a new mixed-use local centre to support Cherrybrook Station and the needs of the local community.

At the same time, DPE is also working with Hornsby Shire and The Hills Shire Councils, as well as other agencies such as Transport for NSW, to undertake a separate planning process for a broader area called the Cherrybrook Precinct. Unlike the State Significant Precinct, the outcome of this process will not be a rezoning. Instead, it will create a Place Strategy that will help set the longer term future for this broader area. Landcom will be consulted as part of this process.

Figure 1 illustrates the site boundaries of the State Significant Precinct and the Cherrybrook Precinct.

Figure 1: Cherrybrook Precinct and Cherrybrook Station State Significant Precinct (subject of this proposal) (source: NSW Department of Planning, Industry & Environment)



1.2 Purpose

The purpose of this study is to address the relevant study requirements for the State Significant Precinct, as issued by DPE. It is part of a larger, overall State Significant Precinct Study. This State Significant Precinct Study undertakes planning investigations for the precinct in order to achieve a number of objectives that are summarised as follows (refer to the State Significant Precinct Study Planning Report for a full list of the study requirements):

- facilitate a mixed-use local centre at Cherrybrook Station that supports the function of the station and the needs of the local community
- deliver public benefit through a mixed use local centre
- deliver transport and movement initiatives and benefits
- demonstrate the suitability of the site for the proposed land uses
- prepare a new planning framework for the site to achieve the above objectives.

1.3 Proposal

The proposed new planning controls for the State Significant Precinct are based on the investigations undertaken as part of the State Significant Precinct Study process. A Reference Scheme has also been prepared to illustrate one way in which the State Significant Precinct may be developed in the future under the proposed new planning controls.

The proposed planning controls comprise amendments to the Hornsby LEP 2013 to accommodate:

- Rezoning of the site for a combination of R4 High Density Residential, B4 Mixed Use and RE1 Public Recreation zoned land;

- Heights of between 18.5m – 22m;
- FSR controls of 1:1 – 1.25:1;
- Inclusion of residential flat buildings as an additional permitted use on the site in the B4 Mixed Use zone;
- Site specific LEP provisions requiring the delivery of a minimum quantity of public open space and a maximum amount of commercial floor space; and
- New site-specific Design Guide addressing matters such as open space, landscaping, land use, built form, sustainability and heritage.

The Reference Scheme (refer to Figure 2) seeks to create a vibrant, transit-oriented local centre, which will improve housing choice and affordability and seeks to integrate with Hornsby's bushland character. The Reference Scheme includes the following key components:

- Approximately 33,350m2 of residential GFA, with a yield of approximately 390 dwellings across 12 buildings ranging in height from 2 to 5 storeys (when viewed from Bradfield Parade).
- A multi-purpose community hub with a GFA of approximately 1,300m².
- Approximately 3,200m² of retail GFA.
- Over 1 hectare of public open space, comprising:
    - A village square with an area of approximately 1,250m², flanked by active retail and community uses.
    - A community gathering space with an area of approximately 3,250m².
    - An environmental space around the pond and Blue Gum High Forest with an area of approximately 8,450m2.
- Green corridors and pedestrian through site links, providing opportunities for potential future precinct-wide integration and linkages to the north.

Figure 2: Reference Scheme (source: SJB)

Parcel	*Area	Res GFA	Units	Non-Res GFA	Community	Portion FSR*
A	8,597	12,031	141	749		1.49
B	9,610	11,924	140	2,452	1,300	1.68
C	2,574	2,736	32			1.06
D	6,715	6,621	78			0.98
	27,272	33,312	391	3,201	1,300	

1.4 Study Requirements

State Significant Precinct Study Requirements addressed by this report include items *11.2 and 11.3 Climate Change Mitigation and Adaptation* which read as follows:

- *11.2 Provide a Climate Change Adaptation Report which details how the proposal will address temperature increases from climate change (see NSW and ACT Regional Climate Modelling: NARCLIM), including the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features into the design of the development.*
- *11.3 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and increase of rainfall intensity integrated with the Water Quality, Flooding and Stormwater Study.*

It is noted that the accomplishment of item 11.3 is also assisted by the delivery of the Water Quality, Flooding and Stormwater Study to assess the impacts of increased rainfall intensity.

It is also noted that this Climate Resilience Assessment is focussed on climate adaptation and resilience, and as such item 11.1 of the Study Requirements (related to developing options for net-zero buildings and SSP site) is not within scope of this assessment. Instead, this Study Requirement is covered by the ESD Plan (Edge Environment, 2022). The outputs of the updated report will however also support the delivery of item 10.1, a component of which relates to the impacts of increased wind and storm events in the future. Table 1 outlines the sections of this that address these study requirements.

Table 1 Study Requirements

SSP Study Requirement	Report reference
11.2 Provide a Climate Change Adaptation Report which details how the proposal will address temperature increases from climate change (see NSW and ACT Regional Climate	**Section 2.0** outlines historical and future projected climate (including temperature increases) for the Cherrybrook area adopting NARCliM-sourced data.

SSP Study Requirement	Report reference
Modelling: NARCLIM), including the integration of vegetation (existing and future), permeable and reflective surfaces, and Water Sensitive Urban Design features into the design of the development.	**Section 3.0** outlines eight priority climate risks for the precinct out of an identified 37 risks (Appendix A). **Section 4.0** outlines adaptation responses to address risks including those relating to vegetation, permeable and reflective surfaces, and WSUD.
11.3 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and increase of rainfall intensity integrated with the Water Quality, Flooding and Stormwater Study.	**Section 2.3** outlines the sensitivity and scenario testing approach. **Sections 2.3.1** and **2.3.2** outline and compare projections across different climate scenarios. **Section 4.0** outlines adaptation responses to address risks across different scenarios.
10.1 Provide a Sustainability Plan that identifies the key sustainable design opportunities for the design, construction and ongoing operation phases of the proposal and establishes a baseline and target for environmental footprint for water, water, and greenhouse gas emissions in addition to renewable energy targets. This should include reference to the Green Star Communities tool, climate change adaptation and a methodology for implementation. It should also include the impacts of climate change including the increase in wind/storm events in the future.	The majority of SR10.1 is not covered by this report and is instead within scope of the ESD Plan (Edge Environment, 2022). However, **Section 2.0** outlines historical and future projected climate (including wind/storm events) for the Cherrybrook area and **Section 4.0** outlines adaptation responses to address risks including those associated with wind/storm events.

1.5 About Climate Resilience

Recent extreme climate events across Australia and particularly heatwave, flooding, bushfire and storm events have demonstrated the vulnerability of communities to climate hazards. Landcom has made existing commitments to assess these climate risks and the resilience of their communities as part of the Sustainable Places Strategy which was formalised in 2017. This demonstrates a clear commitment to increase the resilience of all Landcom communities to climate hazards, including the Cherrybrook Precinct.

Resilience

Resilience refers to the ability and capacity of properties and communities to withstand; recover and adapt from shocks and stresses, it is a measure of how much disturbance from a changing climate communities can handle without losing functionality. This implies that Landcom can anticipate and plan according to projected and current climate events. Therefore, the ability to avoid potential damage will be a critical factor in resilience to a changing climate.

In addition, the approach undertaken to assess climate resilience aligns with the requirements of version 1.1 of the Green Buildings Council of Australia's Green Star - Communities Adaptation and Resilience credit (Gov-4). The assessment has also been designed to support delivery of the Resilience category outlined in version 2 of the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Rating Scheme.

The assessment is designed to provide a deeper understanding of the community's exposure, sensitivity and adaptive capacity to a range of shocks and stresses, with a particular in-depth review of climate change impacts. It is intended that this assessment will act as a live document, to be reviewed and updated on a regular basis. The results are intended to be shared with residents, businesses, and other key community stakeholders (e.g. proponents of the individual commercial, residential and community infrastructure projects within development) for consideration in their individual resilience and emergency management planning.

1.6 Methodology

This report comprises two key components:

- A **Climate Change Risk Assessment**, which assesses the risks of climate change to the community based on the most recently available climate change projections and local hazard mapping.
- A **Climate Adaptation Plan**, which identifies adaptation actions to improve the resilience of the community. A Community Resilience Plan has also been produced under separate copy as part of Landcom's business-as-usual development process, and this has also informed the development of adaptation actions described in Section 4.0.

In completing the assessment, a desktop analysis was initially undertaken using readily available property information such as:

- Design specifications
- Flood and bushfire studies
- Master plans
- Local or regional climate adaptation plans
- Community strategic plans
- Emergency management plans and local disaster plans.

The desktop analysis was then followed by a detailed site visit which included inspection of the adjacent environs and key property aspects. During the site visit, interviews were conducted with project team members to inform the assessment, validate climate risks to the community and identify appropriate adaptation responses. The climate change risk assessment provided in this report has been undertaken in line with the following relevant standards and guidelines:

- The risk assessment approach set out in *AS/NZS ISO 31000:2009 Risk management – Principles and guidelines* and *ISO/IEC 31010 Risk management – Risk assessment techniques*. Both build upon *AS/NZ 4360:2004 Risk management* and its application to climate change risks.
- The climate change projections used in this assessment have been derived and collated in accordance with *AS 5334:2013 Climate change adaptation for settlements and infrastructure*.
- The climate change risks to the community have been assessed in line with the methods recommended in *Climate Change Impacts and Risk Management: A Guide for Business and Government*[1].

This assessment meets the submission requirements for the Climate Adaptation Plan credit (Gov-4: Climate Adaptation and Resilience) under Green Star Communities v.1.1.

The following steps were undertaken to complete the climate change risk assessment in accordance with the relevant standards and guidelines:

1. Identification of the climate context of the community, including the observed climate, exposure to existing climate hazards and development of a number of potential climate change scenarios, based on the latest climate science.
2. Identification and assessment of climate risks to the community, with risks evaluated using the assessment criteria set out in the Landcom Risk Workbook to determine the consequence and likelihood, and overall rating of each risk.

Appendix B also includes an emergency response checklist to support the dissemination of emergency planning and preparedness information to community stakeholders.

[1] Department of Environment and Heritage (DEH) 2006. Climate Change Impacts and Risk Management: A Guide for Business and Government. Report prepared for the Australian Greenhouse Office, Commonwealth of Australia

2.0 Climate context and projections

Climate differs from region to region due to changes in influencing factors such as geographical location, latitude, physical characteristics, variable patterns of atmosphere, ocean circulation and in some cases, human interaction. Consequently, climate change and the associated impacts can be expected to vary from region to region. The following sections present an overview of the climate context for the local region and Cherrybrook community.

