Randwick Health &
Innovation Precinct

Living Infrastructure Strategy

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Figure 1: Randwick Health & Innovation Precinct area.
(Photo: Craig Willoughby SKYview Aerial Photography)

UNSW SYDNEY

RANDWICK HEALTH &
INNOVATION PRECINCT
The future of lifelong health

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Acknowledgement of Country

The Randwick Health & Innovation Precinct partners acknowledge the Traditional Custodians on whose land the Precinct stands and pay respect to the Bidjigal and Gadigal peoples who traditionally occupied the Eastern Suburbs Coast. The Precinct pays respect to their continued and unbroken connection to the land, sea and community; and to Elders past and present.

Figure 2

Buriburi artwork designed by local Aboriginal artist, Jordan Ardler.
The artwork acknowledges the local La Perouse region and incorporates elements symbolic to the eastern coastline.
(Source: Randwick Campus Redevelopment, Newsfeed No.36, April 2022)

Celebrating the rich Aboriginal history and proud cultural heritage at the Precinct

The La Perouse Aboriginal community is the longest functioning and discrete Aboriginal Community in Sydney, with a rich cultural heritage and a continued connection to Country including the Randwick Health & Innovation Precinct. (Randwick Health & Innovation Precinct 2021-2024 Strategy, p.2)

Contents

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Executive Summary

Interactive Living Infrastructure offers RHIP transformative opportunities for environmental enhancement and management, social health and wellbeing and greater engagement with the surrounding community, an ideal 'living lab'. RHIP champions and values sustainability and innovation, adopting this Strategy will place RHIP at the forefront of precinct healthcare design, demonstrating clear benefits and best practice.

Project Purpose

Contact with nature and natural environments has a fundamental impact on all dimensions of human wellbeing - physical, social, cultural, psychological and spiritual. When these opportunities are co-located with health precincts then these green installations - be they temporary or permanent – have the capacity to contribute positively and regeneratively to the experience of multiple social groups with varying needs. Health precincts are visited by their onsite working community, the general public from the community surrounding the precinct and patients, families and other visitors. Views of and access to, nature and green spaces in this context have numerous roles. In these complex contexts the full spectrum of living infrastructure is useful from benign, beautiful natural settings that make no demands on those experiencing them (passive living infrastructure), to portable urban farms that enable office workers to grow their own vegetables and get their hands into soil in their lunchbreaks (interactive living infrastructure).

This project recognises the potential social, environmental and health benefits of the inclusion of both passive and interactive living infrastructure for a healthcare precinct. It unpacks the evidence-based benefits of living infrastructure and identifies educational and research opportunities that could be initiated on the Randwick Health & Innovation Precinct (RHIP) site. It offers a unique opportunity to identify and articulate the multiple significant benefits of living infrastructure to the Precinct and its surrounding communities.

Innovation and Contribution

The RHIP Living Infrastructure Strategy (the Strategy) is innovative and pioneering. The Strategy assists in setting up the Precinct as a best practice model and a 'living lab', addressing 21st century health challenges. The compounding health issues associated with increasing levels of chronic disease, ageing populations, degraded natural areas and food insecurity reinforce important roles for living infrastructure and particularly within health precincts. The significant co-benefits of living infrastructure extend to mitigating emissions and urban heat, while also supporting habitat provision and biodiversity (Alexandra 2017).

The term, 'living infrastructure' encompasses a range of natural biological or aquatic elements and features that are incorporated in the design and construction of human built environments. The features considered under the RHIP Living Infrastructure Strategy will include the Precinct's built environment assets that incorporate living elements, enhance biodiversity and/or generate ecosystem services. These assets include parks, streetscape plantings, bioswales, living roofs and walls, gardens, water features, micro-farms, contained plantings, terrariums and green views. The Strategy will propose how living infrastructure assets can become features or places that are actively used in the daily life of the Precinct.

Strategy Structure: Priority Areas

The Strategy draws on the Randwick Health & Innovation Precinct 2021-2024 Strategy which includes a radial hierarchy strategy map that was collaboratively developed by Precinct partners.

The Strategy is structured using three major priority areas that were established in the Project Charter (Appendix A) The three priorities are:

1. **Health Promotion**: for all communities engaged with the Precinct
2. **Social Connection**: between all communities in and around the Precinct
3. **Environmental Enhancement**: of the Precinct. Supporting sustainable development and management of living infrastructure in the Precinct

Strategy: Aims

1. **Add value** to the Precinct's existing and developing living infrastructure through capacity building and enhancement projects
2. **Identify opportunities** for long-term monitoring and whole life cycle management of living infrastructure within the Precinct
3. **Engage with community programs** focused on placemaking, arts and culture
4. **Provide an evidence base** for the health and environmental benefits of living infrastructure at precinct-scale

Plan of Action

Interactive Living Infrastructure offers RHIP transformative opportunities for environmental enhancement and management, social health and wellbeing and greater engagement with the surrounding community, an ideal 'living lab'. RHIP champions and values sustainability and innovation, adopting this Strategy will place RHIP at the forefront of precinct healthcare design, demonstrating clear benefits and best practice.

In addition to developing the Strategy, this initiative generates the first set of living infrastructure projects in the Precinct and identifies the scope, partners and potential sources of funding for each of them.

Matrix of Recommended Projects

The projects are broadly divided into two categories of Capacity Building and Environmental Enhancement. Capacity Building Projects are continuous, process and people focused efforts to improve how the Precinct manages and develops its living infrastructure. Environmental Enhancement Projects are interactive, place focused initiatives, targeting opportunities identified either within this Strategy or from future capacity project efforts, producing time and place appropriate living infrastructure for chosen locations. These inclusions could be temporary, recurring, long-term and fixed, or mobile.

The Project Matrix below (Table 1) briefly summarises the three Capacity Building and the three Environmental Enhancement projects that are proposed by this Strategy for development in the near term which will be discussed later in detail (section 2). A further four of each kind of project which were identified during the Strategy formation have also been listed here in Italics as they may be considered for future development. The Matrix provides a suggested implementation priority rating, with three stars recommending implementation as soon as feasibly possible, two stars recommending implementation once sufficient capacity has been developed and resources are available and one star recommending implementation only after clear opportunities have been identified and resources are available.

Table 1

The Project Matrix

Capacity	Project Overview	Priority
Living Assets	Inventory database for Precinct living infrastructure assets	***
Living Champions	Enabling grassroots support for Precinct living infrastructure	***
Living Assessments	Periodic assessments to identify living infrastructure opportunities	**
Living Views	Measuring living views access from work areas and patient rooms	**
Living Pathways	Path assessments and wayfinding maps for living infrastructure	**
Living Therapy	Using living infrastructure for therapy programming	**
Living Circles	Organics circularity and recycling program for the Precinct	**
Enhancement	**Project Overview**	
Living Walls	Living infrastructure enhancements for vertical spaces	*
Living Pop-Ups	Mobile living infrastructure for temporary ‘pop-up’ enhancements	*
Living ‘Farms’	Living infrastructure for food education or production	*
Living Shelter	Using living infrastructure to shelter outdoor seating and paths	*
Living Roofs	Identifying and converting appropriate roof areas to living roofs	*
Living Alcoves	Restoration spots with interactive living infrastructure	*
Pet Pots	DIY plant pots or terrariums for therapy and placemaking	*

Section 1
The Strategy

1.1 Introduction

Contact with nature and natural environments has a fundamental impact on all dimensions of human wellbeing - physical, social, cultural, psychological and spiritual. When these opportunities are co-located with health precincts then these green installations - be they temporary or permanent – have the capacity to contribute positively and regeneratively to the experience of multiple social groups with varying needs. Health precincts are visited by their onsite working community, the general public from the community surrounding the precinct and patients, families and other visitors. Views of and access to, nature and green spaces in this context have numerous roles. Green spaces provide something nourishing for the everyday working community; they may draw in the surrounding community and connect them to the health precinct; and they offer patients and their families opportunities to use to de-stress and restore emotionally and psychologically.

In these complex contexts the full spectrum of living infrastructure is useful from benign, beautiful natural settings that make no demands on those experiencing them (passive living infrastructure), to portable urban farms that enable office workers to grow their own vegetables and get their hands into soil in their lunchbreaks (interactive living infrastructure).

There are two crucial levels of response to green spaces and living infrastructure that are in play in a healthcare context: one is associated with environmental perception and one is associated with environmental experience. Views of nature (real views through windows, photographic images and depictions in art) have been proven to bring about positive physiological effects in patients beginning with Ulrich's (1984) work. The perception of nearby nature and of natural imagery can be powerful in human health and feeling of wellbeing. The second level is environmental experience – the capacity to experience something living in an otherwise institutional building – such as flowers by a bedside or sensory gardens or food gardens in the healthcare precinct which provide relief from the intensity of a patient's health situation, a stressful working life and a place to restore

emotional strength. For adolescent patients, these places can provide a place to hang out together and socialise.

This project recognises the potential social, environmental and health benefits of the inclusion of both passive and interactive living infrastructure for a healthcare precinct. It unpacks the evidence-based benefits of living infrastructure and identifies educational and research opportunities that could be initiated in the Randwick Health & Innovation Precinct (RHIP) site with both local and more generalisable benefits. It also offers a unique opportunity to identify and articulate the multiple significant benefits of living infrastructure to the Precinct and its surrounding communities.

1.2 Contribution and Innovation

The RHIP Living Infrastructure Strategy is innovative and pioneering. A review of the literature for this project reveals living infrastructure strategies have been developed at city scale; however, few health precincts have developed a place-based, precinct-wide strategic approach to understanding, monitoring, evaluating and managing living infrastructure over the long term.

The RHIP Living Infrastructure Strategy assists in setting up the Precinct as a best practice model and a 'living lab', addressing 21st century health challenges. The compounding health issues associated with increasing levels of chronic disease, ageing populations, degraded natural areas and food insecurity reinforce important roles for living infrastructure within health precincts. For example, living infrastructure in the form of micro scale farming can produce fresh food, while also being places for education and learning for staff and patients (Veldheer et al. 2020). Evaporative cooling and shade from green canopies can help heat-vulnerable groups (older people, people with chronic disease and socioeconomically disadvantaged groups) adapt and live better in warming environments, contributing to comfortable, cool outdoor and semi-outdoor areas for walking, socialising and resting (Alexandra 2017; McKenzie 2022).

The significant co-benefits of living infrastructure extend to mitigating emissions and urban heat, while also supporting habitat provision and biodiversity (Alexandra 2017). Strategically located living infrastructure elements—both indoors and outdoors—can provide shade, improve air quality, connect biodiversity corridors, create habitat and help sequester emissions produced by the mechanical cooling needs of buildings. In turn, reducing the urban heat island effect helps relieve temperatures that add to accumulated heat stress and can be life-threatening to vulnerable people and species (Alexandra 2017; Santamouris and Osmond, 2020).

1.3 Defining 'Living Infrastructure'

The term, 'living infrastructure' encompasses a range of natural biological or aquatic elements and features that are incorporated in the design and construction of human built environments, or as a reference to the interconnected ecosystems found within urban areas (ACT Government 2018; Melbourne Metro Rail Authority 2017).

The crucial role that supportive and restorative environments play in promoting human wellbeing and improving health outcomes is widely recognised in contemporary healthcare practice and corroborated by a growing body of research (Bae and Asojo 2022; Abdelaal and Soebarto 2019). Natural elements, materials and features—trees, shrubs, flowers, water, timber and stone—are considered especially valuable

assets for creating restorative settings that can bolster human health and wellbeing (Abdelaal and Soebarto 2019). This is not only because of direct environmental and health benefits that they can provide, such as providing shade and improving air quality, but also due to the inherent human desire for nature experiences called biophilia (Grinde and Patil 2009).

The features considered under the RHIP Living Infrastructure Strategy will include the Precinct's built environment assets that incorporate living elements, enhance biodiversity and/or generate ecosystem services (the benefits provided to humans by the world's ecosystems such as food and fibre, clean air and water, carbon sequestration, pollination). These assets include

Figure 3 - 7

Top Left: Rooftop vegetable garden, Bangkok (Source: Adobe)

Top Right: Green wall of hospital in Strasbourg, France (Source: Adobe)

Bottom Left: Living Canopy (Source: Adobe).

Bottom Middle: Plant pots (Source: Adobe)

Bottom Right: Garden Terrace, Kinghorne Cancer Institute, Sydney (Photo: Louise McKenzie)

parks, streetscape plantings, bioswales, living roofs and walls, gardens, water features, micro-farms, contained plantings, terrariums and green views. The Strategy will propose how living infrastructure assets can become features or places that are actively used in the daily life of the Precinct. Figures 3 - 7 illustrate some diverse examples of living infrastructure elements.

1.4 Strategy Structure, Aims and Objectives

Strategy Structure

Priority Areas

The RHIP Living Infrastructure Strategy (the Strategy) is structured using three major priority areas that were established in the Project Charter (Appendix A) The three priorities are:

1. Health Promotion: for all communities engaged with the Precinct
2. Social Connection: between all communities in and around the Precinct
3. Environmental Enhancement: of the Precinct. Supporting sustainable development and management of living infrastructure in the Precinct

The strategy is divided into three sections plus a set of appendices:

Section 1: The strategy

- 'Living Infrastructure' is defined and the Strategy sets out the aims, objectives and format of the Strategy

Section 2: The projects

- Presents six living infrastructure project proposals; three focused on capacity building and management and three on interactive environmental enhancements

Section 3: Context, literature review and precedents

- Includes the context and guiding precedents for the Strategy derived from the review of relevant literature and case studies

Appendices: Two sets of case studies

Aims

This Living Infrastructure Strategy for the RHIP is a place-specific framework that aims to:

1. **Add value** to the Precinct's existing and developing living infrastructure through capacity building and enhancement projects
2. **Identify opportunities** for long-term monitoring and whole life cycle management of living infrastructure within the Precinct
3. **Engage with community programs** focused on placemaking, arts and culture
4. **Provide an evidence base** for the health and environmental benefits of living infrastructure at precinct-scale

Objectives

1. **Enhance value**: The Strategy aims to build on and add value to existing and planned living infrastructure for the Precinct. As a foundation, the Strategy responds to the design principles adopted by the Precinct landscape architects: Aspect Studios. These principles include:

- Provide a green outlook and landscape spaces that are healing, engaging and transformative to the patients, carers and staff
- Create legible and welcoming entrances with

pedestrian through-site connections that are clear, open and intuitive

- Provide an integrated approach to cultural recognition and storytelling within the planting, paving and play elements
- Create places that are welcoming for children of all ages and meet the needs of families (Aspect Studios 2021, p.11).

2. **Enhance the masterplan**: The Strategy considers the design principles and processes that inform the landscape masterplan. Four design principles underpin Aspect's approach to creating public spaces for the Precinct:

- Green and Healthy
- Connected
- Integrated
- Responsive (Aspect Studios 2018, p.6).

Other site considerations by Aspect include tree canopy coverage, landscape structure, solar access and deep soil. Tree canopy cover serves to mitigate the impacts of the urban heat island effect and contribute to enhancing the biodiversity of the site. Landscape structure aims to provide green outlooks and spaces

Figure 8

Heath-leaved Banksia
(endangered Eastern Suburbs Banksia Scrub species)
(Photo: Louise McKenzie)

for healing and engagement. Solar access dictates outdoor microclimates and appropriate spatial arrangement of activities and plant species. Deep soil allows for on-site stormwater infiltration and the planting of larger tree species (Aspect Studios 2021, pp.13-20).

3. **Preserve native vegetation**: Regarding the human health benefits attributed to biodiversity, the Strategy takes account of the fact that the Precinct's original native vegetation is now a critically endangered ecological community. This community, known as the Eastern Suburbs Banksia Scrub (ESBS), comprises scrub and heath species (Figure 8) which have evolved to tolerate the salt, winds and poor soils characteristic of the area. As less than three percent of the original ESBS coverage still remains, opportunities to re-establish and enhance the ESBS community are considered especially important (Aspect Studios 2018; Osmond and Blair 2016).

4. **Strengthen partnerships**: The Strategy seeks to strengthen the partnerships established through the Precinct's design, construction and ongoing maintenance stages for living infrastructure. Of note are partnerships built with First Nations peoples through the RHIP Arts and Culture program which focuses on valuing, respecting and passing on Aboriginal cultural knowledge. Programs included stone carving workshops (see Box A) and an Aboriginal garden for the Prince of Wales Hospital Acute Services Building co-designed with La Perouse Local Aboriginal Land Council and Yerrabingin. The Living Infrastructure Strategy will seek ways to ensure and scale up, ongoing community learning and co-design practices, including the potential to create culturally safe outdoor spaces for First Nations' traditional practices (see Appendix B: Secondary Case Study Summary for Westmead Health Precinct).

Existing living infrastructure offers opportunities to connect with community development programs, such as the Prince of Wales Hospital Community Garden (see Box B) and the Randwick Community Garden (located south of the Precinct alongside the Paine Reserve). The Strategy also aims to foster new partnerships and ongoing learning and social connection through the Precinct's existing and future community engagement programs focused on placemaking, arts and culture.

5. **Identify beneficial collaborations**: Potential collaborations between consultant groups like Aspect and the UNSW Faculty of Arts, Design and Architecture and School of the Built Environment, offer opportunities to engage in research projects that continue to build an Australian evidence base validating the health benefits of living infrastructure. The Precinct will provide significant opportunities for research and teaching that examines the performance and management of living infrastructure over the long term. Opportunities also exist for research collaborations, led by UNSW Indigenous scholars, that explores roles for Indigenous knowledge towards climate change adaptation (Petzold et a. 2020) and 'Caring for Country' associated with biodiversity, conservation and the spiritual process of renewal (Anderson 2022).

Box A

RHIP Redevelopment and 'Connection to Country'

- stone carving workshops and sculptures

Connection to Country

The Randwick Campus Redevelopment has worked alongside the La Perouse Local Aboriginal Land Council and the Aboriginal Community to recognise their rich continued connection to Country through stone carving sculptures. Workshops for the sculptures have provided the opportunity for Elder, David Ingrey to pass on traditional techniques and stories, unique to their culture.

In 2019, young men from La Perouse Youth Haven carved a large-scale whale on sandstone that had been excavated from the Randwick Campus Redevelopment site. The carving workshop enabled the young men to learn the technique of carving using traditional stones. The sandstone artwork from a second stone carving workshop will be integrated into the landscape design of the refurbished cottage. This work is the twin to Burri Burri, a work created by the group for the Aboriginal garden for the Prince of Wales Hospital Acute Services Building.

Sources: Randwick Campus Redevelopment Newsfeed. (2022); Randwick Campus Redevelopment Arts and Culture Strategy Update. (n.d.)

Box B

Prince of Wales Hospital Community Garden

Community development initiative with existing living infrastructure

Prince of Wales Hospital Community Garden

The Randwick Hospital's Campus recognises the significance of the La Perouse Aboriginal community's continued connection to country. The campus partnered with Gujaga and the Dharawal Language Program to develop the 'Bush Medicine' theme for this community garden.

The native species present in this garden were chosen for their medicinal potential and cultural significance for the Bidjigal and Gadigal peoples, who traditionally occupied the eastern suburbs and coastal areas of Sydney.

All produce grown in this garden will be donated to Eastern Suburbs Mental Health Service programs. Creating opportunities for social inclusiveness and physical activity and the provision of healthy produce are integral to the garden's aim to enhance the consumer experience.

Sources: Randwick Campus Redevelopment Arts and Culture Strategy Updates (2022)

1.5. Strategic Priorities

The RHIP Living Infrastructure Strategy map draws on the Randwick Health & Innovation Precinct 2021-2024 Strategy which includes a radial hierarchy strategy map that was collaboratively developed by Precinct partners. Based on this previously developed approach, the RHIP Living Infrastructure Strategy Map (Figure 9) also adopts a radial, hierarchical structure using a modified 'sunburst' diagram.

Sunburst diagrams place the highest-level elements in the centre of the rings with each successive segmented ring representing a lower level in the hierarchy as it moves towards the outer ring. The Strategy map depicts primary priorities that were established in the RHIP Living Infrastructure Strategy Project Charter, substantiated by strategic themes and key focus areas derived from reviewing the literature and case studies discussed in Section 3.

