Central Precinct Renewal Program

July 2022

Green Infrastructure Strategy

Transport for NSW

NSW GOVERNMENT

Acknowledgement of Country

We respectfully acknowledge the Traditional Custodians of the Central Precinct, the Gadigal, and recognise the importance of the place to Aboriginal people and their continuing connection to Country and culture. We pay our respect to Elders past, present and emerging.

Contents

Document Control

Document Control	
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Branch	IP Development
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Versions

Version	Amendment notes
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1 Introduction

1.1 Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
BAU	Business as usual
BCA	Building Code of Australia
CIV	Capital investment value
CoS	City of Sydney Council
CSPS	Central Sydney Planning Strategy
DA	Development application
DCP	Development control plan
DPE	NSW Department of Planning and Environment
EP&A ACT	Environmental Planning and Assessment Act 1979
EP&A Regulation	Environmental Planning and Assessment Regulation 2000
EPI	Environmental planning instrument
ESD	Ecologically sustainable development
FSR	Floor space ratio
GANSW	Government Architect NSW
GFA	Gross floor area
GCC	Greater Cities Commission
LEP	Local environmental plan
LGA	The City of Sydney local government area
LSPS	Local strategic planning statement
NABERS	National Australian Built Environment Rating System

Abbreviation	Definition
PRP	Project Review Panel
SCA	Special character area
SDCP2012	Sydney Development Control Plan 2012
SDRP	State Design Review Panel
SEPP	State Environmental Planning Policy
SLEP2012	Sydney Local Environmental Plan 2012
SSDA	State significant development application
SSP	State Significant Precinct

1.2 Definitions

Term	Definition
Accessibility	The ability for everyone, regardless of age, disability or special needs or where they live, to use and benefit from the transport system
Active transport	Transport that is human powered, such as walking or cycling
Amenity	The extent to which a place, experience or service is pleasant, attractive or comfortable. Improved features, facilities or services may contribute to increase amenity.
Bradfield Flying Junctions	Series of flyover tracks between the Cleveland Street bridge at Redfern and Central Stations that allow trains to move from any one line to another without crossing a line in the opposing direction
Bus interchange	Where customers have access to a number of different bus routes at a central location
Bus stand	A place to board or alight from bus services
Camperdown-Ultimo Collaboration Area	The Health and Education Precinct which includes the Royal Prince Alfred Hospital, TAFE NSW, University of Notre Dame, University of Sydney and University of Technology Sydney, and medical and research institutions and other health services facilities and educational establishments
Catchment	Area from which a location or service attracts people
CBD and South East Light Rail	means to the light rail network extending from Randwick and Kingsford to Circular Quay
Central Precinct	Central Precinct State Significant Precinct
Central Sydney	Land identified as Central Sydney under the Sydney Local Environmental Plan 2012 and represents the Metropolitan Centre of Sydney. Central Sydney includes Sydney's Central Business District
Central Walk	The underground paid pedestrian connection, currently under construction, that is to be delivered by Sydney Metro City and South West. Once complete, it will be a link between the new station entrance on Chalmers Street, the Eastern Suburbs Railway concourse, suburban platforms 16-23 (via escalators and lifts) and the new Sydney Metro north-south concourse
Character	The combination of the attributes, characteristics and qualities of a place (GANSW, 2021, Draft Urban Design Guide)
City Plan 2036	City of Sydney local strategic planning statement
Community	Particular types of stakeholder and refers to groups of people in particular places who are both affected by our work and experience the outcomes and benefits of our activities

Term	Definition
Control	A numerical standard that is applied in a prescriptive manner
Corridor	A broad, linear geographical area between places
Council	The City of Sydney Council
Customer interface	The point at which transport services interact with their customer
Customers	Those who use transport networks and services. They include car drivers, heavy vehicle operators, public transport and point to point passengers, pedestrians, cyclists and freight and goods providers
Department	The Department of Planning and Environment
Determination	The approval made in accordance with the Environmental Planning and Assessment (EP&A) Act 1979. In relation to Central Precinct SSP, a determination will be made by the Minister for Planning and Public Spaces
Devonshire Street Tunnel	The official name of the pedestrian tunnel connecting Chalmers and Lee Streets
District Plan	means the Eastern City District Plan
Future Transport Strategy	Transport for NSW's approach to planning transport and engaging customers, to address future technological, economic and social changes. Future Transport Strategy comprises two focus areas – planning ('Future Transport Planning') and technology ('Future Transport Technology' and 'Technology Roadmap')
Gateway	Cities that provide state level services and facilities to support a broad population catchment while also having international connections through their cities airport and/or port.
Goods Line	The official name for the partly elevated walkway from Central Station to Darling Harbour following the route of a disused railway line
Grand Concourse	Part of Central Station
Greater Sydney's Green Grid	The link between parks, open spaces, bushland and walking and cycling paths
Interchange	A facility to transfer from one mode of transport or one transport service to another. For example, a station with an adjoining light rail stop
Local streets	Places that are part of the fabric of suburban neighbourhoods where we live our lives and facilitate local community access

Definitions

Term	Definition
Merit based assessment	An assessment of a matter that allows for reasonable flexibility to consider a range of possible solutions
Minister	The Minister for Planning
Mixed-use	A building or area containing more than one type of land use
Mobility	The ability to move or be moved easily and without constraints
Mortuary Station	The building formerly used as a railway station on the Rookwood Cemetery railway line, now disused
NABERS	A national rating system that measures the environmental performance of Australian buildings and tenancies
Objective	A statement of a desired future outcome, generally expressed in a qualitative manner that enables merit based assessment
Over rail corridor development or Over Station Development	Development of air space over railway corridors
Place	An intersection of transport infrastructure with social infrastructure and commercial activity. These are the areas within and around transit stops where people live and commute. Places can be created as an outcome of Placemaking
Placemaking	Scoping and delivering places for the community, beyond the immediate transport infrastructure. Successful placemaking either preserves or enhances the character of our public spaces, making them more accessible, attractive, comfortable and safe
Planning instrument	Means any of the following: • strategic plan (comprising regional strategic plans and district strategic plans) and local strategic planning statements • environmental planning instrument (comprising State environmental planning policies and local environmental plans) • development control plan
Planning Secretary	The Secretary of the Department of Planning
Precinct	Geographical area with boundaries determined by land use and other unique characteristics. For example, an area where there is an agglomeration of warehouses may be termed a freight precinct
Principal development standards	Matters addressed in Part 4 of the Standard Instrument
Proponent	Transport for NSW

Term	Definition
Proposal	Proposed amendments to the planning framework
Provisions	means a broad term covering objectives and controls
Public spaces	means areas that are publicly accessible where people can interact with each other and make social connections
Rail network	means the rail infrastructure in NSW
Railway corridor	The land within Central Precinct on which a railway is built; comprising all property between property fences, or if no fences, everywhere within 15m from the outermost rails. Under planning legislation rail corridor is defined as land: a) that is owned, leased, managed or controlled by a public authority for the purpose of a railway or rail infrastructure facilities: or b) that is zoned under an environmental planning instrument predominately or solely for development of the purpose of a railway or rail infrastructure facilities
Railway Square	The area between Lee Street and Broadway, comprising a plaza, bus stands and underground access/uses
Reference Master Plan	A non-statutory document that shows one way in which the precinct may develop in the future in accordance with the proposed amendments to the planning framework Note: Refer to the GANSW Advisory Note v2, dated 12/09/2018 for further guidance
Region Plan	The Greater Sydney Region Plan - A Metropolis of Three Cities
Rezoning	Amendments to environmental planning instruments, in particular for land use zones and principal development standards such as height of buildings and floor space ratio
Shocks and stresses	The acute short term damaging events or long term trends causing inequity impacting a city's resilience
Siding	A short stretch of rail track used to store rolling stock or enable trains on the same line to pass
Social procurement	Purchasing decisions based on good social outcomes
Standard Instrument	The Standard Instrument — Principal Local Environmental Plan
State	The state of New South Wales

Definitions

Term	Definition
State-led rezonings	A focus on precincts where there is a strategic imperative for the Department of Planning to lead the process, including places that benefit from current or future city-shaping infrastructure or investment, and where we can create great public spaces in collaboration with councils and communities. These rezonings generally occur under a SEPP
State Significant Precinct	The areas with state or regional planning significance because of their social, economic or environmental characteristics
Strategic Framework	The document prepared by Transport for NSW for Central Precinct in 2021 that addresses key matters including vision, priorities, public space, strategic connections, design excellence, identify sub-precincts for future detailed planning and also outlines the next steps in the State Significant Precinct process for Central Precinct
Strategic plan	The regional strategic plan, district strategic plan or a local strategic planning statement
Sub-precinct	The definable areas within Central Precinct SSP due to its unique local character, opportunities and constraints, either current or future. The Western Gateway is a sub-precinct
Sydney Metro	A fully-automated, high frequency rail network connecting Sydney
Tech Central	The State government initiative as set out in The Sydney Innovation and Technology Precinct Panel Report 2018. Tech Central is located south of the Sydney central business district, surrounded by the suburbs of Redfern, Ultimo, Haymarket, Camperdown, Chippendale, Darlington, Surry Hills and Eveleigh
Transport for NSW	The statutory authority of the New South Wales Government responsible for managing transport services in New South Wales.
Transport interchange	A facility designed for transitioning between different modes, such as a major bus stop or train station
Transport modes	The five public transport modes are metro, trains, buses, ferries and light rail. The two active transport modes are walking and cycling
Urban renewal	A planned approach to the improvement and rehabilitation of city areas with new infrastructure, new commercial/mixed uses, improved services and renovation or reconstruction of housing and public works
Vibrant streets / places	Places that have a high demand for movement as well as place with a need to balance different demands within available road space

1.3 Executive summary

The Central Precinct Green Infrastructure Strategy has been prepared to identify how the renewal project can integrate green infrastructure into the development in order to provide environmental, social and economic benefits both to the precinct, and the wider city.

The strategy analyses the existing situation, in which the precinct has low ecological value, low canopy and greening cover and minimal public open space. It identifies opportunities in the renewal project to provide additional public open space and improve access and connectivity, and to integrate green infrastructure into the engineered deck structure above the rail lines to significantly increase the amount of canopy cover, greening and urban habitat within the site. The planning framework chapter identifies recommendations to embed these principles into the ongoing phases of the development, including planning, design, and ongoing management.

1.4 Introduction

Located within the heart of Eastern Harbour City, Central Precinct is Australia's busiest transport interchange. The precinct currently holds latent potential with all its inherent advantages of location and transport connections to revitalise Central Sydney. Capitalising on Central Precinct's prime location within Tech Central, a NSW Government commitment to create the biggest technology hub of its kind in Australia, Central Precinct presents the ultimate transformative opportunity to deliver a connected destination for living, creativity and jobs. The renewal of Central Precinct will provide a world-class transport interchange experience, important space for jobs of the future, improved connections with surrounding areas, new and improved public spaces and social infrastructure to support the community.

1.4.1 Tech Central

1.4.1.1 Overview

The NSW Government is committed to working with the local community to develop the biggest innovation district of its kind in Australia. Bringing together six neighbourhoods near the Sydney CBD (Haymarket, Ultimo, Surry Hills, Camperdown, Darlington North Eveleigh and South Eveleigh), Tech Central is a thriving innovation ecosystem that includes world-class universities, a world-leading research hospital, 100 + research institutions, investors and a wide range of tech and innovation companies. The vision for Tech Central is for it to be a place where universities, startups, scaleups, high-tech giants and the community collaborate to solve problems, socialise and spark ideas that change our world. It is also for it to be place where centring First Nations voices, low carbon living, green spaces, places for all people and easy transport and digital connections support resilience, amenity, inclusivity, vitality and growth.

Tech Central is an essential component of the Greater Sydney Region Plan's Eastern Harbour City Innovation Corridor. It aims to leverage the existing rich heritage, culture, activity, innovation and technology, education and health institutions within the precinct as well as the excellent transport links provided by the Central and Redfern Station transport interchanges.

The Central Precinct is located within the Haymarket neighbourhood of Tech Central. Planned to become the CBD for Sydney's 21st century, this neighbourhood is already home to The Quantum Terminal (affordable coworking space in the iconic Central Station Sydney Terminal Building) the Scaleup Hub (affordable and flexible workspace for high-growth technology scaleups) and is soon to be the home of Atlassian's headquarters. It is also in close proximity to a number of important education and research institutions.

The planned urban renewal of the Central Precinct has been identified as a key project to achieving the vision for Tech Central.

1.4.1.2 Background & Context

In August 2018, the NSW Government established the Sydney Innovation and Technology Precinct Panel (the Panel) comprising representatives from various industry, health, education, government agencies and key community members. In December 2018 'The Sydney Innovation and Technology Precinct Panel Report' was produced, setting out the Panel's recommendations for a pathway to delivering a successful innovation and technology district at Tech Central. In February 2019, the NSW Government adopted the Panel's report and committed to delivering the following:

- 25,000 additional innovation jobs
- 25,000 new STEM and life sciences students
- 200,000 m^2 for technology companies, and
- 50,000 m^2 of affordable space for startups and scaleups

In February 2019, the Greater Sydney Commission released a Place Strategy for the area that is now known as Tech Central (Camperdown-Ultimo Collaboration Area Place Strategy, GSC). The Place Strategy, developed collaboratively by a range of stakeholders involved in planning for Tech Central's future, was prepared to inform public and private policy and investment decisions by identifying and recognising the complex, place-specific issues inhibiting growth and change. The strategy identifies shared objectives for the place and sets out priorities and actions to realise the vision for the area under the key themes of Connectivity, Liveability, Productivity, Sustainability and Governance.

Both the Panel Report and Place Strategy recognise the importance of the Central Precinct to Tech Central's future.

In July 2019, Central Precinct was declared a nominated State Significant Precinct (SSP) in recognition of its potential to boost investment and deliver new jobs. The SSP planning process for Central Precinct will identify a new statutory planning framework for Central Precinct. This involves two key stages:

Stage 1: Development of a draft Strategic Vision which has since evolved into the Central Precinct Strategic Framework

Stage 2: Preparation of an SSP study with associated technical analysis and community and stakeholder consultation.

In March 2021, the Central Precinct Strategic Framework was adopted representing the completion of Stage 1 of the planning process to develop a new planning framework for Central Precinct. The Strategic Framework outlines the vision, planning priorities, design principles, and the proposed future character of sub-precincts within Central Precinct. This is intended to inform and guide further detailed planning and design investigations as part of this SSP Study (Stage 2 of the SSP planning process).

This SSP Study intends to amend the planning controls applicable to Central Precinct under the <Sydney LEP 2012 / SSP SEPP 2005> to reflect the vision and planning priorities set for the Precinct under the Strategic Framework. Study Requirements were issued in December 2020 to guide the investigations and the proposed new planning controls.

1.4.2 Central Precinct vision

Central Precinct will be a vibrant and exciting place that unites a world-class transport interchange with innovative and diverse businesses and high-quality public spaces. It will embrace design, sustainability and connectivity, celebrate its unique built form and social and cultural heritage and become a centre for the jobs of the future and economic growth.

1.4.3 Case for change

Over the coming years, Central Station will come under increasing pressure as technological innovations progress, investment in transport infrastructure increases and daily passenger movements increase.

Sydney Metro, Australia's biggest public transport project, will result in the delivery of a new generation of world-class, fast, safe, and reliable trains enabling faster services across Sydney's rail network. In 2024, Sydney Metro's Central Station will open with daily passenger movements forecast to increase from 270,000 persons to 450,000 persons over the next 30 years.

In its current state, Central Station is underperforming as Australia's major transport interchange, lacking connectivity, activation and quality public spaces.

The renewal of Central Precinct will expand and revitalise Central Station, and transform this underutilised part of Sydney from a place that people simply move through to one where they want to visit, work, relax, connect and socialise. Its renewal also presents the potential to deliver on the strategic intent and key policies of regional, district and local strategic plans, providing for a city-shaping opportunity that can deliver economic, social and environmental benefit. Specifically, it will:

- make a substantial direct and indirect contribution to achieving the Premier's Priorities by facilitating upgrades to Sydney's largest and most significant public transport interchange, improving the level of service for users and visitors, and supporting the creation of new jobs and housing
- implement the recommendations of the NSW State

Infrastructure Strategy 2018-2038, in particular the upgrading of the major transport interchange at Central to meet future customer growth

- contribute to key 'Directions' of the Greater Sydney Region Plan, to deliver 'a city supported by infrastructure', help create 'a city of great places', support 'a well connected city', deliver new 'jobs and skills for the city' and create 'an efficient city'
- implement the outcomes envisaged within the Eastern City District Plan including reinforcing the Harbour CBD's role as the national economic powerhouse of Australia and supporting its continued growth as a Global International City
- deliver on the shared objectives and priorities for Tech Central, the future focal point of Sydney's innovation and technology community, which aims to boost innovation, economic development and knowledge intensive jobs while creating an environment that foster collaboration and the exchanging of ideas
- deliver an outcome that responds to the overarching vision and objectives of the Central Sydney Planning Strategy. In particular it will assist with implementing a number of 'key moves' outlined in the strategy, including to 'ensure development responds to its context', 'ensure infrastructure keeps pace with growth', 'move people more easily', 'protect, enhance and expand Central Sydney's heritage, public places and spaces', and to 'reaffirm commitment to design excellence.'

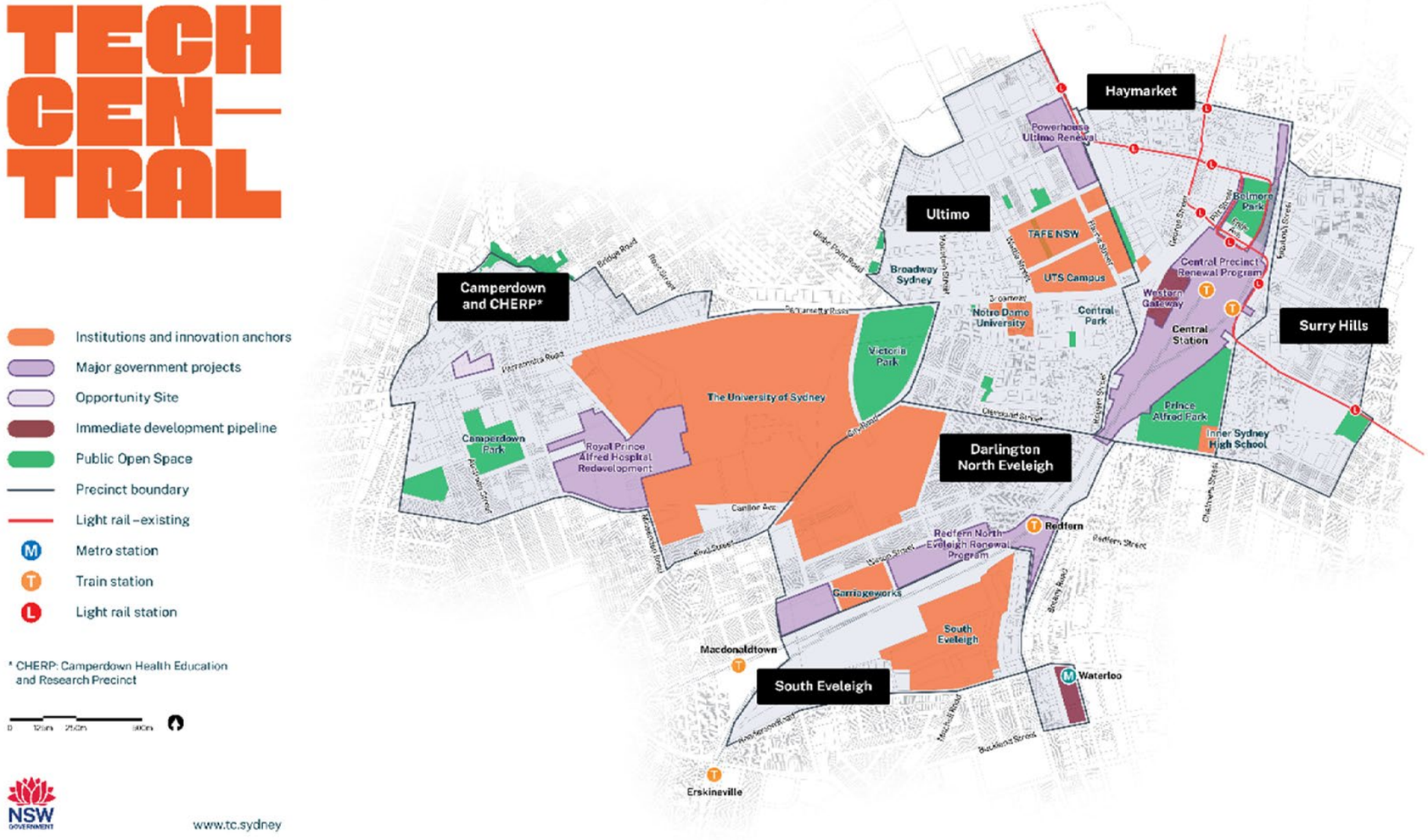


Figure 1.1 location plan of Tech Central

1.5 About this report

The purpose of this report is to provide a detailed Green Infrastructure Study and assessment of the proposed changes, and consider any potential impacts that may result within and surrounding the Central Precinct. This report addresses study requirement 9. Green Infrastructure, Ecology, Urban Forest and Greening. The relevant study requirements, considerations and consultation requirements, and location of where these have been responded to is outlined in Table 1 below.

1.5.1 SSP Study Requirements

Table 1.1 Study requirements, considerations and consultation requirements	
Prepare a Green Infrastructure Study for the Precinct that:	
Identifies the existing situation, including constraints, opportunities and key issues;	Refer to 03 Existing Situation
Outlines the likely impacts of the proposal in relation to climate change, heat impacts and community health needs (i.e. mental and physical health);	Refer to 05.1 Urban heat and community health and to the Environmental Sustainability, Climate Change and Waste Management Report (Atelier Ten & Integral, 2022)
Provides detail of proposed green infrastructure principles and how they will be incorporated into the proposal (consistent with Greener Places);	Refer to 02 Vision and Principles
Includes an urban forest and greening strategy – which outlines the percentage of greening and canopy cover across each land classification (e.g. streets, parks, private land) and private property zoning type;	Refer to 05 Urban Forest and greening
Includes measures to address storm water retention management and opportunities for beneficial reuse;	Refer to 08 Water Strategy For further detail refer to the Environmental Sustainability, Climate Change and Waste Management Report (Atelier Ten & Integral, 2022), and the Water Quality, Flooding and Stormwater Report (Arcadis, 2022)
Includes an Ecological Assessment for the Precinct;	Refer to 06 Urban habitat, and A.2 Ecological Constraints and Opportunities (EcoLogical).
Informs and supports the preparation of the proposed planning framework including any recommended planning controls or DCP/Design Guideline provisions that would deliver an appropriate green infrastructure and sustainability outcome.	Refer to 09 Planning Framework
This study is to demonstrate consideration of:	
Relevant case studies and transferable principles that will apply to the proposal;	Refer to 11 Case Studies
Percentage and distribution of greening and canopy cover across all private (including green roofs and walls) and public domain areas within the precinct;	Refer to 05 Urban Forest and greening

SSP Study Requirements

Table 1.1 Study requirements, considerations and consultation requirements	
Retention of existing trees and provision of new trees, the capacity of the proposal to allow for the growth of new trees to maturity;	Refer to 05 Urban Forest and greening
The provision of sufficient soil volumes and quality to provide for long term tree health;	Refer to 07 Soil Strategy
Canopy design concepts that improve streetscape amenity;	Refer to 05 Urban Forest and greening
Taking a whole-of-life-approach to green infrastructure through planning design, construction and ongoing precinct management;	Refer to 09 Planning Framework and the Environmental Sustainability, Climate Change and Waste Management Report (Atelier Ten & Integral, 2022)
Impacts on biodiversity and measures to avoid and minimise impacts, protect and enhance biodiversity through the greening of public and private spaces and the retention of existing habitat including habitat provided by built structures;	Refer to 06 Urban habitat.
The use of a diversity of local native plant species in street tree planting, open space areas and any site landscaping;	Refer to 05 Urban forest and greening
The use of advanced sized trees in any street, open space and site landscaping;	Refer to 05 Urban forest and greening
The potential habitat linkage provided by the railway corridor outlined in the City's Urban Ecology Strategic Action Plan, currently under review as an important biodiversity corridor;	Refer to 06 Urban habitat
The bush restoration works at Prince Alfred Park that includes the native meadow;	Refer to 03 Existing Situation
Protection of microbats near central station;	Refer to 06 Urban habitat, and A.2 Ecological Constraints and Opportunities (EcoLogical).
Water sensitive urban design and integration with the flood study, plus options for potential alternative water supply;	Refer to 08 Water Strategy

Table 1.1 Study requirements, considerations and consultation requirements	
The Premier's priorities for 'Greening our city' and 'Greener public spaces'.	Refer to 02 Vision and Principles
Consultation	
The Study is to demonstrate that it has been undertaken in consultation with the City of Sydney, key agencies, the local community and any other key stakeholders.	Refer to 10 Consultation Register
Author	
The Study is to be prepared by suitably qualified landscape architect with specialist advice and input as necessary from an ecologist, arborist, Water Sensitive Urban Design engineer, soil scientist and urban forestry professionals with the necessary experience and knowledge of the site and expertise to undertake the works.	This study identifies planning principles for urban tree planting, WSUD, and connected soil provision. It is recommended that more detailed specialist advice is sought as necessary from an arborist, Water Sensitive Urban Design engineer, soil scientist and urban forestry professional as planning and design progresses.
Guidance documents	
The following documents provide guidance for this Study: City of Sydney Urban Forest Strategy (and draft revised targets), Urban Ecology Strategic Action Plan, Green Roof and Walls Strategy, and Landscape Code; Greater Sydney Commission – District Plans and Greener Places - Urban Tree Canopy Guide; Guidelines set out in Southern Sydney Regional Organisation of Councils (SSROC) Connected Corridors for Biodiversity and the City's Urban Ecology Strategic Action Plan; and Government Architect NSW – Greener Places.	Referenced throughout. Refer to A.1 for Document reviews

1.6 Study Area

Central Precinct is located at the south-east edge of Central Sydney (refer to Figure 1.2). Central Precinct is surrounded by a number of suburbs including, Haymarket to the north, Chippendale to the south and Surry Hills to the south-east. It is located within the City of Sydney local government area (LGA) with an approximate gross site area of 24 hectares of Government owned land. The precinct comprises land bounded by Pitt Street and Regent Street to the west, Cleveland Street to the south, Eddy Avenue, Hay Street and Goulburn Street to the north and Elizabeth Street and Chalmers Street to the east.

Central Precinct has been an important site for transport operations for over 150 years. Today, Central Station is Australia's busiest transport interchanges and is the anchor of New South Wales's (NSW) rail network. It provides 24 platforms for suburban and Intercity and Regional train connections as well as a direct link to Sydney Airport. The broader transport interchange also caters for light rail, bus, coach and point to point connections such as taxis. The transport interchange will also form part of the Sydney Metro network, with new underground platforms to be provided for Sydney Metro services under Platform 13, 15 and 16 at Central Station. Sydney Metro services will begin in 2024. The precinct also comprises several significant heritage items including the state-heritage listed Sydney Terminal Building and the Clock Tower.

Figure 1.2 location plan of Central Precinct

Study Area

As part of the Strategic Framework, eight sub-precincts have been defined that reflect and positively respond to the varying character of the surrounding areas. These sub-precincts are:

Central Station

Northern Over Station Development

Western Gateway

Regent Street Sidings

Southern Over Station Development

Prince Alfred Sidings

Eastern Gateway

Goulburn Street.

The location of these sub-precincts and relevant boundaries is illustrated in Figure 1.3.

Figure 1.3 Central Precinct and sub-precincts

1.6.1 Planning priorities

To help realise the vision of Central Precinct and the desired local character of the sub-precincts, the following planning priorities have been developed and are grouped into five key themes as outlined in Table 1.2 below.

Table 1.2 Central Precinct planning priorities

Theme	Planning priorities
Place and destination	• Unite the city by reconnecting with the surrounding suburbs • Shape a great place that is vibrant, diverse, active, inclusive and has a high level of amenity • Deliver a precinct which responds to its urban context and embeds design excellence Improve existing and providing additional connected public space in the precinct of high environmental amenity and comfort • Protect and celebrate the Precinct's heritage values • Create a people focussed precinct through a focus on public transport, cycling and walkability • Facilitate the precinct's focus on transport and economic diversity in tourism and across commercial sectors including office, business and retail.
People and community	• Design public spaces that promote health, equality and well-being • Promote social cohesion by providing spaces for gathering, connection, exchange, opportunity and cultural expression • Honour and celebrate the cultural heritage and identity of the Precinct's past and present Aboriginal community • Create a safe and intuitive precinct that promotes social access and inclusion • Support programs and initiatives that benefit communities and people • Create a precinct that responds to the current and future needs of transport customers, workers, residents and visitors, including those of the broader local community.

Table 1.2 Central Precinct planning priorities

Theme	Planning priorities
Mobility and access	• Provide a world class, integrated and seamless transport interchange • Maintain the precinct's role as NSW's main transport interchange • Improve the transport customer experience, including wayfinding, pedestrian flows and interchange between different transport modes • Facilitate and enhancing connections within and towards key locations in southern Central Sydney • Deliver a people focussed precinct that is walkable, well connected, safe and puts people first • Design infrastructure that will adapt to future changes in transport and mobility.
Economy and innovation	• Advance Sydney's status as a global city • Support the creation of jobs and economic growth including new and emerging industries such as innovation and technology and explore the provision of space for cultural and creative uses and start-ups • Provide an active and diverse commercial hub with a rich network of complementary uses that nurture and support business • Support both the day and night economies of the precinct through diverse complementary uses, promoting liveability and productivity • Foster collaboration between major institutions in the precinct including transport, education, health and business • Create a smart precinct that incorporates digital infrastructure to support research and innovation.

1.6.2 Reference Master Plan

Architectus and Tyrrell Studio have prepared a Place Strategy, Urban Design Framework and a Public Domain Strategy which establishes the Reference Master Plan for Central Precinct. The Urban Design Framework and Public Domain Strategy provides a comprehensive urban design vision and strategy to guide future development of Central Precinct and has informed the proposed planning framework of the SSP Study.

The Reference Master Plan includes:

- Approximately 22,000 sqm of publicly accessible open space comprising:
  - Central Green – a 6,000 square metre publicly accessible park located in immediately south of the Sydney Terminal building
  - Central Square – 7,000 square metre publicly accessible square located at the George Street and Pitt Street junction
  - Mortuary Station Gardens – a 4,470 square metre publicly accessible park (excluding Mortuary Station building) located at Mortuary Station
  - Henry Deane Plaza – a publicly accessible plaza located in the Western Gateway sub-precinct
  - Eddy Avenue Plaza – a 1,680 square metre publicly accessible plaza located in the north-eastern portion of the Sydney Terminal building
  - Western Terminal Extension Building Rooftop - a 970sqm publicly accessible space above the Western Terminal Extension Building Rooftop.
- Approximately 269,500 square metres of office gross floor area (GFA)
- Approximately 22,850 square metres of retail GFA
- Approximately 53,600 square metres of hotel GFA
- Approximately 84,900 square metres of residential accommodation GFA, providing for approximately 850 dwellings (assuming 1 dwelling per 100sqm GFA) . The Central Precinct SSP Study will include the commitment to deliver 15 per cent of any new residential floor space as affordable housing.
- Approximately 47,250 square metres of education/tech space GFA
- Approximately 22,500 square metres of student accommodation GFA
- Approximately 14,300 square metres of community/cultural space GFA.

The key features of the Indicative Reference Master Plan, include:

- A network of new and enhanced open spaces linked by green connections. This will include:
  - A Central Green (Dune Gardens) at the north of Central Precinct that will create a new civic public realm extension of the Sydney Terminal building and a new vantage point for Central Sydney
  - A new Central Square which will deliver on the vision for a new public square at Central Station, as one of three major public spaces within Central Sydney connected by a people-friendly spine along George Street
  - Mortuary Station Park at Mortuary Station that will be a key public domain interface between Chippendale and the over-station development. that will draw on the story of Rookwood Cemetery and the Victorian Garden context with the established rail heritage of the Goods Line and the rail lines
  - Henry Deane Plaza which will prioritise the pedestrian experience, improving connectivity and pedestrian legibility within the Western Gateway sub-precinct and provide clear direct links to and from the State heritage listed Central Station and its surrounds
  - Eddy Avenue Plaza – will transform into a high-amenity environment with significant greening and an enhanced interface with the Sydney Terminal building.
- A new network of circulation that will establish a clear layer of legibility and public use of the place. This will include:
  - A 15 - 24 metre wide Central Avenue that is laid out in the spirit of other street layouts within Central Sydney and which responds to the position of the Central clocktower, providing new key landmark views to the clocktower. Central Avenue will be a place for people to dwell and to move through quickly. It brings together the threads of character from the wider city and wraps them
  - Three over-rail connections to enhance access and circulation through Central Precinct, as well as provide pedestrian and bicycle cross connections through the precinct
  - The extension of public access along the Goods Line from Mortuary Station Gardens, offering a new connection to Darling Harbour
  - New vertical transportation locations throughout the precinct allowing for seamless vertical connections.
  - An active recreation system supports health and well-being through its running and cycling loops, fitness stations, distributed play elements, informal sports provision, and additional formal recreation courts.
  - a network of fine grain laneways that are open to the sky

1.6.2 Reference Master Plan

The proposed land allocation for Central Precinct is described in Table 1.3 below.

Table 1.3 Breakdown of allocation of land within Central Precinct

Land allocation	Proposed
Open-air rail corridor	101,755 sqm
Developable area	119,619 sqm
Public open space	19,185 sqm / 16% of Developable area
Other publicly accessible open space (including movement zones, streets, and links)	41,773 sqm / 35% of Developable area
Building area	58,661 sqm / 49% of Developable area
Central SSP total area	23.8 ha

The Indicative Reference Masterplan for Central Precinct is illustrated in Figure 1.4.

Figure 1.4 Reference Master Plan

2

Vision and Principles

02.1 Vision & Principles

Green Infrastructure vision

A system of high performing green infrastructure that is seamlessly integrated with the grey infrastructure of the development.

An over station development ‘deck’ structure that supports the performance and delivery of an integrated green infrastructure system.

Cohesive management and staged delivery of a successful green infrastructure system by TfNSW and a single development partner.

The Green Infrastructure strategy is guided by the following principles:

Country

Embed a strong connection with Country within the design of green infrastructure.

Ensure the design allows users of the precinct to connect with the history, stories, people, culture and contemporary meaning of Country.

Heritage

Ensure the design of green infrastructure responds to the heritage of the site. Improve the setting of iconic heritage places through design that respects the history and meaning of place.

Open Space

Ensure equitable distribution of open space.

Ensure high levels of amenity and comfort including sun and daylight access, wind protection, and user comfort.

Involve stakeholders in the design of public places to ensure spaces reflect the breadth of public life in the city.

Connected Network

Connect green infrastructure to surrounding parks to create a high performing network of open space.

Design the public domain network to support active modes of transport such as walking, cycling, and jogging.

Urban Forest

Increase tree canopy and green cover in the public and private domain.

Improve air quality through extensive greening.

Shade and cool the urban environment to assist with resilience to heat extremes.

Habitat

Improve biodiversity through diverse planting and habitat creation.

Connect the site to the wider habitat network of the surrounding city.

Target appropriate species for improved habitat.

Improve diversity of flora in line with the city’s wider planting strategy.

Soil

Connect soil throughout the development on structure and to true deep soil where possible.

Design soil mix and volume to support proposed green infrastructure.

Water

Provide recycled water for irrigation.

Capture and treat stormwater in the public and private domain to mitigate flooding and to improve water quality.

02.2 Green Infrastructure

The Central Precinct Green Infrastructure Strategy has been prepared to identify how the renewal project can integrate green infrastructure into the development in order to provide environmental, social and economic benefits both to the precinct, and the wider city.

The strategy analyses the existing situation,finding that the precinct has low ecological value, low canopy and greening cover and minimal public open space. It identifies opportunities in the renewal project to provide additional public open space and improve access and connectivity, and to integrate green infrastructure into the engineered deck structure above the rail lines to significantly increase the amount of canopy cover, greening and urban habitat within the site.

The urban forest and greening strategy outlines canopy and greening targets for individual areas of the precinct, and demonstrates how planting characters and species palettes that are attuned to the environmental conditions of the various spaces can create a biophilic environment with a rich and varied planting character. The proposed targets and planting plan focus on ensuring the creation of a comfortable environment for the community, including creating cool microclimates through shading and evapotranspiration.

The urban habitat strategy shows how the precinct can contribute to the wider ecological network of the city and proposed habitat linkages between surrounding green spaces. It identifies design opportunities to increase biodiversity and provide habitat, foraging and shelter for a range of native species which still occur in the city centre.

The soil and water strategies provide guidance on the integration of soil and water systems into the engineered deck structure to ensure the success of the planting and habitat creation.

The planning framework details recommendations to embed these principles into the ongoing phases of the development, including planning, design, construction and ongoing maintenance.

Sustainability ambitions and objectives

The recommendations in the Green Infrastructure report support the sustainability themes identified in the Environmental Sustainability, Climate Change and Waste Management Report (Atelier Ten & Integral, 2022). The recommendations and opportunities identified in the Habitat chapter supports the ambition to 'have a net positive impact on biodiversity through project activities by 2030' including the following objectives:

- To provide local biodiversity initiatives that mitigate the immediate impact of the program on-site and create new urban habitat for the city's ecosystem;

- To provide habitat connectivity for mobile species between key local and regional green spaces – Prince Alfred Park and Belmore Park, as well as the Domain, Hyde Park and Moore Park.

- To establish a biophilic environment at Central that provides a material connection for tenants and visitors to natural systems;

The recommendations detailed in the Water Strategy chapter support the ambition to 'preserve non-renewable water resources and to provide a net improvement to environmental water quality as a result of development', including the following objectives:

- To reduce overall consumption of water resources to achieve the equivalent of 5 Star NABERS Water baselines through best practice water conserving systems, equipment, fixtures, fittings and appliances;

- To reduce stormwater pollution flowing to Sydney Harbour significantly beyond best practice guidelines;

- Alignment of water quality, supply source, and treatment needs to enable effective water harvesting and re-use;

- To identify mechanisms for waste-water treatment and re-use aligned with best practice utilities and implement solutions that can be sustainably operated over the full life of the asset.

Green Infrastructure definition

Greener Places, (GANSW), defines Green Infrastructure in the following way:

Green infrastructure is the network of green spaces, natural systems, and semi-natural systems that support sustainable communities and includes waterways; bushland; tree canopy and green ground cover; parks; and open spaces that are strategically planned, designed, and managed to support a good quality of life in an urban environment.

Green infrastructure should be envisioned as a three-dimensional envelope that surrounds and connects buildings, streets, and utilities. The concept of landscape as green infrastructure provides a framework for integrating the work of designers, planners, developers, and policymakers, and leveraging this collaboration to achieve larger local or State goals.

Green infrastructure is as crucial as transport, cultural, and communications infrastructure and together they compliment each other. It contributes to the urban layout of a place delivering a range of benefits including:

- supporting healthy living
- mitigating flooding
- improving air and water quality
- cooling the urban environment
- encouraging walking and cycling
- enhancing local habitat and ecological resilience
- learning opportunities through Aboriginal story telling
- spaces for cultural celebrations.

Well-designed green infrastructure connects vital life support systems for urban environments. It needs to connect with other elements of a well-designed built environment created through urban design processes, involving a range of disciplines from architecture, urban planning, and landscape architecture.

02.2 Consistency with Premier's Priorities

Table 2.1 Consistency of Green Infrastructure Strategy with Premier's Priorities	
Policy target or outcome	**Consistency of Green Infrastructure Strategy**
Greener Public Spaces	
The NSW Government is committed to delivering a network of welcoming and inclusive public spaces to create connected communities where people love to live.	The strategy proposes a network of new, connected public spaces which will be activated, welcoming and inclusive.
Our target is to have 230,000 more homes in urban areas within 10 minutes' walk of a new or improved quality green, open, and public space by 30 June 2023.	The strategy proposes a network of new, connected public spaces, as well as improved connections between existing public spaces like Prince Alfred Park and Belmore Park and their surrounding suburbs.
Greening our City	
Increase the tree canopy and green cover across Greater Sydney by planting 1 million trees by 2022.	The strategy proposes a large increase in tree canopy and green cover of the site, and the reference public domain plan proposes 500 new trees to be planted.
This Premier's Priority is part of our longer-term commitment to bring average canopy coverage to 40% across Greater Sydney.	The strategy proposes a large increase in the canopy cover and green cover of the site
We are aiming to lessen the impact of the urban heat island effect and increase the city's resilience to a changing climate.	The strategy proposes a large increase in the canopy cover and green cover of the site, which can help to create cool areas in the public domain and reduce the impacts of the urban heat island effect.

02.3 Consistency with Greener Places (GANSW)

Table 2.2 Consistency of Green Infrastructure Strategy with Premier's Priorities	
Design Principles	**Consistency of Green Infrastructure Strategy**
Integration: combine green infrastructure with urban development and grey infrastructure Connectivity: create an interconnected network of open space Multifunctionality: deliver multiple ecosystem services simultaneously Participation: involve stakeholders in development and implementation	The strategy integrates the provision of green infrastructure, public space, tree canopy, and urban habitat with the proposed urban development and the grey infrastructure of the rail line. The proposed deck structure above the rail line will be engineered to support green infrastructure, including significant planting, soil volume, water collection and storage. The strategy creates a connected network of new open spaces, and improves connections between the existing open spaces of Belmore Park and Prince Alfred Park. The strategy will deliver multiple ecosystem services, including urban habitat creation, tree canopy, and water sensitive urban design to improve stormwater quality.
Outcomes	
Increased access to open space; improved connections to regional destinations, foreshores, beaches and bays, and continued investment in major parks and associated green infrastructure new open space allocation forms a part of urban renewal projects, infill development and infrastructure projects. equitable distribution of open space forms the basis for a well-connected and accessible network as well as ongoing investment in high-quality parks and public domain quantity, quality, distribution, and accessibility of green space enables the delivery of multifunctional open spaces that promote healthy lifestyles.	The strategy improves connections to major parks such as Prince Alfred Park, as well as connections from Redfern through to Sydney Harbour, the Botanic Gardens and the Domain. The strategy provides significant new open space as part of an urban renewal project. The strategy creates a new network of well connected, accessible, high quality open spaces, and improves connections to existing major parks. Stronger connections to and between open spaces, including the active recreation facilities at Prince Alfred Park will help promote healthy lifestyles.

Table 2.2 Consistency of Green Infrastructure Strategy with Premier's Priorities	
Improved connectivity to promote active living; improvements to the public domain that promote exercise and alternative modes of transport such as walking, cycling, and jogging protection of green corridors that create a network of walking trails, cycle paths and open spaces along river and creek corridors enhanced connections to the Green Grid, particularly in and around high-density precincts.	The strategy creates a network of new public spaces, and new public domain and cycling connections to promote exercise and alternative modes of transport.
Increase urban greening to ameliorate climate extremes; resilient built environments created through coordinated planning and design of green cover strategies including street trees, green walls and roofs, canopy trees, cool pavements, and water-sensitive urban design more green cover will keep our cities cool while providing benefits such as improved amenity, comfort, health, reduced stormwater run-off, improved air and water quality, and energy and resource efficiency promotion of the development of underused open space corridors for local community use such as community gardens.	The strategy significantly increases the canopy and greening cover of the site, through street trees, green roofs, cool shaded pavements and water sensitive urban design.
Conservation of the natural environment; protection and enhancement of natural resources and local habitat by improving the quality of watercourses, creating green habitat corridors and protecting endangered ecological communities. creation of new ecologies that support local habitat such as constructed wetlands and green roofs.	The strategy creates new urban habitat, to contribute to the proposed biodiversity corridor connecting Victoria Park with Hyde Park, the Domain and Sydney Harbour along the rail corridor. The strategy creates a new ecology of urban habitat and layered planting above existing rail lines.

02.4 TfNSW Integrating Green Infrastructure Guide

Table 2.3 Consistency of Green Infrastructure Strategy with TfNSW Integrating Green Infrastructure Guide

Subject	Detailed design considerations	Refer To:
Site Considerations	The design of GI should be integrated with the existing site features. This includes consideration of topography, adjacent land use, community character, history, heritage, and streetscape.	Refer to 02. Existing Situation, as well as the Urban Design Framework (Architectus) and the Public Domain Strategy (TYRRELLSTUDIO) for more detail.
Vegetation Species	Prioritise the use of native vegetation species unless there are demonstrated changes in environmental conditions which cannot be restored (for example, changes, or predicted changes in environmental conditions like climate and micro-climate) or if native plantings are not 'fit for purpose'.	Refer to 04 Urban Forest and Greening Strategy
Vegetation Species	Obtain a list of native vegetation from the local government where the project site is located	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review
WSUD	Identify opportunities for inclusion of WSUD elements. Refer to RMS's Water Sensitive Urban Design Guideline for options.	Refer to 08 Water Strategy

Table 2.3 Consistency of Green Infrastructure Strategy with TfNSW Integrating Green Infrastructure Guide

Subject	Detailed design considerations	Refer To:
Connectivity	For projects within the greater Sydney area, ensure the Transport plan contributes to the delivery of Sydney's city-wide green grid plan. Local Government Area open space, public domain and landscape strategies should also be consulted for information on opportunities to integrate green infrastructure into a wider network.	Refer to 03 Open Space and Connectivity and A2 Document Review
Graffiti Control	Where there are plain surface barriers (noise wall, retaining wall, and boundary fences) it may be far more cost-effective to increase plantings on or near the plain surface barrier than to try to deter graffiti by providing a textured treatment with an anti-graffiti coating.	To be addressed in future planning and design stages
CPTED	GI should be designed to ensure it supports good passive surveillance and does not create potential places of concealment. The design and mitigating measures implemented in the design should be based on the result of a CPTED risk assessment.	Refer Public Domain Report

Table 2.3 Consistency of Green Infrastructure Strategy with TfNSW Integrating Green Infrastructure Guide

Subject	Detailed design considerations	Refer To:
Biodiversity Enhancement	GI in the transport network through its linear layout can conserve, enhance, and restore biodiversity by increasing functional connectivity of natural areas, mitigating fragmentation, and increasing spatial wildlife habitats.	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review
Mitigate impact of extreme heat events	According to the Intergovernmental Panel on Climate Change (IPCC) 2012 report, extreme heat events (heatwaves) are expected to occur more frequently and become more severe over most land areas of the globe. Incorporating GI across the transport network can impact on city temperatures.	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review
Flood mitigation and hazard reduction	Vegetation within and around transport networks can result in increased canopy cover, increased greenspace and pervious surface, acting to reduce and control run-off, improve absorption rates and provide water storage capacity.	Refer Arcadis flood study
Carbon sequestration and storage	Vegetation transforms carbon dioxide to biomass through photosynthesis. This function is beneficial because it counteracts emissions of carbon dioxide and other greenhouse gases.	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review

Table 2.3 Consistency of Green Infrastructure Strategy with TfNSW Integrating Green Infrastructure Guide

Subject	Detailed design considerations	Refer To:
Air quality regulation	Vegetation (including green roofs) intercepts airborne particulate matter (PM10) and exchanges gases with the atmosphere, thereby reducing concentrations of harmful gases in the air and improving air quality.	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review
Biodiversity enhancement	GI in the transport network through its linear layout can conserve, enhance, and restore biodiversity by increasing functional connectivity of natural areas, mitigating fragmentation, and increasing spatial wildlife habitats.	Refer to 04 Urban Forest and Greening Strategy, 05 Urban Ecology and A2. Document Review
Health and well-being	The temperature regulation function of GI in the transport network offers corresponding direct health benefits by mitigating the effect of heat waves.	Refer to Public Domain Strategy (TYRRELLSTUDIO) for more detail.
Visual amenity	GI is an excellent mitigation and solution to achieving an attractive network. TfNSW Transport network design should consider the effects of visual appearance for both commuters and adjacent public viewers by creating and maintaining views to the wider landscape, softening the impact of the built structure, and creating a ‘sense of place’ via landmark features.	Refer to Public Domain Strategy (TYRRELLSTUDIO) for more detail.

