NATURE

DESIGN GUIDE

A practical, industry-led resource created to help shape a Country-centred approach to nature-based design in the built environment.

October 2025

> Country is not just the land.
> It's the sky, the water,
> the trees, the animals, and us.
> We are all part of it.

— Uncle Max Dulumunmun Harrison, Yuin Elder

ACKNOWLEDGEMENT OF COUNTRY

The Nature Design Guide collaboration group acknowledge the Traditional Owners of Country throughout Australia and their continuing connection to land, sea and community.
We pay our respects to them and their cultures, and to their Elders both past and present.

Creek Restoration at Bur'uda (Hanlon Park), Coorparoo, Brisbane

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Helping you understand why this matters and how to use this guide

FOREWORD

The places we design and build today shape the future of our communities, our environment and our shared connection to Country. Across the built environment industry, there is growing recognition that we must do more than minimise harm—we must actively protect, regenerate, restore and respect the natural world and the cultural landscapes that sustain us all.

This requires a shift in mindset: from a solely human-centred view of development to one that is Country and Nature-centred—of which people are a part.

This Nature Design Guide has been created to support that shift. It offers practical, actionable nature-based solutions to help project teams, clients and partners embed Nature outcomes and benefits at the heart of design. It also details design considerations to support projects in addressing the challenges we face—and shows how, through collaboration and innovation, these can be overcome.

Crucially, this guide reflects the voices and insights of industry experts, researchers, designers and practitioners. Together, we have explored what it means to design with Country and Nature in mind—and how we can leave a positive legacy for generations to come.

This is not just a guide—it is an invitation to lead. To challenge old ways of thinking. To see Country and Nature as partners in design, not constraints. And to create places that support thriving ecosystems, healthy communities and enduring cultural connections.

The task ahead is pivotal—but rich with possibility. Together, we can shape a built environment that restores, rather than depletes—one that respects the deep wisdom of Country and the vital importance of Nature.

Barangaroo Reserve 2022. Image courtesy of SESL

On behalf of the Nature Design Guide collaboration group.

Abigail Heywood NATURE & CLIMATE · AECOM · ARCADIS · Curtin University · FRANCISII ECOLOGY · Fytogreen · Global GreenTag International · H&L · HOLLOW LOG HOMES · lendlease · LIVING FUTURE INSTITUTE AUSTRALIA · LIVING SEAWALLS · Mansfield ADVISORY · MOTT MACDONALD · OCULUS

ABOUT THIS GUIDE

PURPOSE

The world is experiencing an accelerating loss of biodiversity due to human activity, with nearly one million plant and animal species at the point of extinction[1]. The call for stronger nature outcomes is gaining momentum across the built environment. What was once considered a 'nice to have' is quickly becoming a core expectation—from investors, clients, communities and regulators alike.

As Australians and Australian built environment professionals we have a responsibility to listen, learn and walk alongside First Nations peoples to ensure our actions support the ongoing connection to their land, waters, cultures, languages and traditions.

To create places that respect and regenerate nature, we must start with Country, be led by First Nations voices and knowledge in First Nations place-making[2] to benefit both Country and community. At the Australian Institute of Landscape Architecture Festival of Landscape Architecture - Country, Aunty Kerry invited designers to develop a Country Vision Statement.

This guide can be seen as an individual and practice commitment that sets a vision for improving the health of Country without placing a heavy cultural load on, or relying solely on engagement with Traditional Owners or Indigenous Knowledge Holders.

The *Nature Design Guide* is a collaborative industry initiative created to turn ambition into action. The guide compliments and builds on existing industry resources and publications relating to Country and Nature. It provides practical steps to help project teams embed cultural heritage and nature-positive[3] outcomes into the design process. It outlines a process to determine opportunities to benefit Country and Nature and identifies nature-based design elements that deliver those opportunities.

Recognising the real-world challenges of delivery, the guide also offers examples and proven solutions—demonstrating that positive change is not only possible, but achievable.

Images courtesy of David Francis

1. Intergovernmental Panel of Biodiversity and Ecosystem Services [IPBES], 2019, Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, **Read more**

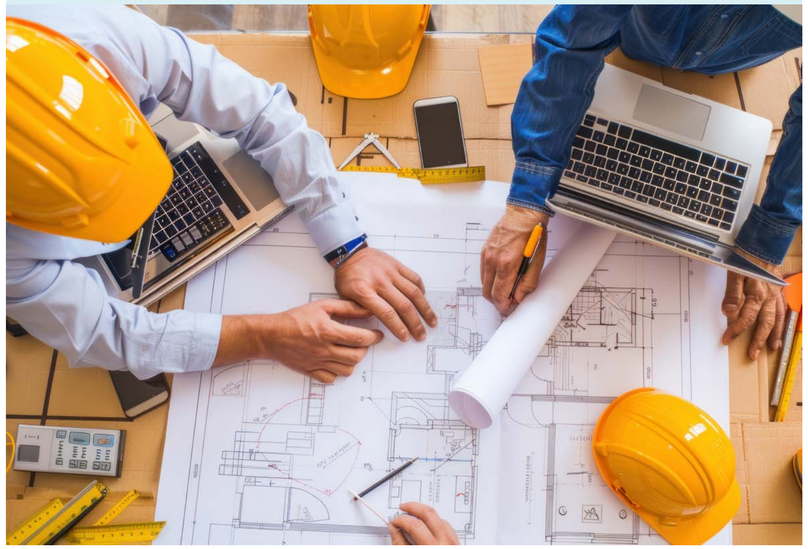
2. For more information on Country Centred Design and First Nations Place-making concepts, please see NSW Government, Government Architect New South Wales (2023), Connecting with Country **Read more**

3. **Nature Positive** is a global societal goal defined as 'halt and reverse nature loss by 2030 on a 2020 baseline and achieve full recovery by 2050', in line with the mission of the Kunming-Montreal Global Biodiversity Framework. What is nature positive? To put this more simply, it means ensuring more nature in the world in 2030 than in 2020 and continued recovery after that. Nature Positive Initiative **Read more**

AUDIENCE

This guide is intended for anyone involved in shaping the built environment, including:

- Design teams and architects.
- Project and development managers.
- Clients and investors.
- Sustainability and environment professionals.
- Contractors, suppliers and delivery partners.



SCOPE

- Applicable to both building and precinct-scale projects.
- Includes external nature-based design elements.
- Excludes nature-based design elements within buildings.
- Excludes materials and supply chain impacts at this stage.
- Excludes whole of project community engagement and participation.

Image courtesy of David Francis

WHAT YOU'LL FIND INSIDE

This guide includes:

- **Key concepts** for Designing with Country and the four nature realms: Land, Water, Atmosphere and Biodiversity.
- **Nature-based design elements** that bring these concepts to life—what they are, how they work, the benefits they deliver and considerations during design.
- **Case studies** showcasing real-world examples and measurable benefits achieved through nature-positive design.
- **Implementation guidance** to help project teams understand when and how to integrate cultural heritage and nature-based solutions from the earliest stages.
- **Visual examples** of "What Good Looks Like," across different project types and contexts.
- **A decision-making tool** to help project teams assess opportunities, design considerations and make informed choices for better Country and Nature outcomes.

Note: This is a living document. As knowledge evolves, legislation changes and new solutions emerge, the guide will be regularly updated to reflect the latest thinking and best practice.

BUSINESS DRIVERS

Image courtesy of Hollow Log Homes

The built environment needs to play a critical role in restoring and respecting Country and Nature. As community expectations rise, investor scrutiny intensifies and biodiversity continues to decline, the need for tangible, nature-positive design solutions has never been greater.

This guide responds to that challenge—equipping project teams to understand and act on the key drivers shaping the future of design.

KEY DRIVERS:

DRIVER 1

Community Expectations

- Heightened public awareness of biodiversity loss and environmental degradation.
- Growing expectation that developments will deliver health, wellbeing and environmental benefits.
- Strong consumer drive toward sustainable and ethically designed / built products.

DRIVER 2

Market and Investor Forces

- Increasing client requirements and nature-positive tender criteria.
- Rising investor expectations for biodiversity and nature-positive outcomes.
- Growing demand for transparency through nature-related financial disclosures:
  i. Taskforce on Nature-related Financial Disclosures (TNFD).
  ii. Australian Sustainability Reporting Standards (ASRS).

DRIVER 3

Industry Leadership

- Living Building Challenge embeds nature ambition.
- Green Building Council of Australia leading the development of a Nature Roadmap.
- Green Star sustainability rating tools raising ambitions for nature outcomes.
- Green Factor Tools (Brisbane and Melbourne).

DRIVER 4

Policy and Regulatory Shifts

- Federal Government's *Nature Positive Plan*.
- Emerging "Green Factor Tools" in planning frameworks (Melbourne and Brisbane).
- Local government strategy and policy (e.g. green grids in cities).

DRIVER 5

Country and Cultural Connection

- Increasing recognition of the need for Country Centred Design and First Nations place-making in design.
- *Connecting with Country Framework* (Government Architect NSW, 2023).
- *Dhawura Ngilan Vision* (2020) and *Guide for Businesses and Investors* (2023).

WHAT IS COUNTRY?

“Country is all living things. Country is multidimensional - it consists of people, animals, plants, Dreamings; underground, earth, soils, minerals and waters, surface water and air. Country is all seasons and cycles. Country is all things in the sky and the universe. Country is a living entity with a yesterday, today and tomorrow, with a consciousness and a will toward life.”[1]

In this guide we understand Country’s relationship nature through the lens of Cultural Heritage, Caring for Country and self-determination. We must always start with Country by engaging and building relationships with community enabling their voice as agents for the landscapes, places and stories. Acknowledging and protecting the heritage vested within the landscape and the languages which continue to whisper through time.

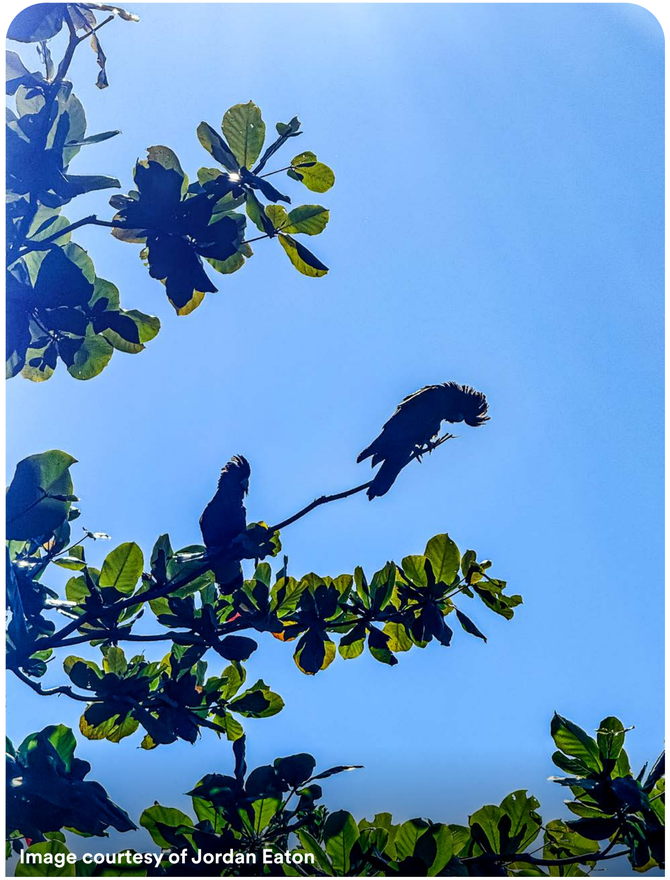


Image courtesy of Jordan Eaton

WHAT IS NATURE?

Nature, in this guide, refers to the ecosystems and life-supporting processes within and around the built environment—of which people are a part and from which they benefit.

“The natural world, with an emphasis on the diversity of living organisms (including people) and their interactions among themselves and with their environment.”[2] Nature includes the realms of land, water, biodiversity, atmosphere and people.

Nature is not separate from us nor a backdrop to development. It is a dynamic, interdependent system that sustains all life. In cities and towns, nature can exist in many forms – waterways, green spaces, street trees, green roofs, habitats and more.

Nature is also the stock of natural resources (e.g. plants, animals, air, water, soils, land) that combine to create co-benefits for people such as improving air and water quality, sequestering carbon, providing materials as well as supporting mental and physical health. These translate into value for society.

Designing with Nature means growing the capacity of its ecosystems and restoring its presence in our urban environments. Doing so is win-win – more nature in the built environment means enhancing the long-term resilience of our communities to the impacts of a changing climate as well as prioritising health and wellbeing for people.

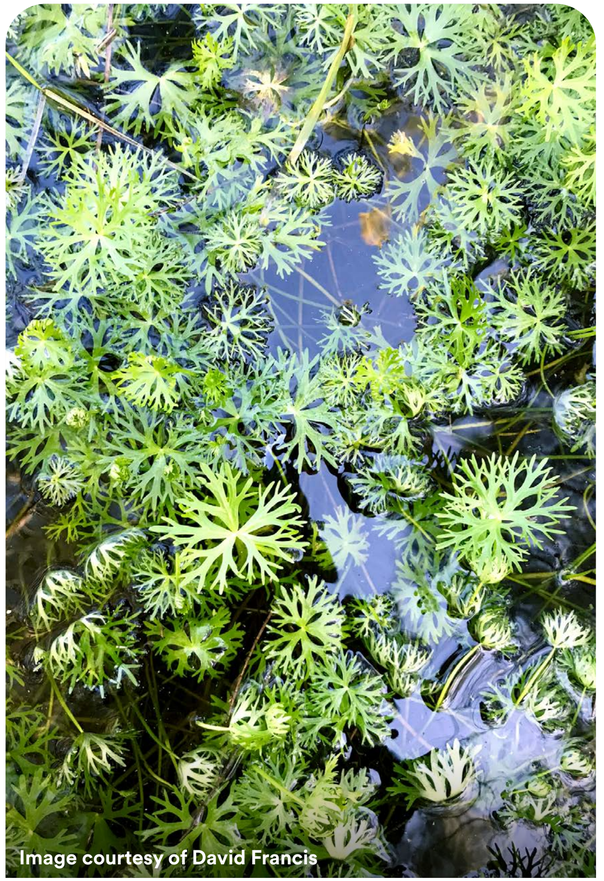


Image courtesy of David Francis

1. Mick Dodson, Yawuru man and legal scholar

2. Adapted from Díaz, S et al. (2015) The IPBES Conceptual Framework – Connecting Nature and People

Embedding Country and Nature from the start

BEFORE DESIGN: EMBEDDING COUNTRY AND NATURE FROM THE START

Image courtesy of David Francis

To increase Country and Nature outcomes on projects, the following process should ideally be undertaken as early as possible in the project lifecycle—for example, during due diligence prior to site acquisition or in the master planning phase. Where this has not occurred, the process can still be implemented at any stage of the project.

In practice, this process will be iterative, with projects 'looping' back through the stages to refine Country and Nature objectives and targets throughout the project's duration.

THE FOLLOWING PROCESS OUTLINES:

STAGE 1

Context

Develop a deep understanding of Country and Nature relevant to the project site and its past and present contextual landscape.

STAGE 2

From Context to Understanding

Informed by the Context stage, deepen understanding and consolidate findings.

STAGE 3

From Understanding to Opportunities

Use the information gathered during Context and Understanding stages to envision the site's *future potential* for nature and identify opportunities for nature benefit to inform the Country and Nature Workshop.

STAGE 4

Country and Nature workshop

Determine project - specific opportunities for nature benefit and set Country and Nature objectives and targets.

STAGE 5

Embed Country and Nature objectives and targets into the project brief and project governance.

Refine objectives and targets throughout project duration

Image courtesy of David Francis

Designing with Country and Nature must be undertaken in collaboration with Traditional Owners, stakeholders, community and industry. Engagement should be ongoing and form part of the project's engagement and participation strategy. Please consider involving the following communities, stakeholders and professionals:

- Traditional Owners
- Local community and residents
- Community and environmental groups
- NP Rangers and Caring for Country Rangers
- Owner / investor
- Scientists and technical specialists, including: geologists, ecologists, hydrologists, archaeologists, GIS technicians and environmental scientists
- Planners, urban designers, First Nations designers, architects and landscape architects
- Cultural heritage practitioners
- Engineers
- Property developers
- Property advisers and economists

STAGE 1

CONTEXT

Develop a deep understanding of Country and Nature relevant to the project site and its past and present contextual landscape

1a. Undertake a baseline assessment - biodiversity, land, water, atmosphere and cultural heritage.

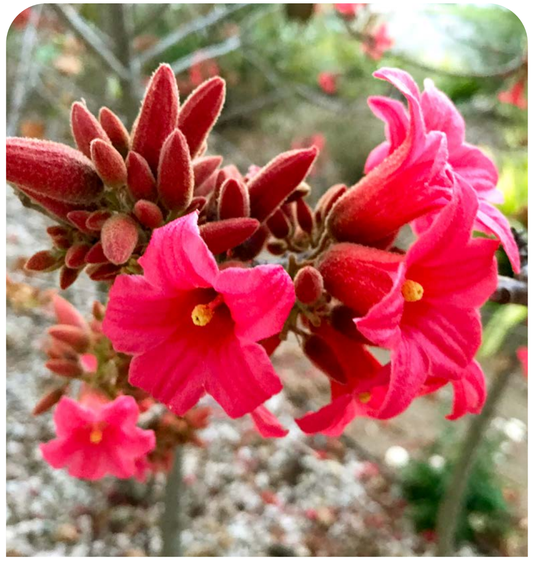
1b. Understand the historical context the site.

Identify current and historical biodiversity, species and habitats; land topography and natural landforms; geology and soil properties; hydrology; air quality and noise baselines; and tangible and intangible cultural heritage. This may involve:

- Engaging early with local stakeholders, First Nations communities, local residents and environmental groups.
- Reviewing local, state and federal strategic plans and legal frameworks (e.g. biodiversity conservation plans, blue/green grid strategies, urban greening plans, local council planning overlays, Caring for Country plans, nature conservation and cultural heritage legislation).
- Undertaking a climate risk assessment to identify climate risks.
- Using available data sources, including but not limited to government databases, open-source platforms (e.g. Atlas of Living Australia), other ecological databases (e.g. EcoSmart Database), Local Environmental Records Centres, scientific publications, historic images and local museums.
- Conducting targeted, site-based surveys by specialists to record what is present on site and in surrounding areas (e.g. First Nations cultural heritage practitioners, geologists, ecologists, hydrologists, archaeologists).
- Performing spatial analysis to understand:
  - Connectivity potential between the site and surrounding landscape.
  - The interconnectedness of biodiversity, water, land and atmosphere on site and their interactions with the surrounding landscape.