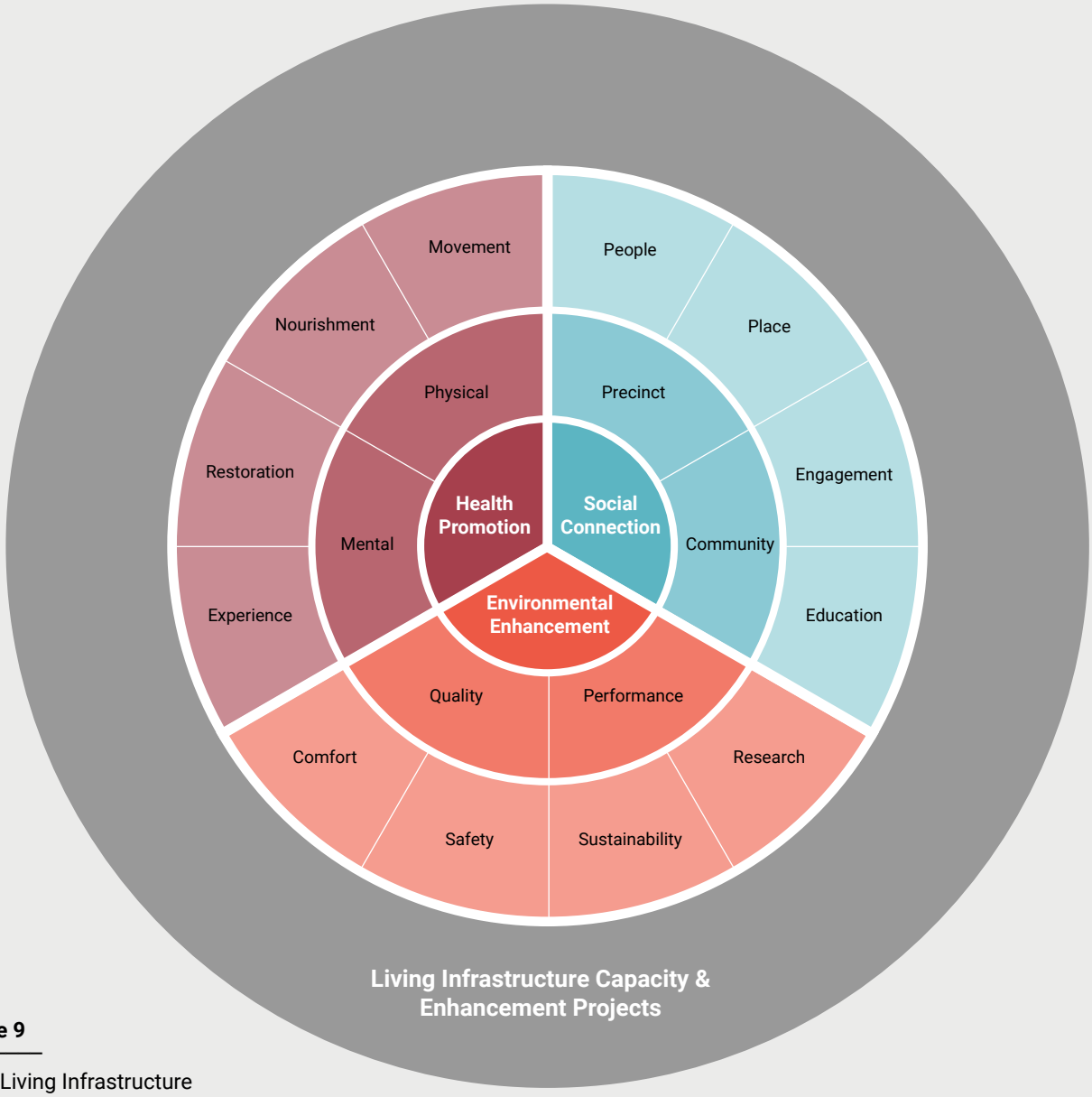

Figure 9

RHIP Living Infrastructure Strategy Map. (Adapted from the Randwick Health & Innovation Precinct Strategy 2021-2024 n.d., p.13)

Strategic Priority 1: Health Promotion

In this strategy health promotion is concerned with "physical, social and mental wellbeing and strives to help people take control over the matters that influence their health" (Walker et al. 2011, p. S8). The tenets of contemporary health promotion include the "notions of participation, community control and respect for people not as unthinking objects of research but as partners in knowledge development" (Springett 2001, p.139).

Health promotion is subdivided into the supporting themes of physical and mental health and wellbeing. The physical theme specifically focuses on how living infrastructure can help support two major public health and wellbeing issues, the promotion of physical activity and sufficient access to healthy, nourishing food (Richard et al. 2011). Physical activity incorporates 'movement' and choice into daily life in the Precinct, with the potential for more interactive activities and programs. Access to fresh and meaningful food may be generalised as 'nourishment', involving opportunities for learning about healthy nutrition and food preparation, recognising and respecting food culture, as well as actively growing and consuming fresh foods. The mental theme focuses on the benefits of living infrastructure in terms of people's innate connection with nature and associated biophilic health and wellbeing benefits. Benefits may be either restorative, experiential, or both (Kaplan 1995; Ulrich and Zimring 2004).

Evaluating health and wellbeing promotion interventions appropriately depends on many factors and needs to be determined in partnership with Precinct healthcare staff. Factors addressed include what is being evaluated; appropriate for whom; and appropriate for what. Action research and participatory action research approaches, often utilised for health and wellbeing promotion evaluation, emphasise learning over proving (Springett 2001, p.139).

Theme 1: Physical Health and Wellbeing

Physical health and wellbeing promotion indicators for living infrastructure were selected through a review of the abundant body of public health literature focused on promoting physical activity and supporting good nutrition. Focus was given to the healthy-built environment literature along with rating standards for healthy built environments like WELL and Fitwel, from which the key issues of 'movement' and 'nourishment' were derived.

Impact Area 1: Movement

- Physical activities: Determining how living infrastructure can help enable diverse physical activities, such as making spaces more conducive for exercise and playing or providing opportunities for hands-on activities like gardening.
- Path quality: Ascertaining how living infrastructure can help encourage movement by increasing the safety and comfort of travel pathways, such as sheltering paths from harsh weather and strong sunlight or serving as barriers to prevent accidents or unsafe behaviour.
- Clear wayfinding: Identifying how living infrastructure can be used to improve wayfinding, such as using themed planters as visual way markers or distinctive living infrastructure elements providing easily recognizable landmarks.
- Rehabilitation therapy: Discerning how living infrastructure can be used to support physical rehabilitation, such as acting as

gently challenging mobility obstacles or as serving as mediums for horticulture therapy.

Impact Area 2: Nourishment

- Fresh food: Exploring how living infrastructure can supplement the supply of fresh and healthy food for the Precinct and surrounding community, such as the use of edible landscaping or providing space for hydroponic micro-farms and community food gardens.
- Food waste: Investigating how living infrastructure can help reduce Precinct food waste, such as providing spaces for composting and using compost on the Precinct.
- Food education: Establishing how living infrastructure can help deliver food focused education, such as providing the settings and ingredients for gardening, cooking and nutrition classes.
- Food culture: Determining how living infrastructure can serve as an avenue for food culture expression and solace, such as providing access to culturally familiar ingredients or foods.
- Food connections: Ascertaining how living infrastructure can help support food-based social activities, such as supplying ingredients for event meals or acting as backdrops for food related discussions.

Theme 2: Mental Health and Wellbeing

The experience of nature can bring various psychological benefits, including attention restoration, stress recovery and mood improvement (Lyu et al. 2022). Mental health and wellbeing promotion indicators for living infrastructure were selected from the literature review regarding the health and wellbeing benefits of spending time in nature, alongside the therapeutic and healing functions of greening and greenspaces. The literature highlighted 'restoration' and 'experience' as key concepts for living infrastructure projects, noting that these areas overlap to a degree.

Impact Area 3: Restoration

- Refuge spaces: Identifying how living infrastructure can help create areas that are sheltered from sources of distraction and stress, such as planters that shield meditation or study areas from sounds and sights.
- Fatigue relief: Establishing how living infrastructure can help enable fatigue relief, such as making rest and sleep areas more pleasant or provide energizing stimulus.
- Active relaxation: Examining how living infrastructure can support immersive relaxation activities for attention recovery, such as providing spaces for play or engaging interactive elements.
- Passive attention: Determining how living infrastructure can enable attention recovery through observable elements that allow soft fascination or reflection, such as flowing water features or colourful plant arrangements.

Impact Area 4: Experience

- Nature access: Ascertaining how living infrastructure can be strategically placed to provide easy access to natural elements, such as providing access to natural or green views within a certain distance of workspaces or from inside patient rooms.
- Occupant satisfaction: Determining how living infrastructure can be used to improve

the impressions that occupants have towards spaces, such as making rooms feel more pleasant or blocking unpleasant views.

- Sensory stimulation: Recognising how living infrastructure can provide a variety of pleasantly stimulating sensory experiences, such as pleasing scents from herbs and flowers or plant varieties that are pleasing and resilient to touch.
- Intrinsic enjoyment: Exploring how living infrastructure can enable the enjoyment of intrinsically motivated activities, such as observing or surveying which activities are the most popular and modifying living infrastructure to support those activities.

Strategic Priority 2: Social Connection

Social connection serves essential functions vital to survival (e.g., safety and efficiency of effort) and is viewed as "adaptive across the life span, suggesting that humans are 'wired' to be social, such that our brains and bodies expect the proximity to others" (Holt-Lunstad 2021, p.251). Social connectedness is defined as the "sense of belonging and subjective psychological bond that people feel in relation to individuals and groups of others", suggesting that "identification with others is the basis for social connectedness" (Haslam et al. 2016, p.1). The strategic priority of social connection is subdivided into the supporting themes of 'precinct' and 'community'. Social connection in relation to the precinct considers the way living infrastructure can support social interactions between people and create places or 'behaviour settings' (Barker 1968) that are comfortable, appealing and enable social activities. While interrelated, community focuses on how living infrastructure can support the engagement and education of the precinct community and broader Randwick community.

Theme 3: Precinct Connections

Precinct indicators for living infrastructure were selected through reviewing the literature and health precinct case studies related to social interactions and people's relationship to place. The indicators selected include 'people' and 'place'. They are also informed by an assessment of roles for living infrastructure in the design and use of public spaces as well as education and research methods involving participatory design.

Impact Area 5: People

- Conversation starters: Exploring how living infrastructure can spark new opportunities for conversation, such as seasonal flowers acting as topic starting sources of novelty.
- Inviting spaces: Identifying how living infrastructure can encourage chance encounters via more frequent and longer-lasting use of spaces, such as trees shading outdoor seating in the summer so occupants can stay outside longer.
- Shared use: Determining how living infrastructure can enable flexible and simultaneous use of spaces by multiple users, such as mobile planters that can act as space dividers (a useful concept in an era of "living with COVID") or be moved to create shared spaces.
- Convenient access: Ascertaining how living infrastructure can be conveniently placed to create social spaces where they are needed, such as parklets nearby cafes or entryways.

Impact Area 6: Places

- Event settings: Establishing how living infrastructure can help create places for holding different events, such as a garden courtyard for small groups or a large lawn area for large gatherings.

- Utility features: Determining how living infrastructure can integrate useful features that can support place-based activities or events, such as planters with speakers or trees with hanging lights for outdoor or festive illumination.
- Flexible arrangements: Identifying how living infrastructure can be useful for creating temporary place arrangements for events, such as using mobile planters to mark seating areas or as way markers for event guests.
- Exhibition locations: Recognising how living infrastructure can serve as exhibition platforms for distinguishing places, such as exhibiting unique and innovative living infrastructure features.

Theme 4: Community Connections

Community capacity describes the ability of community groups to collaborate with regards to conducting activities and resolving issues (Labonte and Laverack 2001). For the Precinct, building capacity for the community is a fundamental strategic priority and developing projects that incorporate community engagement and education will also require collaboration between Precinct partners. Community indicators for living infrastructure include 'engagement' and 'education'. They were selected through reviewing literature related to community participation and engagement in environmental initiatives and education-focused programs.

Impact Area 7: Engagement

- Community participation: Identifying how living infrastructure can create participation opportunities for community residents, such as co-design workshops for living infrastructure or community volunteers for gardening and food activities.
- Community events: Determining how living infrastructure can be used to support community-run activities, such as lending mobile planters for a community event or a community group to using a lawn area for an event.
- Community amenity: Recognising how living infrastructure can serve the surrounding community as public amenities, such as providing shelter or interesting landmarks for a community walking tours through the Precinct.
- Community support: Exploring how living infrastructure can help provide support to the surrounding community, such as extra food produced by micro-farms or food gardens being donated to community food pantries.

Impact Area 8: Education

- Primary/Secondary students: Examining how living infrastructure can provide learning experiences for primary and secondary students, such as exhibition items for fields trips or study assignments for long-stay student patients.
- Tertiary and TAFE students: Identifying how living infrastructure can serve as platforms for educating tertiary and TAFE students, such as integrating living infrastructure into UNSW research coursework or providing opportunities for student work experiences for UNSW and TAFE interns.
- Informational displays: Recognising how living infrastructure can be paired with educational information displays, such as signs providing information on biodiversity or ecological benefits of plant species, or food nutrition and preparation suggestions

alongside edible plants.

- Community health: Exploring how living infrastructure can be used to support community health education events and activities, such as providing direct examples for seminars on the various health benefits derived from nature experiences and fresh food.

Strategic Priority 3: Environmental Enhancement

Environmental enhancement involves proactively implementing measures to improve the beneficial impacts of Precinct living infrastructure, both in terms of human wellbeing and environmental sustainability (McCluskey and João 2011). As a priority in this strategy, environmental enhancement is split into the supporting themes of 'quality' and 'performance'. Environmental quality specifically focuses on how living infrastructure assets will enhance the characteristics affecting experiential and wellbeing outcomes for Precinct inhabitants, such as factors like thermal comfort and sound levels or safety factors like water and microbial management. Environmental performance more broadly considers measuring and improving additional performance indicators for living infrastructure identified from various environmental and sustainability resources such as biodiversity or energy management, as well as coordinating any research efforts relating to performance indicators and Precinct living infrastructure assets.

Theme 5: Environmental Quality

Environmental quality indicators for living infrastructure were selected by reviewing several quality standards for healthy built environments, such as WELL, Fitwel and NABERS. Once compiled, the focus areas of 'comfort' and 'safety' were derived as a reasonable representation of the various indicators, with safety concentrating on ensuring overall safe environmental conditions and comfort aiming for adjustable options for individual needs.

Impact Area 9: Comfort

- Thermal comfort options: Tracking how living infrastructure can provide microclimate choices for users in a space, for example trees arranged to provide both shaded and sunny areas that users can choose between according to their preference.
- Air flow management: Examining how living infrastructure can be used to manage air flow in a space, for example planters placed to block or redirect air flow.
- Light exposure control: Assessing how living infrastructure can be used to adjust indoor lighting conditions, such as using planters to shield or soften bright lighting.
- Sound exposure reduction: Considering how living infrastructure can absorb ambient noise or block undesirable noise.
- Spatial layouts and proxemics: Evaluating how living infrastructure can modify movement through spaces and creating space boundaries, for example using planters to create queuing lines or separate waiting areas (noting also the earlier reference to COVID).
- Shelter and seating placement: Determining how living infrastructure can be placed to provide optimum shelter for outdoor pathways and seating areas from uncomfortable weather conditions.
- View quality factors: Gauging how living infrastructure can be used to improve view

quality, such as serving as aesthetic visual features or blocking undesirable views.

- Space quality: Assessing how living infrastructure impacts space use and experience, such as recording frequency of user visits and length of stay in spaces or surveying user satisfaction.
- Path quality: Measuring how living infrastructure influences path use and experience, such as noting path travel behaviours or surveying user satisfaction.

Impact Area 10: Safety

- Temperature stress: Identifying how living infrastructure can be used to prevent or reduce instances of extreme temperature stress, especially during heatwaves, such as shading heat retentive surfaces or insulating areas with high thermal transmission.
- Moisture management: Tracking how living infrastructure affects moisture conditions and taking suitable action, such as fixing irrigation leaks or maintaining appropriate relative humidity levels.
- Biological control: Monitoring how living infrastructure impacts biological conditions, such as avoiding biological risks from pests or disease vectors and supporting the development of healthy microbiomes.
- Air quality: Testing how living infrastructure changes air quality conditions, such as removing air pollutants while avoiding the introduction of allergens.
- Water management: Analysing how living infrastructure can be used to improve water management, such as reducing stormwater runoff and pollutant levels or using recycled water for irrigating plants.
- Waste management: Considering how living infrastructure can be managed to avoid waste accumulation and enable organic circularity, such as gathering fallen leaves and branches to use as mulch or compost for garden beds.

Theme 6: Environmental Performance

Environmental performance indicators for living infrastructure were identified and gathered from various standards and resources, including Green Star, SITES, academic articles and government reports. The 'sustainability' focus area acts as the repository for various important to monitor environmental sustainability indicators. However, there are still many underdeveloped knowledge areas for optimising the performance of living infrastructure not only for environmental outcomes, but also health and social outcomes. Therefore, the 'research' focus area considers various research directions and indicators for conducting living infrastructure performance research on the Precinct. Delivery of living infrastructure services to enhance human health also requires optimising the health of the living infrastructure.

Impact Area 11: Sustainability

- Water efficiency: Evaluating how living infrastructure can be as water efficient as possible, such as using effluent, greywater, or rainfed irrigation methods for living infrastructure.
- Energy efficiency: Tracking how living infrastructure impacts energy usage, such as reducing energy use by reducing heat gain and loss or the increasing energy use due to plant lights.
- Material life cycles: Exploring how living infrastructure can impact built environment material life cycles to support carbon avoidance or sequestration and material circularity.

- Soil health: Monitoring soil chemistry and biology change over time to ensure healthy conditions for living infrastructure, along with soil health supporting practices such as using mulch or compost.
- Vegetation health: Observing how living infrastructure physically changes over time to identify and address vegetation health issues, for example changes in leaf colour and coverage that might indicate nutrient deficiencies or disease.
- Habitat health: Determining how living infrastructure affects habitat provision and balance, such as providing flowers for pollinators or nesting areas for birds.
- Responsible procurement: Verifying that living infrastructure projects and any related tender activities utilise materials or products from sustainable sources and companies following responsible practices.
- Asset accounting: Documenting how living infrastructure assets are used and change over time, such as compiling locations, attributes and monitoring data in a registry.
- Asset maintenance: Recording how and when living infrastructure is maintained to ensure effective long-term management and identify chronic issues, as well as confirming the use of sustainable practices and products for all maintenance and tender activities.

Impact Area 12: Research

- Patient experience: Studying living infrastructure performance in terms of patients and their health outcomes and feeling of wellbeing.
- Staff experience: Examining living infrastructure performance in terms of staff and their workplace wellbeing and satisfaction.
- Student outcomes: Evaluating living infrastructure performance in terms of students and their educational development.
- Community experience and perception: Analysing living infrastructure performance in terms of its capacity to support community resilience and wellbeing.
- Ecological research: Investigating living infrastructure performance in terms of ecosystem health and sustainability.
- Prototypes and innovations: Developing and testing new types of living infrastructure.
- Comparative research: Comparing the performance of various types of living infrastructure.
- Research data access: Providing convenient and public access to living infrastructure performance data.
- Research communication: Publishing and communicating living infrastructure performance research results.

The comprehensive nature of this framework and its strategic inclusions provides the basis for proposing subsequent Precinct based projects focused on both passive and interactive living infrastructure and both environmental enhancement and capacity building projects. The three tiers of the Strategy map span both qualitative research and quantitative measures and indicators. The breadth of this reviewed material enables a comprehensive strategy which provides a sound framework from which to indicate prospective projects following the development of the Strategy. The next section will outline the first six of these projects including three environmental enhancement projects and three capacity building projects.

Section 2
The Projects

The Living Infrastructure Projects proposed in this section were developed according to the opportunities identified from examinations of Precinct environments and reference documents or discussions with the Precinct Advisory Group. These proposals are not meant to be a list of definitive projects, but to serve as preliminary concepts that the Precinct and partners can use to guide project development and implementation.

The projects are broadly divided into two categories of Capacity Building and Environmental Enhancement projects. Capacity Building Projects are continuous, process and people focused efforts to improve how the Precinct manages and develops its living infrastructure, in addition to serving as the long-term supporting foundation for enhancement projects by ascertaining need or opportunity to implement living infrastructure enhancements and ensuring their continued maintenance after completion. Environmental Enhancement Projects are interactive, place focused initiatives, targeting opportunities identified either within this Strategy or from future capacity project efforts, producing time and place appropriate living infrastructure for chosen locations. These inclusions could be temporary, recurring, long-term and fixed, or mobile.