3

Existing Situation

03.1 Site and co

The Central Precinct is a 24 hectare parcel of land that sits within the heart of Inner Sydney city.

The Central Precinct includes the rail corridor, rail yards, light rail lines, and Central Station, including the Sydney Terminal Building and Devonshire Tunnel.

Existing public open space within the Central Precinct comprises four small plazas with minimal green cover: Eddy Avenue Plaza, Henry Deane Plaza, Ibero-American Plaza and the western forecourt, Railway Colonnade Drive.

Fig. 3.1: Context Plan

SSP Study Area

Surrounding Public Open Space

Site and context analysis

The Central Precinct is heavily urbanised with predominantly paved surfaces. Green cover and canopy exist mainly within the adjacent open spaces of Prince Alfred Park and Belmore Park.

Central Precinct

The Central Precinct has low ecological value and current canopy coverage of 0-6%, one of the lowest in the LGA. The CPRP offers potential to contribute significant green infrastructure benefits to the city.

The precinct contains potential habitat for some species of microbats known to use built structures for roosting. These locations could be within tunnels or disused buildings on the site.

Adjacent Parklands

Prince Alfred Park

Historically a hub of play and respite for rail workers, this park continues to provide significant recreation opportunities in the inner city, including sports courts, playground, the Prince Alfred Park Pool, fitness and open lawns. The park features a relatively diverse spread of large tree species, including Moreton Bay Fig, Eucalyptus, Brush Box, Plane and Palm trees.

The recent upgrade of the park included the planting of a native meadow under the fig trees on Cleveland Street. The meadow contributes to the ecological value of the park with endemic species such as *Themeda australis, Microleana stipoides, Wahlenbergia stricta, Eragrostis elongata, Cymbopogon refractus, Dichondra repens* and *Viola hederacea*.

Belmore Park

Belmore Park is a significant Victorian-era park with a valuable mature tree population and canopy coverage. The park provides an important open space for the surrounding community.

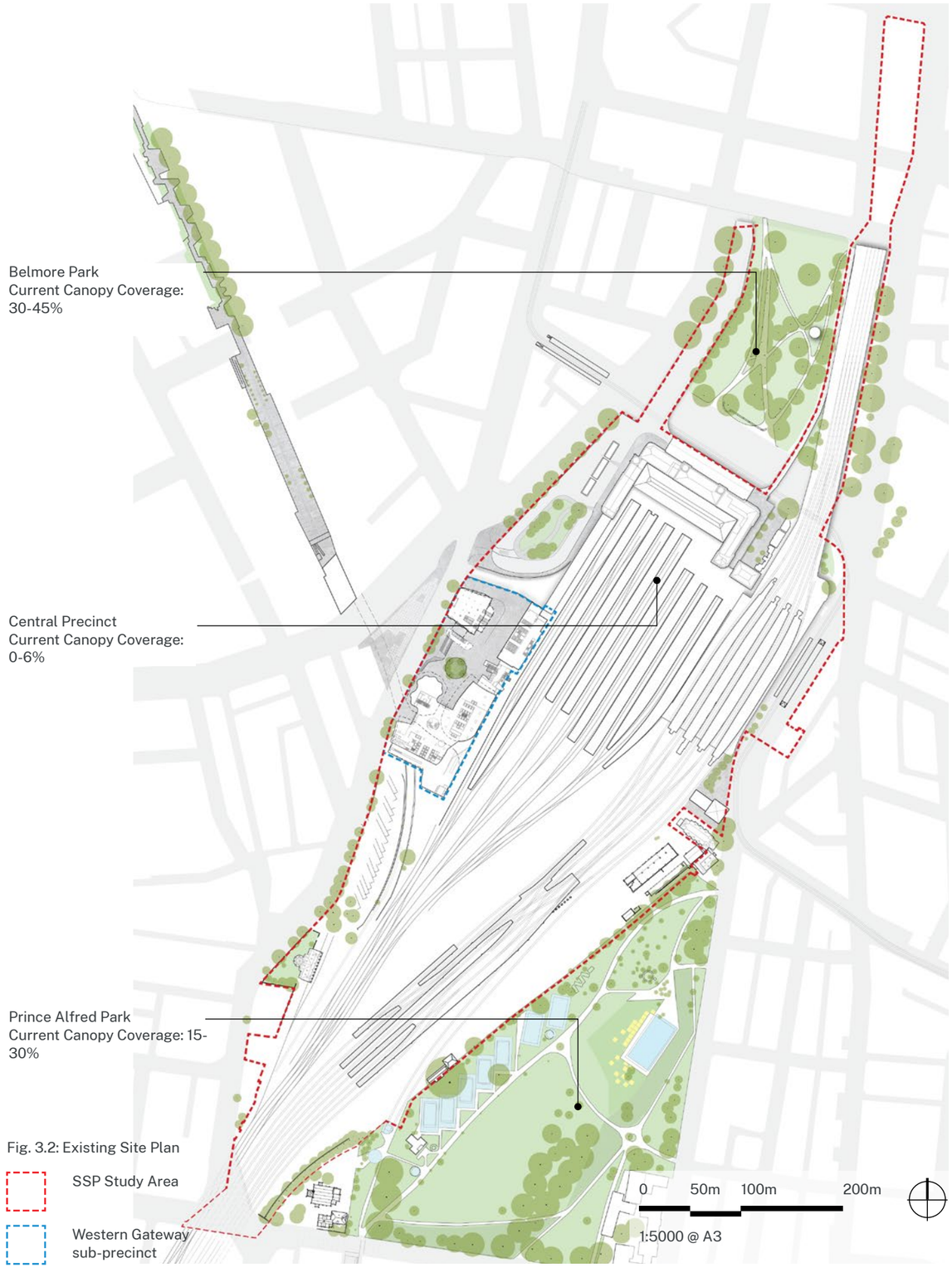


Fig. 3.2: Existing Site Plan

03.2 Canopy cover in the LGA

Canopy Cover and Greening in the surrounding context

The Central Precinct is located south of the Sydney CBD. The CBD and Haymarket have some of the lowest amounts of canopy cover, and community access to canopy cover within 100m in the LGA (refer to Fig. 3.3). This contributes to the community's vulnerability during heat waves; the area is considered one of the more vulnerable areas of the LGA (refer to Fig. 3.5).

Action 4 of the City of Sydney Greening Strategy is to distribute greening equitably, so that the whole community has access to the benefits of trees, canopy cover, greenery and open spaces.

Research shows that '30 per cent canopy cover, within an area of around 1.6 kilometres, provides key heat and health benefits' for the community.[1] Figure 3.5 shows the current canopy access within 1.6 kilometres.

This project is an opportunity to increase canopy cover and greening in this area of the city and increase the surrounding community's access to canopy cover and cool, green public spaces.

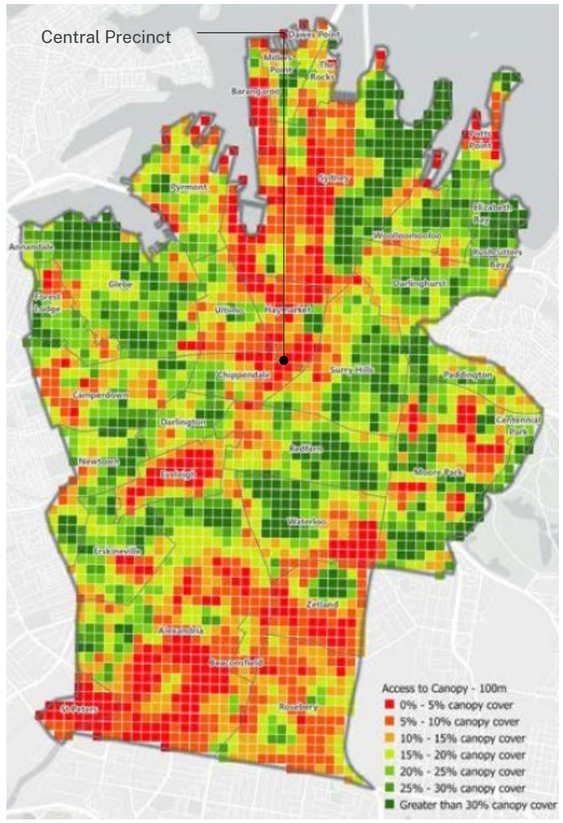


Fig. 3.3 Access to canopy cover across the local government area.

Each coloured point measures the amount of canopy in streets, parks and private land, within a 100m radius of that point (including surrounding council areas).
Source: City of Sydney Greening Sydney Strategy

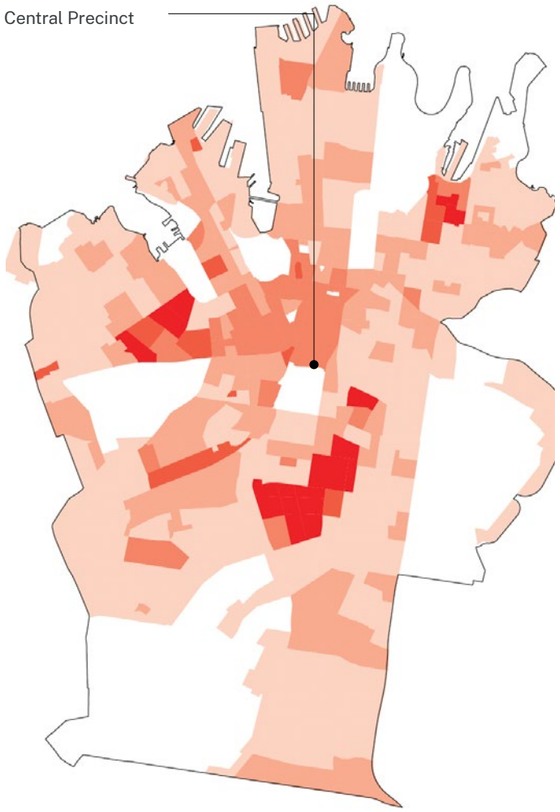


Fig. 3.4: the community's vulnerability to heatwaves

Source: City of Sydney Greening Sydney Strategy and Australian Bureau of Statistics (ABS)

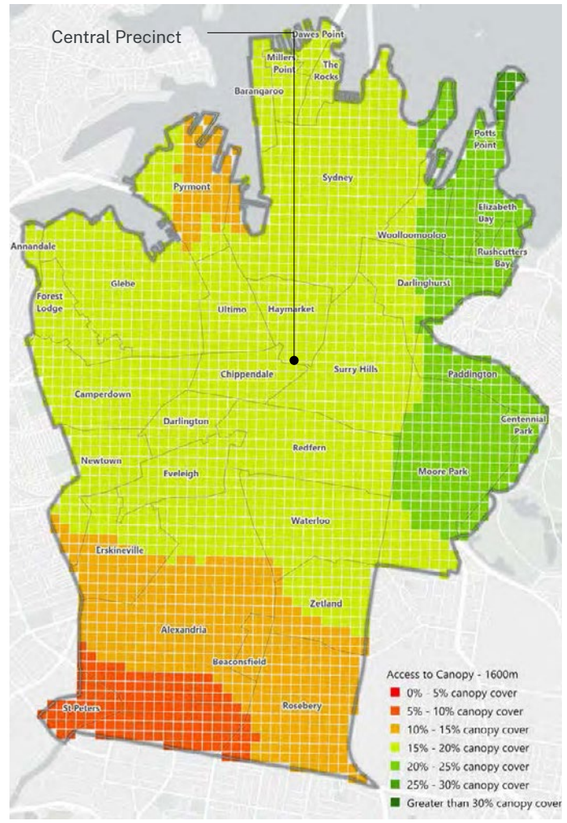


Fig. 3.5: Access to canopy cover across the local government area.

Each coloured point measures the amount of canopy, in streets, parks and private land, within a 1600m radius of that point (including surrounding council areas).
Source: City of Sydney Greening Sydney Strategy

1 City of Sydney Greening Sydney Strategy

Canopy cover in the LGA

Existing urban forest and street tree master plan

Species diversity is an important consideration for the urban forest of a city. The wider the range of tree species and families, the lower the risk to the canopy cover in the event of pest and disease outbreaks, and impacts such as climate change.[1] Increased diversity can also help support a larger diversity of fauna such as insects and bats by providing a variety of food and habitat.[2] The City of Sydney Urban Forest Strategy outlines the existing species diversity in the LGA and makes recommendations for maintaining diversity;

- ideally no more than 40% of trees should be represented by any one family city wide.
- ideally no more than 10% of trees should be represented in any one species.
- The Myrtaceae family (Eucalypts, Paperbarks, Brush Box, Angophora, Lilly Pilly, Water Gum) are at 40% in the LGA.
- The existing site character is currently largely defined by large Plane trees on Pitt St, Regent St, Elizabeth St and Chalmers St. Plane trees make up 9.5% of the City of Sydney's trees and additional Plane trees should not be proposed
- After Plane trees, the next most common species in the LGA are Broad Leaf Paperbark at 8.8% (*Melaleuca quinquenervia*) and Brush Box at 8.5% (*Lophostemon confertus*).

Figure 2.7 shows the City of Sydney Street Tree Master Plan which proposes street tree species for the surrounding area to create character and provide diversity. There are some opportunities to draw on the character of the surrounding street trees to create continuity between the Central precinct and the surrounding streets:

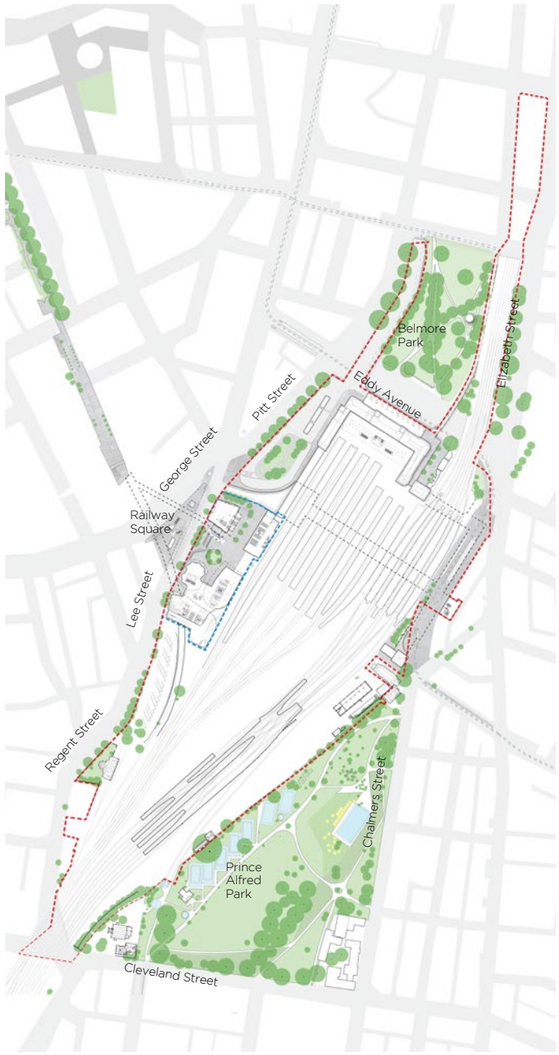
- Continue the character of the George Street planting by using *Zelkova serrata* in Central Square.
- Continue the Devonshire Street Tulip trees (*Liriodendron tulipifera*) on the Devonshire connection.
- Draw on the character of Water Gums (*Tristaniopsis laurina*) in local streets in Chippendale and Surry Hills, including Rutland Street, Bedford Street, Buckingham Street, Belvoir Street and Meagher Street.
- Limit use of the Myrtaceae family to a maximum of 40% of new tree numbers to ensure city target is not breached.
- Consider the most common species in the LGA to maintain the diversity targets. For example, no more than 10% of the proposed trees should be Melaleuca quinquenervia to avoid increasing the proportion in the LGA.

Fig. 3.6: Proposed street tree species of the surrounding context. Source: City of Sydney Street Tree Master Plan

1 City of Sydney Urban Forest Strategy
2 City of Sydney Urban Forest Strategy

03.3 Street character

The precinct offers a range of street types with varying levels of pedestrian amenity. Streets with high amenity benefit from park edges, mature trees, local connections and visible activity. Streets with physical barriers, no shade, poor visibility and heavy traffic offer pedestrians little protection from the noise, pace and scale of the rail precinct.



Key Plan

Framed by Belmore Park, the Sydney Terminal Building and two overpasses, **Eddy Avenue** has the proportions of a grand civic boulevard. Currently eight lanes of vehicles, bus bays and light rail, pedestrians crowd along the edges and funnel through tunnels with limited opportunities to cross. The mature Fig trees of Belmore Park and the terminal colonnade provide street presence and offer pedestrians protection from the elements.

On the eastern side of **Pitt Street** a row of mature Plane trees lines the sandstone wall of the western forecourt. The western side comprises younger street trees with a narrow footpath alongside youth hostels and Christ Church St Lawrence. As Pitt Street nears Railway Square the public domain is exposed to heat, wind and traffic as pedestrians navigate shared driveways and multiple crossings.

Street character

On **Regent Street,** Plane trees and Mortuary Station gardens provide a breath of green, yet pedestrians on the eastern footpath navigate a bus depot, railyards access and a petrol station. The western side skirts apartments, terraces and warehouses with links through to Chippendale.

Majestic Plane trees and planted garden beds on **Elizabeth Street** follow the sandstone rail abutment and form a green buffer to traffic. The eastern footpath offers rain gardens and active links up into Surry Hills with sections of blank podium walls to the commercial towers.

Chalmers Street has been transformed by the recent light rail development and will improve further with greater activation and larger tree canopies. The current pedestrian experience offers clear sightlines yet little protection from the elements.

The public domain of **Lee Street** benefits from mature Plane trees and bluestone footpaths. Street level activation deteriorates north of Railway Square and Henry Deane Plaza with service access, loading docks and blank walls dominating the pedestrian experience.

The greatest amenity on **Cleveland Street** is the southern edge of Prince Alfred Park offering shade and city views beneath mature Fig trees. The remainder of the pedestrian experience is exposed and traffic-dominated with narrow footpaths and limited canopy cover.

At Railway Square, **George Street** provides wide footpaths with quality stone paving, linking high pedestrian volumes to transport, work and study. The precinct offers the potential to reconnect George Street through to Redfern.

03.4 Endemic vegetation communities

The plan opposite shows the likely original vegetation communities, topography, waterways and shoreline of the area. Before the tidal mudflats were filled, a waterway just north of the precinct (in present day Belmore Park) would have drained towards Darling Harbour. A second waterway south of the precinct would have drained to Blackwattle Bay. Swamp forest of Swamp She Oak (*Casuarina glauca)* and Swamp Mahogany (*Eucalyptus robusta)* would have grown along the waterways.

The precinct sits over a sand dune system that extends through to Botany Bay, supporting Eastern Suburbs Banksia Scrub. East and west of the precinct would have been vegetated with Turpentine Ironbark Forest and Hawkesbury Sandstone Slopes Woodland, which include Sydney Red Gum (*Angophora costata)*, Blackbutt (*Eucalyptus pilularis)*, Red Bloodwood (*Corymbia gummifera)* and Sydney Peppermint *(Eucalyptus piperita)*.

Although these vegetation communities cannot be remade, some of the landscape character of the past can be visually and experientially brought back to the precinct to give it layers of meaning beyond the present.

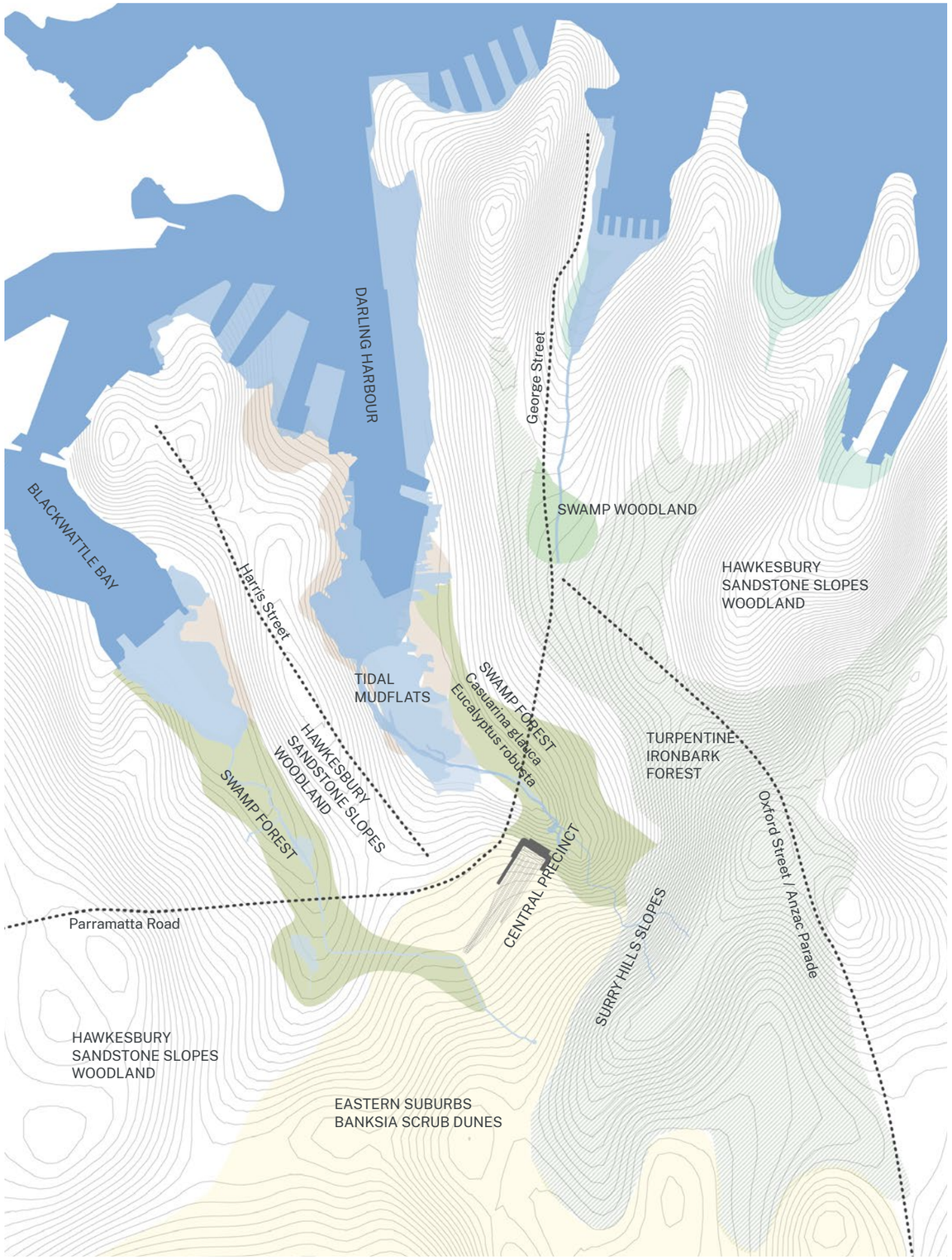


Fig. 3.7: Plan showing likely original vegetation communities, topography, waterways and shoreline.

Adapted from Taken for Granted, the Bushland of Sydney and its Suburbs by Benson and Howell, and City of Sydney Urban Ecology Action Plan

Endemic vegetation communities

Eastern Suburbs Banksia Scrub

Eastern Suburbs Banksia Scrub is an endangered ecological community that occurs on patches of nutrient-poor, aeolian (wind-blown) dune sand. This material resulted in a natural landform of rounded sand dunes and gentle slopes with local depressions and exposed water tables such as ponds and marshes.

Species:

- Swamp Oak (*Casuarina glauca*)
- Swamp Mahogany (*Eucalyptus robusta*)
- Wallum Banksia (*Banksia aemula*)
- Heath-leaved Banksia (*Banksia ericifolia*)
- Old Man Banksia (*Banksia serrata*)
- Pink Wax Flower (*Eriostemon australasius*)
- Variable Sword Sedge (*Lepidosperma laterale*)
- Coast Tea Tree (*Leptospermum laevigatum*)
- Tree Broom (Heath *Monotoca elliptica*)
- Grass Tree (*Xanthorrhoea resinifera*)

Eastern Suburbs Banksia Scrub

Banksia aemula

Eriostemon australasius

Hawkesbury Sandstone Slopes

Hawkesbury Sandstone Slopes Woodland would have occurred on rolling to very steep hills, along with pockets of tall open forest (wet sclerophyll) and closed forest (rainforest).[1]

Species:

- Blackbutt (*Eucalyptus pilularis*)
- Red Bloodwood (*Corymbia gummifera)*
- Sydney Peppermint *(Eucalyptus piperita)*
- Sydney Red Gum (*Angophora costata)*

1 NSW Office of Environment and Heritage, NSW Gov., accessed 7 July 2021, <https://www.environment.nsw.gov.au/Salisapp/resources/spade/reports/9130ha.pdf>

Hawkesbury Sandstone slopes

Turpentine Ironbark Forest

Turpentine Ironbark Forest is heavily fragmented across Sydney, with only 0.5 percent of its original extent remaining intact. The forests that occupied the Central Precinct were on the eastern limit of the community, expressing a slightly altered make-up of Angophora costata and Blackbutt (Eucalyptus pilularis).[1]

Species:

- Sydney Red Gum (*Angophora costata)*
- Sydney Peppermint *(Eucalyptus piperita)*

1 NSW Office of Environment and Heritage, NSW Gov., accessed 7 July 2021, <https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10789>

Angophora costata

Endemic vegetation communities

Coastal Swamp / Alluvial Forest

This swamp community has an open to dense tree layer of Eucalypts and Paperbarks. The community also includes some areas of ferns, tall reeds and sedges where trees are sparse or absent. The composition of the community is primarily determined by the amount of waterlogging, type of soil and latitude.[1]

Species:

- Swamp Oak *(Casuarina glauca)*
- Swamp Mahogany *(Eucalyptus robusta)*
- Broad-leaved Paperbark *(Melaleuca quinquenervia)*

Swamp Forest

Eucalyptus robusta

Melaleuca quinquenervia

Swamp Woodland

Traces of swamp woodland may have been similar to the Kurri Sand Swamp Woodland found in the lower Hunter Valley, however the predominant species is thought to be Eucalyptus racemosa.[1]

Species:

- Narrow-leaved Scribbly Gum (*Eucalyptus racemosa*)

Swamp woodland

Eucalyptus racemosa

1 NSW Office of Environment and Heritage 2020, NSW Gov., accessed 7 July 2021, <https://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10786>

1 D. Benson, J Howell 1990, *Taken for Granted*, Simon & Schuster, Australia

03.5 Opportunities, constraints and key issues

Opportunities

- Increase tree canopy and green cover by creating a new constructed ecology of planting on the deck structure above the rail lines.
- Increase biodiversity by planting a range of plants, including locally indigenous plants.
- Create new urban habitat for invertebrates, reptiles, small birds and birds of prey.
- Create foraging and roosting habitat for microbat species, as the site is located close to known microbat flyways and foraging habitat.
- Improve the quality of stormwater on the site and use Water Sensitive Urban Design principles to slow stormwater runoff and filter stormwater through planted areas.
- Create new public spaces as part of a well-connected, vibrant, high quality network of public domain to help encourage active, healthy lifestyles and walkability.
- Improve connections to existing public spaces including Belmore Park and Prince Alfred Park.
- Create a biophilic environment for people, to increase the community's connection with the natural environment.
- Contribute to potential habitat linkage along the rail corridor identified in the City of Sydney Urban Ecology Strategic Action Plan.
- Create cooler public spaces through planting and canopy cover as areas of respite to help mitigate the impacts of urban heat island effect.
- Help build community resilience by creating public domain with high amenity and environmental comfort created through green infrastructure.

Constraints

- The site has low existing tree canopy and low green cover.
- The site has low overall biodiversity and low ecological value.
- There is limited potential for increased biodiversity, canopy and greening in the active rail corridor.
- The site is in a heavily urbanised area, which impacts the range of target species to those that can adapt to highly urban environments.

Key Issues

- A significant amount of the proposed new public space, trees and planting will be located above structures, primarily the Over station development (OSD) deck structure above the rail lines, which limits potential soil volumes. Water and soil strategies will need to ensure that trees can grow to maturity in these conditions.
- A suitable irrigation water supply will be needed to create a biophilic environment with high biodiversity and environmental amenity on a structure. Supply should be sourced from collected rainwater or recycled water to meet sustainability principles for the precinct.
- The site's urban CBD location creates unfavourable environmental conditions for plants including wind tunnels and overshadowing by surrounding tall buildings. These constraints will need to be mitigated through plant selection and additional design measures to ensure healthy growth.

4

Open Space and Connectivity

04.1 Public Domain Plan

The proposed public domain system provides a high quality network of new and revitalised public open space. Major north-south and east-west connections will pull the city together around a remade Sydney Terminal Building. The Sydney Terminal Building will be set in an iconic public landscape consisting of new CBD spaces including Central Square and Central Green.

Public Spaces

1 Eddy Avenue (Upgrade)
2 Eddy Avenue Plaza (Upgrade)
3 The Grand Concourse (Upgrade)
4 Regional Coach Terminal
5 Central Square
6 Central Green
7 Central Avenue
8 Devonshire St Bridge and Connection
9 Railway Square (Upgrade)
10 Henry Deane Plaza (Part of Western Gateway Sub-precinct, not within this rezoning proposal)
11 Eastern Walk
12 Laneways
13 Prince Alfred Park Bridge
14 Southern Plaza
15 The Goods Line
16 George Street Bridge
17 Mortuary Station and Garden
18 Ibero-American Plaza (Upgrade)

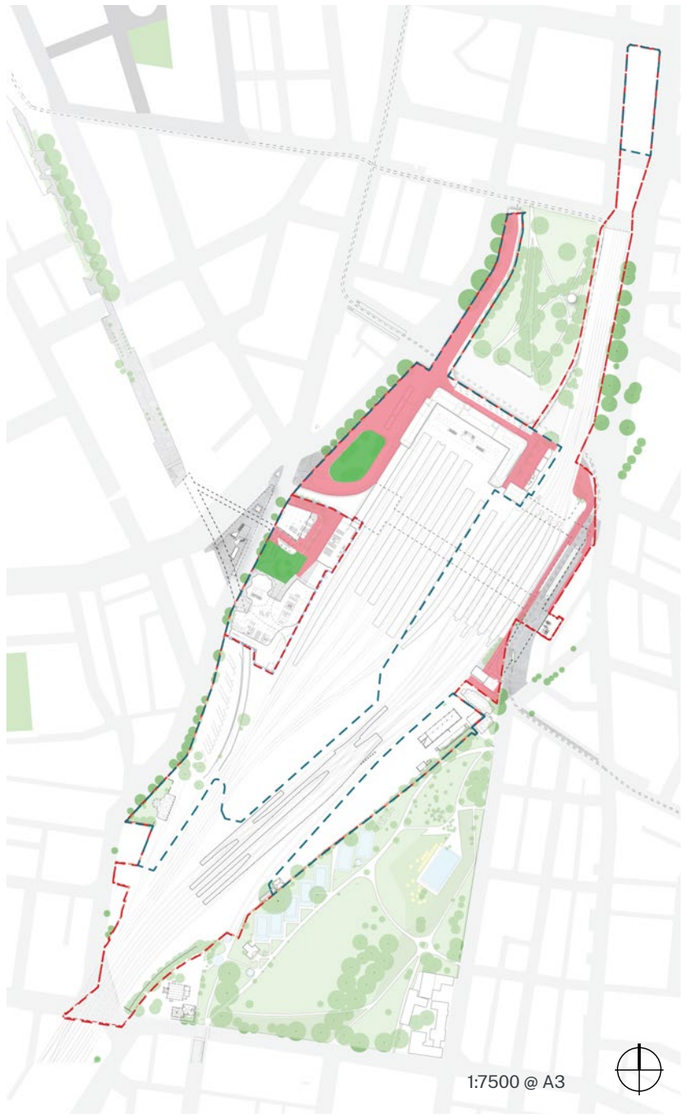
Fig. 4.1 Public Domain Plan

04.2 Proposed open spaces and public domain connections

The Structure Plan significantly increases the amount of public domain within the precinct including new and upgraded public spaces on the OSD.

Excellent connectivity is provided by new avenues and laneways that form vibrant civic spaces adjacent to ground floor retail. These links substantially improve connectivity across the precinct and into the wider urban network. Increased access between surrounding communities, existing and new open spaces will help promote active living and alternative modes of transport such as walking, cycling and jogging.

Fig. 4.2 Existing Public Domain Areas



Primary Open Spaces

Other Public Domain

Fig. 4.3 Proposed Public Domain Areas

Primary Open Spaces

Other Public Domain

04.3 Connectivity

The proposed structure plan substantially improves connectivity across the precinct both north-south and east-west, helping to connect neighbourhoods, open spaces, Sydney CBD and the harbour.

Fig. 4.4 Existing Condition
Redfern is currently disconnected from the city and harbour by the barrier of the train corridor, which has limited crossing opportunities.

Fig. 4.5 Reconnecting North-South from Redfern to the harbour

The structure plan connects from George St, Redfern through the Central Precinct, and on through the city to the harbour at Circular Quay.

Connectivity

Fig. 4.6 Existing Condition
The rail corridor currently forms a barrier between neighbourhoods to the east and the west.

Fig. 4.7 Reconnecting Neighbourhoods East-West

The structure plan reconnects Devonshire St with Broadway and Railway Square through a new connection open to the sky. Reinstating the historic Devonshire St alignment, this link also connects Chippendale with Prince Alfred Park and Surry Hills.

Fig. 4.8 Reconnecting Central Precinct with the Goods Line and Darling Harbour

The structure plan strengthens the connection between Central Precinct and Darling Harbour through the Goods Line, linking to the redeveloped public domain of the Goods Line north of Broadway.

5

Urban Forest and Greening

5. Urban forest and greening

The landscape setting of Central station is critical to the success of the precinct. The opportunity to be close to nature in Sydney's largest rail interchange will bring social, economic and environmental benefits. Moving beyond targets, the urban forest and greening strategy requires commitment through planning, design, implementation and maintenance.

A series of distinctive public spaces provide generous planted areas for cool green cover and increased biodiversity through the precinct.

Urban Forest

A canopy strategy that showcases healthy mature trees bringing value to a highly constrained urban environment.

Microclimate design

A focus on planting arrangements that promote comfortable microclimates through shade and evapotranspiration.

Diversity

A broad range of species and plant types that enhance biodiversity and connect the precinct to Country by referencing pre-colonial plant communities.

Place

An approach to planting design that is not seen elsewhere, giving the precinct a recognisable identity and character.

Fig. 5.1 Visualisation of the Central Green,

Connecting with Country Framework, Balarinji (2021)

The project team will integrate native flora and fauna into the Central Precinct. The project team will interpret traditional land management practices.

The stakeholders viewed the integration of native flora and fauna into the Central Precinct as a priority to help restore Country.

Gadigal horticulturalist Adam Byrne discussed how areas such as the Eastern Suburbs and Manly support Eastern Suburbs Banksia Scrub, and that this type of scrub would have traditionally grown throughout the Central Precinct area.

Suggested species to include were Banksia, Waratah, Sydney Wattle, Angophora, Eucalypt, Ironbark, Flannel flower, Coastal Tea Tree and Dog Rose, as well as other wetland species and weaving grasses.

Shirley Lomas mentioned seasonal planting as a traditional land management practice that could easily be incorporated into the Central Precinct through landscaping and green spaces.

Themes

- Biodiversity and Restoring the Sounds of Country
- Six Seasons Planting
- Replacing Landmarks of Country

5.1 Urban heat island effect and community health

Urban heat island effect and climate change

The urban heat island effect is caused by the built materials of an urban area such as roads and buildings, absorbing heat during the day and releasing it at night. The urban heat island effect intensifies the impacts of heat waves by increasing the local temperature. Due to climate change, the city will see increased temperatures, many more hot days (over 35°C) and heat waves lasting longer.[1]

Canopy trees can help mitigate the urban heat island effect by shading surfaces and by cooling through evapotranspiration. Greening can help mitigate the effect by reducing the amount of paved surfaces, or roof structures which can absorb and re-emit heat energy. As the Greening Sydney Strategy notes 'Extreme heat is moderated most effectively where there is more canopy cover and less hard paved surfaces.'

Recent research by the Western Sydney University found that the extent of canopy cover can significantly impact temperatures. The research compared two streets located 1km apart with the same microclimate and other site factors. The street which had 30 per cent canopy cover was 10°C cooler than the street with 10 per cent canopy cover.[2]

Community health

Urban canopy cover and greening can provide substantial health benefits for urban populations. These benefits include mitigating the impacts of heat waves, improving air quality and providing mental health benefits. The Greening Sydney Strategy identifies the following benefits;

- Urban heat mitigation through greening can significantly reduce human heat related morbidity and mortality. Heat creates physical stressors on humans. Hospital admission rates already rise dramatically during heatwave events because heat exacerbates underlying health conditions. Sick, young and older patients are particularly vulnerable.
- Canopy coverage of at least 30% reduces mental health issues, leads to better perceptions of overall health, reduces employee sick leave and improves employee and student concentration.
- Simply being in, near, or with a view of green spaces may help build mental health capacity, contribute to our ability to restore depleted cognitive capacities, enhance recovery from stress and increase our optimism. Exposure to nature including sensory elements such as bird song, also has beneficial outcomes for mental health.
- A 2019 Australian study 'Association of Urban Green Space with Mental Health and General Health Among Adults in Australia' found that urban communities with a healthy amount of tree cover - not just grass and green space - were psychologically healthier than those that didn't'.
- Greening also helps to address urban air quality. In most cities, the most damaging air pollutant is particulate matter. Fine particulate matter (less than 2.5 micrograms in diameter) can be deeply inhaled into the lungs and is estimated to cause 3.2 million deaths per year primarily from strokes and heart disease. It also contributes to chronic and acute respiratory diseases, including asthma.
- Dozens of studies now show that tree leaves filter out particulate matter from the atmosphere, along with absorbing many other air pollutants.
- Shade provision will reduce exposure to damaging UV.
- Shaded and cooler streets improve walkability and help promote active transport, which contributes to improving community health.

Green infrastructure strategy

The proposed open spaces and shaded planted spaces will provide cool places of respite for the public during heat waves. Shaded public domain and green roofs will reduce the amount of hard paved surfaces that can absorb heat and contribute to the urban heat island effect. Public domain connections shaded by tree canopy will improve walkability, helping to promote active living. The creation of a highly planted, biophilic environment in the centre of the city will offer a connection with the natural world, providing mental health benefits of green spaces.

Supporting the urban forest and greening targets on an engineered deck structure will require significant water use, particularly to provide areas of planting that maximise the cooling effect of evapotranspiration. In order to achieve these benefits the precinct should ensure that a recycled water supply is available so as not to impact on potable water supply (refer to 7. Water strategy for more detail).

While urban development will always have positive and negative impacts in terms of sustainability, the recommendations and targets in the green infrastructure strategy will ensure the renewal precinct contributes substantial additional canopy cover and greening to the wider city, with associated environmental and health benefits. For a broader assessment of the sustainability impacts of the scheme refer to the Central Precinct Renewal - Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022).

1 City of Sydney Greening Sydney Strategy
2 City of Sydney Greening Sydney Strategy

5.2 Historical planting characters

This botanical timeline tracks the historic influences on planting in the precinct, from pre-colonial sand dunes to cultural plantings and present-day urban cultivars. Indigenous plant communities have been largely removed. The act of reintroducing some locally-native species would be significant for cultural and environmental reasons.

Pre-colonial (1788)

The area would have been typified by Turpentine-Ironbark Forest on shale slopes with Eastern Suburbs Banksia Scrub on sandy areas and sedgelands in poorly drained depressions. Original stands of vegetation are likely to have been cleared by 1840.

The Victorian era (1837-1901)

The last native remaining Eucalypts were removed from the Domain in 1879. In Belmore Park there was a European rose garden, with Mexican Fan Palms (Washingtonia robusta) planted late in the Victorian era. Prince Alfred Park was dominated by Stone Pines, Norfolk Island Pines and Fig trees.

1879 photograph of construction in Belmore Park. Source: NSW State Archives

Planting of belmore park (1905-1910)

From 1900 to 1906 Belmore Park was bare earth with a few trees. The three Moreton Bay Figs on the Eddy Avenue frontage are survivors of the original park. Additional plantings include Figs, Plane trees, Brush Box and Mexican Fan Palms that remain today.

1906 photograph of Belmore Park and Sydney Terminal Building. Source: NSW State Archives

Angophora costata

Casuarina glauca

Rose bush

London Plane (Platanus x acerifolia)

Hackberry (Celtis occidentalis)

Historical planting characters

‘City beautifying scheme’ (1910-1925)

Avenues of shade trees were planted along the main access ways in Prince Alfred Park including Brush Box, Plane Trees and Oaks. Colourful flowerbeds and miniature gardens were laid out. An additional avenue of Golden Poplars was planted.

Introduction of exotics and indoor tropicals (1960-70)

An introduction of exotic species such as the Senegal Date Palm (Phoenix reclinata) and Umbrella Tree (Schefflera sp) can be seen inside the Sydney Terminal Building. Meanwhile, this period also saw a resurgence of native species in street trees.

Contemporary

Today, the City’s 29,500 street trees include more than 230 different species. The dominant street tree population (the Myrtaceae family) comprise 40% of trees in the LGA. Plane trees alone make up 11% of the population and Fig trees represent 6%.

Future

More planting of locally native species could increase diversity, support key fauna species and provide a sense of place, alongside a mix of native and exotic species that can withstand tough urban conditions.

1926 Photograph of Belmore Park and Sydney Terminal Building. Source: City of Sydney Archives

1981 photograph of the Grand Concourse. Source: Sydney Living Museums

2012 photograph of Belmore Park and Sydney Terminal Building

Moreton Bay Fig (Ficus macrophylla)

American Cotton Palm Washingtonia filifera

Brush Box (Lophostemon confertus)

Senegal Date Palm (Phoenix reclinata)

Umberella Tree (Schefflera sp.)

Old Man Banksia (Banksia serrata)

Wallum Banksia (Banksia aemula)

Pink Wax Flower (Eriostemon australasicus)

5.3 Planting Strategy

A range of green infrastructure initiatives are embedded into the fabric of the public domain to ensure a green, biodiverse precinct.

Public domain: environmental conditions and proposed planting characters:

1. Central Green
   Primary public open space on structure, with good solar access and a fairly exposed aspect. The proposed planting palette of sand dune planting and native groves uses species from the Eastern Suburbs Banksia Scrub which will suit this location.
2. Central Square
   Major civic plaza with significant canopy, green cover and good solar access. The proposed planting palette includes deciduous civic trees which relate the open space to surrounding streets, and planting that reflects the character of the Hawkesbury Sandstone Slopes.
3. Eddy Avenue Plaza (Upgrade)
   Pedestrian plaza on ground with existing tree canopy and proposed microforest.
4. Central Avenue
   The major pedestrian street on structure. The northern part has good solar access and the proposed planting character responds to this, creating a transition between the dune planting and the rainforest character of the shadier southern part of the avenue where planting responds to the shaded location with rainforest and gully species.
5. Devonshire St Connection
   Pedestrian connection with an ‘Eat Street’ character. Tree selection will need to consider the shading impacts of the development.
6. Southern Plaza
   Public plaza on structure. The proposed planting character of rainforest gully trees responds to the shaded location at the southern end of the over station development.
7. George Street Bridge
   Pedestrian and cyclist bridge with grassy native meadow plant species, building on the meadow habitat in Prince Alfred Park.
8. Mortuary Station and Garden
   New public open space around the heritage Mortuary Station building. The proposed planting retains the existing trees and garden to the Regent St frontage. The proposed planting palette to the east of the building draws on the cultural history of Mortuary Station.
9. The Goods Line
   This section of the Goods Line is a disused railway track in a heritage cutting, adjoining the tunnel beneath Railway Square and Broadway. The proposed planting palette of rainforest gully species responds to the shaded location of the cutting.

Fig. 5.2 Public Domain Plan

Planting strategy

The Central Precinct planting strategy supports diverse planting characters, each drawing from cultural and environmental narratives of the site. A study of the Indigenous plant communities within the precinct has influenced the species composition of each character, further interpreted to suit the environmental conditions and public domain experience of each precinct, such as solar access. The planting strategy also draws on the cultural character of each precinct in terms of historical and social significance.

The nature of how plants adapt and respond to water influences their placement within the constructed landscape. Dune landscape communities are elevated in well-drained, exposed positions while swamp and gully communities present an opportunity to engage with water. These gardens will capture stormwater and provide passive cooling through evapotranspiration.

Private open space, for example roof gardens, should follow the City of Sydney Landscape Code. Proposed planting design and species should be appropriate for the environmental conditions.

Legend

- Dune planting with evapotranspiration groves
- Rainforest and Gully
- Sandstone slopes
- North Avenue
- South-Avenue
- Meadow
- Civic trees (some deciduous)
- Mortuary Station cultural planting
- Eddy Avenue and Railway Square planting

Fig. 5.3 Planting characters plan

Planting strategy

Indicative Planting Palettes

Dune Planting with Evapotranspiration Groves

Responds to the native communities of the Eastern Suburbs Banksia Scrub in elevated positions and Swamp Woodland or Swamp Forest in sunken areas.

The evapotranspiration groves have an open to dense canopy surrounding clearings, focusing on careful arrangement of trees and low groundcovers to retain visibility through the midstorey to ensure safe viewlines.

Location: Central Green and Sydney Terminal Building western rooftop.

Key species include: **Dunes;** *Banksia aemula, Banksia ericifolia, Eriostemon australasius, Leptospermum laevigatum.* **Groves;** *Melaleuca quinquenervia, Eucalyptus racemosa, Blechnum camfieldii, Ficinia nodosa, Juncus usitatus.*

View of Central Green

Sandstone slopes

Draws on the Hawkesbury Sandstone Slopes community, which supports a range of vegetation types such as open woodland on ridges and pockets of tall open forest. Grass trees have been included to create an iconic entrance leading to the grand concourse. Red Angophora trunks complement the heritage brick of the terminal facade.