1c. Understand nature in the context of Country.

- Engage Traditional Owners, local First Nations communities and subject matter experts to understand the site's cultural significance within the broader cultural landscape, the community's vision for Country and past, present or future Caring for Country practices.
- Enable self-determination and cultural decision-making processes throughout the project, including during engagement and consultation.
- Undertake First Nations-led Cultural Heritage Assessments and Cultural Mapping of Country in collaboration with Traditional Owners and First Nations cultural heritage practitioners.



Images courtesy of David Francis

STAGE 2

FROM CONTEXT TO UNDERSTANDING

Informed by the Context stage, deepen understanding and consolidate findings

Biodiversity

Identify:

- Historical and currently present habitat and species
- Habitats and species that are notable and/or culturally significant
- Local/State/Federal protected areas, habitats or species
- Targets and/or objectives set by local strategic plans
- Site issues (e.g. threats to habitat or species)

Land

Identify:

- Historic and current landscape typography and geology
- Cultural heritage connected to landforms, features or land management practices
- Current and historical land uses (e.g. natural habitats, residential buildings, industrial, primary industries)
- Soil condition and pollution
- Site issues (e.g. urban heat island effect (UHI))

Water

Identify:

- Historic and current hydrology, including natural waterways, waterbodies, wetlands, ephemeral water flows and coastal habitats
- Cultural Heritage connected to waterways, waterbodies or wetlands
- Current and historical uses (e.g. drinking water, maritime, primary industries, energy generation such as hydro)
- Water quality and ecological condition of waterways, waterbodies or wetlands
- Site issues (e.g. stormwater or river flooding; threats to water from human activities such as pollution or over abstraction)

Atmosphere

Identify:

- Current air quality
- Noise and light pollution sources

STAGE 3

FROM UNDERSTANDING TO OPPORTUNITIES

Use the information gathered during the Context and Understanding stages to envision the site's *future potential* for nature and identify opportunities for nature benefit to inform the Country and Nature Workshop.

Biodiversity

Opportunity for nature benefit

- ☐ **Habitat and Species Protection and Restoration** - Habitats and species on site are protected or restored rather than cleared and removed (e.g. coastal, freshwater, or terrestrial habitats)
- ☐ **Habitat Creation (ground)** - Historical or current habitats are created or extended on site (e.g. coastal, freshwater, or terrestrial habitats)
- ☐ **Habitat Creation (Incorporated into Building)** - Historical or current terrestrial habitats are created or extended on site within the built form
- ☐ **Habitat Connection** - Existing or new habitats on site are connected into existing habitats in the surrounding urban landscape

Co-benefit

- ☐ Pollination
- ☐ Stormwater management
- ☐ Improve water quality
- ☐ Urban temperature regulation (reduce UHI)
- ☐ Urban greening
- ☐ Carbon sequestration
- ☐ Improve air quality
- ☐ Noise attenuation

Land

Opportunity for nature benefit

- ☐ **Working with landform** – Natural landforms and features on site are retained and incorporated into the design
- ☐ **Land restoration** – Historical landforms are recreated or restored
- ☐ **Soil restoration** - Soil is restored due to poor quality or pollution
- ☐ **Urban greening** - Increase vegetation cover to reduce urban heat island effect
- ☐ **Urban greening (incorporated into building)** - Increase vegetation cover to reduce urban heat island effect
- ☐ **Urban greening (Community Use)** - Provide green spaces, parks and community gardens for food production

Co-benefit

- ☐ Urban temperature regulation (reduce UHI)
- ☐ Nutrient cycling
- ☐ Soil erosion control
- ☐ Soil health
- ☐ Food production
- ☐ Habitat and Species Protection and Restoration
- ☐ Habitat Creation (ground)
- ☐ Habitat Creation (incorporated into building)
- ☐ Habitat Connection
- ☐ Pollination
- ☐ Stormwater management
- ☐ Improve water quality
- ☐ Flood control
- ☐ Water cycling
- ☐ Carbon sequestration
- ☐ Improve air quality
- ☐ Noise attenuation

STAGE 3

Water

Opportunity for nature benefit

- ☐ **Stormwater Management** - Manage stormwater using Water Sensitive Urban Design (WSUD) principles, including nature-based solutions and daylighting of culverts
- ☐ **Stormwater management** – Protect and restore historical water flows and connections to the surrounding landscape
- ☐ **River Restoration** – Protect and restore existing creeks, rivers or wetlands on site
- ☐ **River flooding management** – Reconnect creeks and rivers on site to their natural floodplains
- ☐ **Water harvesting** – Retain rainwater for reuse

Co-benefit

- ☐ Flood control
- ☐ Improve water quality
- ☐ Water cycling (e.g. ground water recharge)
- ☐ Water supply
- ☐ Reduce stormwater thermal pollution
- ☐ Habitat and Species Protection and Restoration
- ☐ Habitat Creation (ground)
- ☐ Habitat Connection
- ☐ Pollination
- ☐ Urban temperature regulation (reduce UHI)
- ☐ Urban greening
- ☐ Nutrient cycling
- ☐ Soil erosion control

Atmosphere

Opportunity for nature benefit

- ☐ **Habitat Creation (ground)** - Increase vegetation cover to improve carbon sequestration, air quality and noise attenuation
- ☐ **Habitat Creation (incorporated into building)** - Integrate vegetation into the built form to improve carbon sequestration, air quality and noise attenuation
- ☐ **Urban greening** - Increase vegetation cover at ground level to improve carbon sequestration, air quality and noise attenuation
- ☐ **Urban greening (incorporated into building)** - Apply greening strategies within or on buildings to improve carbon sequestration, air quality and noise attenuation
- ☐ **Biobased materials** - Use biobased materials for structural or other purposes to support carbon sequestration (e.g. cross-laminated timber, bamboo)

Co-benefit

- ☐ Carbon sequestration
- ☐ Improves air quality
- ☐ Noise attenuation
- ☐ Urban temperature regulation (reduce UHI)
- ☐ Urban greening
- ☐ Stormwater management
- ☐ Improves water quality

Benefits for people

Co-Benefits that people gain from nature to be prioritised

- ☐ Caring for Country practice
- ☐ Connection to Country and Nature
- ☐ Nature stewardship
- ☐ Recreation (e.g. walking cycling, swimming, fishing)
- ☐ Community cohesion
- ☐ Urban aesthetic values
- ☐ Increase in property values
- ☐ Education and research
- ☐ Physical health
- ☐ Mental wellbeing

Image courtesy of Abigail Heywood

STAGE 4

COUNTRY AND NATURE WORKSHOP

Determine project specific opportunities for nature benefit and set Country and Nature objectives and targets

Using information from Context, Understanding and Opportunities stages:

- Confirm project-specific opportunities for nature benefit and co-benefits to be explored further by the project.
- Set clear, place-based Country and Nature objectives and targets related to identified opportunities and co-benefits.
- Explore opportunities for co-design with First Nations representatives.
- These objectives and targets should shape early design concepts, guide decisions throughout project planning and delivery and define measures of success for each objective.
- Ensure multidisciplinary involvement.

Urban Wetland Project. Image courtesy of Holly Kirk

STAGE 5

EMBED COUNTRY AND NATURE OBJECTIVES AND TARGETS INTO THE PROJECT BRIEF AND PROJECT GOVERNANCE

- Use the Country and Nature ‘tool’ or Part 6 of this Design Guide to identify a shortlist of nature-based design elements—based on the opportunities for nature benefit and co-benefits identified in the Country and Nature Workshop—to be explored further during design development and project delivery.
- Embed the Country and Nature objectives, targets and shortlisted nature-based design elements into the Project Brief and Project Governance.
- Embed monitoring and review processes to track progress towards the Country and Nature objectives and targets.

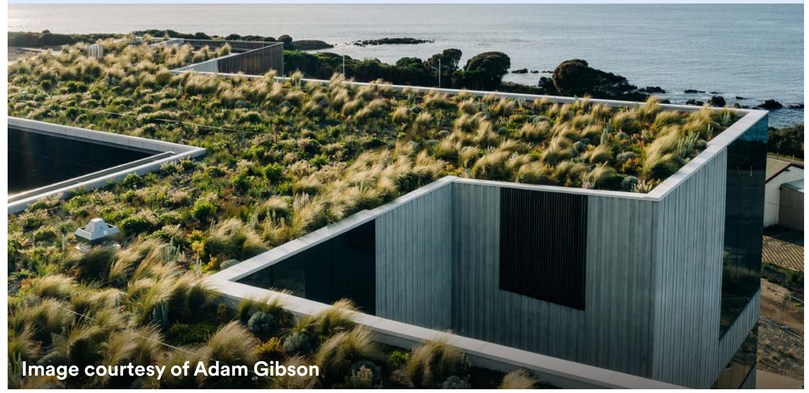


Image courtesy of Adam Gibson

03 COUNTRY:

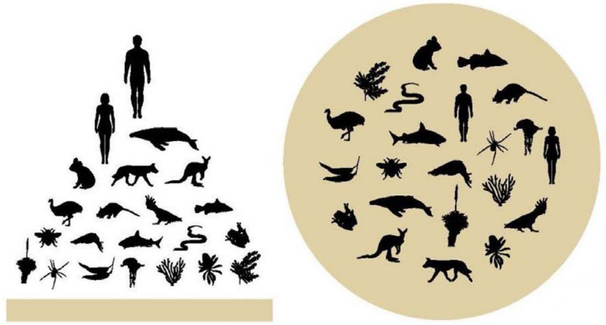
Designing with Country

COUNTRY

ASPIRATION

That our built environments respect and celebrate Country, while acknowledging truths and histories.

Image courtesy of David Francis



WHAT IS DESIGNING WITH COUNTRY - AND WHY DOES IT MATTER?

Over the past few centuries, the establishment of modern Australia has pursued progress with little regard for what has been left in its wake. Our cities have been designed and built through Western perspectives that privilege progress over authentic connection to place. This has created a built environment vernacular void of Country and Nature—one that has ignored prior occupation and the world's oldest living culture. Country has been silenced, and nature is often valued in our minds but not on the balance sheet.

In this power imbalance, we must seek intersections between the old and the new, allowing nature to flourish and Country to be revealed.

Designing with Country means foregrounding culture, knowledge and relationships with land, water, sky and all living things in the design of built environments. It represents a fundamental shift in how we conceive and create places. It ensures that First Nations voices, ecological resilience, cultural practice and ethical urban development shape a more just and connected future.

This approach recognises that places hold memory—there is no blank slate. There are 65,000 years of occupation, adaptation and tradition. The role of designers is to reveal and remember Country, led by First Nations voices and guided by the principle of self-determination. We must move from a mindset that sees Country and Nature as resources, to one that sees them as foundations for human and planetary health.

To design with Country is to engage respectfully with Traditional Custodians, understand the deep cultural and spiritual significance of place, and embed First Nations perspectives and values at every stage of the design process.

This is not a checklist. It is a mindset—a practice of listening, learning, and acting with care. It is about connection, regeneration, cultural expression and ongoing Custodianship.

NSWGA Connecting with Country Framework 2023, Figure 6: Human-centred or Country-centred Diagram adapted from German architect Steffen Lehmann's 'Eco v Ego' diagram, 2010

STARTING WITH COUNTRY

Projects must adopt a Country-centred approach, beginning with a deep understanding of place through cultural heritage, Traditional Owner knowledge and community engagement.

- **Identify:** Determine whose Country the project is on. This is the first step to preparing respectfully for engagement and safeguarding cultural heritage.
- **Engagement:** Seek guidance from Traditional Owners and knowledge holders to understand the cultural significance of the site's biodiversity, land, water and atmosphere.
- **Cultural Heritage:** Develop a First Nations-led understanding of both the traditional and contemporary cultural heritage of the site.
- **Deep Listening:** Undertake place-based, on-Country learning led by Traditional Owners and community representatives.
- **Practice:** Explore traditional and contemporary cultural practices, such as land management and climate adaptation, that can strengthen site resilience.
- **Context:** Understand the wider Country context, including hydrology, geology and ecology. Consider regional systems such as water catchments and fragmented vegetation corridors that need to be reconnected.

Not adopting this approach can result in:

- Excluding First Nations voices, leading to designs that are disconnected from Country's needs, cultural heritage, ecological balance and community aspirations.
- Tokenistic consultation instead of meaningful engagement with Traditional Owners.
- Habitat loss and biodiversity fragmentation.
- Mismanagement of ecological and water systems.
- Ongoing destruction of cultural heritage sites, degrading Country and erasing culture.
- A lack of climate-responsive design, creating unsustainable and uninhabitable precincts over time.

SUPPORTING NATURE AND LIVING SYSTEMS

In Country-centred and community-informed projects, nature-based design outcomes should express Country across Biodiversity, Land, Water and Atmosphere.

Biodiversity

- **Ecosystems:** Restore ecosystem health and connect with regional ecological systems.
- **Endemic and habitat specific planting:** Use native and endemic vegetation suited to local fauna, and incorporate multi-layered plant structures (canopy, mid-storey, ground cover) to support diverse species needs.
- **Connections:** Establish green networks with continuous and connected habitat for flora and fauna across urban environments.
- **Habitat analogues:** Support species that rely on structural habitat by integrating nest boxes, hollow logs, and ground shelters.
- **Protect:** Retain existing native trees and rock formations. Avoid unnecessary disturbance, especially to habitat sites or remnant endemic vegetation.
- **Microclimates:** Design microhabitats using shade trees, windbreaks and moisture-retaining zones to support heat- and drought-sensitive fauna.

Water

- **Source and catchments:** Understand site-specific water sources, flow and absorption. Acknowledge and maintain regional hydrological systems—from aquifers to rainfall, rivers to oceans.
- **Restore:** Reinstate natural water flows to support aquatic ecosystems, including wetlands, riparian zones and ephemeral water bodies.
- **Extend:** Integrate natural aquatic ecosystems into the urban fabric.
- **Recognise:** Treat water as a living entity—worthy of stewardship and vital to cultural practice.

Land

- **Cultural Landscape:** Restore cultural landscapes using appropriate species, revive waterways and apply land management practices that enhance biodiversity.
- **Protecting:** Celebrate and protect cultural heritage through vision, design, art and interpretive elements that express contemporary stories of Country.
- **Topography:** Minimise bulk earthworks. Retain natural landforms, watercourses, and significant geological features.
- **Materiality and resources:** Use local materials that respect cultural significance, traditional uses and circularity, supporting both historic and contemporary cultural practice.
- **Seasons:** Design in harmony with seasonal change, exploring the relationships between climate, plants, animals and culture to reflect the seasonal calendar of Country.

Atmosphere

- **Restore clean air:** Use plants to filter and improve air quality.
- **Restore a safe climate:** Incorporate biobased materials and vegetation that sequester carbon.
- **Sky connections:** Preserve sightlines to the night sky, recognising its cultural and spiritual significance. Reduce light pollution and frame views to the sky where possible.

CARING FOR COUNTRY AND MAINTENANCE

- **Practices:** Embed Caring for Country practices—such as cultural land management techniques—into the design, delivery and ongoing operation of places.
- **Access:** Enable appropriate access for Traditional Owners to continue cultural practices and Caring for Country activities.
- **Culture:** Support Country-led ways of recording the health of Nature through art, song, and storytelling—fostering community involvement and intergenerational knowledge sharing.
- **Old x New:** Create intersections between traditional knowledge and Western science, encouraging collaborative research between knowledge holders and scientists.

RESEARCH AND MEASUREMENT

- **Time:** Identifying an appropriate baseline is critical when measuring and monitoring Country and Nature. Contemporary benchmarks must not overlook the deep time of Country and ongoing cultural memory.
- **Documentation:** Use cultural landscape audits to document seasonal change, habitat health and climate impacts over time.
- **Alternative methods:** Embrace methods of recording and sharing knowledge through art, song, storytelling and ceremony. These practices support intergenerational knowledge-sharing and embed community participation into the stewardship of Country.
- **Collaborative research:** Foster partnerships with Indigenous scientists, Elders and community researchers to generate shared knowledge and support culturally appropriate monitoring frameworks. Intergenerational involvement ensures cultural continuity and strengthens long-term environmental care.

Image courtesy of David Francis

Traditional Owners led walk on Country. Image courtesy of Jordan Eaton

04 NATURE REALMS:

Concepts, design elements and case studies

NATURE REALMS: CONCEPTS, DESIGN ELEMENTS AND CASE STUDIES

Topics covered in this section include: nature, climate change, nature-based solutions, benefits and co-benefits, design considerations, Biophilia and sustainability rating tools.

WHAT IS NATURE?

In this guide, *nature* refers to the ecosystems and life-supporting processes that exist within and around our built environment—of which people are a part and benefit from.

Nature is the natural world, with an emphasis on the diversity of living organisms (including people) and their interactions with each other and with their environment[1]. It encompasses the realms of land, water, biodiversity, atmosphere and people.

Nature is not separate from us, nor is it simply a backdrop to development. It is a dynamic, interdependent system that sustains all life. In cities and towns, nature can take many forms: waterways, green spaces, street trees, green roofs, habitats and more.

Note: It is recommended to read this section in conjunction with Part 6 of this guide, which provides guidance to help projects identify a shortlist of nature-based design elements. These shortlisted design elements can then be explored further during design development and project delivery.