2.1 Observed climate

Local climate for the region is predominantly temperate, which typically results in warm wet summers and mild, dry winters. The inland location of the community also influences local climate, with higher temperatures experienced compared with coastal areas.

Rainfall patterns are typically seasonal, with higher rainfall experienced during summer months and lower rainfall in winter. Trends indicate variability in the amount of rainfall received from year to year. Storms result in periods of heavy rainfall and strong winds and may lead to flood events.

Table 2 Climate exposure (Bureau of Meteorology for Parramatta weather station - the nearest available with long-term historical data)

Climate variable	Averages
Average minimum daily temperature	Ranging from 17.1°C (January), to 6.2°C (July).
Average maximum daily temperature	Ranging from 28.6°C (January), to 17.5°C (July).
Extreme temperatures above 35°C (ideal conditions for bushfires)	11.3 days per year over 35°C, typically over the summer months
Average monthly rainfall	Ranging from 126mm (February) to 46.1mm (July)

2.1.1 Current climate exposure

A range of primary and secondary climate variables have been considered in the context of the assessment to assess the level of exposure and impact on the community (refer Table 3). The selection of relevant climate variables and associated climate risks combined with the community's sensitivity and adaptive capacity will help provide an overall indication of the community's climate resilience.

Note, as the community is not located within a coastal zone and is not anticipated that it will be susceptible to sea level rise impacts, variables related to changes in sea level and sea surface temperature have not been included in the assessment.

Table 3 Primary and Secondary Climate Variables relevant to Cherrybrook

Primary Variables	Secondary Variables
• Mean surface temperature • Solar radiation • Humidity • Precipitation	• Extreme temperature and heatwaves • Extreme rainfall and flooding • Wind and hail • Extreme Storms • Bushfire conditions

Local hazard mapping aids in identifying the exposure and extent of existing climate hazards for the community. Local hazard mapping was obtained and reviewed from several sources, including:

- University of Western Australia (urban heat mapping) for metropolitan Sydney
- The Hills Shire Council (bushfire mapping)
- Hornsby Shire Council (bushfire mapping)

- Royal HaskoningDHV's (2022) Concept Stormwater Management and Preliminary Flood Risk Assessment - Cherrybrook Developable Government Lands.
- AdaptNSW – NSW Office of the Environment and Heritage (climate change projections)
- CSIRO and Bureau of Meteorology (climate change projections)
- Sydney Metro – Northwest Rail Link Project Documents.

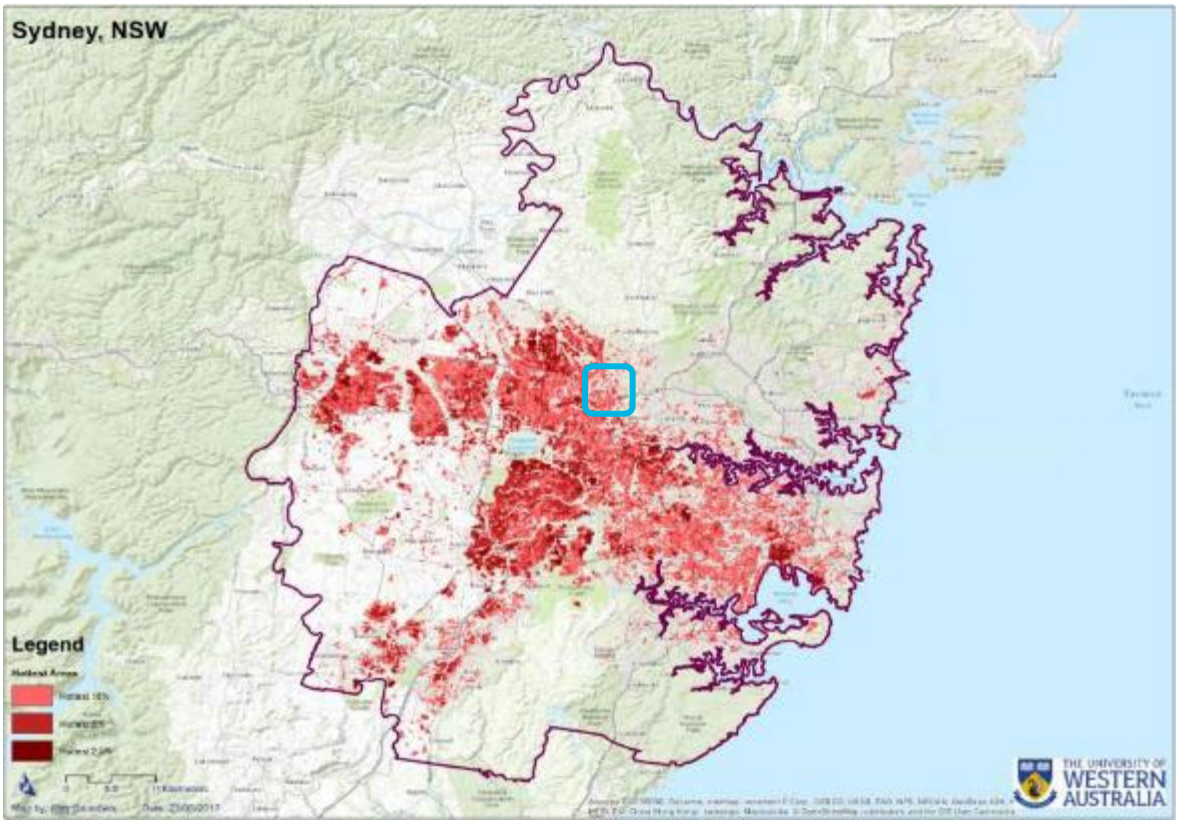
Examples of local hazard mapping available for the community are provided in the following figures. Where mapping was unable to be obtained, a cursory review using desktop tools (including satellite imagery) is undertaken to help determine impact exposure and relative risk from the climate variables.

2.1.2 Extreme heat

The Sydney region currently experiences an average of 9.6 days above 35°C per year. Both mean annual temperature and extreme heat days are anticipated to increase in the future.

Figure 3 shows increased temperatures attributed to urban heat across the north western regions of Sydney. The result shows that Cherrybrook is likely impacted by the urban heat island effect however only to a moderate extent relative to other Landcom development sites along the Sydney Metro route to the north west. However, as development continues in the area, the urban heat island effect can be expected to continue increasing and it is prudent to consider how the development of the Cherrybrook Station Precinct will contribute to increasing urban temperatures.

Figure 3: Urban Heat Mapping for Greater Sydney. Source: University of Western Australia, 2017.

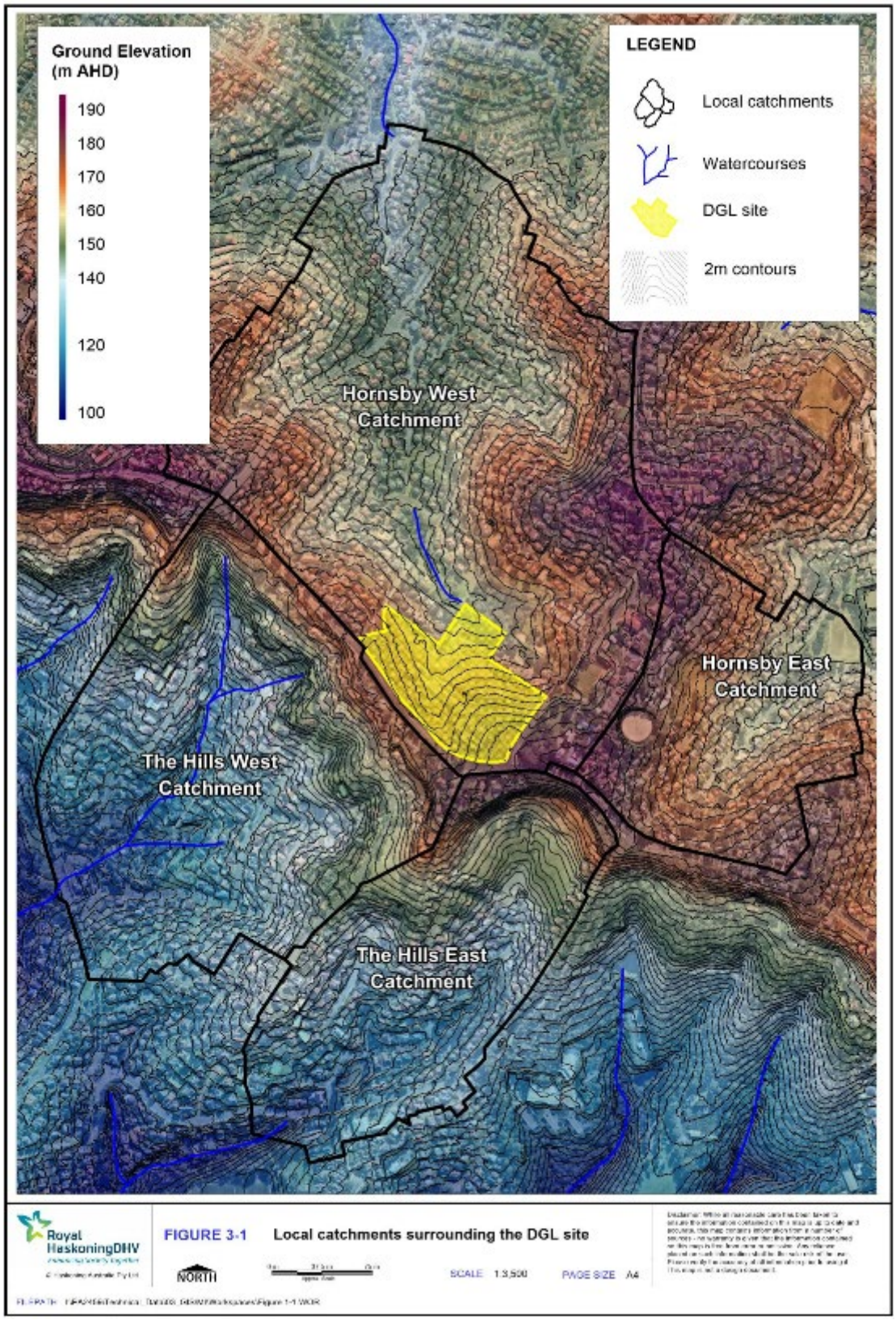


2.1.3 Extreme rainfall and flooding

The site's topography is mixed, with the highest elevation in the south-east corner (184m) and the lowest elevation towards the drainage basin on the northern site boundary (164m). The Cherrybrook Metro Station and car park is cut into the southern slope. Figure 4 highlights the stormwater drainage basin on the northern boundary of the site and drainage infrastructure to the south and east of the Metro Station carpark. Figure 5 identifies the site boundary (yellow shading) and the elevation profile and catchments surrounding the site.