Location: Central Square terraces

Key species include: *Angophora costata, Xanthorrhoea resinifera, Doryanthes excelsa.*

View of Central Square

Meadow

Drawing from the meadow planting character of Prince Alfred Park, this character is threaded into the precinct along the South Bridge, where abundant sunlight encourages native grasses and flowering groundcovers.

Location: George Street Bridge and Prince Alfred Park Bridge.

Key species include: *Scaevola aemula, Brachyscome multifida, Themeda australis, Rhodanthe anthemoides, Chrysocephalum apiculatum, Bulbine bulbosa, Thysanotus tuberosus, Wahlenbergia stricta, Microleana stipoides.*

View of George St Bridge

Rainforest and Gully

The species composition of this character includes plants found in closed rainforests in the gullies of the Hawkesbury Sandstone Slopes community, as well as native fern species that can be layered to promote cool microclimates through shade and evapotranspiration.

Location: Central Square colonnade, south Central Avenue, Southern Plaza, the Goods Line.

Key species include: *Livistona australis, Cyathea cooperi, Cyathea cunninghamii, Dicksonia antarctica, Asplenium australasicum.*

View of Southern Plaza

Planting Palette: Meadow; Themeda australia, Wahlenbergia stricta, Bulbine bulbosa, Rhodanthe anthemoides, Thysanotus tuberosus, Microleana stipoides.

Planting strategy

North Avenue

North Central Avenue demonstrates an intimate garden character, utilising solar access to support small-flowering native shrubs and groundcovers that form a woody meadow and provide a transition from the deck open space to Central Avenue. Appropriate deciduous trees may be used in this part of the avenue to allow sun in winter.

Location: north Central Avenue

Key species include: *Tristaniopsis laurina, Zelkova serrata, Liriodendron tulipifera, Westringia fruticosa, Stylidium graminifolium, Dianella longifolia, Viminaria juncea, Violacea hederacea syn. V. banksii, Scaevola aemula, Hardenbergia violacea, Rhagodia spinescens.*

View of Central Avenue

Civic character

This character takes precedent from the streets surrounding the precinct to bring the city character into the site and knit the site into its context. Appropriate deciduous trees are proposed to suit the specific urban conditions.

Location: Central Square Plaza, Devonshire Link, Eddy Avenue Plaza, bosque in Central Green.

Key species include: *Zelkova serrata, Liriodendron tulipifera.*

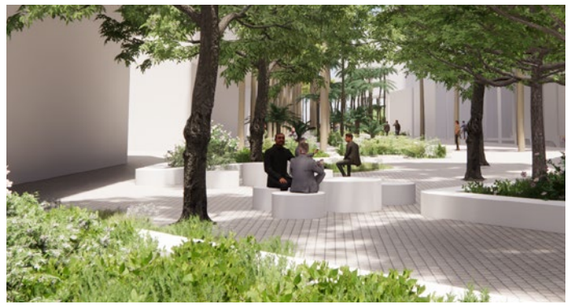
View of Central Square

Mid-Avenue

The mid-avenue incorporates a canopy of native trees and garden beds that have Aboriginal significance or uses, including reference to six seasons planting. Canopy trees include rainforest understorey species that tolerate low light.

Location: Mid Central Avenue

Key species include: *Acacia melanoxylon, Backhousia citriodora, Acacia binervia, Dianella longifolia, Bauera rubioides, Lomandra sp.*



View of Central Avenue

Mortuary Station

A garden setting of flowering shrubs that complements the heritage of Mortuary Station and brings the landscape character of Rookwood Cemetery into the precinct which is linked by the historic train line, including the use of Canary Island Date Palm, Hoop Pine and Pencil Pine to reference the iconic plantings of Rookwood Cemetery.

Location: Mortuary Station

Key species include: *Phoenix canariensis, Araucaria cunninghamii, Cupressus sempervirens.*

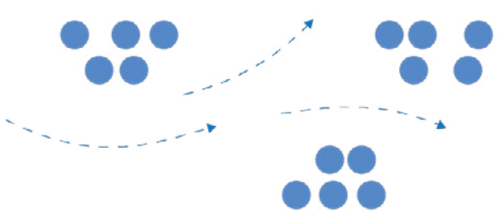
View of Mortuary Station Garden

5.4 Microclimate design

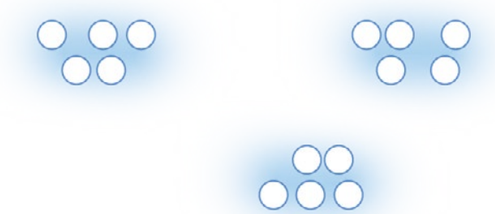
Evapotranspiration in green infrastructure has the ability to contribute largely to urban cooling, and presents an opportunity for the strategic design of the Central Precinct to incorporate green cooling as a central design principle in the selection and placement of plant and tree species.

Whilst all trees transpire, some do more than others. This is due to a range of both physiological and environmental factors that must be considered to understand average evapotranspiration rates. Differences in transpiration between species can be due to species-specific differences including; water-use strategies, optimal depth to groundwater, responses to stress, cumulative sapwood area density and leaf area index (LAI)

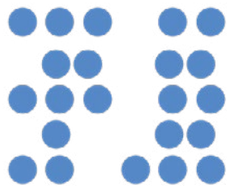
Design Opportunities:



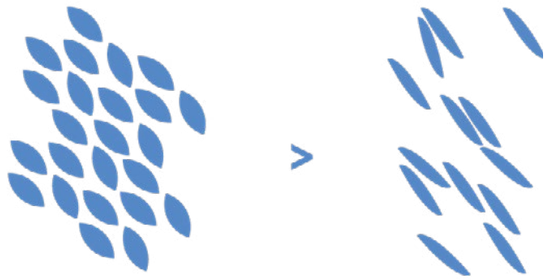
Cluster planting allows breezes and diffused wind to pass through, further enhancing evaporative cooling



Canopy trees occur in groups to retain ambient humidity



Minimum 40% canopy cover is required for adequate cooling



Trees with a high leaf area index (LAI) provide both high quality shade and higher rates of transpiration

Microclimate Design

Evapotranspiration groves

The aeolian sand dunes that once occurred on the site featured gentle slopes with local ponds and marshes. This naturally occurring landform has been interpreted to inform habitable groves that are designed for cooling and to provide respite from the surrounding urban setting.

The Central Green will include a range of seating types from in situ benches with and without arm rests, to work benches with charge points, through to movable tables and chairs and movable deck chairs. This will allow all people to be accommodated in comfort and give choice throughout the year.

In this typical section, Banksias provides a sheltered evapotranspiration grove

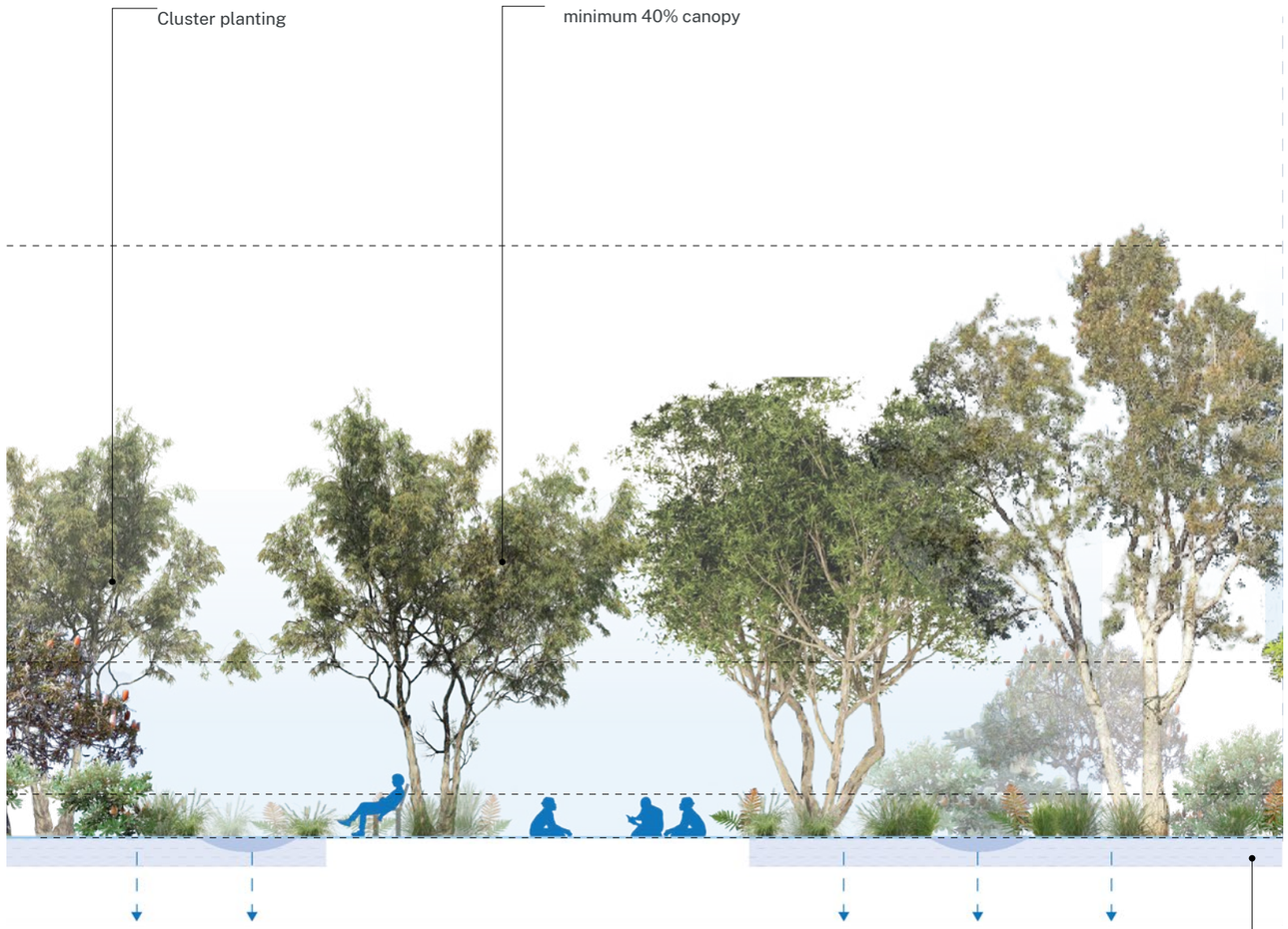


Fig. 5.4 Illustrative section: Evapotranspiration grove

Microclimate Design

In this typical section, Banskia scrub provides a shelter on one side while the opposite edge in sheltered by a dense canopy of Water Gums.

Fig. 5.5 Illustrative section: Groves of Green Cooling and Native Trees

Microclimate design

As green cooling becomes increasingly essential in our warming urban environment, solar access remains equally important, especially in colder winter months. Here, turf dunes create a relaxed setting for basking and lounging.

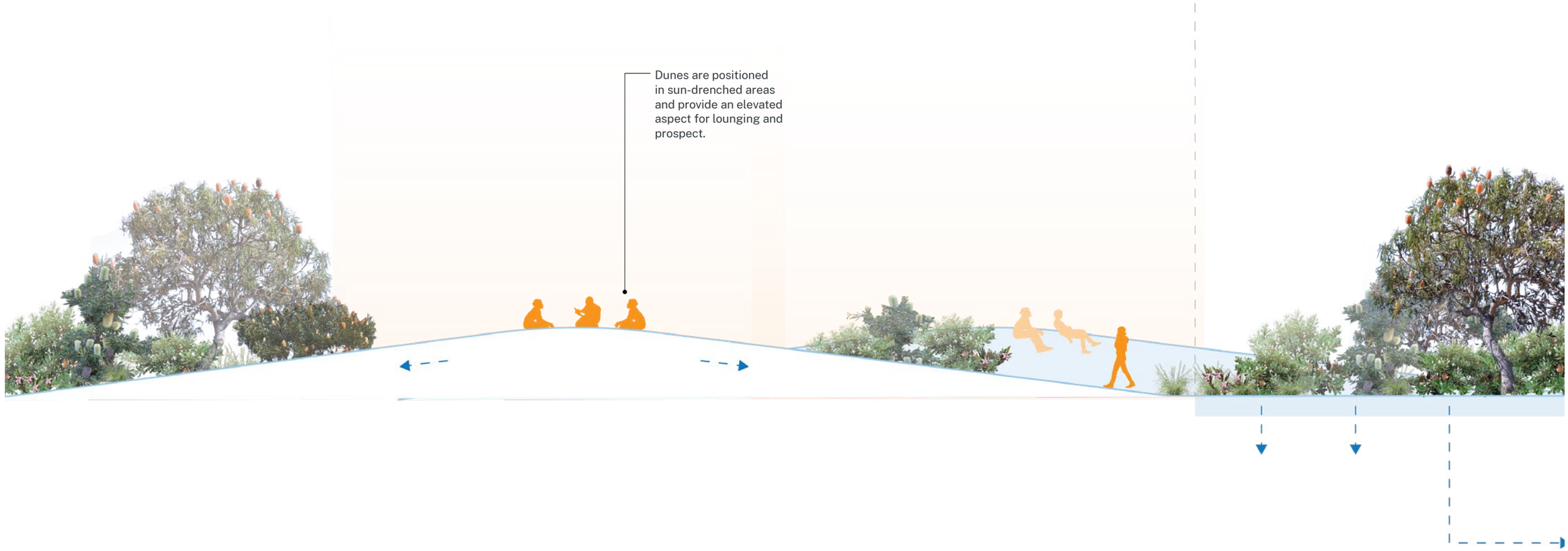


Fig. 5.4 Illustrative section: Sunny turf dunes

5.5 Canopy and greening targets

City of Sydney Canopy and Greening Targets

The City of Sydney identifies tree canopy and green cover targets for individual land use types. These include specific targets for property and various classifications of open space and streets. The public domain areas of the structure plan fall within the Civic and Iconic Parks categories with associated targets shown below.

The built form areas of the structure plan fall within the Property classification and will target rooftop green cover.

Canopy Cover	Green Cover
50% for Iconic Parks	85% for Iconic Parks
50% for Civic Open Space	55% for Civic Open Space
20% for Property	28% for Property

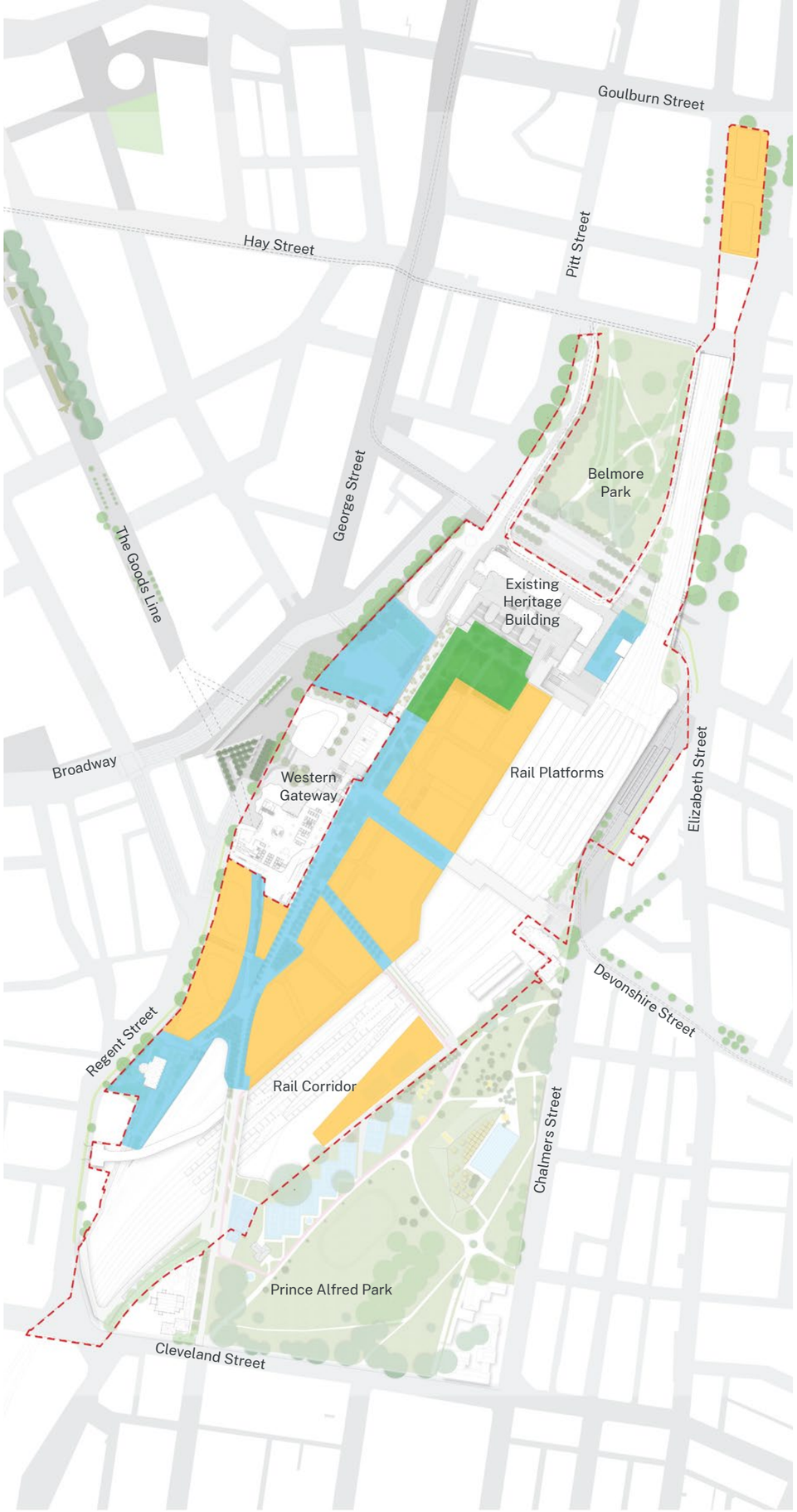


Fig. 5.7 Plan showing City of Sydney land use types and canopy targets

Canopy and greening targets

Locating tree canopy in response to site factors

The public domain plan considers a range of factors when locating trees. Tree layout is arranged to:

- allow free movement for projected volumes of pedestrians and service access,
- meet solar access requirements to public space,
- preserve key views for wayfinding and heritage significance, such as to and from the clock tower, and;
- consider heritage sensitivity of the clock tower, Mortuary Station and the Goods Line wall.

These considerations informed the preparation of the Public Domain plan as well as the canopy and greening targets for specific areas of the public domain.

Fig 5.8: Plans showing site factors influencing tree locations

Diagram showng solar access and gathering spaces

Diagram showing key views

Diagram showing heritage sensitivity

Diagram showing key movement paths

Diagram showing combined factors influencing tree locations

Canopy and greening targets

Public Domain plan tree canopy and green cover

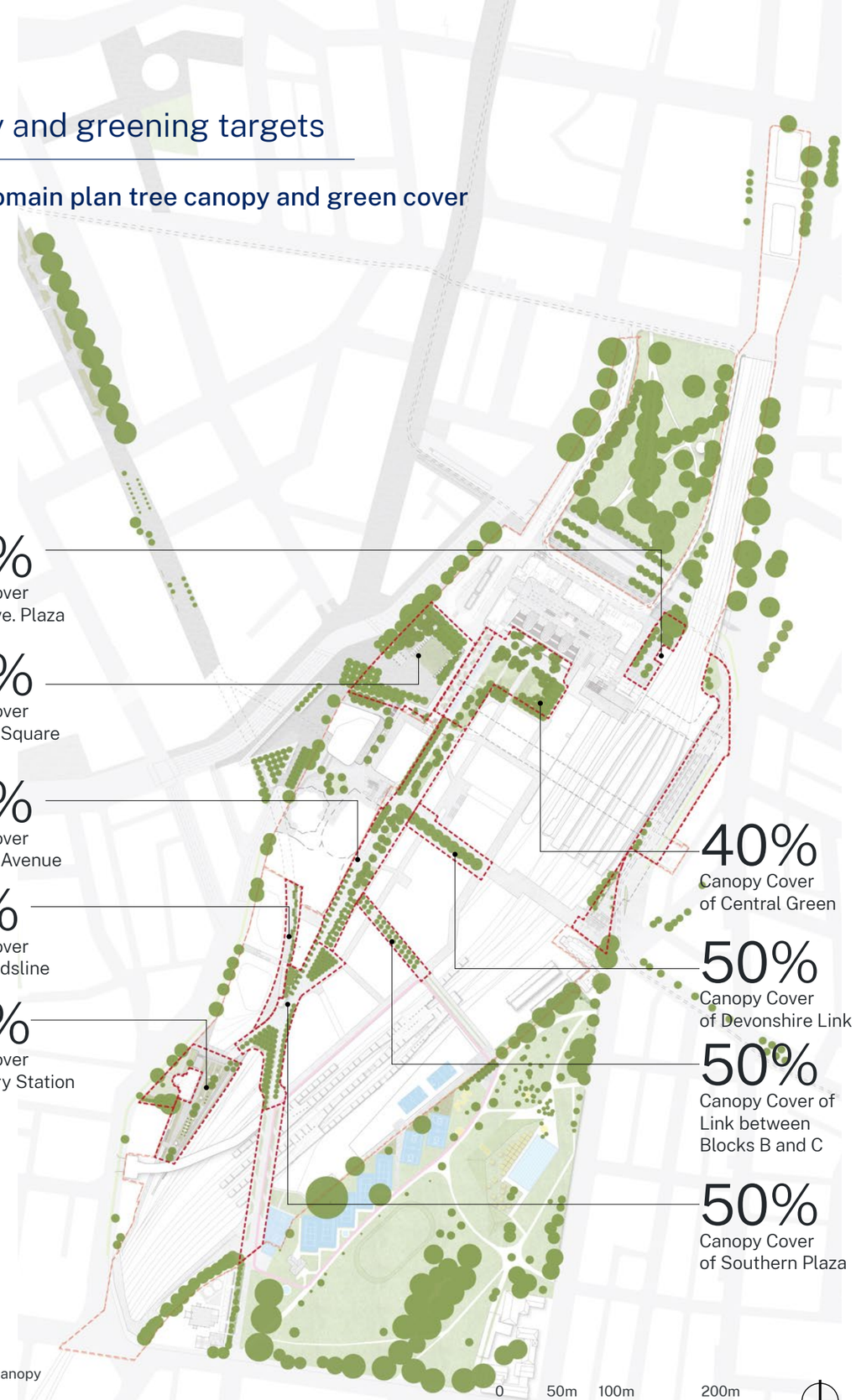


Fig 5.9: Plan showing tree canopy cover of the public domain plan

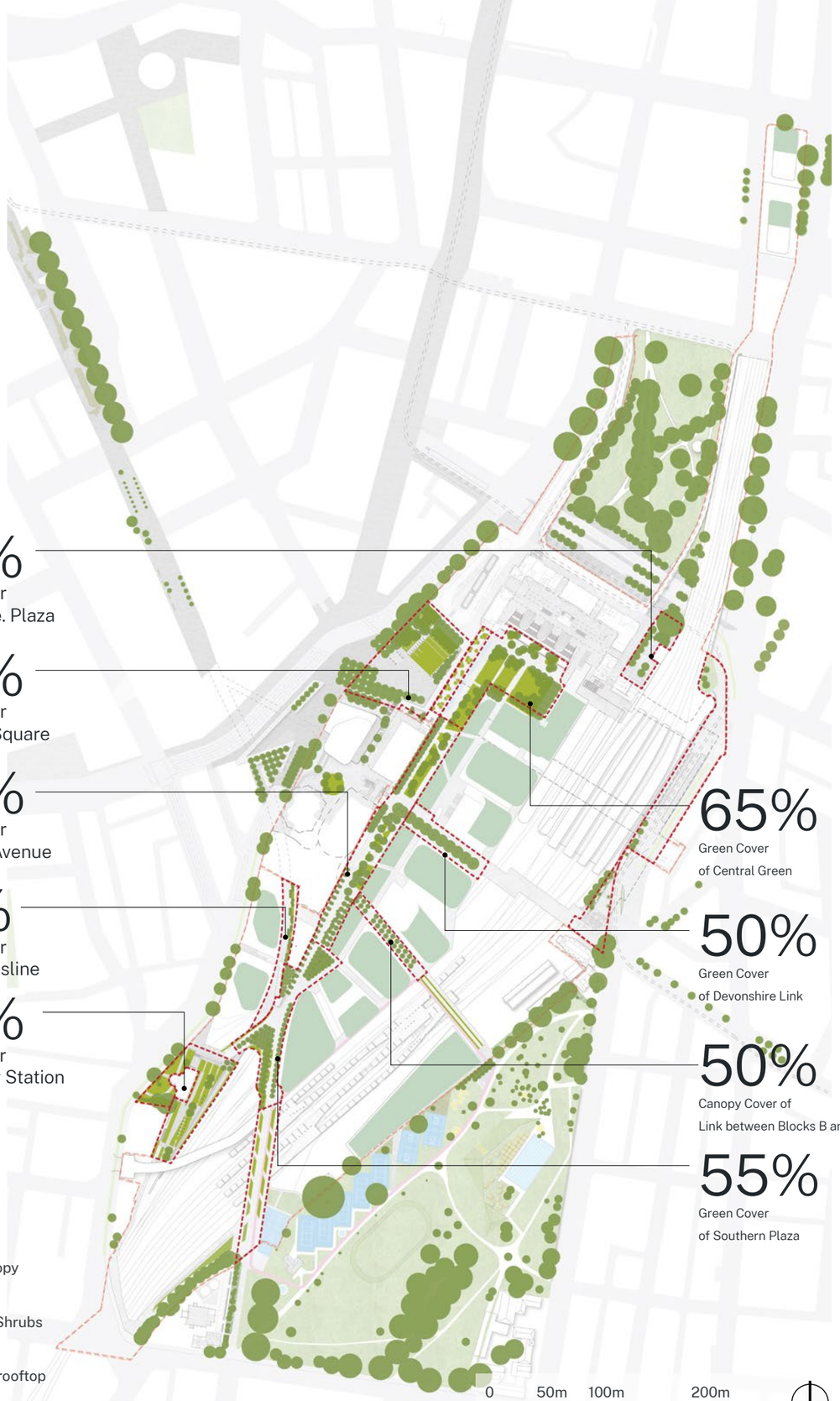


Fig 5.10: Plan showing green cover of the public domain plan

Canopy and greening targets

Existing trees to be retained and removed

The environments surrounding the Central Precinct contain many mature and iconic tree specimens, such as the Plane trees along Pitt Street, the Fig trees in Belmore Park and Brush Box in Prince Alfred Park. These trees will all be protected.

The design proposal within the development boundary comprises a complete reshaping of urban form, with suspended decks, platforms, elevated streets and bridges that span Central's rail infrastructure and integrate with existing city fabric at the edges. This requires some existing trees within the study area to be removed.

The study proposes a new tree planting strategy using best practice principles of urban greening and cooling. Despite the removal of a number of trees, the redevelopment and recommended canopy targets will ensure a significant increase in the number of trees and the canopy coverage of the site.

Trees to be removed

The Structure Plan and Public Domain Plan proposes to remove 45 trees within the site, including:

- Trees within the Western forecourt. This enables this area to be remodelled to create the proposed Central Square, connecting Railway Square with Central Walk West, and the Sydney Terminal Building.
- Trees within Regent Street sidings to allow for redevelopment.
- Five street trees on Regent Street to allow for the configuration of the new bus layover area
- Trees along the boundary of Prince Alfred Park to allow for Prince Alfred Sidings, and the George Street bridge connection. These trees are of low value. All significant Fig trees are protected.

Trees to be retained

The Public Domain Plan proposes to retain a number of trees within the site:

- Existing trees in the Mortuary Station Garden which form part of the heritage setting of Mortuary Station.
- Existing trees in Eddy Avenue plaza
- Existing trees in the Ibero-American Plaza, Chalmers Street and Elizabeth Street Entry
- Significant and high value trees along the boundary with Prince Alfred Park, including significant Fig trees.

Tree planting considerations

The success of urban tree canopy will depend on consideration of the following factors:

- Pre-ordered, contract grown tree stock to ensure supply and installation of super advanced trees.
- Permeable paving within mature dripline of trees to support healthy root growth.
- A phased irrigation system that supports optimum root growth. Irrigation should keep the root ball moist at the time of planting until established, then be directed incrementally further from the trunk to encourage roots to seek water and thereby develop a stable network.
- Protection from strong wind to achieve full canopy. Root anchors may be required to provide additional structural support.

Fig. 5.11 Tree management plan

Canopy and greening targets

Table 5.1: Canopy and greening cover targets

Location	Land use type	City of Sydney canopy cover target	Reference scheme canopy cover	Recommended canopy cover for planning controls	City of Sydney greening cover target	Reference scheme greening cover	Recommended green cover for planning controls	Comments
Central Green	Iconic Park	50%	40%	40%	85%	65%	65%	The proposed canopy and greening targets allow for the particular requirements of this space, which requires a key pedestrian connection - Central Avenue to the Sydney Terminal Building.
Central Square	Civic Open Space	50%	45%	45%	55%	56%	55%	The proposed canopy and greening targets allow for the particular requirements of this public space with a major station entry. The reduced canopy cover target allows space for the required covered station entries, movement space for high volumes of commuter movements, and space for events.
Eddy Avenue Plaza	Civic Open Space	50%	50%	50%	55%	50%	50%	The proposed canopy and greening targets allow for the movement space required at a major station entry.
Central Avenue	Civic Open Space	50%	50%	50%	55%	55%	55%	
Devonshire Link	Civic Open Space	50%	50%	50%	55%	50%	50%	
Southern Plaza	Civic Open Space	50%	50%	50%	55%	55%	55%	
Mortuary Station Garden	Civic Open Space	50%	20%	20%	55%	55%	55%	Mortuary Station Garden cannot support the 50% canopy target without compromising heritage values, including the views from Regent St to the facade, and the proposal to preserve the existing disused rail tracks.
Link between Block B and C	Civic Open Space	50%	50%	50%	55%	50%	50%	
Western Edge, including Western Extension Building Rooftop and adjacent Central Avenue	Civic Open Space	50%	0%	0%	55%	12%	10%	Trees would not be appropriate in this area, in order to maintain views towards the Sydney Terminal Building. A low greening target is set to allow for planting on the Western edge, but maintain key movement routes.

Canopy and greening targets

Table 5.1: Canopy and greening cover targets

Location	Land use type	City of Sydney canopy cover target	Reference scheme canopy cover	Recommended canopy cover for planning controls	City of Sydney greening cover target	Reference scheme greening cover	Recommended green cover for planning controls	Comments
Ibero American Plaza and Chalmers St light rail station	Civic Open Space	50%	10%	10%	55%	16%	16%	The targets maintain the existing level of canopy and greening cover, which takes into account the infrastructural constraints of the light rail station and maintain the key movement spaces and clear viewlines required at a key transport interchange.
Devonshire Bridge	Targets are not set for bridges in the Greening Strategy	N/A	0%	0%	N/A	0%	0%	Due to key views and the civc nature of this bridge, trees and greening are not considered appropriate for the character of the Devonshire Bridge.
Prince Alfred Park Bridge	Targets are not set for bridges in the Greening Strategy	N/A	0%	0%	N/A	20%	15%	Canopy trees cannot be supported due to limited soil depth for required train clearances, however a greening target is provided.
George St Bridge	Targets are not set for bridges in the Greening Strategy	N/A	0%	0%	N/A	18%	15%	Canopy trees cannot be supported due to limited soil depth for required train clearances, however a greening target is provided.
The Goodsline	Adaptive reuse of a rail cutting, not a typical land use type	N/A	12%	10%	N/A	15%	15%	These targets enable the retention of the existing disused rail tracks in the Goodsline cutting and the heritage retaining walls.
Block A, Block B and Block C, Block D, Block E and Block F	Property	20%	0%	0%	28%	20%	20%	Tree canopy provision is maximised in the public domain areas. The buildings will be required to provide at least 20% green cover as rooftop planting.

6

Urban Habitat

06.1 Habitat Linkages

The Central Precinct has low existing biodiversity value, however it presents an opportunity to increase biodiversity through additional planting, particularly of native and endemic species, and the creation of habitat for more native fauna species.

Habitat Linkages and Biodiversity Corridors

Improving the site ecology of the Central Precinct can help improve biodiversity and habitat linkages through the city.

Figure 6.1 shows the priority habitats, supporting habitats and supporting areas identified in the Connected Corridors for Biodiversity strategy by the Southern Sydney Regional Organisation of Councils (SSROC).

The Connected Corridors strategy states: 'Habitat connectivity is essential for the long-term conservation of a diverse range of species and ecological communities', by providing 'stepping stones' for fauna species to move between different areas to feed and reproduce. Isolated habitats over time will lead to 'dwindling population sizes, reduced genetic diversity, and having adverse impacts on ecosystem function and health, with consequent increases in the susceptibility of populations to threats such as disease, competition, predation, and weed invasion - as well as to climate change, which is likely to exacerbate these other threats'. Providing more stepping stones of habitat could help fauna like small native birds re-establish in parts of the city they are not found in presently, as they can only move short distances between habitat areas.

East–West Connection

Along with Prince Alfred Park, the precinct can contribute to a habitat linkage between Victoria Park and the University of Sydney campus to the west, and Moore Park and Centennial Park to the east.

North–South Connection

The precinct can also contribute to creating a linkage between this east-west connection and the harbour, through the significant open space corridor of Hyde Park, The Domain and the Royal Botanic Gardens.

The connection from Hyde Park to the harbour is likely to be used as a flyway by microbats, and there is potential to extend this connection

Figure 6.1: Supporting habitats and supporting areas from the Connected Corridors for Biodiversity, Southern Sydney Regional Organisation of Councils (SSROC).

Habitat linkages

through Belmore Park to the Central Precinct.

Figure 6.2 shows the Priority Sites, supporting sites and potential habitat linkages identified in the City of Sydney urban Ecology Strategic Action Plan. The linkages are proposed to connect the priority and supporting sites, noting; "While it is unlikely that continuous habitat 'corridors' can be created along their full length, there is considerable potential to at least create 'stepping stones' of habitat along or in the vicinity of these potential habitat linkages to facilitate the movement of more mobile species across the landscape."

The Central Precinct can contribute habitat to the linkage identified along the rail corridor, running from the Eveleigh-Redfern rail corridor, identified as a Supporting Site, through Prince Alfred Park, the Central Precinct and Hyde Park towards the harbour.

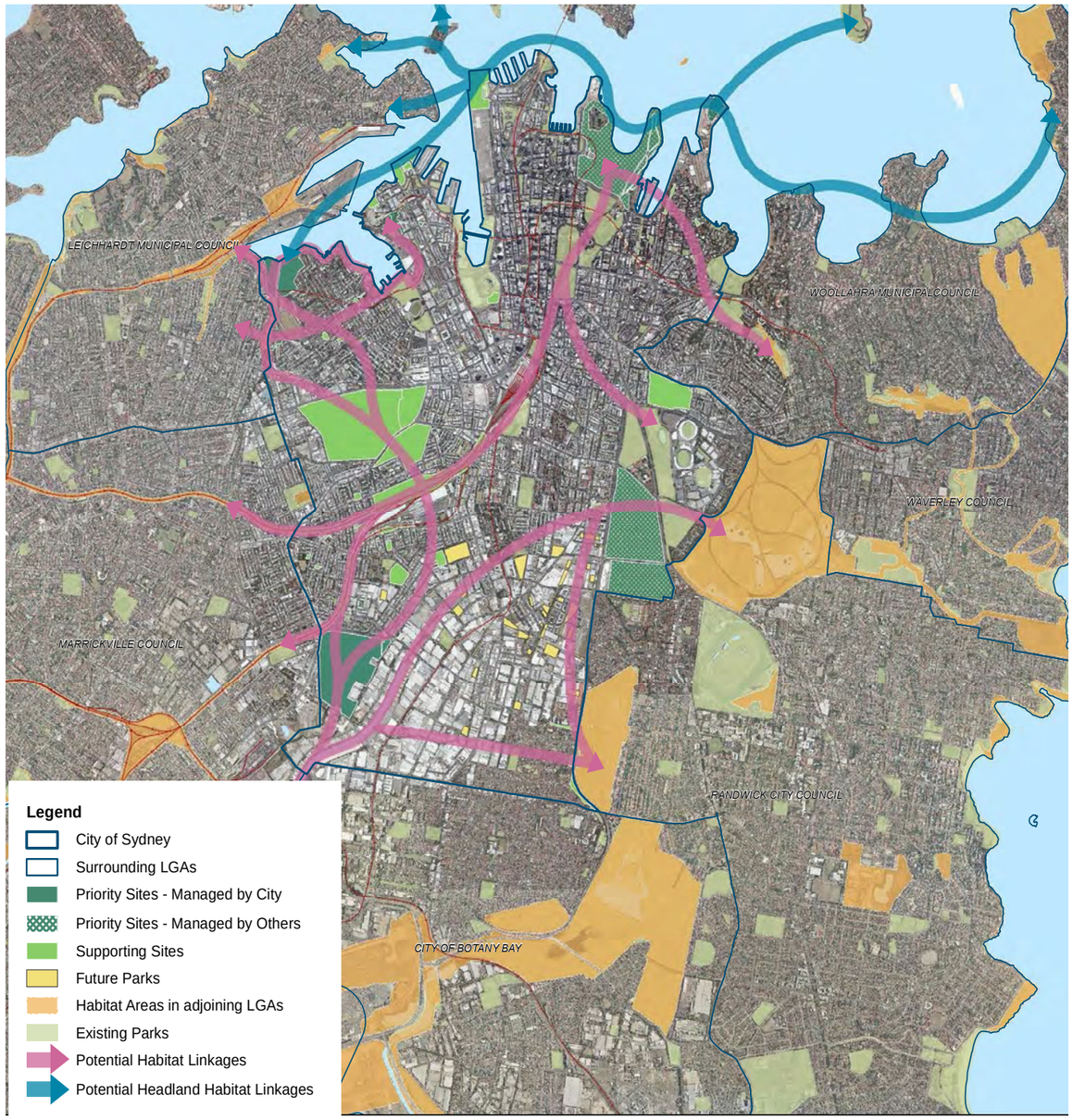


Figure 6.2: Potential Habitat Linkages from the City of Sydney Urban Ecology Strategic Action Plan

Design Opportunities from the City of Sydney Urban Ecology Strategic Action Plan

Design ecological communities to support existing remnant communities including; Sydney Turpentine Ironbark Forest, Coastal Swamp/Alluvial Forest and Coastal Sandstone Outcrop Complex.

Create structurally complex and diverse understorey habitat that connect potential habitat linkages. These communities support small native birds and encourage foraging and habitat.

Plant diverse tree species including Eucalyptus, Corymbia and Angophora species together with the understorey planting.

Design elements to consider habitat opportunities for Priority Fauna Species.

Improve habitat for microbats. Consider the 17 known species of microbat in Sydney, including the Gould's Wattled Bat, the Eastern Freetail Bat, and Little Forest Bat and the Eastern Bent-Wing Bat.

06.2 Ecological Assessment

An ecological assessment conducted by EcoLogical Australia provides an overall snapshot of ecological values and potential for enhancement. For the full report refer to Appendix A3.

Method

The study area was investigated for threatened species, key habitat features and existing vegetation. The study comprised a desktop review and rapid field survey during daylight hours. It identified biodiversity objectives and outlined statutory requirements for detailed ecological assessment.

Findings

The study area has low existing biodiversity value, although some areas provide habitat for threatened species. Specific findings include:

- Very limited habitat for native species other than highly mobile birds and bats.
- Vegetation type is classified as urban/exotic comprising mown grass, weeds and mixed plantings.
- Grey Headed Flying Fox (listed as vulnerable under the BC Act and EPBC Act) has previously been recorded near the study area.
- No threatened flora or fauna were recorded on site.
- The proposal has potential to impact five vulnerable bat species that may use Central Station and surrounds for habitat or foraging, particularly the Large Bent-winged Bat.
- Further investigation will be required, particularly into bats and microbats. This may include nocturnal surveys. This assessment would form part of a BDAR, and would be completed for a State Significant Development Application.
- The low biodiversity value of the site means that even minor changes will such as weed removal and increasing the quantity of native plants will be an improvement.

Biodiversity objectives

Enhancing biodiversity in highly urbanised environments is a challenge but can transform the liveability of an area when it is implemented effectively. The study area currently has low biodiversity so has potential for significant improvement. Enhancing biodiversity will result in environmental and social benefits, such as air temperature regulation, carbon sequestration, reduction of pests and weeds, and improved amenity and wellbeing.

The following are recommended biodiversity objectives and performance criteria for the precinct that could be incorporated in planning controls;

- Landscaping to feature native plants that are characteristic of communities that would have been in this area.
- Plantings should achieve structural integrity where possible (canopy, mid storey, groundcover).
- Management and maintenance plan to consider ongoing weed removal.
- Protect important threatened species habitat during redevelopment, where possible.
- Install additional microbat habitat. Roosting habitat could be provided along the edge or underneath the deck structure. Future ecological assessments should be completed to determine the most appropriate habitat type.
- At future stages of the design process, detailed targeted microbat surveys to be undertaken in accordance with Threatened Species Survey Guidelines for areas proposed to be affected; assessment to be included in BDAR/s and including specific management and mitigation measures.
- incorporate hollows / boxes for birds, roost platforms for birds of prey, and planting that supports invertebrates.
- Incorporate water sensitive urban design features to provide water in the landscape for fauna.
- Provide vegetation and habitat (not just canopy trees) throughout the public domain, including parks, avenues, and rooftops, to create habitat connections with surrounding areas.
- Consider local and regional flyways in landscape, building and infrastructure design. Avoid building typologies that could harm flying fauna, such as highly reflective glass building facades.

06.3 Target Fauna Species

The precinct can support a number of target fauna species by providing additional habitat and foraging opportunities. Microbats are an important focus for the CPRP. Facilitating their habitat and food source is a top priority.

Improved vegetation integrity and abundance

The precinct can offer an increase in canopy and green cover with a greater proportion of native species. Plantings are to have good structural integrity with consideration of groundcover, some mid-storey and canopy layers. Refer to the Urban Forest and Greening chapter for details.

Providing a range of flowering plants and native bee hives will create habitat and food sources for native bees and butterflies.

Small-flowered plants, dense shrubs and plants with spiky leaves or stems can provide habitat and food sources for small birds, as well as protection from larger, more aggressive birds.

The Central Precinct can create places for large birds of prey to build nests, including the Peregrine Falcon and White-bellied Sea Eagle known to be in the area.

Providing dense grasses and understorey plants can create habitat for many small reptiles such as skink species.

Water in the landscape

Water sensitive urban design features can be considered in the public domain as resources for birds, reptiles and invertebrates to hydrate and cool off. Refer to the Water chapter for details.


Eastern bent-wing bat


Redbrowed Finch


Eastern Bluetongue Lizard


Blue Banded Bee


Microbats


Spotted Pardalote


Dark-flecked Garden Skink


Striped Marsh Frog


White-bellied Sea Eagle


Superb Fairy-Wren


Wall Skink


Pearl White Butterfly

Urban Habitat

Improving biodiversity and creating urban habitat will connect the precinct to the wider ecological network of the city, such as the likely microbat flyway through Hyde Park to the Harbour.

Fig 6.3 Plan showing connections with wider ecological network

Urban Habitat

Biodiversity Web

By developing a strong ecological web of both habitat and food, the site will able to support microbats, birds of prey, frogs, lizards, native bees, butterflies and other insects. Although there are currently few small birds in the vicinity of the site, the biodiversity strategy proposes creating habitat and food sources to support small birds in the future, as other ecological connections and corridors enable them to re-establish in the area.

Fig 6.4 Habitat and supporting infrastructure for target fauna species

0 200m 400m 800m

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Urban Habitat

Target fauna species

Microbats

Many microbat species, both common and threatened, persist within Sydney, despite extensive urbanisation and development. The CPRP presents opportunities to enhance and create foraging and roosting habitat for microbats. Disused, dilapidated buildings, tunnels and small crevices in built structures on site have the potential to provide habitat for six threatened microbat species. Species identified as having the potential to occur or being likely to occur are the Eastern Coastal Free-tailed Bat, Little Bent-winged Bat, Eastern Bent-winged Bat, Yellow-bellied Sheath-tailed Bat and Greater Broad-nosed Bat.

Studies conducted within central and north Sydney demonstrated that microbat species richness and activity levels can be increased by extending tree cover, creating routes that could bypass major structural barriers or roads, minimising or optimising night lighting and connecting existing flyway corridors.

At future stages of the planning process a BDAR (Biodiversity Development Assessment Report) will be required to determine the potential impacts of the development. This may involve surveys to determine whether microbats are currently using the site.

Habitat

Microbats typically spend 50% of their lives in day roosts, which serve to protect them from predators and weather elements. Day roosts range from naturally occurring caves, dense tree foliage and tree cavities, to constructed sites in buildings and tunnels. In urban areas, microbats are known to roost in roof and wall cavities, and dark and disused buildings with clear entry and exit points.

They commonly live in areas of shale soils (such as the Blacktown soils), which are located from Central Station along the rail line towards Redfern and beyond.

Foraging

Microbats have a wide range of foraging niches, depending on specific species and location opportunities. The species identified as having the potential to occur on site include trawling bats and insectivorous bats. Trawling bats require a connection from their roosting space to a local water body. Insectivorous bats forage for aerial insects, often above and around tree canopies including single isolated trees and large open bushland patches.

Flight Range

Microbats have preferred flyways between foraging and roosting locations. waterways, parks and bushland reserves are preferred because they provide good foraging habitat and unobstructed flight paths. There is the potential for a flyway connection between the precinct, Hyde Park, the Domain, the Royal Botanic Gardens and Sydney Harbour.

Lighting

While street lighting can negatively influence some bats, some species may benefit from increase foraging on insects attracted to white street lights. The spectrum and type of light emitted can impact bat activity; lights with energy efficient broad spectrum metal halide lights (550 – 600nm, peaking at 400 – 420nm and 2800K CCT) have been shown to be preferred by many bat species. White light should be avoided in areas which provide flyway connectivity, and lighting should be avoided close to roosting sites. Types of lighting should be considered in future detailed biodiversity plans and assessments.

Design Opportunities:

Provide space for microbats to roost in above-ground spots, such as artificial tree-hollows and subterranean areas, like the disused tunnels beneath Central Station to encourage microbat usage of the site.

Increase the canopy cover within the northern flyway gap to increase the CPRP's connection to Sydney Harbour, improving connectivity for trawling bats.

Increase canopy cover across the site and provide planting that supports food sources for insectivorous bats.

Optimise lighting design to allow for flyway connectivity and to provide foraging opportunities.

Urban Habitat

Target fauna species

Bees

Introducing bees to the CPRP requires the construction of beehives that allow for colonisation or nesting by solitary native bees. These structures encourage use by small native bees occurring in low numbers and are less likely to be used by non-native European bees. Structures can include drilled holes in blocks of hardwood, rammed earth bricks and standalone prefabricated hives.