The Project Matrix below (Table 1) briefly summarises the three Capacity Building and the three Environmental Enhancement projects that are proposed by this Strategy for development in the near term which will be discussed in this chapter in detail. A further four of each kind of project which were identified during the Strategy formation have also been listed here in Italics as they may be considered for future development. The Matrix also provides a suggested implementation priority rating, with three stars recommending implementation as soon as feasibly possible, two stars recommending implementation once sufficient capacity has been developed and resources are available and one star recommending implementation only after clear opportunities have been identified and resources are available.

Following the Matrix are six project proposal briefs, which detail the first three Capacity and the first three Enhancement projects considered for implementation because 1) they help establish long-term supporting foundations for future projects, or 2) they align with current opportunities presented in the Precinct's development program. The proposal briefs outline implementation options, primary benefits, possible locations, potential partners, relevant grants, as well as prospects for research and education integration.

Table 1

The Project Matrix

Capacity	Project Overview	Priority
Living Assets	Inventory database for Precinct living infrastructure assets	***
Living Champions	Enabling grassroots support for Precinct living infrastructure	***
Living Assessments	Periodic assessments to identify living infrastructure opportunities	**
Living Views	Measuring living views access from work areas and patient rooms	**
Living Pathways	Path assessments and wayfinding maps for living infrastructure	**
Living Therapy	Using living infrastructure for therapy programming	**
Living Circles	Organics circularity and recycling program for the Precinct	**
Enhancement	**Project Overview**	
Living Walls	Living infrastructure enhancements for vertical spaces	*
Living Pop-Ups	Mobile living infrastructure for temporary ‘pop-up’ enhancements	*
Living ‘Farms’	Living infrastructure for food education or production	*
Living Shelter	Using living infrastructure to shelter outdoor seating and paths	*
Living Roofs	Identifying and converting appropriate roof areas to living roofs	*
Living Alcoves	Restoration spots with interactive living infrastructure	*
Pet Pots	DIY plant pots or terrariums for therapy and placemaking	*

2.1 Capacity Building Project 1: Living Assets

Overview	This Capacity Project aims to create an inventory or registry system and processes for tracking and compiling information for all notable living infrastructure assets in the Precinct. The collected data can then be used to facilitate living asset management, development and research.
Implementation Options	The approach for the Precinct living asset inventory system will depend on the resources that are available for its development and management. As such, this Strategy considers three potential approaches for implementation: Basic, Advanced and Hybrid. The Basic approach would emphasise efficiency by primarily using existing available UNSW data collection and management resources to create and maintain the inventory system. This could include relying on UNSW equipment or research assets for data collection, hosting and managing the inventory database on the UNSW data platforms, along with incorporating data collection and management activities into applied coursework or internships for UNSW students. The Advanced approach would aim for full integration with the Precinct operations by dedicating the necessary resources to implement the living asset inventory system and processes as a routine part of Precinct facilities management procedures. This could involve the Precinct purchasing and using data collection tools or monitoring sensors, hosting and managing the inventory database on Precinct data platforms and assigning relevant staff to manage the inventory system and collect data. The Hybrid approach would integrate the Basic and Advanced approaches by using a mix of available UNSW resources and Precinct resources for the inventory system and processes as appropriate to circumstances. This could entail using available UNSW resources for initial establishment after which the Precinct would gradually merge the inventory system and processes into its standard operations, or the Precinct could initially invest resources for inventory establishment which would then be supplemented and sustained with UNSW support. While the amount and diversity of data that can be collected for the inventory database would be dependent on available resources, the organisation of collected data can be similar for all approaches by drawing upon methods for tree registries or forest inventories (Boogaerdt and Brown 2022; Tomppo et al. 2011). Data categories could include: • Asset ID: Unique designations assigned to each living asset using numbers and abbreviations.

- Type: The category of living infrastructure that the asset is assigned, for example living walls, living roofs, micro-farms, trees, planters, etc.
- Location: Where the living asset is located on the Precinct. If the living asset is mobile, then the current location is indicated along with appropriate alternate locations.
- Attributes: Notable qualities or components of the living asset, such as LED grow lights, irrigation systems, mobile capability, historical or aesthetic significance, etc.
- Condition: The current physical or health condition of the living asset (such as Good, Poor, Planting, Replanting, etc.)and if composed of many components condition can be described in percentage or proportion terms (80% Good/20% Poor). This data can also include vegetation health indicators, such as size, age, canopy status, etc.
- Environment: Measurements taken from the environment surrounding the living asset, such as temperature, humidity, soil moisture, etc. This data can also be used to extrapolate the impact that the living asset has on the Precinct environment.
- Maintenance: Maintenance procedures and records for living assets to ensure successful long-term management of living assets, as well as verifying sustainable practices such as responsible procurement and material circularity.
- Data: Data collection procedures and technology for living assets, such as scheduled measurements or dedicated sensors, measurement frequency, most recent measurement, etc.
- Additional: Supplemental data types that can be extrapolated from collected data such as Values, Costs, Benefits, Services or Disservices.

Primary Benefits

The information compiled in the inventory database can be used for a variety of purposes, such as benchmarking, supplying evidence to guide living infrastructure management and research, along with providing crucial data support for the other project proposals in this Strategy (Boogaerdt and Brown 2022; Hülsmann et al. 2017). The data collection and management activities for the inventory can also serve as a useful platform to increase awareness of living infrastructure and relevant useful technology by creating interactive learning and engagement opportunities throughout the Precinct.

Possible Locations

While the ultimate objective would be to include all notable living

	infrastructure assets throughout the entire Precinct in the inventory, at least the initial sequence of data collection locations can be decided by practical reasons. One option would be to begin with the living infrastructure assets for newer buildings, as still up-to-date planning and installation documentation would facilitate data collection. Alternatively, the inventory could begin by focusing on the mature living assets of older Precinct buildings as their longer existence and history of use could produce valuable data.
Potential Partners	Royal Botanic Gardens and Domain Trust could be a helpful resource for conducting plant diagnostics and inventory management, as well as for research collaboration via their Restore & Renew program. The Landscape Architecture Foundation (U.S) provides guidance for landscape performance monitoring and data collection as well as funding landscape case study research which could support inventory development. Earthwatch Australia runs citizen science programs that coordinates community volunteers which could help collect data for the living asset inventory. National Trust NSW provides support for registering, protecting and restoring significant landscapes and trees, which could be relevant for some of the older living assets on the Precinct. Possible suppliers for data collection technology, tools or sensors include ICT International and OneTemp.
Project Cost	$50,000 - $200,000 per annum, dependent upon assigned staff or research assistant pay rates and data collection equipment purchased.
Sources of Funding and Grants	Funding programs that support environmental data collection, research and education would be relevant for this project, such as NSW Environmental Trust environmental research (annual, closes 6 June) and environmental education grants (annual, opens Sept), Landscape Architecture Foundation case study investigation program (competitive, annual, closes 1 Nov), NSW Local Land Services funding for landscape management projects (details by inquiry) and ARC research grants.
Research and Education	Living asset data collection and management could be integrated as a field study or tutorial assignment for UNSW or TAFE courses or as research internships or assistantships for UNSW postgraduate students from the Schools of Built Environment, Civil and Environmental Engineering, or Biological, Earth and Environmental Sciences. Living asset data collection

	activities could also create research learning opportunities for the surrounding community, such as for TAFE students, primary or secondary school students or volunteer citizen scientists. The living asset inventory database could also serve as a valuable secondary data source for a wide variety of potential UNSW and Precinct research projects.
Relevant Case Studies	Hospital Grounds Greenspace Project – See Appendix B

2.2 Capacity Building Project 2: Living Champions

Overview	This Capacity Project would seek to identify and engage Precinct community members who are willing to participate as 'grassroots' support for Living Infrastructure Projects, either serving as volunteers or 'champions' who could help implement and maintain projects over time, or even proposing and implementing 'grassroots' living infrastructure ideas.
Implementation Options	There are various measures that could be employed in order to encourage grassroots participation for the Living Infrastructure Projects. One measure would be an active communication and engagement campaign to advertise the Living Infrastructure Strategy and proposed projects to Precinct and community members, which would include providing or collecting contact info for any interested participants or submitting project ideas and feedback. Another option would be periodic 'Living Infrastructure Contests or Challenges' for selecting or proposing new Enhancement Projects or the next location for enhancement. There could also be a dedicated volunteer programs that would seek to engage Precinct staff, local community members, or UNSW students as 'living champions' on a weekly or monthly basis for various project activities, such as data collection for Living Assets or assembling Living Pop-Ups. These volunteer activities would also encourage physical activity and use of greenspace for restorative benefits and reducing stress.

Primary Benefits	Benefits from incorporating grassroots engagement and support will include increasing community awareness and acceptance of the Living Infrastructure Strategy and projects, obtaining community feedback that will help verify Enhancement Projects are addressing community needs and avoiding on the ground issues, providing a pathway for innovative grassroots project ideas and helping ensure the long-term success of various projects via continued support. Volunteer and engagement activities could improve participant wellbeing due to the physical activities, social interactions and exposure to greenspace that would be experienced.
Possible Locations	The activities related to this project could take place anywhere in the Precinct and some engagement events could even take place outside the Precinct by taking advantage of adjacent or nearby greenspace.
Potential Partners	ARC @ UNSW student clubs such as Volunteers United could serve as partners for recruiting student volunteers, while Earthwatch Australia could be a partner for recruiting citizen science volunteers. The Newmarket development by CBUS and the Randwick Organic Community Garden could be partners for community volunteer activities as well as conducting engagement events.
Project Cost	$50,000 - $115,000 per annum, dependent upon assigned staff pay rates and funds for engagement events or activities.
Sources of Funding and Grants	Funding programs that support grassroots or community engagement efforts or community health would be relevant for this project, such as the Multicultural NSW Empowering and Supporting Local Communities Grants Program, the Federation Council Community Grants Program, or NSW Department of Health grants for reducing obesity and physical inactivity.
Research and Education	Coordinating project engagement events and activities could serve as valuable experience for UNSW student interns from the School of Marketing or the School of Social Sciences, as well as TAFE interns. The project could also serve as a platform for research examining the outcomes from community engagement or grassroots participation activities, such as walking audits conducted by health promotion or healthy built environment programs at UNSW Schools of Public Health and Built Environment.

Relevant Case Studies	Hospital Grounds Greenspace Project – See Appendix B Mater Hospital Brisbane – See Appendix B

2.3 Capacity Building Project 3: Living Assessments

Overview	This Capacity Project focuses on establishing a suite of routine assessments and accompanying analysis procedures that will identify over time any emerging opportunities for Enhancement Projects to improve existing or install new living infrastructure assets for the Precinct, as well as assess key performance indicators to confirm and provide evidence for whether desired Living Infrastructure Strategy objectives are being achieved.
Implementation Options	As each type of assessment would only need to be conducted on a periodic basis, it would be practical to primarily utilise existing UNSW research or educational resources and personnel to conduct the assessments with the Precinct providing support only as needed, such as supplying administrative permissions or location access. Assessment categories and analysis procedures can be selected from reviewing existing evaluation methods for built environments and wellbeing, including WELL, Fitwel, SITES, Landscape Performance Series, NABERS and Green Star. Assessment selection and timing would likely be influenced or decided by the availability schedule of relevant UNSW personnel and current conditions on the Precinct. The following are some potential example assessments and how their analysis outputs could be utilised: • *Behavioural observations and mapping* to reveal how people are interacting with existing living infrastructure assets or any high use areas that are lacking living infrastructure assets, revealing opportunities for improvement or evidence for performance evaluation (Keane and Grant 2022).

- *Satisfaction surveys* to determine which living infrastructure assets are highly valued and why they are valued, providing guidance and evidence for future enhancements or evaluating performance (NABERS 2020).
- *Microclimate analysis* to discover which Precinct locations have uncomfortable microclimate conditions that could be improved by using living infrastructure enhancements (NABERS 2020).
- *Living view analysis* to ascertain if any areas on the Precinct, such staff workstations or patient rooms, have insufficient access to living infrastructure views, for example needing to travel a certain distance in order to see views of greenspaces (Robinson et al. 2021).

Primary Benefits	While exact benefits derived from this project could vary significantly depending on selected assessments and how analysis outputs are utilised, the project would improve the overall implementation of the Living Infrastructure Strategy and future Enhancement Projects by ensuring that living infrastructure opportunities or issues on the Precinct are quickly recognised. Additionally, analysis outputs can inform best practices for living infrastructure implementation, evaluation, research and education. The assessments could also increase awareness of living infrastructure and relevant useful technology by creating opportunities for interactive learning and engagement.
Possible Locations	While the full range of the project could eventually include all areas of the Precinct, the type of assessment being conducted would dictate specifically which locations and the order of their analysis. However, initial assessments would likely focus on older areas of the Precinct, as it would be difficult to effectively assess newly constructed or incomplete areas of the Precinct until they have been completed and in use for at least 1 year.
Potential Partners	The George Institute for Global Health could be a research partner for conducting assessments that can produce evidence for improving clinical treatments, healthcare provision, or population health.
Project Cost	$25,000 - $65,000 per assessment, dependent upon research assistant pay rates and data collection equipment purchased.

Sources of Funding and Grants	Funding programs that sponsor efforts to evaluate built environment performance or wellbeing outcomes could be useful for this project, such as Landscape Architecture Foundation case study investigation program (annual, closes 1 Nov). Additionally, if assessments can be directly integrated with existing and future UNSW research program efforts, then ARC and NH&MRC funding could be applied to cover research costs of assessment and analysis activities.
Research and Education	A variety of existing UNSW research or education programs could be smoothly integrated with this project. Assessment and analysis activities could also be integrated as a field studies or tutorial assignments for various UNSW methods courses, or as research internships or assistantships for UNSW postgraduate students from various schools. However, as certain assessments could require extensive ethics approvals or strict research protocols, integrating any additional research and education opportunities for those besides approved UNSW personnel, such as TAFE personnel, would need to be carefully considered.
Relevant Case Studies	NHS Forest 'Space to Breathe' – See Appendix B Bendigo Hospital – See Appendix B

2.4 Environmental Enhancement Project 1: Living Walls

Overview	This Enhancement Project explores options for integrating living infrastructure into suitable vertical spaces on the Precinct.
Implementation Options	Several variations of living walls, which are also called green walls or vertical garden systems, were identified as being potentially useful for the Precinct, each suited for different objectives or environmental conditions. 'Traditional' living walls can be composed from a variety of anchoring systems with embedded growing mediums for vegetation that can then be attached to existing walls and structures, often including other built-in support features such as independent irrigation systems, lighting systems,

or frames with caster wheels for mobility (Radić et al. 2019; Green Design, 2022). 'Breathing' living walls incorporate low-power fans in their design to increase the rate that air is filtered through the plant foliage and roots systems, improving their air filtration performance. (Pettit et al. 2019; Pettit et al. 2017; Junglefy, 2022c). 'Façade' living walls are typically simple trellis systems for ground or planter rooted climbing plants like bower vine to grow on and usually do not include any complex built-in features (Radić et al. 2019; Fytogreen 2022). 'Moss' walls are assembled using mosses or lichen attached to mat panels that can either be still living or preserved via glycerine treatment to halt further growth (Wang, Li and Neoh 2019; Vista Concepts 2022).

Primary Benefits

While several benefits can be delivered by all living wall types, such as air purification or sensory experiences, each type is better suited to deliver certain benefits, which are as follows:

- *Traditional* living walls are useful for covering sun-exposed walls to improve energy efficiency and micro-climate conditions, being able to reduce noise levels and serve as privacy dividers in indoor settings, along with having many suppliers, design features and purchase or leasing options available (Radić et al. 2019).
- *Breathing* walls are significantly more effective at improving air quality while still providing most of the benefits of traditional living walls (though the fans may produce noticeable sound) and there are breathing stands from one supplier which are mobile and can be leased (Pettit et al. 2019; Junglefy 2022c).
- *Façade* living walls can be used outdoors where climbing plants can be rooted in the ground or in suitable planters to provide shelter or privacy, as well as being less costly to install and with various suppliers available (Radić et al. 2019; Fytogreen 2022).
- *Moss* walls do not need direct sunlight and generally require less maintenance than traditional living walls, making them viable in areas that are unsuitable conditions for other wall types and can also serve as humidity and noise regulators (Wang, Li and Neoh 2019; Vista Concepts 2022).

Possible Locations

Each type of living wall has locations for which they are either suited or unsuited based on environmental conditions, which are as follows:

- *Traditional* living walls are suitable for exterior walls or indoor areas that

receive direct sunlight or can allow high illumination plant lights.

- *Breathing* walls are appropriate for high circulation indoor areas like front of office or locations that tend to collect air pollutants such as enclosed car parks. Frequent direct sunlight or high illumination plant lights are often needed for optimum filtration performance, though certain species may maintain efficacy in lower light conditions.
- *Façade* living walls would be best placed around outdoor seating, social areas and high circulation pathways that receive direct sunlight and irrigation or rainfall run-off.
- *Moss* walls are suitable for exterior walls or indoor areas that do not receive any direct sunlight or cannot have high illumination plant lights, however they require relative humidity levels above 40% to avoid drying out, though moss can recover from short-term desiccation without damage (Wang, Li and Neoh 2019).

Potential Partners

While there are many potential suppliers for living walls, the following suppliers with Sydney offices were identified due to supplying and maintaining multiple types of living walls:

- Junglefy: Traditional living walls, breathing walls or mobile breathing stands and various planter types.
- Green Design: Traditional living walls, mobile living walls, preserved moss walls and a large selection of planters.
- Fytogreen: Traditional living walls, façade living walls and a variety of planter installations.
- Vista Concepts: Traditional living walls, façade living walls and moss walls.

Project Cost

$8,000 - $20,000 per wall unit installation (approx. 4 square meters with 1 year maintenance), dependent upon selected wall type. Cost per square meter lowers as wall size increases.

Sources of Funding and Grants

Funding programs that target urban greening, urban heat, or climate change resilience could be relevant for this project, such as NSW Environmental Trust environmental research grants (annual, closes 6 June), NSW Climate Change Fund programs, Greening our City programs, Horticulture Innovation Green Cities Fund.

Research and Education	The WaterGUM group at UNSW Water Research Centre is performing green walls for greywater treatment research which could be incorporated with this project. The High-Performance Architecture research cluster conducts urban heat mitigation research that could provide and receive useful data from this project.
Relevant Case Studies	Queensland Children's Hospital – See Appendix B Lendlease Head Office – See Appendix B

2.5 Environmental Enhancement Project 2: Living Pop-Ups

Overview	This Enhancement Project would utilise interactive and mobile 'pop-up' methods with living infrastructure to create novel or temporary spots for restoration and relaxation activities throughout the Precinct.
Implementation Options	The project could use mobile, interactive 'pop-up' features in two primary ways for establishing Living Pop-Ups. The first option is the 'Activation' approach, which would focus on using 'pop-up' amenity features to activate areas that already have living infrastructure but are underutilised, enticing people to use these spots for restoration. Examples could include setting up shaded seating or outdoor games in open lawn areas, placing tables with board games or phone chargers under large trees and setting up artistic or educational displays in garden areas. The second option is the 'Transformation' approach, which would place 'pop-up' living infrastructure assets in areas without living infrastructure, transforming these locations to be more restorative. Examples could include placing mobile planters with benches in parking lots to create 'parklets', arranging mobile living walls around outdoor seating to create outdoor 'living rooms', or having mobile terrariums or "Vegepods" gardens which could be periodically moved to different outdoor or indoor areas (Vegepods 2022).
Primary Benefits	The project would not only increase the number and variety of restoration experiences available on the Precinct for staff, patients, students and

	visitors, but the flexible qualities of the 'pop-up' features could also provide additional benefits. Since all 'pop-up' features used for this project would be mobile, they could be implemented in areas that would be unfeasible to install fixed living infrastructure assets. This mobility also means that if desired outcomes are not being achieved or unforeseen issues emerge at a particular location, then the 'pop-up' features could be easily moved to a new location. The 'pop-up' features could also serve as preliminary 'prototypes' or 'placeholders' for more permanent living infrastructure assets that would be built in the future. There is also the possibility that periodically moving the Living Pop-ups will promote more engagement and use due to the novelty of new locations.
Possible Locations	The exact locations for implementing the Living Pop-Ups would need to be determined after more detailed assessments, such as places of opportunity identified by the Living Assessments project but reviewing existing pop-up examples in Sydney suggest areas with extensive lawn or pavement areas are likely good starting points for implementation (NSW DPE 2022b).
Potential Partners	This project should be carried out in close collaboration with the Precinct Placemaking Curator to ensure compatibility with the Precinct Placemaking Strategy. The Randwick City Council would be a valuable collaborator as the project would align well with several of the Council's public space and community development initiatives. Bunnings Randwick and other local suppliers could be sponsors and sources of in-kind donations for 'pop-up' elements and materials used by the project.
Project Cost	$600 - $4500 per site per month, dependent on the number and types of pop-up elements. Cost lowers if pop-up elements are reused or obtained by donation.
Sources of Funding and Grants	Funding programs that target health and wellbeing promotion, public or community spaces and urban greening would all be applicable for this project. Examples include Everyone Can Play grants, Streets as Shared Spaces fund, the Places to Love program, Greening our City initiative, the Metropolitan Greenspace Program, the Green Cities Fund and the Randwick Community Investment Program.