Figure 4: Vegetation and drainage basin to the north east of site (top) (Ecological, 2019), drainage infrastructure to the south (bottom left) and east (bottom right) of Metro Station carpark.

Figure 5: Elevation profile and catchments surrounding the site (Royal HaskoningDHV, 2022)

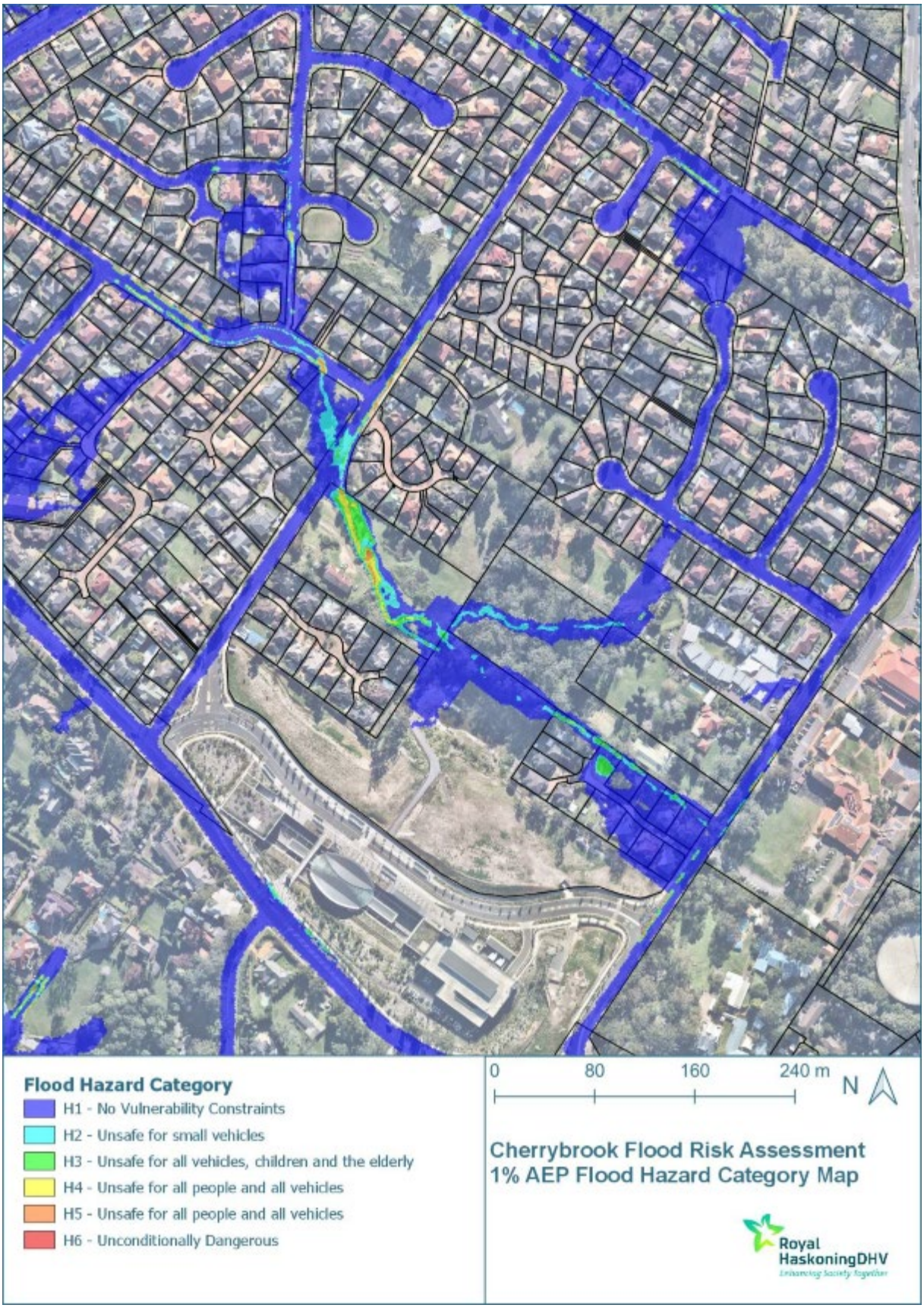


Hydraulic modelling of the piped drainage systems and overland flow paths in the Hornsby West Catchment was undertaken as part of a precinct wide stormwater and flooding assessment prepared by Royal HaskoningDHV (2022). This study found that during the 1% AEP event the flood hazard

category map shown on Figure 6 indicates that flood hazards within residential property and road reserves generally do not exceed the H1 flood hazard category except for the following areas:

- An isolated area on the southern side of Robert Road between Louise Way and Arundel Way;
- From the downstream outlet of the existing detention basin at the north of the site to the informal detention basin at the inlet of the trunk drainage system.
- The area immediately downstream of the informal detention basin in Robert Road where flood flows are temporarily stored prior to overtopping into Robert Road Park.
- Within the road reserve of Dalkeith Road.
- Within the road reserve immediately downstream of Robert Road Reserve.

Figure 6: Cherrybrook Flood Risk Assessment 1% AEP flood hazard category map (Royal HaskoningDHV, 2022)



Modelling has also been undertaken by Royal HaskoningDHV (2022) to consider a 30% increase in rainfall intensity associated with climate change in accordance with SR 11.2 relating to sensitivity testing. This is presented in Section 2.2.5.

The Study recommends for stormwater management that an additional piped stormwater drainage system would need to be established to manage stormwater runoff from future development within the DGL site, and connected with the stormwater system constructed by Sydney Metro for Cherrybrook Metro Station. Further optimisation to reduce the detention storage volume requirement could be explored during the detailed design process, and could be provided in a number of configurations by either

a. Maintaining the Sydney Metro basin and provide additional lot scale detention storage within the future development lots,
b. Expanding the existing Sydney Metro basin to provide the fully developed site storage requirements, or
c. Replacing the Sydney Metro basin with underground detention storage tank(s). A preferred configuration or combination of configurations would need to be established at future development stages.

Regarding flood risks, Royal HaskoningDHV (2022) found that a majority (more than 90%) of the DGL is not subject to flooding during events up to and including an extreme flood event the existing flooding behaviour (level, depth/extent, velocity, hazard) estimated near the DGL site does not present a significant risk to property or life associated with the proposed re-development. Localised stormwater drainage issues/nuisance flooding may occur during an extreme event within Bradfield Parade to the north of Cherrybrook Station as the underground stormwater system may not be designed to convey such a large storm event. However, carefully planned mitigation measures during the detailed design process of the DGL site could successfully eliminate the potential for loss of life for the proposed development.

Downstream of the site, the flood impacts during the 1% AEP and 1% AEP with climate change flood events exceed the capacity of the trunk drainage system. However, the model indicates that Robert Road, Robert Road Park, Dalkeith Road and Ashford Road provide a sufficient flow area to allow these flood events to pass without hazardous flood conditions negatively impacting on properties neighbouring the overland flow path (Royal HaskoningDHV, 2022).

2.1.4 Storm events

The Sydney region is susceptible to storm events, predominantly in the form of east coast lows that develop as a result of ex-tropical cyclones that decay as they move south or interactions between troughs of low pressures/cold fronts with warmer sea surface temperatures.

Within the Cherrybrook Station Precinct region, a number of recent storm events have been observed.

- In August 2014, a severe storm in Western Sydney resulted in road closures due to fallen trees and water entering properties[2]
- In June 2016, the East Coast Storms and Flood events resulted in flash flooding and property damage across Sydney
- In March 2017 a severe thunderstorm impacted on the Castle Hill area, resulting in 33,000 homes without power across western Sydney and road closures[3]
- In December 2018 a severe thunderstorm impacted Sydney's north west, leading to 3788 calls for assistance to the NSW State Emergency Service, and left 55,000 homes without power throughout nearby Castle Hill, North Parramatta, Winston Hills, and Carlingford[4].

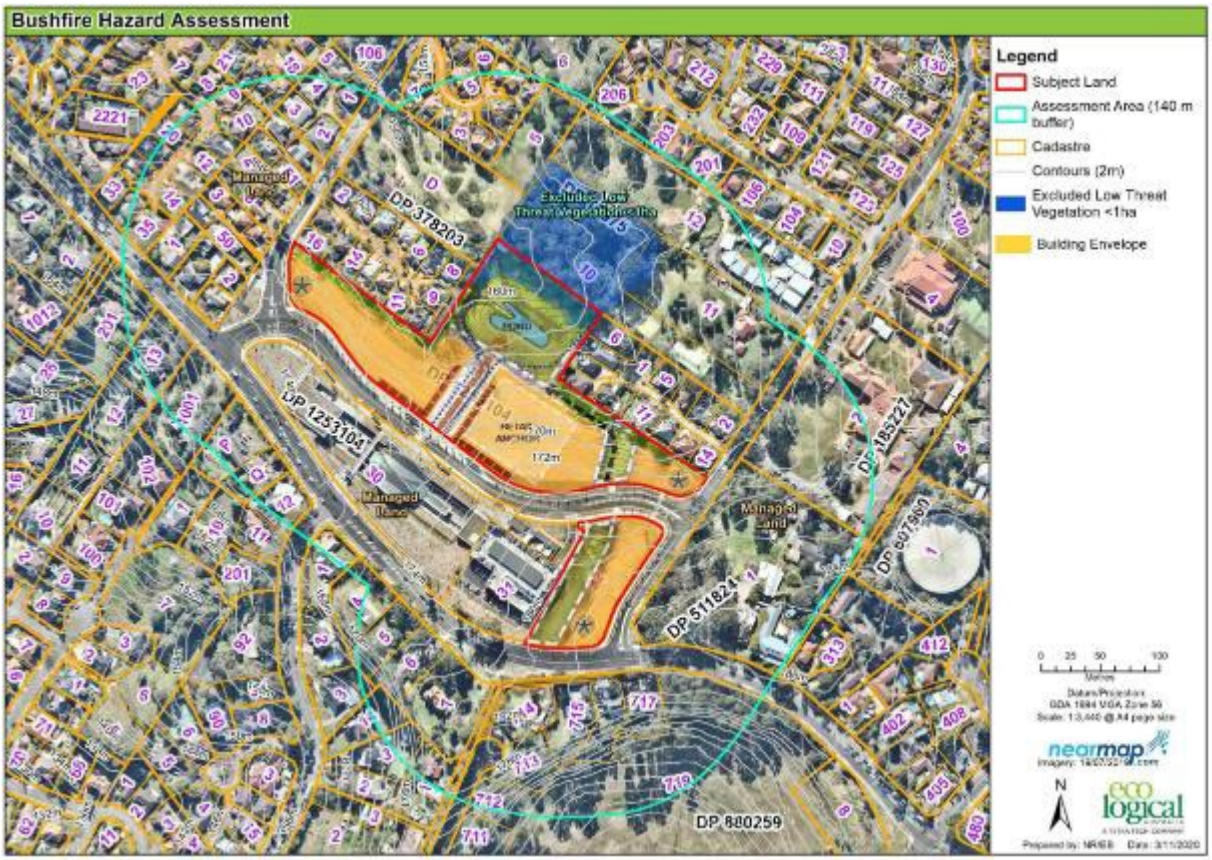
[2] Western Sydney flood and storm update – Hawkesbury Gazette - https://www.hawkesburygazette.com.au/story/2494739/western-sydney-flood-and-storm-update/
[3] https://www.dailytelegraph.com.au/newslocal/hills-shire-times/sydney-storm-heavy-thunderstorm-wreaks-havoc-in-the-hills/news-story/22b93fb105f0fbc579910023a30e6310
[4] https://www.smh.com.au/national/nsw/devastating-thousands-of-homes-still-without-power-after-sydney-storm-20181216-p50mjh.html