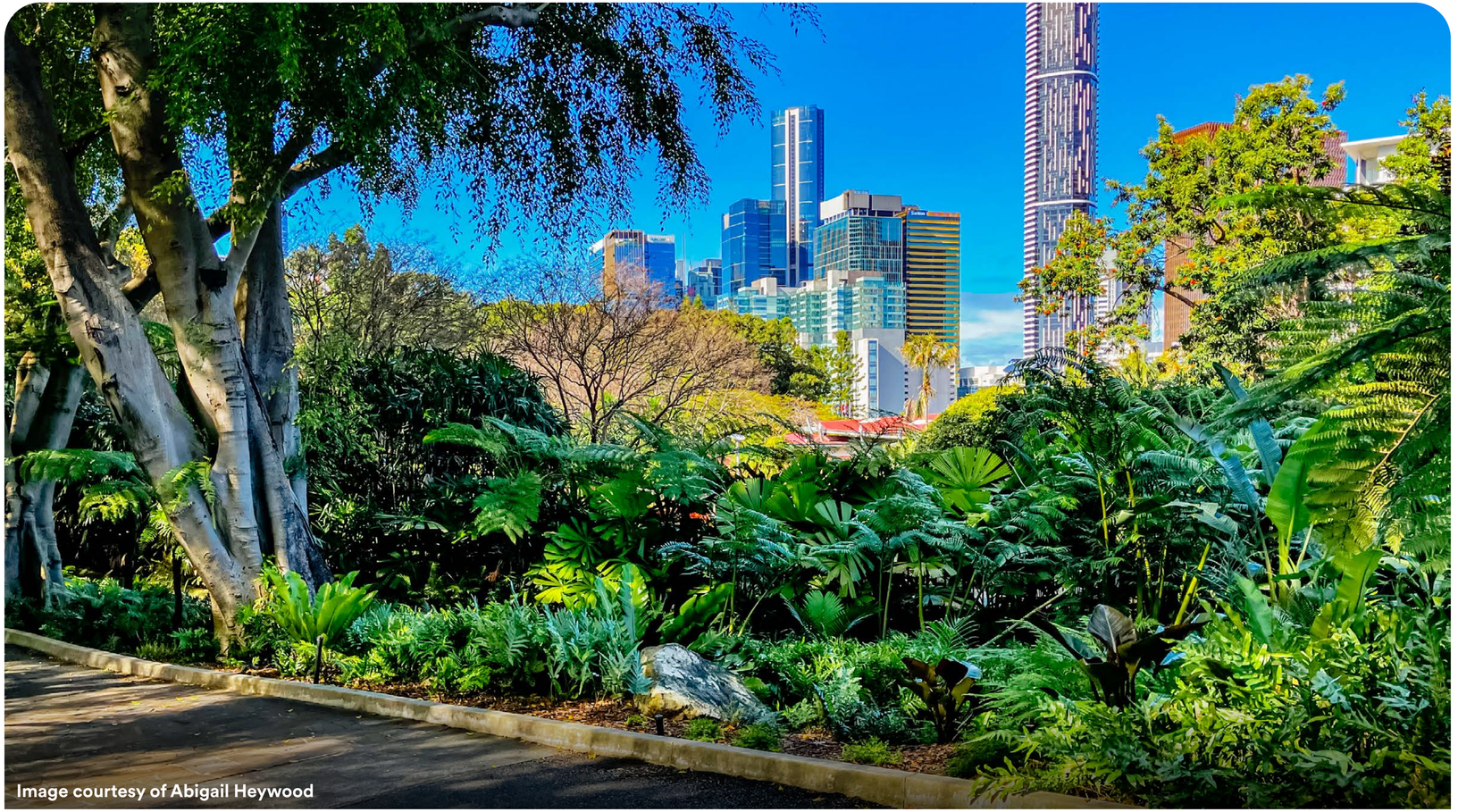


Image courtesy of Abigail Heywood

1. Adapted from Díaz, S et al. (2015) The IPBES Conceptual Framework – Connecting Nature and People

URBANISATION IS A SIGNIFICANT THREAT TO NATURE

Urbanisation and the ongoing development of our built environment significantly impact nature. These impacts include:

- **Loss of biodiversity:** As natural habitats are cleared, fragmented or severed by roads, buildings and infrastructure, ecosystems are disrupted and species lose access to the resources they need to survive.
- **Disruption of natural landforms:** Landforms that support ecological processes, provide vital habitat, regulate climate and play a critical role in the water cycle are often cleared, flattened or sealed with hard surfaces. This degrades soil health, alters water flows, amplifies urban heat and weakens climate resilience.
- **Disturbance to hydrology:** Urban development commonly alters natural hydrological processes. Hard surfaces increase runoff, degrade water quality and elevate flood risk.
- **Climate and environmental degradation:** The buildings and construction sector is a major contributor to global carbon emissions, driving climate change and creating intergenerational injustice. Our cities also pollute the air we breathe and produce excessive noise and poor acoustics—impacting human health, comfort and productivity.
- **Light pollution:** The built environment alters the light landscape—casting shade during the day and introducing artificial light at night. Both can negatively affect biodiversity.

NATURE POSITIVE

Nature positive is a global goal defined as: **"Halt and reverse nature loss by 2030 (against a 2020 baseline) and achieve full recovery by 2050."**[2]

Put simply, this means ensuring there is more nature in the world in 2030 than in 2020, with continued recovery beyond that.

In the built environment, a nature-positive approach doesn't just benefit ecosystems—it actively supports decarbonisation. A nature-positive built environment contributes to climate resilience, enhances liveability and ensures long-term value for both people and planet.

CLIMATE CHANGE

Urbanisation both contributes to—and is increasingly impacted by—climate change.

Urban areas contribute to climate change through:

- High energy consumption in buildings and transport
- Embodied carbon in construction materials
- Emissions from landfill and construction waste

At the same time, the built environment is highly vulnerable to climate change impacts. These include:

- Extreme heat, intensified by the urban heat island effect
- Increased frequency and severity of urban and river flooding
- Rising sea levels
- More frequent and intense cyclones, storms and bushfires

These challenges make it critical to design cities, towns and precincts that are prepared for projected climate impacts.

CLIMATE RESILIENCE

To make our cities and towns safer, more liveable places in the face of climate change, we must prioritise climate resilience in the built environment.

Climate resilience refers to the capacity of buildings, infrastructure and urban systems to anticipate, absorb, accommodate and recover from hazardous climate events in a timely and efficient manner—while maintaining essential functions, structure and identity[3].

This means planning and designing for:

- Increased rainfall intensity (requiring robust overflow and drainage capacity)
- Prolonged droughts (requiring drought-tolerant vegetation and/or supplementary irrigation)
- Urban heat (requiring increased vegetation, shaded areas and light coloured materials)
- Flood risk (requiring permeable surfaces, natural drainage corridors and water-retaining landscapes)

Embedding resilience strategies early in the design process helps safeguard communities, reduce long-term maintenance and recovery costs and support sustainable development goals.


Image courtesy of Fytogreen

2. Nature Positive Initiative https://www.naturepositive.org/

3. World Green Building Council 2023, https://worldgbc.org/article/climate-change-resilience-in-the-built-environment-guide/

NATURE-BASED SOLUTIONS: THE NEXUS OF NATURE POSITIVE AND CLIMATE RESILIENCE

By embracing a nature-positive approach, we don't just conserve nature—we also unlock vital climate resilience outcomes and enhance nature's contributions to people and place.

Nature-based solutions (NbS) are defined by the UN as:

"Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits." (UNEA, 2022)

In the built environment, nature-based solutions may include (but are not limited to):

- Water-sensitive urban design (WSUD) that uses vegetation to manage runoff and reduce water pollution
- Green infrastructure, such as green roofs and walls
- Habitat restoration and installation of habitat analogues (e.g. nest boxes, invertebrate hotels)
- Urban greening with trees and vegetation to cool streets, sequester carbon and improve air quality

These strategies offer multiple, interconnected benefits—supporting biodiversity, reducing emissions, building climate resilience and improving human health and wellbeing.

> **We can never re-create what has gone before, but we can continue the story and encourage nature itself to create the future.**
>
> — Isabella Tree, Wilding

NATURE-BASED DESIGN ELEMENTS IN THE BUILT ENVIRONMENT

Nature-based solutions in this guide are referred to as **nature-based design elements**—specific, actionable interventions that can be incorporated into the design of buildings and precincts to support nature, people and place.

These elements span across the four interconnected **nature realms: Biodiversity, Land, Water, Atmosphere**

While the realms are inherently linked on the ground, they are grouped in this guide to help categorise and communicate the primary benefit of each design element. It is important to note that most elements deliver benefits across multiple realms.

Design elements detailed in this guide for each nature realm

Biodiversity

- Landscape planting for habitat creation
- Habitat restoration
- Biodiverse green roof
- Biosolar green roof
- External green wall
- Habitat Analogues
- Living Seawalls habitat enhancement modules

Land

- Land formation retention and restoration
- Soil retention and restoration
- Blue / Green streetscape
- Green space
- Community gardens
- Elevated park
- External green façade
- External planter boxes

Water

- River and creek restoration
- Reconnecting river and floodplain
- Bioretention systems
- Swales
- Naturalised basin
- Constructed wetlands
- Rainwater Tanks

Atmosphere

- Mass engineered timber
- Engineered bamboo
- Soundscaping - water feature

This guide provides structured information for each design element, including:

- Description of the design element
- Benefits and co-benefits for nature and people
- Structural/technical diagrams
- Drivers of success and design considerations
- Limitations and practical constraints
- Integration into the project lifecycle
- Applicability at building, precinct or retrofit scale
- Opportunities to combine with other elements
- Links to further reading

THE BENEFITS AND CO-BENEFITS OF NATURE-BASED DESIGN ELEMENTS

> **The first and perhaps biggest challenge to a nature-positive transition is a cultural one: acknowledging the multitude of values of nature and properly accounting for them when we make decisions that can affect nature. The inconvenient truth is that we have always—and are continuing to—take nature for granted.**
>
> — Nature Positive Initiative (2025), Becoming Nature Positive: Transitioning to a Safe and Just Future

Nature-based design elements deliver a wide range of direct benefits to nature and co-benefits for both nature and people in the built environment.

Nature is also referred to as natural capital—the world's stocks of natural assets, including geology, soil, air, water and all living organisms.[4] Enhancing this capital supports the functioning of healthy ecosystems.

DIRECT BENEFITS TO NATURE (NATURAL CAPITAL)

Examples include:

- Increasing biodiversity capital by creating and connecting habitats
- Enhancing land capital by restoring landforms and soils
- Improving atmosphere capital by sequestering carbon and filtering particulates
- Boosting water capital by restoring water cycles, protecting waterways and harvesting stormwater

Because the four nature realms are interconnected, increasing one realm often improves the others. For example:

- Land restoration supports biodiversity, soil health and water infiltration
- Biodiversity improvements enhance carbon sequestration and ecosystem resilience
- River restoration improves water quality and habitat connectivity

CO-BENEFITS: ECOSYSTEM SERVICES TO PEOPLE AND NATURE

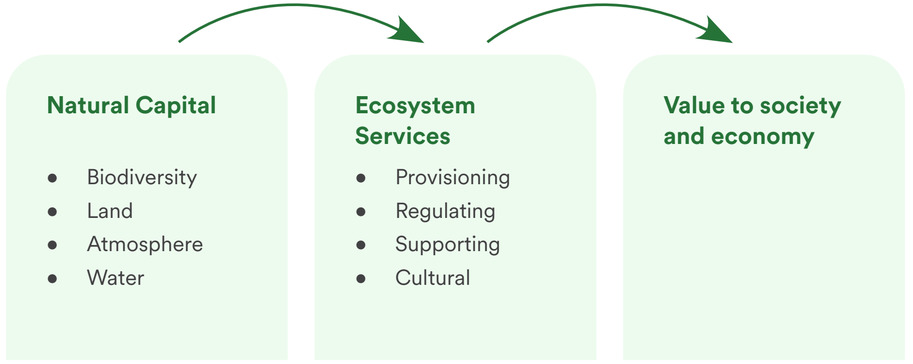
These natural systems also generate wide-ranging benefits for people, often referred to as **ecosystem services**. There are four main types:

- **Provisioning Services:** e.g. water supply, food production
- **Supporting Services:** e.g. nutrient cycling, photosynthesis
- **Regulating Services:** e.g. pollination, carbon sequestration, temperature regulation
- **Cultural Services:** e.g. Connection to Country, recreation, aesthetics

> **Achieving at least a 30% urban greening target in local communities could lower the odds of psychological distress by up to 31%, loneliness by 24% and dementia by 16%, as well as reducing the odds of developing diabetes, heart disease and hypertension.**
>
> — Beyond Blue (2023), Greener Spaces Better Places

Image courtesy of Fytogreen

Relationship between natural capital and ecosystem services, resulting in value to society and economy.



4. Convention on Biological Diversity https://www.cbd.int/business/projects/natcap.shtml

DIRECT BENEFITS: EXAMPLES OF OPPORTUNITIES IN THE BUILT ENVIRONMENT

The following table outlines examples of **direct benefits** that nature-based design elements can deliver for nature and people across the four nature realms:

Examples of opportunities for direct benefits for nature and people in the built environment

Biodiversity

- Habitat creation
- Habitat connection
- Habitat and species protection and Restoration

Land

- Land restoration
- Retaining landforms
- Soil restoration
- Urban greening

Water

- Stormwater management
- River restoration
- Restoration of drainage lines and overland flows
- River flooding management
- Water harvesting

Atmosphere

- Use of biobased materials to sequester carbon
- Carbon emission savings from:
  - renewable energy use
  - reduced energy use of water treatment
  - reduced energy use of building

People

- Financial savings
- Renewable energy
- Energy use savings
- Active transport

CO-BENEFITS: INDIRECT, COMPOUNDING VALUE FOR NATURE AND PEOPLE

This table outlines examples of **co-benefits** delivered by the same interventions—demonstrating how nature-positive design supports broader health, environmental and economic outcomes:

Examples of opportunities for co-benefits for nature and people in the built environment

Biodiversity

- Pollination
- Biodiversity health

Land

- Urban temperature regulation (reduce UHI)
- Nutrient cycling
- Soil erosion control
- Food production
- Space for habitats

Water

- Flood control
- Improves water quality
- Water cycling (e.g. ground water recharge)
- Water supply
- Reduce stormwater thermal pollution

Atmosphere

- Carbon sequestration
- Improves air quality
- Noise attenuation

People

- Caring for Country practice
- Connection to Country and Nature
- Community cohesion
- Nature stewardship
- Recreation (e.g. walking cycling, swimming, fishing)
- Urban aesthetic values
- Increase in property values
- Education and research
- Physical health
- Mental wellbeing

Image courtesy of David Francis

> “Cities are human environments and public engagement is key to successful conservation... Urban design can help facilitate local stewardship of biodiversity by providing “cues to care”..., creating opportunities for positive interactions with nature”[5]

5. https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/conl.12411

COMBINING DESIGN ELEMENTS TO MAXIMISE IMPACT

The benefits and co-benefits of nature-based design elements are significantly amplified when they are combined—rather than applied in isolation. Integrated design supports more complex and connected outcomes across biodiversity, land, water and atmosphere.

By layering and linking elements, projects can:

- Increase ecological connectivity
- Support more diverse species
- Improve water and climate regulation
- Enhance the usability and liveability of a space

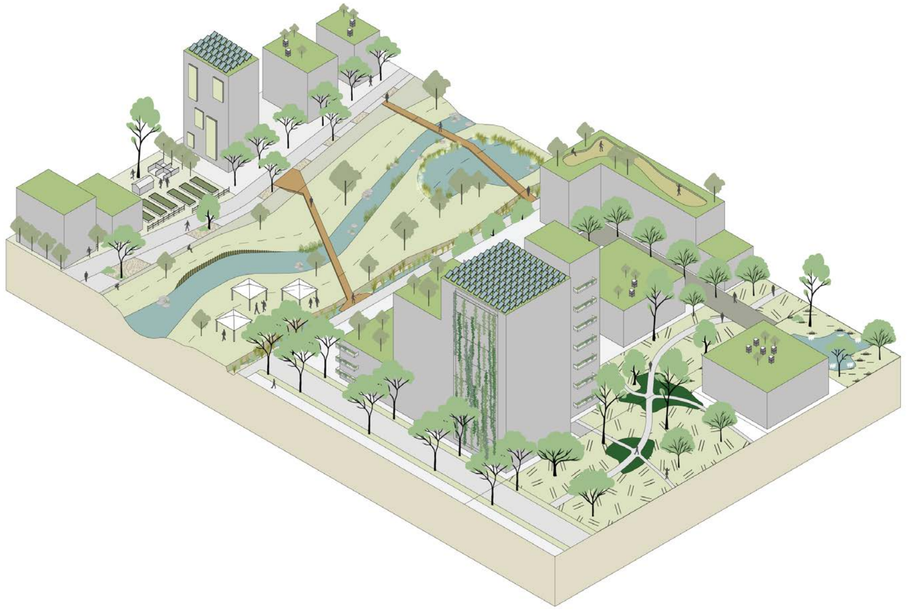
EXAMPLES OF COMPOUNDING DESIGN IMPACT

1. **Vertical biodiversity networks**
   Combining green roofs, green walls and ground-level planting creates a continuous vertical network of habitat—allowing species to move between levels of the built environment and increasing overall ecological value.
2. **Water + vegetation**
   Pairing water features with adjacent planting and shade provides hydration, habitat and shelter—supporting birds, amphibians, insects and small mammals. This also regulates temperature and improves stormwater outcomes.
3. **Land + structure**
   Embedding habitat analogues (e.g. nest boxes, invertebrate hotels, logs) into greenspaces creates species-specific refuges while integrating urban greening into the built environment.
4. **Marine + built infrastructure**
   Combining habitat modules on seawalls with marine plantings like seagrass or kelp beds supports higher trophic species, boosts biodiversity and increases resilience to erosion and tidal forces.

By intentionally designing for **overlap and synergy,** projects can achieve greater value for nature and people—and deliver more resilient, high-performance outcomes.

SINGLE BUILDING EXAMPLE

PRECINCT EXAMPLE



DESIGN CONSIDERATIONS

Successfully integrating nature-based design elements into buildings or precincts requires careful consideration of a range of design factors. These factors influence whether a solution performs as intended—and whether its benefits are sustained over time.

Design considerations may relate to:

- The **nature element** itself (e.g. plant selection, water requirements)
- The **building or site** it is integrated into (e.g. structural capacity, access)
- Or a **combination** of both

Overlooking key considerations can compromise the performance of nature-based elements, limit their impact, or introduce unintended risks.

EXAMPLES OF DESIGN CONSIDERATIONS

- **Element-specific:** For example, a green wall requires careful plant selection. If species are not suited to local conditions, the system may fail to establish or require excessive maintenance.
- **Building-related:** Waterproofing is critical when integrating vegetation into façades or rooftops. Without proper detailing and materials, water ingress can damage structures or reduce occupant comfort.

HIGH IMPACT DESIGN CONSIDERATIONS

Some design considerations carry greater risks or opportunities. These high-impact considerations should be prioritised in early planning and detailed design.

Nature design element specific

Plant selection and ecology: Species must be suited to local conditions, resilient to climate change and ecologically beneficial.

Climate Adaptation & Resilience: Does the design element tolerate future projected climate impacts (e.g. heat, drought, storm intensity)?

Building / precinct specific

Structural capacity: Can the building or infrastructure safely support the weight and loading of the nature element (e.g. saturated green roof)?