The native species which these habitats support include Blue-banded Bee, Resin Bee, Wasp Mimic Bee and Masked Bee.

The indigenous bee hive installations can be created in concert with the City of Sydney Urban Ecology Program.

Butterflies

Known species surrounding the precinct include the Pearl White Butterfly, Common Jezebel, Australian Painted Lady, Yellow Admiral, Citrus Swallowtail, Zebra Blue, Splendid Ochre, Blue Triangle and Monarch Butterfly.

Most butterflies require warm conditions to fly, and therefore prefer sunny habitats, often basking in the sun. Butterflies like some moisture in the form of surface water, moist soils or mud to absorb minerals.

Most butterflies feed on the nectar of flowering plants. They also need plants on which females can lay eggs and on which larvae can feed when they hatch. The larvae of many butterfly species will only feed on one or a small number of particular plant species – often native grasses, peas and daisies.

Design Opportunities:

Provide ample species of flowering plants as a food source for invertebrates.

Integrate native beehives in existing or new infrastructure.

Urban Habitat

Target fauna species

Small Birds

Small birds help control insect pests and assist with pollination and seed dispersal.

Known species surrounding the precinct include Spotted Pardalote, Redbrowed Finch, Superb Fairy-wren, New Holland Honeyeater, Silvereye, Rufous Fantail, Fairy Martin, Golden-headed Cisticola and White-plumed Honeyeater (when migrating).

Small birds require dense shrubs in which to find shelter and food (which, depending on the species, comprises insects, nectar or seeds). Shrubs with spiky leaves, such as Silky Hakea (Hakea sericea) can provide protection for small birds.

Small birds favour plants with small flowers that only small birds will be able to get their beaks into, such as the Pink Spider Flower (Grevillea sericea) and Red Spider Flower (Grevillea speciosa). However, not the large flowering hybrid Grevilleas that promote Noisy Miners and other aggressive birds. Shrubs with softer leaves, such as Sunshine Wattle (Acacia longifolia) or Largeleaf Hop Bush (Dodonaea triquetra) are a good food source.

The City of Sydney recorded 12 small bird species at last count in 2017, with others still common in large bushland areas around Sydney. If appropriate habitat is provided as an ecological stepping stone, it is possible that some of the species that have disappeared from the city will recolonise the area in the future.

The precinct can provide dense shrubs in which small birds can find shelter and food, plants with spiky leaves that provide protection and plants with small flowers that favour smaller beaks, providing a food source inaccessible to larger, more competitive birds.

Birds of Prey

Large birds of prey can build nests on artificial platforms including the tops of high-rise buildings. Constructing lipped edges on overhanging areas of buildings can help prevent the rolling of eggs. Nest padding materials, such as sawdust or wood shavings added to these areas will facilitate nesting.

Birds of prey require a food source within their hunting range in order to nest on high buildings.

Known species within the precinct include Peregrine Falcon and White-bellied Sea Eagle. These species typically have a hunting range of 3km from their nest.

Provide large, flat platforms for eagles and osprey to build nests. These platforms should be in open areas that allow for a 360° view for the nesting bird.

Consider building edges, such as on rooftop ledges as possible nesting locations to be incorporated into new building designs

Redbrowed Finch

Spotted Pardalote

White bellied Sea Eagle

Design Opportunities

Provide structurally complex and diverse understorey habitat including dense shrubs in which small birds can find shelter and food.

Utilise shrubs with spiky leaves, such as Silky Hakea (Hakea sericea) to provide protection for small birds.

Utilise plants that have small flowers that only small birds can get their beaks into, providing a food source inaccessible to larger, more competitive birds.

Avoid planting large-flowering plants, including Grevillea hybrids, and soft-fruiting plants that promote aggressive bird species.

Consider nesting opportunities for birds of prey, such as rooftop ledges incorporated into new building designs or large, flat platforms that allow for a 360° view for the nesting bird.

Urban Habitat

Target fauna species

Reptiles

The most important habitat features for lizards are sites for shelter and basking. These can be designed as hardscape elements in full sun, crevices in walls for habitat and organic mulch layers in garden beds. Known species surrounding the precinct include the Wall Skink, Dark-flecked Garden Sunskink, Pale-flecked Garden Sunskink, Eastern Bluetongue, Bar-sided Skink, Gully Skink, Eastern Water Skink and Eastern Water Dragon.

Frogs

Striped Marsh frogs can thrive in urban habitats, and are native to the eastern coast of NSW. This frog could be supported by water in the landscape, bringing the opportunity to re-introduce the sound of Country to the project area and help establish a thriving ecosystem. These opportunities should be explored in future detailed design of the precinct.

Eastern Bluetongue Lizard

Dark-flecked Garden Skink

Design Opportunities

Provide hardscape landscape elements for sun basking.

Provide some dense understorey plants, particularly long grasses and/or sedges.

CASE STUDY

South Eveleigh Native Rooftop Farm: Creating high density habitat in South Eveleigh

The co-founders of Indigenous start-up Yerrabingin brought to life the 500-metre-square space on top of an office building in the industrial area with more than 2,000 medicinal, edible or cultural plants.

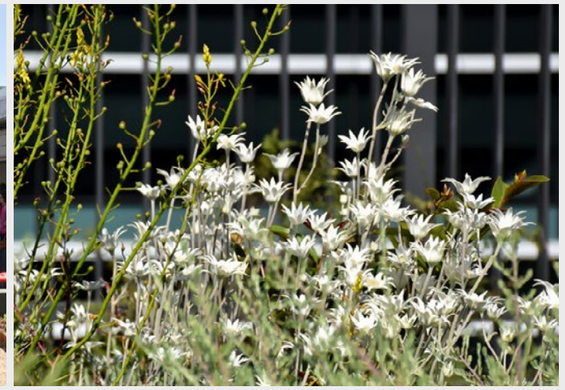
In addition to producing over 30 bushfoods, the rooftop will serve as a space for education, Indigenous employment opportunities and a range of community benefits including workshops on sustainability and wellbeing.

"The land is our mother, our teacher and our library. The landscape will inspire the next generation of environmental custodians, both Indigenous and non-Indigenous, the future of our mother Earth."

— Christian Hampson, CEO and Co-Founder of Yerrabingin

The rooftop contributes to a connected network of green infrastructure, even in a heavily urbanised environment.

The rooftop provides space for community gathering, cultural exchange and storytelling. Source: Yerrabingin



The rooftop is planted with native plants that attract pollinators. Source: Yerrabingin

7

Soil Strategy

7. Soil Strategy

Soil Profiles

Areas of Deep Soil

Deep Soil is defined as free draining, contiguous, deep soil with a minimum dimension of 3m, and cannot be located above an impermeable surface (ADG 2015). While a significant proportion of the proposed planting and new public spaces will be located above structures, there are a few areas of the site with access to deep soil for planting. These are:

- Eddy Avenue Plaza
- Mortuary Station
- Central Square, south of the BOOS (Bondi Ocean Outfall Sewer)

Planting above structures

Much of the proposed planting and new public spaces will be above a structure, as part of the development above the rail lines. Proposed areas of planting above structures includes:

- Planting on the OSD; Central Green, Central Avenue, Southern Plaza, Devonshire Link
- Planting on George Street Bridge and Prince Alfred Park Bridge
- Central Square, where a basement is located beneath the plaza, north of the BOOS (Bondi Ocean Outfall Sewer).

Soil provision on structures to provide for long term tree health

Although the success of healthy tree plantings is often attributed to their access to deep soil zones, this is not because tree root systems require large soil depths. Under appropriate conditions, trees can happily reach maturity in constructed environments by encouraging roots to grow laterally, improving tree anchorage where planting above a structure limits the available soil depth.

The deck platform must be designed to support optimal tree health to maturity. It will function as an engineered planting system based on principles of soil science, plant physiology and ecology. The proposed structural design of the OSD deck allows for minimum 1m depth for soil for tree planting, with greater depth possible in some locations. Soil volume and soil connectivity are equally important to enable trees to grow successfully on structures. Recommendations for planning provisions are provided to ensure both volume and connectivity is delivered.

The following minimum soil depths for planting on structure is outlined in the ADG. Depths have been calculated assuming fortnightly irrigation. Any sub-surface drainage requirements are in addition to the soil depths listed.

Mature Size	Height	Canopy Width	Soil Volume (per tree)	Soil Area on Structure	Minimum Depth
Small Trees	6-8m	4m	9m³	3.5m x 3.5m	800mm
Medium Trees	8-12m	8m	35m³	6m x 6m	1000mm
Large Trees	12-18m	16m	150m³	10m x 10m	1200mm

All volumes are subject to review against current industry best practice standards. An arborist or soil scientist can provide specific advice about the volume of soil that planting requires in your development.

Fig. 7.1: Table from City of Sydney Landscape Code Vol. 2 showing minimum soil depths for planting on structures.

Fig 7.2: Diagram of connected soil volume to support planting on the OSD structure

Soil Strategy

Soil Volumes

Overall soil volume, including width of tree pits, is as important as depth for tree growth and stability. The City of Sydney Landscape Code Vol. 2 notes “most trees have a root plate rather than a root ball. This means that they prefer to spread their roots across a broad, shallow area of soil rather than growing in a narrow, deep area of soil. The relationship between the width of the root plate and the diameter of the tree trunk needs to be balanced to give the tree stability. The volume of soil required for a tree differs depending on the type of tree, the type of soil and the amount of water (rainfall or irrigation) that the tree receives”. The recommendations for minimum volume and depth requirements when planting above structures from the City of Sydney Landscape Code Vol. 2 are shown in Fig. 7.1. The soil depth recommended by the Landscape Code for turf is a minimum of 200mm and for shrubs minimum 500-600mm. This strategy recommends a 300mm minimum depth for turf.

Other studies, such as ‘Planting and establishment of trees on difficult sites’ by Judy Fakes, have suggested that soil depths between 500 and 900mm are optimum. The report also states that “the area of soil exposed to the surface for gaseous exchange is also an important consideration”.[1] Areas of turf and planting around trees, or permeable paving, will allow for gaseous exchange between soil and air.

Connected Soil

The CPRP presents an opportunity to establish a continuous soil volume in the OSD, spanning from the Central Green to the south deck, as well as connecting to the existing soil volume of Prince Alfred Park via the South Bridge. In the Central Square, the soil volume above the basement should be connected with the deep soil area to the south of the BOOS. These connections will allow for the exchange of microbiota, as well as the development of mycorrhizal fungi networks for the exchange of plant nutrients to boost the overall health of planted communities.

1 Fakes, J., 2001, Planting and Establishment of Trees on Difficult Sites, National Street Tree Symposium, Treenet Inc.

Typical Section

Fig 7.3 shows a typical section through the Central Avenue, demonstrating how sufficient soil volumes and connectivity can be achieved on the OSD;

- Minimum soil depth of 1m soil for tree planting soil volumes in the structural design of the deck.
- The width of the soil volume is maximised across Central Avenue, including underneath the paved areas. This provides soil volumes for tree planting in line with the volumes specified in Fig. 6.1
- Extensive planted and turf areas allow for a large surface area of gaseous exchange with the soil.
- The soil volume connects all the trees and planting on the Central Avenue, rather than isolating trees in individual tree pits, allowing the development of fungi networks and movement of micro-organisms.
- These principles also apply to other areas of the OSD including the Southern Plaza, Devonshire Link and bridges, and have informed the recommended planning controls and design guideline provisions.

It is also recommended that in detailed design stages the advice of soil scientists, arborists or urban forestry professionals is sought to provide more specific advice.

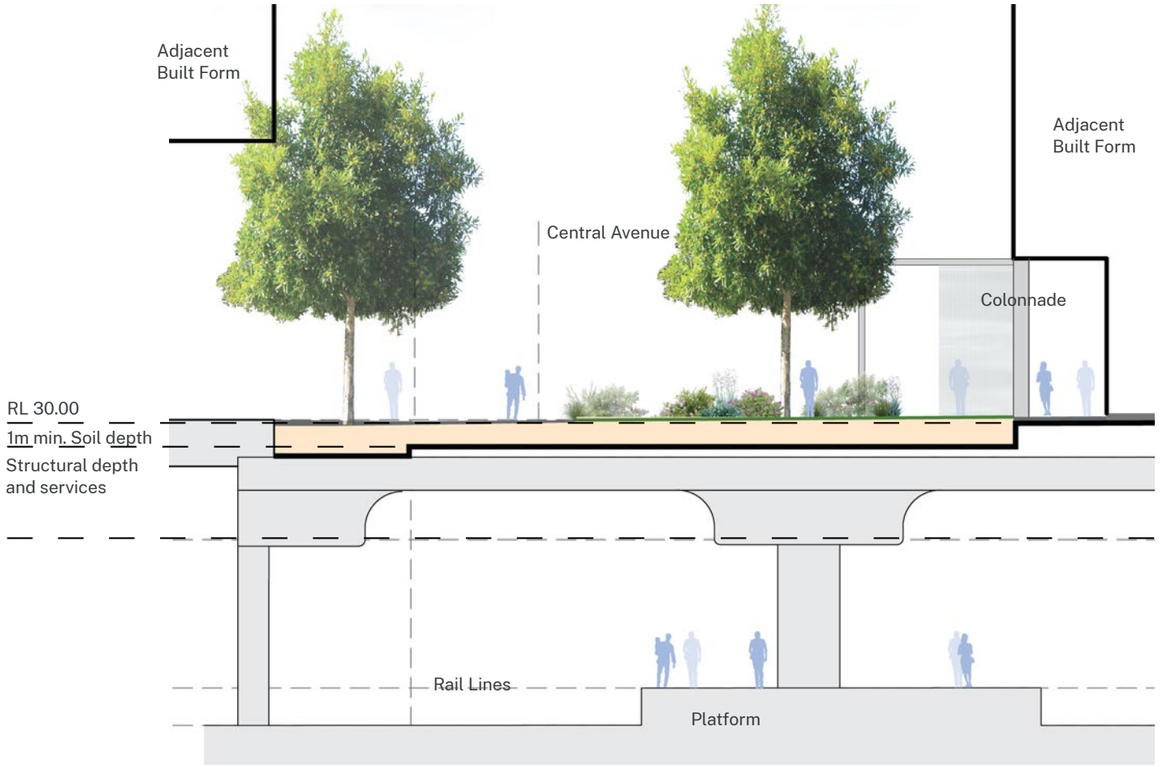


Fig 7.3: Typical Section through Central Avenue showing deck structure and soil depth available

Soil Strategy

Concept sections through the OSD structure showing 1m minimum allowance for soil depth and connected soil volumes.

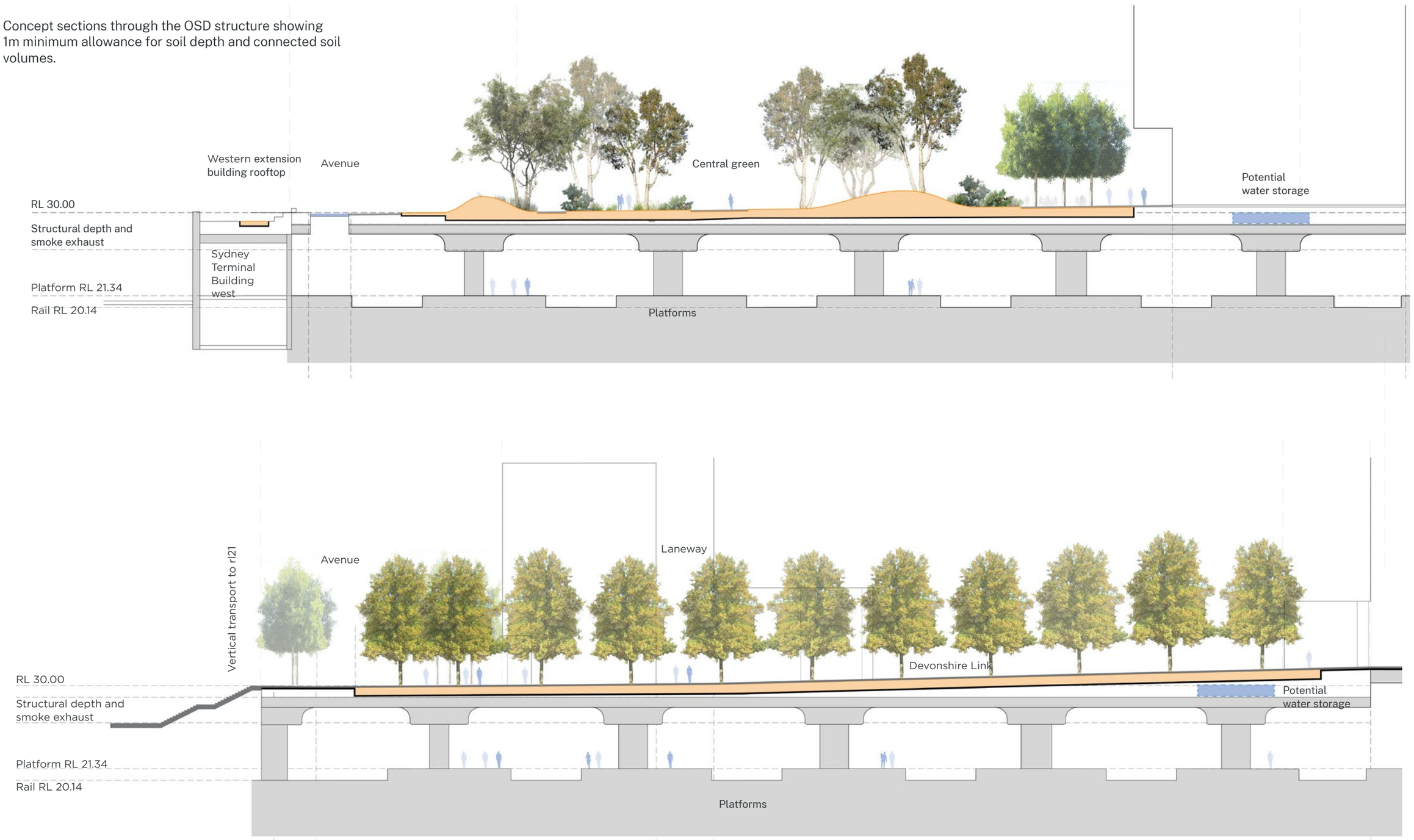


Fig 7.4: Illustrative sections through Central Green and Devonshire Link

Soil Strategy

Report Reference: Judy Fakes, Planting and Establishment of Trees on Difficult Sites

Adequate soil depth is essential for aeration and drainage, water storage and support (especially during wet conditions). Craul (1992) suggests that a (drained) depth of 450-600mm provides sufficient water storage and rooting volume in areas of reliable rainfall. Drier areas would require deeper soils unless irrigation was supplied. Perry (1994) suggests a depth of 400mm for good tree growth and 500-750mm for excellent tree growth.[1]

Lindsay & Bassuk make a general recommendation of 2 cubic feet (approx. 0.06 cubic metres) for every square foot (approx. 0.09 square metres) of crown projection (i.e. the area under the tree's dripline). This translates to the soil being 600mm deep in the area that will be within the dripline of the mature tree (Watson & Himelick, 1997).

A generous planting hole presently specified by a major Sydney council is 2.4m long x 1.2m wide x 1.5m deep or 4.3m^3. This appears to be generous by local standards but consider that the depth is 1.5m, far deeper than the roots are likely to grow. If we assume that the roots are likely to exploit the top 500mm then the effective rooting volume is now only 1.5 m^3. The area of soil exposed to the surface for gaseous exchange is also an important consideration and therefore suitable volumes should not be achieved by simply increasing depth (Perry, 1994). Craul (1992) suggests that tree pit depth should be a minimum of 450-500mm and should not exceed 600-900mm.

1 Fakes, J., 2001, Planting and Establishment of Trees on Difficult Sites, National Street Tree Symposium, Treenet Inc.

Recommended Planning Controls or Design Guideline provisions - Soil Strategy

- Allow for a minimum of 1m soil depth for tree planting in the structural design of the deck, with provision for deeper areas where possible. All soil areas must be well drained.
- Provide soil volumes for tree planting as per the City of Sydney Landscape Code (Fig. 6.1). Provide soil underneath paved surfaces where the volumes cannot be provided beneath planted areas.
- Consider the use of permeable paving or other methods to allow gaseous exchange with soil where trees are planting in paved areas.
- Provide a minimum of 600mm soil depth for areas of shrub planting, and a minimum of 300mm soil depth for turf planting.
- Create a continuous soil volume on the OSD connecting all planting areas together. Trees should be planted in wide continuous areas of soil rather than individual soil volumes.
- Connect the soil volume of the OSD to the deep soil of Prince Alfred Park.
- Connect the soil volume in Central Square above the basement with the deep soil to the south of the BOOS.
- During detailed design, further advice should be sought from a soil scientist and arborist / urban forestry professional to provide more specific advice. Final design of soil depths, profiles and type should take into account tree species, irrigation, size of rootball, placement and environmental conditions.

8

Water Strategy

8. Water Strategy

Water Supply and Irrigation Strategy

The CPRP provides the opportunity for a consolidated recycled water supply, as detailed in the Environmental Sustainability, Climate Change and Waste Management Report. This report notes that the provision of a reliable recycled water supply should be a priority for Central Precinct to mitigate water resource constraints.

A reliable and low-impact water supply is vital to support the irrigation requirements of creating biophilic, green public spaces. The planting strategy also targets species with high evapo-transpiration rates for some areas to enhance the cooling effect of planted areas, which increases the amount of water needed. This is proposed on the basis that a recycled water supply is available to provide reliable supply that does not deplete potable water resources.

Rainwater collected from buildings could be used in buildings and for landscape irrigation. There is capacity to store rainwater for re-use in the proposed deck structure, as detailed in Fig 7.1.

Water re-use and potable water demand reduction targets for buildings are detailed in the Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9.

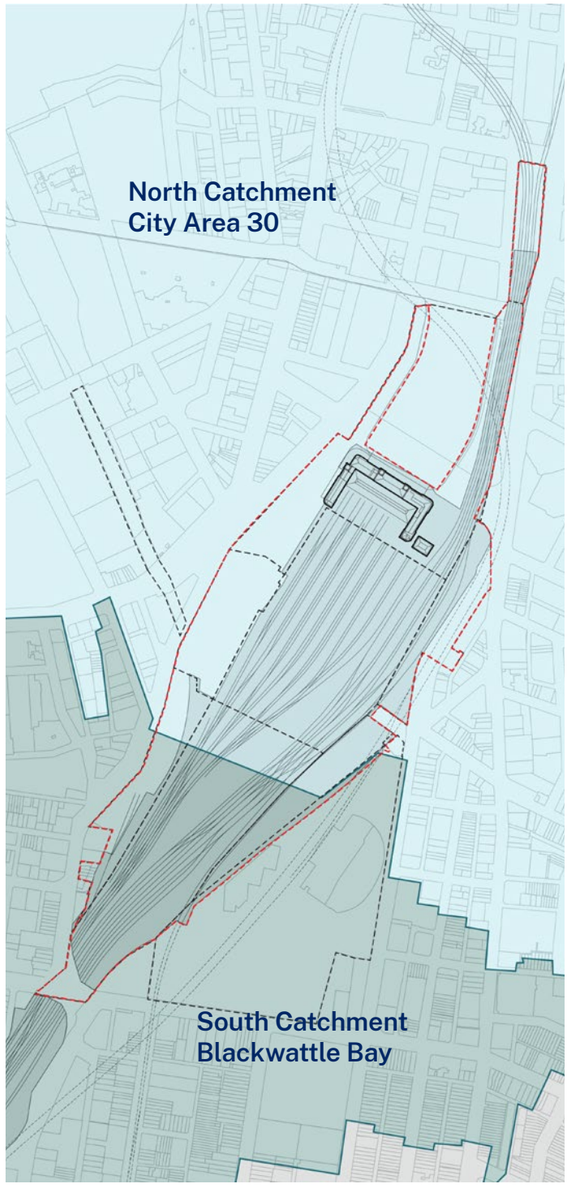


Fig. 8.1: Plan showing the existing north and south sub-catchment areas across the site.

Stormwater: Existing situation

The study area spans two sub-catchments, both of which flow to Sydney Harbour:

- Catchment 01 - City Area 30 includes: Central Station, Western Gateway, Eastern Gateway, Goulburn Car Park, Regent Street Sidings, Prince Alfred Sidings and Northern OSD sub-precincts
  This catchments drains to Darling Harbour.
- Catchment 02 - Blackwattle Bay includes: Regent Street Sidings, Prince Alfred Sidings and Southern OST sub-precincts.
  This catchment drains to Blackwattle Bay.

The majority of the site is currently a relatively flat ballasted rail corridor. Given the compacted nature of the ground surface, the infiltration rate may be low, causing most rainfall to flow into the drainage network. The quality of stormwater runoff from these areas is expected to be poor.1 There is the potential for a range of pollutants to enter the stormwater system from these areas with nutrients likely to be draining from railway ballast and other contaminants (from such sources as diesel residue and brake dust) arising from train activity.

The Central Precinct Renewal is an opportunity to improve stormwater outcomes for the site.

Stormwater and Water Sensitive Urban Design

The proposed stormwater system should maintain the existing sub-catchment areas by draining the northern areas of the site to the northern catchment and southern areas to the south. A concept Stormwater Management Plan has been prepared, refer to the Water Quality, Flooding and Stormwater Report (Arcadis, 2022).

The Central Precinct Renewal is an opportunity to improve the quality of stormwater runoff from the site. Employing water sensitive urban design principles will help to support the sustainability ambition to "reduce stormwater pollution flowing to Sydney Harbour significantly beyond best practice guidelines."[2]

The following water sensitive urban design principles should be employed:

- Grading paved areas to drain run off towards planted areas to provide passive irrigation, slow run off and help improve water quality.
- Grading paving to direct water run-off to areas of permeable paving beneath trees, to provide passive irrigation, slow water run-off and help improve water quality.
- Consider whether strategies like wicking beds or water storages under planted areas would be appropriate in the deck structure.

These strategies will provide passive irrigation to the planted areas, and slow run off and improve water quality by filtering water through soil volumes and allowing plants to take up water.

The overall grading concept for the deck structure is shown in Fig. 7.2. Generally, the deck is graded to fall towards Central Avenue, where water can passively irrigate trees and other planting, as well as being collected for detention in the deck structure if appropriate. As shown in the stormwater concept plan[3] the northern portion of the deck will drain to the northern catchment, while the southern part of the deck will drain to the southern catchment.

1 Central Precinct Renewal - Water Quality, Flooding and Stormwater Report, Arcadis, 2022

2 Central Precinct Renewal - Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022)

3 Central Precinct Renewal - Water Quality, Flooding and Stormwater Report, Arcadis, 2022

Water Strategy

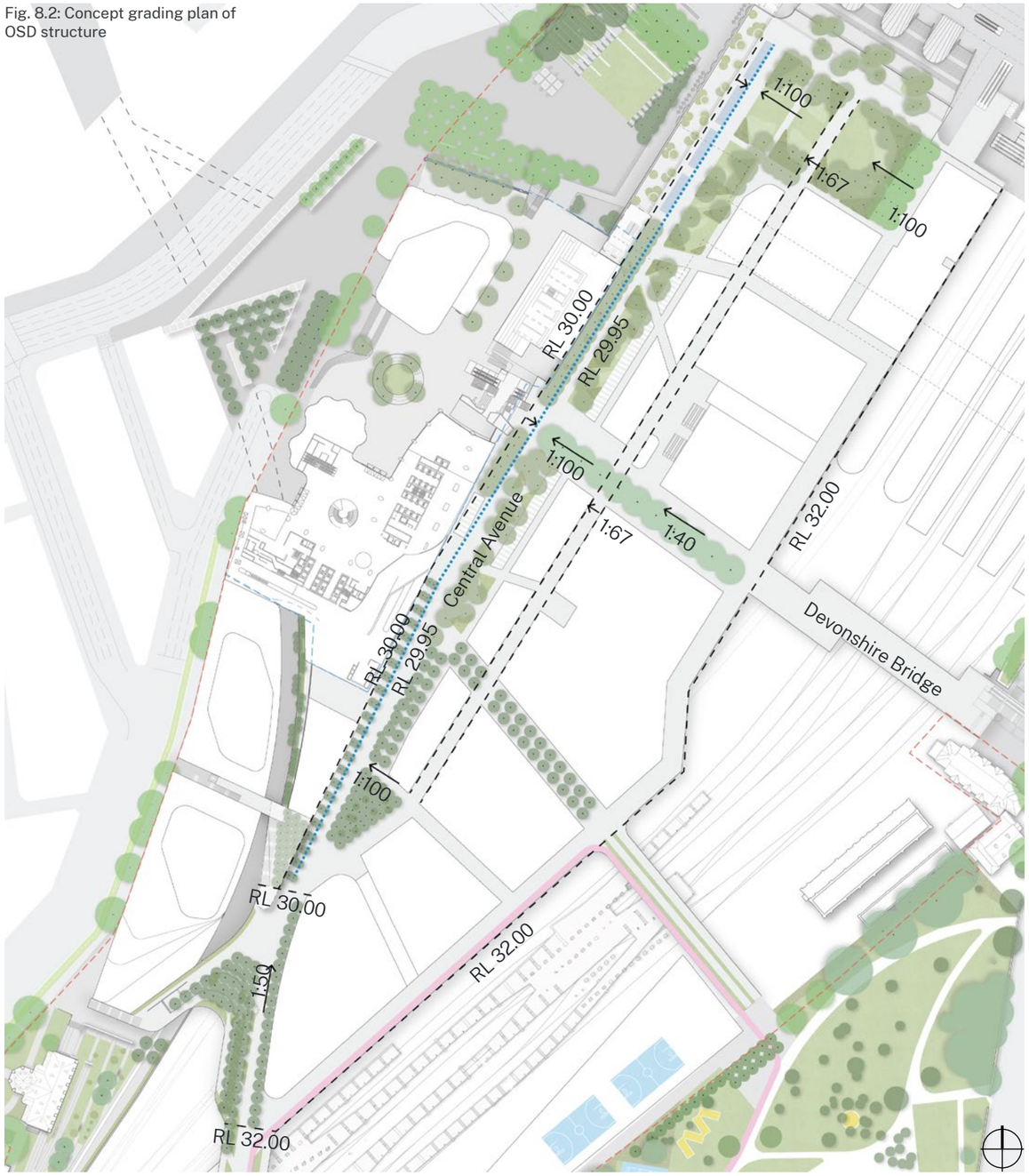
Water Quality

City of Sydney policy targets for pollutants in water are detailed in the Pollution Assessment (Arcadis, 2022). To support the sustainability ambition to reduce stormwater pollution flowing to Sydney Harbour significantly beyond best practice guidelines, it is recommended that a detailed integrated water cycle management plan is developed as the design is progressed. This should quantify water quality treatment targets for specific parts of the site, based on their unique opportunities and constraints, and should identify how water sensitive urban design principles can be optimised across the development area.

Flood Modelling

A flood model has been created for the Central Precinct Renewal, which will be developed as planning and detailed design progresses to ensure any potential flood impacts are mitigated sufficiently. At this high level of planning it is too early to assess how much stormwater detention might be required, or might be beneficial for the downstream catchments. However, it is recommended that provision for stormwater storage is provided in the deck structure, potentially along the eastern edge. This will allow stormwater detention to be provided as detailed design and flood modelling progresses.

Fig. 8.2: Concept grading plan of OSD structure



Water Strategy

Section showing OSD structure grading concept, with stormwater run-off passively irrigating tree planting through the connected soil volumes.

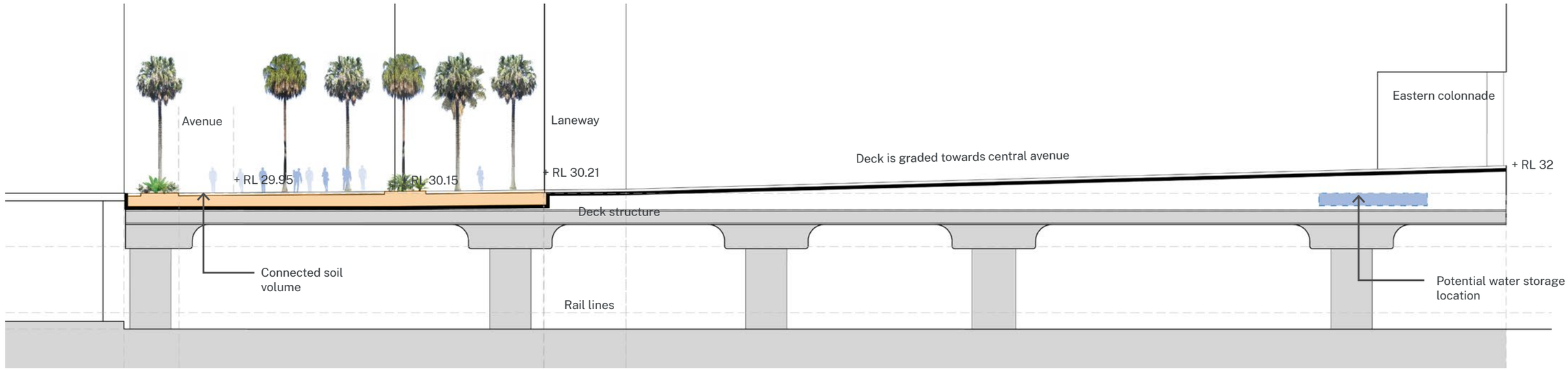


Fig. 8.3 Illustrative OSD Section

Key Plan

Water Strategy

Recommended Planning Controls or Design Guideline provisions - Water Strategy

- Provide a recycled water supply for irrigation in order to support the objectives for canopy coverage, greening and the creation of a biophilic environment. Refer to the Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022) for a detailed discussion of Integrated water cycle management. This report notes that for planning purposes, Central Precinct should make spatial allowance for water recycling within the masterplan, and that the investment case for which model of delivering recycled water is most appropriate should be established through a bespoke feasibility assessment and the precinct procurement process.
- Use Water Sensitive Urban Design principles to slow stormwater run-off entering the drainage system and to improve water quality, including;
  -Grade paving to direct water into planted areas where possible.
  -Consider grading paving to direct water run-off to areas of permeable paving beneath trees.
  -Consider whether strategies like wicking beds or water storages under planted areas would be appropriate in the deck structure. This supports the sustainability target to reduce stormwater pollution flowing to Sydney Harbour. (Refer to Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022).
- Develop a detailed integrated water cycle management plan as the design is progressed, to quantify water quality treatment targets for specific areas, and to identify how water sensitive urban design principles can be optimised across the study area. (Also refer to the Water Quality, Flooding and Stormwater Report (Arcadis, 2022).
- At planning stages, allow spatial capacity in the deck structure for stormwater storage to enable detention if future flood modelling shows this would be beneficial to the downstream flooding impacts. (Refer to the Water Quality, Flooding and Stormwater Report (Arcadis, 2022).
- Maintain the existing sub-catchment areas of the site, as detailed in the Stormwater Management Plan. (Refer to the Water Quality, Flooding and Stormwater Report (Arcadis, 2022).
- For targets and controls related to private buildings in the development, including rainwater collection, water re-use and reducing potable water demand, refer to the Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022).

9

Planning framework

9. Planning framework

Intended Delivery mechanisms

The following recommendations are intended to guide the ongoing planning and detailed design phases of the precinct renewal. They will inform the planning controls, DCP and Public Domain Design Guide. Integration of the green infrastructure principles and recommendations across the precinct is important to achieving the benefits of green infrastructure. It is understood that the public domain strategy will form a reference scheme to guide future design and approvals stages, and that there will be a single public domain strategy which each development application will need to align to.

At the construction stage is understood that the intent of TfNSW is to have the precinct developed by one development partner, and that the ongoing ownership and maintenance of the public open space will be by TfNSW. Should this intention change, it will be important to consider how to ensure integration of soil, water, planting and maintenance will still be achieved.

Table 9.1: Recommended Planning controls or design guideline provisions	Implementation by the planning framework
Open Space and Connectivity	
Provide the public open spaces and connections identified in the Structure Plan, Public Domain Plan and Public Domain Overlay	LEP and Design Guide
Urban Forest and Greening	
Detailed design to meet the canopy and greening targets specified in Table 5.1: Canopy and Greening Targets.	Design Guide
Planting design to include a diverse range of plants including locally endemic species, including a range of species which are adaptive to RCP 8.5 conditions.	Design Guide
Choose plants that will provide habitat for invertebrates, foraging for small birds and microbats. Consider dense planting and species with small flowers.	Design Guide
Choose species that are suitable for the environmental conditions of the place. This will need to be considered as detailed design progresses with updated solar and wind analysis.	Design Guide
Arborist Study to be completed at future stages of the work	Design Guide
Adopt the planting character plan and planting palettes.	Design Guide
Private open space, for example roof gardens, should follow the City of Sydney Landscape Code. Proposed planting design and species should be appropriate for the environmental conditions.	Design Guide
Consider the proposed tree species in relation to the current LGA species diversity and the family and species targets identified in the City of Sydney Urban Forest Strategy.	Design Guide
Provide a maintenance plan to ensure successful establishment and ongoing health of canopy trees and planting, as well as managing weeds, pests and diseases.	Design Guide
Urban Habitat	
Landscaping to feature native plants that are characteristic of communities that would have been in this area.	Design Guide
Plantings should achieve structural integrity where possible (canopy, mid storey, groundcover).	Design Guide
Management and maintenance plan to consider ongoing weed removal.	Design Guide
Protect important threatened species habitat during redevelopment, where possible.	Design Guide
Install additional microbat habitat. Roosting habitat could be provided along the edge or underneath the deck structure. Future ecological assessments should be completed to	Design Guide

Planning Framework

Table 9.1: Recommended Planning controls or design guideline provisions	Implementation by the planning framework
At future stages of the design process, detailed targeted microbat surveys to be undertaken in accordance with Threatened Species Survey Guidelines for areas proposed to be affected; assessment to be included in BDAR/s and including specific management and mitigation measures.	Design Guide
Consider the following design opportunities to provide habitat for fauna in future biodiversity strategies and landscape plans; • Increase canopy cover and provide planting that supports food sources for insectivorous bats. • Optimise lighting to allow for flyway connectivity and to provide foraging opportunities for microbats • Provide ample species of flowering plants as a food source for invertebrates • Integrate native beehives in existing or new infrastructure • Provide structurally complex and diverse understorey habitat including dense shrubs in which small birds can find shelter and food. • Utilise shrubs with spiky leaves to provide protection for small birds. • Utilise plants that have small flowers that only small birds can get their beaks into • Avoid planting large-flowering plants and soft fruiting plants that promote aggressive bird species • Integrate nesting opportunities for birds of prey, such as rooftop ledges or platforms. • Provide hardscape landscape elements for sun basking reptiles • Provide some dense understorey plants, particularly long grasses and/or sedges.	Design Guide
Incorporate water sensitive urban design features to provide water in the landscape for fauna.	Design Guide
Provide vegetation and habitat (not just canopy trees) throughout the public domain, including parks, avenues, and rooftops, to create habitat connections with surrounding areas.	Design Guide
Consider local and regional flyways in landscape, building and infrastructure design. Avoid building typologies that could harm flying fauna, such as highly reflective glass building facades.	Design Guide
Soil Strategy	
Allow for a minimum of 1m soil depth for tree planting in the structural design of the deck, with provision for deeper areas where possible. All soil areas must be well drained.	Design Guide
Provide soil volumes for tree planting as per the City of Sydney Landscape Code (Fig. 6.1). Provide soil underneath paved surfaces where the volumes cannot be provided beneath planted areas.	Design Guide
Consider the use of permeable paving or other methods to allow gaseous exchange with soil where trees are planting in paved areas.	Design Guide
Provide a minimum of 600mm soil depth for areas of shrub planting, and a minimum of 300mm soil depth for turf planting.	Design Guide
Create a continuous soil volume on the OSD connecting all planting areas together. Trees should be planted in wide continuous areas of soil rather than individual soil volumes.	Design Guide
Connect the soil volume of the OSD to the deep soil of Prince Alfred Park.	Design Guide

Planning Framework

Table 9.1: Recommended Planning controls or design guideline provisions	Implementation by the planning framework
During detailed design, further advice should be sought from a soil scientist and arborist / urban forestry professional to provide more specific advice. Final design of soil depths, profiles and type should take into account tree species, irrigation, size of rootball, placement and environmental conditions.	Design Guide
Water Strategy	
Provide a recycled water supply for irrigation in order to support the objectives for canopy coverage, greening and the creation of a biophilic environment.	Design Guide
Use Water Sensitive Urban Design principles to slow stormwater run-off entering the drainage system and to improve water quality, including; -Where possible grade paving to direct water into planted areas -consider grading paving to direct water run-off to areas of permeable paving beneath trees. -Consider whether strategies like wicking beds or water storages under planted areas would be appropriate in the deck structure.	Design Guide
Develop a detailed integrated water cycle management plan as the design is progressed, to quantify water quality treatment targets for specific areas, and to identify how water sensitive urban design principles can be optimised across the study area.	Design Guide
At planning stages, allow spatial capacity in the deck structure for stormwater storage to enable detention if future flood modelling shows this would be beneficial to the downstream flooding impacts.	Design Guide

Planning Framework

Climate Adaptation Plan

The Green Infrastructure strategy supports various adaptation measures in the Climate Adaptation Plan in the Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022). The following tables shows the relevant adaptation measures.

Table 9.2: Relevant adaptation measures from the Climate Adaptation Plan

Element	Variable	Potential Impact	Incumbent Adaptation Measures	Potential Additional Adaptation Measures
Temperature	Increased annual mean temperature	**Biodiversity collapse** Direct: Loss of biodiversity and ecosystem function (e.g. extreme heat mortality)	Plant selection includes a diversity of locally indigenous species adaptive to RCP 8.5 climate conditions. Develop support system for Central surrounds. Support community stewardship programs.	Landscapes designed to provide shelter to local fauna during times of heat stress in the form of beehives, nesting boxes, structured earth forms and select vegetation.
Temperature	Increased annual mean temperature	**Landscapes** Direct: Combined with lower rainfall will result in the loss of many plant species and less vigorous growth of many of the survivors, issues with management of pest plants and animals, loss of landscape amenity.	Balance of high-and low evapotranspirative plant species takes into account RCP 8.5 climate predictions. Stormwater collection and storage on deck used to irrigate landscapes. Recycled water supply for reliable irrigation.	
Temperature	Increased number of hot days over 35°C	**Heat Islands** Direct: Increases in number of days above 35°C may contribute towards urban heat island effects, leading to reduced comfort and increased complaints from building occupants and pedestrians	Urban forest strategy with vegetation and canopy coverage targets in line with City of Sydney's Greening Sydney Strategy (Draft) will reduce regional UHI effects. Smaller evapotranspiration gardens for urban cooling provide local areas of respite for visitors.	WSUD strategies-swales, basins, wetlands, ponds, permeable pavement Green roofs/walls/facades Materials-light coloured roofing, concrete, asphalt, high-reflectivity
Precipitation	Greater frequency of higher intensity rainfall events	**Building structures-floor levels and roof drainage** Direct: Greater frequency of higher intensity rainfall events may lead to localised flooding, damage due to scour and less safe operating conditions.		WSUD to reduce pressure on municipal systems
Drought	Decrease in annual total rainfall	**Landscapes** Indirect: Decrease in annual total rainfall leading to a reduction in regional water storages and reduce water supplies making it difficult to water landscaping.	Recycled water supply ensures reliable irrigation. Onsite rainwater storage.	
Wind	Increased wind speeds	**Debris** Direct: Increasing wind speeds may dislodge loose furniture or equipment (including vegetation) damaging exposed plant equipment and facades, or make the public domain unsafe.	Tree species selected for appropriateness to wind environments.	

Planning Framework

Table 9.2: Relevant adaptation measures from the Climate Adaptation Plan

Element	Variable	Potential Impact	Incumbent Adaptation Measures	Potential Additional Adaptation Measures
Extreme storms	Increase in frequency and severity of storms	**Dust storms** Direct: Last major dust storm 2009, combination of drought, hot weather and westerly wind. Increased risk of systems damage and occupant respiratory illness	Significant public domain landscaping to capture particulate matter	
Humidity	Changes to relative humidity	**Thermal comfort** Direct: Changes in relative humidity resulting in decreasing thermal comfort resulting in health impacts or decreased productivity.	Extensive shading in the public realm from tree canopy and buildings.	Design buildings and public domain to capture cool breezes during summer months when relative humidity is highest
Humidity	Changes to relative humidity	**Pest distribution** Indirect: Changes in humidity may increase encroachment pest species.	Regular landscape maintenance and monitoring to ensure optimal growth and health of landscapes, and identification of any issues. Specify durable, pest resistant materials in the public domain and other areas prone to pest encroachment. Design landscapes and infrastructure for easy inspection.	Prioritise cultural, mechanical, biological, and biorational management of pests in the landscape so as not to encourage the development of pesticide resistance.
Solar radiation	Increase in level of UV	**Occupants, workers and visitor health** Direct: Increased incidence of sunburn and associated skin cancer risks, sun stroke. Outdoor public domain and private balconies terraces key areas to consider	Extensive shading in the public realm from tree canopy and structures Areas of respite for visitors.	Covered access throughout public domain and along active transport routes.
Civil Disturbance	Stresses identified by Resilient Sydney	**Diminishing community cohesion** Indirect: Evidence from places that have suffered extreme events shows constantly that mortality is highest where social cohesion is lowest. When people know each other, they look out and help one another through an extreme event.	Social infrastructure for shelter Water fountains in public domain Shading Local social connectedness – casual social connection	

10

Consultation

10. Consultation register

Table 10.1 City of Sydney feedback, 13.12.2021

Category	Issue	Design team response - how issue has been addressed	Reference / further information
Canopy and Greening targets	The canopy and greening targets for streets, parks and property outlined in the GSS are the overall portfolio targets for that land classification. Since the overall target and street / park type targets are summary total of all parks and streets as a collective, they cannot be applied to any single individual streets or parks. We have more specific targets for these types.	The Urban forest and Greening Strategy is based on the specific targets provided by City of Sydney on 13.12.2021 for the various open space types.	Urban forest and Greening Strategy
Canopy and Greening targets	New parks and streets, such as those designed and constructed as part of major urban renewal projects, are a clean slate. They provide the best opportunity to plan and accommodate the optimum amounts of greening and canopy cover. In considering the targets outlined above, the canopy cover targets proposed are considerably lower, and the greening targets are also lower than the targets indicated above	The canopy and greening targets have been increased, and aim to maximise the canopy and greening that can be achieved on this site, taking into consideration transport requirements, heritage and environmental conditions.	Urban forest and Greening Strategy.
Canopy and Greening targets	In reviewing the proposed park designs and character it is considered the majority would be classified as either “iconic” or “civic” parks. For example, we would consider Central Square as a civic park, and the Central Green as an iconic park. Action: Review the current park designs, apply the appropriate classification and required canopy & greening target, noting there needs to be considerable increase in canopy and green cover.	The canopy and greening targets have been increased, and the open spaces have been considered based on the park types of ‘civic’ and ‘iconic’.	Urban forest and Greening Strategy
Canopy and Greening targets	The proposed property targets do not contain any canopy cover and rely solely on the greening targets from the rooftop planting. Whilst this roof top planting is critical, especially in managing stormwater and increasing habitat etc, it does not adequately offset the canopy cover required on the properties, or the streets and parks. If the streets and parks met the City’s canopy and greening targets, and the greening on the roof tops was maximised, that would be sufficient for no inclusion / increase in canopy on the property classification. Action: Maximise the canopy in the street and parks, to meet the City’s targets, to reduce the need for including canopy on property. Maximise the green roof space available to also minimise the inclusion of canopy on this land classification.	The canopy and greening targets have been increased, and aim to maximise the canopy and greening that can be achieved on this site, taking into consideration transport requirements, heritage and environmental conditions. A target to ensure green rooftop planting has also been included.	Urban forest and Greening Strategy

Consultation register

Table 10.1 City of Sydney feedback, 13.12.2021			
Category	**Issue**	**Design team response - how issue has been addressed**	**Reference / further information**
Soil	The quality and volume of soils is a critical aspect of this proposal. The proposed soil volumes look appropriate at this stage, however a more detailed assessment will be required to ensure they can sustain the plantings into the long term. This include assessing details on soil types (structural, voids, cells), materials used, depths and then overall volume to match species / tree sizes.	A soil strategy is to provided to ensure sufficient integrated volumes and depths of soil will be provided. It recommends that a more detailed assessment will be required at future stages of the project to assess soil types, species and tree sizes in further detail.	Soil Strategy
Wind	Trees are not to be used to mitigate winds. It will be important that the built form is deigned to mitigate this issue.	Trees have not been proposed to mitigate winds. The urban design framework details the amenity and wind modelling studies that have been completed to assess the built form.	Urban Design Framework.
Wind	The species selection will need to be carefully considered for these windy locations, such as the Central Green and roof top gardens, to ensure they will be ale to thrive in the site conditions.	The proposed planting palette considers species selection for the environmental conditions, including endemic plants which are adapted to exposed locations, and trees which have been successfully used in windy urban situations. Future stages will consider the species in more detail as the built form and wind modelling is further developed.	Urban forest and Greening Strategy
Evapotranspiration planting	The proposal to maximise green cooling through evapotranspiration is supported.		
Water	As the greening is on structures, and exposed to high wind, managing water in this landscape will be critical. To ensure long-term success, additional information is required on the management of water through the system. This includes the; - water source / quality (we assume it is rain or recycled water), - water storage and the impact of any sub-surface storage on soil volumes design. Whilst the ESD strategy comments that some water will be stored within the cellular structure of the deck, how is stored in other areas across the site. - watering method, for example is it passive irrigation? Action: Provide further information on the management of water within the landscape, to address the points above.	A water strategy covering recommendations for water source, storage, and irrigation has been provided.	Water strategy, Water Quality, Flooding and Stormwater Report (Arcadis, 2022).and Environmental Sustainability, Climate Change and Waste Management Report, Chapter 9 (Atelier Ten & Integral, 2022).