- In February 2019 45,000 homes in Sydney's north west lost power due to a storm event, with up to 5,000 homes without power for multiple days.
- During the period March 2021 to May 2021, insurer NRMA received the highest number of severe weather home claims in any single season since summer 2019-20 (Black Summer). Of Sydney suburbs, Castle Hill ranked number one, and Cherrybrook ranked number six, indicating the high exposure of the area to extreme storms[5].

2.1.5 Bushfire

The Bushfire Protection Assessment (EcoLogical, 2022) found that there is no bushfire hazard within 140 m of the subject land, therefore no Asset Protection Zones (APZ) are required for this development. Similarly, the proposal is exposed to a maximum of BAL-LOW, based on insufficient risk to warrant specific bushfire construction standards. Figure 7 outlines the buffer area assessed. The Bushfire Protection Assessment (EcoLogical, 2022) should be referred to for detailed information regarding bushfire planning requirements.

Figure 7: Bushfire hazard assessment and Asset Protection Zones (APZ) (EcoLogical, 2022)



Recent events have shown bushfire intensity and extent is generally increasing in trend, and the wider local area (e.g. Figure 8) and greater Sydney region have shown broader exposure to bushfire-related risks including poor air quality and evacuation difficulties. For the Cherrybrook Precinct, likely risks are associated with indirect impacts of bushfires that are likely to occur, such as the risk of reduced air quality leading to health impacts on residents, which may be compounded with the increasing density in population and traffic within the area.

[5] https://www.nrma.com.au/nrma-insurance-launches-wild-weather-tracker-help-communities-prepare-extreme-weather

Figure 8: Bushire Prone Land (The Hills Shire Council)

2.2 Future climate projections

To assess the risk to Cherrybrook precinct posed by climate change, the current climate science and model projections have been investigated. Key data sources include:

- Adapt NSW and NARCliM developed by the NSW Office of Environment and Heritage (OEH, 2014 & 2015).
- CSIRO and Bureau of Meteorology (BOM) Climate Futures (CSIRO & BOM, 2015).

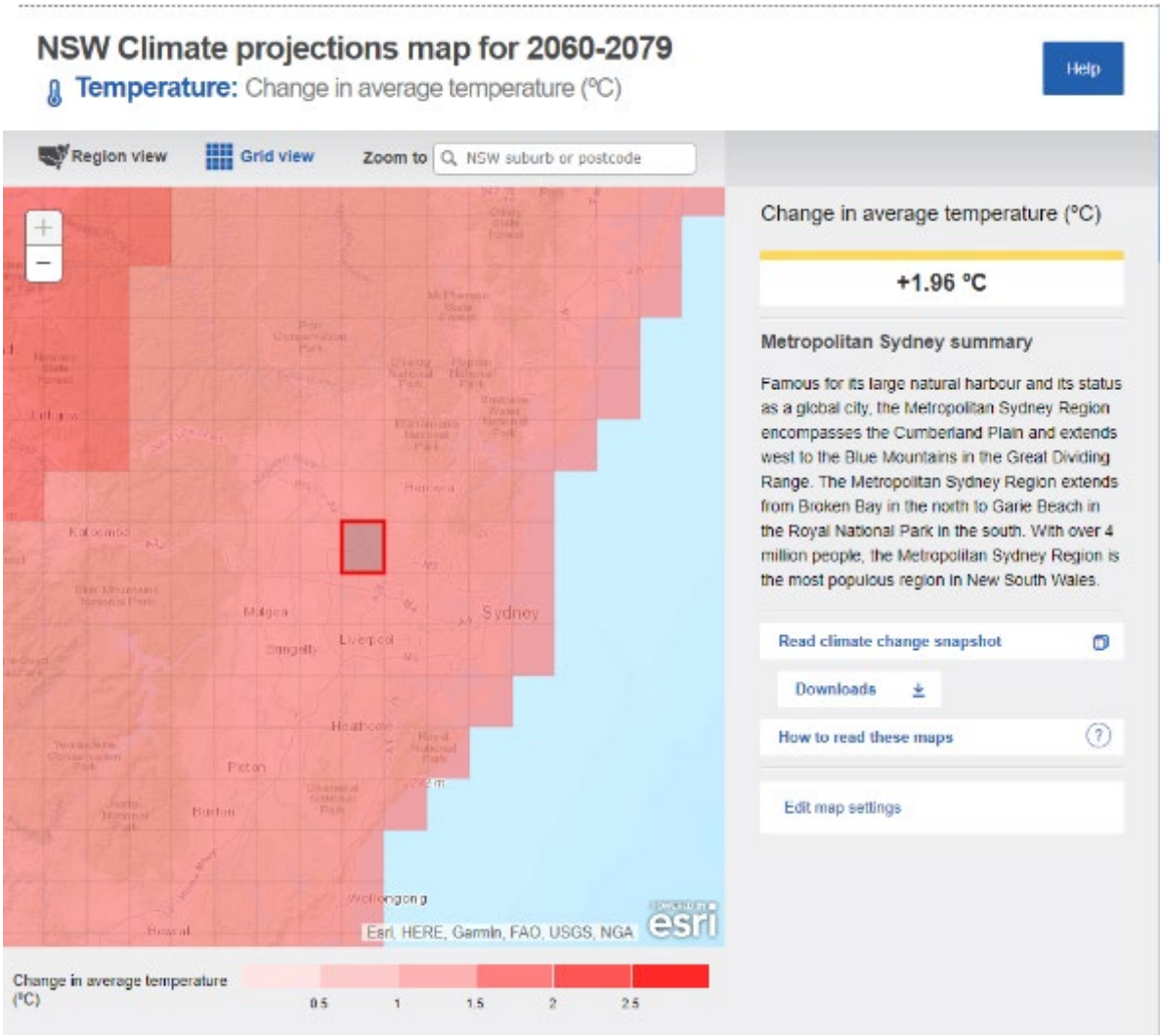
It is important to note the integrity of each climate data set as a whole, as the projections presented by each source represent a range of climate futures based on specific modelling parameters, scenarios and assumptions as described in the following sections. Care has been taken to consider each set of climate projections to ensure an internally consistent climate future approach.

2.2.1 Mean temperature

Under RCP8.5 there is very high confidence in projections relating to average temperatures – all climate models show increases in mean temperatures across the region for both the near future and far future. By 2030, mean warming is around 0.6 to 1.3°C above the baseline climate of 1986–2005. By 2090, mean warming is projected to increase by 2.9 to 4.6°C above the 1986–2005 baseline (CSIRO & BOM).

These are in line with projections developed by NARCliM who note that average annual temperatures are expected to increase by 1.96°C by 2070 (Figure 9).

Figure 9: Change in mean temperature across Metropolitan Sydney (NSW OEH 2016)



2.2.2 Extreme temperature

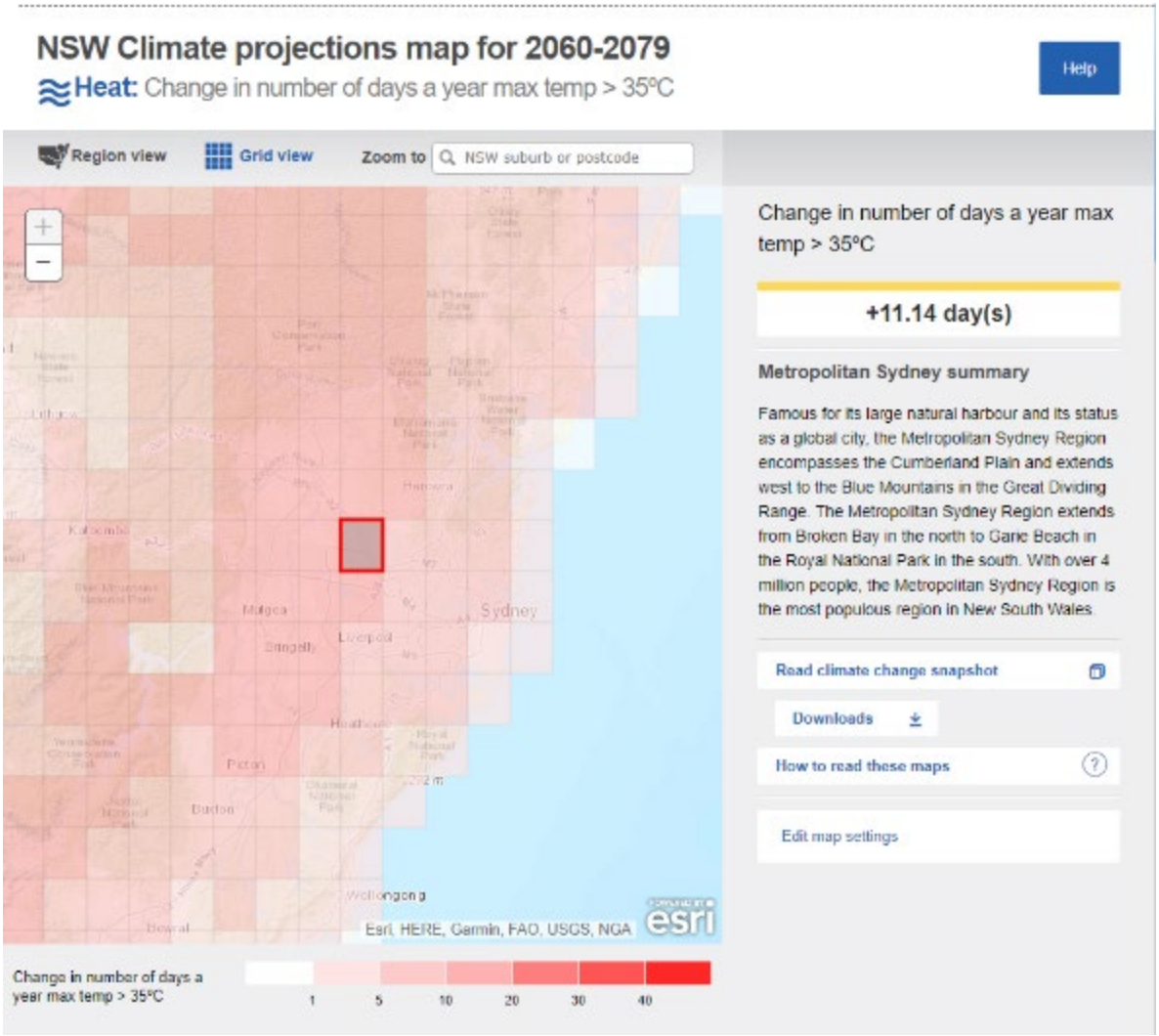
Extreme temperature days are projected to increase across the region, with a substantial increase in the frequency and duration of heat wave events. CSIRO & BOM note that average annual extreme temperature days above 35°C are projected to increase across the area, with an average increase to 4.3 days per year by 2030 under RCP4.5, and an average increase to 11 days per year under RCP8.5 by 2090.