Research and Education	Multiple aspects of this proposal could be used as applied course or degree projects for UNSW or TAFE students, for example Art & Design students could craft the interactive 'pop-up' elements while Built Environment students design and assemble the Living Pop-ups. The project also creates many opportunities for conducting various 'living lab' experiments, such as comparing the restorative potential of different 'pop-up' features and arrangements or measuring the impact that the sudden introduction of living infrastructure can have on different spaces and any resulting changes in how people use or think about a space.
Relevant Case Studies	Bosk "Walking Forest" – See Appendix B

2.6 Environmental Enhancement Project 3: Living 'Farms'

Overview	This Enhancement Project would focus on deploying living infrastructure that can directly support or improve food related activities or education on the Precinct.
Implementation Options	Potential options that this project could pursue include educational 'Farmacies', hydroponic or aeroponic 'Micro-Farms' and composting 'Farmaseats' for food waste. 'Farmacies' would be food gardens designed around providing patients or community members healthy food education or therapeutic horticulture therapy, supplying ingredients and settings for nutrition, therapy, gardening, or cooking programming and any excess ingredients being used for Precinct kitchens or food donations (Akron Children's Hospital, 2022). 'Micro-Farms' would be small hydroponic, aeroponic, or "Vegepod" farming systems containing fast growing micro-greens or culinary ingredients that could be placed nearby hospital cafes or kitchens to provide fresh and nutritious ingredients for meals (Urban Green Farms 2022; Vegepod 2022). 'Farmaseats' would be dual function composting seats that can be placed in raised garden beds, which incorporate a bench-like top seat with a composting worm farm underneath (Coolseats 2022) and can be placed nearby Precinct cafes or kitchens to divert food waste from the landfill as well as provide compost for Precinct

	living infrastructure. Each of the above implementation options would also include educational signage to spread nutrition, gardening and composting knowledge and practice tips for the wider community.
Primary Benefits	Potential benefits of this project include encouraging healthier dietary habits across the Precinct and surrounding community, providing Precinct kitchens and cafes high quality ingredients and helping the Precinct meet Environmental Sustainability goals related to food waste or emissions reduction. Precinct staff, patients and volunteers could reduce stress and improve wellbeing by interacting with or caring for the living 'farms' as a form of therapeutic horticulture.
Possible Locations	While the best locations for implementation would need to be determined after further assessment, such as via the Living Assessments project, some potential locations for each option are as follows: • *'Farmacies'* meant for patient programming could be in terrace or courtyard areas near patient wards, while those meant for community programming could be located near the Precinct periphery for easy community access. • *'Micro-Farms'* could be located near the kitchens or cafes that they are supplying, but they could also be placed in areas with low activity receiving direct sunlight, such as rooftops or service access areas. • *'Farmaseats'* could be placed in any existing raised garden beds that are compatible, or new raised garden beds with composting seats could be placed nearby Precinct kitchens and cafes.
Potential Partners	The Randwick Organic Community Garden and UNSW Growers' Group could be community partners for collaborating on community food education and volunteer activities or events, as well as being resources for local food gardening knowledge. Nutrition Australia could be a useful partner for conducting nutrition education and healthy food activities, while NSW EPA could provide support for food waste reduction activities. Local garden suppliers like Bunnings Randwick could be sources of in-kind donations or sponsorships for food gardening education activities.
Project Cost	$1000 - $7000 per "farm" bed or unit, dependent on the size, features and type of garden bed or farming unit.

Sources of Funding and Grants	Funding programs focused on food, nutrition, gardening, or food waste activities or education are relevant for this project, such as the NSW EPA Love Food Hate Waste education grants, NSW Environmental Trust Organics Infrastructure grants and Life Ed Growing Good Gardens grants.
Research and Education	Besides educational opportunities mentioned above, the project could also provide applied project or internship opportunities for UNSW or TAFE students, such as School of Arts & Design, Built Environment, or Engineering students designing and building project features or Schools of Health Sciences or Social Work assisting educational activities. Research that could be conducted in conjunction with the project include studies related to dietary behaviours, patient nutritional health and the therapeutic or wellbeing effects of interactive garden or horticulture experiences.
Relevant Case Studies	Boston Medical Center – See Appendix B Centra Lynchburg General Hospital – See Appendix B Mater Hospital Brisbane – See Appendix B

Section 3: Context and Literature Review

3.1 The Location of the Randwick Health & Innovation Precinct

The RHIP is in the City of Randwick, a suburb of the Eastern City District within Greater Sydney. It is situated in proximity to the Sydney CBD (8 km), the Sydney Airport (7km) and has access to road and transport infrastructure, local amenities and services and a skilled workforce (SGS RHIP Economics and Planning 2021). The Precinct is bordered by the University of New South Wales (UNSW) Kensington Campus to the west, 'The Spot' heritage area to the east, the Newmarket neighbourhood to the south and Randwick Town Centre to the north (Figure 10).

The RHIP was initially formed in 2016 by the NSW Government with four founding partners including: South Eastern Sydney Local Health District (SESLHD), Sydney Children's Hospital Network (SCHN), University of New South Wales (UNSW) and Health Infrastructure of NSW Health (HI NSW). The Precinct includes the Randwick Hospitals Campus and more than 15 collaborating partners in the immediate surrounding area, comprising a diverse collection of globally renowned healthcare, education and research institutions and a multitude of related community organisations. The RHIP aspires to be a world-class location where transformational change occurs across research, education and health outcomes. Three strategic priorities have been identified to achieve this:

1. Clinical and academic excellence
2. Innovation and collaboration
3. Global and local impact.

The creation of the Precinct was accompanied by the announcement of the Randwick Campus Redevelopment project. The Campus Redevelopment is a major initiative by the NSW Government to create an integrated environment to expand and enhance the Precinct's capability to provide world-class clinical services, healthcare education and research, as well as provide accessible and inclusive community spaces for not only Precinct staff and patients, but also the public at large. The Redevelopment involves an expansion of the Randwick Hospitals Campus with three new buildings: Prince of Wales Hospital Acute Services Building, UNSW's Health Translation Hub and Sydney Children's Hospital Stage 1 including a new Children's Comprehensive Cancer Centre.

Figure 10

Randwick Health & Innovation Precinct (outlined) with UNSW campus (left), the Spot (right), Newmarket (below) and Randwick Town Centre (above) (Source: Bing Maps 2022)

3.2 Background and Policy Context

Background and Development Process

The RHIP Living Infrastructure Strategy was developed by a team from the UNSW School of Built Environment and undertaken in partnership with a RHIP Living Infrastructure Strategy Advisory Committee, coordinated by the Executive Director of the Randwick Health & Innovation Precinct. Members of this advisory committee included representatives from the Sydney Children's Hospital Network, Health Infrastructure NSW and UNSW Facilities Management. The Strategy development also involved a number of consultations, including sessions with the Precinct's consultant landscape architects (Aspect Studios) and representatives from Precinct partners such as the George Institute, SESLHD and Health Infrastructure NSW.

The Strategy development process reviewed diverse resources to ensure that it responds to current academic research, professional standards and industry innovations and is informed by the needs of the Precinct partners and the community. The process included six steps:

1. Review of recent academic and broader industry literature related to living infrastructure and healthcare design and health promotion
2. Review of case studies involving living infrastructure in healthcare settings
3. Review and compilation of performance indicators for living infrastructure from established rating standards
4. A program of meetings between the UNSW LI Strategy project team and RHIP Living Infrastructure Strategy Advisory Group to identify and confirm strategic priorities and potential project directions, with follow-up key actions
5. Discussions with Aspect Studio landscape architects regarding potential projects to support and build upon planned living infrastructure assets
6. Consultations with a range of community and health groups for input into the Strategy and potential project partnerships

Policy Context

The RHIP Living Infrastructure Strategy aspires to provide a place-based, precinct-wide framework for understanding, monitoring, evaluating and managing interactive living infrastructure, with which the Precinct and wider community can directly and physically engage beyond simply viewing. The Strategy strives to add value to existing living infrastructure across the Precinct, as well as that which is still to be developed. With a focus on innovation and technology, the Strategy seeks to provide a robust evidence-base for the health benefits of living infrastructure obtained through long-term research, teaching and collaborative partnerships; as well as to promote integrated community engagement programs that can strengthen existing local partnerships and foster new relationships. At a higher, overarching level, the Strategy objectives also align with those for global and state health initiatives, as described in the following sections.

Global Health Strategies

At a global scale, the Strategy aligns with broad, high-level goals for health and wellbeing and health benefits from biodiversity, including:

1. *UN Sustainable Development Goals*

The Strategy principally addresses three of the 17 goals: SDG 3 -- Good health and wellbeing; SDG 9 -- Industry, innovation and infrastructure; and SDG 11 --Sustainable cities and communities (United Nations Department of Economic and Social Affairs Sustainable Development n.d.).

2. *Connecting Global Priorities: Biodiversity and Human Health - A State of Knowledge Review*

   The Strategy centres on well-functioning ecosystems that support human health, particularly in relation to biodiversity, clean air and food security (World Health Organization and Secretariat of the Convention on Biological Diversity 2015).

State Health Strategies

At a state scale, the Strategy will provide an evidence-base that supports the inclusion and value of living infrastructure, including a set of evaluation measures. It aligns with:

1. *NSW Premier's Priorities*

   The Strategy aims to synchronise with the NSW Premier's Priorities that recognise "green infrastructure and public spaces play an important role in providing quality of life and amenity for our communities" (NSW DPE 2022a, n.p.). These priorities target green and public spaces to help "improve physical and mental health, increase urban amenity, … and provide places for our unique plants and animals to live". The two priorities of relevance to the Strategy are:

   Priority 11 Greener public spaces, which aims to 'increase the proportion of homes in urban areas within 10 minutes' walk of green and public spaces by 10% by 2023'.

   Priority 12 Greening our city, which seeks to "expand urban tree canopy and green cover across Greater Sydney by planting one million trees by 2022." (NSW DPE 2022a, n.p.).

2. *NSW Interim Framework for Valuing Green Infrastructure and Public Spaces*

   The Strategy contributes towards the Interim Framework for Valuing Green Infrastructure and Public Spaces. This sector-specific valuation framework works towards the Premier's Priorities 11 and 12 and is delivered by NSW Treasury (NSW DPE 2022a).

The Strategy also builds on relationships and co-design programs undertaken for the Precinct's living infrastructure with local Aboriginal communities, with the aim of ensuring Aboriginal cultural knowledge continues to be valued and respected in the future of the Precinct, as outlined in:

3. *GANSW Connecting with Country Framework*

   The NSW Government Architect's Connecting with Country Framework is committed to improving health and wellbeing of Country through realising three long-term strategic goals:

   1. Reduce the impacts of natural events such as fire, drought and flooding through sustainable land and water use practices
   2. Value and respect Aboriginal cultural knowledge with Aboriginal people co-leading design and development of all NSW infrastructure projects
   3. Ensure Country is cared for appropriately and sensitive sites are protected by Aboriginal people having access to their homelands to continue their cultural practices (GANSW 2019, n.p.).

The following chapter provides a discussion of an extensive literature review which provides the theoretical framework and a series of guiding principles that are used to underpin and frame the subsequent strategy.

3.3 Reviewing the literature

Overview of the literature reviewed

The principles for guiding the RHIP Living Infrastructure Strategy development were derived from a review of relevant literature spanning a range of subjects including ecological models of health, healthcare facility design, health promotion policy design and living infrastructure benefits and performance metrics. Principles were also drawn from case studies of living infrastructure projects and outcomes (Appendix B).

The topic areas discussed in this review include:

1. Ecological models of health
2. Salutogenic and biophilic design
3. Therapeutic and healing gardens
4. Urban ecosystems under pressure
5. Sustainable and healthy built environments
6. Performance measures for evaluating living infrastructure
7. Health promotion and climate change
8. Case study examples of living infrastructure in health settings
9. Emerging themes from literature and case study review

Ecological Models of Health

The Living Infrastructure Strategy draws on an ecological model of health; a well-recognised way to understand health from the perspective of interactions between environmental influences and individual choices and attributes. Direct and indirect relationships between ecosystem health and human health are also fundamental to health promotion: a key priority of the strategy (Patrick and Capetola 2011). Ecological models emerged from developments in several disciplines and fields (for example, public health, sociology, biology, education, psychology) and converged to form the ecological and behavioural foundations of health promotion (Richard et al. 2011).

In 1979, Bronfenbrenner proposed his 'ecological systems theory', a theory that explores the human life course from early childhood through to adulthood by way of a "multidimensional systems model for understanding the influence of family through to economic and political structures" (Elliot and Davis 2020, n.p.). The original formulation of the theory conceptualises the environment as successively nested systems ranging from micro- to macro-systems. The 'bioecological model', which evolved from the original theory, accords "equal importance to the role in development of the biopsychological characteristics of the individual person" (Bronfenbrenner 2000, p.129). This model focuses on 'proximal processes', the mechanisms that produce development. Bronfenbrenner's theory involves mapping information about individuals and their contexts over time in order to understand their diverse systemic interconnections. However, the model is viewed as limited due to its 'human-centered systems approach' that works against sustainability and overlooks human-nature interconnections' (Elliot and Davis 2020, n.p.).

In the 1990s, Stokols (1996) identified the increasing ecological orientation of the health promotion field. Beyond behavioural and environmental change strategies, social ecology was viewed is as "an overarching framework, or set of theoretical principles, for understanding the interrelations among diverse personal and environmental factors in human health and illness" (Stokols 1996, p.283).

More recently, key aspects of ecological models employed in public health discourse focus on integrating and conceptualising the environment amid other influences on behavior (Richard et al. 2011). The core concept is that behaviour has multiple levels of influence: intrapersonal, interpersonal, organisational, community, physical environment and public policy (Sallis et al. 2008). These levels are inherent to environmental settings and their physical and social characteristics; natural and built (or designed) attributes; objective (material, observable) and subjective (perceived, semiotic) qualities; and scale or immediacy to individuals and groups (proximal versus distal). In addition, participants in environments include individuals, small groups and organisations comprising larger communities and populations (Stokols et al. 2013).

Understanding the interrelationships among people and their surroundings takes account of the key concepts of systems theory, such as interdependence, homeostasis, negative feedback and deviation amplification. Indeed, human environments are "complex systems in which local settings and organisations are nested within more complex and remote regions" (Stokols et al. 2013, n.p.), with interdependencies between immediate and more distant environments. To illustrate, systems analyses indicate the ways multiple aspects of the physical environment (for example, geography, architecture, technology) and the social environment (for example, culture, ethics, economics, politics, law) collectively influence the resilience of environment settings and the wellbeing of their participants (Stokols et al. 2013).

Stokols enhanced his notion of health supportive environments by "emphasizing the concept of community capacity for health improvement and hence proposing a new typology of community assets for health promotion" (Richard et al. 2011, p.313). Multiple situations and settings, such as homes, workplaces, schools and institutions, are held as jointly affecting the wellbeing of community members. Dimensions and criteria of health-promotive environments are outlined as physical health, mental and emotional wellbeing and social cohesion at organisational and community levels (Stokols 1992). Best et al. (2003) proposed a similar framework incorporating community partnering, but with the addition of a temporal dimension highlighting life-course and life-span processes.

Ecological models are often applied in research and practice "due in part to their promise for guiding comprehensive population-wide approaches to changing behaviours that will reduce serious and prevalent health problems" (Sallis et al. 2008, n.p.). Together with the more generic ecological models described above, a range of applications has been developed targeting specific public health issues, such as physical activity, nutrition, child health and aging (Richard et al. 2011). Such targeted approaches offer potential areas of connection and research for the project proposals (Section 4) in this Strategy.

Salutogenic and Biophilic Design

Integral to the health promotion 'root' priority of this Strategy (Section 3.2) is 'Salutogenics', the concept of a holistic understanding of health and wellness that places an "emphasis on factors that create and support health and wellbeing rather than disease prevention and behavioural risk factors" (Taylor et al. 2014, p.284). The need for a salutogenic approach to health promotion was first proposed in the 1990s by Antonovsky (1996). The central tenet of salutogenic theory is "understanding what causes health, rather than what causes disease" (Taylor et al. 2014, p.285).

Salutogenesis is synergistic with modern health promotion and therefore an appropriate approach for health promotion research and practice. To illustrate, Taylor et al. (2014, p.285) outline a salutogenic approach encompassing "perceived health and happiness, purpose in life, spiritual connections, social support, a healthy ecosystem, physical resilience, optimism and hope and the ability to experience emotions." These aspects are additional to dealing with "risk factors for poor health such as poverty, unemployment, disparity, powerlessness, isolation and discrimination" (Taylor et al. (2014, p.285).

Green and natural environments are viewed as salutogenic and not simply therapeutic places for people who are ill. Ward Thompson et al. (2014, p.11) argue that landscape can provide a salutogenic context that is "health-enhancing", contributing significantly to quality of life. Using an objective method for measuring the salutogenic effects of green environmental settings, their study examined diurnal salivary cortisol patterns in a sample of unemployed men and women. Results found a "significant association between higher levels of green space and lower levels of physiological stress" (p.20), important to mental health. Responses differed in women compared with men, associated with "generally higher levels of stress found in the female sample compared with the male" (p.19). This was further explained by the results using cortisol as a biomarker (p.19). The study's findings suggest that green and natural environments near to where people live may potentially help relieve stress and enhance mental wellbeing and quality of life, informing the strategy's supporting themes of physical and mental health (Section 3.2).

Salutogenic Design for Hospitals

Counterintuitive and countertherapeutic to the concepts of salutogenic healing environments, hospitals are often removed from their immediate surroundings and disconnected from greenspaces that may potentially help patients to heal and improve the day-to-day experience of families and staff. Nonetheless, hospital redevelopments are beginning to capitalise on the value of engaging with nature (Jiang and Verderber 2016). The RHIP redevelopment clearly seeks connections with nature for human health benefits and local biodiversity enhancement, as outlined in Section 1.3.

Towards a best practice, salutogenic alternative to hospital architecture and campus planning, Jiang and Verderber (2016, pp.12-13) propose the concept of 'theraserialization', a hybrid assemblage of the terms 'therapeutic' and 'serialize'. This concept is defined as a "continuum of indoor to outdoor space that is consciously designed in support of biophilic environmental design principles", offering guidance for project proposals discussed in Chapter 4, particularly Living Pop-Ups (Restoration Spots). It involves "creating spaces that are serialised in function and in their affordances - by means of layering, collage, superimposition and relative transparency."

Sequenced spaces may extend from public areas (such as parking areas and entrances) to the interior main arrival foyer to corridors throughout the health facility that open up and into gardens. Views are afforded through, to and outward from corridors to semi-private spaces such as dayrooms and terraces, landscaped roof terraces and ultimately to inpatient rooms. Patients' direct experience with the outdoors is facilitated by views, daylight and sounds of nature. The in-between spaces are given equal 'anchor' functions with regard to "illusion, immersion, light/dark contrasts, interesting changes in path directionality, volume and shifts from transparency to opaqueness" (p.13).