Waterproofing: Are suitable systems in place to prevent leaks or water damage?

Access & Maintenance: What level of care is needed over time—and how will this be safely and effectively provided?

Fire Risk: Do materials or planting schemes increase fire hazards? What mitigation strategies are in place?

A thorough understanding of these considerations is essential for delivering **low-risk, high-performance outcomes**—ensuring nature-based elements are both functional and resilient over time.

SOLVING DESIGN CONSIDERATIONS IMPACTS

To effectively manage risks associated with design considerations, solutions must be identified and integrated **early in the design process.**

The first and most critical step is ensuring access to **appropriate expertise**—either through in-house capability or engagement with qualified consultants. A multidisciplinary approach supports informed, site-specific decisions.

Key specialists may include:

- Landscape architects
- Ecologists
- Structural engineers
- Waterproofing consultants
- Fire safety engineers
- Maintenance and asset management advisors

Engaging these experts at the right stage enables:

- Targeted risk mitigation
- Improved cost-efficiency
- Greater alignment between nature, structure and performance

Understanding key design considerations—and planning accordingly—helps focus resources where they will have the most impact.

This proactive approach not only improves outcomes for nature and people, but also **de-risks delivery** by reducing the chance of costly redesign, remediation or underperformance.

CONNECTION TO NATURE THROUGH BIOPHILIC DESIGN

Biophilic design connects people with the natural world through architecture and built environments. It incorporates natural elements—such as light, air, water and greenery—to create spaces that are healthier, more productive and restorative.

Nature-based design elements in this guide align strongly with Biophilic design principles and can be incorporated to increase human-centred co-benefits in urban environments.

WHAT IS BIOPHILIA?

Biophilia, meaning *love of life*, was popularised by E.O. Wilson (1984), who suggested humans are inherently drawn to nature. Stephen Kellert later expanded on this in *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*, outlining six core elements and nearly 80 strategies for integrating nature into the built form.

Though formally named only recently, Biophilic design is an ancient practice. Humans have long used local materials, airflow, daylight and natural forms to enhance comfort, beauty and safety. However, modern construction has often replaced these principles with standardised, disconnected spaces.

Biophilic design is **not just about adding plants**. While vegetation is one attribute, Biophilic design encompasses a broader framework of sensory, spatial and cultural strategies.

PRINCIPLES OF BIOPHILIC DESIGN

(Adapted from Kellert & Calabrese)

1. **Sustained interaction with nature**: design should foster regular, meaningful contact
2. **Support for human adaptation:** leverage evolutionary links between people and nature
3. **Emotional connection to place:** create settings that feel familiar, calming and inspiring
4. **Positive human–nature interactions:** encourage stewardship and responsibility
5. **Interconnected solutions:** integrate nature across spatial, structural and functional layers

TWO DIMENSIONS OF BIOPHILIC DESIGN

Kellert describes two overarching dimensions:

- **Organic (Naturalistic):** Built forms that reflect nature's shapes, materials and processes (e.g. curves, water features, natural light)
- **Place-Based (Vernacular):** Design tied to local ecology and culture, using native species, traditional forms and materials

THESE ARE EXPRESSED THROUGH SIX ELEMENTS:

Element	Description
Environmental Features	Use of natural light, vegetation, water, views, airflow
Natural Shapes & Forms	Curves, spirals, fractals, botanical motifs
Natural Patterns & Processes	Growth, ageing, decay, seasonal cycles
Light & Space	Access to daylight, variation in lighting, spaciousness
Place-Based Relationships	Local identity, materials, native planting, cultural relevance
Evolved Human–Nature Relationships	Feelings of refuge, prospect, awe, complexity, discovery

WHY BIOPHILIC DESIGN MATTERS

Numerous studies have linked nature contact to improved:

- Recovery from illness or surgery
- Workplace performance and reduced stress
- Cognitive function
- Child development
- Quality of life and place attachment

HOW TO INCORPORATE BIOPHILIC DESIGN

Biophilic design can be included at any project stage—but the greatest value comes when it's integrated early.

Recommended approach:

- **Run a Biophilic Design workshop** at project concept stage
- Include diverse stakeholders: client, architect, builder, facilities, operations, contractors
- Use the workshop to identify shared values and develop project-specific Biophilic goals
- Document outcomes in a **Biophilic framework** with guiding strategies

This early engagement fosters alignment, enhances design quality and builds stronger buy-in from all involved.

HOW DOES THIS GUIDE RELATE TO NATURE LEADERSHIP IN THE INDUSTRY AND SUSTAINABILITY RATING TOOLS?

Image courtesy of Abigail Heywood

The strategies and design elements in this guide align with emerging nature-positive leadership across the built environment—and can directly support project teams in meeting sustainability rating criteria and national policy directions.

INDUSTRY LEADERSHIP: GREEN BUILDING COUNCIL OF AUSTRALIA NATURE ROADMAP

The **Green Building Council of Australia's (GBCA)** *Nature Roadmap for New Developments* (Draft, June 2025) sets a long-term vision for a **nature-positive built environment by 2050,** aligned with global goals such as the Kunming-Montreal Global Biodiversity Framework.

The nature-based design elements detailed in this guide directly support the following principles from the roadmap by offering practical, scalable solutions for buildings and precincts:

1. **Prevent nature loss**
2. **Increase and connect nature**

SUSTAINABILITY RATING TOOLS: HOW THIS GUIDE SUPPORTS CERTIFICATION

This guide complements a number of widely used sustainability rating tools. Nature-based design elements can contribute to achieving credits, improving performance scores and supporting certification goals.

Sustainability Rating System	Owned by	Description	How this guide supports it
Green Star Buildings / Green Star Communities	Green Building Council of Australia	Frameworks to assess and certify sustainability in buildings and precincts	Nature-based design elements contribute to multiple credit categories across design, ecology, resilience, health and innovation
Living Building Challenge	Living Future	Certification program promoting the most advanced sustainability performance in the built environment	Supports performance areas (Petals) such as Place, Beauty, Materials, Health+Happiness and Equity
Melbourne Green Factor Tool	City of Melbourne	Online tool to benchmark and improve green infrastructure performance in new developments	Elements in this guide increase Green Factor scores through higher quality and quantity of green infrastructure
Brisbane Green Factor Tool	Brisbane City Council	Tool to support sustainable urban development in Brisbane	Elements in this guide improve scores by delivering better-integrated, climate-adapted green infrastructure

These tools increasingly reward nature-positive outcomes and the integration of green-blue infrastructure, making the adoption of strategies in this guide both **ecologically responsible** and **highly pragmatic.**

WHAT YOU WILL FIND NEXT

The remainder of this document provides practical guidance to help project teams deliver nature-positive outcomes through design.

Each nature realm—**biodiversity, land, water** and **atmosphere**—is explored in a dedicated section. While these realms are deeply interconnected in practice, they are presented separately in this guide to help categorise design elements according to their **primary benefit.**

SECTION STRUCTURE

Each nature realm section contains three core components:

1. Concept

- **Aspiration:** A high-level goal for that nature realm
- **Why it matters:** Explanation of its importance to ecological function and human wellbeing
- **Design context:** Integration with Country, community and broader ecological systems
- **Benefits and co-benefits:** Direct impacts and ecosystem services for nature and people
- **Design principles:** Practical considerations to support successful delivery
- **Combined impact:** Opportunities to layer design elements for greater effect

2. Nature-Based Design Elements

Each element includes:

- **Description:** What the element is and how it works
- **Benefits and co-benefits:** For nature and people
- **Diagram:** Illustrating key structural components
- **Success factors:** What supports effective implementation
- **Limitations:** Constraints or known challenges
- **Design considerations:** Technical and contextual planning factors
- **Lifecycle integration:** Guidance across planning, design, construction and operation
- **Applicability:** Where the element can be applied (building, precinct, retrofit)
- **Combining elements:** Synergies with other interventions
- **Further reading:** External links and technical references

3. Case Studies

Each design element is paired with a real-world example. These case studies showcase:

- Project context and partners
- Nature-based strategies used
- Benefits delivered
- Construction and operational insights
- Links to more detailed project information

This structure is intended to support practical implementation while demonstrating that **nature-positive outcomes are both achievable and scalable**—across project types, climates and disciplines.

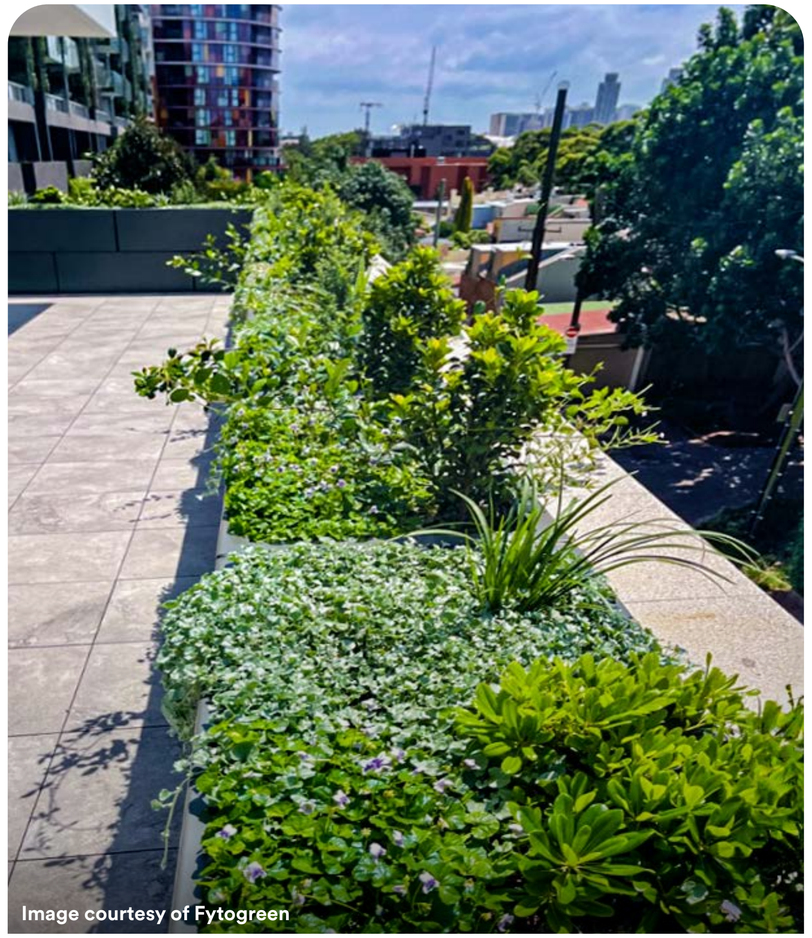


Image courtesy of Fytogreen

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Green Building Council of Australia.
- Green Star Buildings and Green Star Communities

Journal of Biophilic Design (2023).

Kellert, S.R. & Calabrese, E.F. (2015).
- The Practice of Biophilic Design

Living Future Institute of Australia.
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Tree, Isabella (2018).
- Wilding: The Return of Nature to a British Farm

UNEA (2022).
- Nature-Based Solutions for Supporting Sustainable Development

Wilson, E.O. (1984).
- Biophilia

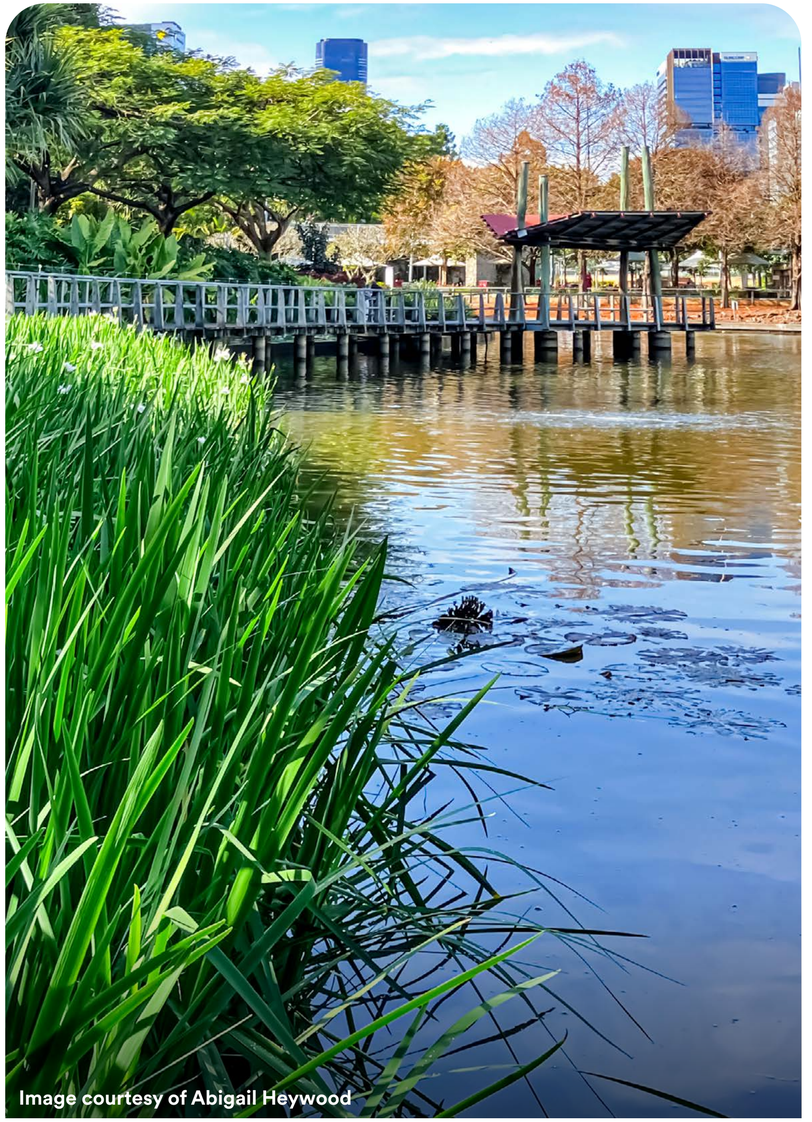

Image courtesy of Abigail Heywood

FURTHER READING

Living Future Institute Australia
- https://living-future.org.au/biophilia/
- https://living-future.org.au/biophilic-design-case-studies/
- https://living-future.org.au/biophilic-design-resources-and-references/

Journal of Biophilic Design
- https://journalofbiophilicdesign.com/

Terrapin Bright Green
- https://www.terrapinbrightgreen.com/publications/

Padlet Biophilic Design Map
- https://padlet.com/ilfieducation/biophilic-design-map-69t2qoowelms4flh

Biodiversity

Concept, design elements and case studies

BIODIVERSITY
CONCEPT

BIODIVERSITY

ASPIRATION

Protect, regenerate and create habitats that are locally relevant, support native species and connect meaningfully to broader landscapes and seascapes.

Every project is an opportunity to regenerate - for people, place, Country and Nature.

DESIGNING WITH COUNTRY

Eucalyptus, Banksia, Grevillia, and Wombats, Tasmanian Devils and Bilbies, the biodiversity of this continent is one of its greatest gifts and through Country we can begin to understand their connections and relationships. Flora, fauna and non-human kin are more important to Country than humans, with this perspective we reframe our connection to them and our relationship with nature. Through Designing with Country we can project and heal biodiversity, amplifying its relationship to Country, people and all living things.

Images courtesy of David Francis

WHAT IS BIODIVERSITY - AND WHY DOES IT MATTER?

Biodiversity refers to the full variety of different lifeforms found in a particular area - including all species of plants, animals, fungi, algae and micro-organisms - across terrestrial, freshwater and marine ecosystems.

Healthy ecosystems depend on a mix of species, each playing a unique role that both supports and is supported by natural environmental processes. These processes include carbon and nutrient cycling, water filtration, air quality regulation, coastal protection and wave attenuation, and overall ecosystem function.

Urbanisation poses a major challenge to biodiversity. As natural habitats are cleared or fragmented by roads, buildings and infrastructure, ecosystems and environmental processes are disrupted and species lose access to the resources they need to survive.

Bringing nature back into cities and towns has become a key global priority. **The Kunming-Montreal Global Biodiversity Framework** (Convention on Biological Diversity, 2022) calls for action to enhance biodiversity in urban environments - with **Target 12** focused specifically on nature-positive outcomes in cities and settlements (**CBD Target 12**).

Importantly, improving urban nature isn't just a biodiversity conservation issue. Nature-rich urban environments improve human health, wellbeing and Connection to Country, sequester carbon and support climate regulation, improve water and air quality, support climate resilience and create more liveable, connected places.

Global biodiversity targets - including those within the Global Biodiversity Framework - are working towards a shared vision: **To become 'nature positive' by halting and reversing biodiversity loss by 2030 on a 2020 baseline and achieve full recovery by 2050[1].**

Urban environments have a critical role to play in halting and reversing nature loss **and ensuring that nature is visibly and measurably on the path to recovery**. When designed with a nature positive intention, our cities, buildings and public spaces can contribute to the recovery of ecosystems - not just their protection.

1. Nature Positive is a global societal goal defined as 'halt and reverse nature loss by 2030 on a 2020 baseline, and achieve full recovery by 2050', Nature Positive Initiative https://www.naturepositive.org/what-is-nature-positive/ (viewed 27/5/25)

BIODIVERSITY CONCEPT

BIODIVERSITY SENSITIVE URBAN DESIGN (BSUD)

BSUD is a practical framework that helps integrate ecological thinking into urban development from the earliest stages. Developed by Garrard et al. (2018), BSUD is designed to guide planners, designers and developers in creating places that make a **positive onsite contribution to biodiversity** - from individual buildings to entire precincts.

BSUD benefits for biodiversity include protecting and restoring existing habitats, increasing areas of habitat, connecting habitats and increasing species (fauna) associated with those habitats such as invertebrates, mammals, reptiles, and birds.

The framework is built around five key principles, which are deliberately flexible, allowing them to be applied across a wide range of development types - from greenfield to brownfield and from land-based to freshwater and marine settings.

The BSUD framework also aligns with typical urban development workflows, helping teams incorporate biodiversity objectives into design, planning and delivery processes from concept to completion.

The BSUD framework compliments the conservation/ecological ‘mitigation hierarchy’ and projects need to ensure they give genuine priority to ‘avoiding’ impacts to biodiversity in project design.

Reference: Garrard, G.E. et al. (2018). Conservation Letters, 11(2), e12411.

FIVE KEY PRINCIPLES OF BIODIVERSITY SENSITIVE URBAN DESIGN

PRINCIPLE 1

Protect, restore and expand habitats

Protect and restore existing habitat, enhance key resources such as water, shelter, vegetation and habitat analogues. Increase habitat area and connectivity across the landscape.