Consultation register

Table 10.1 City of Sydney feedback, 13.12.2021			
Category	**Issue**	**Design team response - how issue has been addressed**	**Reference / further information**
Tree Species	A key requirement of this to select tree species that are proven performers, and those that will thrive in the changing climate. Research indicates that by 2050, the City's climate will be more like Grafton's. Further, consideration needs to be given to ensuring appropriate species diversity, which can be applied at the city or precinct scale. The City's current for diversity targets are for no more than 40% for any one family, 30% for any one genus and 10% for any one species. Action: In reviewing the species list, the following needs to be removed and substituted: - Melalueca quinquenervia - Platanus x acerifolia It is considered that the following species should be substituted or used sparingly - Banksia serrata	Urban forest and greening strategy outlines and planting palette which considers environmental conditions and species diversity. -Platanus x acerifolia is not proposed -Melaleuca quinquenervia is proposed only in small numbers, in targeted locations for their evapotranspirative benefits. They will not make up more than 10% of the trees proposed for the precinct, and therefore would not increase the proportion of the species across the LGA. -Banksia serrata substituted.	Urban forest and greening strategy
Existing trees - Prince Alfred Park	There are significant Fig trees and other important plantings in Prince Alfred Park that will need to be retained and protected as part of the proposal vehicular connect through the southern area of the park. Insufficient information has been provided to demonstrate the proposed access route will be able to be installed and constructed without requiring the removal, or sufficient pruning (above and below ground) of these trees. The City will strongly oppose the removal or any works that impacts on the long-term health and structure of these significant trees for this access route. Action: An Arboricultural Impact Assessment (AIA) must be proposed in accordance with the Australian Standard for the protection of trees on development sites. The AIA must be prepared by an AQF Level 5 arborist who has extensive demonstrated experience in managing significant trees and complex development sites. The report must be submitted to the City asap, as major changes to the proposal may be required to ensure the trees protection.	The proposed accessway is outside the existing tree canopies of the significant trees and will not require regrading of the ground within the canopy of the tree to construct. An Arboricultural Impact Assessment (AIA) will be prepared at future development application stages, and construction will consider the Tree Protection Recommendations.	Public Domain Strategy

Consultation register

Table 10.2 Greater Cities Commission feedback - 25.01.2022			
Category	**Issue**	**Design team response - how issue has been addressed**	**Reference / further information**
Delivery	Question as to how the reference scheme will deliver on its objectives and principles.	The recommendations and reference scheme will inform the preparation of the planning controls, DCP and a design guide.	Planning Strategy
Delivery	Question as to how will TfNSW maintain control of the process once a developer is on board so that the directions established in the work to date can be delivered	The development will be undertaken as a partnership between TfNSW and a single developer partner allowing ongoing control and integration.	Planning Strategy

11

Case Studies

11. Case Studies

Khoo Teck Puat Hospital, Singapore

Designer:	RMJM, CPG Consultants
Scale:	10.5ha
Client:	Alexandra Hospital
Year:	2005

Summary

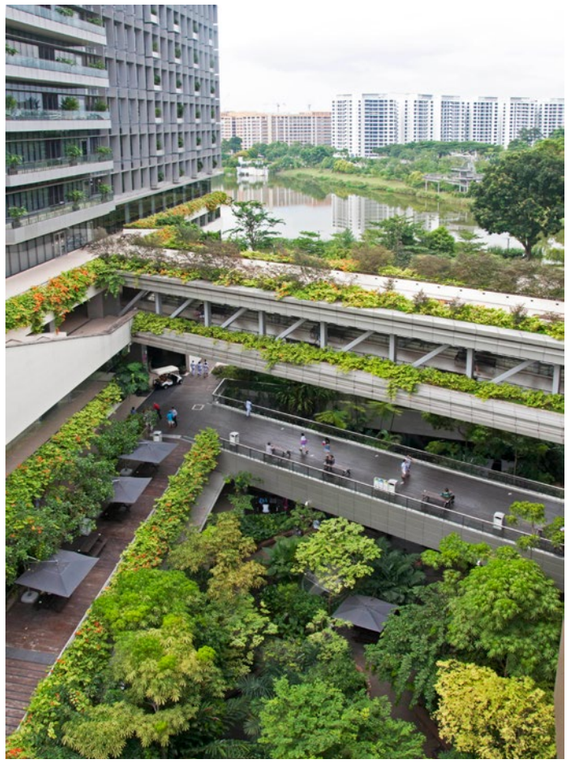
This project uses green infrastructure to immerse a 10.5ha hospital development in a garden setting, ensuring staff, visitors and patients have access to nature. Water features with aquatic species, and plants that attract birds and butterflies were introduced. Greenery extended from the central courtyard to upper levels of the buildings and down into the open-to-sky basement, creating the impression of architecture deeply enmeshed in a garden.

Remarkably for a development located in a dense urban setting, KTPH managed to achieve a green plot ratio of 3.92; this meant that the total surface area of horizontal and vertical greenery is almost four times the size of the land that the hospital sits on. In addition, 18% of the hospital's floor area account for blue-green spaces and 40% of all such spaces are publicly accessible.

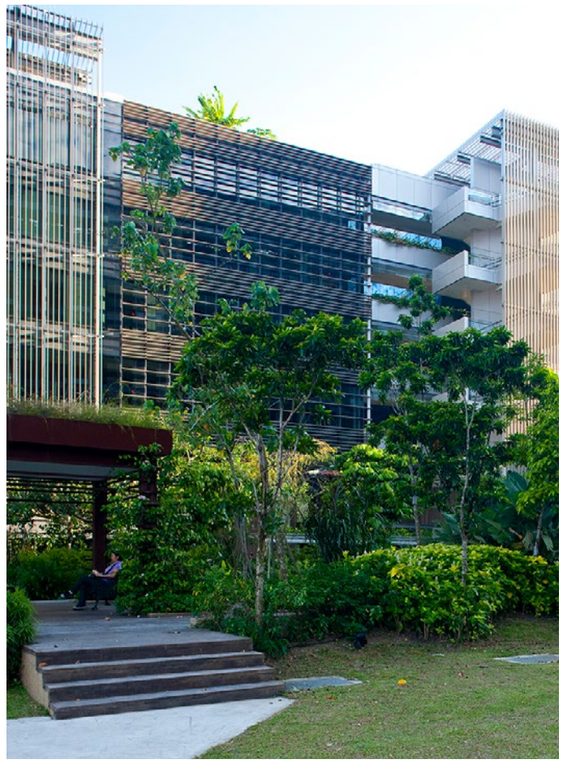
To suit the local climate, indigenous tropical plant were chosen for ease of maintenance. By providing host plants and various habitats within the hospital grounds, the hospital becomes part of the larger ecosystem encompassing various green patches throughout the north of Singapore.

Key Transferable Principles

- Use locally native plants to suit the climate, reduce maintenance and attract local birds and insects.
- Consider the potential of large scale urban developments to provide links in wider ecological corridors.
- Commitment to vertical and horizontal greencover.



Khoo Teck Puat Hospital courtyard. Image: KTPH.



Khoo Teck Puat Hospital. Image: JY Architecture Photography

Khoo Teck Puat Hospital Courtyard. Image: RMJM

Case studies

Ng Teng Fong General Hospital & Jurong Community Hospital, Singapore

Designer:
HOK, Singapore Ministry of Health, CPG Corporation, Studio 505, Peridian Asia

Scale: 17.1ha

Client: Singapore Ministry of Health

Year: 2015

Summary

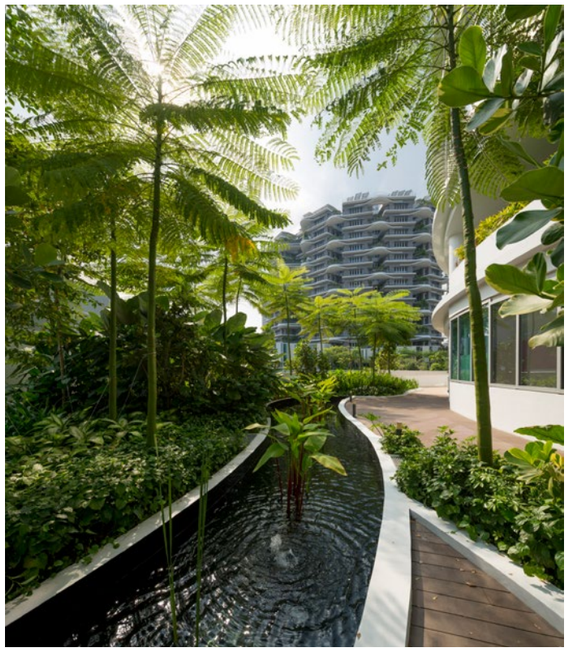
Built in a dense urban area of Singapore, this project reintroduces ecology to an otherwise heavily developed region. Two hundred years ago, before it was filled in to make way for an industrial district, a mangrove swamp covered this edge of Singapore. Although mangroves are no longer an option for this site, ecological benefits have been restored through other native vegetation and stormwater capture, reuse, and infiltration.

As a new oasis within a dense city, the site features a large garden that is open to the public, as well as distinct gardens designated for patients and staff. These gardens are positioned at all levels throughout the campus, with focal points adjacent to public spaces such as the cafeteria. Vertical plantings that rise up the sides of the buildings give patients direct views of nature from their own windows. Additional vegetation and street trees align the main roadways, and a jogging trail surrounds the site. All of the plants and trees are native or adapted to Singapore, which minimizes the need for irrigation and creates a habitat that attracts local fauna.

Percentage of the site area designed to support vegetation: 55 percent

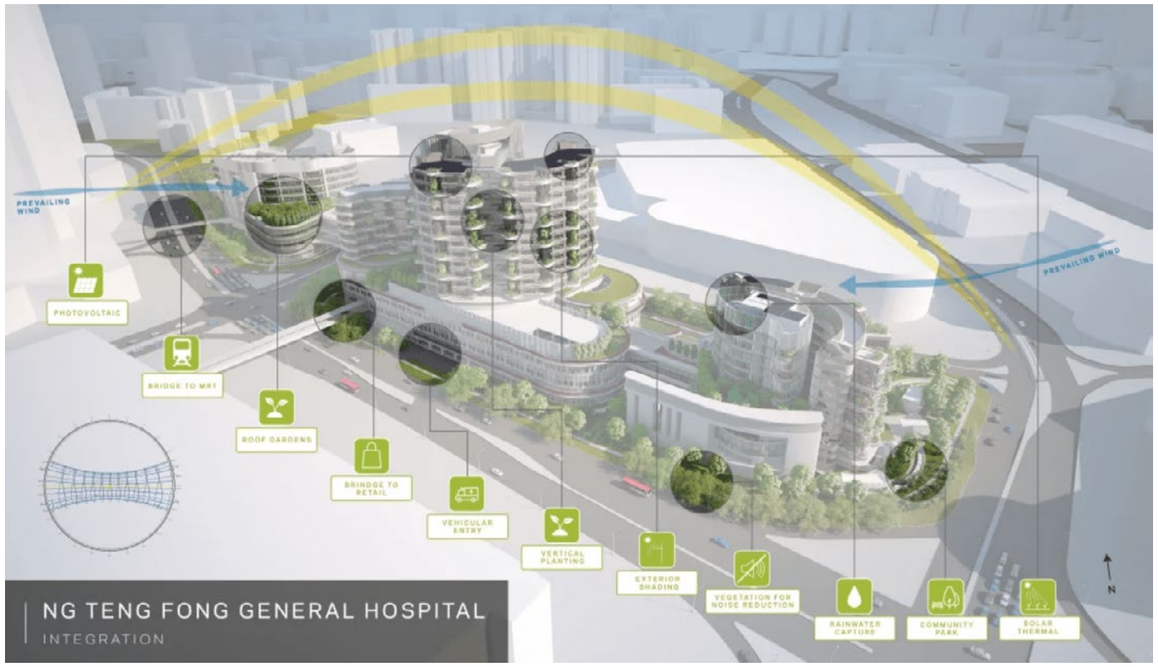
Key Transferable Principles

- Use of levels of planting (canopy, mid level and groundcover) to create comfort and mitigate high rise towers.
- Use of water features for microclimate cooling.
- The Ng Teng Fong Roof Garden Commission series invites leading international artists to create site-specific installations at the Ng Teng Fong Roof Garden Gallery



Ng Teng Fong General Hospital Respite Garden. Image: HOK

Ng Teng Fong General Hospital Roof Garden. Image: HOK



Ng Teng Fong General Hospital Sustainability diagram. Source HOK

Case studies

Bendigo Hospital

Designers:	Oculus
Scale:	13 ha
Client:	State Government of Victoria
Year:	2013-2018

Summary

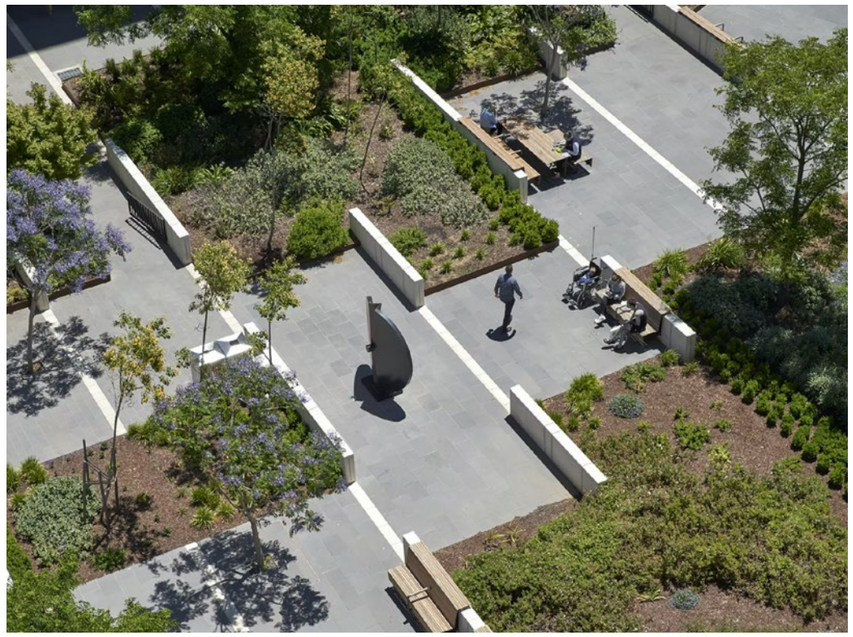
The design created a walkable precinct with a clear hierarchy of streets and pathways that engage with the broader city, heritage buildings and topography. Canopy cover and green links provide a high-quality vibrant public realm, with a north-south civic axis creating an important, inviting through-site link. A diversity of community, collaborative and private space was created across the precinct with over 46 balconies, green roofs, roof decks, and courtyards.

OCULUS used an evidence-based, biophilic design approach across the project, utilising natural and local materials, moving water and textured planting. Green infrastructure initiatives include water sensitive urban design, structural soils and significant increases in biodiversity, habitat and urban forest, restoring valuable ecological and hydrological systems across the precinct. The project has been assessed in consideration of best practice and will inform project planning of future health care environments in Victoria.

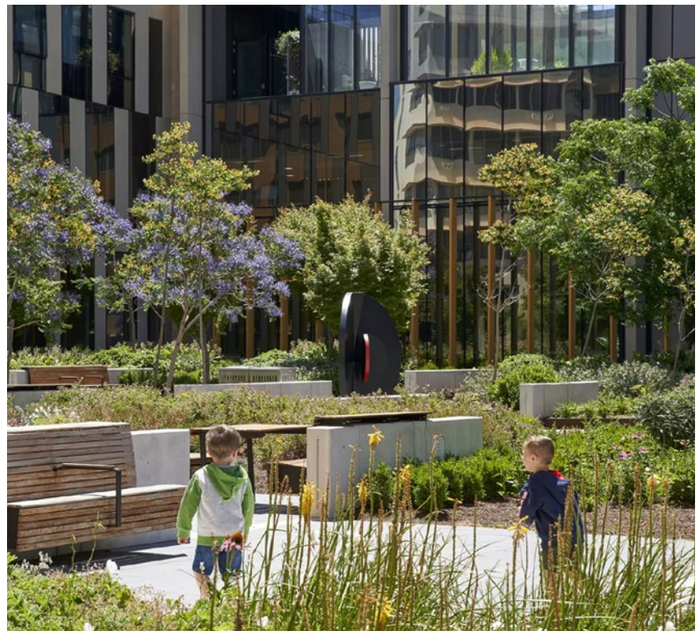
Key Transferable Principles

- Rich, layered planting to create comfortable microclimates and increased biodiversity.
- Groves of mature trees in strong avenues to define circulation
- Consideration of suitable plant species for urban environment.

Garden at Bendigo Hospital. Image: Tom Adelph



Garden at Bendigo Hospital. Image: Peter Clarke



Garden at Bendigo Hospital. Image: Peter Clarke

Case studies

The Goods Line, Ultimo

Designers:	Aspect Studios, CHROFI
Scale:	0.2 ha
Client:	Property NSW
Year:	2015

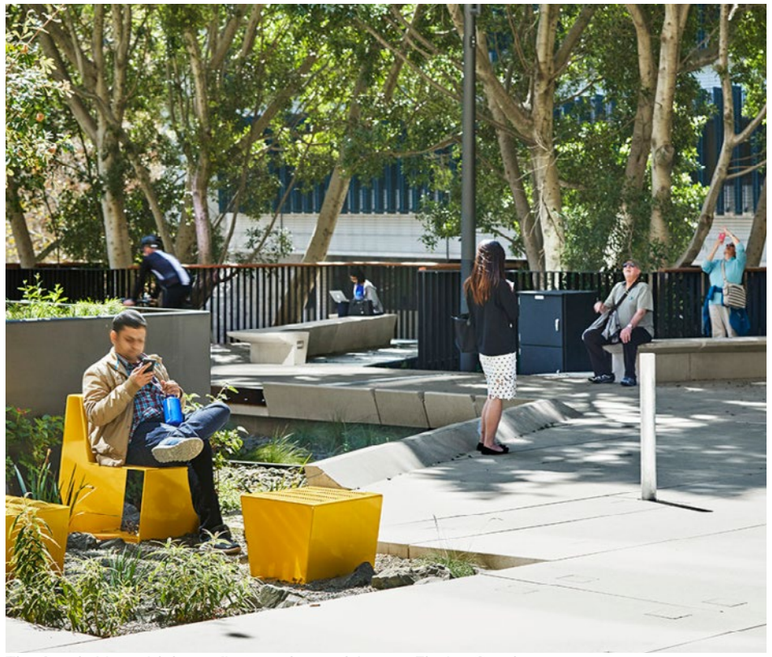
Summary

This unique elevated park has seen a disused rail corridor running from Railway Square to Darling Harbour reimagined as a leafy, energised civic spine in the heart of Sydney's most densely populated area. The project adds 0.2ha of much needed new green space to the Haymarket and Ultimo precincts. Over 33% of the project's surface cover was developed as green space, reducing cross-surface runoff from large areas of previously bituminised hardscape as well as decreasing the urban heat island effect.

Predominantly native, drought-tolerant plants ensure low maintenance and increased biodiversity. The retention of mature fig trees shade the eastern edge of the site. WSUD initiatives enable The Goods Line (North) to meet the New South Wales Government's objective of 80% potable water consumption reduction. Concealed inlet pits within garden beds enable stormwater to infiltrate and naturally irrigate the garden spaces.

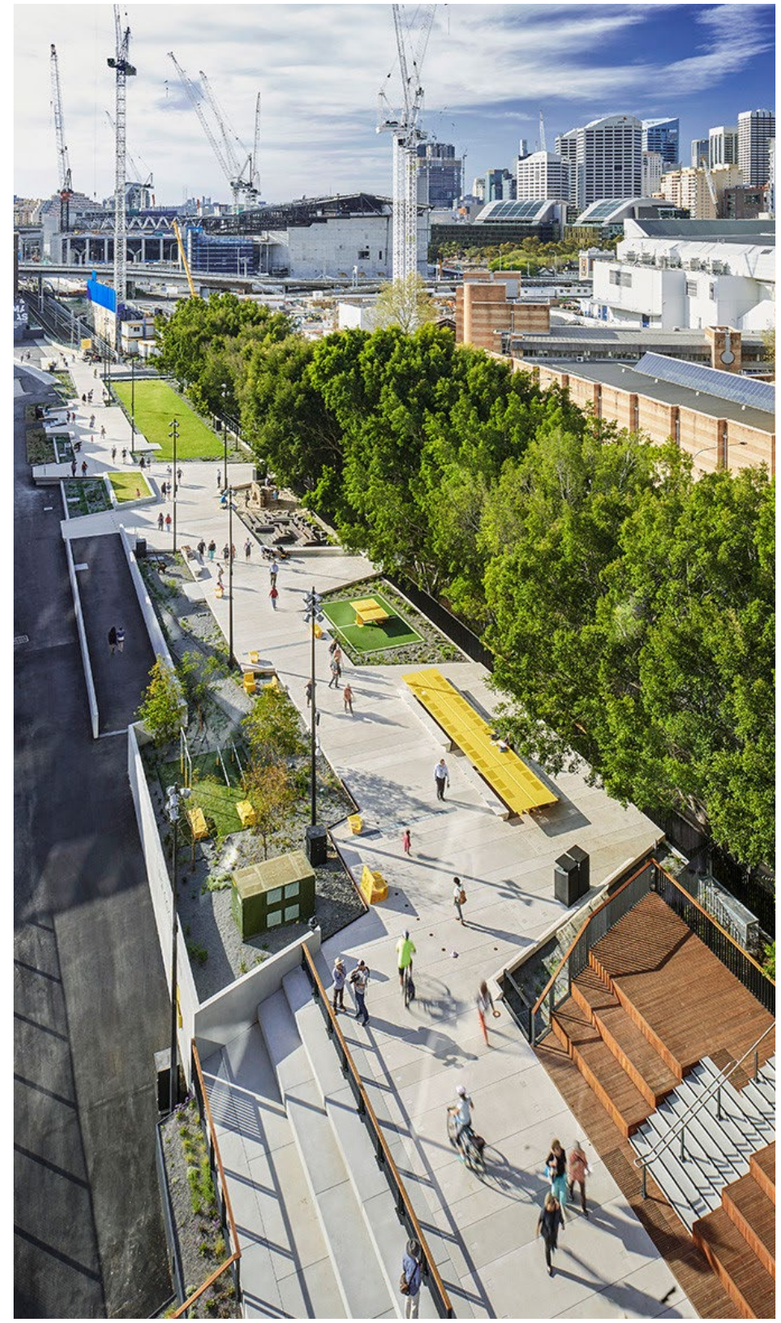
Key Transferable Principles

- Bridge as social infrastructure with green cover, dwell space, play and circulation.
- Diverse planting that attracts pollinators.
- Retention of mature trees showcase the importance of canopy and deep shade.
- Connection of new public domain to existing neighbourhoods, revitalising leftover spaces of the city.



The Goods Line with large fig trees beyond. Image: Florian Groehn

The Goods Line Image: Florian Groehn



The Goods Line aerial view. Image: Florian Groehn

Case studies

Hudson Yards, New York

Designer: Kohn Pedesen Fox, Thomas Heatherwick, Nelson Byrd Woltz Landscape Architects

Scale: 11ha

Client: Private Development by Related Companies with Oxford Properties

Year: 2012-2024

Summary

The eastern portion of Hudson Yards includes two hectares of gardens and public plazas featuring over 28,000 plants and an urban forest of 200 mature trees. Dense canopies of native trees, expansive native perennial gardens and patches of wildflowers will be home to migratory birds and pollinators.

Beyond hardscape and planting design, the landscape platform itself is a technical innovation. Serving as a ventilating cover over the working rail yards, the platform is engineered to support the expansive large-scale plantings and serve as a reservoir for site storm-water management and reuse.

The platform's thickness puts a limit on soil depth -450mm for plants and 1200mm for large trees - but soil beds are designed to provide room for horizontal soil growth. Where trees are planted in paving, a 'soil sandwich' of sand, gravel and concrete slab protects roots while again allowing them to expand. The sophisticated layering of the system also includes provisions for aeration, irrigation, drainage and ongoing control of nutrients.

Key Transferable Principles

- Design platforms to support tree health into maturity. Include water storage, room for lateral root growth, temperature.
- Use of diverse locally native trees and plants to attract native pollinators.

Hudson Yards and the High Line. Image: Max Touhey

Case studies

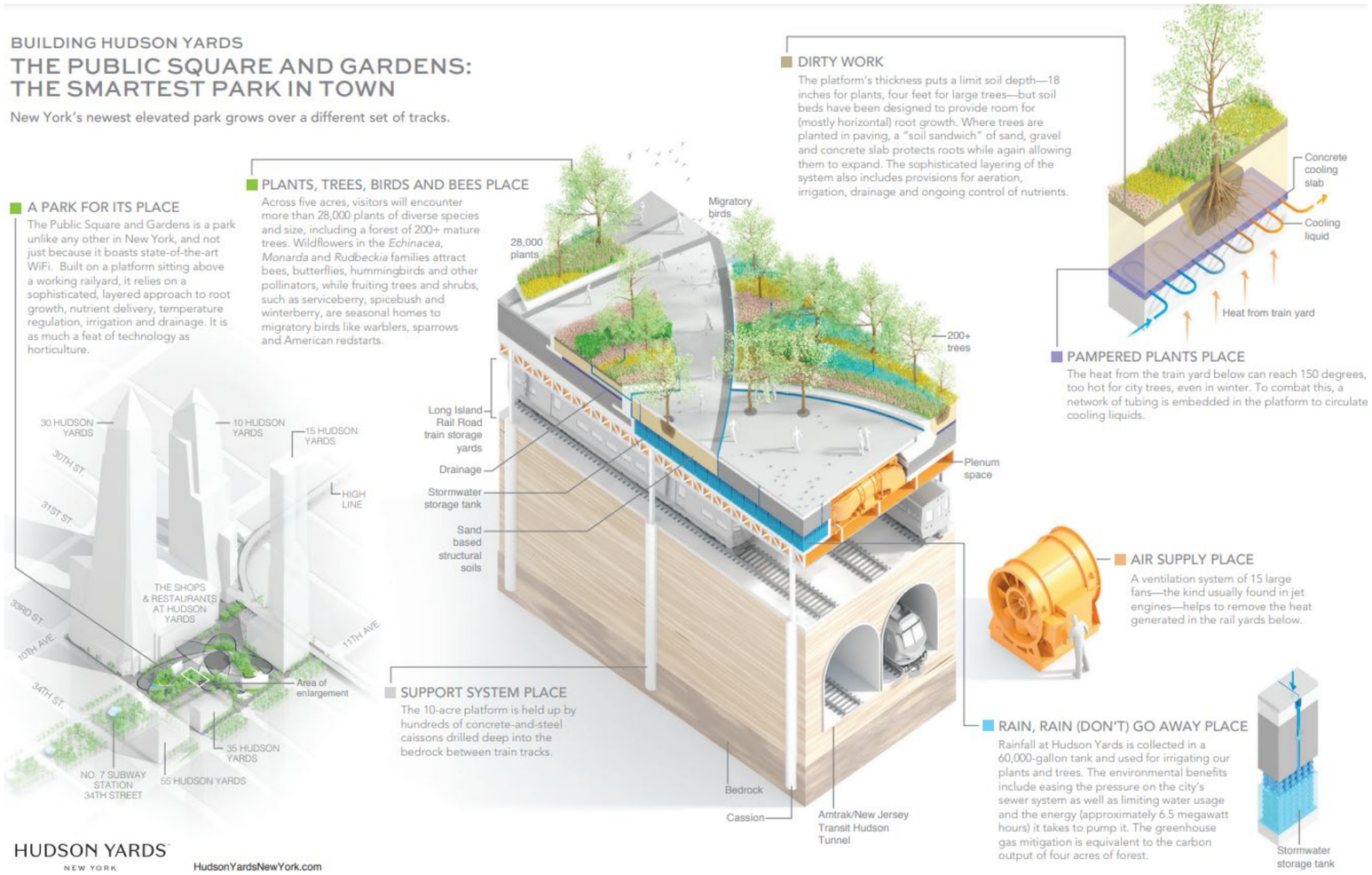


Diagram of Hudson Yards deck structure over rail lines to support planting and water management in the public domain. Image NBW

Public domain at Hudson Yards. Image: Barrett Doherty

Public domain at Hudson Yards. Image: Barrett Doherty

Case studies

Crossrail Place retail and leisure oversite development, Canary Wharf Station, London, UK

Designers: Foster and Partners, Adamson Associates International, Tony Meadows Associates, Gillespies, Arup

Scale: 1ha

Client: Canary Wharf Group

Year: 2015

Summary

This project provides approximately 10,000m2 of public open space above the station that unites the residential neighbourhood of Poplar and the business district of Canary Wharf. Hundreds of plants collectively represent and showcase the many countries visited by ships of the West India Dock Company, which unloaded their wares where the station now sits.

Physical constraints and challenges of shallow substrate depth and weight of planting were embraced by constructing the garden over a slab that acted as a wide tray containing enough soil to support mature trees and plants. Footpaths were elevated on lightweight supporting structures to allow for root growth and drainage. Structural loading constrains the soil depth to 1.2m generally: deeper zones were created by placing polystyrene void formers beneath the soil. Where the garden spans over Bank Street, a 27m span steel I-beam structure was adopted, with composite fl oor on metal decking. In this area, soil depth is restricted to 0.6m. All structures in the roof garden, including the retaining walls, amphitheatre structure and roof access plinths are designed to be ‘free standing’ and do not penetrate the waterproof membrane or insulation on top of the Level +1 slab. This enables the garden to be reconfigured (if needed) without disturbing retail tenants below.

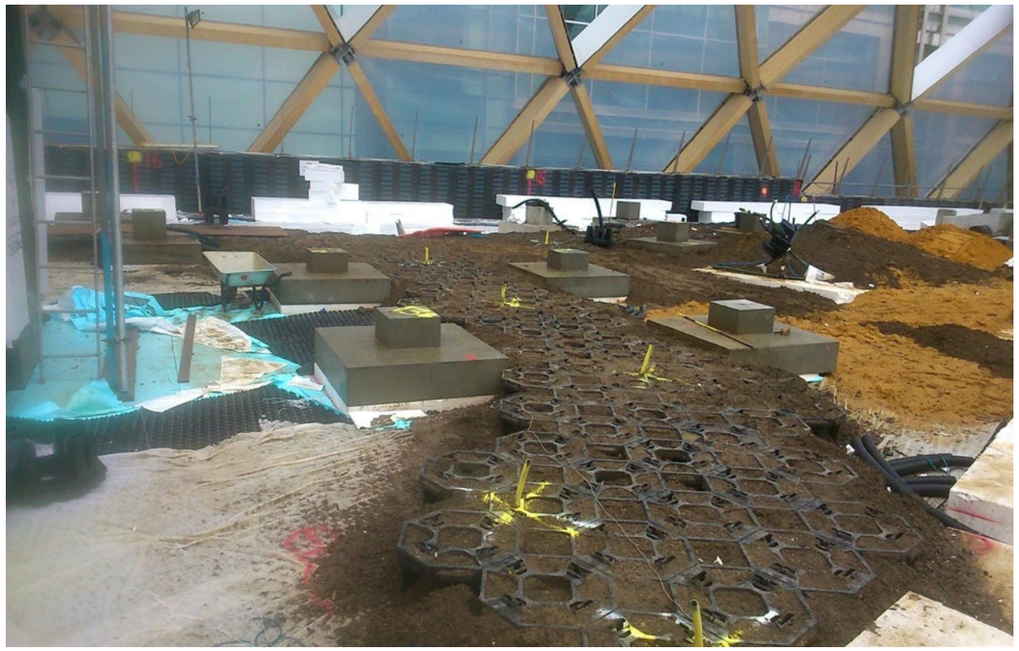
Key Transferable Principles

- Diverse plantings reference to local area’s heritage relating to both new and heritage values of the site.
- Deck structure allows for tree health to maturity including sufficient soil volume and minimal compaction.
- Design of structure facilitates future maintenance of plants.
- Layered planting creates comfortable microclimate for humans and pollinators.

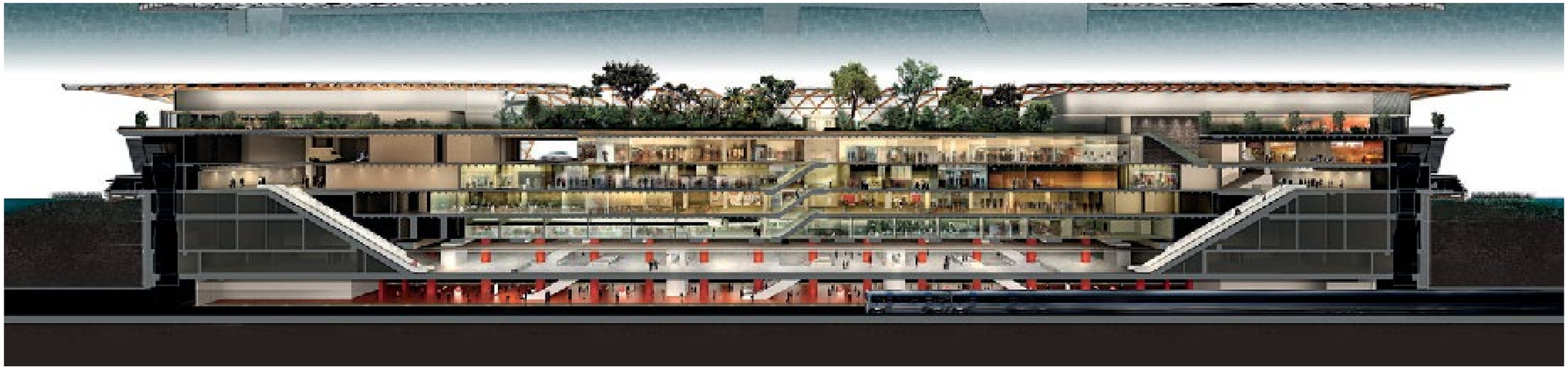
Aerial view of Crossrail place. Image: Nigel Young

Case studies

Public open space above station at Crossrail place. Image: Foster + Partners



Construction of public open space above station at Crossrail place. Image: GreenBlue Urban



Section diagram through Crossrail place. Image: Foster + Partners, Canary Wharf Group

Case studies

Teardrop Park, Battery Park City, NY

Designers:	Michael Van Valkenburgh Associates
Scale:	0.72 ha
Client:	Hugh L. Carey Battery Park City Authority
Year:	2004

Summary

Teardrop Park is a 1.8-acre public park in lower Manhattan that transcends its small size, shady environment and mid-block location through bold topography, complex irregular space, and robust plantings. Design and construction were coordinated with the development of four surrounding apartment buildings ranging from 64m to 71m in height. The site had no existing soil, so all planting soil was imported. Special bracing allowed concrete to be installed before soils, which prevented compaction of adjacent planting beds.

Soil depths and formulas were calibrated for each planting condition at Teardrop Park. Lawns have 450mm of compaction-resistant soil while plant beds have 900mm deep, more organic soil.

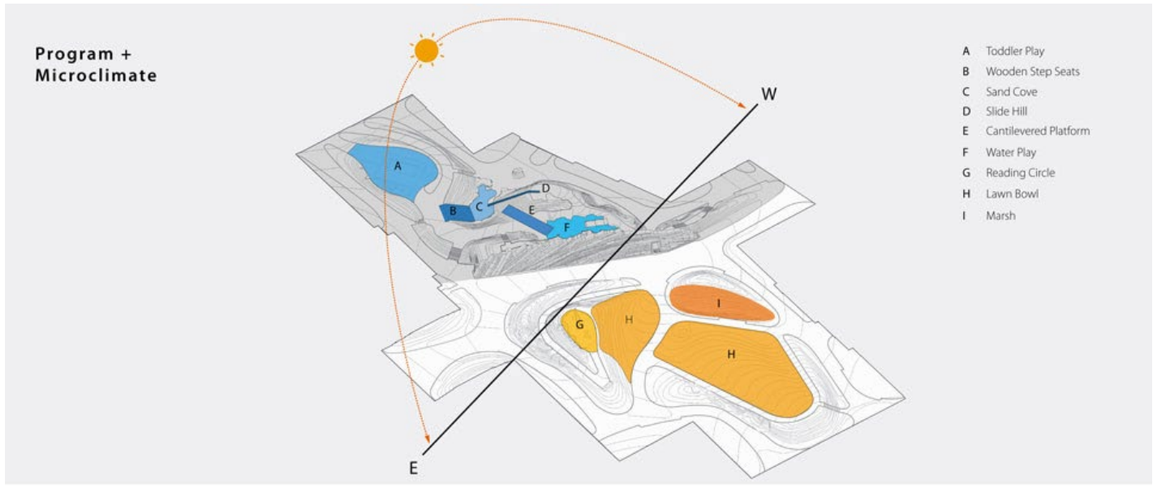
The project achieved 99.5% establishment of the 3,260 woody trees and shrubs by calibrating manufactured soils in factors such as load bearing capacity, water retention, drainage and nutrient levels. Treated and recycled greywater from the adjacent LEED Gold-rated Solaire Building and stormwater runoff from the site are captured in an underground storage pipe, supplying all of the park's irrigation needs.

Key Transferable Principles

- Design soil media to support tree and plant health.
- Consider soil volume, depth and extent to suit lawn, planting beds and trees.
- Coordinate requirements for healthy plants with requirements for surrounding buildings.
- Consider recycled water for irrigation.
- Design responds to microclimate by use of deciduous trees, shaded groves and open sunny lawns.

Teardrop Park turf area and rolling landform. Image: MVVA

Case studies



Diagrams of Program, microclimate, constructed geology and topography: MVVA

Aerial photograph of Teardrop Park. Image: MVVA

Construction of the mounded landform. Image: MVVA

Teardrop Park turf landform surrounded by trees and planting. Image: Linda Corkery

Case studies

Monash University Western Precinct

Clayton, VIC

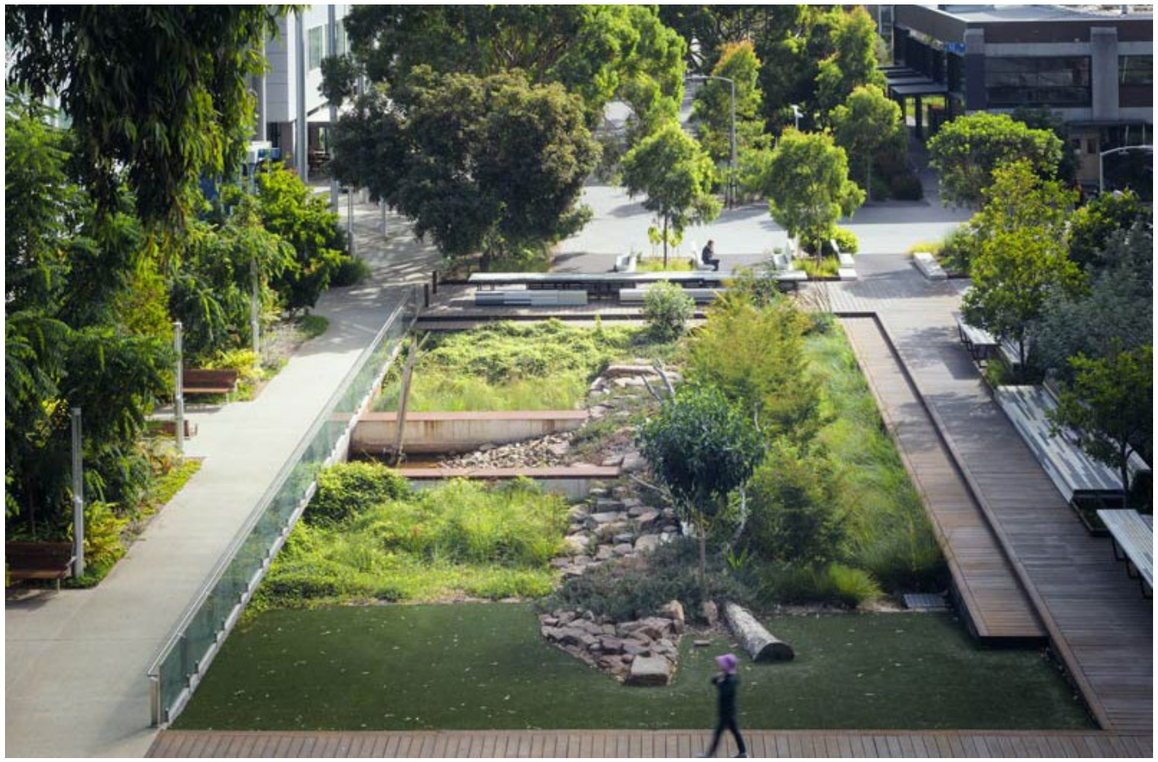
Designers:	Rush Wright Associates
Scale:	0.4 ha
Client:	Monash University
Year:	2015-2018

Summary

The project focuses on water conservation, resilience and sustainability featuring canopy-lined pedestrian walkways and inviting gathering spaces. A biobasin manages rainwater and runoff from adjacent roofs and adjoining paths. Wetland plants filter stormwater and an underground tank stores the treated results for reuse.

Key Transferable Principles

- Use garden beds and tree pits to manage and filter on site stormwater, consider demonstration gardens for WSUD.
- Use diverse native species to create a clear sense of place.
- Strong avenues of trees to define pedestrian pathways
- Combination of clear sightlines and pockets of layered vegetation to encourage biodiversity and define different zones.



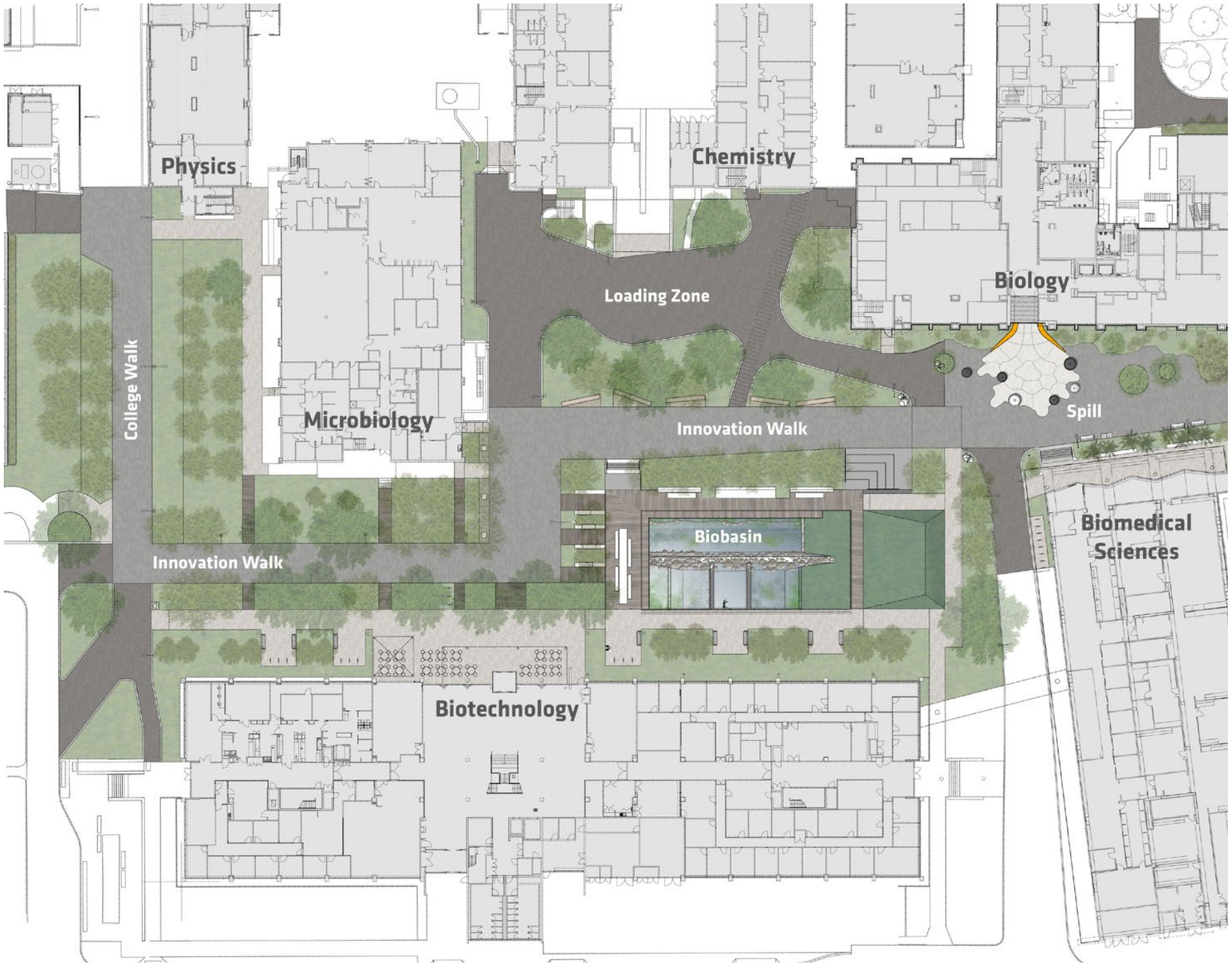
Biobasin to manage stormwater. Image: John Gollings

Seating and gathering areas. Image: John Gollings

Case studies

Avenue with trees and planting either side. Image: John Gollings

Avenue with trees and planting either side. Image: John Gollings



Plan. Source Rush Wright Associates

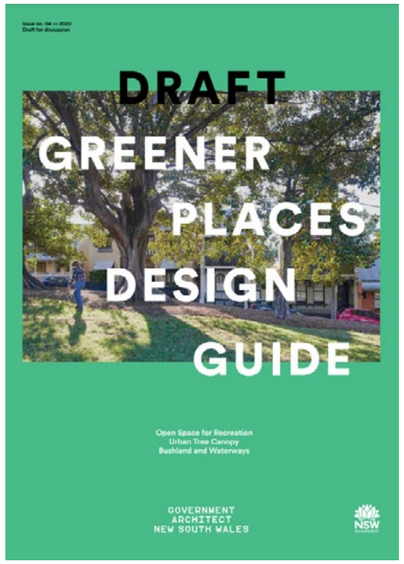
A

Appendix

A.1 Document Reviews

Greener Places Design Guide

Issue no. 4- 2020



Design Considerations for CPRP:

Open Space for Recreation
Use the Accessibility, Distribution and Size and Shape metrics to guide suitable size and location of open spaces.