When applied to hospital settings, theraserialization ideally leads to spaces being experienced as a "continuum, graduated, as opposed to being abrupt, or disjointed", traversing different planes and enabling indoor-outdoor transitions. For example, the high atrium of the Lurie Children's Hospital winter garden in Chicago (2012) is vertically expressed, while terraces providing views of a nearby mountain range in Boulder Foothills Community Hospital in Colorado (2003) is a horizontal expression. The walls of an interior meditation garden at the Banner Estrella Medical Center in Phoenix (2005) are moveable, dissolving the barrier between inside and outside. Jiang and Verderber (2016 p.13) describe this open-air condition as "biophilic, fluid and connected to indigenous vernacular traditions", enabling the building to be "literally capable of breathing - by achieving direct connectivity with the landscape" (Jiang and Verderber 2016 p.13).

Biophilia

Living infrastructure comprises natural biological or aquatic elements that intersect with 'biophilia', a concept defined as the "inherent human inclination to affiliate with natural systems and processes, especially life and life-like features of the nonhuman environment" (Kellert 2008, p.3). This human desire for contact with nature originates from the evolutionary context for the development of the human mind and body, a "mainly sensory world dominated by critical environmental features such as light, sound, odor, wind, weather, water, vegetation, animals and landscapes" (p.3). The term 'biophilia' was first used in the 1960s by social psychologist Erich Fromm to describe the "tendency of humans to be attracted to everything that is alive and vital" (Totafort 2018, p.3). Fromm's analysis suggested biophilia is the result of the non-disruptive relationship of humans with the environment, centred on the presence of security, justice and freedom.

Building on earlier concepts, Salingaros (2019, p.14) views biophilia as the "human response to living things and to very special 'biophilic' geometries in our environment." The positive effects of biophilia are derived from two sources: firstly, close proximity and visual contact with plants, animals and other people; and secondly, positive response to artificial creations that adhere to geometrical rules for the structure of organisms. The positive physiological effect of people's neurological responses to biophilic environments is "measurable by medical sensors such as heart rate, skin temperature and conductivity, adrenaline level, pupil size, etc." (Salingaros 2019, p.14).

Biophilic and Restorative Environmental Design

Living infrastructure may be incorporated into biophilic design, an approach that emphasises the need to maintain, enhance and restore the beneficial experience of nature in the built environment. While there are many historic examples of buildings designed in ways that

provided biophilic health benefits, the approach is largely held as innovative in contemporary urban environments. In healthcare settings, such as the RHIP, biophilic design integrates gardens and nature into clinical spaces to create a sense of 'being away' from the hospital (El Baghdadi et al. 2017). The six biophilic design elements identified by Kellert (2008 p.6) are evident in the Precinct landscape design and further considered in the Strategy and proposed projects. Elements include:

- Environmental features
- Natural shapes and forms
- Natural patterns and processes
- Light and space
- Place-based relationships
- Evolved human-nature relationships.

Similarly, 'restorative environmental design' strives for a biophilic design approach with the additional focus on positively impacting or enhancing the natural environment (Kellert 2008). It capitalises on the qualities of natural settings that help produce restoration, including "spatial openness that fosters visual surveillance; sunshine or good light in contrast to poor light or threatening weather; and qualities linked with high habitability and food availability" (Ulrich 2008, p.90). Physical features encompass calm or slowly moving water, fertile vegetation, flowers, savanna-like or park-like features and unthreatening wildlife. This design approach offers relevant insights for two of the strategy's supporting themes, mental health and environmental quality.

The restorative benefits underpinning biophilic design are supported by two theories: attention restoration theory and stress recovery theory. Attention restoration theory offers an "analysis of the kinds of environments that lead to improvements in directed-attention abilities" (Berman et al. 2008, p.1207). Nature is replete with 'intriguing stimuli' that modestly draw attention in a "bottom-up fashion, allowing top-down directed-attention abilities a chance to replenish." In contrast to natural environments, urban environments are filled with stimuli that "capture attention dramatically and additionally require directed attention", rendering them less restorative. Four components are central to the restorative process embedded in the Kaplan's Attention Restoration Theory (Kaplan 1995): fascination, being away, extent and compatibility. 'Fascination' refers to the process whereby people's attention is effortlessly drawn to the environment, object, or ongoing activity, with the advantage of providing opportunities for reflection (p.172). 'Being away' refers to distraction and the ability to distance oneself from attention-demanding mental activities that require directed attention to keep going. Environments with 'extent' are rich and coherent enough to "constitute a whole other world" (p.173). Finally, 'compatibility' refers to the fit between the "environment and one's purposes and inclinations", that is, "what one is trying to do and what one would like to do" (Kaplan 1995, p.173).

Stress recovery theory focuses on the affective response of natural experience from an evolutionary perspective, in addition to mechanisms of attention or fascination. According to Ulrich et al. (1991), the restorative influences of nature involve a shift towards a more positively toned emotional state and positive changes in physiological activity levels accompanied by sustained attention. Lyu et al. (2022) explains the biological preparedness of humans to respond adaptively to their environment. On one hand, environments that support human survival will "elicit an immediate

positive response and facilitate the recovery of our adaptive resources to function effectively for the long term" (Lyu et al. 2022 p.2). On the other hand, a negative stress response may be developed when encountering threatening environments.

Hospital Wayfinding and Spatial Navigation

Hospital circulation zones can occupy a significant area of a facility's overall physical footprint and play a vital role in the experience of all types of users. In many cases, however, healthcare settings are built and expanded in stages across decades in ways that inadvertently isolate their occupants from 'experiencing sustained visual-spatial sensory contact with the external world' (Jiang and Verderber 2017, p.125).

Jiang et al. (2022 p.18) conducted one of few studies exploring hospital greenspaces and views to nature as salient environmental features impacting wayfinding performance and experience. Using an immersive virtual environment (IVE) hospital, results indicated that meaningful exposure to views of nature from within hospital circulation zones can potentially enhance wayfinding and spatial navigation. For a complex wayfinding task, people tended to walk shorter distances, stop less frequently and view the door signs less frequently in the IVE hospital with visible greenspaces (p.17). Participants also experienced "enhanced mood states and favorable spatial experience and perceived aesthetics in the IVE hospital with visible greenspaces than the same environment without window views" (p.1). Findings suggest hospital greenspaces positioned at key decision points could serve as landmarks that positively attract people's attention, aid wayfinding and improve their navigational experience. Gardens and window views to nature may also facilitate people's route selection efficiency during hospital wayfinding.

Recent healthcare redevelopments incorporate nature views into main circulation routes, suggesting wayfinding functions. The redevelopment of the Westmead Health Precinct in Sydney (Appendix B) features green views of Hospital Street along corridors radiating from the main entrance foyer (Figure 10). Transition spaces connect outdoors and indoor spaces, such as routes connecting carparks to buildings, featuring sequential landscaped spaces with artworks offering landmarks (Figures 11). Figures 12 and 13 depict views of green walls, garden terraces and a distant green feature throughout the main entry foyer, multi-level circulation spaces and cafeteria of Kinghorn Cancer Centre in Sydney (see Appendix B for more detail). Research exploring the wayfinding attributes of green views in these redevelopments is not evident, which suggests that this is a research opportunity for future living infrastructure assessments to explore.

Views of Nature

The Strategy considers the evidence for designing window outlooks and spatial layouts so as to capture the healing benefits of visual exposure to nature. Evidence outlines improved healing, reduced stress and pain and the qualities of preferred views. The classic experiments of Ulrich (1984) showed how exposure to a biophilic environment, specifically a view of trees rather than a blank wall, helped speed up post-operative healing. Investigations by Ulrich et al. (1991) supported the interpretation that nature serves as a positive distraction, in turn, reducing stress and diverting patients from focusing on their pain or distress (Ulrich and Zimring 2004, p.22).

Figure 11 - 14

Top Left: Green view of 'Hospital Street', Westmead Health Precinct. (Photo: Louise McKenzie)

Top Right: Green rest area and artwork in a carpark, Westmead Health Precinct (Photo: Louise McKenzie)

Bottom Left: Views of exterior and interior green from the foyer, Kinghorn Cancer Centre. (Photo: Louise McKenzie)

Bottom Right: Views of distant green from cafeteria, Kinghorn Cancer Centre. (Photo: Louise McKenzie)

Studies of bedridden patients indicated a particularly high preference for window views of nature (Verderber 1986). Landscape representations are generally classed as "natural" or "urban", with natural landscapes generally giving a stronger positive health effect compared to urban landscapes. Beyond these broad groups, few studies delve into subcategories, a gap in knowledge cited by Velardea et al. (2007) for future research. Revealing a gap for potential project proposals, Totafort (2018 p.1) recognises the need for further studies that not only deepen our understanding of the human-nature relationship and its impact on health, but also change the status quo design approach to patients' health through a 'new vision of medicine, healthcare and healing environment'.

Loftness and Snyder (2008 n.p.) argue a rich and informed design process for windows in buildings, such as hospitals, needs to guarantee "windows become doors." This concept is founded on the necessity for windows to ensure access to multiple factors, including 'views, sunlight, daylight, fresh air, breezes, natural comfort, passive survivability, outdoor spaces and activities, extended space, circadian regulation, seasons, climate and nature's sounds, smells and life'.

The Strategy considers the way windows and views have been designed in case study hospital redevelopments, for example, the Fiona Stanley Hospital in Perth (see Appendix B). Views from internal hospital areas were designed to focus on external landscapes, with all living infrastructure courtyards serving as views from window for patients within. Full-length window seats in the children's ward facilitate strong connection to the adjacent roof garden, offering an "incongruous and wondrous" view (Sack 2014, p.45). Similarly, the Queensland Children's Hospital in Brisbane capitalises on the health benefits of views (see Appendix B).

Therapeutic and Healing Landscapes

The Strategy continues the centuries-old understanding that green nature, sunlight and fresh air are essential components of healing. Around 1950 to 1990, however, the therapeutic value of access to nature was mostly overlooked in hospitals in western countries. An evident change occurred in the 1980s and 1990s when research brought support to "what one might intuitively believe to be so: that views to, or time in, nature have positive influences on health outcomes" (Cooper-Marcus 2007, pp.1-2).

In addition to providing restorative or calming nature views, hospital gardens can reduce stress and improve outcomes through other mechanisms, for example, "fostering access to social support and providing opportunities for positive escape and sense of control with respect to stressful clinical settings" (Ulrich and Zimring 2004, p.22). Drawing from Ulrich's Theory of Supportive Garden Design, Cooper-Marcus (2007, p.6) proposes gardens help to mitigate stress to the extent that they:

- Create opportunities for physical movement and exercise
- Provide opportunities to make choices, seek privacy and experience a sense of control
- Provide settings which encourage people to gather and experience social support
- Provide access to nature and other positive distractions

The healing and therapeutic potential of living infrastructure, particularly gardens, within the RHIP can be determined according to designated design principles: visibility, accessibility,

familiarity, quiet, comfort and unambiguously positive art (Cooper-Marcus 2007). A limited number of studies on art in hospitals indicate the majority of patients respond positively to representational nature art, while many react negatively to chaotic abstract art (Ulrich and Zimring 2004).

An important resource for the Strategy is the seminal work by Cooper-Marcus and Sachs (2013), Therapeutic Landscapes: An Evidence-Based Approach to Designing Healing Gardens and Restorative Outdoor Spaces. This text provides an evidence-based overview of healing gardens and therapeutic landscapes from planning to post-occupancy evaluation and general guidelines for designers and stakeholders. Critical to potential projects, patient-specific guidelines are presented covering 12 categories ranging from burn patients, psychiatric patients, to hospice and Alzheimer's patients. Participatory design, planting, budgetary concerns and maintenance are also addressed. The Therapeutic Landscapes Network (2022) is a further resource for gardens and landscapes that promote health and wellbeing. The evidence-base for therapeutic gardens also addresses children, including children with autism, encompassing work by Winterbottom (Jiang 2021) and Reeve et al. (2017).

Due to connections with two areas considered in the Strategy and employed in case studies (see Appendix B), a specific note is made here regarding designing for people with dementia. The particular area of interest relevant to living infrastructure is the treatment of transition (or 'edge') spaces and creating normality in outdoor greenspaces. Chalfont (Rahmati 2021) explores the benefits of nature to holistic health, in particular nature's contribution to preventing dementia. The visual qualities of a person's lived experience of spending time outdoors can enable connection to nature through 'normal' everyday activities, such as caring for house plants and pets, gardening and cooking. Evidence-based dementia prevention activities that relate to nature include horticultural therapy, gardening, barefoot walking (grounding) and sunshine. Other activities focus on exercise, for instance, swimming, cycling, aerobics and walking. Edge spaces between indoor and outdoor spaces are emphasised as highly relevant for people with dementia who are often uncomfortable going outside. Well-designed edge spaces consider views of the outdoors, giving people the comfort of indoors and the benefits of outdoors.

Beyond the scope of this review, a comprehensive and growing body of evidence informs ways to create and maintain therapeutic landscapes. Nonetheless, this body of evidence offers guidance for the Strategy's ongoing implementation program. Current resources include the American Society of Landscape Architects' Professional Practice Network for Healthcare and Therapeutic Design which showcases the work of practitioners and academics working in healthcare and therapeutic garden design. Of particular note is the work of Cooper Marcus (Cooper Marcus 2007; Baily 2018), Sachs (Cooper and Sachs 2013), Chalfont (Chalfont 2020,2006; Rahmati 2021) and Winterbottom (Jiang 2021; Winterbottom and Wagenfeld 2015).

Health Precincts as Unique Urban Ecosystems

The unique bio-physical environments and ecosystems services of health precincts, such as the RHIP, are often under threat due to urban development pressures within and beyond their boundaries. Degraded natural landscapes

and loss of biodiversity, increased areas of impermeable surfaces leading to flooding and urban heat islanding are significant pressures, amongst others. To address these precarious conditions, environmental enhancements that can help preserve or supplement valuable ecosystems services are increasingly considered and proposed for new landscape projects.

Informed landscape planning and design, such as that undertaken for the RHIP is fundamental to addressing environmental sustainability pressures and enhancing and supporting ecosystem services. Landscape design and planning considers a breadth of environmental data related to a site, such as climate and microclimate, topography and hydrology, flora and fauna and green corridor networks. Design and planning may lead to innovations for enhancing natural environments, such as creating habitat and biodiversity, employing water sensitive designs to mitigate flooding and developing detailed site-specific maintenance plans.

Two recent health precinct redevelopments presented in Appendix B, the Fiona Stanley Hospital and the New York University (NYU) Langone Medical Centre, illustrate innovative living infrastructure outcomes. The Fiona Stanley Hospital comprises a designated conservation bushland covering approximately 10 percent of the site, resulting from the Environment Protection and Biodiversity Conservation Act constraining conditions for clearing in preparation for building. A highly prescribed plant species palette was used for the constructed landscapes within the precinct. The botanical diversity of the roof garden incorporates local plant species and was designed as habitat for the endangered Carnaby's black cockatoo (Sack 2014; TERG n.d.).

The landscape design of the Alumni Courtyard of NYU Langone Medical Centre mitigates flooding by employing an elevated infrastructure system and a range of flood-control measures. Landscape maintenance, a primary focus of the precinct's management plan, stipulates a log to track visitors and document plant issues. The log requires a detailed description of possible reasons for plant problems, such as pests and over-/underwatering. Maintenance also involves decisions as to whether to leave ornamental grasses and flower heads during the winter to provide food and habitat for wildlife. Such decisions are in tandem with whether to remove dying perennials to maintain a tidy appearance (Ulam 2021).

Intersections of Health Promotion and Climate Change

Confronted by global warming, living infrastructure has significant roles to play regarding the three priorities recognised by health and built environment sectors for helping reduce the heat-vulnerability of urban dwellers. The first priority, a "quintessential 'no regrets' approach", involves reducing the rates of chronic disease to, in turn, decrease the population's heat-sensitivity (Bambrick et al. 2011, p.76S). Living infrastructure is critical to cool, comfortable outdoor places that support daily physical activity and social interaction by people living in cities. The second priority involves mitigating urban heat to reduce air temperature and improve air quality, including evaporative cooling, shading and air filtering afforded by hydrated greening. The third priority comprises supporting the social nature of the city - social cohesion, community functioning and active social networks - as an important heat-protection measure.

In the 2011 Australian Health Promotion journal special edition titled, 'Health promotion and

climate change', environmental interventions were recognised as having key roles to play with regards to overcoming the health challenges posed by climate change. In tandem with strategies for community development, inter-sectoral partnerships and behaviour change, living infrastructure interventions are expected to play especially valuable roles by producing health promotion and climate change co-benefits (Patrick and Capetola 2011). In addition to enhancing outdoor areas for activity and socialising, living infrastructure may help address food security issues arising from climate change. As emphasised in the Australian Health Promotion Journal Special Edition (2011), sustainable food systems, community gardens and urban agriculture are viewed as strategies compatible with climate change mitigation and securing long-term community food. Community gardens and newer food production projects have been found to "raise community awareness about climate change and promote mental health, social connectedness, physical activity and community empowerment" (Patrick and Capetola 2011 p. S62). Other initiatives involve active and sustainable transport programs and organisational capacity-building approaches, such regular auditing and benchmarking, staff awareness sessions, the introduction of indoor plants and a reference group for developing a green strategy. All of these can be part of the 'living laboratory' activities and capacity building measures informed by the Strategy.

Sustainable and Healthy Built Environments

While healthcare fields have long recognised that natural and built environments can greatly affect individual health and wellbeing, built environment design practice and standards have only recently begun to actively employ principles that aim to enhance the health and wellbeing of occupants (Ige et al. 2019; Callway et al. 2020). Historically, the design of built environments had been primarily shaped by reactive building regulations and environmental standards that established basic safety requirements in response to health risks revealed by disastrous events or pervasive illness (Evans 2018).

Starting in the 1990s, more proactive standards began to emerge that aimed to enhance built environment quality and produce diverse benefits beyond just fulfilling minimum safety requirements, such as the Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED). These early standards primarily focused on performance criteria and enhancements related to environmental sustainability, such as improving building energy and water use efficiency, although some health- related criteria were also included as an additional aspect of built environment sustainability (Callway et al. 2020; Trowbridge et al. 2016).

As sustainable built environment practice and standards proliferated and evolved, with over 50 rating systems established globally by 2020, standards that explicitly focused on enhancements for health and wellbeing eventually emerged under the moniker of healthy built environments, such as the Fitwel Certification System in 2014 and the WELL Building Standard in 2015 (Callway et al. 2020). Healthy built environment standards inherited various characteristics and criteria from established sustainability standards to make certification across multiple standards easier, but they also included additional conditions and enhancements for improving built environment safety and comfort, by minimising sources of health risks or discomfort and providing occupants the means to satisfy comfort needs,

as well as encouraging or requiring occupant satisfaction surveys to evaluate health and wellbeing outcomes (Fitwel 2020; WELL 2022). In response various sustainable built environment standards, including the National Australian Built Environment Rating System (NABERS 2020) and the Green Building Council Australia Green Star rating system (GBCA 2021), have updated their criteria to either include more health and wellbeing measures or directly align with the Fitwel or WELL standards. The NSW government has also been inspired by these standards to compile their own Healthy Built Environment Checklist (NSW Ministry of Health 2020).

Along with the proliferation and interconnections between sustainable and healthy built environment standards, there has been growing interest towards using living infrastructure to enhance built environments' performance due to the accumulated research findings indicating living infrastructure can provide both environmental sustainability and human health benefits (Al-Kayiem et al. 2020; Parker and de Baro 2019). Early sustainable built environment standards mainly focused on preserving or minimising damage to natural living infrastructure, but later standards like the SITES Rating System began introducing criteria that evaluated how adding living infrastructure features could improve the performance of built environments (SITES 2014). Healthy built environment standards and guidelines also directly reference providing living infrastructure in terms of occupant access to restorative nature, recreational spaces, or fresh produce (Fitwel 2020; NSW Ministry of Health 2020; WELL 2022). But as research has revealed the full range of health benefits from living infrastructure, connections to many other healthy built environment metrics are increasingly recognized, such as improvements to air quality, thermal comfort and noise levels (Parker and de Baro 2019). As such, living infrastructure features are increasingly seen as multi-purpose enhancements that can fulfill both sustainable and healthy built environment performance criteria.