PRINCIPLE 2

Enable connectivity of habitat and species movement

Protect and provide areas of habitat that allow species to move easily through and between habitats in the landscape, supporting dispersal, migration and genetic exchange.

PRINCIPLE 3

Support functioning ecosystems

Facilitate natural ecological processes and ecosystem function like pollination, seed dispersal, carbon sequestration, nutrient cycling, and increasing ecosystem resilience to climate change.

PRINCIPLE 4

Minimise threats and human disturbances

Reduce natural resource exploitation and the impacts of chemical use and pollution, invasive species, habitat fragmentation and light or noise pollution.

PRINCIPLE 5

Foster positive human–nature relationships

Create opportunities for people to engage with nature - supporting education, wellbeing and long-term community stewardship.

Barangaroo Living Seawall

Image courtesy of Sian Liddy

Victorian Desalination Plant

Image courtesy of Fytogreen

Daramu House Bee Hotels

Image courtesy of Lendlease

Image courtesy of Hollow Log Homes

Roof Garden at Melbourne University

Image courtesy of Holly Kirk

BIODIVERSITY
CONCEPT

CO-BENEFITS OF BSUD

Implementing BSUD within the built environment offers a multitude of co-benefits beyond just biodiversity:

Land

- **Provides urban greening,** increasing amenity for people and the availability of different habitats for urban wildlife.
- **Reduces urban heat island effect:** Increased green spaces and evapotranspiration cool urban microclimates.

People

- **Provides Connection to Country and Nature.**
- **Provides Caring for Country** practice.
- **Provides amenity:** Creation of attractive green spaces, improving liveability, walkability of neighbours and recreation.
- **Improves mental wellbeing.**
- **Improves urban aesthetics:** Enhances the visual appeal and amenity of urban landscapes by introducing green infrastructure elements and diverse planting, improving property values.
- **Cost savings** - reduced energy use of building due to the insulation properties of design features such as green roofs and walls, and biosolar roofs that also generate renewable energy.
- **Opportunity to foster positive human–nature relationships** through education, stewardship, citizen science and connection to biodiversity.
- **Water quality benefits increase recreational activities** such as swimming, kayaking and fishing.

Water

- **Improves water quality:** Supports water filtration ecosystem functioning and services. Effectively filters a range of pollutants common in urban runoff, including heavy metals, excess nutrients (nitrogen, phosphorus), sediments, oils, and other contaminants. This significantly improves the quality of water entering natural waterways.
- **Stormwater management:** Absorbs and retains stormwater, significantly reducing the volume and peak flow rate of runoff in urban environments, thereby alleviating pressure on conventional drainage infrastructure.

Atmosphere

- **Improves air quality** by capturing airborne particulates.
- **Supports carbon sequestration** through the natural carbon cycle.
- **Energy use savings** - reduced energy use of building due to the insulation properties of design features such as green roofs and walls, and associated energy carbon emission savings.
- **Carbon emissions savings** from design features such as biosolar roofs that generate renewable energy.

Image courtesy of Fytogreen

Image courtesy of David Francis

BIODIVERSITY
CONCEPT

FOUNDATIONS FOR SUCCESSFUL BSUD

UNDERSTANDING LANDSCAPE-SCALE BIODIVERSITY: PAST, PRESENT AND FUTURE POTENTIAL

The success of biodiversity strategies depends on understanding the broader ecological and cultural context of a site - both past and present – in the landscape or seascape. Ensure a suitably qualified ecologist and other stakeholders are engaged early. The following steps guide understanding the broader ecological and cultural context of a site, determining future potential of a site, defining objectives and ongoing requirements:

Images courtesy of David Francis

1. **Assessment of current and nearby biodiversity**

   Engage a suitably qualified ecologist early in the process to conduct a **Biodiversity Baseline Assessment**. Identify species and habitats present on and adjacent to the site (e.g. within 1 km for less mobile species, up to 5 km for more mobile species). This may involve:

   - A desktop review of local, state and federal conservation plans to identify priority species and align with other local biodiversity strategies
   - Use of ecological data to capture presence and distribution information of local habitats and species. Available data sources include, but not limited to, government, open source (e.g. Atlas of Living Australia), and other ecological databases (e.g EcoSmart Database), Local Environmental Records Centres, scientific publications,
   - Targeted ecological field surveys by a qualified consultant to record current species, habitats and ecological conditions
   - Spatial analysis of surrounding landscape features such as waterways, remnant vegetation and green infrastructure to understand connectivity potential

2. **Cultural and historical insights**

   Engage Traditional Custodians and local stakeholders to understand the site's ecological history and culturally significant species or landscapes. These insights should directly inform project biodiversity objectives and targets.

3. **Determining the future potential of the site for biodiversity**

   Use the information gathered to assess the *potential* of the site for future biodiversity and determine opportunities for protection and restoration of existing terrestrial, freshwater and marine habitats within the site, opportunities for increasing habitat areas and connectivity into the surrounding landscape.

4. **Defining biodiversity objectives and targets**

   From determining the future potential of the site, set clear, place-based biodiversity objectives and targets with local stakeholders for the building or precinct. These objectives and targets should shape early design concepts and guide decisions throughout project planning and delivery.

5. **Plan for long-term maintenance**

   Biodiversity outcomes depend on ongoing care. Ensure your project planning, design and budget include provisions for long-term maintenance - such as irrigation, weed control, monitoring of plant health and growth and the replacement of plants where needed.

6. **Monitoring and research for continuous improvement**

   Embed biodiversity monitoring and evaluation into project delivery from the outset. Allocate budget and resources to track outcomes over ecologically meaningful timeframes - ideally 5 to 10 years - to capture real ecological change. Monitoring should focus on **ecologically relevant metrics** aligned with project objectives and targets (e.g. species richness, habitat condition, or ecological function).

   Consider partnering with **local universities or research organisations** to support data collection, analysis and industry knowledge-sharing.

BIODIVERSITY CONCEPT

FOUNDATIONS FOR SUCCESSFUL BIODIVERSITY OUTCOMES

PRINCIPLE 1

PROTECT, RESTORE AND EXPAND HABITATS

Designing for species-specific needs[1]

Each species has unique ecological requirements - from food and water to shelter, temperature and nesting conditions. To ensure your design supports a broad and resilient ecosystem, it's important to understand and respond to these varying needs.

Use the BSUD framework to identify target species or groups and ensure your planting and habitat features are suited to the local microclimate and environmental conditions. By selecting a mix of species across different taxonomic groups - such as birds, mammals, reptiles, amphibians, fish and invertebrates - you can provide the range of resources needed to support a healthy and diverse community of native wildlife.

Prioritise native and structurally diverse planting

Planting should prioritise native species of local provenance, with a strong focus on diversity - both in species selection and structural form. A mix of groundcovers, shrubs and trees supports a wider range of wildlife than any single type alone, offering varied shelter, food and microclimates.

Select species that collectively provide flowering and fruiting throughout the year to maintain food sources for birds, insects and other fauna. In freshwater and marine environments, this may also include seeding or planting of native aquatic species e.g. seagrasses and shellfish to restore underwater marine habitats.

Diverse planting structure brings multiple benefits, including:

- Creating habitat for a broad range of species
- Supporting bird, reptile and insect populations
- Enhancing carbon capture
- Reducing stormwater runoff
- Suppressing weed growth through increased groundcover

As highlighted in *Biodiversity in Place*[2], **structural diversity** is just as important as **species diversity** in ensuring viable, resilient habitat that supports a rich and thriving ecosystem.

Habitat analogues and integrated structural design

Not all wildlife habitat comes from plants alone. Many native species require dedicated places to nest, roost, hibernate, or hide - making structural habitat features an important part of biodiversity-supportive design.

Artificial habitat analogues - like nest boxes and invertebrate hotels - should be tailored to the specific needs of target species. Natural structural elements such as fallen logs, tree hollows and rock piles – also provide essential shelter and breeding sites.

It's critical that all habitat analogues are **evidence-based** and appropriately located. Poorly designed or placed features may act as **ecological traps**, attracting animals into conditions that ultimately reduce survival or reproductive success.

Thoughtful, species-specific integration of these features into built form and landscape can significantly increase the ecological value of a site.

Water as a vital resource

Access to fresh water is essential for supporting urban biodiversity. From ponds and water features to simple bowls in gardens, water sources provide critical relief for wildlife - especially during hot or dry conditions.

When integrating water into a landscape, consider placement carefully:

- Position near **shade and planting** to offer refuge.
- Ensure **gentle slopes or textured edges** for safe access by small species such as lizards, amphibians and insects.
- Use **elevated or integrated water features** that can be connected to automated irrigation systems where possible.

In addition to supporting wildlife, **irrigation** should be factored into project planning to ensure long-term plant survival - even for drought-tolerant species. Healthy vegetation is key to maintaining habitat quality and ecological resilience.

Image courtesy of Town of Victoria Park, WA – Bird Waterers Initiative

1. Reference: Kirk et al. (2021). Urban Forestry & Urban Greening, 62, 127176.

2. Reference: NSW Government Architect. Biodiversity in Place

BIODIVERSITY CONCEPT

PRINCIPLE 2

ENABLE CONNECTIVITY OF HABITAT AND SPECIES MOVEMENT

Landscape and seascape context: supporting habitat connectivity

Habitat connectivity is critical to species survival. Animals need to move safely and easily across the landscape or seascape to find food, shelter and mates - supporting healthy populations and genetic diversity.

Understanding the spatial arrangement of nearby ecological features - such as waterways, remnant vegetation and green or blue infrastructure - helps determine the most effective design actions. For example, knowing which vegetation patches to protect or which corridors to enhance can significantly improve outcomes.

Connectivity can be achieved through:

- Direct habitat links (beneficial for all species)
- 'Stepping stone' habitats (especially useful for mobile species)

Even small habitat patches can be vital in fragmented urban environments. The placement and design of built infrastructure also play a major role - influencing species movement, the spread of invasive species and the overall integrity of habitat networks.

Effective spatial planning is essential to avoid unintended impacts and to strengthen ecological function at the precinct and city scale.

PRINCIPLE 4

MINIMISE THREATS AND HUMAN DISTURBANCES

Designing to avoid key ecological threats

Well-intentioned designs can unintentionally harm biodiversity if common threats are not carefully considered and addressed. The following strategies can help reduce negative impacts on urban and marine wildlife:

1. **Prevent bird collisions with glass**[1]

   Glass façades that reflect sky or vegetation can be invisible to birds, resulting in high collision rates. Use **bird-friendly glass** that is either angled to reduce reflections or patterned/textured so birds can detect it in flight.

2. **Minimise light pollution**

   Artificial lighting is disruptive to a wide range of species - including bats, birds, small mammals, insects and aquatic fauna. It can alter feeding, movement and reproductive behaviours.

   Apply principles from the **National Light Pollution Guidelines for Wildlife:**

   - Use motion sensors or timers to limit duration
   - Direct lights downward and shield from the sky
   - Position lights low to the ground
   - Opt for low-intensity **amber or red wavelengths** instead of white LEDs, especially near aquatic environments (as blue light penetrates deeper underwater and has greater impact)
   - Use vegetation as a buffer for sensitive habitats from light spill

3. **Consider material selection in marine environments**

   - Avoid **dark materials** in intertidal zones, which absorb heat and can raise surface temperatures beyond what marine life can tolerate.
   - Use **light-coloured**, rough and porous materials (e.g. sandstone or concrete) to support the colonisation of marine organisms.
   - Avoid smooth-surfaced materials such as plastics or metals, which offer limited habitat value.

4. **Minimise mortality from traffic**

   - Include road crossing structures designed for different fauna species, both above the and below roads.

5. **Minimise predation of wildlife by free-roaming pet cats**

   - Consider outdoor enclosures as part of residential architectural designs.

By addressing these common threats through thoughtful design, developments can significantly improve outcomes for biodiversity - and avoid unintended harm.

Image courtesy of David Francis

Image courtesy of Hollow Log Homes

1. Reference: NSW Government Architect. Biodiversity in Place

BIODIVERSITY
CONCEPT

DESIGN ELEMENTS THAT ENHANCE BIODIVERSITY

Well-designed and maintained elements within buildings and precincts can actively support biodiversity. The following features are commonly used to create or restore habitat and ecological function:

- Landscape planting for habitat creation and restoration
- Biodiverse green roofs
- Biosolar green roofs
- External green walls
- Habitat analogues
- Living seawalls habitat enhancement modules

COMBINING DESIGN ELEMENTS TO MAXIMISE BIODIVERSITY IMPACT

Biodiversity outcomes are strengthened when design strategies are not applied in isolation but combined to create more complex, connected and functional ecosystems.

For example, combining **green roofs, green walls and ground-level planting** creates a horizontal and vertical network of habitat that allows species to move through and between different levels of the built environment - increasing usability and ecological value.

This principle of **compounding design impact** applies across nature systems:

- **Water + vegetation:** Pairing water features with adjacent planting and shade provides habitat, hydration and shelter - supporting birds, amphibians, insects and small mammals.
- **Land + structure:** Integrating habitat analogues (e.g. nest boxes, logs, invertebrate hotels) into landscape features like retaining walls or seating enhances habitat availability and species-specific shelter.
- **Marine + built infrastructure:** Combining seawall habitat modules with marine planting (e.g. seagrass or kelp beds) creates multi-layered coastal environments that support higher trophic species and improve resilience to erosion.

By thinking holistically and designing for overlap, projects can **amplify the ecological benefits** of each intervention - creating habitats that are more diverse, accessible and enduring.

Image courtesy of Adam Gibson

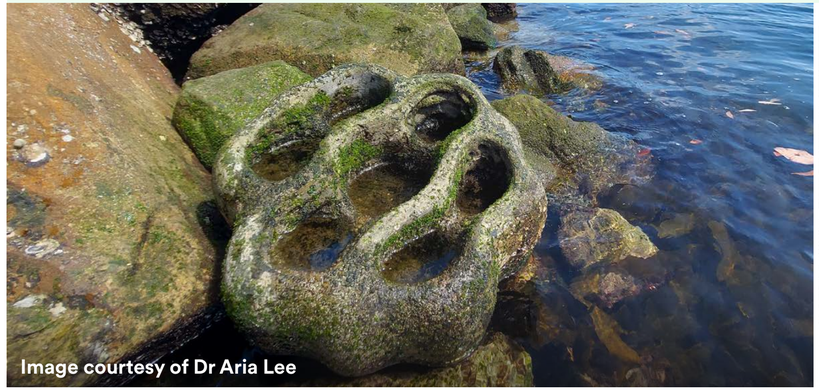

Image courtesy of Dr Aria Lee

Image courtesy of Fytogreen

BIODIVERSITY
CONCEPT

Image courtesy of Hollow Log Homes

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University of Melbourne (2023).

- Playbook for Urban Biodiversity.

City of Melbourne (2023).

- Guidelines for Biodiversity and Green Roofs.

NSW Government Architect:

- Biodiversity in Place: A Framework to Improve Biodiversity in NSW.

Which Plant Where:

- https://www.whichplantwhere.com.au

Bird Waterers Initiative:

- https://www.victoriapark.wa.gov.au/residents/environment/supporting-our-environment/bird-waterers.aspx

Aussie Bee Hotel Building Tips:

- https://www.aussiebee.com.au/bee-hotel-building-tips.html

International Standards of the Practice of Ecological Restoration:

- https://seraustralasia.com/wheel/index.html

National Light Pollution Guidelines for Wildlife:

- https://www.dcceew.gov.au/sites/default/files/documents/national-light-pollution-guidelines-wildlife.pdf

The effects of light pollution on Australian wildlife | Biodiversity Council Australia:

- https://biodiversitycouncil.org.au/resources/helping-wildlife-through-biodiversity-sensitive-lighting-the-effects-of-light-pollution-on-australian-wildlife

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: LANDSCAPE PLANTING FOR HABITAT CREATION

Landscaping and planting activities introduce vegetation into urban environments, enhancing aesthetics while supporting urban cooling, air quality and overall wellbeing.

To move beyond general urban greening and deliver biodiversity benefits, planting must be designed to create habitat with genuine ecological value.

This requires the use of diverse, resilient indigenous species and the incorporation of complex vegetation structures to support a wide range of species.

> “planting must be designed to create habitat with genuine ecological value.

BENEFITS AND CO-BENEFITS

Land

- Regulates urban temperatures (reduces urban heat island effect).
- Enhances urban greening.
- Supports soil restoration and erosion control.
- Promotes nutrient cycling.
- Creates space for habitats.

Water

- Supports water cycling (e.g. groundwater recharge).
- Improves water quality.
- Contributes to flood control.

Biodiversity

- Habitat creation and associated species – Increases habitat for a diverse range of fauna, including invertebrates, birds, bats, frogs and reptiles.
- Habitat analogues – Provides artificial structures that mimic natural habitats.
- Supports pollination – Enhances conditions for native pollinators through targeted planting.
- Increases habitat connectivity – Improves ecological linkages across the urban landscape.

Atmosphere

- Improves air quality by capturing airborne particulates.
- Supports carbon sequestration through vegetation growth and soil health.

People

- Fosters connection to Country and Nature.
- Supports Caring for Country practices.
- Improves physical health and mental wellbeing.
- Encourages recreation (e.g. walking).
- Enhances urban aesthetics, increasing the visual appeal of landscapes and supporting property values.
- Promotes nature stewardship by fostering positive human–nature relationships through education, research and biodiversity engagement.

Image courtesy of David Francis

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Engage an ecologist early** to identify planting areas that will benefit biodiversity and to guide species selection and other habitat enhancement measures.
- **Design habitats using a diverse range of indigenous plant species.** Preference must be given to indigenous species before considering other native alternatives, with a strong focus on plant diversity and resilience to climate change.
- **Planting structure:** Include multiple vegetation layers—groundcovers, shrubs and canopy—to create complex structures that offer diverse niches and support biodiversity. Avoid monocultures, which rarely deliver biodiversity benefits.
- **Street tree planting**: Avoid monocultures of street trees. Incorporate a diversity of species and use under plantings instead of turf. Grouping trees in clusters can also enhance structural complexity.
- **Select species and habitat resources known to support biodiversity,** such as:
  - Host plants for butterflies and moths
  - Food plants for native bees
  - Flowering and fruiting trees for birds and flying foxes
  - Habitat analogues for nesting, roosting and foraging
- **Examples include:**
  - *Hoya australis* – A native of QLD, NSW, WA and the NT and a host plant for the Common Crow Butterfly (readily available).
  - Love flower (*Pseuderanthemum variabile*) – Found in QLD, NSW and the NT, a host for the Leafwing Butterfly and others (less commercially available).