The NSW Government through the Adapt NSW tool has also downscaled the extreme heat projections for the Metropolitan Sydney region using IPCC AR4 (however, note the difference in far future timescale of 2070). The results presented are averages of model outputs for the region for days over 35°C per year (refer Table 4 and Figure 10).

Table 4 Extreme heat days across Sydney and Western Sydney regions (NSW OEH 2016) (model means)

Region	Current days over 35°C per year	Near future (2030)	Far future (2070)
Sydney	< 10 days	Additional 4 days per year over 35°C	Additional 11 days per year over 35°C
Western Sydney	10-20 days	Additional 5 – 10 days per year over 35°C	Additional 10 – 20 days per year over 35°C

Figure 10 Change in number of extreme heat days across Metropolitan Sydney (NSW OEH 2016) (model means)



2.2.3 Urban heat island effects

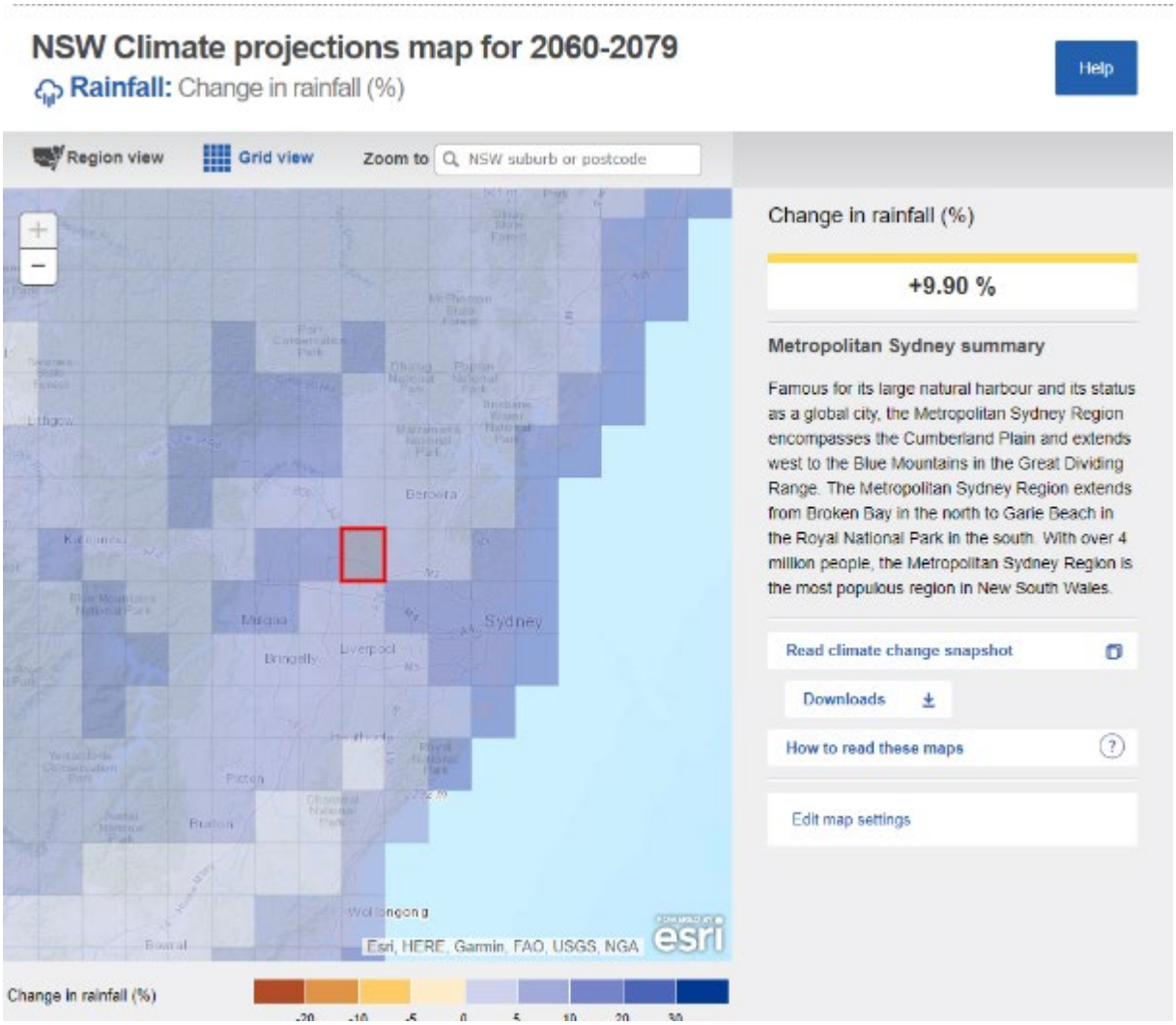
Urban heat islands occur in an area such as a city or industrial site leading to consistently higher temperatures than surrounding areas because of a greater retention of heat. This is caused by the sun's heat being absorbed, and not reflected, by buildings, dark roofs, car parks, paved services and roads.

Human activities, such as motorised transport and using air conditioning also increase the level of waste heat generated (City of Sydney, 2013). Urban heat island effects and the ongoing development of greenfield sites throughout the Sydney region exacerbate stresses associated with climate change related temperature increases as discussed above. Given the increasing development across the site, urban heat island effects are likely to exacerbate these impacts and result in higher frequencies of extreme temperatures and heat waves for the community.

2.2.4 Mean rainfall

Natural climate variability is considered to remain the key driver for rainfall. The range of results of climate projections for change in mean rainfall demonstrates the need to consider a range of climate futures and assess potential risks of both drier and wetter conditions.

Figure 11: Change in mean rainfall across Metropolitan Sydney (NSW OEH 2016)



2.2.5 Extreme rainfall

Using an understanding of the physical processes that cause extreme rainfall, climate change projections indicate a future increase in the intensity of extreme rainfall events. However, given the natural variability of rainfall the frequency and magnitude of increases in extreme rainfall cannot be confidently projected. Royal HaskoningDHV (2022) modelled the 1% AEP with a 30% increase in rainfall intensity to account for climate change, which is in line with existing practice. The flood hazard associated with this event is shown in Figure 12.

The hazard profile is very similar to the 1% AEP event that excludes a sensitivity test for climate change. Royal HaskoningDHV (2022) notes the same exposures (outlined in Section 2.1.3), with one additional area of impact:

The road reserve of Ashford Road including the pedestrian access easement at the upstream end of Ashford Road. Insufficient hydraulic capacity within the trunk drainage system results in increased overland flows from Robert Road Park flowing at velocities over 2 m/s down the pedestrian access path and into the road reserve at the southern end of Ashford Road. These high velocity flows

combined with flood depths of up to 0.5 m result in an H5 flood hazard category for the access path and Ashford Road.

Figure 12: 1% AEP with 30% increase in rainfall intensity to account for climate change (Royal HaskoningDHV, 2022)

2.2.6 Storm events

The National Environmental Science Programme's Earth Systems and Climate Change Hub[6] note that east coast lows (ECLs) can cause extreme wind, ocean waves, rainfall and flooding which can have

[6] http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_East_Coast_Lows_Nov11_2019_WEB.pdf

severe impacts on coastal communities, businesses and ecosystems. ECLs have been observed to occur on average about 22 times per year, for 36 days per year (as some events last longer than a day). Of the 22 ECLs observed per year, on average 2–3 cause extreme daily rainfall above 100 mm, 7–8 cause widespread daily rain above 25 mm, and one will intensify rapidly. There is large variability from year to year in the number of ECLs that occur, with observations in recent decades showing no clear trend in ECL numbers.

Climate projections based on modelling indicate that fewer ECLs are expected to occur in the future, particularly during the cooler months of the year. The projections show larger reductions for higher greenhouse gas emissions scenarios. These reductions in ECL numbers are due to changes in conditions at higher levels in the atmosphere associated with ECL development.

Although fewer ECLs are projected to occur in the future under a changing climate, other important changes in our climate will affect the impacts of future ECLs on eastern Australia. For example, rising sea levels are likely to increase the impacts of large waves on coastal regions, and extreme rainfall is predicted to increase in intensity resulting in increased risk factors for flooding in some cases. In addition, changes in storm characteristics under climate change can potentially have significant influences on various coastal processes, such as changes in the intensity, frequency and duration of extreme wind and wave events caused by ECLs. Changes in the intensity and duration of ECLs, and associated extreme wind events, are not clear based on current knowledge.

2.2.7 Drought

Projected changes in drought would be influenced by changes to mean rainfall. Projections for the region indicate that drought will continue to be a regular feature of the regional climate and that time spent in drought will increase, particularly for the far future (2090).