Performance Evaluation and Research for Living Infrastructure

Despite the increasing recognition and support for using living infrastructure to create more sustainable and healthier built environments, implementation efforts often encounter organisational resistance due to living infrastructure designs being perceived as more difficult or costly to build and maintain than standard designs. This consistently results in calls for evidence to justify the assumed challenges of living infrastructure features. In response to these calls for justification, many research studies have been conducted in recent decades examining the performance benefits of living infrastructure, with systematic reviews finding over 170 studies relating to living infrastructure performance since 2001, as well as various built environment guidelines or standards providing performance indicators for evaluating living infrastructure features (ACT Government 2018; Al-Kayiem et al. 2020; Callway et al. 2020; LAF 2018; Parker and de Baro 2019; Victoria State Government 2017).

Performance measures for living infrastructure applied by studies and guidelines include a range of quantitative and qualitative indicators that are clustered under a variety of categories including thermal, energy, air quality, water, soil, noise reduction, health and wellbeing, aesthetics, economic, habitat and more (Al-Kayiem et al. 2020; LAF 2018; Parker and de Baro 2019; Radić et al. 2019). Post-completion performance evaluation case studies by researchers or rating organisations consistently find that the

benefits from incorporating living infrastructure features into built environments outweigh their costs over time, providing justification for their implementation (LPS 2022). However, such beneficial outcomes are not guaranteed as implementation costs and derived benefits from living infrastructure can vary greatly according to environmental and operational conditions, thus conducting performance research to obtain justifying evidence or determine best practices for implementing living infrastructure in specific contexts remains a consistent necessity (LAF 2018). While there has been living infrastructure performance research conducted by Australian hospitals, these assessments have generally been short-term or for a single hospital complex (CRC Water Sensitive Cities 2020; Sack 2014), meaning there remains a need for living infrastructure performance research in Australia conducted over longer time periods and at health precinct scales.

Living Infrastructure in Healthcare Settings

The national and international case studies, reviewed to inform this strategy, illustrate how healthcare facilities have explored, adopted and adapted living infrastructure elements to the benefit of staff, patients and the broader community. Summary briefs of the case studies are presented in Appendix B, including seven primary case studies in healthcare settings and a series of secondary case studies in various healthcare and non-healthcare settings.

The primary case studies examined in Appendix B are healthcare settings and were selected for their innovations and for the lessons learnt from incorporating living infrastructure. The case studies showcase evidence-based landscape design, capacity building measures, interactive approaches and evaluative methods and tools. They highlight how building management capacity for living infrastructure and implementing living infrastructure enhancements may be undertaken in a range of ways, shaped by a health precinct's distinct physical and social environments and the inspiration and needs of their communities. While generic recommendations and applications are offered, the studies establish the importance of place-specific approaches and outcomes. They illustrate collaborative approaches to living infrastructure projects involving partnerships between government and non-government health agencies, research institutions and communities. They also provide insights into consultation and engagement processes and design and planning approaches. Tools and methods developed through various projects are noted for the purpose of informing this Strategy and the proposed projects.

Critical insights from the case study review emphasise the contribution that greenspace provides to the health and wellbeing of staff in hospital settings. They also illustrate the breadth of ways living infrastructure can be incorporated into healthcare settings, offering salutogenic, biophilic and therapeutic health benefits. Innovative applications of living infrastructure have been shown to provide habitat and biodiversity, assist wayfinding, encourage people to walk and socialise outdoors and supply restorative views of nature from indoor spaces. Case studies show how edible living infrastructure can be installed at varying scales and in different forms, providing fresh, nutritious food, as well as education and rehabilitation opportunities.

In relation to the literature review, the selected case studies put into practice many theoretical aspects related to living infrastructure. Additional insights from the case studies highlight the diversity of contexts in which living

infrastructure has been implemented, reinforcing the importance of and opportunities offered by place-specific considerations. Examples of place-specific approaches are provided by Case Studies 1 and 2 (see Appendix B) where staff provided feedback on how best to use and benefit from a particular precinct's greenspace for their health and their respective programs e.g., cardiac health. Areas for future research, particularly in Australian settings, are also recognised, such as the need to explore the impacts of specific interventions.

Towards developing concepts and priorities for the project proposals, the review raised apparent gaps in the case study documentation regarding monitoring and managing living infrastructure and methods related to asset management. However, case study 4 (Appendix B) noted a validated post-occupancy user survey and evaluation that demonstrated the tangible benefits of therapeutic landscapesand that future research would comprise measuring and evaluating the healing gardens.

The reviewed primary case studies comprise:

1. Space to Breathe Project – greenspace value for staff health and wellbeing
2. Hospital Grounds Greenspace Project – greenspace and creative ways to engage staff
3. Fiona Stanley Hospital – living roofs and courtyards, garden walking guide and habitat area
4. Queensland Children's Hospital – therapeutic gardens, living walls and community spaces
5. Boston Medical Centre – highly productive rooftop farm and teaching kitchen
6. Lynchburg General Hospital – cafeteria, hydroponic micro-farms and outdoor gardens
7. Bendigo Hospital – performance assessment of outdoor courtyards

Emerging Themes from the Literature Review

When viewed with the three major Strategy priority areas of Health Promotion, Social Connection and Environmental Enhancement in mind, consistent themes were identified from the reviewed literature and case studies related to the implementation and derived benefits of living infrastructure. Some illustrative examples and their emerging themes include:

1. Greenspaces for staff health and wellbeing (physical and mental health)
2. Creative ways to engage community (community engagement and education)
3. Informal and formal social activities and spaces (people and place connections)
4. Restorative and therapeutic environments (mental restoration and physical movement)
5. Landscape performance assessments and research (environmental sustainability)
6. Comfort, walking and wayfinding (environmental experience and quality)
7. Orientation, attention and views (environmental experience and quality)
8. Healing gardens and 'normalcy'(El Baghdadi et al. 2016) (mental restoration and experience)
9. Habitat and nature interaction (environmental sustainability, community education)
10. Edible gardens and micro-farms (physical nourishment, community education)
11. Air and water quality (environmental safety and comfort)

Table 2 presents the reviewed literature and case study precedents in relation to the identified emerging themes for living infrastructure. These themes and areas of focus offer the basis for the development of the Strategy.

Having established the basis and origins of a theoretical framework and a set of operating themes these departure points and reference points have been used both directly and indirectly to shape the Strategy and its ambitions for the RHIP precinct.

Table 2

Emerging themes from literature and case studies for living infrastructure

Maroon indicates the presence of the theme in the literature or case reviewed.

Themes for Living Infrastructure	Physical Health Promotion (Movement & Nourishment)	Mental Health Promotion (Restoration & Experience)	Health Setting Connections (People & Place)	Community Connections (Engagement & Education)	Environmental Quality (Safety & Comfort)	Environmental Performance (Sustainability & Research)
Ecological models of health	■	■	■	■	■	
Salutogenic and biophilic design	■	■			■	
Therapeutic and healing gardens	■	■	■		■	
Urban ecosystems under pressure				■	■	■
Health promotion and climate change	■			■	■	■
Sustainable and healthy built environments	■	■		■	■	■
Performance measures for evaluating living infrastructure	■	■		■	■	■
NHS 'Space to Breathe' Project	■	■	■		■	
Hospital Grounds Project	■	■	■	■		
Fiona Stanley Hospital	■	■	■	■	■	■
Queensland Children's Hospital	■	■	■	■	■	■
Boston Medical Centre	■	■		■		■
Lynchburg Hospital	■		■			■
Bendigo Hospital	■	■	■		■	■

3.4. Summary

Having reviewed the literature, Precinct documents and policies, national and international case studies the RHIP Living Infrastructure Strategy offers sound departure points for introducing and valuing living infrastructure as a system of living assets of value to the Precinct environment, communities and potentially its economy. It grounds this claim in a sound review of the literature and of existing examples of installed living infrastructure in health precincts.

This strategy offers a place-based, community sensitive approach to valuing and adding living infrastructure to the Precinct which could either build on the capacity and potential of existing living infrastructure on the Precinct or by enhancing the environment through the inclusion of new living infrastructure on the Precinct.

A simple post strategy action plan may involve the following steps:

1. Endorsing the RHIP Living Infrastructure Strategy as a key focus for the Precinct and its future development
2. Selecting 1-3 Capacity Building projects to use to create momentum around living infrastructure on the Precinct to be completed over the next three years
3. Selecting 1-3 Environmental Enhancement projects to use as an experiment within the next two years
4. Cultivating partners and funding opportunities for each of these projects, including integrating this strategy soundly with other operating programs such as the Placemaking program and developing mutually beneficial projects that help to realise both placemaking and living infrastructure ambitions
5. Implementing the first generation of projects and evaluating them for their success

The associated benefits of living infrastructure have been well established in the literature and these benefits offer a platform for developing the potential of this type of infrastructure to become a much more readily understand, valued and readily incorporated component of a health precinct which supports health promotion, social connection as well as enhancing the environment.

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Figure Reference List

Randwick Health & Innovation Precinct |Project Charter – Green Infrastructure Strategy Project

RANDWICK HEALTH & INNOVATION PRECINCT
The future of lifelong health

General Project Information			
Project Name	RHIP Green Infrastructure Strategy		
Project Leads	Dr Kate Bishop, Dr Paul Osmond and E/Prof Linda Corkery		
Project Support	Research Assistants, Precinct Program Manager	**Expected start and end date**	Mid-February 2022 – Mid-August 2022

Background / Vision

1. ***Context*** - Common ground across recent large scale contemporary health infrastructure projects incorporating the explicit recognition of the need for social, environmental and economic sustainability; emphasis on holistic wellbeing for the on-site communities of patients, visitors and staff; and consideration of the precinct's influence on its broader community context.
2. ***Focus***- Green infrastructure - both natural and designed ecological systems, at a range of scales, e.g. from canopy trees to pot plants - deliver a well-evidenced variety of health benefits, improved social, environmental and economic outcomes for a health precinct and an interface between the precinct and surrounding neighbourhood and community. *Interactive* green infrastructure, with which the healthcare and wider communities can directly and physically engage, as distinct from simply viewing, significantly expands the benefits on offer.
3. ***Opportunity*** - This project offers a unique opportunity to demonstrate, monitor and validate the breadth and depth of the multiple significant benefits of interactive green infrastructure to the Precinct and its surrounding communities.

VALUE PROPOSITION

1. Completion of the Green Infrastructure Strategy that has the capacity to establish a program of projects that are beneficial across the RHIP which can be developed to target external funding opportunities.
2. The project will produce a *strategy* for embedding these innovations and evaluating them that complements the development trajectory across the life course of the whole precinct project.
3. This project enacts key considerations of performance in the *Randwick Health and Innovation Precinct Strategy 2020-2023*:
   a. The Green Infrastructure Strategy will establish a longitudinal framework for piloting innovative green infrastructure across a healthcare precinct and its development that is transferable to other healthcare contexts
   b. The Green Infrastructure Strategy and the subsequent projects it recommends will be unique and innovative, demonstrating best practice and enhancing the Precinct's reputation for innovation and leadership in its approach to holistic, sustainable healthcare design
4. The Green Infrastructure Strategy consider the key priorities as established in all Founding Partner existing and proposed aligned strategic initiatives.

Project Goal

A fully developed and actionable Green Infrastructure Strategy for the Randwick Health & Innovation Precinct with clear implementation next steps

Deliverables

Desired Outcomes	Measures
1. A matrix of strategic projects, benefits, partners and possible funding sources spanning the life of the precinct development	• A developed matrix
2. Detailed briefs for each project identified, including recommended modes of delivery, community consultation, stakeholders, strategic partners, education and research opportunities	• Meetings with stakeholders will be held • A list of projects created • A list of partners will be created • Briefs will be created
3. Corresponding identification and sequencing of external funding proposals for the research projects centred on health promotion, social connection and environmental quality and efficiencies for the following 5 years	• A list of funding sources • A program for research projects and external funding proposals for next 5 years
4. Identification of educational and research opportunities for UNSW students, CPD units for BE and health professionals and short online course opportunities with potential funding sources	• A matrix of potential projects and units suitable for students, professionals • A list of industry partners interested in being involved in these opportunities
5. A peer-reviewed strategy, evaluated for economic, environmental, and social benefit and feasibility	• A completed external review

	In scope	Out of scope
Facilities/services	N/A	N/A
Technology and systems	N/A	N/A
Processes	N/A	N/A
Infrastructure	N/A	N/A
People (staff, patients, others)	UNSW project leads + 2 x Research Assistants	

Risks, Issues and Mitigations

Risk/issue description	Rating	Mitigation Strategy
Corona Virus restrictions continue – undermining the team's capacity to meet with stakeholders and visit sites	Med	• Conducting online consultations • Using project and site plans, and programs like Near Map and Google Earth to compensate for a lack of site access

Project Governance | Key Stakeholders

Responsible	Dr Kate Bishop, Dr Paul Osmond and E/Prof Linda Corkery
Accountable	Dr Kate Bishop, Dr Paul Osmond and E/Prof Linda Corkery
Consulted	Randwick Campus Oversight Committee, PCC/EPC & Precinct Council Members, other key community stakeholders
Informed	Identified RHIP stakeholders including members of PCC/EPC & Precinct Council as appropriate and the broader community

Resources (Include People & Non-People Costs)

Need	Output	Total Cost
Two part time research assistants (2 days per week) for 6 months.	See list of deliverables as described above 1-4.	$71, 000
Independent review from within UNSW of overall strategy (20 hours @ $200/hr)	A peer-reviewed strategy, evaluated for economic, environmental, and social benefit and feasibility (Deliverable 5)	$4000

Sustainability and Spread

PROPOSED SCOPE: On several occasions the UNSW academic team met with members of the Precinct leadership team proposing the Green Infrastructure Strategy Project refining the proposal and scope outlined below:

1. Project will identify strategic, distinct interactive green infrastructure interventions across the site and the life of the project that complement the overall landscape design intentions for the site.
2. Using the three major areas identified: *Health promotion, Social connection* and *Environmental quality and efficiencies* as a frame for identifying strategic projects, a matrix of projects, benefits, partners, and potential sources of funding will be developed.
3. Each project identified will be described fully against the parameters of the associated disciplinary and cross-disciplinary educational and research opportunities it presents.
4. These projects will focus on interactive green interventions, (see above) capitalising on new smart technology which enhances social, health and environmental benefits, and on our capacity as a multidisciplinary institution with a broad cross-section of knowledge and expertise.
5. The Precinct is viewed as an innovation hub and testing ground for green infrastructure projects with social, economic and environmental benefit that could potentially be deployed in other health precinct contexts.

Appendix B – Case Studies: Primary and Secondary Series

Case Studies Overview

Selected case studies highlight the wide-ranging approaches and benefits of living infrastructure in health precincts and are useful in providing direction and lessons for the project proposals in the strategy.

As discussed in Chapter 2, illustrative principles from the cases studies include:

- Untapped health value of greenspace
- Creative community engagement
- Informal and formal social spaces
- Restorative, rehabilitative, or therapeutic environments
- Landscape performance research
- Comfort, walking and wayfinding
- Orientation, attention and views
- Healing gardens and normality
- Habitat and nature interaction
- Edible gardens and micro-farms
- Air and water quality

The set of primary case studies include those cases that have significant relevance to the proposed projects and formation of the *RHIP Living Infrastructure Strategy*:

1. Primary Case Study 1: 'Space to Breathe', United Kingdom
2. Primary Case Study 2: Hospital Grounds Greenspace Project, Scotland, United Kingdom
3. Primary Case Study 3: Fiona Stanley Hospital, Perth, Australia
4. Primary Case Study 4: Queensland Children's Hospital, Brisbane, Australia
5. Primary Case Study 5: Boston Medical Center, Massachusetts, United States
6. Primary Case Study 6: Centra Lynchburg General Hospital, Virginia, United States
7. Primary Case Study 7: Bendigo Hospital, Victoria, Australia

A secondary series of case studies is also included. They include examples where living infrastructure is applied in healthcare and corporate settings.

Primary Case Study 1: 'Space to Breathe', United Kingdom

Figure i - ii

'Space to Breathe' Report (left) and Big Woodland Walk at a NHS site (right) (Source: (Newson et al. 2020, pp.1 & 89) (Image left: Julia Glassman))

Overview

The 'Space to Breathe' project explored whether the restorative use of greenspace at NHS health sites could help in alleviating staff stress and add to quality of life. Staff stress and absenteeism have long been critical issues for the NHS In 2019, more than four in 10 staff reported feeling unwell as a result of work-related stress in the previous 12 months. These problems have been greatly exacerbated by the Covid-19 pandemic, making staff wellbeing a greater priority than ever. The prompt for the study included the growing evidence documenting the physical and mental wellbeing benefits of spending time in and being physically active in, green space (Copeland, 2019; Newson et al. 2020).

The project was carried out in collaboration with the University of Essex and with support from the Health Foundation, an independent charity committed to bringing about better health and healthcare for people in the UK.

Implementation

1. Study methods

Multiple methods were employed in the study: in-depth case study interviews with 'green space leads' (those leading green space work); site tours and observations; interviews with staff who did and staff who did not spend time in green space at work; consultation workshops; and site-wide staff surveys.

2. Staff feedback and actions

Key findings from feedback indicated staff who regularly spent time in their sites' green spaces during the working day reported significantly higher levels of wellbeing. The most common way in which staff spent time in green space at work was taking a walk at the site during a break. While relatively few staff at each site had engaged in organised recreational activities at work, those who had had slightly higher wellbeing scores than those who had not. Staff who had face-to-face contact with patients spent less time in green space than those who did not.

Feedback from staff was acted upon, including institutional cultural shifts that encourage staff to walk outdoors during breaks and green interventions (for example, therapeutic gardens) (Newson et al. 2020).

3. Staff recruitment and retention

Results indicated 44-52 percent of staff agreed that the availability of garden areas and green spaces at a hospital site was important to them in considering where to work – suggesting that this could have an impact on recruitment and retention.

Primary Benefits

The research findings showed that for NHS sites to realise the wellbeing benefits of green space for staff, it is important to design-in green spaces close to people's workspace. Hospital canteens should ideally have access to green views and outdoor seating with shade. In locating restorative green areas close to work areas it is important to consider staff privacy and to avoid locations that are readily overlooked or where staff feel their conversations cannot be private.

Well-signed and well-delineated walking routes that are not dominated by parked cars or moving vehicles can also enable staff walking about the hospital to better enjoy the benefits of green space as part of their everyday working lives. For staff to make use of such amenities, a supportive working culture is needed. Future research could usefully focus on the impact of specific interventions.

Resources and Weblinks

- Copeland, A. (2019). NHS sickness absence: Let's talk about mental health, Kings Fund. https://www.kingsfund.org.uk/blog/2019/10/nhs-sickness-absence
- Newson, C., Dandy, S., Gladwell V. and Hase A. (2020). Space to Breathe: Valuing Green Space at NHS Sites for Staff Wellbeing, Centre for Sustainable Healthcare. https://nhsforest.org/wp-content/uploads/2022/02/Space-to-Breathe-Full-Report-.pdf

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Primary Case Study 2: Hospital Grounds Greenspace Project, Scotland, United Kingdom

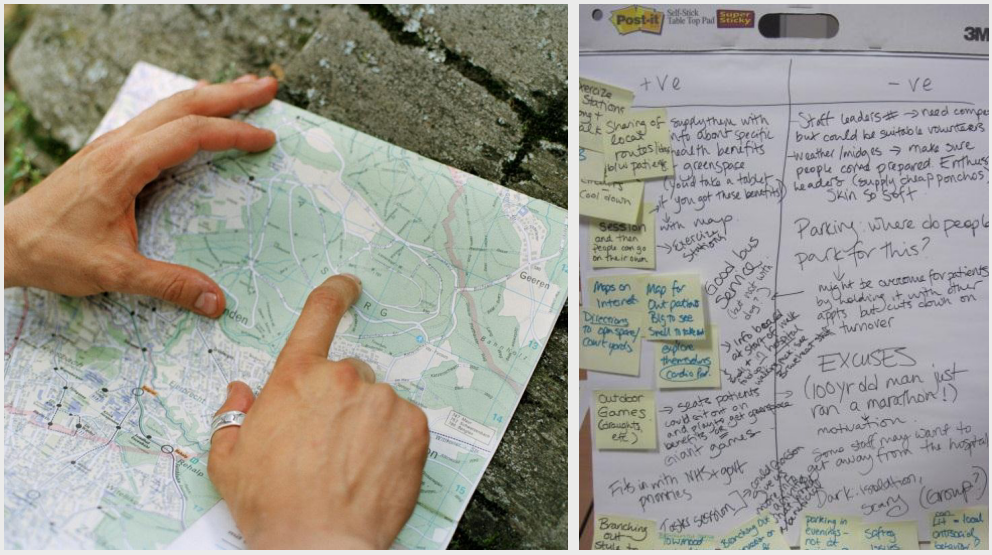

Figure i - ii

Participatory mapping (left) and SWOT analysis example (right)
(Source: Munoz and Nimegeer 2012 pp. 32 & 38)

Overview

The Hospital Grounds Greenspace Project explored best practice for involving people in the design, use and maintenance of hospital and 'hospital-adjacent' greenspace, using Forth Valley Royal Hospital (Lambert, Scotland) as the study case study. The project led to the piloting of activities to get staff, patients and community members using the woodland adjacent to a hospital and involved the development of ways of evaluating the impact of these activities. It also developed a framework for estimating the Social Return on Investment (SROI) in hospital grounds greenspace. The project was a collaboration between the University of the Highlands and Islands (Scotland), National Health Services (Forth Valley and Highland) and Forestry Commission Scotland.