Hoya australis with Common Crow Caterpillar

An adult Common Crow Butterfly

Love Flower *(Pseuderanthemum variabile)*

Leafwing Butterfly

Images courtesy of David Francis

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Plants for native bees:** Consider flower shape and bee type. Small-tongue bees prefer shallow, cup-like flowers (e.g. *Leptospermum*), while long-tongue bees (e.g. Blue Banded Bees) can access deeper flowers like *Teucrium argutum*. Providing nesting resources (e.g. bare ground, 'nest blocks') can also benefit Cuckoo Bees, which parasitise other bee nests.
- **Microbat habitat:** Microbats are among the most diverse mammals in Australia but are under threat due to habitat loss. Retain hollow-bearing trees and supplement with bat boxes. Supporting insect abundance also improves food availability.
- **Bird habitat and food sources:** Structurally diverse planting provides roosting, nesting and foraging opportunities. It also helps deter aggressive species like Noisy Miners, listed as a Key Threatening Process under Commonwealth law. Avoid over-planting nectar-rich species like Grevilleas that favour Noisy Miners. Instead, include a mix of fruiting trees (e.g. Weeping Pittosporum, Gumbi Gumbi) and specialised food sources for obligate feeders like the Glossy Black Cockatoo, which depends on specific Sheoak species.
- **Soil preparation:** To ensure trees and shrubs reach their optimal size and condition, proper site preparation is essential. Sufficient space must be provided to accommodate root growth and long-term health.
- **Commercial availability of indigenous species and project timing:** A key limitation to achieving biodiversity outcomes is the availability of indigenous species. Project planning must account for the time needed to source or grow appropriate stock. Consider the following:
  - **Size:** While some species may be available as tubestock, larger sizes (e.g. 45L street trees) are often not readily available. Planning ahead allows growers time to cultivate appropriate stock.
  - **Availability:** Some species are suitable for cultivation but are not commercially produced. Time is needed for seed or cutting collection and propagation through contract growing arrangements.
- **Need for trialling less commonly cultivated species:** Of the approximately 24,000 native Australian plant species, only a small fraction are cultivated. This is largely due to a lack of trialling and confidence in their performance. As a result, exotic species—deemed 'safe'—are often favoured, despite offering limited or even negative biodiversity outcomes, including weed risk. To overcome this, projects should:
  - Incorporate underused native and indigenous species
  - Allow time in the program for propagation and trialling
  - Engage with growers and researchers to expand plant palettes

  These actions can significantly increase biodiversity value and reduce reliance on limited 'tried and tested' options.

LIMITATIONS

Landscape planting cannot fully replicate the ecological value of original habitats lost to development.


Blue Banded Bee visiting a Native Germander *(Teucrium argutum)*


Cuckoo Bee


Microbat


Habitat roosting boxes for microbats

Images courtesy of David Francis

BIODIVERSITY
DESIGN ELEMENT

Diverse vegetation structure supports bird habitat

Gumbi Gumbi is a food source for birds

Images courtesy of David Francis

DESIGN CONSIDERATIONS

- **Engage an ecologist early** to identify planting areas that will deliver biodiversity benefits and to guide species selection and habitat enhancement measures.
- **Allow sufficient lead time** for plant acquisition and, if needed, for the trialling of less commonly cultivated species.
- **Prepare sites adequately** to support the healthy growth of the selected indigenous plant palette.
- **Plan and budget for maintenance,** ensuring adequate time and resources are allocated for ongoing care.
- **Recognise that plants eaten by wildlife often indicates success.** In most cases, if wildlife is feeding on planted specimens, biodiversity objectives are being met and intervention is unnecessary. However, some exceptions require management:
  - **Native wetland birds** may uproot and eat freshly planted stock in wetland projects. Protective measures may be needed during establishment.
  - **Macropods** may browse on young tubestock. Use tree guards or other deterrents until plants are established.
  - **Insects** generally do not cause lasting damage, though some species (e.g. Amaryllid Moth Spodoptera picta) can severely impact specific plants such as Crinum pedunculatum and may require targeted management.

INTEGRATION ACROSS PROJECT LIFECYCLE

- Landscape planting for habitat creation must be considered at all stages of project planning. Early engagement with ecologists and restoration practitioners is essential for preliminary input. Timing is critical to ensure the successful delivery of a diverse indigenous planting palette.

APPLICABILITY

Biodiversity outcomes can be achieved in most built environments through appropriate landscape planting.

FURTHER READING

Backyards for biodiversity:
- https://backyardsforbiodiversity.org/resources

Australian Caterpillars and their butterflies and moths:
- https://lepidoptera.butterflyhouse.com.au/larvae.html

Moths and Butterflies Australia:
- https://maba.org.au/projects/maba_projects/butterflies_australia/

Pollinator link:
- https://pollinatorlink.org/resources/

Aussie Bee:
- https://www.aussiebee.com.au/

Ausbats:
- https://www.ausbats.org.au/install-a-microbat-house.html

City of Melbourne Urban nature planting guide:
- https://www.melbourne.vic.gov.au/planting-guide

BIODIVERSITY
CASE STUDY

CASE STUDY: THE OVAL AT SUBI EAST

PROJECT OVERVIEW

Located on Whadjuk Country in Perth, The Oval at Subi East is a generous, landscape-led community space that honours living memory and reuses existing materials, while envisioning a vibrant, connected future.

Delivered as the first stage of DevelopmentWA's broader Subi East Redevelopment Masterplan, The Oval reimagines the former Subiaco Oval Stadium site as a series of inclusive public spaces. These include a revitalised community oval, new playground, parkour course and an extensive Noongar Six Seasons Bidi trail.

GREEN LINK AND CULTURAL LAYERS

The Subi East Masterplan contributes to a regional east–west Green Link connecting Kings Park to the coast. At The Oval, parklands and civic spaces link to Market Square and Mueller Park, enhancing tree canopy and biodiversity. Carefully selected plant species support urban ecology, fauna habitats and the Noongar cultural narrative expressed through the Bidi.

The Bidi unites the site through a layered trail that embeds Noongar kadadjin (knowledge) on Noongar boodjar (Country), while celebrating the six Noongar seasons and cultural heritage.

Client:
DevelopmentWA

Location:
Subiaco, Western Australia

Project type:
Urban Renewal (Infill)

Completion date:
2024

First Nations Country:
Whadjuk Country

Key Partners:

- Landscape Architecture and Architecture: OCULUS + UDLA
- Aboriginal Reference Group: Subi East Elder Group
- Aboriginal Development Manager: Karrda
- Artists of Six Season Bidi: Rubeun Yorkshire, David Jones, Lea Taylor, Kam Bin Salleh, Dellas Bennell, Jarni McGuire
- Public Art Consultant: Apparatus
- Engineering: Stantec, Acor, PJ Wright, 3E, Greco
- Project Manager: Bridge 42
- Heritage Interpretation: Studio Field
- Irrigation: Pinion

Image courtesy of Yvonne Doherty

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

Urban ecology in practice
The Oval joined the Woody Meadow network, becoming a live case study for the University of Melbourne's ongoing urban ecology research. Its planting system features coppiced Australian shrubs in deep scoria mulch—minimising weed growth, maintenance, and water use, while increasing biodiversity and habitat value.

The design team collaborated with the Woody Meadow team, Jane Chambers, and Traditional Owners including Vivienne Hansen to curate a tailored plant palette.

Ecological outcomes
The project enhances local biodiversity and urban habitat, with over 16,000 plants and 200 new trees planted across 46,270 sqm of public green space.

Image courtesy of Yvonne Doherty

BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

- **Cultural leadership and co-design:** Authentic, ongoing cultural engagement underpins the project. The Noongar-led design process was guided by cultural protocols and included co-creation of the Six Seasons Bidi trail, which incorporates soil from all 14 Noongar language groups. This trail exemplifies the empowerment of Traditional Owners in shaping a self-guided cultural learning experience grounded in Country.
- **Innovative governance:** The Subi East project piloted Western Australia's first Aboriginal Development Manager program—embedding Aboriginal voices, history and culture directly into development decision-making.
- **Community engagement:** Extensive stakeholder consultation uncovered powerful stories connected to Subiaco Oval. These were expressed in the final design through interpretive elements, signage, and public space programming. The engagement process captured diverse perspectives and shaped a layered, community-connected outcome.

CONSTRUCTION CONSIDERATIONS

Materiality and environmental sustainability

The project prioritised heritage, circular economy principles, and environmental performance through the adaptive reuse of materials from the demolished Subiaco Oval stadium—99% of which were salvaged, reused, or recycled.

Key reuse strategies included:

- Intact changing room bricks repurposed for retaining walls.
- Crushed bricks and concrete used in rammed earth elements and road base.
- Grandstand timbers, player dugouts and stadium roof beams integrated into new public space features.

The 3.7-tonne steel beams from the stadium were re-engineered, restored, and powder-coated to serve as structural supports for shade canopies and a skating ledge in the youth precinct.

The iconic Heritage Entry Gates were retained. In total, over 50,000 tonnes of materials have been recycled, reimagined, or restored across the project.

Images courtesy of Yvonne Doherty

FURTHER READING

Landscape Australia – Round and Round Again: The Oval at Subi East

- https://landscapeaustralia.com/articles/round-and-round-again-the-oval-at-subi-east

UDLA – Subi East Oval

- https://www.udla.com.au/projects/subi-east-oval

OCULUS – Subi East

- https://www.oculus.info/projects/subi-east

The University of Melbourne

- https://woodymeadow.unimelb.edu.au/

BIODIVERSITY
CASE STUDY

CASE STUDY:
SHORELINE MANGROVE OFFSET PROJECT

PROJECT OVERVIEW

This project involves the construction of a 10-hectare mangrove and saltmarsh wetland system to offset nutrient loads from a new advanced wastewater treatment plant (WWTP), built to service the 15,000 residents of the Shoreline urban development and surrounding area. It is the first project of its kind in Queensland.

The plant treats sewage from Southern Redland Bay to Class A recycled water standard, which is then discharged into the wetland system comprising 9.8 hectares of constructed mangrove and saltmarsh habitat. The wetland system receives flows from, and discharges to, the Logan River.

The site, historically cleared for agriculture, has been rehabilitated with approximately 35,000 mangroves planted.

Client:
Stockland

Project type:
New build

Completion date:
Ongoing project

Location:
Redland Bay, Queensland

First Nations Country:
Quandamooka Country

Owner:
The completed project will be owned by Redland City Council

Key Partners:

- Redland City Council
- Water Technology
- Griffith University

Artist impression. Image source: Stockland

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

The project creates a significant new waterway and mangrove system connected to the Logan River, substantially enhancing local biodiversity through the creation of new marine and intertidal habitats.

Key initiatives include:

- **Planting:** Around 35,000 mangroves are proposed as part of a broader wetland restoration effort, establishing 9.8 hectares of mangrove and saltmarsh habitat. This includes the translocation of 14,000m² of saltmarsh. Seedlings have been salvaged from a 50km radius, including areas impacted by development.
- **Habitat creation:** The wetland provides habitat for fish, birds and other wildlife, while enhancing surrounding terrestrial vegetation.
- **Environmental impact reduction:** By pairing advanced wastewater treatment with natural wetland processes, the project ensures no change to water quality in the Logan River and boosts local biodiversity.
- **Ecological benefits:** The integration of water treatment (WWTP) and habitat creation (wetland) provides a net gain in ecological function, contributing to the resilience of the surrounding ecosystem.
- **Nursery grounds:** Mangroves offer critical nursery habitat for fish and shellfish species, supporting broader fisheries health.
- **Bird habitat:** The restored wetland attracts migratory and resident bird species, providing food and shelter.

Atmosphere

- **Carbon sequestration:** The mangrove ecosystem will absorb atmospheric carbon. As the wetland matures, it will store increasing amounts of carbon within both plant biomass and soil.

Water

- **Water quality:** Mangroves line the low-flow drain, acting as a natural system that offsets nutrients entering with flow from the Logan River such that recycled water discharged from the wastewater treatment plant does not affect water quality in the river. The new mangrove and saltmarsh habitats will in fact remove more nutrients from the Logan River than are discharged by the plant, resulting in improved water quality and healthier aquatic ecosystems.
- **Hydrological benefits:** The project reconnects the Logan River with its historic floodplain wetland habitat, restoring natural flow dynamics and supporting ecological function.
- **Recycled water supply:** The wastewater treatment plant provides a reliable source of Class A recycled water for non-potable uses such as irrigation, construction and landscaping.

Land

- **Land restoration:** The project rehabilitates land that was historically cleared for agriculture, transforming it into mangrove and saltmarsh habitat.
- **Coastal protection:** The newly established mangrove forest helps stabilise the coastline, reduces erosion, and provides natural defences against sea level rise and flooding.

People

- **Protecting waterways:** The project safeguards the health of the Logan River and its ecosystems, providing long-term environmental benefits for the community.
- **Community value:** Improved water quality and restored natural landscapes enhance opportunities for recreation, supporting residents who enjoy the area for leisure and nature-based activities.

Image courtesy of Fernanda Adame

BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

Hydrology and site design:

- Careful modelling of tidal hydrodynamics in the Logan River ensured that wetland inflows and outflows would support habitat creation and nutrient assimilation.
- Dedicated inlet and outlet structures were designed using hydraulic modelling to optimise tidal range and nutrient uptake efficiency.

Flood risk and site protection:

- The design accounted for Logan River flood behaviour to prevent off-site impacts and ensure the wetland would remain resilient during major flood events.

Environmental impact assessment:

- A comprehensive environmental impact assessment identified potential risks and informed mitigation strategies.

Odour and wind:

- Wind conditions were considered to manage potential odour dispersal from the treatment plant, with odour management incorporated into the overall design.

CONSTRUCTION CONSIDERATIONS

Rainfall:

- Heavy and prolonged rainfall created construction challenges, providing valuable lessons for future projects of this kind.

Acid sulphate soils:

- As the site sits at or below sea level, sulphate-rich soils required careful management. Lime was added to neutralise acidity prior to relocating soil, reducing environmental risk.

Water discharge compliance:

- Working near the Logan River and other sensitive waterways required strict adherence to discharge standards. The project monitored and treated construction water for heavy metals, turbidity and pH to meet regulatory limits before release.

OPERATIONAL CONSIDERATIONS

- **Low-maintenance ecosystem:** Once established, the mangrove forest is expected to function with minimal intervention, similar to any natural mangrove system.
- **Sediment management:** A dedicated sediment forebay has been constructed near the tidal inlet to capture coarse sediment brought in by tidal flows. This will address concerns around long-term sediment accumulation within the wetland.
- **Stormwater management:** Clearpro was engaged to manage stormwater runoff and enhance sediment basin performance within the wetland system.

Images courtesy of Fernanda Adame

FURTHER READING

Southern Redland Bay Wastewater Treatment Plant

- https://www.stockland.com.au/residential/qld/southern-redland-bay-wastewater-treatment-plant

Clearpro – Southern Redland Bay Wastewater Treatment Plan

- https://clearpro.com.au/portfolio-item/southern-redland-bay-wastewater-treatment-plan

Hall Contracting – Shoreline Mangrove Offset Project

- https://www.hallcontracting.com.au/projects/urban/shoreline-mangrove-offset-project

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: HABITAT RESTORATION

Habitat restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. The choice of approach depends on the site's ecological value and habitat condition, desired outcomes and available resources.

Common approaches include:

- **Natural Regeneration:** Relies on the ecosystem's ability to recover with minimal human intervention once the source of disturbance (e.g. weeds, grazing) is removed. Suitable for sites with intact seed banks and low levels of ongoing threat.
- **Assisted Natural Regeneration:** Involves actively managing threats—such as invasive species or grazing pressure—to create favourable conditions for natural recovery. May include some enrichment planting.
- **Reconstruction:** Used when natural regeneration is not viable. Involves actively planting or seeding to re-establish a target ecosystem. Reference sites are often used to guide species selection and planting densities.
- **Fabrication**: Applies when a site cannot support its original ecosystem. Converts the area into a different, locally appropriate ecosystem better suited to altered conditions—restoring ecological function and landscape integrity.

BENEFITS AND CO-BENEFITS

Land

- **Landform retention and restoration:** Maintaining natural landforms helps preserve native propagules and soil symbionts, supporting ecological restoration.
- **Urban temperature regulation:** Helps reduce the urban heat island (UHI) effect.
- **Urban greening:** Enhances vegetative cover.
- **Soil restoration and erosion control:** Improves soil stability and health.
- **Supports nutrient cycling:** Promotes soil fertility and ecological function.
- **Provides space for habitats:** Enables habitat integration within urban settings.

Water

- **Supports water cycling:** Aids in groundwater recharge and hydrological balance.
- **Improves water quality:** Through filtration and reduced runoff.
- **Flood control:** Enhances stormwater management and resilience.

Atmosphere

- **Improves air quality:** Vegetation captures airborne particulates.
- **Supports carbon sequestration:** Stores carbon in biomass and soils.

Biodiversity

- **Habitat and species protection and restoration:** Supports recovery of degraded ecosystems.
- **Supports pollination:** Encourages pollinator activity through appropriate planting.
- **Habitat analogues:** Provides artificial structures that mimic natural habitats.
- **Increases habitat connectivity:** Strengthens ecological networks across urban landscapes.
- **Improves biodiversity health:** Promotes resilience and species richness.

People

- **Fosters connection to Country and Nature.**
- **Enables Caring for Country practices.**
- **Improves physical and mental wellbeing.**
- **Increases recreational opportunities:** Encourages walking, outdoor activity and community use.
- **Enhances urban aesthetics:** Improves landscape character and property values.
- **Promotes nature stewardship:** Builds positive human–nature relationships through education, research and engagement with biodiversity.