Urban Tree Canopy
Use the targets for the Greater Sydney Region of **40% urban tree canopy cover by 2056** as a guide for the project. This should be considered together with City of Sydney canopy targets.

Bushland and Waterways
Create new ecosystems and habitat linkages within the open space network. This should be considered together with City of Sydney Urban Ecology Plan. Link ecological elements including WSUD, green roofs and multilayered ecological plantings. Design to connect people to nature and to connect urban habitats together.

Summary

The Green Places Design Guide provides guidance for the following three categories:

- Open Space for Recreation,
- Urban Tree Canopy
- Bushland and Waterways

Open Space for Recreation

Strategies for providing open space for recreation.

1. Improve the provision and diversity of open space
2. Understand the demands on existing open space and plan for open space in new and growing communities.
3. Improve the quality of open space for between parks and facilities
4. Use open space to connect people to nature
5. Link to the network of green infrastructure
6. Encourage physical activity by providing better parks and better amenity
7. Provide open space that is multifunctional and fit for purpose
8. Design versatile, flexible spaces
9. Consider life-cycle costs, management and maintenance

Open Space for Recreation Criteria

The following six criteria can guide the success of open spaces for recreation.

Accessibility and Connectivity

High-density areas > 60 dwellings/ha
2–3 minutes walk / 200 m walking distance to a local park (barrier free)

Medium-to low-density areas < 60 dwellings/ha
5 minutes walk / 400 m walking distance to a local park (barrier free)

District Parks
25 minutes walk / 2 km proximity to a district park

Regional Parks
Up to 30 minutes travel time on public transport or by vehicle to regional open space

Distribution

High-density areas
Size: 0.15–0.5 ha public open space
Distance: 200 m from most houses

Distance of open space from schools
Distance: 400 m

Distance of open space from workplaces
Distance: 400 m

Local distribution
Size: 0.3–2 ha public open space
Distance: 400 m from most houses

District distribution
Size: 2–5 ha public open space
Distance: 2 km from most houses

Regional/metropolitan distribution
Size: > 5 ha public open space
Distance: 5–10 km from most houses

Size and Shape

High-density areas – the minimum size of a local park is 3000 m2. In high-density areas, parks are sometimes as small as 1500 m2.

Smaller spaces can provide local amenity but are not adequate for a diverse range of recreational needs. Smaller parks need to be supported by larger open spaces in the network.

Medium to low density areas – the minimum size of a local park is 5000–7000 m2. Road frontage and visibility are key considerations, especially in high-density areas so open space is accessible for all.

Sporting facilities have specific size and shape requirements that need to be met to provide functional space for their use.

Quantity

In low-and high-density areas, good provision of public open space is essential to compensate for the lack of private open space to support active living and contribute to a more liveable neighbourhood.

Quantity should be considered in the number of opportunities available. Larger public open space areas mean more opportunities can be provided in one location.

High-density areas with high numbers of non-resident users – typically new mixed-use developments with both high-density residential and significant commercial or retail development. The non-residential uses can generate a substantial daytime population of workers which adds to demand for open space for recreation. Demand from non-resident population can be estimated as 10% of the anticipated resident population.

General capacity measures for existing open space under investigation
Small and local parks are deemed to be at capacity if more than 1500 residents to 5000 m2 of parkland are within 500m.

Outdoor sporting land supply would be deemed to be at capacity if the ratio of residential population to area of public sporting land exceeded a rate of 1000 people/ha.

Quality

Open space needs to be strategically planned and designed to create a quality open space network. High quality parks is just as important as adequate quantity.

Diversity

Provision of a diverse range of recreation opportunities reflects the diversity of the community. Diversity is important not just in the range of activities but in the settings that create the spaces and places for these activities. Within any urban area, the public open space network should offer both a range of landscape settings for activity and a range of activities.

Document Reviews

Urban Tree Canopy

Urban trees have a critical role in creating healthy cities. They provide shade and shelter, improve air quality, absorb carbon and rainfall, cool local environments, and support wildlife. Trees provide economic, health and wellbeing, biodiversity and environmental benefits.

Urban Tree Canopy Strategies

1. Protect, maintain, and enhance the existing urban tree canopy
2. Create an interconnected urban tree canopy across NSW
3. Build knowledge and awareness of urban tree canopy across State and local government, and the community

Urban Tree Canopy Targets

The target for the Greater Sydney Region is to achieve **40% urban tree canopy cover by 2056**.

The percentages in figure 2, right, are indicative place based tree canopy targets based on urban conditions. These are informed by City of Sydney, City of Melbourne and Greater Sydney Commission targets.

Global and national tree canopy targets

TREE CANOPY TARGETS	EXISTING TREE CANOPY COVER	URBAN TREE CANOPY TARGET	TARGET DATE	CLIMATE (KOPPEN CLASSIFICATION)
NATIONAL CITY* TARGETS				
Melbourne	22% (2017)	40%	2040	Marine west coast
Adelaide	27.8 % (2017)	>30%: 20% increase <30%: no net loss	2045	Mediterranean
Perth	19% (2016)	30%	2036	Mediterranean
INTERNATIONAL CITY TARGETS				
Toronto, CA	27% (2008)	40%	2060	Humid continental
Washington DC, USA	35% (2009)	40%	2029	Humid subtropical
Detroit, USA	22% (2008)	40%	N/A	Hot summer continental
New York, USA	24% (2006)	30%	2036	Humid subtropical
London, UK	20% (2008)	30%	2050	Marine west coast

Fig 1: Global and national tree canopy cover and targets

Fig 2: Indicative place-based targets

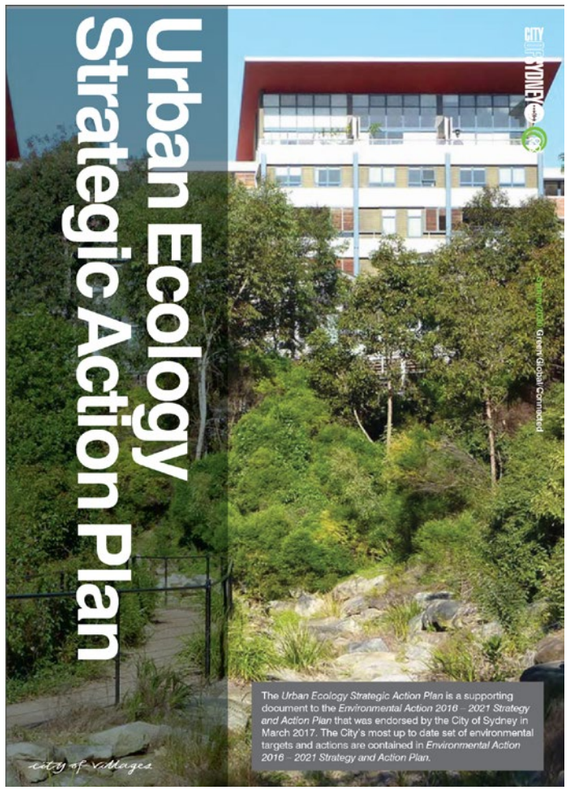
Bushland and Waterways

Five key strategies have been developed to connect, protect, restore, enhance, and create urban habitat as an integral part of how urban areas are planned, constructed, and maintained. The strategies apply to remnant, transition, and urban environments that provide connections between core habitat. This approach recognises the important role of integrating nature into urban areas and the lives of people, not just protecting selected sites and landscapes.

1. Protect and conserve ecological values
2. Restore disturbed ecosystems to enhance ecological value and function
3. Create new ecosystems
4. Connect people to nature
5. Connect urban habitats

Document Reviews

Urban Ecology Strategic Action Plan



Urban Ecology Targets Summary

The targets required to achieve the City's vision for the Plan have been grouped into the following three categories:

Locally Indigenous Vegetation

Area of naturally occurring vegetation maintained or increased from 2012 baseline of 2.7 hectares by 2023

- Area of bush restoration sites increased by 100 percent from 2012 baseline of 4.2 hectares by 2023
- Bush restoration sites characterised by well established, structurally complex vegetation, free of weeds by 2023

Representative patches of at least three of the likely original vegetation communities established by 2023

Fauna

Indigenous fauna species diversity maintained or increased by 2023 based on 2012 baseline.

Priority fauna species recorded from greater number of locations and in higher numbers compared to 2012 baseline by 2023

Habitat Connectivity

Progressive increase in number of habitat features for priority fauna species established along potential habitat linkages by 2023.

Urban Ecology Methodology

An Urban Ecology Survey was undertaken, which comprised:

1. A review of existing information;
2. Flora and fauna surveys, vegetation mapping and habitat assessment;
3. Community consultation;
4. Identification of priority sites, supporting sites and priority fauna species;
5. Identification of potential habitat linkages across the LGA and between adjacent LGAs; and
6. Identification of threats to biodiversity within the LGA.

Priority Sites

From this information a number of key sites were established in correlation with conducted surveys to identify priority sites and fauna species within the LGA. The 6 priority sites across the LGA are :

Sydney Park, Glebe Foreshore Walk East to Orphan School Creek, **Pyrmont** (sandstone cliffs and outcrops and bush restoration sites), The **Royal Botanic Gardens** and **Domain, Garden Island** and **Moore Park**

Central Station is part of key linkage corridors between all of these priority sites and presents an opportunity to support all of these communities.

Flora

Vegetation representative of five recognisable communities with naturally occurring species, were identified in the LGA:

Design Considerations for CPRP:

Design ecological communities to support existing remnant communities including; Sydney Turpentine Ironbark Forest, Coastal Swamp/Alluvial Forest and Coastal Sandstone Outcrop Complex.

Create structurally complex and diverse understorey habitat that connect potential habitat linkages. These communities support small native birds and encourage foraging and habitat.

Plant diverse tree species including Eucalyptus, Corymbia, and Angophora species together with the understorey planting.

Design elements to consider habitat opportunities for Priority Fauna Species.

Improve habitat for the 17 known species of microbat, including the Gould's Wattled Bat, the Eastern Freetail Bat, and Little Forest Bat and the Eastern Bent-Wing Bat.

Document Reviews

Objectives and targets

In order to achieve the City's vision for the Plan, a series of objectives and targets have been developed, as outlined in Table A.

Table A Urban Ecology Strategic Action Plan objectives, targets, and monitoring requirements

Category	Objectives	Targets
Locally indigenous vegetation	Protect, expand and improve condition of naturally occurring locally indigenous vegetation, including possible remnants	• Area of naturally occurring vegetation maintained or increased from 2012 baseline of 2.7 hectares by 2023 • Naturally occurring vegetation in good condition by 2023
	Increase the extent of bush restoration sites across the LGA, and maintain sites in good condition	• Area of bush restoration sites increased by 100 per cent from 2012 baseline of 4.2 hectares by 2023 • Bush restoration sites characterised by well-established, structurally complex vegetation, free of weeds by 2023
	Re-establish representative patches of the likely original vegetation communities	Representative patches of at least three likely original vegetation communities established by 2024
Fauna	Protect and enhance sites that provide habitat for priority fauna species	Indigenous fauna species diversity maintained or increased by 2023 based on 2012 baseline
	Increase the distribution and abundance of priority fauna species across the LGA	Priority fauna species recorded from greater number of locations and in higher numbers compared to 2012 baseline by 2023
Habitat connectivity	Improve habitat connectivity across the LGA, particularly between priority sites, and between identified habitat areas in adjoining LGAs	Progressive increase in number of habitat features for priority fauna species established along potential habitat linkages by 2023

- **Sydney Turpentine Ironbark Forest** – possible remnant trees;
- **Coastal Saltmarsh** – planted and naturally regenerating patches;
- **Coastal Swamp/Alluvial Forest** – possible remnant trees;
- **Mangrove Forest** – planted and naturally regenerating trees;
- **Coastal Sandstone Outcrop Complex** – possible remnants and other naturally occurring species; and
- **Freshwater Wetlands** – vegetated constructed wetlands/ponds.

Several bush restoration sites and other plantings comprising indigenous/mostly indigenous species were also mapped.

All of the above are of conservation significance. Sydney Turpentine Ironbark Forest, Coastal Saltmarsh and Coastal Swamp/Alluvial Forest are of particular significance as they are representative of endangered ecological communities.

Fauna

A total of 99 fauna species was confirmed in the LGA, comprising 87 indigenous species and 12 introduced species. The total comprises:

- 70 bird species, including seven introduced species;
- 13 mammal species (with an additional two unconfirmed), including five introduced species;
- 11 reptile species; and
- Five frog species.

Priority Fauna Species

There are eight (8) priority fauna species/groups identified in the LGA, including all of the threatened species, as well as the species that were recorded in small numbers and at a small number of sites, and that are generally uncommon in urban areas. The priority species are:

- **Frogs:** the Green and Golden Bell Frog and other frogs such as the Eastern Dwarf Tree Frog and Perons Tree Frog;
- **Microbats** such as Gould's Wattled Bat, Eastern Freetail Bat, and Little Forest Bat;
- **Small birds** such as the Superb Fairy-wren, New Holland Honeyeater and Silvereye;
- **Freshwater wetland birds** such as the Australian Reedwarbler, Black-fronted Dotterel, Black-winged Stilt, Buffbanded Rail and Royal Spoonbill; and
- **Reptiles** such as the Eastern Blue-tongue, Bar-sided Skink and Gully Skink.
- Grey-headed Flying-fox;
- Powerful Owl;
- Long-nosed Bandicoot;

Document Reviews

Urban Ecology Strategic Action Plan (cont.)

Priority Species Relevant Actions

Below are a selection of relevant actions for the CPRP project, drawn from the report for each of the priority species.

Small birds

1. The area of structurally complex and diverse understorey habitat will be maximised, particularly at priority sites, supporting sites and along and near potential habitat linkages, using species from the likely original vegetation communities.

2. Wherever possible, round or squarish rather than long, thin habitat patches will be created to provide a more protected, 'core' area of habitat.

4. Small bird-friendly habitat planting will be encouraged ... particularly at sites along and near potential habitat linkages, and this will be reinforced by the Landscape Code.

7. Understorey planting, including bipinnate Acacia species, will be encouraged under isolated trees or lines of trees, particularly Eucalyptus, Corymbia, and Angophora species, to assist small birds avoid the Noisy Miner and other aggressive and/or predatory birds.

8. Planting of large-flowering plants, including Grevillea hybrids, and of soft-fruiting plants will be avoided at habitat planting sites.

Frogs

2. Installation of new ponds with ability to be drained and with fine mesh screens at inlets and outlets to prevent Mosquito Fish access will be investigated at Sydney Park and City-managed parks in Rosebery, and implemented if practicable.

7. Freshwater wetlands, ponds, raingardens and other frog-friendly water-sensitive urban design features vegetated with appropriate species will be constructed wherever possible in City-managed parks and streetscapes, and similar features will be encouraged in new developments and on land managed by others.

Microbats

1. Microbat roost boxes will be installed at a selection of sites, with a focus on riparian areas, the largest areas of indigenous vegetation, and parts of the LGA in which original soils were shale-derived (indicated by Blacktown soil landscape in Figure 5), and with design and placement to be based on advice from a bat specialist.

6. Increased understorey planting as specified for small birds will also be undertaken to improve the extent and diversity of foraging habitat for microbats.

7. Dark corridors will be investigated in sites that are feasible e.g. Sydney Park and Federal Park, that are also connected with the potential habitat linkages (Figure 17).

Reptiles

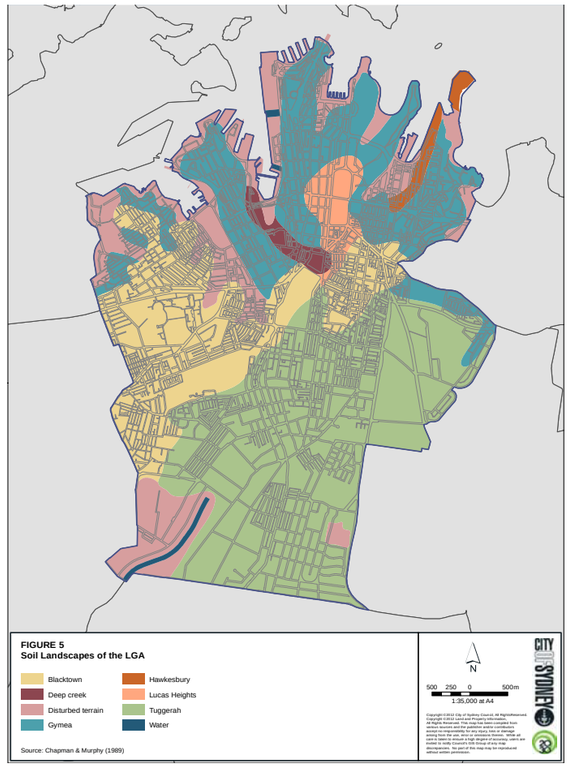
6. Reptile-friendly habitat features will be encouraged... particularly at sites along and near potential habitat linkages, and this will be reinforced by the Landscape Code.

Native Bees

The existing indigenous bee hive installation program will be continued at interested community gardens, and installation of indigenous bee hives at other sites will be encouraged.

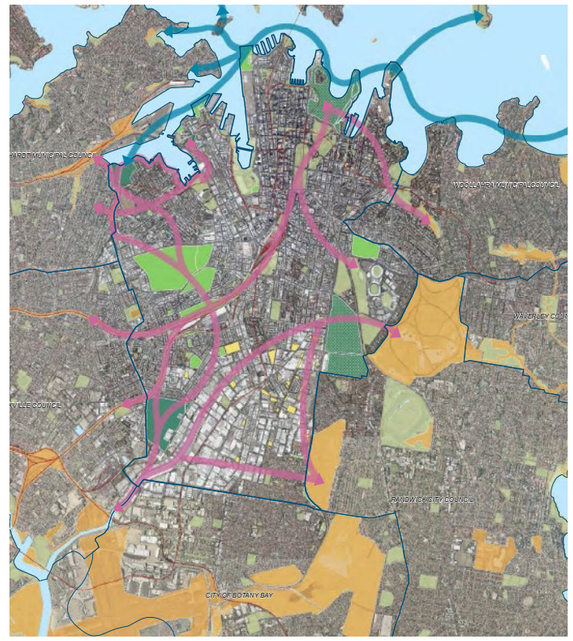
Birds of Prey

The potential to install a web-based camera will be investigated to enable Peregrine Falcon nesting activity to be observed by the community, should an active nest site be identified in the city centre where individuals are periodically reported.



Soil Landscapes of Sydney LGA

Central Station shown as Blacktown Soils (yellow), one of the preferred areas for Microbats



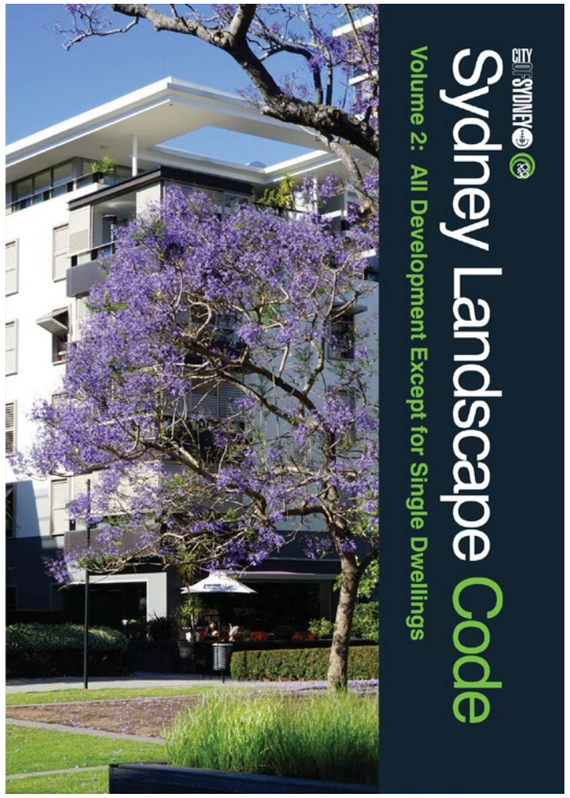
Potential Habitat Linkages

Central Station and rail corridor shown as a Potential Habitat Linkage (purple arrows) connecting to many of the Urban Ecology Priority Sites including Sydney Park, Moore Park, Hyde Park and RBG, and University of Sydney.

While it is unlikely that continuous habitat 'corridors' can be created along their full length, there is considerable potential to at least create 'stepping stones' of habitat along or in the vicinity of these potential habitat linkages to facilitate the movement of more mobile species across the landscape.

Document Reviews

Sydney Landscape Code



Design Considerations for CPRP:

Ensure the design meets the primary guidance requirements in the Landscape Code.

Summary

The Sydney Landscape Code provides guidance on the design of landscape spaces in private developments. The code provides design requirements including; Sustainability, Urban Canopy, Urban Ecology, Water Management, Circulation, Deep Soil, Landscapes on Structures, Setbacks and other more detailed requirements. The Code is intended as a guide in preparing landscape design for DA. Below summarises the primary guidance in each category, with further detail on each provided in the code.

Landscape Code Site Scale Primary Guidance

Sustainability
Demonstrate that your development is sustainable and has implemented initiatives that support the City's Sustainable Sydney 2030 vision.

Urban Canopy
Demonstrate that your proposal has met the SDCP required 15% canopy cover percentage and has located trees in appropriate locations.

Urban Ecology
Demonstrate that your proposal has considered the importance of providing vegetation for preserving, improving and creating habitat in urban areas.

Water Management
Demonstrate how your proposal manages, stores and treats storm water on site. Consider what system type is appropriate and how it will contribute to meeting the City's water management targets.

Site Planning and Circulation
Demonstrate that your development has incorporated a variety of usable landscape spaces and provides legible, safe circulation for occupants.

Deep Soil
Demonstrate that you have provided appropriately sized and located deep soil areas within your development.

Landscapes on Structures
Demonstrate that your proposal has incorporated set downs, soil depths and structural provisions to support planting.

Setbacks
Demonstrate how you have used the setback treatment of your development to create an attractive visual outlook and to improve the environmental viability of your development.

Accessibility
Demonstrate that your landscape proposal is accessible to people of all abilities.

Additional guidance is provided on detailed scale items including:
Amenity
Demonstrate that your proposal has provided adequate and appropriate amenity items in all landscape spaces.

Planting Selection
Demonstrate that you have selected plant species suitable for your site conditions and the scale of your development.

Soil Depth and Volume
Demonstrate that the soil proposed in your design is fit for purpose and complies with minimum depth and volume requirements. (Using ADG guide calculations)

Green Roofs
Demonstrate that your proposal specifies a green roof or wall system that is appropriate for your site. It should utilise appropriate plant species and incorporate ongoing maintenance systems.

Entries
Demonstrate how landscape has defined and reinforced visual hierarchy and clarity of all entry points to your development including to private and communal courtyards, lobbies, and vehicular entries.

Vehicle Access
Demonstrate that landscape has been used to promote pedestrian safety and minimise visual dominance of vehicle access ways within your development.

Materials
Demonstrate that your proposal uses appropriate materials for each application and meets the requirements of use, aesthetics, privacy, safety, maintenance and sustainability.

Maintenance, Lighting and Irrigation
Demonstrate appropriate and efficient strategies for each of the above.

Also included are the below relevant commercial specific requirements:
Site Planning
Demonstrate that you have incorporated a range of integrated, functional and well connected landscape spaces into your site and have addressed environmental and social requirements of your development.

Private Open Space
Demonstrate how you have integrated flexible and accessible private open space within your development.

Surface Carparks
Demonstrate that your surface car park is environmentally sensitive, safe and functional.

Document Reviews

Greening Sydney Strategy

Canopy Targets for the City of Sydney:

The minimum overall green target for the city is 40 per cent, including an overall canopy target of 27%.

- **streets** provide 39% green cover with a minimum 34% canopy cover
- **parks** provide 86 per cent green cover with a minimum of 46 per cent canopy cover
- **property** areas provide 28 per cent green cover with a minimum of 20 per cent canopy cover
- The City of Sydney have more detailed targets for specific land use types in order to reach these average targets, as described in the Urban Forest Chapter.

Principles:

1. Turn grey to green
2. Greening for all
3. Cool and Calm Spaces
4. Greener buildings
5. Nature in the city
6. Greening together

Intent in Relation to CPRP:

The revised 'Greening Sydney Strategy' document presents a more community oriented outcome, and is subsequently indistinct in its intentions for large-scale commercial developments. It is currently unclear how developments should interpret canopy targets when they may tend to sit across the designated land-use themes.

However, this is partially recognised, with indications toward further developments of the strategy to include a 'green factor score' to encourage more difficult sites to reach greening outcomes including through the implementation of green roofs and walls. This is intended for sites; "particularly where green cover is currently limited, such as in the CBD, commercial and industrial areas."(pg.56)

Document Reviews

Methodology

Urban local government areas differ in their capacity to accommodate tree canopy and greening. Analysis at such a fine scale allows for the data to be aggregated in many different ways, but for the purpose of setting greening and canopy targets it was summarised

under three broad land-use themes; being Streets, Parks, and Properties.

Streets:

Most street segments follow a conventional layout, with road pavement areas allowing movement of heavy traffic and roadside verge or nature strip areas between the road pavement and other land parcels being the space for typical street tree planting.

The optimal mature size of tree suitable for planting in each street segment was determined based on the available street verge width in accordance with the City's Street Tree Master Plan guidelines.

The formula assumes typical street segments have two single rows of trees and a 10m tree setback on approach to intersections. Tree spacing is proportional to the size of tree suitable for the street segment, and was equal to mature tree canopy diameter.

Parks:

Parks are parcels of land dedicated for public open space and recreation. A total of 421 parks covering a total of 401.7 hectares were assessed in this analysis, representing 15% of the city land area. They are owned and managed by a number of government agencies, including the City, the Royal Botanic Gardens and Domain Trust, Centennial Parklands, and Property NSW.

All parks were grouped into one of the following park types; iconic, neighbourhood, pocket, civic, sports field, or golf course. The relevant target percentages were applied to each park, with target canopy and greening areas calculated and summed to determine an overall target amount of canopy and greening area and percentage canopy and greening cover for the entire park land-use area of the city.

A survey was developed asking respondents to score each of the examples on a scale on 1 (least appropriate) to 5 (most appropriate) in terms of the amount of canopy cover being appropriate for the type of park. 46 responses to the survey were received. The survey results were used to consider and identify the most appropriate target for canopy cover for each park type.

Property:

For the purposes of this analysis, property was considered to be any land parcel not classified as a street or a park. They range from small single lot private residences through to large commercial CBD properties and large tracts of government owned land used for transport infrastructure or education. Analysis was undertaken to estimate the amount of

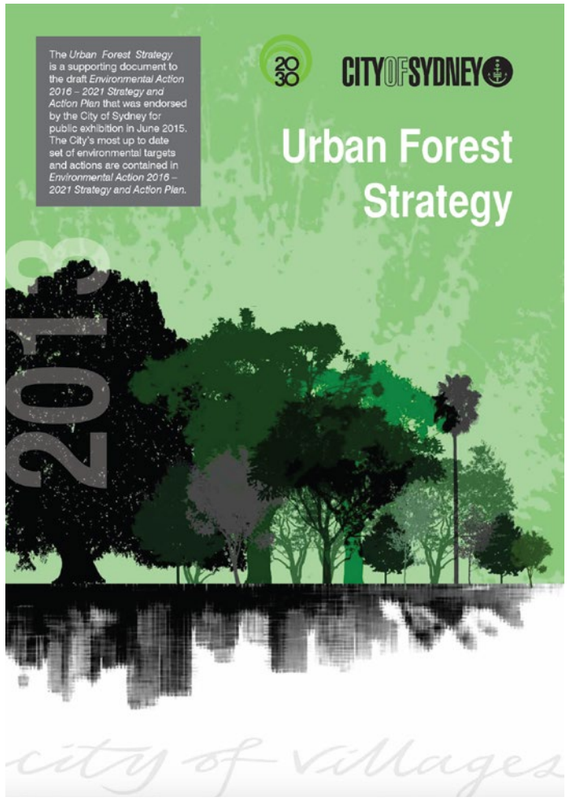
open space potentially available for tree planting within these land parcels. Data gathered from the City's floor space and employment survey was used to calculate an approximate building footprint area per land parcel, with the remaining unbuilt portion of each land parcel then used to assess the potential for tree canopy.

The above analysis for private land is based on a number of assumptions that make it less reliable than the capacity analysis used for the street land area. The analysis inaccurately assumes that any open space not occupied by a building is available for tree planting, and that tree canopy is unable to overhand buildings. It is also based on existing land development only, with no consideration for how properties may change or be developed in future.

Green Factor Score

A bias has been placed on the ability to retain and protect existing trees on private land in deep soil. The score favours the re-establishment of medium and larger trees. Where retention and tree planting cannot be achieved, only then are other greening options considered in the scoring. As a guide to designers, hierarchy of greening alternatives and benefits is provided on a sliding scale. These include installing green roofs, walls and permeable pavements amongst many other types of greening.

Document Reviews



Canopy Targets for the City of Sydney:

Increasing the existing coverage of 15.5% to:

- 2030: 22.3%
- 2050: 27.13%

Individual canopy targets for suburbs comprising CPRP:

- Haymarket : 15%
- Surry Hills: 25%
- Ultimo: 20%
- Chippendale: 15%
- CBD: 15%

Tree diversity spread should not exceed:

- Species: 10%
- Genus: 30%
- Family: 40%

Principles:

1. Prioritise the protection and maintenance the existing urban forest
2. Increase urban canopy cover to meet targets
3. Improve urban forest age spread of trees and diversity of species to increase
4. Engage and educate the community on the benefits of canopy coverage

Intent in Relation to CPRP:

This document breaks down each suburb within the City of Sydney LGA and identifies a reasonable canopy target for each, based on the land use type and planting opportunity. From this, it can be reasonably assumed a 15% mix of both green cover and canopy cover can be expected for the CPRP.

Two case studies are used to establish that highly developed areas, similar to the CPRP, require certain concessions for their relative canopy coverage target due to the land area type. Specifically, the document identifies that Eveleigh can reach feasibly reach the required canopy target due to a large proportion of land being used for state rail infrastructure. It also establishes that Alexandria, an industrial area, will require the implementation of green roofs and walls to meet the requirements, as there is insufficient land to establish adequate tree coverage.

Document Reviews

Methodology:

Tree Canopy:

Firstly, a total land use breakdown was established by the City of Sydney to reveal 3 main land use types, **private property, roads** and **parks**.

To measure the canopy coverage of the LGA, a GIS study using aerial photography and LiDAR data of study area was measured. The proportion of land area occupied by the tree's crown of canopy when visualised from directly above. Two dimensional horizontal extent of the combined canopies on a given land area, expressed as a percentage of the total area covered.

An overall canopy coverage assessment reveals that **84.5% of the City has no canopy**.

A percentage breakdown of canopy coverage within streets, parks and private properties of each suburb identified that:

- Private property makes up **61.7% of the total land use and 6.6% of the canopy cover.**
- Roads make up **22.7% of the total land use and 4.9% of the canopy cover.**
- Parks make up **15.6% of the total land use and 4.1% of the canopy cover.**

Additionally, a breakdown of canopy cover by landuse was identified.

- **10.6**% of private property is cover by canopy.
- **21.5**% of roads are covered by canopy.
- **26**% of parks are covered by canopy.

Suburb Breakdown:

The data gathered from these assessments was used to create a selection of suburbs with varying degrees of canopy coverage to present as both examples of areas performing well, or areas which are under performing. This information was created to aid in the development of strategies for adding canopy to areas with lower than desired canopy coverage.

Suburbs with high canopy coverage, averaging over 20% included: Centennial Park, Forest Lodge, Erskineville, Surry Hills, Darlinghurst and Rushcutters Bay.

Suburbs with low canopy coverage, averaging less than 7-9% included: Millers Point, Pyrmont, Haymarket, Eveleigh and St Peters.

Tree Height Range and Age Class

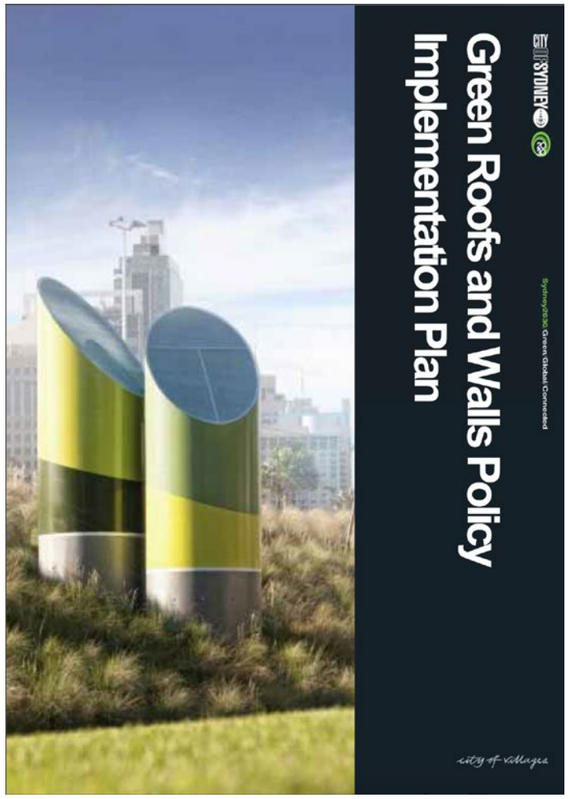
Finally, the vegetation height and age class were measured as a part of the data collection.

Height classification was broken down into 4 categories: >20m, 10-20m, 5-10m and 3-5m. The larger the tree, the larger the canopy coverage, and understanding which trees provide what benefits aids in determining which species to plant in certain locations. The findings reveal that the majority of the vegetation is with 5-20m in height, and 3.3% of vegetation is over 20m in height.

Trees were sorted into **age classes** in order to determine the overall spread of tree maturities across the LGA. A key objective for the CoS is to maintain a healthy spread of age classes to maintain a consistent canopy coverage, should an older generation need to be removed. Findings revealed that the city's park trees in particular are predominantly mature-age trees.

Document Reviews

Green Roofs and Walls Policy



Design Considerations for CPRP:

Where possible, green roofs and green walls should be included for their environmental, biodiversity and biophilic values.

Where urban tree canopy is not able to be provided the Urban Forest Strategy suggests green roofs should be provided to help make us for the reduced tree canopy.

Green Roof and Wall Policy Objectives

This policy outlines City of Sydney's objectives for Green Roofs and Green Walls (Green façades and Living Walls) policies. Their objectives include:

- Providing leadership in supporting the development of green roofs and walls.
- Addressing barriers to the adoption of green roof and wall technology.
- Supporting sustainable design through research, education, guidelines and standards.
- Collaborating with community, industry and other stakeholders.
- Informing and educating the community about green roofs and walls.
- Supporting local, practical research.
- Supporting the recognition of green roofs and walls in existing planning systems and rating tools.
- Installing green roofs and walls on Council properties.
- Monitoring, evaluating and reporting on progress.

Green Roof Benefits

Green Roofs can provide many benefits for development and the broader community. These benefits include:

- extra space for urban greening, food production and private open space
- slow and cleaning stormwater
- reduce impacts of urban heat island effect
- improve air quality
- provide amenity and liveability
- increase the absorption of carbon dioxide
- create more habitat to support biodiversity
- improve building efficiency through heating, cooling and sound insulation;
- boost the efficiency of solar panels
- extend life of roof structures

Green Roof Sustainability Principles

Green roofs and walls need to be designed to:

- Minimise resource use;
- Maximise recycled or reusable products in their construction and use;
- Minimise water usage including incorporating sustainable water sources;
- Maximise longevity through appropriate design and maintenance regimes; and
- Minimise any potentially harmful impacts on the environment.

Green Roof Design Considerations

With good design underutilised roof and wall spaces can be used as green roofs. The key design considerations raised in the guide for green roofs include;

- Access
- Biodiversity
- Food Source Planting
- Noise Reduction and Insulation
- Privacy
- Safety
- Slope
- Soil Depth and Volume
- Solar and Wind Access
- Solar Panel Integration

Terminology

A green roof is vegetation covering at least 30% of available rooftop space that is, space which is not occupied by structures housing plant, equipment or stairway accesses.

Green walls are either free-standing or part of a building that is partially or completely covered with vegetation. The wall may incorporate soil and/or inorganic material as the growing medium. There are two main types of green wall: green façades and living walls.

The Urban Forest Strategy suggests that not all areas can contribute to canopy coverage in the same way. Planting trees where possible is recommended, however when it is not feasible to plant mature trees, green roofs should be used to help make up for the reduced canopy coverage. The Urban Forest Strategy refers to the Green Roof and Walls Policy when designing green roofs.

A2

Existing trees in Prince Alfred Park

Existing trees in Prince Alfred Park

Existing trees at Cleveland St entry

The existing fig trees in Prince Alfred Park are valuable mature fig trees which contribute to the character of the park and the streetscape.

The proposed paved entryway is located outside the extent of the tree canopies identified by the survey, and largely aligns with, or is further away than, the existing path.

Figure A3.1 shows a plan of the existing trees and proposed and existing paved areas.

An arborist report, along with tree protection measures will be developed during future stages of the project.

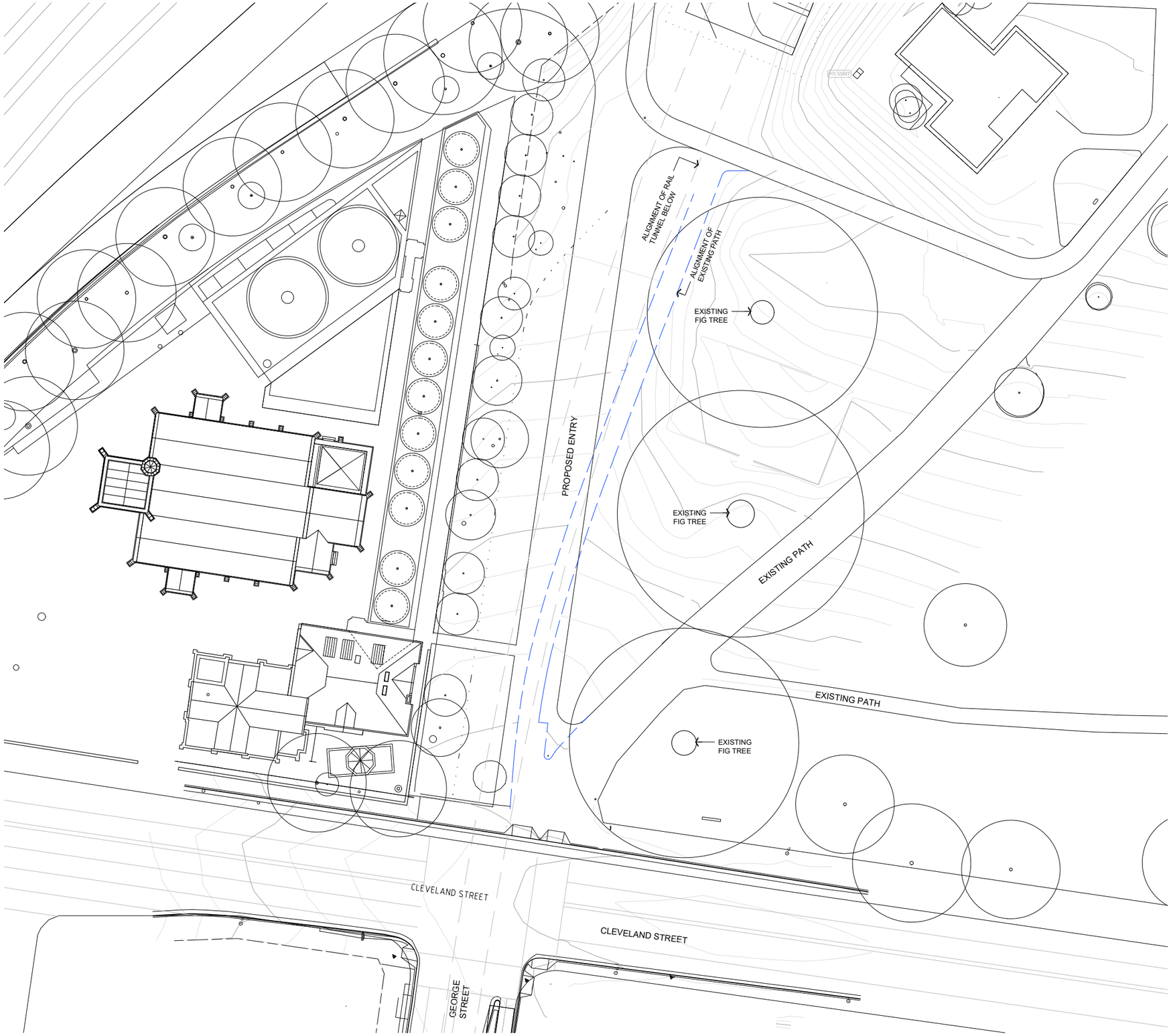


Fig. A3.1 Plan of existing trees at Cleveland St Entry

0 5m 10m 20m

1:500 @ A3

Existing trees in Prince Alfred Park

Fig. A3.2 Plan and aerial image of existing trees at Cleveland St Entry

0 5m 10m 20m

1:500 @ A3

Existing trees in Prince Alfred Park

Existing trees adjacent to Prince Alfred Sidings

The existing fig trees in Prince Alfred Park are valuable mature fig trees which contribute to the character of the park.

The proposed building footprint has been reduced at the southern end of the development parcel to retain the existing significant fig tree. An arborist report, along with tree protection measures will be developed during future stages of the project.

Fig. A3.3 Plan of existing trees adjacent to Prince Alfred Sidings

0 5m 10m 20m

1:500 @ A3

Existing trees in Prince Alfred Park

Fig. A3.4 Plan of existing trees adjacent to Prince Alfred Sidings

0 5m 10m 20m

1:500 @ A3

Central Precinct Renewal Program

A3

Ecological constraints and opportunities

Transport for NSW

Transport
for NSW

Central Precinct Renewal

Ecological Constraints and Opportunities

July 2022

NSW GOVERNMENT

transport.nsw.gov.au

Acknowledgement of Country

We respectfully acknowledge the Traditional Custodians of the Central Precinct, the Gadigal and recognise the importance of place to Aboriginal people and their continuing connection to Country and culture. We pay our respect to Elders past, present and emerging.