Implementation

1. Creative, participatory methods

These included site visits to case study sites (to examine how hospital greenspace use was already being carried out); collaborative engagement processes between project partners and three key groups (hospital staff, local residents and clinicians and patient representatives from a cardiac-focused group); workshops (participatory mapping, SWOT analysis and led site walks); 'drop in' events; and a survey of stakeholders.

2. Key results

Key results highlighted staff and patient groups were keen to use the grounds for mental health benefits. Organised events held in the hospital grounds made local people feel 'welcome'.

3. Pilot projects

Pilot projects put into practice staff suggestions for using the woodland adjacent to the hospital: weekly woodland-conservation sessions for Cardiac patients in Stage Two of rehabilitation; and weekly Tai Chi classes for community members and staff.

4. Social Return on Investment

The 'Social Return on Investment' analyses for each project indicated participants in the Cardiac Program experienced benefits such as improved mood, better physical health and wider peer networks. For every £1 (approximately $1.67 AUS) that was spent on this activity, £3.86 (approximately $6.46 AUS) worth of social value was created. The analyses also showed participants in the Tai Chi Program experienced benefits such as decreased stress and better joint and muscle health. For every £1 that was spent on this activity, £4.32 worth of social value was created.

5. Framework for evaluating activities and improvements

The developed framework for evaluating activities and improvements uses a series of evaluative tools, potentially applicable to other hospital greenspace. The tools include: longitudinal mixed method questionnaires; participant observation; qualitative and quantitative data gathering; after-event evaluation forms; and interviews (Munoz and Nimegeer 2012).

Primary Benefits

The study demonstrated the importance and effectiveness of using creative participatory methods as engagement techniques. The framework for evaluating activities and improvements developed through this study provides useful tools for studies with similar aims. For studies of this nature and scope, aspects of 'Social Return on Investment' analyses may be useful. However, a full analysis may be too time-consuming.

Use of hospital grounds greenspace for health benefit can be complicated by 'clinical' dimensions, such as institutional cultures. Multi-sector working is needed to maximise the success of hospital grounds greenspace interventions (Munoz and Nimegeer 2012).

Resources and Weblinks

- Munoz, S. and Nimegeer, A. (2012). Hospital Grounds Reimagined: Facilitating Engagement with Hospital Grounds Greenspace Design, Development and Management for Health and Wellbeing, Final Report and Toolkit. https://202020vision.com.au/media/41878/hospital-grounds-reimagined-greenspace-final-report-and-toolkit.pdf

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Primary Case Study 3: Fiona Stanley Hospital, Perth, Australia

Figure i

Rehabilitation service terrace with netted enclosure designed and detailed for active therapy (Source: Sack 2014) (Image: Peter Bennetts)

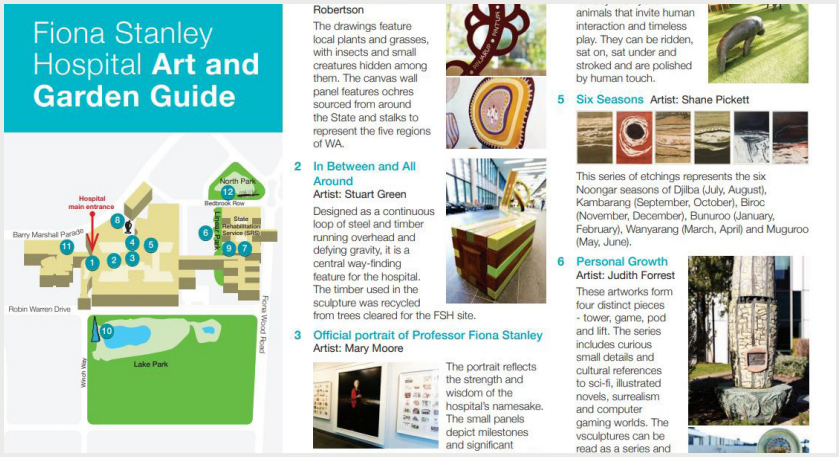

Figure i - ii

Fiona Stanley Art and Garden Guide
(Source: WA Government, South Metropolitan Health Service n.d.)

Overview

The Fiona Stanley Hospital, opened 2014, incorporates buildings, bushland, roof gardens and courtyard gardens into a unified complex, with 2,100 trees and 160,000 shrubs, some recovered from the original site.

Implementation

1. Conservation bushland

The site also comprises a designated conservation bushland area covering approximately 10 percent of the site (see 3.5).

2. Therapeutic and rehabilitative terraces

Courtyards are located on every level of the campus. They are accessible, allow for quiet retreat and many serve as views from windows for patients. Key courtyard areas and functions include:

- entry courtyard with cafe pod providing opportunities for pause, gathering and retreat
- rehabilitation service courtyards comprising a terrace with everyday 'normality' elements (such as those typically found and used in a person's backyard e.g. clothesline, barbecue, lemon tree) and another with a netted enclosure designed for active therapy (Figure x)
- intensive care unit courtyard allowing patients in ICU beds to be wheeled out and hooked up to essential electronic sentries while benefiting from being outside.

3. Roof gardens

Roof gardens provide green views from patient rooms and treatment areas, particularly from the children's ward (Sack 2014).

4. Art and Garden Guide

The 'Fiona Stanley Art and Garden Guide' (figure x) was developed for staff and visitors. The guide highlights the numerous gardens within the campus and celebrates the multiple artworks commissioned by the precinct.

Primary Benefits

The living infrastructure elements in Fiona Stanley Hospital support and strengthen habitat and biodiversity in the region, provide a diversity of rehabilitative functions and offer health-benefiting views from most patient windows. The art and garden guide initiative demonstrates a hospital culture that values spending time outdoors, encouraging people to walk, socialise, access natural light and fresh air and interact with nature. The guide also offers distraction and opportunities for restoration.

Resources and Weblinks

- Sack, T. (2014), A Room with a View, Landscape Architecture Australia, No.144, November 2014, pp.40-48
- WA Government - South Metropolitan Health Service (n.d.), Fiona Stanley Hospital Art and Garden Guide https://www.fionastanley.health.wa.gov.au/~/media/HSPs/SMHS/Hospitals/FSH/Files/PDF/FSH-Art-and-Garden-Guide.pdf

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Primary Case Study 4: Queensland Children's Hospital, Brisbane, Australia

Figure i - iv

The Secret Garden (Image: Christopher Frederick Jones) (Source: Bull 2015)
Figure ii & iii: Green columns adjacent the mental health unit (Image: Christopher Frederick Jones) (Source: Bull 2015)

Overview

The Queensland Children's Hospital (formerly Lady Cilento Children's Hospital) redevelopment is viewed as representing a symbolic shift in hospital design, offering opportunities for outlook, restorative exercise, play, socialising, respite and retreat and contributing to the broader urban landscape. The design of the hospital's therapeutic landscapes is evidence-based and emphasises the benefits of nature and importance of contextual design in supporting healing outcomes.

The design is based on a 'living tree' concept, comprising a network of trunks and branches that assist wayfinding, afford views to the surrounding landscape, provide natural light where possible and lead to outdoor gardens and terraces (CRC Water Sensitive Cities 2020) (Figure x).

Implementation

1. Engagement with urban context

The principal forecourt for the main complex contributes to the broader urban landscape through the provision of a shady plaza at a reconfigured street intersection. The project combines the peripheral roads and plazas with the expansive roof gardens so that nearly 80 percent of the site can be classified as public open space. A 600m2 green sloping roof which can be seen from afar promotes the hospital's green credentials to the wider community.

2. 'Normality' integrated into landscape design

Everyday activities are incorporated into the design to make patients and visitors feel a sense of 'normality', for example, the smell of freshly cut grass and access to sunshine, fresh air, wind, rain and river views. Low impact and relatively unobtrusive landscape maintenance tasks during hospital hours provide human interaction and a sense of normality (El Baghdadi et al. 2017).

3. Gardens, green walls and green roofs

Eleven gardens offer various opportunities to access nature and natural light, while allowing time away in nature to help re-establish the capacity to pay attention. The gardens act as rooms that 'offer parents and children places that inspire curiosity and play as well as a reprieve from hospital visits'. Green walls and green roofs suggest 'wonderlands' and provide green, verdant views from hospital beds. The design acknowledges the service and needs of hospital staff by providing separate staff gardens for 'time out' (Bull 2015; El Baghdadi et al. 2017).

4. Green technical innovations

Subtropical green monoliths and epiphyte columns on roof terraces aid the structural integrity of both the building and green infrastructure. The shallow 300 mm rootzone supporting the green infrastructure is custom designed. Established fig trees on the community plaza are in custom designed tree pits and provide shade and eliminate the need for built shade structures.

Pavement design passively irrigates vegetation and minimises stormwater flows in the drainage system. Rainwater harvesting for storage in in an underground tank assists with irrigation water supply and reduces dependency on mains water. The irrigation system complies with Queensland Health protocols for the safe use of water in hospitals. Garden irrigation is fully automated, programmed and operated to minimise the risk to health compromised users. Shared spaces for services and landscape infrastructure (irrigation, drainage and rootzone) lie between building floors (CRC Water Sensitive Cities 2020).

5. Evaluation, future research and transferability

A validated post-occupancy user survey and evaluation demonstrates the tangible benefits of therapeutic landscapes. Future research will continue to measure and evaluate the healing gardens. The design thinking, engagement process, implementation and post-occupancy evaluation of the gardens can be transferred to other healthcare projects in different locations and at different scales (CRC Water Sensitive Cities 2020).

Primary Benefits

A distinguishing feature of the Queensland Children's Hospital is the way the site engages with the urban context to form a connected public space network, extending beyond the site boundaries. Living infrastructure also plays key roles in incorporating 'normality' and wonder into greenspaces. Green technical innovations are comprehensive, detailed by the assessment by CRC Water Sensitive Cities (n.d.). Evaluation stresses the importance of post-occupancy assessments and transferability to other healthcare projects.

Resources and Weblinks

- CRC Water Sensitive Cities. (2020). Queensland Children's Hospital therapeutic landscapes. https://watersensitivecities.org.au/wp-content/uploads/2020/12/201124_V2_Green-Roof-Case-Study.pdf
- El Baghdadi, O., Ziviani, J., Nieberler-Walker, K., Reeve, A. and Desha, C. (2017). Normalcy in healthcare design: An extension of the natural and built environment, Proceedings in European Healthcare Design (EHD), London, 11-14 June.
- Bull, C. (2015). Lady Cilento Children's Hospital landscapes, ArchitectureAU. https://architectureau.com/articles/lady-cilento-landscapes/#:~:text=For%20Brisbane%27s%20new%20Lady%20Cilento,full%20of%20drama%20and%20novelty.&text=Lush%2C%20tropical%20vegetation%20is%20fast,arbour%20in%20the%20Secret%20Garden

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Primary Case Study 5: Boston Medical Center, Massachusetts, United States

Figure i - ii

Rooftop Farm and Beehives at Boston Medical Centre (Source: Higher Ground Farm n.d.)

Overview

The Boston Medical Center, a tertiary academic medical, has since 2017 maintained a highly productive farm on the third story roof of its power plant building.

Implementation

The rooftop farm is constructed using carefully arranged recycled milk crates as raised garden beds along with a smart irrigation system, covering a roof area of approximately 650 square meters with 247 square meters of growing space and also includes two beehives for pollination and honey (Boston Medical n.d.). The farm supplies food for Center patients, cafeterias, a teaching kitchen and a food pantry. The farm is managed by Higher Ground Farm, an urban farming education and service company, which dedicates about 30 hours weekly to farm maintenance as well as organising and conducting farm tours, educational classes, volunteer activities and youth summer camps at the farm and teaching kitchen (Higher Ground Farm n.d.).

Primary Benefits

Annual harvests yield between 2270-3175 kilograms of food that can include up to 25 different crop varieties, including radishes, tomatoes, beans, leafy greens, carrots, cucumbers, peppers, eggplant, squash, herbs, etc. The food education, food donation, volunteer and community activities enabled by the farm provide health and wellbeing benefits for patients, employees and local community residents. The farm also serves to reduce building heating and cooling costs as well as extending the operational life of the roofing materials underneath (Boston Medical n.d.).

Resources and Weblinks

- Boston Medical. (n.d.). Rooftop Farm. https://www.bmc.org/nourishing-our-community/rooftop-farm
- Higher Ground Farm (n.d.). Boston Medical Centre. http://www.highergroundrooftopfarm.com/boston-medical-center-farm.html

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Primary Case Study 6: Centra Lynchburg General Hospital, Virginia, United States

Figure i

Babylon Micro-Farm units at Centra Lynchburg General Hospital (Source: Babylon Micro-Farms, 2021)

Overview

Centra Lynchburg General Hospital, located in the US state of Virginia, uses both indoor hydroponic micro-farms and outdoor gardens to supply their cafeteria with fresh ingredients.

Implementation

Two indoor hydroponic micro-farm units, each about 1.4 square metres in size, made by Babylon Micro-Farms were prominently installed and displayed at the Centra Lynchburg main lobby cafeteria entrance, along with informational signage explaining their functions to visitors (Babylon Micro-Farms 2021). The micro-farms are operated through a phone application by the cafeteria executive chef and primarily produce lettuces and spring mix for the cafeteria salad bar (Centra Health, 2019). The outdoor gardens at Centra Lynchburg are

managed by cafeteria staff and supply a variety of herbs and other crops for hospital kitchens, such as cilantro, basil, jalapenos, cherry tomatoes and more (Food Management 2020).

Primary Benefits

The hydroponic micro-farms can operate year-round with six-week harvest cycles for lettuce and were found to produce about 45 kilograms of lettuce over two months, while the outdoor gardens produce substantial seasonal harvests. Cafeteria staff reported increased diner satisfaction when using freshly harvested ingredients, as well as the controlled hydroponic conditions reducing concerns towards food safety (Food Management 2020).

Resources and Weblinks

- Babylon Micro-Farms. (2021). Babylon Micro-Farms: Empowering Healthcare Systems To Get Healthier. https://babylonmicrofarms.com/babylon-micro-farms-empowering-healthcare-systems-to-get-healthier/
- Centra Health. (2019). Micro Farms at LGH. https://www.centrahealth.com/micro-farms-lgh
- Food Management. (2020). Babylon hydroponic micro-farm grows in Centra Lynchburg General Hospital cafeteria. https://www.food-management.com/healthcare/babylon-hydroponic-micro-farm-grows-centra-lynchburg-general-hospital-cafeteria

Primary Case Study 7: Bendigo Hospital, Victoria, Australia

Figure i

Green outdoor sitting area, Bendigo Hospital.
(Image: Tom Adolph) Source: Oculus. (2022). Bendigo Hospital https://www.oculus.info/projects/bendigo-hospital

Overview

The redevelopment of Bendigo Hospital, completed in June 2018, involves two precincts and an integrated landscape network of 46 courtyards, green roofs, balconies, walkways and gardens. The use of solar photovoltaic and recycled water systems underpins the performance of the buildings and ensures that the precinct delivers both environmental and economic benefits to the local community (Keane and Grant, 2022).

A landscape performance assessment was undertaken of the 'therapeutic garden' – considered the heart of the hospital - by RMIT researchers and Oculus Landscape Architects funded by the Landscape Architecture Foundation. Landscape performance assessments offer ways to measure the effectiveness with which landscape solutions fulfill their intended purpose and contribute to sustainability (Keane and Grant, 2022).

Implementation

1. Indoor comfort benefits

Enhanced greenspaces improve indoor comfort by reducing glare and the heat island effect.

2. Landscape performance assessment

The assessment explored how was the therapeutic garden used, who used it, when was it used and how. Methods for the assessment involved desktop analysis, staff survey and behaviour observations (Keane & Grant, 2022).

Primary Benefits

Results the assessment indicated fine-grained, daily use of the garden – beyond general design intentions and a few unanticipated observations – and that the garden was consistently used, even in cold weather and for long periods (>30mins). Groups of staff with coffee used the garden, possibly due to COVID space restrictions inside. Patients being transported on trolleys through the garden had social interactions with others. The report of the assessment is yet to be published by the Landscape Architecture Foundation. These notes are informed by a recorded presentation by the assessment team as part of the 'LAF 2022 CSI Program: Health-Focused Projects' (available: https://www.lafoundation.org/resources/2022/07/2022-csi-finale-webinar-health).

Resources and Weblinks

- Oculus. (2022). Bendigo Hospital https://www.oculus.info/projects/bendigo-hospital
- Keane, B and Grant, P. (2022). Measuring Landscape Performance: LAF'S 2022 CSI Program, Health-Focused Projects – Bendigo Hospital. https://www.lafoundation.org/resources/2022/07/2022-csi-finale-webinar-health

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Secondary Case Study Summaries

1. Daramu House Living Roof with Solar Array, Sydney, Australia

Living infrastructure: green roof with solar panels

Figure i

International House & Daramu House rooftops
(Source: Malone 2021; Junglefy 2022b)

Overview

Daramu House is a commercial retail building that is part of Barangaroo South in Sydney which combines photovoltaic solar panels with a living roof as part of comparative research study. Daramu House and its near-identical sister building International House were both equipped with the same type of solar array on their roofs; however, Daramu House roof was also planted with vegetation beneath and around the solar panels while the International House only used normal roof materials. The two roofs were then directly compared over the course of eight months in terms of solar panel performance and other derived benefits (ABC News 2021; Junglefy 2022b). The presence of vegetation kept the Daramu House roof surface temperatures cooler by up to 20 degrees Celsius, which resulted in improved solar panel performance by increasing panel efficiency up to 20% at peak energy times and by 3.6% overall. Over the eight-month study period this improved efficiency generated an additional 9.5 MWh of energy, which was equivalent to $2595 AUD at that time.

The Daramu House living roof also provided many additional benefits besides efficiency improvements, such as providing biodiverse habitat for pollinators and birds, carbon sequestration, stormwater runoff reduction and reducing building HVAC energy costs (ABC News 2021).

Resources and Weblinks

- Junglefy (2022b). Daramu House - A High-Performance Rooftop Ecosystem. https://www.junglefy.com.au/project/daramu-house
- Malone, U. (2021). Study finds green roofs make solar panels more efficient, ABC News 24 August 2021 https://www.abc.net.au/news/2021-08-24/nsw-green-roofs-make-solar-panels-more-efficient/100400552

2. Yerrabingin South Eveleigh Community Rooftop Garden, Sydney, Australia

Living infrastructure: First Nations rooftop food garden

Figure i

Yerrabingin rooftop garden design - traditional symbolic Indigenous forms and patterns form the pathway structure and framework for the central social space and garden beds (Image: Shane Eberle Photography) (Source: Landscape Architecture Foundation n.d.)

Overview

The Yerrabingin native garden, located on the rooftop of a four-storey community building, uses principles of Indigenous knowledge, collaborative design and permaculture to create and maintain the Australia's first Indigenous rooftop farm for urban food production. The garden grows over 2,000 edible, medicinal and culturally significant plants. A large bank of solar panels sits on the roof's southern side. A landscape performance assessment of the garden was undertaken in collaboration with Indigenous practice partner Jiwah. One of the core principles that have underpinned the development and collaboration of this case study is the concept of 'give back'. Give back is a core principle of Aboriginal and Torres Strait Islander cultures.