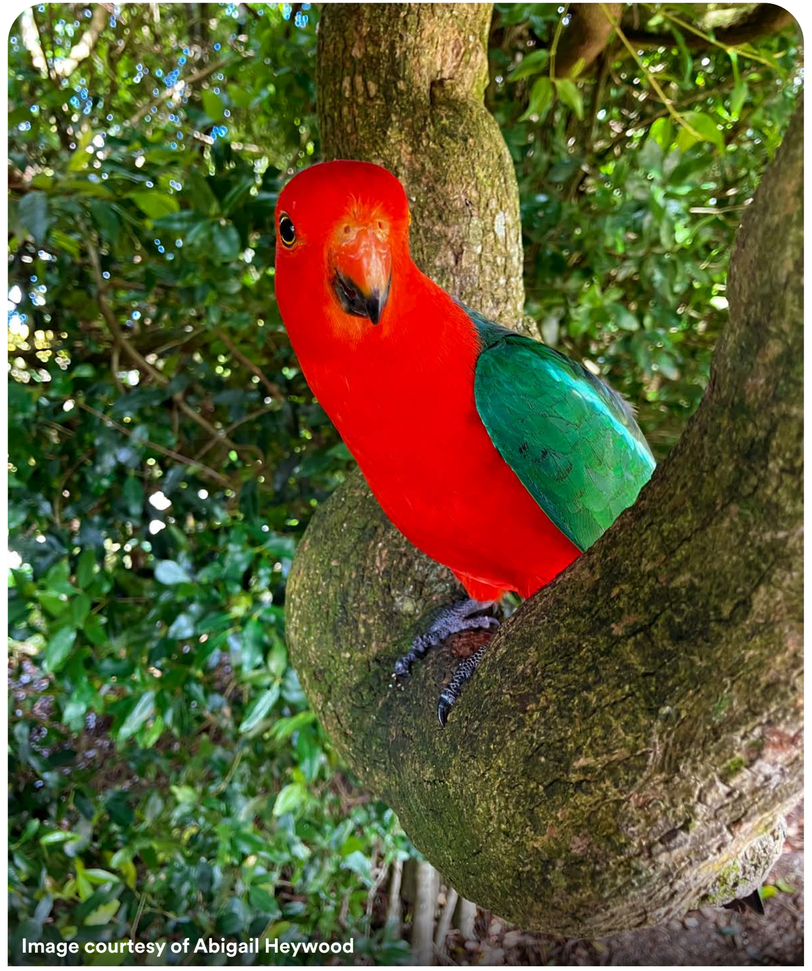


Image courtesy of Abigail Heywood

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Ecosystems are intrinsically linked to landform** (e.g. drainage lines, wetlands, ridgetop complexes). Restoration objectives must align with the underlying landform and cannot be treated in isolation.
- **Select the appropriate restoration approach.** A qualified ecologist with restoration experience should identify whether natural regeneration, assisted regeneration, reconstruction, or fabrication is the preferred strategy for each area.
- **Ensure adequate planning.** Restoration zones, objectives, performance indicators, selected methods and maintenance periods must be clearly defined before works commence.
- **Adopt adaptive management where appropriate.** This involves implementing interventions, monitoring outcomes and adjusting actions based on observed results—especially useful in contexts of uncertainty or change.
- **Engage skilled practitioners.** Restoration works should be delivered by experienced professionals with appropriate ecological expertise.
- **Allow sufficient time and funding for maintenance and monitoring.** In some cases, several years of follow-up may be required to ensure long-term success.
- **Plan for contingencies.** Risk-based planning should be included to address site-specific challenges, including those associated with a changing climate.

DESIGN CONSIDERATIONS

- **Engage qualified practitioners** to plan, implement and monitor restoration projects.
- **Allow adequate lead time** for seed collection and plant propagation. Many projects fail due to poor planning and unavailability of suitable planting material.
- **Prioritise maintenance.** Inadequate maintenance is a leading cause of project failure. Ensure maintenance access is incorporated into site planning.
- **Recognise wildlife interactions as a positive sign.** If wildlife feed on planted species, it often indicates biodiversity objectives are being met. Intervention is generally unnecessary, except in cases such as:
  - Native wetland birds uprooting newly planted stock – temporary protection may be needed
  - Macropods browsing on young tubestock – tree guards may be required
  - Insects like Spodoptera picta damaging Crinum pedunculatum – may warrant targeted management
- **Be prepared to adapt.** Events like fire, flood, drought, or species failure may necessitate adjustments to the restoration approach.
- **Use long-term monitoring tools** such as the **Society for Ecological Restoration's Wheel**, designed to assess ecosystem recovery over time.

INTEGRATION ACROSS PROJECT LIFECYCLE

- Ecological restoration areas must be considered at all stages of project planning. Early engagement with ecologists and restoration practitioners is essential to inform desired outcomes and guide appropriate strategies.
- *For example,* restoring an ecological corridor may only require a Natural Regeneration approach. Ensuring these areas are protected from earthworks and other impacts during planning can prevent the need for more costly interventions like Reconstruction or Fabrication later.

APPLICABILITY

Precincts where natural or semi-natural areas can be retained or enhanced within public or private open space.

BIODIVERSITY
CASE STUDY

CASE STUDY: JARRAMLEE NATURE RESERVE

Image courtesy of PLACE Laboratory

PROJECT OVERVIEW

Jarramlee–West MacGregor Grasslands Nature Reserve is a 145-hectare protected area on the north-western edge of the ACT. The reserve stretches from Stony Knob—a small hill—down to the minor floodplains where Ginninderra and Gooromon Ponds creeks flow.

Following the decommissioning of a former sewerage facility, the site was left fragmented and unsafe due to ground subsidence. An extensive restoration project was initiated to address safety concerns and rehabilitate the landscape.

Works included the removal of abandoned infrastructure, construction of a stormwater swale, remediation of subsidence areas and restoration of two hectares of degraded grassland with native species. The project also established a publicly accessible Ngunnawal interpretation garden, featuring a gravel path that represents Ginninderra Creek and breakout spaces that share the land's cultural and ecological history.

The project enhances biodiversity, supports habitat connectivity and strengthens cultural ties to place—fostering a more sustainable relationship with Country.

Client:
ACT Parks and Conservation Service | Environment Division | Environment, Planning and Sustainable Development

Project type:
Retrofit

Completion date:
May 2023

Location:
MacGregor, ACT

First Nations Country:
Ngunnawal Country

Key Partners:

- Lead Consultant: WSP
- Landscape Architect: PLACE Laboratory
- Artwork: Well Spring Environmental Design in collaboration with Wilay Designs
- Construction: Cord Civil
- First Nations Cultural Collaborators: Dhawura Ngunnawal Caring for Country Committee, Ngunnawal Elders

Image courtesy of PLACE Laboratory

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Restoration of Natural Temperate Grassland habitat**
  The Jarramlee reserve features areas of Natural Temperate Grassland, a nationally threatened ecological community. Restoration efforts have focused on revegetating degraded pasture with native species, including the planting of 25,000 plants and sowing of 130 kg of native grass seed to increase habitat quality and extent.
- **Golden Sun Moth habitat**: The grassland supports a significant portion of the ACT's second-largest population of the vulnerable Golden Sun Moth—a nationally listed threatened species.
- **Canberra Raspy Cricket:** Jarramlee is one of the few known habitats for the rare and locally endemic Canberra Raspy Cricket.
- **Woodland birds:** The reserve's woodland areas provide important habitat for a number of threatened and declining woodland bird species.
- **Wildlife corridor:** Together with surrounding grasslands, the reserve contributes to a large and connected habitat area. Restoration efforts are improving ecological connectivity across the site, particularly along Ginninderra and Gooromon Ponds creeks, which support migratory birds and other fauna.

Water

- **Water management:** A swale and rock chutes were constructed to manage flows from an onsite pond, helping to disperse and filter runoff before it enters Ginninderra Creek via a bio-retention system.
- **Water quality monitoring:** The Jarramlee Park Landcare Group, along with other local community groups, plays an active role in monitoring water quality across the reserve.
- **Catchment health:** Located within the Ginninderra Catchment, the reserve benefits from collaborative efforts between community groups and government initiatives—such as the Healthy Waterways program—to support broader catchment health.

Land

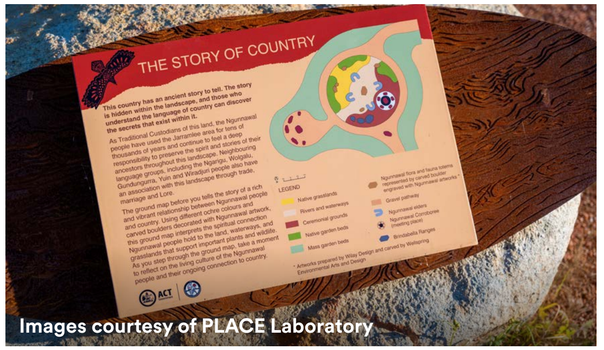
- **Land restoration:** Areas disturbed by remediation works were rehabilitated and reseeded with native species. This included the landscaping of the stormwater swale and restoration of previously impacted zones to support natural temperate grassland regeneration.

People

- **Passive recreation:** The reserve supports passive, low-impact recreation such as walking and birdwatching. It also includes designated areas for cycling and horse riding as part of the National Trail.
- **Community involvement:** Local groups, including the Jarramlee Park Landcare Group, are actively engaged in habitat restoration and ongoing environmental monitoring.
- **Public access:** A section of the reserve previously closed due to legacy infrastructure has been reopened following remediation, improving access for the community.
- **First Nations heritage sites:** The reserve protects 13 Aboriginal heritage sites, including areas historically used for ceremony and cultural practices—reflecting the site's deep cultural significance.
- **Ngunnawal space:** A newly established Ngunnawal interpretation space and cultural garden allows for the sharing of Ngunnawal stories and knowledge. This space supports ongoing cultural connection to Country and provides an opportunity for the broader community to engage with the area's heritage.

Atmosphere

- **Carbon sequestration:** While not formally studied, natural temperate grasslands like those at Jarramlee are known to be effective carbon sinks—sequestering carbon in both plant biomass and soil.



Images courtesy of PLACE Laboratory

BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

The reserve was designed with a strong focus on protecting and restoring native grassland habitat, particularly for the endangered Golden Sun Moth. Key design considerations included enhancing habitat connectivity—especially along riparian corridors—and managing Aboriginal cultural heritage, including artefact scatters.

The design also prioritised opportunities for community recreation and education, incorporating features such as an interpretation space and native garden to foster awareness of ecological and cultural values.

CONSTRUCTION CONSIDERATIONS

Construction was carefully managed to minimise environmental and cultural impacts. Key priorities included protecting habitat for the endangered Golden Sun Moth, avoiding disturbance to Aboriginal heritage sites and mitigating typical construction risks such as weed spread and impacts on water quality.

OPERATIONAL CONSIDERATIONS

- **Pest and weed control:** Ongoing monitoring and management of invasive plant species (e.g. Serrated Tussock, Chilean Needle Grass) and pest animals is critical to maintaining the integrity of the native grassland ecosystem.
- **Habitat management:** The reserve is managed to support the health of the Natural Temperate Grassland community—primary habitat for the Golden Sun Moth. This includes revegetation, biomass control (e.g. through fire management) and addressing issues such as soil compaction and erosion.
- **Community engagement:** Ongoing engagement is essential to uphold the cultural and ecological values of the site. The Ngunnawal interpretation space and native entry garden provide opportunities to educate and involve the community.
- **Monitoring:** As habitat for endangered species, the reserve requires continuous monitoring—particularly of the quality and extent of Golden Sun Moth habitat—to inform adaptive management practices.

Images courtesy of PLACE Laboratory

FURTHER READING

National Standards for the Practice of Ecological Restoration in Australia:

- https://www.seraustralasia.com/standards/National%20Restoration%20Standards%202nd%20Edition.pdf

South East Queensland Ecological Restoration Framework: Guideline

- https://www.hlw.org.au/region/about/restoration-framework#gsc.tab=0

Australian Association of Bush Regenerators (AABR):

- https://www.aabr.org.au/

Certified Environmental Practitioners (CEnvP):

- https://www.cenvp.org/directory/

Society For Ecological Restoration's tool, The Wheel:

- https://seraustralasia.com/wheel/index.html

ACT Parks Overview:

- Jarramlee–West MacGregor Grasslands Nature Reserve

Jarramlee Offset Monitoring Report 2015:

- Natural Temperate Grassland and Golden Sun Moth Habitat

BIODIVERSITY
CASE STUDY

CASE STUDY:
PAKAPAKANTHI / SOUTH PARKLANDS WETLAND

PROJECT OVERVIEW

The Pakapakanthi / South Parklands Wetland detains and treats flows from Brownhill Creek as part of the broader Brown Hill Keswick Creek Stormwater Project flood mitigation strategy. Throughout the project, TCL worked closely with multiple local councils, stakeholders, design professionals and Kaurna community members to integrate cultural heritage, enhance biodiversity and embed sustainable practices.

The wetland improves water quality and ecological value, while also enhancing amenity and recreational benefits for Parklands users. New public amenities include over 2 km of shared paths and walking trails, a large amphitheatre and mounded lawns, gabion walls, viewing decks, boardwalks and Kaurna cultural interpretation elements carefully integrated among existing remnant trees and sensitive ecosystems.

This project demonstrates how landscape architecture can leverage green infrastructure to mitigate flood risk, support climate resilience and deliver meaningful social and environmental benefits. The wetland system significantly reduces the risk of a 1-in-100-year flood across five council areas. Its design prioritises community health and wellbeing—enhancing access and connectivity, contributing to neighbourhood identity and resilience and strengthening connections to nature.

> **“This project has a sensitivity towards the protection of stands of existing Eucalyptus trees, native butterfly habitat and a skilful crafting of earthworks by creating passive recreation areas seamlessly woven through the site, TCL and its design team has achieved an outstanding outcome.**
>
> Jury Citation, AILA South Australia 2023 Awards

Client:
Brown Hill Keswick Creek Stormwater Project

Location:
Adelaide / Tarntanyangga, South Australia

Project type:
New Build

Completion date:
May 2022

First Nations Country:
Kauma Country

Owner:
The City of Adelaide, through the Kadaltilla / Adelaide Park Lands Authority

Key Partners:

- Landscape Architecture: TCL
- Hydraulic Engineering: Design Flow
- Lead / Civil Engineering: Tonkin
- Project Management: Procure PM
- Artist / Kaurna Ngarrindjeri and Yankunytjatjara: Allan Sumner
- Cultural Heritage Survey: RAW
- Civil / Landscape Construction Lead: Bardavcol
- Landscape Construction Partner: EcoDynamics
- Traditional Owner Engagement: Kaurna Yerta Aboriginal Corporation (Lynette Crocker, Merle Simpson, Trevor Wanganeen, Ann Newchurch)

Image courtesy of Jackie Gu

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Habitat creation:** The 3.2-hectare wetland provides a diverse range of habitats, including aquatic zones, riparian corridors and extensive revegetated areas with endemic and native plant species. It contributes to a more resilient and connected green network across the Parklands.
- **Improved species diversity:** The project has supported the reintroduction and return of native plant and animal species to the southern Parklands, including the protection of Chequered Copper butterfly habitat and critical habitat for birdlife, reptiles and amphibians.
- **Removal of introduced species:** The project included the removal of invasive species such as poplars and kikuyu grass, restoring the landscape to a more ecologically diverse river corridor system.

People

- **Cultural engagement:** The project involved collaboration with First Nations people throughout the design and delivery process, ensuring cultural values and knowledge were embedded in both the wetland and its interpretive elements. Engagement included the preparation of cultural heritage surveys, participation in design workshops, design and fabrication of cultural interpretation, on-site monitoring during earthworks and excavations and a welcome to Country, smoking ceremony and repatriation of cultural artefacts upon completion.
- **Recreation and amenities:** The wetland incorporates over 2 km of walking trails and shared paths, several viewing decks and boardwalks, amphitheatres and lookout mounds and day-use shelters with picnic facilities—allowing the community to connect with nature and learn about the local environment.
- **Educational opportunities:** The project provides opportunities for the public to learn about water management, landscape ecologies, cultural heritage and the role of green infrastructure in urban environments.

Water

- **Water quality improvements:** The wet/dry wetland system and deep water ponds are designed to improve water quality by removing litter and suspended solids, sequestering heavy pollutants and particulates and filtering stormwater runoff before it enters Parklands Creek. This helps protect aquatic ecosystems and supports the overall health of the local environment.
- **Flood mitigation:** The wetland plays a critical role in managing stormwater runoff and mitigating flood risk in surrounding areas. Acting as a detention basin, it temporarily holds stormwater and releases it at a controlled rate—reducing the impact of heavy rainfall on downstream locations. The system helps to manage extreme weather events such as a 1-in-100-year flood, protecting homes and infrastructure in Adelaide's southern suburbs.

Land

- **Erosion control:** While not formally studied, the integration of wetlands into the parklands is likely to help control erosion—reducing the release of stored carbon and dust particles into the atmosphere.
- **Temperature regulation:** Similarly, while not directly measured, the addition of wetlands and increased tree canopy is expected to regulate local temperatures, offering respite for people and wildlife and helping to reduce the urban heat island effect. Increased vegetative biomass across the Parklands also contributes to improved air quality.

Atmosphere

- **Carbon Sequestration:** Wetlands are widely reported to store over a third of the world's terrestrial carbon, with the south parkland wetlands playing a significant role in the absorption and storage of carbon dioxide from the atmosphere. This process helps to reduce greenhouse gas emissions and mitigate climate change.