2.2.8 Bushfire weather

Modelling shows more severe bushfire weather in the future for the region, however the magnitude of the increase due to uncertainties around projections in rainfall variability is uncertain.

2.2.9 Summary

A summary of climate change projections for the region is provided in Table 5, with projections presented for each relevant climate variable and for two future time scales: near future (2030) and far future (2090). These projections are taken directly from publicly available data provided by the CSIRO and Bureau of Meteorology's *Climate Change in Australia* portal[7] using the most extreme emission scenario, referred to as RCP8.5. Over the past decade observed emissions have been tracking close to this most extreme emission scenario. Over the next 15 years, in the absence of global action on curbing emissions, this trajectory is unlikely to change significantly, suggesting that the most extreme emissions scenario is more likely to occur through to 2030.

Additional data has also been sourced from AdaptNSW (NARCliM) which follows an alternative emissions scenario SRES A2, which was current at the time of development. The SRES A2 emission scenario was selected for the NARCliM climate projections because the global emissions trajectory suggested that it was the most likely scenario. As with RCP8.5, recent publications have confirmed that we are tracking at the higher end of the A2 scenario.

[7] http://www.climatechangeinaustralia.gov.au/en/

Table 5 East Coast – South Region Climate Projections (CSIRO & BoM, 2015)[8]

Climate variable	Summary of regional projections[1, 2]	
	2030	2090
Mean temperature	Increase by 1.0°C (range of 0.7°C to 1.3°C)	Increase by 3.7°C (range of 2.9°C to 4.6°C)
Extreme heat	Average annual number of days above 35°C for Sydney to increase by 4.3 days (range of 4.0 to 5.0 days) under RCP4.5[4]	Average annual number of days above 35°C for Sydney to increase by 11 days (range of 8.2 to 15.0 days) under RCP8.5
Solar radiation	0.8% change (range of -0.7% to 2.7%)	1.3% change (range of -1.2% to 3.4%)
Mean annual rainfall	-1% change (range of -11% to 6%)	-3% change (range of -20% to 16%)
Extreme rainfall	Extreme rainfall to increase in intensity	
Drought	Time spent in drought conditions to increase	
Wind and hail	Minimal change in wind speed of -0.5% (range of –2.3% to 1.9%)	Small change in wind speed of -1.1% (range of -6.9% to 4.2%)
Storm events	Increased in intensity of extreme storms (east coast lows)	
Bushfire[3]	Severe fire weather days to increase by 1.5 days (range of 1.5 to 1.6 days)	Severe fire weather days to increase by 2.3 days (range of 1.4 to 3.0 days)
Relative humidity	Minimal change in humidity of -0.6% (range of -1.4% to 0.9%)	Minimal change in humidity of -1.5% (range of -3.8% to 1.3%)

[1] Projections are presented relative to the 1986-2005 baseline climate
[2] Quantitative projections are presented as the median (50th percentile) of model results, with the 10th to 90th percentile range in brackets
[3] Number of severe fire danger days (Forest Fire Danger Index (FFDI) >50). FFDI combines observations of temperature, humidity and wind speed.
[4] RCP8.5 data not available for 2030 for extreme heat in the East Coast – South Region Climate Projections.

[8] CSIRO Climate Futures climate projections for the East Coast South sub-cluster gathered from the East Coast Cluster https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/172/EAST_COAST_CLUSTER_REPORT_1.pdf

2.3 Climate change sensitivity analysis

The following section compares projections under different scenarios of climate emissions across multiple timeframes to understand how the Cherrybrook precinct may change with respect to the climate over the life of the project, including impacts to those living and using the Cherrybrook precinct. In accordance with SR11.3, sensitivity analysis has been undertaken as described below:

> *11.3 Undertake sensitivity analysis to address the impact of climate change due to increased temperatures, extreme heat events and increase of rainfall intensity integrated with the Water Quality, Flooding and Stormwater Study.*

Sensitivity testing has been undertaken through a comparison of projections available from the CSIRO & BOM (2015), assessing those available for emissions scenarios of RCP4.5 (representing a medium-low emissions scenario) and RCP8.5 (representing a high emissions scenario). These have also been compared to the projections available from NARCliM under the SRES A2 scenario (which, similar to RCP8.5, represents a scenario of high emissions). This comparison aims to determine the relative impact on the proposed site and resulting decisions and aims to ensure that the Climate Risk Register and recommended adaptation options are appropriate for the range of scenarios, particularly accounting for the worst-case scenario (RCP8.5).

2.3.1 Increased temperatures, extreme heat events

The range of projections for increased temperatures and extreme heat events mean that sensitivity testing is undertaken at a high level, by comparing NARCliM projections (which use an older generation of climate models) to the more recent representative concentration pathways, RCP4.5 and RCP8.5 data have been used as a comparison point for key climate variables to serve as sensitivity testing and scenario planning to understand the impacts based on different projections. A comparison of mean temperature and extreme heat days between SRES A2, RCP4.5, and RCP8.5 is provided in Table 6.

Table 6 Change in average temperature and extreme heat days associated with SRESA2, RCP4.5 and RCP8.5

		Emissions scenario		
Climate hazard	**Time period**	**RCP4.5[9] *(AR5 medium-low emissions scenario)***	**SRESA2[10] *(AR4 high emissions scenario)***	**RCP8.5[11] *(AR5 high emissions scenario)***
Change to annual average temperature	2030	0.9°C *(likely range +0.6°C to +1.1°C)*	+0.7°C	-
	2090	1.8°C *(likely range +1.3°C to +2.5°C)*	+1.9°C (2070)	3.75°C *(likely range* +2.9°C to +4.6°C)
Extreme heat days[12] *(baseline: 3.1 days)*	2030	+4.3 days *(likely range 4.0 to 5.0)*	+4 days	-
	2090	+6 days *(likely range 4.9 to 8.2)*	+11 days (2070)	+11 days *(likely range* 8.2 to 15 days)

It is also important to note that Sydney has a variable topography, and significant local variance is present given that the above projections encompass the city's coast through to the western suburbs. As the projections under RCP8.5 exceed the projections under SRES A2, and RCP4.5, RCP8.5

[9] https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/176/CCIA_Australian_cities_1.pdf
[10] https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Metro-Sydney-Climate-Change-Downloads
[11] https://www.climatechangeinaustralia.gov.au/media/ccia/2.1.6/cms_page_media/176/CCIA_Australian_cities_1.pdf
[12] Annual number of days above 35°C

represents a ‘worst case scenario’. Risk assessments and recommended adaptation actions have therefore taken into consideration of this worst-case scenario.

2.3.2 Changing rainfall patterns – Increased rainfall intensity

Rainfall intensities are predicted to increase over time in response to climate change. The Department of Environment and Climate Change (DECC) provides potential increases to rainfall by the year 2070 in ‘Practical Consideration of Climate Change – Floodplain Risk management Guideline’ (DECC, 2007). The timeframe of 2070 has been adopted as the basis for rainfall increase, however longer timeframes could be adopted ‘particularly for critical infrastructure’. The DECC recommend sensitivity analysis, with rainfall intensities increasing between 10% - 30% in peak rainfall and storm volume.

The Australian Rainfall and Runoff (2016) is a national guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. It outlines best available projections of rainfall intensity, adopting findings of the CSIRO and BOM. The values published with are intended to be applied to the key system design event (i.e. the design standard for the structure or infrastructure). It is applicable for current-day rainfall intensities within the range of probability of one Exceedance per Year and 50% to 1% AEP. Table 7 outlines projections for changes in rainfall intensity in 2030 and 2090 under RCP4.5 (representing a medium-low emissions scenario) and RCP8.5 (representing a high emissions scenario).

Table 7 Change in rainfall intensity associated with RCP4.5 and RCP8.5

		Emissions scenario		
Climate hazard	**Time period**	**RCP4.5[13] *(AR5 medium-low emissions scenario)***	**SRESA2 *(AR4 high emissions scenario)***	**RCP8.5[14] *(AR5 high emissions scenario)***
Change in rainfall intensity	2030	4.3%	N/A	4.9%
	2090	9.5%	N/A	19.7%

There is little difference in the projections of rainfall intensity in 2030 between the two scenarios. For 2090, there is a significant increase projected under RCP8.5 compared to RCP4.5.

Given this small change, the Concept Stormwater Management and Preliminary Flood Risk Assessment - Cherrybrook Developable Government Lands (Royal HaskoningDHV, 2022) has modelled a 30% increase in rainfall intensities to account for the most conservative esimates. As this increase exceeds the projections published by AR&R 2016 the 30% increase is assessed as a ‘worst case scenario’. Risk assessments and recommended adaptation actions have therefore taken into consideration of this worst-case scenario.

The implications of an increase in rainfall intensities is discussed in Section 2.2.5 and by Royal Haskoning (DHV, 2022).

[13] https://data.arr-software.org/
[14] https://data.arr-software.org/

3.0 Climate change risk assessment

Of climate related variables, the site's exposure to increasing frequency and intensity of heat events, extreme rainfall and flooding, and storms have been identified as priority focus areas for adaptation. Potential impacts associated with these hazards, relevant for the community, are described in Table 8.

Table 8 Summary of potential impacts for Cherrybrook

Hazard	Climate Impact
Heat	• Extreme heat both increases demand on the energy network because air conditioning units work harder to maintain temperature and reduces energy network capacity, which can cause brownouts and blackouts when the power grid is at or beyond capacity. • Increased heat stress events can lead to significant health impacts to residents, particularly vulnerable community members. This leads to increasing requirements for cooling and areas of respite.
Flooding	• Greater intensity of rainfall and runoff has the potential to overwhelm drainage capacity and cause flooding and inundation of roof, ground, and subterranean systems • Greater intensity of rainfall and runoff has the potential to cause inundation and malfunction of underground utilities such as electricity distribution, fibre cables, pumping stations, other network infrastructure.
Storms	• Greater intensity of rainfall and runoff has the potential to cause inundation and malfunction of underground utilities such as electricity distribution, fibre cables, pumping stations, other network infrastructure.
Drought	• Drought risk affecting water storage systems on site and increasing dependency on mains water supply for non-potable water use.
Bushfires	• Increased bushfire frequency and intensity causing reduced air quality leading to health impacts to community members.

Risk ratings were evaluated using the assessment criteria set out in the Landcom Risk Workbook to determine the consequence and likelihood, and overall rating of each risk.