Resources and Weblinks

- Landscape Architecture Foundation, (n.d.). 'South Eveleigh Community Rooftop Garden', Landscape Performance Series. https://www.landscapeperformance.org/case-study-briefs/south-eveleigh-community-rooftop-garden
- Corkery, L., Padgett Kjaersgaard, S. and Thomson, L. (2020). 'South Eveleigh Community Rooftop Garden Methods', Landscape Performance Series, Landscape Architecture Foundation. https://doi.org/10.31353/cs1681
- Yerrabingin. (n.d.), 'Yerrabingin South Eveleigh Native Rooftop Farm'. https://www.yerrabingin.com.au/projects/rooftop-farm

3. Westmead Health Precinct, Sydney, Australia

Living infrastructure: First Nations peoples' culturally safe garden space for traditional practices and green rest areas in carparks

Figure i

Artworks by Indigenous artists in culturally safe outdoor space for First Nations peoples' traditional practices (Photo: Louise McKenzie 2022)

Figure ii

Artwork in green rest area in carpark. (Photo: Louise McKenzie 2022)

Overview

Westmead Health Precinct redevelopment created a series of outdoor and semi-outdoor circulation, garden and courtyard spaces that assist with wayfinding and navigation and incorporate artworks by Aboriginal and non-Aboriginal artists. The works are initiatives of the Westmead Arts and Culture Strategy. Living infrastructure includes a culturally safe garden space used for Aboriginal and Torres Strait Islander peoples' traditional practices with a series of artworks: Tools of Knowledge' (Matt Poll and Jamie Eastwood) and 'All that Remains' (Joe Hurst) (Figure i). Green rest areas (including ones with artworks) are located adjacent to carpark steps (Figure ii).

Resources and Weblinks

- Warami Westmead. (n.d.). https://www.warami-westmead.com.au/
- Cintra, M. (2000). Placemaking in Health Facilities: An Australian Model. In Turner, F. and Senior, P. (ed.). A Powerful Force for Good: Culture, health and the arts-an anthology. Manchester Metropolitan University (2000), Manchester Metropolitan University
- Westmead Redevelopment Arts and Culture Strategy. (n.d.). https://www.westmeadproject.health.nsw.gov.au/WWW_Westmead/media/Media/Publications/strategic%20documents/WRD044_Wesmead-Arts-Culture-v10.pdf

4. New York University Langone Medical Centre, New York, US

Living infrastructure: Green courtyard for flood resilience

Figure i

Alumni courtyard - New York University Langone Medical Centre
Source: JPLA (2017)

Overview

Living infrastructure includes an elevated green courtyard that acts as flood resilience infrastructure, together with other flood-control measures. This courtyard also connects patients and staff to the healing properties of the outdoors.

Resources and Weblinks

- JPLA (2017). Category: HEALTH CARE - NYU LMC ALUMNI COURTYARD https://joannapertz.com/skill/healthcare/
- Ulam, A. (2021). 'A Resilient Renewal', Landscape Architecture Magazine, January 2021. http://bt.royle.com/publication/?i=687128&article_id=3838077&view=articleBrowser&ver=html5

5. The Johns Hopkins Hospital, Baltimore, US

Living infrastructure: Green roof and gardens

Figure i

John Hopkins Hospital Green Roof
(Source: The Johns Hopkins Hospital Office of Sustainability 2022)

Overview

An energy conserving green roof, not accessible by the public, lies atop the hospital MRI building. Gardens feature at the various hospital entrances and ground level areas between buildings. A garden with a labyrinth, created along the west wall of one of the buildings, honours the 'anonymous people whose bodies are donated for medical students' human anatomy course as well as the living volunteers who help with their training'.

Resources and Weblinks

- Smith, L. (2022), 'Cultivating a Landscape of Wellbeing at The Johns Hopkins Hospital', Dome, 7 Nov 2022. https://www.hopkinsmedicine.org/news/articles/cultivating-a-landscape-of-wellbeing-at-the-johns-hopkins-hospital

6. Kinghorn Cancer Centre, Sydney, Australia

Living infrastructure: Green walls and garden terraces

Figure i

Garden Terrace, Kinghorne Cancer Institute, Sydney
Source: Louise McKenzie

Overview

The Kinghorn Cancer Centre includes a series of green walls, garden terraces and a roof garden designed to improve the wellbeing of the staff and patients. Views of the green outdoors feature in the multi-level circulation atrium that includes the main entrance foyer. See Chapter 3. for further details.

Resources and Weblinks

- Architecture AU, (2013). 'National Architecture Awards: Public', 7 Nov 2013. https://architectureau.com/articles/2013-national-architecture-awards-public-8/

7. Maggie's Centre for Cancer Patients, Leeds, UK

Living infrastructure: Rooftop garden

Figure i

Grassy gardens atop the Maggie's Centre for cancer patient, St James's University Hospital in Leeds (Image: Hufton + Crow) Source: Block, I. (2020)

Overview

Maggie's Centre, a charity that provides free support for people with cancer, is located within the campus of St. James's University Hospital in Leeds. The rooftop garden, inspired by Yorkshire woodlands, features native English species of plants, alongside areas of evergreen to provide warmth in the winter months. Visitors are encouraged to participate in the care of the 23,000 bulbs and 17,000 plants on site.

There are several Maggie's Centres distributed across the UK, with associated landscapes and gardens that are carefully considered aspects for health and wellbeing. The centres are named after Maggie Keswick, a landscape architect and wife of renowned English architect, Charles Jencks.

Resources and Weblinks

- ArchDaily. (n.d.).'Maggie's Leeds Centre / Heatherwick Studio', available: https://www.archdaily.com/941540/maggies-leeds-centre-heatherwick-studio
- Block, I. (2020). Heatherwick Studio designs plant-filled Maggie's Centre in Leeds, Dezeen, 12 June 2020 https://www.dezeen.com/2020/06/12/heatherwick-studio-maggies-centre-leeds-architecture/

8. Oberlin College, Oberlin, Ohio, US

Living infrastructure: Constructed ecosystems

Figure i

Adam Joseph Lewis Center for Environmental Studies - indoors, a specially engineered wetland called the Living Machine purifies non-potable wastewater for reuse in toilets and the landscape (Image: Dale Preston ’83) Source: Oberlin College and Conservatory (2022)

Overview

The Adam Joseph Lewis Centre of Oberlin College is an integrated building-landscape system that strives to teach positive lessons about human relationships with the natural environment. The Centre’s landscape features a variety of constructed ecosystems that simulate native ecosystems and incorporate cultigens that produce food for humans. The building and surrounding landscape are built to the following principles of sustainable architecture: extensive use of plants native to the region; responsible stormwater management and storage; integration of social and ecological space; and interior landscaping designed to connect inhabitants to earth's natural cycles.

Resources and Weblinks

- Oberlin College and Conservatory (2022). Adam Joseph Lewis Center for Environmental Studies https://www.oberlin.edu/aj-lewis
- Orr, D. (2011). ‘The Oberlin Project’, Oberlin Alumni Magazine. https://www2.oberlin.edu/alummag/fall2011/features/project.html

9. ‘Walking forest’ - Bosk public art installation, Leeuwarden, Netherlands

Living infrastructure: Mobile forest

Figure i

Walking Forest Route (Source: Arcadia 2022)

Overview

From 7 May to 14 August 2022, over one thousand trees were moved through a city center - in stages through neighborhoods - so “the forest decreased in one place while growing somewhere else.” The installation, led by traffic controllers and captains, sought to imagine what else could be done [using living infrastructure].

Resources and Weblinks

- Green, J. (2022). ‘A Moveable Forest in the Netherlands’, The Dirt 22 Aug 2022, available: https://dirt.asla.org/2022/08/22/a-walking-forest-in-the-netherlands/?utm_medium=email&_hsmi=223811510&_hsenc=p2ANqtz-9vOnf6XtHn2NzhriF5E8VRGEq7kqnVIQvp3lBDtlR6_em4l6J4cWJV3l0bKQo-z1bxSCnB0-0raEpDE2H6TyInjw2M9Q&utm_content=223811510&utm_source=hs_email
- Arcadia. (2022). ‘Bosk’ available: https://arcadia.frl/en/projecten/bosk/

10. Melbourne Pollinator Corridor (MPC), Melbourne, Australia

Living infrastructure: Green wildlife corridor

Figure i

Melbourne Pollinator Garden created by the local community (Source: The Heart Gardening Project 2022)

Overview

The Melbourne Pollinator Corridor involves an 8km community-driven wildlife corridor that will link two large green patches that run along the Birrarung (Yarra River), Westgate Park and the Royal Botanic Gardens Melbourne. The MPC will focus on native bees and other native pollinating insects, the aim being 18,000 indigenous plants in 200 gardens by the end of 2024. The MCP corridor project could potentially link into Sydney and Adelaide.

Resources and Weblinks

- The Heart Gardening Project. (2022). 'Melbourne Pollinator Corridor', available: https://www.theheartgardeningproject.com/melbourne-pollinator-corridor

11. Mater Hospital Redland, Cleveland, Australia

Living infrastructure: Balcony healing garden for patients

Figure i

Mater Hospital Healing Garden
(Source: Green Roofs Australasia 2013)

Overview

A first-floor balcony at the hospital had raised garden beds, potted plants, shading and outdoor furniture installed to provide patients with tranquil healing environment. The healing garden was funded by $40,000 in donations from Redland community individuals and businesses.

Resources and Weblinks

- Green Roofs Australasia. (2013). Mater Hospital Healing Garden https://test.greenroofsaustralasia.com.au/projects/mater-hospital-healing-garden
- Mater. (2021). Healing garden blooms into life at Mater Redland. https://www.mater.org.au/group/news/mater-news/august-2021/healing-garden-blooms-into-life-at-mater-redland

12. Mater Hospital Brisbane, Brisbane, Australia

Living infrastructure: Edible garden wellbeing program for hospital staff

Figure i

'Vegepods' gardens with canopies and self-watering systems
(Source: South bank News n.d.)

Overview

The hospital has installed 'Vegepods' gardens equipped with canopies and self-watering systems in sunlit locations around the hospital. The gardens are maintained by staff that have joined a wellbeing edible garden program, who are able to choose what they want to grow and can take home harvested produce. Harvested food will also be used to provide fresh ingredients for the patient menu and boost their nutritional intake. Alongside the wellbeing edible garden program, Bond University researchers will measure mental health and wellbeing indicators to examine the benefits of therapeutic horticulture work breaks.

Resources and Weblinks

- ABC News (2022), Gardening breaks hoped to boost staff mental health at Brisbane's Mater Hospital 30 Aug 2022 https://www.abc.net.au/news/2022-08-30/mater-hospital-edible-garden-boosts-staff-mental-health/101372538
- Mater. (2022). Mater plants pilot study to boost wellbeing of health workers. https://www.mater.org.au/group/news/mater-news/august-2022/mater-plants-pilot-study-to-boost-wellbeing-of-hea
- South Bank News (n.d.), Mater South Brisbane Pioneers Edible Garden Project https://southbanknews.com.au/mater-south-brisbane-pioneers-edible-garden-project/
- Vegepod. (2022). Homepage. https://vegepod.com.au/

13. Lendlease Head Office

Living infrastructure: Breathing wall

Figure i

Breathing Wall - Lendlease Head Office. (Photo: Louise McKenzie 2018)

Overview

A six-metre tall, two-storey breathing wall with 5,000 plants was installed at the Lendlease headquarters at Barangaroo South. After installation, air quality tests and monitoring by University of Technology Sydney researchers confirmed that breathing wall areas had lower levels of particulate matter, carbon dioxide than other building areas, as well carbon monoxide, volatile organic compounds and sulphur dioxide levels that were below the research equipment detection limit.

Resources and Weblinks

- P.J. Irga., N.J. Paull., P. Abdo., B.P. Huynh., V. Avakian., T. Nguyen., F.R. Torpy. 2016 Developing the Junglefy Breathing Wall for enhanced indoor air quality remediation. Plants and Environmental Quality Research Group. Report prepared for Junglefy Pty Ltd. University of Technology Sydney, Australia. https://opus.lib.uts.edu.au/bitstream/10453/155436/2/Junglefy-UTS-2016-Report.pdf
- Lendlease. (2016). Australia's first breathing wall lifts Lendlease new global headquarters. https://www.lendlease.com/au/-/media/llcom/investor-relations/media-releases/2016/20160704-breathing-wall-barangaroo.ashx

14. Ryde Hospital, Ryde, Australia

Living infrastructure: Composting from food waste

Figure i

Food muncher at Ryde Hospital converts food waste to compost (Source: Northern Sydney Local Health District 2021)

Overview

A food waste processor converts 100kg of food waste into 10kg of organic compost every week, which is used to fertilise the hospital's gardens. The initiative prevents over five tonnes of patient food waste from going to landfill.

Resources and Weblinks

- Northern Sydney Local Health District. (2021). Food muncher at Ryde converts food waste to compost. https://www.nslhd.health.nsw.gov.au/News/Pages/Food-muncher-Ryde-converts-food-waste-to-compost.aspx#

15. Cafe “coolseats” Sydney, Australia

Living infrastructure: Composting benches for cafe food waste

Figure i

“Coolseat” composting bench
(Source: Coolseats 2022)

Overview

Ten cafes in Chippendale and Bathurst have installed “coolseat” composting benches to reduce their food waste. The coolseats consist of a bench seat lids over composting worm farm baskets placed inside raised garden beds. The coolseats avoid producing odours by being fully ventilated and turn added food waste into compost within 3 to 5 weeks.

Resources and Weblinks

- The Fifth Estate. (2022). This public bench aims to fight food waste, one café at a time. https://thefifthestate.com.au/waste/this-public-bench-aims-to-fight-food-waste-one-cafe-at-a-time/
- Coolseats. (2022). https://www.coolseats.com.au/

16. Perth Children's Hospital, QEII Medical Centre, Perth, Australia

Living infrastructure: First Nations storytelling in a future park and nature playground

Figure i

Render of planned greenspace upgrade next to Perth Children's Hospital (Source: Sutherland 2022)

Overview

A planned upgrade of a vacant space adjacent to the Perth Children's Hospital will create a nature playground, amphitheatre, entertainment space and a natural learning precinct. The future park will offer a place of refuge for patients and their families from the clinical setting of the hospital and is inspired by the "healing energy of Country", incorporating traditional and contemporary cultural themes and Nyoongar dreamtime stories in the design. The design was developed with Aboriginal cultural consultants, Soft Earth, who contributed Nyoongar cultural knowledge to the project. "Greenspace will be a place for young people and their loved ones to spend time together and make cherished memories while enduring the challenges of a diagnosis" (Sutherland 2022).

Resources and Weblinks

- Sutherland, I. (2022). Kids' hospital park inspired by 'healing energy of Country, ArchitectureAU, https://architectureau.com/articles/kids-hospital-park-inspired-by-healing-energy-of-country/?utm_source=ArchitectureAU&utm_campaign=c36650808f-AAU_2022_11_07&utm_medium=email&utm_term=0_e3604e2a4a-c36650808f-40309341&mc_cid=c36650808f&mc_eid=0c1ff187ef
- Hassell. (2022), New Greenspace inspired by the healing energy of Country, 3 Nov 2022 https://www.hassellstudio.com/us/news-event/new-greenspace-inspired-by-the-healing-energy-of-country

Appendix C – Reviewed Performance Indicators

These performance indicators could be used to monitor the performance of living infrastructure as part of both the Capacity Building projects and the Environmental Enhancement projects.

Indicator Type	Sources	Measures or Methods
Thermal	NABERS, Fitwel, WELL & WELL Community, SITES, Landscape Performance, GreenStar, Parker and Zingoni de Baro 2019	temperature, reflectivity, conductivity, capacity
Moisture	NABERS, WELL, GreenStar	%RH, moisture mapping
Air Movement	NABERS	m/s, direction
Air Quality	NABERS, Fitwel, WELL, SITES, Landscape Performance, GreenStar, Parker and Zingoni de Baro, 2019	PM10, PM2.5, CO2, ozone, NOx and Sox odour pleasantness ranking?
Light Exposure	NABERS, Fitwel, WELL, GreenStar	lux, sDA, illuminance, direction
Sound Exposure	NABERS, Fitwel, WELL, Landscape Performance, GreenStar	dBA/dBC, HZ/kHZ, SPL (pascal), direction, sound transmission, sound reduction, noise isolation, weighted difference level and reverberation time.
Spatial Layout	NABERS	GI locations, GI distribution, occupant satisfaction survey, Line of sight (isovist/viewshed), pathway options (axial lines), available space (convex)
View Quality	WELL, Landscape Performance, GreenStar	view type, % line of site, Eye tracking, distance/clarity, occupant satisfaction Likert and isovist parameters
Shelter Provided	Fitwel, WELL Community	sq m, % area, density/opacity/permeability, orientation/angle
Soil Quality	MTLIP, SITES, Landscape Performance, USDA/USFS, Morgenroth et al. 2013, Buzzard et al. 2021	volume, %area, pH, % composition (nutrients/contaminants), organic matter, microbial biomass/species diversity, infiltration/hydraulic conductivity, moisture/water content/capacity/retention coefficient (water content thresholds), structural stability/erosion rate, compaction, nutrient loss, bulk density, electrical conductivity, Gibbs free energy, Shannon diversity

Indicator Type	Sources	Measures or Methods
Water Movement	MTLIP, Fitwel, WELL Community, SITES, Landscape Performance, GreenStar, Longobardi et al. 2019, Parker and Zingoni de Baro 2019	catchment area, storage volume, transfer rate/conveyance capacity, hydraulic conductivity, retention/infiltration (volume/%), evaporation, storm/flood event % capacity, loss/leaks, water body level, underground water table, recharge zone area, peak outlet discharge, permeable surface area/%
Water Quality	MTLIP, Fitwel, WELL & WELL Community, Landscape Performance	mg/L (nutrients/minerals, contaminants), turbidity, pH, microbes (coliforms, Legionella), temperature
Water Efficiency	SITES, Landscape Performance, GreenStar	consumption reduction, potable vs non-potable %, cost savings (operations/usage, maintenance/repairs, stormwater/flood damage?), water feature investment vs return
Energy Efficiency	SITES, Landscape Performance, GreenStar	consumption reduction, renewable vs non-renewable, cost savings (operations/usage, maintenance/repairs, failure impacts), energy feature investment vs return
Vegetation Health	MTLIP, PestID, USDA/USFS	crown/leaves/stem/trunk/root condition, leaf area index, nutritional disorders, pest/diseases, injuries/mortality, abundance, structure, debris, lichens, carbon content/sequestered, drought tolerance, inundation tolerance, thermal tolerance, sun/shade tolerance, fertilizer/pesticide reliance
Habitat Quality	MTLIP, Landscape Performance, Parker and Zingoni de Baro 2019	area (protected/created/restored), biodiversity richness, habitat links or continuous habitat, species appropriateness (native or non-invasive), biomass balance (debris), pesticide or fertilizer usage, irrigation usage, pollinator species (abundance and diversity)
Site Quality	Fitwel, WELL Community, SITES, Landscape Performance,	site visitation, size, accessibility (public/private, staff only, universal design), activity options (physical/social), seating/space availability/flexibility (mobile, groups, privacy), # amenities/features (lighting, shelter), % greenery/soft landscaping, occupant satisfaction Likert, sensory experience (smell, sound, touch)
Path Quality	Fitwel, WELL & WELL Community, SITES, Landscape Performance,	transit frequency, accessibility, walkability indices, destination points, amenity locations/usage, waymark distribution, waymark clarity/visibility, transit corrections, transit satisfaction Likert
Program Quality	Fitwel	# of participants, participant satisfaction Likert, participant health outcomes, new knowledge learned/retention, new behaviours
Food	Fitwel, WELL & WELL Community, SITES, Landscape Performance, Parker and Zingoni de Baro 2019	food produced (# of meals, weight), area of food production, nutritional content, diner satisfaction surveys

Indicator Type	Sources	Measures or Methods
Human Health	Fitwel, WELL, SITES, Landscape Performance, Ulrich, Kaplan, Berman, Dahlkvist et al. 2016, Dzhambov et al. 2020, Parker and Zingoni de Baro 2019	psychophysiological stress sensors, directed attention or fatigue sensors and cognitive performance tests, neurological sensors or imaging, self-perceived health surveys, emotional state surveys, anxiety or depression symptom surveys, salivary and cortisol tests
Asset Accounting	CLIP, SITES, USDA/ USFS	Mapping, inventories, metering, sensors