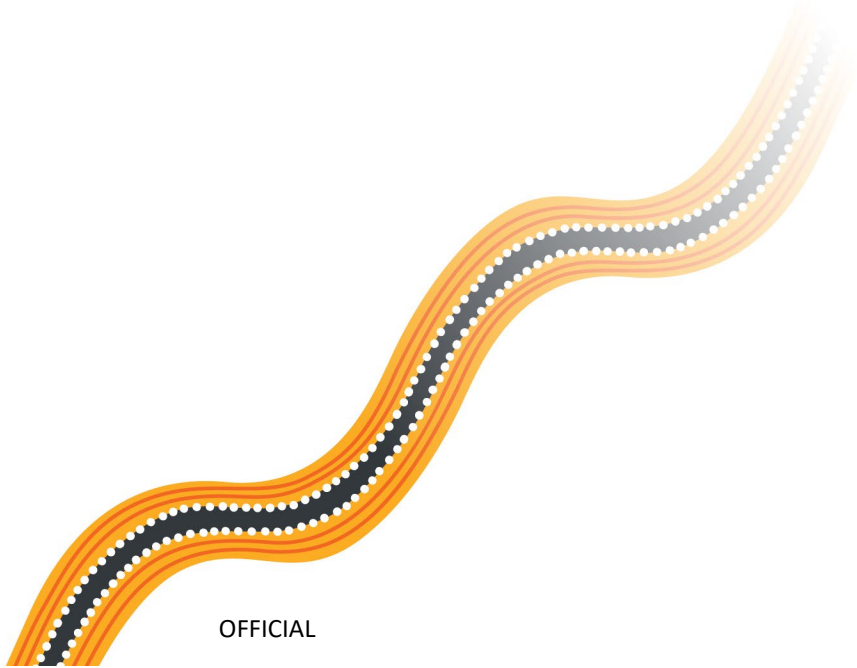


Table of Contents

Document control

Authors	EcoLogical
Approved by	Transport for NSW
Branch	IP Development
Division	Infrastructure and Place (IP)

Versions

Version	Amendment notes
0.1	Final for CPRP Public Exhibition 2022

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1. Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
BAM	Biodiversity assessment method
BAU	Business as usual
BCA	Building Code of Australia
BC Act	*Biodiversity Conservation Act 2016*
BDAR	Biodiversity development assessment report
BOS	Biodiversity offsets scheme
CIV	Capital investment value
CoS	City of Sydney Council
CPRP	Central Precinct Renewal Program
CSPS	Central Sydney Planning Strategy
CSSP	Central State Significant Precinct
DA	Development application
DAWE	Department of Agriculture, Water and the Environment
DCP	Development control plan
DPE	NSW Department of Planning and Environment
EP&A Act	*Environmental Planning and Assessment Act 1979*
EP&A Regulation	*Environmental Planning and Assessment Regulation 2000*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPI	Environmental planning instrument
ESD	Ecologically sustainable development
FFA	Flora and fauna assessment
FM Act	*Fisheries Management Act 1994*
FSR	Floor space ratio
GANSW	Government Architect NSW
GFA	Gross floor area
GIS	Geographic information system
GCC	Greater Cities Commission
KFH	Key fish habitat
LEP	Local environmental plan
LGA	The City of Sydney local government area
LSPS	Local strategic planning statement

Abbreviation	Definition
MNES	Matters of national environmental significance
NABERS	National Australian Built Environment Rating System
PCT	Plant community type
PRP	Project Review Panel
SAII	Serious and irreversible impact
SCA	Special character area
SDCP2012	Sydney Development Control Plan 2012
SDRP	State Design Review Panel
SEPP	State Environmental Planning Policy
SLEP2012	Sydney Local Environmental Plan 2012
SSDA	State significant development application
SSP	State Significant Precinct
TEC	Threatened ecological community
WM Act	*Water Management Act 2000*
WoNS	Weeds of National Significance

2. Definitions

Term	Definition
Accessibility	The ability for everyone, regardless of age, disability or special needs or where they live, to use and benefit from the transport system
Active transport	Transport that is human powered, such as walking or cycling
Amenity	The extent to which a place, experience or service is pleasant, attractive or comfortable. Improved features, facilities or services may contribute to increase amenity.
Bradfield Flying Junctions	Series of flyover tracks between the Cleveland Street bridge at Redfern and Central Stations that allow trains to move from any one line to another without crossing a line in the opposing direction
Bus interchange	Where customers have access to a number of different bus routes at a central location
Bus stand	A place to board or alight from bus services
Camperdown-Ultimo Collaboration Area	The Health and Education Precinct which includes the Royal Prince Alfred Hospital, TAFE NSW, University of Notre Dame, University of Sydney and University of Technology Sydney, and medical and research institutions and other health services facilities and educational establishments
Catchment	Area from which a location or service attracts people
CBD and South East Light Rail	means to the light rail network extending from Randwick and Kingsford to Circular Quay
Central Precinct	Central Precinct State Significant Precinct
Central Sydney	Land identified as Central Sydney under the Sydney Local Environmental Plan 2012 and represents the Metropolitan Centre of Sydney. Central Sydney includes Sydney's Central Business District
Central Walk	The underground paid pedestrian connection, currently under construction, that is to be delivered by Sydney Metro City and South West. Once complete, it will be a link between the new station entrance on Chalmers Street, the Eastern Suburbs Railway concourse, suburban platforms 16-23 (via escalators and lifts) and the new Sydney Metro north-south concourse
Character	The combination of the attributes, characteristics and qualities of a place (GANSW, 2021, Draft Urban Design Guide)
City Plan 2036	City of Sydney local strategic planning statement
Community	Particular types of stakeholder and refers to groups of people in particular places who are both affected by our work and experience the outcomes and benefits of our activities
Control	A numerical standard that is applied in a prescriptive manner
Corridor	A broad, linear geographical area between places
Council	The City of Sydney Council
Customer interface	The point at which transport services interact with their customer
Customers	Those who use transport networks and services. They include car drivers, heavy vehicle operators, public transport and point to point passengers, pedestrians, cyclists and freight and goods providers

Term	Definition
Department	The Department of Planning and Environment
Determination	The approval made in accordance with the *Environmental Planning and Assessment (EP&A) Act 1979*. In relation to Central Precinct SSP, a determination will be made by the Minister for Planning and Public Spaces
Devonshire Street Tunnel	The official name of the pedestrian tunnel connecting Chalmers and Lee Streets
District Plan	means the Eastern City District Plan
Future Transport Strategy	Transport for NSW's approach to planning transport and engaging customers, to address future technological, economic and social changes. Future Transport Strategy comprises two focus areas – planning ('Future Transport Planning') and technology ('Future Transport Technology' and 'Technology Roadmap')
Gateway	Cities that provide state level services and facilities to support a broad population catchment while also having international connections through their cities airport and/or port.
Goods Line	The official name for the partly elevated walkway from Central Station to Darling Harbour following the route of a disused railway line
Grand Concourse	Part of Central Station
Greater Sydney's Green Grid	The link between parks, open spaces, bushland and walking and cycling paths
Interchange	A facility to transfer from one mode of transport or one transport service to another. For example, a station with an adjoining light rail stop
Local streets	Places that are part of the fabric of suburban neighbourhoods where we live our lives and facilitate local community access
Merit based assessment	An assessment of a matter that allows for reasonable flexibility to consider a range of possible solutions
Minister	The Minister for Planning
Mixed-use	A building or area containing more than one type of land use
Mobility	The ability to move or be moved easily and without constraints
Mortuary Station	The building formerly used as a railway station on the Rookwood Cemetery railway line, now disused
NABERS	A national rating system that measures the environmental performance of Australian buildings and tenancies
Objective	A statement of a desired future outcome, generally expressed in a qualitative manner that enables merit based assessment
Over rail corridor development or Over Station Development	Development of air space over railway corridors
Place	An intersection of transport infrastructure with social infrastructure and commercial activity. These are the areas within and around transit stops where people live and commute. Places can be created as an outcome of Placemaking
Placemaking	Scoping and delivering places for the community, beyond the immediate transport infrastructure. Successful placemaking either

Term	Definition
	preserves or enhances the character of our public spaces, making them more accessible, attractive, comfortable and safe
Planning instrument	Means any of the following: • strategic plan (comprising regional strategic plans and district strategic plans) and local strategic planning statements • environmental planning instrument (comprising State environmental planning policies and local environmental plans) • development control plan
Planning Secretary	The Secretary of the Department of Planning
Precinct	Geographical area with boundaries determined by land use and other unique characteristics. For example, an area where there is an agglomeration of warehouses may be termed a freight precinct
Principal development standards	Matters addressed in Part 4 of the Standard Instrument
Proponent	Transport for NSW
Proposal	Proposed amendments to the planning framework
Provisions	means a broad term covering objectives and controls
Public spaces	means areas that are publicly accessible where people can interact with each other and make social connections
Rail network	means the rail infrastructure in NSW
Railway corridor	The land within Central Precinct on which a railway is built; comprising all property between property fences, or if no fences, everywhere within 15m from the outermost rails. Under planning legislation rail corridor is defined as land: a) that is owned, leased, managed or controlled by a public authority for the purpose of a railway or rail infrastructure facilities: or b) that is zoned under an environmental planning instrument predominately or solely for development of the purpose of a railway or rail infrastructure facilities
Railway Square	The area between Lee Street and Broadway, comprising a plaza, bus stands and underground access/uses
Reference Master Plan	A non-statutory document that shows one way in which the precinct may develop in the future in accordance with the proposed amendments to the planning framework Note: Refer to the GANSW Advisory Note v2, dated 12/09/2018 for further guidance
Region Plan	The Greater Sydney Region Plan - A Metropolis of Three Cities
Rezoning	Amendments to environmental planning instruments, in particular for land use zones and principal development standards such as height of buildings and floor space ratio
Shocks and stresses	The acute short term damaging events or long term trends causing inequity impacting a city's resilience
Siding	A short stretch of rail track used to store rolling stock or enable trains on the same line to pass
Social procurement	Purchasing decisions based on good social outcomes
Standard Instrument	The Standard Instrument—Principal Local Environmental Plan
State	The state of New South Wales

Term	Definition
State-led rezonings	A focus on precincts where there is a strategic imperative for the Department of Planning to lead the process, including places that benefit from current or future city-shaping infrastructure or investment, and where we can create great public spaces in collaboration with councils and communities. These rezonings generally occur under a SEPP
State Significant Precinct	The areas with state or regional planning significance because of their social, economic or environmental characteristics
Strategic Framework	The document prepared by Transport for NSW for Central Precinct in 2021 that addresses key matters including vision, priorities, public space, strategic connections, design excellence, identify sub-precincts for future detailed planning and also outlines the next steps in the State Significant Precinct process for Central Precinct
Strategic plan	The regional strategic plan, district strategic plan or a local strategic planning statement
Sub-precinct	The definable areas within Central Precinct SSP due to its unique local character, opportunities and constraints, either current or future. The Western Gateway is a sub-precinct
Sydney Metro	A fully-automated, high frequency rail network connecting Sydney
Tech Central	The State government initiative as set out in The Sydney Innovation and Technology Precinct Panel Report 2018. Tech Central is located south of the Sydney central business district, surrounded by the suburbs of Redfern, Ultimo, Haymarket, Camperdown, Chippendale, Darlington, Surry Hills and Eveleigh
Transport for NSW	The statutory authority of the New South Wales Government responsible for managing transport services in New South Wales.
Transport interchange	A facility designed for transitioning between different modes, such as a major bus stop or train station
Transport modes	The five public transport modes are metro, trains, buses, ferries and light rail. The two active transport modes are walking and cycling
Urban renewal	A planned approach to the improvement and rehabilitation of city areas with new infrastructure, new commercial/mixed uses, improved services and renovation or reconstruction of housing and public works
Vibrant streets / places	Places that have a high demand for movement as well as place with a need to balance different demands within available road space

3. Introduction

3.1 Background and purpose of this report

Transport for NSW (TfNSW) is leading the Central Precinct Renewal Program (CPRP), a state significant urban renewal program in the centre of Sydney. The program aims to revitalise disused areas of State-owned land into a technology and innovation precinct. The CPRP will improve biodiversity and liveability by developing green infrastructure featuring native species and ecological communities linked to other biodiverse areas across the City of Sydney Local Government Area (LGA).

The Central State Significant Precinct (from here referred to as the 'study area' or Central SSP) is located at the southern end of the Sydney Central Business District (CBD) (Figure 1). The study area comprises a 24 hectare corridor between Goulburn and Cleveland Streets, bordering Surry Hills, Haymarket, Chippendale, Ultimo and Redfern. The study area is, and will continue to be, a transport hub featuring Central Station's transport interchange and associated railway infrastructure.

This document aims to inform strategic planning of the Central SSP by:

describing existing biodiversity values in the study area

identifying biodiversity objectives, including design guidelines for protection and creation of habitat

outlining expected statutory requirements for more detailed ecological impact assessment.

3.2 What is biodiversity?

Biodiversity is defined in the NSW *Biodiversity Conservation Act 2016* as the variety of living animal and plant life from all sources and includes diversity within and between species and diversity of ecosystems. Biodiversity values include:

vegetation integrity—being the degree to which the composition, structure and function of vegetation at a particular site and the surrounding landscape has been altered from a near natural state

habitat suitability—being the degree to which the habitat needs of threatened species are present at a particular site.

The *Biodiversity Conservation Regulation 2017* prescribes additional biodiversity values as:

threatened species abundance—being the occurrence and abundance of threatened species or threatened ecological communities, or their habitat, at a particular site

vegetation abundance—being the occurrence and abundance of vegetation at a particular site

habitat connectivity—being the degree to which a particular site connects different areas of habitat of threatened species to facilitate the movement of those species across their range

threatened species movement—being the degree to which a particular site contributes to the movement of threatened species to maintain their lifecycle

flight path integrity—being the degree to which the flight paths of protected animals over a particular site are free from interference

water sustainability—being the degree to which water quality, water bodies and hydrological processes sustain threatened species and threatened ecological communities at a particular site.

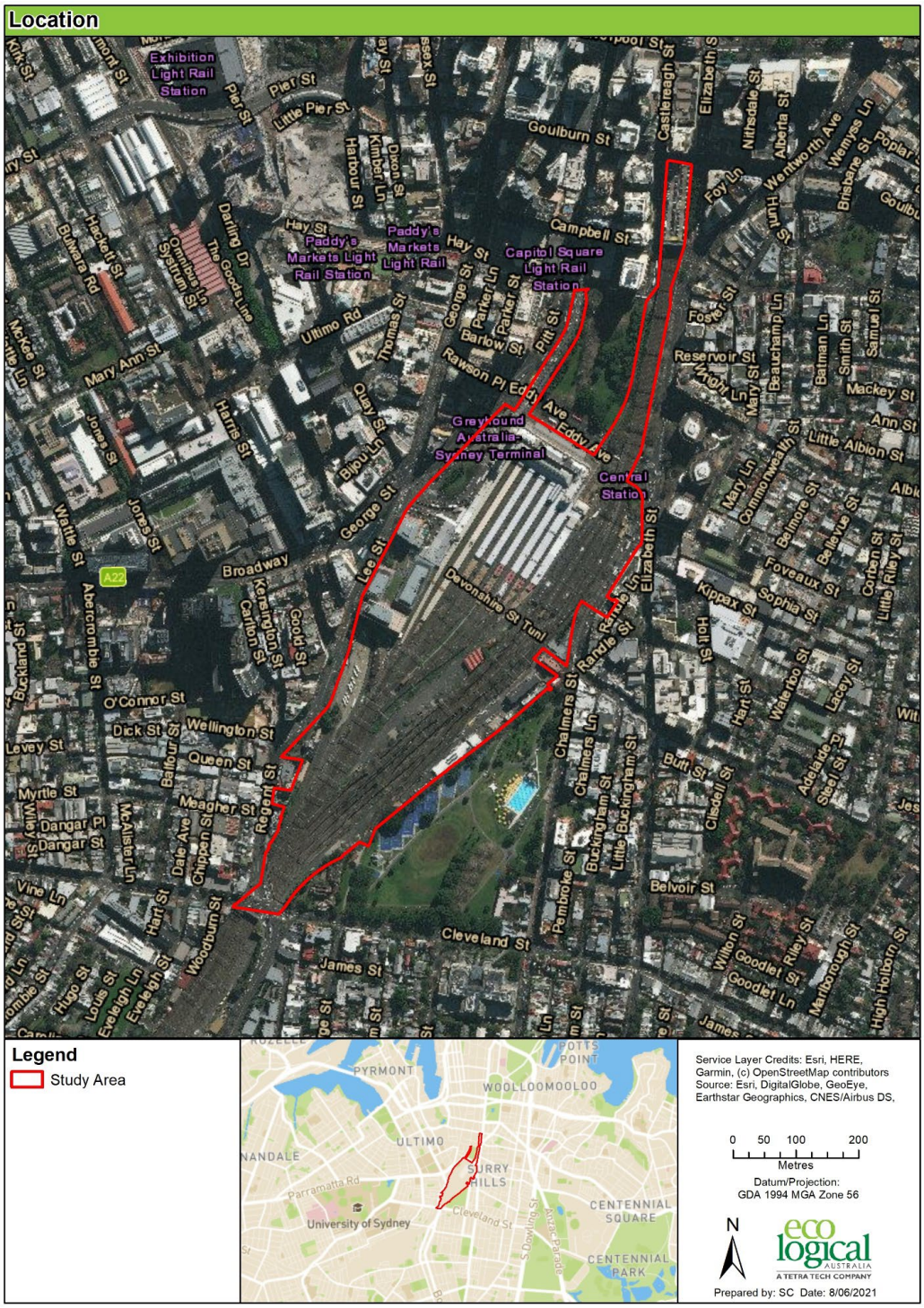


Figure 1: Central Precinct study area

4. Legislative and policy context

The legislative context relevant to the study area is presented in Table 1. This information helps to determine existing biodiversity values as well as requirements for detailed impact assessment at a later stage in the planning process.

Table 1: Legislative and policy context

Name	Relevance to the project
Commonwealth	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	The EPBC Act aims to protect Matters of National Environmental Significance (MNES) including wetlands of international importance, threatened species and communities and listed migratory species. An action that may or is likely to have a significant impact on MNES should be referred to the Commonwealth to determine whether it is a Controlled Action that requires approval from the Commonwealth. There are seven MNES that are triggers for Commonwealth assessment and approval. These are: • World Heritage properties • National Heritage places • Ramsar wetlands of international importance • Nationally threatened species and communities • Migratory species • Nuclear actions • Commonwealth marine environment. Threatened species and ecological communities are listed under Part 13, Division 1, Subdivision A of the EPBC Act. Migratory species are listed under Part 13, Division 2, Subdivision A of the Act. The study area provides potential habitat for MNES, including foraging and potential roost habitat for threatened species of microbats, and foraging habitat for *Pteropus poliocephalus* (Grey-headed Flying-fox), which is listed as vulnerable. The preparation of a Biodiversity Development Assessment Report (BDAR) will require assessments of significance for threatened species listed under the EPBC Act.
State	
Environmental Planning and Assessment Act 1979 (EP&A Act)	The EP&A Act is the principal planning legislation for NSW. It provides a framework for the overall environmental planning and assessment for precinct plans and development proposals. Amendments to the zones and planning controls for State Significant Precincts (SSP) can be made through a State Environmental Planning Policy (SEPP). This can be approved by the Minister for Planning for any matter that the Minister considers to be of state or regional planning significance under section 3.29 of the EP&A Act. The EP&A Act places a duty on the determining authority (such as the Department of Planning (DPE)) to adequately address a range of environmental matters including maintenance of biodiversity and the likely impact to threatened species, populations or ecological communities (under the BC Act – see below).
Biodiversity Conservation Act 2016 (BC Act)	Strategic planning objectives should be consistent with the overall purpose of the BC Act to "maintain a healthy, productive and resilient environment for the greatest well-being of the community, now and into the future, consistent with the principles of ecologically sustainable development". A BDAR or BDARs will be required as part of a State Significant Development application (or equivalent) to assess potential ecological impacts of proposed development within Central SSP. A detailed understanding of the proposed development is needed to undertake a BDAR. Ecological impacts must be avoided or mitigated where possible, otherwise any loss should be offset, and it is likely that DPIE will expect to see a proposal that would have an ecological improvement rather than just no net loss. Offsetting is the option of last resort.
Fisheries Management Act 1994 (FM Act)	The FM Act governs the management of fish and their habitat in NSW. The Schedules of the Act list key threatening processes and threatened species. The FM Act regulates the provision of permits required in relation to harm of protected marine vegetation

Name	Relevance to the project
	(seagrass, macroalgae, mangroves and saltmarsh), dredging, reclamation or obstruction of fish passage on or adjacent to Key Fish Habitat (KFH). This includes direct and indirect impacts, whether temporary or permanent. The study area does not include KFH although indirect impacts to Sydney Harbour waterways need to be considered.
Water Management Act 2000 (WM Act)	The WM Act provides for the sustainable and integrated management of the state's water for the benefit for both present and future generations. If a 'controlled activity' is proposed on 'waterfront land', an approval is required under the WM Act (s91). There is no waterfront land within the study area, however potential changes to groundwater volumes and flows, as well as impacts to groundwater dependent ecosystems, need to be considered once the proposed development scope is more clearly defined. This would be part of the environmental impact assessment for a State Significant Development application (or equivalent).
Biosecurity Act 2015	Under this Act, priority weeds have been identified for local government areas and assigned strategies to contain, remove or manage. Occupiers of land (this includes owners of land) have responsibility for taking appropriate action for priority weeds on the land they occupy. The field survey identified weeds listed as priority weeds in the Greater Sydney Regional Strategic Weed Management Plan 2017 – 2022. Strategies to replace weeds with suitable native species need to be considered.
Planning instruments	
State Environmental Planning Policy (State Significant Precincts) 2005	Aims of this policy include: • to facilitate the development, redevelopment or protection of important urban, coastal and regional sites of economic, environmental or social significance to the State so as to facilitate the orderly use, development or conservation of those State significant precincts for the benefit of the State, • to facilitate service delivery outcomes for a range of public services and to provide for the development of major sites for a public purpose or redevelopment of major sites no longer appropriate or suitable for public purposes.
Sydney Local Environmental Plan (LEP) 2012	The study area is currently zoned B8: Metropolitan Centre and SP2: Infrastructure, the objectives of which area to: B8 - • To recognise and provide for the pre-eminent role of business, office, retail, entertainment and tourist premises in Australia's participation in the global economy. • To provide opportunities for an intensity of land uses commensurate with Sydney's global status. • To permit a diversity of compatible land uses characteristic of Sydney's global status and that serve the workforce, visitors and wider community. • To encourage the use of alternatives to private motor vehicles, such as public transport, walking or cycling. • To promote uses with active street frontages on main streets and on streets in which buildings are used primarily (at street level) for the purposes of retail premises. SP2 - • To provide for infrastructure and related uses. • To prevent development that is not compatible with or that may detract from the provision of infrastructure.
Sydney Development Control Plan (DCP) 2012	The Sydney DCP contains provisions which relates to this development. Section 3.5.1 Biodiversity objectives are: (a) "Protect existing habitat features within and adjacent to development sites". (b) "Improve the diversity and abundance of locally indigenous flora and fauna species across the LGA".
Plans and policies	
Greener Places (NSW Government Architect 2020)	Greener Places defines green infrastructure as the network of green spaces, natural systems and semi-natural systems that supports sustainable communities and includes waterways; bushland; tree canopy and green ground cover; parks, and open spaces that

Name	Relevance to the project
	includes parks; and open spaces that are strategically planned, designed and managed to support a good quality of life in the urban environment. Well-designed green infrastructure responds to four key principles: • Integration - combine green infrastructure with urban development and grey infrastructure • Connectivity - create an interconnected network of open space • Multifunctionality - deliver multiple ecosystem services simultaneously • Participation - involve stakeholder in development and implementation.
City of Sydney	Strategies and plans developed by the City of Sydney include: • Environmental Action 2016-2021: Strategy and Action Plan (2017) • Greening Sydney Plan (2012) • Urban Ecology Strategic Action Plan (2014) • Urban Forest Strategy (2013) These documents recognise the benefits of urban biodiversity and provide the framework for creation of an urban forest and support for biodiversity across the City.

5. Existing biodiversity values

A desktop review and rapid field investigation found that the study area has low biodiversity value, although some areas provide potential habitat for threatened species.

5.1 Investigation methods

This assessment was not intended to provide an inventory of all species present across the study area or satisfy requirements for a BDAR. It provides an overall assessment of the ecological values of the study area and the potential for ecological enhancement. The survey was conducted with an emphasis on threatened species, key fauna habitat features, existing vegetation and potential for ecological enhancement.

Some species may not have been detected within the study area during the inspection as they may be cryptic or seasonal and only detectable during flowering or during breeding. In this case, the likelihood of their occurrence has been assessed based on the presence of potential habitat.

5.1.1 Literature and data review

The following literature and data sources were reviewed prior to undertaking the field survey:

NSW Government BioNet Vegetation Classification

NSW BioNet / Atlas of NSW Wildlife 5 km database search (accessed 8 June 2021)

Commonwealth Department of Agriculture, Water and the Environment (DAWE) Protected Matters Search Tool 5 km database search (accessed 18 June 2021)

Sydney Metropolitan Vegetation Map (OEH, 2016)

NSW Government ePlanning Spatial Viewer

Biodiversity Values Map and Threshold Tool

Additional Geographic Information Systems (GIS) datasets including soil, topography, geology and drainage.

A list of threatened species, either known or considered likely to occur, was compiled to guide the field survey methodology. Maps showing records of threatened species and communities were also prepared to inform the field survey.

5.1.2 Field survey

A rapid field survey assessing the ecological features of the area was undertaken by ecologists Julia Ryeland and James King on 17 June 2021. Weather was cool (maximum 18°C) and sunny with a slight breeze. The survey comprised:

validation of existing vegetation mapping to determine type, condition and extent within the study area

threatened flora and fauna habitat assessment

opportunistic fauna sightings

targeted microbat survey

identifying opportunities for improving ecological values.

The presence of threatened fauna species identified as having potential to occur in the study area was determined through a habitat assessment. Where important habitat features, such as hollow bearing trees, rocky outcrops, deep leaf litter, waterways or abandoned buildings were observed, their location was recorded using a handheld GPS unit. These GPS units can have errors in accuracy of 2-20 m subject to availability of satellites on the day.

Existing potential microbat habitat and opportunities for microbat habitat creation were a focus of the field investigation. A diurnal survey was conducted across the site to establish the presence of suitable roosting habitat and current usage of roosts by microbats. The site was traversed on foot during daylight hours, with the aid of ultrasonic detectors to record any calling microbats that might be roosting within the station or surrounding buildings.

5.2 Results

5.2.1 Vegetation communities and flora

Previous vegetation mapping by OEH (2016) identified one vegetation type within or near the study area, Urban Exotic/Native (Figure 2). This was validated during the field survey, which found mown grass areas, weeds and some planted exotics/natives. There were several areas that contained planted native species, but these did not correspond to a plant community type (PCT). Table 2 lists flora species recorded during field survey. No threatened flora species were recorded in the study area previously (Figure 3) or during the survey.

Table 2: Flora species recorded during field survey

Family	Scientific name	Common name	Native (N) / Exotic (E)
Apocynaceae	*Vinca major*	Periwinkle	E
Araliaceae	*Hedera helix*	English Ivy	E
Commelinaceae	*Tradescantia fluminensis*	Trad	E
Myrtaceae	*Eucalyptus* sp.	Gum	N
Sapindaceae	*Acer* sp.	Maple	E
Verbenaceae	*Lantana camara*	Lantana	E * (WoNS)

Key: PW = Priority Weed: * State Level, ** Regional Level, *** Other Weed of Regional Concern, WoNS = Weeds of National Significance.

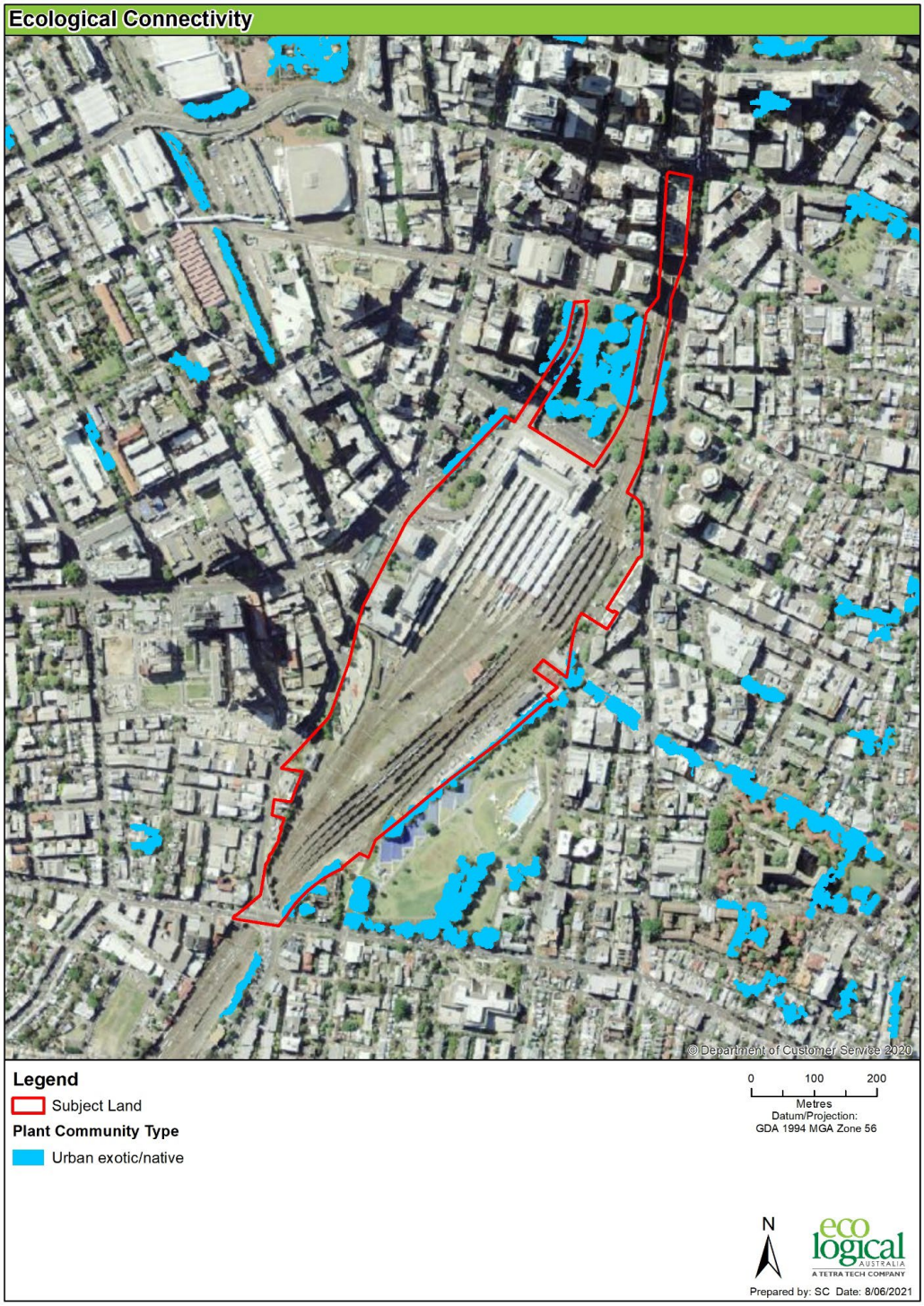


Figure 2: Vegetation communities (OEH 2016)

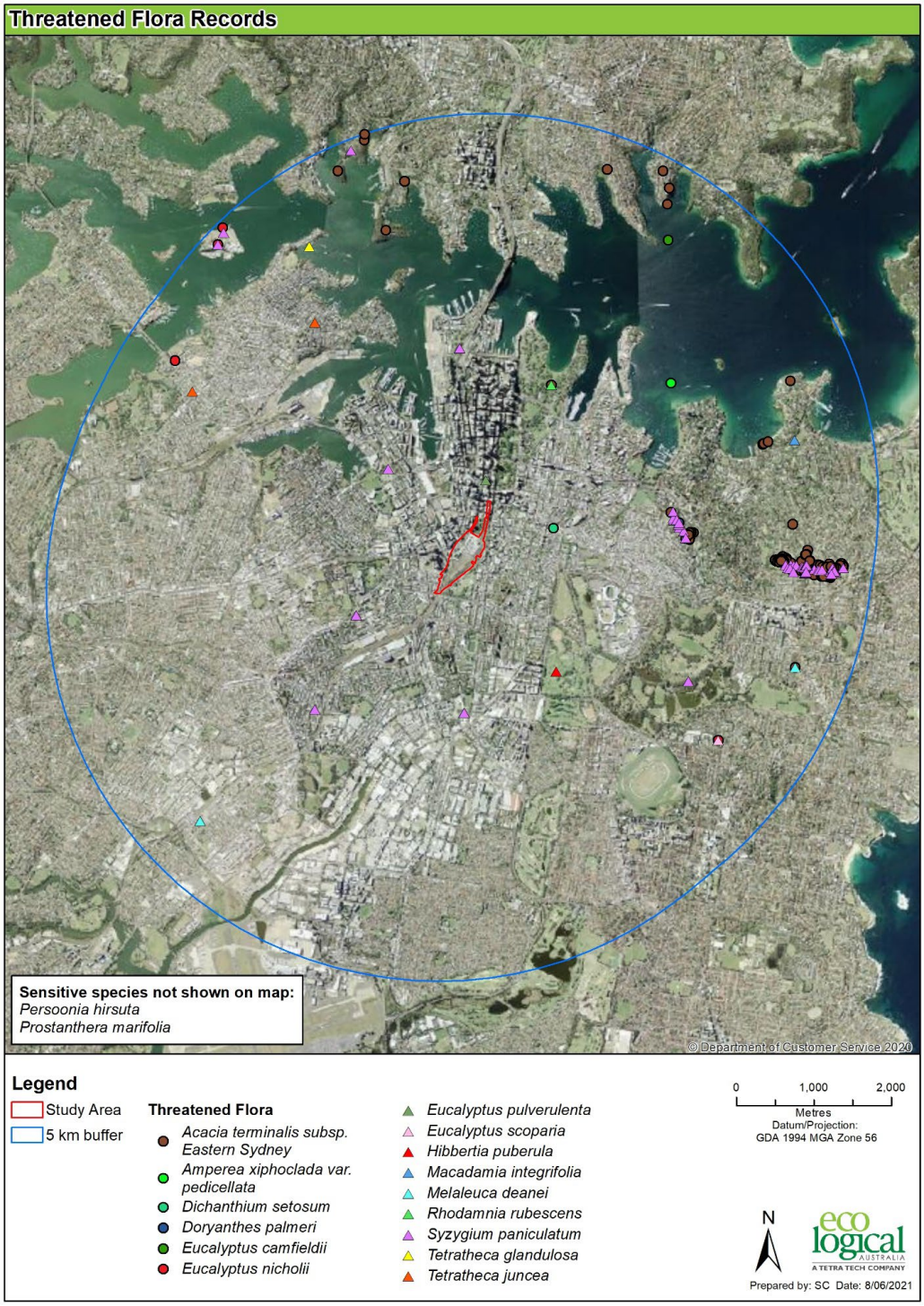


Figure 3: Threatened flora within a 5 km radius of the study area (Bionet 2021)

5.2.2 Fauna

Fauna species recorded during field survey are listed in Table 3. There were no previous records of threatened fauna within the study area (Figure 4) and no threatened fauna species were identified during field survey. However, *Pteropus poliocephalus* (Grey-headed Flying-fox (GHFF), which is listed as Vulnerable under the BC Act and EPBC Act) have previously been recorded near the study area (Figure 4). There is no GHFF camp near or within Central SSP and GHFF have a wide-range for foraging.

Table 3: Fauna species recorded during field survey

Class	Scientific name	Common name	Observation type
Aves	*Columba livia*	Rock Dove	Observed
Aves	*Corvus coronoides*	Australian Raven	Observed
Aves	*Hirundo neoxena*	Welcome Swallow	Observed
Aves	*Larus novaehollandiae*	Silver Gull	Observed
Aves	*Threskiornis moluccus*	Australian White Ibis	Observed

The study area currently offers very limited habitat for native species other than highly mobile birds and bats.

There were no important habitat features such as hollow bearing trees, subterranean termite mounds, rocky overhangs, rocky outcrops or water bodies. Disused/dilapidated buildings, tunnels and small crevices/holes in built structures as well as planted natives within the study area may provide habitat for six threatened microbat species identified as having the potential to occur or being likely to occur. Table 4 summarises the life history and ecology for these species, number of records within a 10 km radius of the subject site and assessment of the likelihood of occurrence in or around Central Station.

Figure 5 indicates the known and likely flyways that are preferred by microbats. Waterways, parks and bushland reserves are generally favoured because they provide good foraging habitat and unobstructed flight paths. It is not known if rail corridors are utilised as flyways.

No roosting microbats, signs of microbats (guano accumulation or stains from roosting microbats) or calls were recorded during the field survey. No tree hollows were present on site that would provide habitat for species known to roost in tree hollows (for example *S. flaviventris, M. macropus* or *M. norfolkensis*). However, many potential roost entry/exit locations were observed around the buildings which would require further surveying (including nocturnal surveys) to determine whether these are in current use.

Built areas accessible to the public generally have high levels of artificial light and noise so are unsuitable for microbats. However, several disused buildings and crevices within the rail corridor not accessible to the public may provide suitable roosting spaces for species that utilise built structures, such as *M. o. oceanensis* and *M. australis*. Additionally, there are likely roost sites that are more suitable than those observed in this study within disused subterranean tunnels. Disused tunnels and culverts provide optimal roost sites for subterranean roosting species, as these have low light and noise disturbance and often provide degraded roof surface from which microbats can attach upon during roosting (Richards, Hall and Parish 2012).

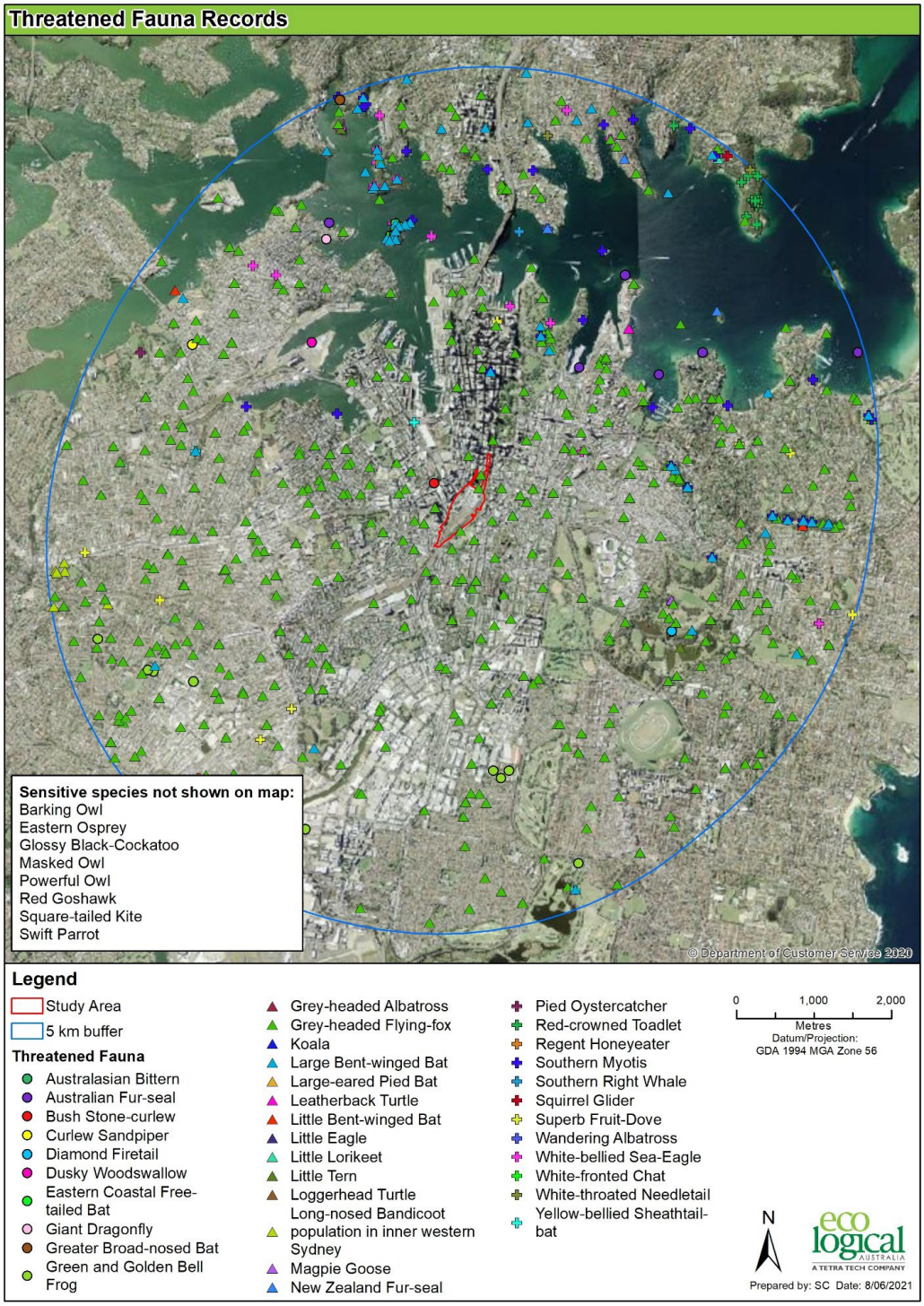


Figure 4: Threatened fauna within a 5 km radius of the study area (Bionet 2021)

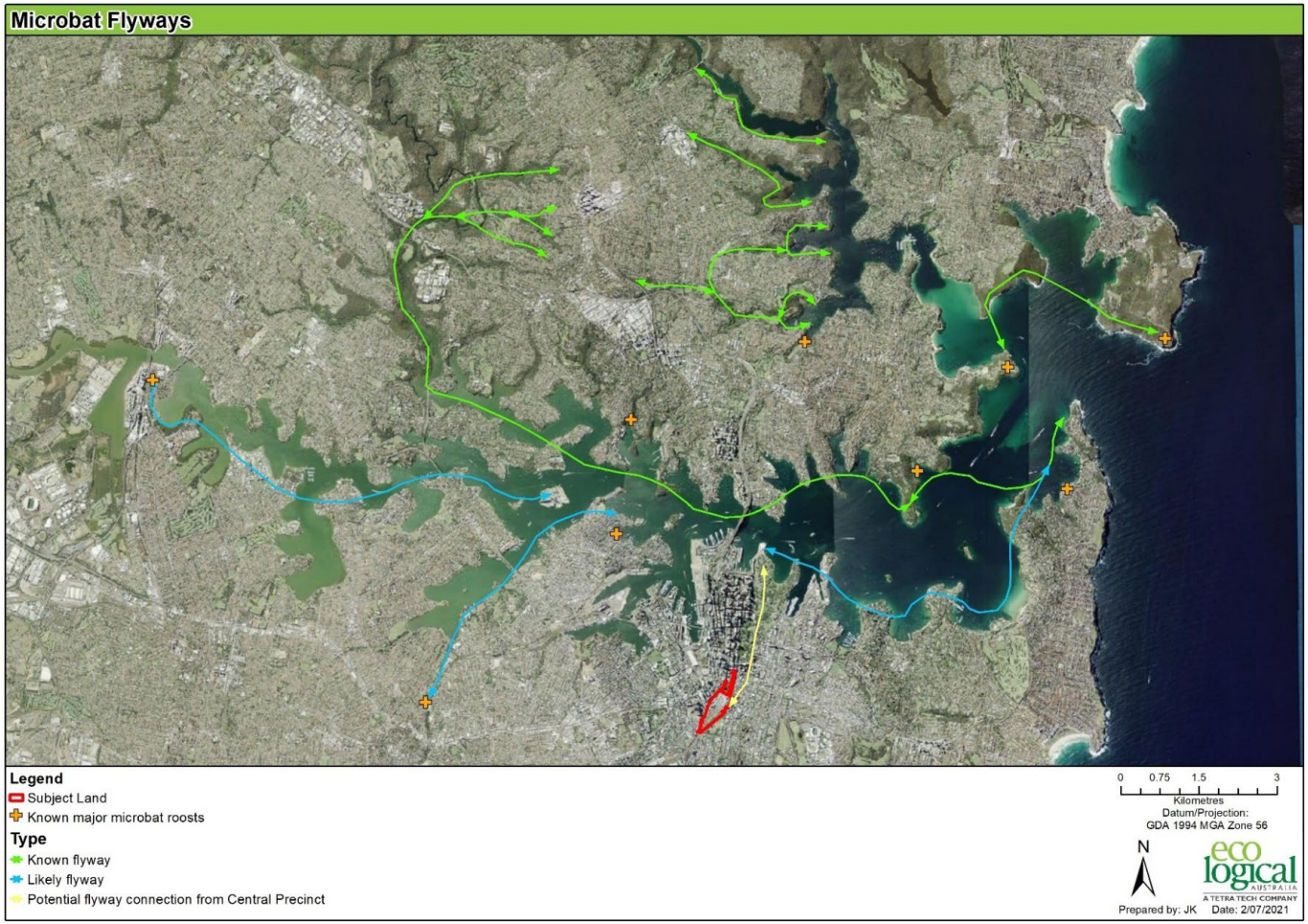


Figure 5: Known and likely microbat flyways (known flyways from White 2011 and Gonsalves and Law 2017)

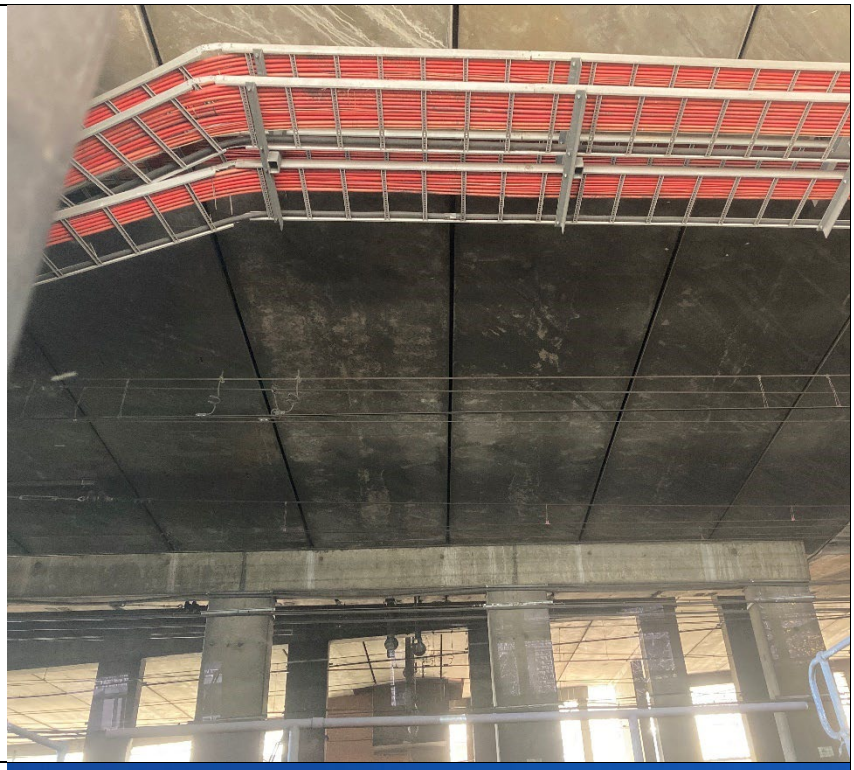
Table 4: Threatened microbat species likely to occur in the study area

Scientific Name	Common Name	BC Act	EPBC Act	Distribution	Habitat requirements	Records within 10 km	Roost preference	Likelihood of impact
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V		East-coast of NSW from south of Sydney into south-east Qld and east of the Great Dividing Range	Commonly occurs in dry eucalypt forests and woodlands east of the Great Dividing Range. Common on Cumberland Plain. Prefers open spaces in forest and woodland, more active on upper slopes of forested areas.	10	Hollows / Buildings / Telegraph poles / Exfoliating bark. Known to use bat boxes	Potential. Not recorded ultrasonically during surveys for this report but suitable foraging habitat present on site (such as trees with exfoliating bark) and suitable roosting habitat present within cavities of buildings and structures.
Miniopterus australis	Little Bent-winged Bat	V		East coast and ranges south to Wollongong in NSW.	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub.	6	Subterranean / Buildings occasionally. Known to use bat boxes placed in subterranean structures in small numbers.	Potential. Not recorded during surveys for this report but potential foraging habitat present within study area (vegetated areas) and may use cavities within Central Station for non-breeding roosting habitat.