Based on the location and local modelling it was determined that extreme heat, extreme rainfall and flooding, and storm events are the key climatic variables relevant for the project. Given these key climatic variables and the undesirable nature of high risks, all seven 'high' and 'extreme' were extracted from the risk register for consideration. Relevant high and extreme risks identified for the community are presented in Table 9. It is worth noting that no extreme risks were identified for the time period of 2030, while one extreme risk was identified for the time period of 2090.

Table 9: Summary of Risk Assessment

Risk rating	2030	2090
Low	15	7
Medium	17	22
High	5	6
Extreme	0	1
Total risks	**37**	**37**

A total of 37 climate risks were identified for the site. Table 10 provides a summary of the assessment for the near future (2030) and far future (2090). The full risk assessment matrix for the community is provided in Appendix A.

Table 10:Summary of Extreme and High Climate Risks for the site

Climate variable	Climate impact/risk statement	Risk assessment					
		2030			2090		
		Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
Extreme heat (days over 35ºC)	Overheating of buildings and increased requirements for cooling causing increased costs	Likely	Moderate	High	Almost Certain	Moderate	High
	Impacts to thermal performance and comfort impact user comfort	Likely	Moderate	High	Almost Certain	Moderate	High
	Increased heat stress events amongst residents, visitors, and other site stakeholders	Likely	Major	High	Almost Certain	Major	Extreme
	Increase in power outages/interruption to mains power due to increased energy demand	Possible	Moderate	Medium	Likely	Moderate	High
	Accelerated degradation of materials requiring more frequent maintenance and costs to repair	Rare	Minor	Low	Likely	Moderate	High
Extreme rainfall (inland flooding)	Inundation of buildings and car parks (both above ground and below ground) causing damage to property and building infrastructure	Unlikely	Moderate	Medium	Possible	Moderate	Medium
Storms (including wind and hail)	Risk to health and safety of community members associated with damage to structures, debris, wind and hail.	Possible	Major	High	Possible	Major	High
Bushfire	Risk to health and safety of community members resulting from poor air quality	Likely	Moderate	High	Likely	Moderate	High

4.0 Climate Adaptation Plan

Overall, extreme rainfall and flooding, extreme heat, and extreme storm events are hazards considered to have the most potential impact on the development and its community.

Extreme rainfall can damage properties through flooding, increase costs associated with flood protection and insurance, limit safe access and egress from a site, and cause structural damage to buildings.

Extreme heat can cause heat stress to residents and increase the incidence of illness, increase the cost of keeping buildings cool because more energy is needed, and increase the risk of critical energy infrastructure failing. In particular, there are significant health impacts associated with heatwaves and extreme heat days, particularly for vulnerable members of the community (e.g. children, the elderly, and those experiencing illness). Adaptation actions regarding the management of heat and its impacts primarily relate to ensuring the health of safety of community members and understanding the implications for infrastructure continuity and building performance.

Adaptation actions related to flood mitigation are primarily targeted to reducing safety hazards to residents and the community, minimising damage, reducing runoff, managing water on site, providing shelter for the wider community, and educating residents on flood safety. Similarly, the primary risks associated with storms include hazards related to wind and hail damage to buildings and outdoor areas, as well as damage and interruption to supporting critical infrastructure such as power and water supplies.

Given the precinct is in early design phases, the proposal's key mitigation actions to the impacts of climate change relate to the proposed controls within the site-specific Design Guide relating to the ecologically sustainable development, stormwater, and tree canopy targets. Drawing on these, Table 11 presents actions that would be considered at future development stages, after rezoning has occurred, where the exact actions can be confirmed as part of a future proposal. The actions have also been developed to not be precluded by the new zoning (e.g. impermissible). Actions have been identified for all extreme and high risks identified in the climate change risk assessment.

Table 11: Recommended adaptation actions for future development stages

Climate variable	Climate impact/ risk statement	Risk rating		Adaptation actions
		2030	2090	
Extreme heat (days over 35ºC)	Overheating of buildings and increased requirements for cooling	High	High	• Encourage public space and buildings to integrate green roofs and vertical planting to help minimise the urban heat island impacts. • Natural (passive) ventilation should be a key principle of the design of the residential units (orientation of the building) to help reduce the burden of the HVAC systems. • Consider incentivising compliance beyond baseline targets for NABERS and/or BASIX to maximise thermal performance of buildings.
	Increased energy and water demand	High	High	• Explore options for allocating additional space for onsite battery storage to support decentralised energy solutions. Consider opportunities to incorporate

Climate variable	Climate impact/ risk statement	Risk rating 2030	Risk rating 2090	Adaptation actions
				additional capacity for solar PV (or other renewable energy) and storage across the precinct. • Consider incentivising compliance beyond baseline targets for NABERS and BASIX to maximise energy efficiency opportunities.
	Impacts to thermal performance and comfort	High	High	• Adoption of principles outlined by the Urban Heat Island Credit under the Green Building Council of Australia's Green Star Communities Rating Tool. • Further consideration or specification of building materials within detailed design stages (light coloured roofing materials, selection of concrete / asphalt colour, high reflectivity materials for build facades). • Outdoor recreation equipment (if provided) should be designed for extreme heat days (e.g. water play, shading, cool surfaces etc.
	Increased heat stress amongst stakeholders	High	Extreme	• Explore opportunities for landscaping to capture and use water (increase cooling effects) and opportunities to reuse water on site for irrigation. • Integrate shading, cooling measures, water sensitive urban design (WSUD) and green infrastructure (street trees, rain gardens) into street design. For example, shading can be provided to main pedestrian walkways, especially pedestrian routes connecting between transport nodes, and between rail and bus stops to retail areas within the local centre. • Provision of mechanically cooled community facilities provides a place of refuge during extreme heat days.
	Increase in power outages/ interruption to mains power	Medium	High	• Ensure that selection of building equipment and materials (e.g. HVAC, cables) caters to higher operating temperatures and extreme heat events (e.g. design to 2070 temperatures) to reduce local incidence of interruptions. • Explore options for allocating additional space for onsite battery storage to support decentralised energy solutions. Consider opportunities to incorporate additional capacity for solar PV (or other renewable energy) and storage across the precinct. • Maximise passive cooling opportunities for buildings (i.e. cross ventilation, breezeways)
	Accelerated degradation of materials requiring more frequent	Low	High	• Ensure that selection of building equipment and materials (e.g. HVAC, cables) caters to higher operating temperatures and extreme heat events (e.g. design to 2070 temperatures).

Climate variable	Climate impact/ risk statement	Risk rating		Adaptation actions
		2030	2090	
	maintenance and costs to repair			• Confirm critical equipment / plant is not sited with direct solar exposure and if required, that they can account for projected future increases in ambient temperature.
Extreme rainfall (inland flooding)	Inundation of buildings and car parks (both above ground and below ground)	Medium	Medium	• Flooding and stormwater plans undertaken on a precinct-wide approach and account for a projected increase in rainfall. • Provide flood adaptation measures at critical locations at risk of overland flow such as entries to buildings (both ground floor and basement levels). This could include elevated entry ways or pervious pavement to allow for adequate infiltration of runoff. • Maximise WSUD opportunities to serve as temporary water storage and as public open space to help capture surface flow and rainfall. • Develop a precinct wide strategy to maximise water capture and reuse and develop suggested targets based on land use and development activity. The strategy should provide a framework for future developers to identify how their developments will contribute to this strategy and identify based on the masterplan for locations where water reuse and storage facilities may be able to be consolidated. For example, within development boundaries identify potential locations where rainwater storage can be incorporated into public domain and or open space where landscaping is planned to minimise the cost of rainwater collection, treatment, and storage and maximise the efficiency and reuse of rainwater. • Ensure that critical systems are housed on the roof or elevated well above any potential flood levels. • Access to consider future flood heights, ensuring evacuation is possible during extreme events, if appropriate. • Confirm hazard signage and emergency planning for extreme rainfall includes translations into languages other than English such as Mandarin, Cantonese, Korean, or Sinhalese.
Storms (including wind and hail)	Risk to health and safety of community members	High	High	• During detailed design, specify the use of building materials (façade, roofing) resistant to hail and can withstand high wind speeds (based on wind study during detailed design). • Engage with emergency services throughout all stages of site delivery to identify specific plans of response and any relevant site considerations. For example, consider working with emergency services to implement stay in place

Climate variable	Climate impact/ risk statement	Risk rating		Adaptation actions
		2030	2090	
				emergency response plan for residents, provided facilities have been built to deliver resilience. • Encourage residents to develop emergency plans in line with NSW Emergency Management published material
Bushfire	Risk to health and safety of community members resulting from poor air quality	High	High	• Specify minimum requirements for mechanical air filtration and outside air shut-off as part of HVAC installation, particularly for public buildings such as community facilities. • Natural ventilation design measures should be reviewed in the context of managing air quality (e.g. high-quality sealing of glazing systems). • Provide education materials to residents, advising the health impacts of poor air quality and recommendations for actions they can take to reduce exposure. • Provide air quality updates to residents and the community.

5.0 Next Steps

This report presents a Climate Adaptation Plan for the Cherrybrook Station Government Land State Significant Precinct. This report reflects the information available at the time of assessment. It is recommended this report is reviewed and revised as needed to align with future development of the design and the staged completion of development within the precinct.

The Plan is intended to be shared with residents, businesses, and other key community stakeholders (e.g. proponents of the individual commercial, residential and community infrastructure projects within development) for consideration in their individual resilience and emergency management planning. The Emergency Response Checklist, provided in Appendix B is intended to be disseminated to residents, businesses and other key stakeholders to support community preparedness.

Next steps for Landcom to address the climate adaptation challenges identified in this report include:

- Review the Climate Adaptation Plan in and identify the relevant development stage and responsibility for implementation of each action
- Integrate implementation of climate adaptation measures with the wider community resilience plan developed by Landcom
- Undertake a workshop to prioritise actions identified in the above task for implementation based on Landcom's sphere of influence and control and develop the roles and responsibilities for implementation.
- Liaise with relevant stakeholders to consider a collaborative and coordinated response to improving community resilience.
- Nominate a review date to track progress of the implementation of climate adaptation and community resilience actions.

Appendix A

Detailed climate risk assessment

Appendix A Detailed climate risk assessment

Climate variable	Climate impact/ risk statement	Risk assessment					
		2030			2090		
		Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
Mean temperature (including mean maximum and minimum temperatures)	Increased pressure on cooling and air conditioning systems (HVAC systems)	Likely	Minor	Medium	Likely	Minor	Medium
	Increased energy and water demand	Likely	Minor	Medium	Likely	Minor	Medium
	Impacts to thermal performance and comfort	Likely	Minor	Medium	Likely	Minor	Medium
	Increased maintenance costs	Possible	Insignificant	Low	Possible	Insignificant	Low
Extreme heat (days over 35ºC)	Overheating of buildings and increased requirements for cooling	Likely	Moderate	High	Almost Certain	Moderate	High
	Increased energy and water demand	Likely	Moderate	High	Likely	Moderate	High
	Impacts to thermal performance and comfort	Likely	Moderate	High	Almost Certain	Moderate	High
	Increased degradation of external surfaces requiring more frequent maintenance and replacement	Rare	Minor	Low	Likely	Moderate	High
	Reduction in outdoor recreational activities and use of public space	Likely	Minor	Medium	Almost Certain	Minor	Medium
	Increased requirements for areas of respite	Likely	Minor	Medium	Almost Certain	Minor	Medium
	Increased heat stress amongst stakeholders	Likely	Major	High	Almost Certain	Major	Extreme

Climate variable	Climate impact/ risk statement	Risk assessment					
		2030			2090		
		Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
	Reduced work capacity of staff in employment areas	Likely	Minor	Medium	Almost Certain	Minor	Medium
	Increase in power outages/ interruption to mains power	Possible	Moderate	Medium	Likely	Moderate	High
Mean rainfall	Decreased security of water supply and decreased roof runoff to fill water storage tanks (requirement for water restrictions)	Likely	Minor	Medium	Almost certain	Minor	Medium
	Soil subsidence, movement and cracking as a result of increased variability of periods of wetting and drying causing reduced integrity of building foundations	Rare	Major	Low	Rare	Major	Medium
Extreme rainfall (inland flooding)	Increased incidence of local flood events, limiting access and egress	Unlikely	Moderate	Medium	Possible	Moderate	Medium
	Drainage and stormwater capacity issues	Possible	Minor	Medium	Likely	Minor	Medium
	Inundation of buildings and car parks (both above ground and below ground)	Unlikely	Moderate	Medium	Possible	Major	Moderate
	Increased overland flow coupled with upstream development resulting in larger flooding events	Rare	Moderate	Low	Rare	Moderate	Low
	Increased soil erosion and landslip, resulting in reduced integrity of building foundations	Rare	Major	Low	Unlikely	Major	Medium
	Accelerated degradation of materials requiring more	Rare	Minor	Low	Rare	Minor	Low

Climate variable	Climate impact/ risk statement	Risk assessment					
		2030			2090		
		Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
	frequent maintenance and costs to repair						
	Disruption of utilities resulting from flood events	Possible	Minor	Medium	Likely	Minor	Medium
Relative humidity	Decreased thermal performance of buildings	Possible	Insignificant	Low	Likely	Insignificant	Low
	Decreased thermal comfort	Possible	Insignificant	Low	Likely	Insignificant	Low
	Accelerated carbonation of concrete structures	Rare	Insignificant	Low	Unlikely	Insignificant	Low
	Change in conditions suitable for water borne diseases and pest species distribution	Possible	Insignificant	Low	Likely	Insignificant	Low
Drought	Decrease in soil moisture resulting in reduced integrity of building foundations	Rare	Major	Low	Unlikely	Major	Medium
Bushfire	Risk to health and safety of community members resulting from poor air quality	Likely	Moderate	High	Likely	Moderate	High
	Risk of bushfire damage to dwellings and community facilities	Possible	Major	Low	Possible	Major	Medium
(increased bushfire weather conditions and risk of bushfire events)	Increased frequency and duration of power outages/ interruption to mains power due to fire damage to electricity transmission assets	Possible	Minor	Medium	Likely	Minor	Medium
	Increased risk of bushfire smoke and embers impacting ventilation/ HVAC systems	Possible	Minor	Medium	Possible	Minor	Medium
	Increased risk of smoke damage in buildings resulting	Unlikely	Minor	Low	Possible	Minor	Medium

Climate variable	Climate impact/ risk statement	Risk assessment					
		2030			2090		
		Likelihood	Consequence	Risk rating	Likelihood	Consequence	Risk rating
	from penetration through unsealed areas						
	Accumulation of ash in roof drainage	Unlikely	Minor	Low	Possible	Minor	Medium
Storms (including wind and hail)	Risk to health and safety of community members	Possible	Major	High	Possible	Major	High
	Increased risk of damage from wind/ hail	Possible	Minor	Medium	Likely	Minor	Medium
	Accelerated degradation of materials requiring more frequent maintenance and costs to repair	Unlikely	Minor	Low	Possible	Minor	Medium
	Increased frequency and duration of power outages/ interruption to mains power	Possible	Minor	Medium	Likely	Minor	Medium

Appendix B

Emergency Response Checklist

Appendix B Emergency Response Checklist

In addition to understanding the key shocks and stresses likely to impact a community, emergency preparedness and planning also plays an important role.

This section outlines the emergency response checklist for the community and is designed to be shared with the residents, businesses and key stakeholders to support community preparedness.

Emergency response requirements	Information, contacts and links
Key community contacts (e.g. local police, senior members of community groups, schools and other community-based leaders).	**Hornsby Shire Council** 296 Peats Ferry Road (formerly Pacific Highway) Hornsby NSW 2077 Telephone: (02) 9847 6666 Fax: (02) 9847 6999 Email: hsc@hornsby.nsw.gov.au Postal address: PO Box 37, Hornsby NSW 1630 **The Hills Shire Council** 3 Columbia Court Norwest NSW 2153 +61 2 9843 0555 General enquiries: https://au.openforms.com/Form/caa65d1d-ca3c-42e4-9e36-3ebc2e90ab77 **Hornsby Shire Council Community Directory** Information about groups and organisations in the Hornsby Shire, as well as regional and state groups of interest to the Hornsby Shire Community. https://www.hornsby.nsw.gov.au/community/services/community-directory **The Hills Shire Council My Neighbourhood** Provides information on the local government area including parks, events and facilities. https://www.thehills.nsw.gov.au/Services/For-Residents/My-Neighbourhood
Emergency contacts (e.g. local authorities, utility providers, insurance, counselling etc.).	**Community Emergency agencies and contacts:** Life-threatening emergencies police/fire/ambulance: 000 (landlines); mobile phones (000 and 112) Castle Hill Police Station: (02) 9680 5399 Hornsby Police Station: (02) 9476 9799 Fire and Rescue NSW – Kellyville: (02) 9629 3222 NSW Ambulance Castle Hill: (02) 9320 7777 Blacktown Hospital (02) 9881 8000 Norwest Private Hospital (02) 8882 8882 The Hills Private Hospital (02) 9639 3333 State Emergency Services (SES) for flood and storm response: 132 500 Note – a SES headquarters for The Hills is proposed for Memorial Avenue, Kellyville. Sydney Water General enquiries: 13 20 92 Faults and emergencies: 133 718 Endeavour Energy General enquiries: 133 718

Emergency response requirements	Information, contacts and links
	Faults and emergencies: 131 003
Nominated emergency shelter location(s) for the community such as a shopping centre or school hall.	Neighbourhood Safer Places are designed as a Place of Last Resort in bush fire emergencies only. The location of the nearest Neighbourhood Safer Places to Cherrybrook is located at Edward Bennett Oval, 48 Edward Bennett Dr, Cherrybrook. This is an open space only. No other specified emergency shelter locations are publicly available for the community. Emergency NSW publishes information on recovery centres on their website for specific emergency events: https://www.emergency.nsw.gov.au/Pages/Home.aspx
Information on how to develop an emergency plan and emergency kit for residents, businesses and others occupying the facilities within the community.	Red Cross Rediplan, a free disaster preparedness guide: http://www.redcross.org.au/emergency-resources.aspx The Office of Emergency Management NSW provides a range of guidance and links to information on developing emergency kits and emergency plans for community members and businesses: https://www.emergency.nsw.gov.au/for-the-community/before-an-emergency/ NSW Rural Fire Service information on how to develop a bushfire survival plan: http://www.rfs.gov.au/_data/assets/pdf_file/0017/2933/BushFireSurvivalplan.pdf State Emergency Service home emergency plan: http://www.stormsafe.com.au
Comprehensive list of communication channels to enable the community to stay informed (e.g. radio, social media).	**Hornsby Shire Council** 296 Peats Ferry Road (formerly Pacific Highway) Hornsby NSW 2077 Telephone: (02) 9847 6666 Fax: (02) 9847 6999 Email: hsc@hornsby.nsw.gov.au Postal address: PO Box 37, Hornsby NSW 1630 **The Hills Shire Council** 3 Columbia Court Norwest NSW 2153 +61 2 9843 0555 General enquiries: https://au.openforms.com/Form/caa65d1d-ca3c-42e4-9e36-3ebc2e90ab77 The National Emergency Alert telephone warning system can provide warnings to all mobile phones based on last known location of the handset. There is no need to register for this service. Further information is available here: http://www.emergencyalert.gov.au/ Emergency NSW also provides a range of social media links to monitor news and updates during an emergency: https://www.emergency.nsw.gov.au/for-the-community/alerts/alertnsw.html ABC Emergency Warnings and Alerts, with links to social media coverage of current hazards and emergencies: http://www.abc.net.au/news/emergency/

Emergency response requirements	Information, contacts and links
	NSW Rural Fire Service provides links to communication channels for up to date information on bushfire hazards: http://www.rfs.nsw.gov.au/ State Emergency Services provides links to communication channels for up to date information on storm hazards including extreme rainfall, flooding, wind and hail: https://www.ses.nsw.gov.au Transport for NSW provides information on road closure information here: http://m.livetraffic.rta.nsw.gov.au/Search.aspx
Guidelines for disaster prevention at a local level, procedure to follow in the event of an emergency and what to do after an emergency.	**North West Metropolitan Emergency Management District Disaster Plan:** The Northwest Metropolitan Emergency Management District Disaster Plan identifies the roles and responsibilities with the district for emergency management and outlines the emergency management framework for the district. https://www.emergency.nsw.gov.au/Pages/about-us/emergency-management-regions/north-west-metro.aspx **NSW Recovery Plan** The NSW Recovery Plan is the NSW Government strategic plan for disaster recovery in NSW and outlines the roles and responsibilities and mechanism for recovery form disasters. https://www.emergency.nsw.gov.au/Pages/publications/plans/supporting-plans/recovery-plan.aspx **NSW State Emergency Plan** The NSW State Emergency Plan (EMPLAN) is the framework for emergency management in NSW. https://www.emergency.nsw.gov.au/Pages/publications/plans/EMPLAN.aspx