Scientific Name	Common Name	BC Act	EPBC Act	Distribution	Habitat requirements	Records within 10 km	Roost preference	Likelihood of impact
Miniopterus orianae oceanensis	Eastern Bentwing-bat	V		In NSW it occurs on both sides of the Great Dividing Range. Rainforest	Wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland.	180	Subterrean	Potential – some foraging/roosting habitat within study area.
Myotis macropus	Southern Myotis	V		In NSW, found in the coastal band. It is rarely found more than 100 km inland, except along major rivers.	Foraging habitat is waterbodies and fringing areas of vegetation up to 20m. Rarely roosts more than 200 m from water.	37	Subterranean / Hollows	Unlikely. Not recorded during surveys. Central Station is located relatively close to known foraging habitat on Sydney Harbour but no tree hollows exist for roosting and the species is usually known to roost near water.
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat	V		Wide-ranging species found across northern and eastern Australia	Forages in most habitats across its very wide range, with and without trees.	1	Hollows / Buildings	Potential. Not recorded ultrasonically during surveys for this report but they likely to forage over the study area. No tree hollows exist for roosting on site, which they are more likely to roost in
Scoteanax rueppellii	Greater Broad-nosed Bat	V		Found mainly in the gullies and river systems that drain the Great Dividing Range from north-eastern Victoria to the Atherton Tableland	Woodland through to moist and dry eucalypt forest and rainforest, though it is commonly found in tall wet forest.	1	Hollows / Buildings	Potential. Not recorded ultrasonically during surveys for this report but they likely to forage over the study area. No tree hollows exist for roosting on site, which they are more likely to roost in (though occasionally found roosting in buildings)

Table 5: Examples of potential fauna habitat within the precinct

Microbat: Dilapidated disused building. Roof structure beginning to fall away presenting ample opportunity for roosting habitat in gaps and crevices. Locked gate means relatively disturbance free. Park adjacent provides potential foraging habitat.	

Microbat: Small gaps between concrete slabs in roof of carpark or pylons allows potential space for roosting habitat.	
Microbat: Microbats often utilise crevices or cracks that appear in the brickwork that are large enough for them to crawl into. Gutters falling away exposing gaps are also used for roosting.	

Microbat: Missing bricks allow space for microbats to enter structure.	
Bird: A small stick nest nestled into small gap in roof.	

Bird: Birds, including some raptors, have adapted well to urban environments and build their nests in nooks and crannies high up on buildings.	

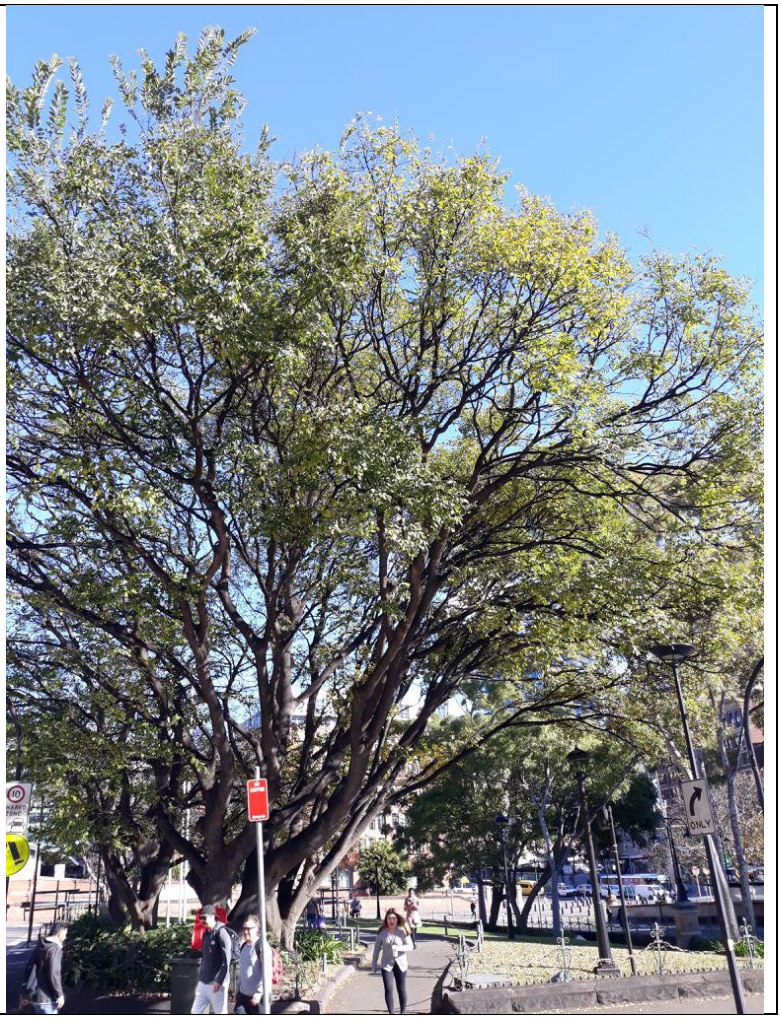
5.3 Opportunities for ecological enhancement

The following table presents locations within the precinct where there is an opportunity to enhance ecological values.

Table 6: Opportunities for ecological enhancement

Strip along railway line sloping down to road currently covered in exotic species. As is the small area in front of the dilapidated building at the end of this strip. Could be planted with native grasses, groundcovers and small flowering plants to encourage pollinators such as native bees and small birds in the area.	

Garden alongside road planted with exotics. Has potential for planted natives to contribute to ecosystem services in the area.	

Parkland space that has some exotics and natives as well as lawn could have a greater proportion of natives that provide fauna habitat.	

6. Objectives and performance criteria

Enhancing biodiversity in highly urbanised environments is a challenge but can transform the liveability of an area when it is implemented effectively. The study area currently has low biodiversity so even minor changes, such as weed removal and adding a few native plants, will be an improvement. However, more ambitious changes will result in greater environmental and social benefits, such as air temperature regulation, carbon sequestration, reduction of pests and weeds, and improved amenity and wellbeing. The following table summarises recommended biodiversity objectives and performance criteria for the Central SSP that could be incorporated in planning controls.

Table 7: Biodiversity objectives and performance criteria

Objective	Performance criteria (compared to baseline conditions)	How can this be achieved
Improve vegetation integrity and abundance	Greater proportion of natives versus weeds and exotic species Increase in native vegetation extent	Landscaping to feature native plants that are characteristic of the vegetation communities that would once have been in this area (i.e. Eastern Suburbs Banksia Scrub and Swamp Forest (Benson and Howell 1990)). New landscaping to feature native species and exotic species to be replaced by natives as they fail. Plantings should achieve good structural integrity where possible (canopy, mid storey, groundcover). Weed control will be ongoing.
Protect habitat suitability and increase threatened species abundance	Important threatened species habitat protected during the redevelopment, where possible Additional microbat habitat installed	Detailed targeted microbat surveys to be undertaken in accordance with Threatened Species Survey Guidelines for areas proposed to be affected; assessment to be included in BDAR/s and including specific management and mitigation measures. In addition to retention of existing microbat habitats, incorporate hollows/boxes for birds and bats, roost platforms for birds of prey, flower beds that support invertebrates.
Increase habitat connectivity within the site and to surrounding corridors	Vegetation is well connected in corridors throughout the site and joins to the main green places in adjacent areas	Increasing vegetation and habitat in defined biodiversity corridors that include parks, green roofs and walls, streetscapes (not just canopy trees).
Flight path integrity	Maintain flyways through the area	Consider local and regional flyways in biodiversity corridor and built infrastructure design. Avoid building designs that could harm flying fauna, such as highly reflective glass building facades.

Objective	Performance criteria (compared to baseline conditions)	How can this be achieved
Water sustainability	Consider water in the landscape to support fauna	Incorporate water sensitive urban design features

7. Design guidelines

This chapter provides examples of habitat features that may be included in the redevelopment for species most likely to utilise this highly urban landscape.

7.1 Microbats

Microbats are the most diverse mammal group in Australia (~90 species) and account for 20% of all mammal species known in Australia (Aust. Museum, 2019). Where many mammals, particularly small terrestrial mammals, are highly sensitive to urbanisation and will not commonly occur within cities, many microbat species can persist in highly urbanised areas (van der Ree and McCarthy 2004). As such, microbats are the most likely group to native fauna to be utilising the buildings and the most likely group to increase their usage with ecological enhancement.

Many microbat species, both common and threatened species, persist within Sydney, despite extensive urbanisation and redevelopment. The CPRP presents opportunities to retain important microbat habitat but also to enhance existing and create new habitat. The key elements required to maintain or create habitat for microbats are:

flyway connectivity (common dispersal routes)

foraging habitat specific to the species' foraging modes

species-specific roosting habitat

potential breeding habitat.

Table 8 identifies examples of microbat habitat improvements and these are described in more detail below.

7.1.1 Microbat flyways

The Central SSP occurs near known microbat roosts and flyways. This provides opportunities to improve connectivity and increase the potential use of the precinct by microbats. Studies conducted within central and north Sydney demonstrated that microbat species richness (i.e. the number of species to occur) and activity levels can be increased by extending tree cover (high density of large diameter trees), creating routes that could bypass major structural barriers or roads, minimising night lighting, and connecting existing flyway corridors (Basham, Law and Banks 2010, White 2011).

There is only a short distance (~ 100 m) between existing vegetation habitat at the northern extent of Central SSP to known microbat flight paths through Hyde Park, the Domain and the Royal Botanic Gardens. Currently, the northern section of the precinct has limited tree cover and high light disturbance. A critical connection could be established in this area by increasing tree canopy cover and optimising lighting (i.e. decreasing building light and using ceramic metal halide streetlights that have a positive effect on microbat activity; Stone et al. 2015). This may increase microbats moving between the Central Precinct and known roosts across the Sydney Harbour (Figure 5). In conjunction with improvement of roosting habitat, this could increase microbat species richness and activity within the study area, increasing the available habitat for a multitude of microbat species in the inner city.

7.1.2 Microbat foraging habitat

Microbat species differ in their foraging strategies and therefore, the habitat in which they persist and their tolerance for urbanisation. Within Sydney, microbats have a range of specific foraging niches including trawling bats (i.e. *Myotis macropus*) or insectivorous bats (e.g. *Saccolaimus flaviventris, Miniopterus* sp.). Insectivorous bats forage for aerial insects in open air, often at the edge of remnant forest or well above the tree canopy (Hourigan et al. 2006). However, species differ in their ability to forage in open habitats, with some known to forage around single, isolated trees, and others requiring large remnant bushland patches (Lumsden & Bennett 2005).

Whilst some species may already forage locally around the Central Precinct where isolate trees occur or lighting attracts insects, increasing microbat occurrence and species richness (particularly for species that require large stands of trees) might be achieved through:

increasing canopy cover across the site

installing landscaping that may increase insect occurrence

increasing habitat connectivity to Sydney Harbour (for trawling bats, i.e. *Myotis Macropus*).

Streetlight negatively influences bats that do not forage in open areas (Stone et al. 2009) and can decrease overall bat richness and activity levels (Scanlon and Petit 2008). Some 'light tolerant' species may benefit from increased foraging on insects attracted to white streetlights commonly used (Stone et al. 2015). However, bat activity differs with the spectrum of light emitted by street lights (reviewed by Stone, Harris and Jones 2015), and replacement of street lights with energy efficient broad spectrum metal halide lights (550 – 600nm, peaking at 400 – 420nm and 2800K CCT) has been shown to be preferred by many bat species. Due to the broad spectrum of light emitted by these streetlights, a wide range of insects are attracted, including moths and flies on which microbats feed (Stone et al. 2015). By installing streetlights that are optimal for attracting insects, suitable foraging for many microbats will be increased. It is important however that lights are not installed near roosting areas as this may disturb microbats when they are in torpor (mostly during winter) and that some areas are left with minimal lighting. White light should be avoided in areas critical for flyway connectivity (i.e. the northern section of the site).

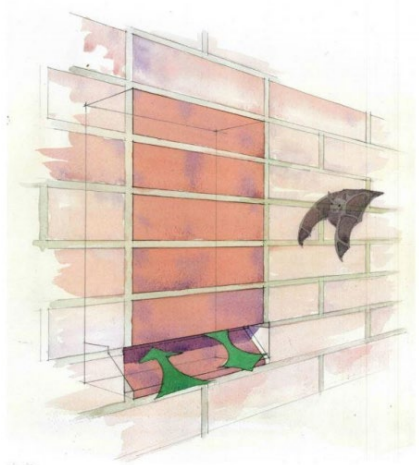
7.1.3 Microbat roost habitat

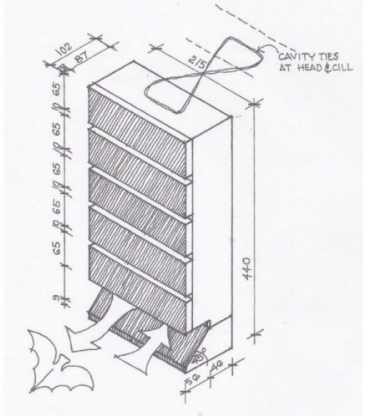
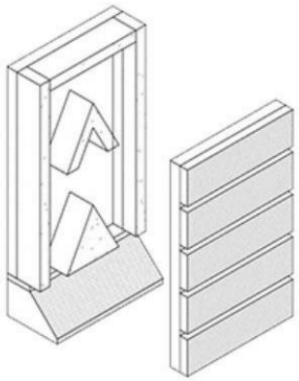
Microbat presence is strongly dictated by the availability of suitable day-roosts, where they can spend over 50% of their lives (Kunz and Lumsden 2003). Whilst some species are reliant on accessible naturally occurring roost, such as foliage, tree cavities and caves, many species can utilise man-made structures for roosting, including buildings, bridges, mine shafts and tunnels (Kunz and Lumsden 2003). Currently the Central Precinct has potential human-made roost sites available for microbats within many of the buildings, increasing the potential for both common (e.g. *C. gouldii*) and threatened (e.g. *Minopterus* sp.) microbats (Churchill 1988, Hoye and Spence 2004). These microbats will often roost within the wall or roof cavity or voids of buildings, or within dark areas of disused buildings that have clear entry/exit points (12 –20 mm wide). These spaces provide insulation from outside weather conditions, rough surfaces on which the bats can hold during roosting and protection from predators. Roosting spaces within the existing building infrastructure and entry/exit points should be maintained and new microbat roost habitat created in the proposed OSD structure.

Roosting habitat for microbats may be further enhanced within the Central Precinct by the installation of external infrastructure suitable for subterranean roosting species (e.g.

Miniopterus sp.) or for hollow roosting species (e.g. *Myotis macropus*). Options for roost creation and the species they target are outlined in Table 8.

Table 8: Microbat habitat roost creation

Roost type	Example target species	Details	Examples
Roof cavity	*M. o. oceanensis, M. australis, S. flaviventris*	Openings to roof cavities 12 –20mm wide allow access to microbats that are known to use buildings for roosting. Roof cavities should be well insulated, and well connected	 Microbat roost entry/exit from Sanderson et al. 2010
Additional wall cavities	*Chalinolobus dwyeri, M. o. oceanensis, M. australis*	Roost space designed in the construction of solid structures or as an addition to solid walls and suitable for a range of cavity roosting and subterranean roosting microbat specie	 Microbat roost habitat design for use in the walls of solid structures

			  Additional wall void for subterrean and cavity roosting species (external view on the right and internal on the left)

Artificial tree hollow	*S. flaviventris, M. macropus, M. norfolkensis*	Hollows created by cuts in existing mature trees, providing spaces for hollow roosting microbats (where no hollows currently exist). These often provide better insulation and protection than bat boxes	

Bat boxes	*S. flaviventris, M. macropus, M. norfolkensis*	Pre-constructed four chamber microbat box constructed from recycled plastic (CyplasTM) that can be installed on trees, under bridges/walkways or on other solid infrastructure	
Artificial crevice	*M. o. oceanensis, M. australis, S. flaviventris*	Constructed crevices that replicate subterrean cracks and crevices in which microbats roost.	 Concrete blocks suitable for Miniopterus roosting

			  Concrete crevices similar to deep bridge expansion joint designed for replacing roosting spaces under concrete bridges

7.2 Foraging habitat for small birds and insects

Although urban landscapes are often designed to improve the site aesthetics, the structure and diversity of plant species can have a strong influence on the occurrence of species such as small birds and invertebrates (e.g. butterflies, dragonflies, bees, and insects). The City of Sydney has 12 small native bird species known to occur including the Superb Fairy-wren, New Holland Honeyeater, Silvereye, Spotted Pardalote and Rufous Fantail, Red-browed Finch. However, many of these small birds occur in low numbers, as there is limited suitable habitat and they are displaced by larger, more aggressive birds who benefit from urbanisation (Smith and Smith 2020).

Most small birds either rely on seed, nectar producing plants or insects which are attracted to these plants. As such, many of the attributes for increasing small bird diversity, will also increase insect diversity and vice versa. Small birds and insects require densely planted native shrubs for both shelter and food, with a recommended density of 1 – 2 plants/m^2 (City of Sydney 2020). The ground layer should be planted with native grasses, sedges, herbs and groundcovers, vines/scramblers and ferns should at 6 to 8 plants/m^2. To attract less common small birds, and avoid dominance by larger, more common nectar feeders (e.g. Noisy Miners and Rainbow Lorikeets), small-flowering Grevilleas, such as the Pink Spider Flower (*Grevillea sericea*) and Red Spider Flower (*Grevillea speciosa*) should be planted. Limiting plants with large flowers and fruiting plants, will avoid dominance by common, more aggressive birds and promote species that are less common in urban habitats.

A list of suitable species to plant for increasing wildlife habitat in urban areas has been created by the City of Sydney (2019). This includes species such as:

Pink Spider Flower (*Grevillea sericea*)

Red Spider Flower (*Grevillea speciosa*)

Silky Hakea (*Hakea sericea*)

Sunshine Wattle (*Acacia longifolia*)

Large-leaf Hop Bush (*Dodonaea triquetra*)

Coastal Rosemary (*Westringia fruticosa*)

7.3 Nesting habitat for birds

With no hollow bearing trees or very large established trees in the area surrounding Central Station, there is limited potential nesting locations for hollow nesting species and stick nest species. Artificial hollows can be created easily for many species by installing nest boxes in the local area. These are commonly used by birds such as Rainbow Lorikeet (*Trichoglossus haematodus*), Galah (*Cactua roseicapilla*) and Eastern Rosella (Platycersus eximius) (Harper et al. 2005). However, not all Australian birds are hollow nesting, with may making mud or stick nests. Many trees in the surrounding area may already support smaller stick nests (such as Australia Magpie, *Cracticus tibicen*) and mud nests (such as Magpie Larks, *Grallina cyanoleuca*). However, larger bird, such as eagles and hawks rely on large platforms or rocky shelves to nest, which are often unavailable in urban areas. Although large birds of prey, such as Peregrine Falcons (*Falco peregrinus*) and White-bellied Sea Eagles(*Haliaeetus leucogaster*) usually build on naturally occurring platforms, such as large established trees and cliff lines, these species have also been known to use artificial platforms.

An overview and examples of previously used artificial nesting platforms is given in Table 9. These structures can be both incorporated into new designs and added to existing building infrastructure. Additionally, some species, such as Peregrine Falcons have been observed nesting on building ledges, which can be added or improved by ensuring adequate overhang, a lipped ledge (to prevent the rolling of eggs), and nest padding (wooden base topped with soft padding, such as wood shavings).

7.4 Habitat for invertebrates

Many invertebrates will rely almost solely on flowering plants, both for food and to reproduce. However, some invertebrates, such as native bees also rely on nests or hives. Native beehives can be easily included in existing or new infrastructure, such as through drilled holes in blocks of hardwood in sheltered positions (Resin Bees, *Megachile* spp.) or using rammed earth bricks placed in sunny positions (Blue-banded bees, *Amegilla* spp.). Alternatively, standalone prefabricated hives can be purchased and attached to pre-existing structures (Table 9). Creating nesting locations specific for native bees is essential, as certain designs will allow for aggressive, non-native European bees to dominate.

Table 9: Artificial nests for native birds and invertebrates

Nest type	Description	Potential species	Example
Hollow	Species that nest in tree hollows will often use artificial hollows such as nest boxes. These can be installed on the edges of buildings, or on established trees that do not already have hollows	Kookaburras, galahs, rainbow lorikeets, rosellas, small forest birds	 Nest boxes for large (e.g. kookaburras or boobook owls, left) and small birds (e.g. pardalotes, right) (supplier Hollow Log Homes)
Platform – edge	Some species that make nests on cliff edges or open stags, have also been known to nest on building edges, such as on rooftop ledges. Suitable ledge spaces can be incorporated into new building designs or shallow wooden boxes added to pre-existing designs and supplemented with nest padding (such as saw dust and leaf litter).	Falcons	 Peregrine falcon nesting on the rooftop of a Melbourne CBD building (ABC News, 2018)

Platform – standalone	Large, flat platforms provide a space for eagles and osprey to build their relatively large, bulky nests, often built of larger twigs or sticks. These platforms should be in open areas that allow for a 360° view for the nesting bird. Platform will be used by nesting pairs across multiple years	Eagles, osprey	  White-bellied sea-eagle nest on artificial pole and platform, Bunnings carpark, Townsville (Debus 2014) (left) and an Osprey nesting on artificial nest platform (right)(Redlands City Council, 2021)
Native bees	Beehives that allow for colonisation or nesting by solitary native bees. These structures allow for the use by small native bees occurring in low numbers and are sub-optimal or unable to be used by non-native European bees. This can include drilled holes in blocks of hardwood, rammed earth bricks placed or standalone prefabricated hives	Native bees such as Blue-banded, resin, wasp mimic and masked bees	   'Bee hotel' made from bamboo cane and drilled timber blocks (top left), clay blocks for blue-banded bees (top right), nest blocks for resin bees (bottom left) (Aussie Bees, 2021)

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Appendix A: Likelihood of occurrence of threatened species

An assessment of likelihood of occurrence was made for threatened and migratory species identified from the database search. Five terms for the likelihood of occurrence of species are used in this report. This assessment was based on database or other records, presence or absence of suitable habitat, features of the proposal site, results of the site inspection and professional judgement. Some Migratory or Marine species identified from the Commonwealth database search have been excluded from the assessment, due to lack of habitat. The terms for likelihood of occurrence are defined below:

“known” = the species was or has been observed on the site

“likely” = a medium to high probability that a species uses the site

“potential” = suitable habitat for a species occurs on the site, but there is insufficient information to categorise the species as likely to occur, or unlikely to occur

“unlikely” = a very low to low probability that a species uses the site

“no” = habitat on site and in the vicinity is unsuitable for the species.

A test of significance will need to be conducted for threatened species or ecological communities that were recorded within the study area or had a higher likelihood of occurring and were not recorded during the site visit. It is noted that some threatened fauna species that are highly mobile, wide ranging and vagrant may use portions of the study area intermittently for foraging. For these fauna species, the habitat present and likely to be impacted is not considered to be important to the threatened species, particularly in relation to the amount of similar habitat remaining in the surrounding landscape. As such, a test of significance in reference to State or Commonwealth legislation may not be considered necessary.

The records column refers to the number of records occurring within 10 km of the study area, as provided by the Atlas of NSW Wildlife (BioNet) and Protected Matters Search Tool database search.

Information provided in the habitat associations’ column has primarily been extracted (and modified) from the Commonwealth Species Profile and Threats Database and the NSW Threatened Species Profiles.

Scientific Name	Common Name	BC Act Status	EPBC Act Status	Distribution and Habitat	Number of records within 5 km	Likelihood of occurrence	Impact Assessment Required
FAUNA							
Anthochaera phrygia	Regent Honeyeater	E4A	CE	Inland slopes of south-east Australia, and less frequently in coastal areas. In NSW, most records are from the North-West Plains, North-West and South-West Slopes, Northern Tablelands, Central Tablelands and Southern Tablelands regions; also recorded in the Central Coast and Hunter Valley regions. Eucalypt woodland and open forest, wooded farmland and urban areas with mature eucalypts, and riparian forests of Casuarina cunninghamiana (River Oak).	4	Unlikely – no foraging/roosting habitat within the study area.	No
Apus pacificus	Fork-tailed Swift	-	M	Recorded in all regions of NSW. Riparian woodland., swamps, low scrub, heathland, saltmarsh, grassland, Spinifex sandplains, open farmland and inland and coastal sand-dunes.	0	Unlikely – this species breeds overseas and forages high up in the air, rarely alighting in vegetation or structures, no local records.	No
Burhinus grallarius	Bush Stone-curlew	E1	-	In NSW, found sporadically in coastal areas, and west of the divide throughout the sheep-wheat belt. In NSW, it occurs in lowland grassy woodland and open forest.	1	Unlikely – no foraging/roosting habitat within the study area.	No
Calyptorhynchus lathami	Glossy Black-Cockatoo, Riverina population	E2,V	-	Within the Narrandera Range and to the north-west in the Brobenah Hills, McPhersons Range, Cocoparra Range, Lachlan Range and Jimberoo State Forests, and the Naradhan Range. Largely restricted to hills and low	51	Unlikely – no foraging/roosting habitat within the study area.	No

				ridges where suitable stands of its food plant Allocasuarina verticillata (Drooping Sheoak) remain.			
Chalinolobus dwyeri	Large-eared Pied Bat	V	V	Recorded from Rockhampton in Qld south to Ulladulla in NSW. Largest concentrations of populations occur in the sandstone escarpments of the Sydney basin and the NSW north-west slopes. Wet and dry sclerophyll forests, Cyprus Pine dominated forest, woodland, sub-alpine woodland, edges of rainforests and sandstone outcrop country.	2	Unlikely – no foraging/roosting habitat within the study area.	No
Cuculus optatus	Oriental Cuckoo, Horsfield's Cuckoo	-	M	Northern and eastern Australia, records mainly coastal in NSW south to Bega area. Non breeding habitat: monsoonal rainforest, vine thickets, wet sclerophyll forest or open Casuarina, Acacia or Eucalyptus woodland.	0	Unlikely – breeds overseas, no foraging habitat substantially degraded, no local records.	No
Dasyurus maculatus maculatus	Spotted-tailed Quoll	V	E	Found on the east coast of NSW, Tasmania, eastern Victoria and north-eastern Qld. Rainforest, open forest, woodland, coastal heath and inland riparian forest, from the sub-alpine zone to the coastline.	0	Unlikely – no foraging/nesting habitat within the study area, no local records.	No
Falco hypoleucos	Grey Falcon	E1	-	Arid and semi-arid zones. In NSW, found chiefly throughout the Murray-Darling Basin, with the occasional vagrant east of the Great Dividing Range. Shrubland, grassland and wooded watercourses, occasionally in open woodlands near the coast, and near wetlands.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Glossopsitta pusilla	Little Lorikeet	V	-	In NSW, found from the coast westward as far as Dubbo and Albury. Dry, open eucalypt forests and woodlands, including remnant woodland patches and roadside vegetation.	9	Unlikely – potential foraging/breeding habitat within site in the form of planted eucalypts, is substantially	No

						degraded and preferable habitat exists within broader locality.	
Grantiella picta	Painted Honeyeater	V	V	Widely distributed in NSW, predominantly on the inland side of the Great Dividing Range but avoiding arid areas. Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark Forests.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Haliaeetus leucogaster	White-bellied Sea-Eagle	V	-	Distributed along the coastline of mainland Australia and Tasmania, extending inland along some of the larger waterways, especially in eastern Australia. Freshwater swamps, rivers, lakes, reservoirs, billabongs, saltmarsh and sewage ponds and coastal waters. Terrestrial habitats include coastal dunes, tidal flats, grassland, heathland, woodland, forest and urban areas.	31	Unlikely – no foraging/roosting habitat within the study area.	No
Heleioporus australiacus	Giant Burrowing Frog	V	V	South eastern NSW and Victoria, in two distinct populations: a northern population in the sandstone geology of the Sydney Basin as far south as Ulladulla, and a southern population occurring from north of Narooma through to Walhalla, Victoria. Heath, woodland and open dry sclerophyll forest on a variety of soil types except those that are clay based.	0	Unlikely – lack of suitable habitat for this species within the study area, no local records.	No
Hieraaetus morphnoides	Little Eagle	V	-	Throughout the Australian mainland, with the exception of the most densely-forested parts of the Dividing Range escarpment. Open eucalypt forest, woodland or open woodland, including she-oak or Acacia woodlands and riparian woodlands of interior NSW.	2	Unlikely – no foraging/roosting habitat within the study area.	No
Hirundapus caudacutus	White-throated Needletail	-	M	All coastal regions of NSW, inland to the western slopes and inland plains of the Great Divide. Occur most often	26	Unlikely – no foraging/roosting	No

				over open forest and rainforest, as well as heathland, and remnant vegetation in farmland.		habitat within the study area.	
Hoplocephalus bungaroides	Broad-headed Snake	E1	V	Largely confined to Triassic and Permian sandstones within the coast and ranges in an area within approximately 250 km of Sydney. Dry and wet sclerophyll forests, riverine forests, coastal heath swamps, rocky outcrops, heaths, grassy woodlands.	0	Unlikely – no habitat within the study area, no local records.	No
Isoodon obesulus obesulus	Southern Brown Bandicoot (eastern)	E1	E	Found in south-eastern NSW, east of the Great Dividing Range south from the Hawkesbury River. Heath or open forest with a heathy understorey on sandy or friable soils.	0	Unlikely – no foraging/nesting habitat within the study area, no local records.	No
Lathamus discolor	Swift Parrot	E1	CE	Migrates from Tasmania to mainland in Autumn-Winter. In NSW, the species mostly occurs on the coast and south west slopes. Box-ironbark forests and woodlands.	28	Unlikely – no foraging/roosting habitat within the study area.	No
Litoria aurea	Green and Golden Bell Frog	E1	V	Since 1990, recorded from ~50 scattered sites within its former range in NSW, from the north coast near Brunswick Heads, south along the coast to Victoria. Records exist west to Bathurst, Tumut and the ACT region. Marshes, dams and stream-sides, particularly those containing Typha spp. (bullrushes) or Eleocharis spp. (spikerushes). Some populations occur in highly disturbed areas.	19	Unlikely – no habitat within the study area, no local records.	No
Lophoictinia isura	Square-tailed Kite	V	-	In NSW, it is a regular resident in the north, north-east and along the major west-flowing river systems. It is a summer breeding migrant to the south-east, including the NSW south coast. Timbered habitats including dry woodlands and open forests, particularly timbered watercourses.	1	Unlikely – no foraging/roosting habitat within the study area.	No

Merops ornatus	Rainbow Bee-eater	-	M	Distributed across much of mainland Australia, including NSW. Open forests and woodlands, shrublands, farmland, areas of human habitation, inland and coastal sand dune systems, heathland, sedgeland, vine forest and vine thicket.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Micronomus norfolkensis	Eastern Coastal Free-tailed Bat	V	-	Found along the east coast from south Qld to southern NSW.	10	Potential – some foraging/roosting habitat within study area.	Yes
Miniopterus australis	Little Bentwing-bat	V	-	Moist eucalypt forest, rainforest, vine thicket, wet and dry sclerophyll forest, Melaleuca swamps, dense coastal forests and banksia scrub. East coast and ranges south to Wollongong in NSW.	5	Potential – some foraging/roosting habitat within study area.	Yes
Miniopterus orianae oceanensis	Eastern Bentwing-bat	V	-	In NSW it occurs on both sides of the Great Dividing Range, from the coast inland to Moree, Dubbo and Wagga Wagga. Rainforest, wet and dry sclerophyll forest, monsoon forest, open woodland, paperbark forests and open grassland.	180	Potential – some foraging/roosting habitat within study area.	Yes
Mixophyes balbus	Stuttering Frog	E1	V	Along the east coast of Australia from southern Qld to north-eastern Victoria. Rainforest and wet, tall open forest in the foothills and escarpment on the eastern side of the Great Dividing Range.	0	Unlikely – no habitat within the study area, no local records.	No
Monarcha melanopsis	Black-faced Monarch	-	M	In NSW, occurs around the eastern slopes and tablelands of the Great Divide, inland to Coutts Crossing, Armidale, Widden Valley, Wollemi National Park and Wombeyan Caves. It is rarely recorded farther inland. Rainforest, open eucalypt forests, dry sclerophyll forests and woodlands, gullies in mountain areas or coastal foothills, Brigalow scrub, coastal scrub, mangroves, parks and gardens.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No

Motacilla flava	Yellow Wagtail	-	M	Regular summer migrant to mostly coastal Australia. In NSW recorded Sydney to Newcastle, the Hawkesbury and inland in the Bogan LGA. Swamp margins, sewage ponds, saltmarshes, playing fields, airfields, ploughed land, lawns.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Myiagra cyanoleuca	Satin Flycatcher	-	M	In NSW, widespread on and east of the Great Divide and sparsely scattered on the western slopes, with very occasional records on the western plains. Eucalypt-dominated forests, especially near wetlands, watercourses, and heavily-vegetated gullies.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Myotis macropus	Southern Myotis	V	-	Foraging habitat is waterbodies (including streams, or lakes or reservoirs) and fringing areas of vegetation up to 20m.	40	Potential – some foraging/roosting habitat within study area.	Yes
Neophema chrysogaster	Orange-bellied Parrot	E4A	CE	Breeds in Tasmania and migrates in autumn to spend the winter on the mainland coast of south-eastern SA and southern Victoria. Occasional reports from NSW, most recently Shellharbour and Maroubra in May 2003. Winter habitat is mostly within 3 km of the coast in sheltered bays, lagoons, estuaries, coastal dunes and saltmarshes. Also small islands and peninsulas, saltworks, golf courses, low samphire herbland and taller coastal shrubland.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Ninox connivens	Barking Owl	V	-	Wide but sparse distribution in NSW, avoiding the most central arid regions. Core populations exist on the western slopes and plains and in some northeast coastal and escarpment forests. Woodland and open forest, including fragmented remnants and partly cleared farmland, wetland and riverine forest.	2	Unlikely – no foraging/roosting habitat within the study area.	No
Ninox strenua	Powerful Owl	V	-	In NSW, it is widely distributed throughout the eastern forests from the coast inland to tablelands, with	200	Unlikely – no foraging/roosting	No

				scattered records on the western slopes and plains. Woodland, open sclerophyll forest, tall open wet forest and rainforest.		habitat within the study area.	
Numenius madagascariensis	Eastern Curlew	-	CE, M	Summer migrant to Australia. Primarily coastal distribution in NSW, with some scattered inland records. Estuaries, bays, harbours, inlets and coastal lagoons, intertidal mudflats or sandflats, ocean beaches, coral reefs, rock platforms, saltmarsh, mangroves, freshwater/brackish lakes, saltworks and sewage farms.	0	Unlikely – no foraging/roosting habitat within the study area, no local records.	No
Pandion cristatus	Eastern Osprey	V	-	Common around the northern NSW coast, and uncommon to rare from coast further south. Some records from inland areas. Rocky shorelines, islands, reefs, mouths of large rivers, lagoons and lakes.	1	Unlikely – no foraging/roosting habitat within the study area.	No
Perameles nasuta	Long-nosed Bandicoot	E2	-	Shelter mostly under older houses and buildings Forage in parkland and back-yards	11	Unlikely – no foraging/nesting habitat within the study area.	No
Petalura gigantea	Giant Dragonfly	E1	-	Found along the east coast of NSW from the Victorian border to northern NSW. Not found west of the Great Dividing Range. Permanent swamps and bogs with some free water and open vegetation.	1	Unlikely – no habitat within the study area.	No
Petaurus norfolcensis	Squirrel Glider	V	-	Widely though sparsely distributed on both sides of the Great Dividing Range in eastern Australia, from northern Qld to western Victoria. Mature or old growth Box, Box-Ironbark woodlands and River Red Gum forest west of the Great Dividing Range and Blackbutt-Bloodwood forest with heath understorey in coastal areas.	1	Unlikely – no foraging/breeding habitat within the study area.	No
Petauroides volans	Greater Glider	E2	V	This population on the south coast of NSW is bounded by the Moruya River to the north, Coila Lake to the south and the Princes Highway and cleared land exceeding 700	0	Unlikely – no foraging/breeding habitat within the	No

				m in width to the west. Eucalypt forests and woodlands.		study area, no local records.	
Petrogale penicillata	Brush-tailed Rock-wallaby	E1	V	In NSW they occur from the Qld border in the north to the Shoalhaven in the south, with the population in the Warrumbungle Ranges being the western limit. Rocky escarpments, outcrops and cliffs with a preference for complex structures with fissures, caves and ledges.	0	Unlikely – no foraging/breeding habitat within the study area, no local records.	No
Phascolarctos cinereus	Koala	V	V	In NSW it mainly occurs on the central and north coasts with some populations in the west of the Great Dividing Range. There are sparse and possibly disjunct populations in the Bega District, and at several sites on the southern tablelands. Eucalypt woodlands and forests.	4	Unlikely – no foraging/breeding habitat within the study area.	No
Pseudomys novaehollandiae	New Holland Mouse	-	V	Fragmented distribution across eastern NSW. Open heathlands, woodlands and forests with a heathland understorey, vegetated sand dunes.	0	Unlikely – no foraging/breeding habitat within the study area, no local records.	No
Pseudophryne australis	Red-crowned Toadlet	V	-	Confined to the Sydney Basin, from Pokolbin in the north, the Nowra area to the south, and west to Mt Victoria in the Blue Mountains. Open forests, mostly on Hawkesbury and Narrabeen Sandstones. Inhabits periodically wet drainage lines below sandstone ridges that often have shale lenses or cappings.	65	Unlikely – no habitat within the study area.	No
Pteropus poliocephalus	Grey-headed Flying-fox	V	V	Along the eastern coast of Australia, from Bundaberg in Qld to Melbourne in Victoria. Subtropical and temperate rainforests, tall sclerophyll forests and woodlands, heaths and swamps as well as urban gardens and cultivated fruit crops.	177655	Likely – some foraging habitat for this species was identified with the study area.	Yes
Ptilinopus superbus	Superb Fruit-Dove	V	-	Principally from north-eastern Qld to north-eastern NSW. Further south, it is confined to pockets of suitable	6	Unlikely – no foraging/breeding	No

				habitat, and occurs as far south as Moruya. Rainforest and closed forests. May also forage in eucalypt or acacia woodland where there are fruit-bearing trees.		habitat within the study area.	
Rhipidura rufifrons	Rufous Fantail	-	M	Coastal and near coastal districts of northern and eastern Australia, including on and east of the Great Divide in NSW. Wet sclerophyll forests, subtropical and temperate rainforests. Sometimes drier sclerophyll forests and woodlands.	0	Unlikely – no foraging/breeding habitat within the study area, no local records.	No
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V	-	Almost all habitats, including wet and dry sclerophyll forest, open woodland, open country, mallee, rainforests, heathland and waterbodies. There are scattered records of this species across the New England Tablelands and North West Slopes. Rare visitor in late summer and autumn to south-western NSW.	3	Potential – some foraging/roosting habitat within study area.	Yes
Scoteanax rueppellii	Greater Broad-nosed Bat	V	-	Both sides of the great divide, from the Atherton Tableland in Qld to north-eastern Victoria, mainly along river systems and gullies. In NSW it is widespread on the New England Tablelands. Woodland, moist and dry eucalypt forest and rainforest.	1	Potential – some foraging/roosting habitat within study area.	Yes
Tyto novaehollandiae	Masked Owl	V	-	Recorded over approximately 90% of NSW, excluding the most arid north-western corner. Most abundant on the coast but extends to the western plains. Dry eucalypt forests and woodlands from sea level to 1100 m.	2	Unlikely – no foraging/breeding habitat within the study area.	No
FLORA							
Acacia bynoeana	Bynoe's Wattle	E1	V	Found in central eastern NSW, from the Hunter District (Morisset) south to the Southern Highlands and west to the Blue Mountains. Heath or dry sclerophyll forest on sandy soils.	0	No – suitable habitat not recorded within the study area, no local records.	No
Acacia pubescens	Downy Wattle	V	V	Open woodland and forest, including Cooks River/Castlereagh Ironbark Forest, Shale/Gravel	0	No – suitable habitat not recorded within	No

				Transition Forest and Cumberland Plain Woodland. Occurs on alluviums, shales and at the intergrade between shales and sandstones.		the study area, no local records.	
Acacia terminalis subsp. Eastern Sydney	Sunshine Wattle	E1	E	Limited mainly to near-coastal areas from the northern shores of Sydney Harbour south to Botany Bay. Coastal scrub and dry sclerophyll woodland on sandy soils.	380	No – suitable habitat not recorded within the study area.	No
Allocasuarina glareicola	-	E1	E	Castlereagh woodland on lateritic soil. Found in open woodland with Eucalyptus parramattensis, Eucalyptus fibrosa, Angophora bakeri, Eucalyptus sclerophylla and Melaleuca decora.	0	No – suitable habitat not recorded within the study area, no local records.	No
Asterolasia elegans		E1	E	Occurs north of Sydney, in the Baulkham Hills, Hawkesbury and Hornsby local government areas. Also likely to occur in the western part of Gosford local government area. Hawkesbury sandstone. Found in sheltered forests on mid- to lower slopes and valleys.	0	No – suitable habitat not recorded within the study area, no local records.	No
Caladenia tessellata	Thick Lip Spider Orchid	E1	V	Currently known from two disjunct areas; one population near Braidwood on the Southern Tablelands and three populations in the Wyong area on the Central Coast. Grassy sclerophyll woodland on clay loam or sandy soils, or low woodland with stony soil.	0	No – suitable habitat not recorded within the study area, no local records.	No
Cryptostylis hunteriana	Leafless Tongue Orchid	V	V	In NSW, recorded mainly on coastal and near coastal ranges north from Victoria to near Forster, with two isolated occurrences inland north-west of Grafton. Coastal heathlands, margins of coastal swamps and sedgelands, coastal forest, dry woodland, and lowland forest.	0	No – suitable habitat not recorded within the study area, no local records.	No
Doryanthes palmeri	Giant Spear Lily	V	-	n NSW, occurs on the coastal ranges that are part of the Mt Warning Caldera. Its southern distributional limit is Mount Billen. Exposed rocky outcrops, cliff-tops and on steep cliff-faces in montane heath next to subtropical	2	No – suitable habitat not recorded within the study area.	No

				rainforest, warm temperate rainforest or wet eucalypt forest.			
Eucalyptus camfieldii	Camfield's Stringybark	V	V	Narrow band from the Raymond Terrace area south to Waterfall. Coastal heath on shallow sandy soils overlying Hawkesbury sandstone, mostly on exposed sandy ridges.	0	No – suitable habitat not recorded within the study area, no local records.	No
Eucalyptus nicholii	Narrow-leaved Black Peppermint	V	V	New England Tablelands from Nundle to north of Tenterfield. Dry grassy woodland, on shallow soils of slopes and ridges.	4	No – suitable habitat not recorded within the study area.	No
Eucalyptus scoparia	Wallangarra White Gum	E1	V	In NSW it is known from only three locations near Tenterfield. Open eucalypt forest, woodland and heaths on well-drained granite/rhyolite hilltops, slopes and rocky outcrops, typically at high altitudes.	1	No – suitable habitat not recorded within the study area.	No
Genoplesium baueri	Bauer's Midge Orchid	E1	E	Has been recorded from locations between Nowra and Pittwater and may occur as far north as Port Stephens. Dry sclerophyll forest and moss gardens over sandstone.	0	No – suitable habitat not recorded within the study area, no local records.	No
Haloragodendron lucasii	-	E1	E	Confined to a very narrow distribution on the north shore of Sydney. Dry sclerophyll forest and low open woodland on sheltered slopes near creeks, in moist sandy loam soils.	0	No – suitable habitat not recorded within the study area, no local records.	No
Lasiopetalum joyceae		V	V	Restricted to the Hornsby Plateau south of the Hawkesbury River, between Berrilee and Duffys Forest. Heath on lateritic to shaley ridgetops over sandstone.	0	No – suitable habitat not recorded within the study area, no local records.	No
Macadamia integrifolia	Macadamia Nut	-	V	Not known to occur naturally in the wild in NSW; recorded from Camden Haven but it is not known if the tree was cultivated or growing naturally. Drier subtropical rainforest.	1	No – suitable habitat not recorded within the study area.	No
Melaleuca biconvexa	Biconvex Paperbark	V	V	Only found in NSW, populations found in the Jervis Bay area in the south and the Gosford-Wyong area in the	0	No – suitable habitat not recorded within	No

				north. Damp places, often near streams or low-lying areas on alluvial soils.		the study area, no local records.	
Melaleuca deanei	Deane's Paperbark	V	V	Ku-ring-gai/Berowra area, Holsworthy/Wedderburn area, Springwood (in the Blue Mountains), Wollemi National Park, Yalwal (west of Nowra) and Central Coast (Hawkesbury River) areas. Heath on sandstone.	0	No – suitable habitat not recorded within the study area, no local records.	No
Persicaria elatior	Knotweed	V	V	In south-eastern NSW recorded from Mt Dromedary, Moruya State Forest near Turlinjah, the Upper Avon River catchment north of Robertson, Bermagui, and Picton Lakes. In northern NSW known from Raymond Terrace (near Newcastle) and the Grafton area (Cherry Tree and Gibberagee State Forests). Beside streams and lakes, swamp forest or disturbed areas.	0	No – suitable habitat not recorded within the study area, no local records.	No
Persoonia hirsuta	Hairy Geebung	E1	E	Scattered distribution around Sydney, from Singleton in the north, along the east coast to Bargo in the south and the Blue Mountains to the west. Sandy soils in dry sclerophyll open forest, woodland and heath on sandstone.	0	No – suitable habitat not recorded within the study area, no local records.	No
Pimelea curviflora var. curviflora	-	V	V	Confined to the coastal area of the Sydney and Illawarra regions between northern Sydney and Maroota in the north-west and Croom Reserve near Albion Park in the south. Woodland, mostly on shaley/lateritic soils over sandstone and shale/sandstone transition soils on ridgetops and upper slopes.	0	No – suitable habitat not recorded within the study area, no local records.	No
Pimelea spicata	Spiked Rice-flower	E1	E	Well-structured clay soils. Eucalyptus moluccana (Grey Box) communities and in areas of ironbark on the Cumberland Plain. Coast Banksia open woodland or coastal grassland in the Illawarra.	0	No – suitable habitat not recorded within the study area, no local records.	No
Rhizanthella slateri	Eastern Australian	V	E	In NSW, currently known from fewer than 10 locations, including near Bulahdelah, the Watagan Mountains, the	0	No – suitable habitat not recorded within	No

	Underground Orchid			Blue Mountains, Wiseman's Ferry area, Agnes Banks and near Nowra. Sclerophyll forest in shallow to deep loams.		the study area, no local records.	
Rhodamnia rubescens	Scrub Turpentine	E4A	-	Found in littoral, warm temperate and subtropical rainforest and wet sclerophyll forest usually on volcanic and sedimentary soils.	0	No – suitable habitat not recorded within the study area, no local records.	No
Rhodomyrtus psidioides	-	E4A	-	is currently known to occur from Broken Bay, approximately 30 km north of Sydney, to the Queensland (Qld) border. Populations of the species extend north to Gympie, Qld. NSW populations are typically restricted to coastal and sub-coastal areas of low elevation	0	No – suitable habitat not recorded within the study area, no local records.	No
Syzygium paniculatum	Magenta Lilly Pilly	E1	V	Only in NSW, in a narrow, linear coastal strip from Upper Lansdowne to Conjola State Forest. Subtropical and littoral rainforest on gravels, sands, silts and clays.	81	No – suitable habitat not recorded within the study area.	No
Thesium australe	Austral Toadflax	V	V	In eastern NSW it is found in very small populations scattered along the coast, and from the Northern to Southern Tablelands. Grassland on coastal headlands or grassland and grassy woodland away from the coast.	0	No – suitable habitat not recorded within the study area, no local records.	No

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