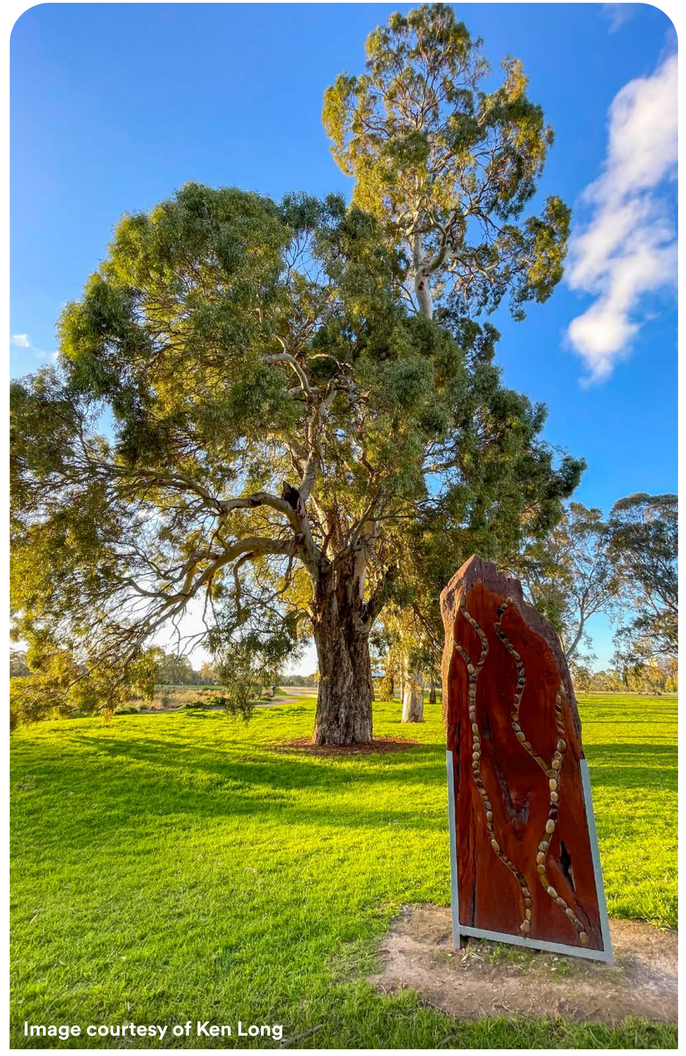


Image courtesy of Ken Long

BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

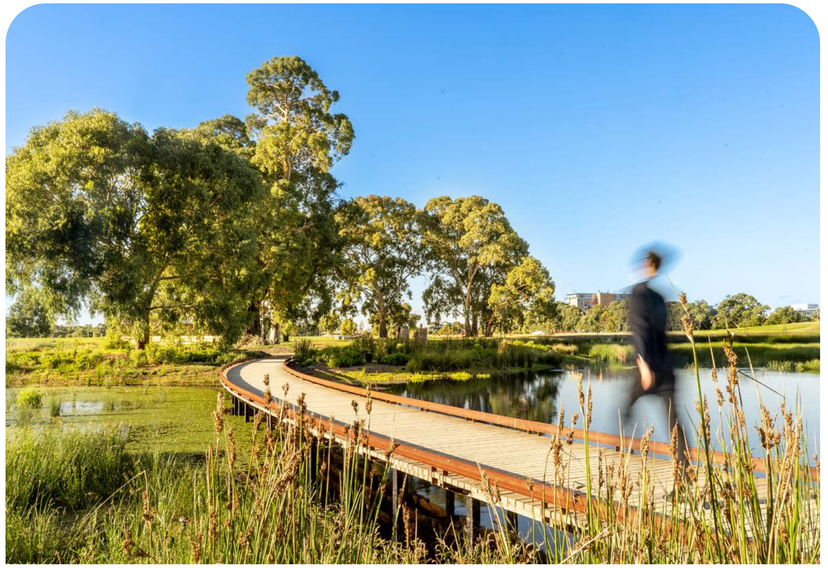
- **Nature connection:** The wetland was designed to connect people with nature through the integration of Indigenous vegetation, habitat zones and educational opportunities.
- **Cultural heritage:** Kaurna cultural interpretation and artwork are embedded throughout the site, carefully positioned among remnant trees and sensitive ecosystems to honour and celebrate cultural history.
- **Sustainable practices:** The design incorporates sustainable strategies such as water harvesting, flow management and the use of native plant species adapted to local conditions.
- **Water management:** The system includes low-flow diversion to maintain environmental flows in Parklands Creek and reduce flood risk. The permanently vegetated 3.2-hectare wetland can harvest up to 150 ML of treated stormwater annually, building resilience in a changing climate.
- **Mosquito control:** The design integrates deep water zones and gently sloped banks to discourage mosquito breeding and support natural predators.
- **Vegetation:** Plant selection focused on site suitability and ecological function, with an emphasis on Indigenous riparian plant communities.
- **3D contour modelling:** Used during design to guide earthworks—including mounds, embankments and cut basins—while retaining all existing trees and meeting stormwater retention targets.
- **Public access and safety:** The wetland prioritises safe, legible circulation using CPTED principles. Clear sightlines, wayfinding and controlled access measures were incorporated. Physical access to waterbodies is restricted through a combination of vegetated buffers, low-height steel and rock barriers.
- **Biodiversity corridors:** The wetland strengthens habitat connectivity along the Parklands Creek corridor, facilitating wildlife movement and seed dispersal.

CONSTRUCTION CONSIDERATIONS

- **Construction logistics:** the construction of the wetlands included managing soil volumes, minimising the impact of construction on existing trees and infrastructure and staging the work to minimise disruption to the parklands.

OPERATIONAL CONSIDERATIONS

- **Water quality:** Ongoing management includes monitoring key water quality parameters (e.g. nutrient levels, turbidity) and regulating inflows to prevent pollutants from overwhelming the system. Periodic cleaning of the inlet pond is carried out using an excavator.
- **Water levels:** Maintaining appropriate water levels is essential for ecological health and system performance. This includes ensuring adequate depth for aquatic life, avoiding stagnant areas that could support mosquito breeding and managing flows to mimic natural hydrological cycles.
- **Vegetation maintenance:** A two-year establishment and maintenance period enabled regular monitoring of plant performance, adaptation to site use changes, control of invasive species and support for adequate water and nutrient availability.
- **Habitat monitoring:** The wetland provides habitat for a variety of bird, amphibian and insect species. Ongoing efforts focus on minimising disturbance to nesting and breeding areas, providing appropriate roosting and perching structures and managing human activity to limit ecological impact.
- **Safety:** Earthworks, trails, vegetation and signage were designed to create an immersive environment while retaining clear sightlines and intuitive circulation. Ongoing maintenance by Council staff, supported by security patrols during events, helps deter vandalism and anti-social behaviour. Lighting and access have been upgraded to define safe and accessible areas after dark.
- **Respect for Kaurna culture:** The wetland should continue to be managed in a way that respects its ongoing cultural significance to the Kaurna people. This includes active consultation with the Kaurna community on management decisions, site use and opportunities for cultural education and interpretation.



Images courtesy of Jackie Gu

BIODIVERSITY
CASE STUDY

Images courtesy of Jackie Gu

FURTHER READING

South Parklands Wetland – Landscape Architects (TCL)

- https://tcl.net.au/projects/south-parklands-wetlands

AILA Awards Gallery

- https://aila.awardsplatform.com/gallery/DPJzDmPY/MyZrBAyo

South Parklands Wetland

- Project Presentation PDF

Webinar: Climate Positive Design Outcomes

- https://www.aila.org.au/iCore/Events/Event_display.aspx?EventKey=NATCLIM524

Victoria Park / Pakapakanthi (Park 16) Wetland – Water Sensitive SA

- https://www.watersensitivesa.com/wsud-projects/victoria-park-pakapakanthi-park-16-wetland-adelaide

Project Videos by ecoDynamics Group

- https://www.youtube.com/watch?v=gnR1PgB2haE
- https://www.youtube.com/watch?v=MClBULzf240

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: BIODIVERSE GREEN ROOF

Biodiverse green roofs are engineered rooftop ecosystems that convert underutilised building surfaces into thriving, living habitats. Designed to support urban biodiversity, they create supplementary habitat for mobile species - such as birds, bats and invertebrates - that can access elevated spaces in the built environment.

By combining varied substrate depths, diverse plant communities and integrated water management, these green roofs act as ecological stepping stones across fragmented cityscapes. They go beyond conventional green roof systems like sedum mats or monocultures, instead fostering complex, resilient ecosystems that support insects, birds and other microfauna - while delivering a range of environmental and social co-benefits.

> “these green roofs act as ecological stepping stones across fragmented cityscapes

BENEFITS AND CO-BENEFITS

Land

- Urban temperature regulation
- Urban greening

Water

- Stormwater management - retains stormwater, reduces stormwater runoff volumes, peak flows and flooding
- Improves water quality
- Enables rainwater harvesting

Biodiversity

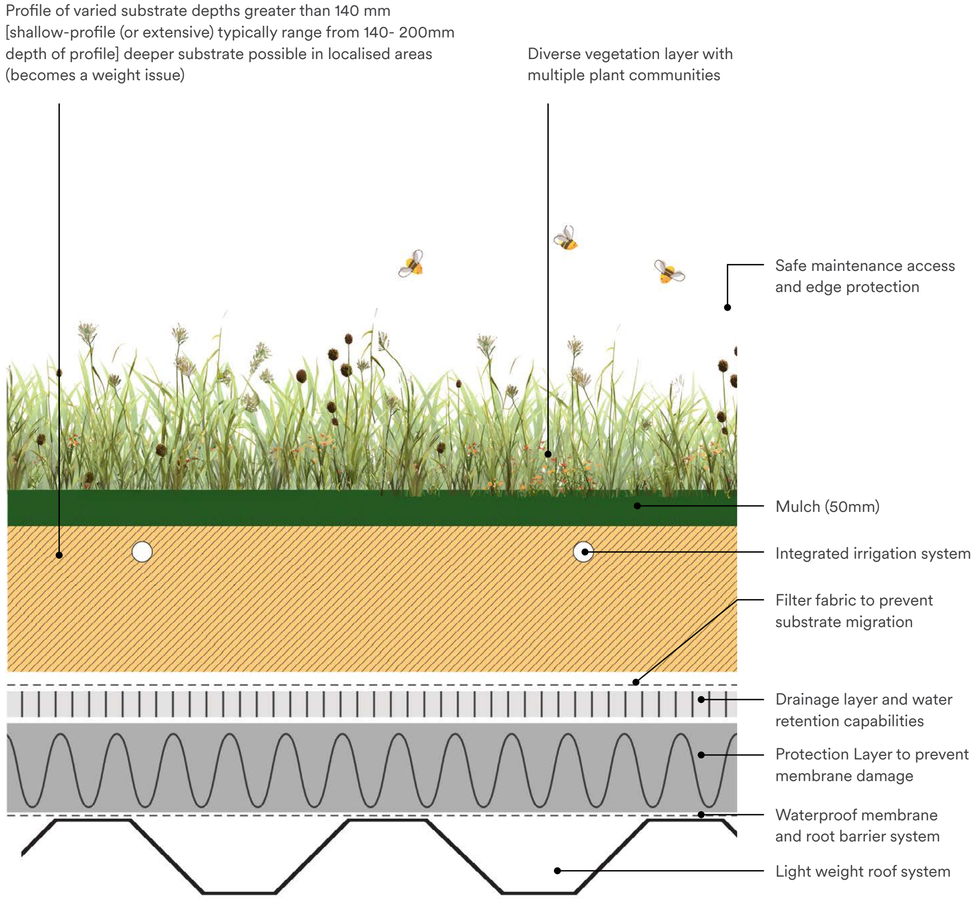
- Increases novel habitat for insects, birds, bats and microfauna
- Additional habitat creation through habitat analogues
- Supports pollination
- Increases habitat connectivity in urban landscape

Atmosphere

- Improves air quality
- Supports carbon sequestration
- Carbon emission savings from reduced energy use of building
- Noise attenuation

People

- Improves urban aesthetics
- Supports Connection to Country
- Reduces building energy use and operational costs due to insulation properties
- Offers educational and stewardship opportunities



Roof garden system build up

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Specialist input:** Involve ecologists, landscape architects, structural and drainage engineers early.
- **Connectivity:** Locate green roofs within a broader green infrastructure network and areas with existing biodiversity.
- **Plant selection:** Use native/indigenous species suited to high-exposure conditions. Consider exotic species for function and resilience. Conduct wind assessments.
- **Planting structure:** Include multiple layers (ground, shrub, canopy) to support a variety of fauna and increase food sources for insectivores.
- **Substrate depth:** Supports plant maturity. Deeper profiles enable larger, more structurally diverse vegetation.
- **Disturbance mitigation:**
  i. Minimise artificial lighting.
  ii. Limit human access where target fauna are more sensitive.
- **Building height:** Above five storeys constrains connectivity to ground habitats and may limit access for some species.
- **Water management:** Irrigation is essential, especially during establishment or extreme heat.
- **Microclimates and seasonal resources:** Provide sun/shade variation, flowering plants across seasons and shelter for fauna.

Optional (as needed):

- Dedicated habitat analogues for fauna (e.g. insect hotels, bird perches).
- Surface water (e.g. ephemeral pools).
- Chemical-free maintenance.
- Low-intervention maintenance approaches.

LIMITATIONS

- Green roofs do not fully replicate ground-level habitat.
- Favoured by mobile species already present locally (e.g. birds, bats, invertebrates).

COMBINING WITH OTHER ELEMENTS

- Enhance connectivity and impact by linking green roofs to ground-level habitats via green walls or other green infrastructure.

DESIGN CONSIDERATIONS

- **Structure:** Ensure the building can support live and dead loads (e.g. saturated substrate).
- **Cost:** Higher up-front cost, especially for retrofits. Cheaper on new builds.
- **Wind:** Assess and mitigate via substrate mounding and plant choice.
- **Substrate:** Use engineered lightweight mixes suitable for target plant species.
- **Waterproofing:** Specify high-quality membranes and leak detection systems.
- **Water management:** Include smart irrigation and drainage systems.
- **Maintenance:**
  i. Budget for both establishment and long-term maintenance.
  ii. Plan safe access (e.g. edge protection, anchor points).
- **Fire safety:** Select low-risk plant species and design irrigation accordingly.

Note:

- All habitat features should be securely fixed and located away from maintenance zones or fall edges.
- Ensure loose elements (e.g. rocks, logs) are pinned or stabilised to meet rooftop safety standards.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify potential roof locations and biodiversity goals.
- **Concept Design:** Assess exposure and microclimate needs; outline planting strategies.
- **Detailed Design:** Specify plant species, densities, maintenance protocols.
- **Construction:** Oversee substrate/media/waterproofing installation, irrigation and planting.
- **Operation:** Monitor vegetation and fauna use; adjust management as needed.

APPLICABILITY

Suitable for single buildings and precinct-scale applications.

BIODIVERSITY
CASE STUDY

CASE STUDY: VICTORIAN DESALINATION PLANT

Image source: Aquasure

PROJECT OVERVIEW

The Victorian Desalination Plant in Wonthaggi features a remarkable 27,000 m² green roof planted with over 100,000 indigenous species - including succulents, ground covers, tussocks and low-lying shrubs. Designed to integrate seamlessly with the surrounding landscape, the roof minimises visual impact and contributes to the site's ecological performance.

The project also includes a 225-hectare ecological reserve - one of the largest ecological restoration efforts in Victoria - featuring restored wetlands, coastal and swampy woodlands and habitat creation for local fauna.

Contributed by:
Fytogreen

Client:
AquaSure

Project type:
New build

Completion date:
2012

Location:
Lower Powlett Road, Wonthaggi, VIC

First Nations Country:
Bunurong/Boonwurrung Country

Owner:
Public-private partnership between the Victorian Government and AquaSure

Key Partners:

- Architecture: ARM / peckvonhartel
- Landscape architecture: ASPECT Studios
- Design, installation & maintenance: Fytogreen
- Civil engineering: Beca
- Waterproofing membrane: Sika Sarnafil
- Drainage cells: Atlantis Corporation
- Plant operator: AquaSure

Image source: Aquasure

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- 27,000 m² planted with over 100,000 indigenous plants, providing habitat for local fauna.
- Connecting green roof habitat with adjacent 225-hectare restored wetlands, coastal and swampy woodlands habitats, providing connectivity across the wider coastal landscape.

Water

- Irrigation runoff and rainwater harvested on site.

Land

- Reconnects missing habitat links in the coastal landscape, creating a new coastal park for community use.

People

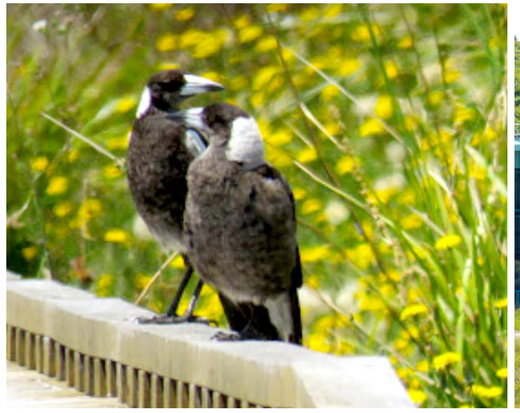
- Integrated walking, cycling and horse-riding paths connect to local trail networks.
- Constructed dunes and woodlands reduce visual impact-making the plant nearly invisible from public viewpoints.

Atmosphere

- Enhances thermal performance of the building, reducing energy use and carbon emissions.
- Supports carbon sequestration through extensive plant coverage.

Image source: Aquasure

Images courtesy of Fytogreen



BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

The client's brief was to replicate pre-settlement vegetation and minimise the plant's visual impact on this ecologically sensitive coastal site - the largest municipal water treatment plant in Australia.

CONSTRUCTION CONSIDERATIONS

- Thin-profile green roof requiring minimal growing media.
- Planted with a diverse palette of salt-tolerant, drought-hardy and wind-resistant indigenous species.
- Vegetation arranged in patterned bands for visual and ecological effect.
- Waterproofing system designed to accommodate expansion and contraction across kilometres of movement joints.

OPERATIONAL CONSIDERATIONS

- Provides acoustic insulation to reduce noise from loud internal pumps.
- Delivers thermal insulation to support energy efficiency.
- Visually conceals plant infrastructure from key public viewpoints, including the Bass Highway.

Image courtesy of Fytogreen

FURTHER READING

City of Melbourne (2023):
- Green Roof Biodiversity Guidelines

Aussie Bee:
- How to Build a Bee Hotel

Australasian Bat Society:
- Bat Fact Sheets

NSW Government Architect:
- Biodiversity in Place

University of Melbourne:
- Playbook for Urban Biodiversity
- Maintenance Guidelines for Australian Green Roofs

Fytogreen:
- Fytogreen Website

Whāngārei Living Roof Guide:
- Living Roofs & Facades

City of Melbourne:
- Growing Green Guide

Green Roofs case study:
- Greenroofs.com

Victorian Government:
- Ecological Reserve 10 Year Anniversary

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: BIOSOLAR GREEN ROOF

Biosolar green roofs integrate photovoltaic solar panels with groundcover vegetation, delivering both biodiversity and energy outcomes. These systems strategically position solar panels above diverse planting areas, creating microhabitat variation through shade patterns, while vegetation provides cooling that improves solar panel efficiency by 4–8%.

Biosolar green roofs represent an evolution in rooftop utilisation—maximising limited urban space by combining renewable energy generation with biodiversity benefits. The intentional design fosters varied microclimates beneath and between panels, supporting diverse groundcover communities while contributing to ecological connectivity and urban energy resilience.

The combination of vegetation and panels creates novel habitat niches—cooler, sheltered zones that offer refuge from predators when paired with well-structured vegetation.

> **“The combination of vegetation and panels creates novel habitat niches**

BIODIVERSITY AND CO-BENEFITS

Biodiversity

- Creates novel habitats for invertebrates, birds, bats and microfauna, and increases urban plant diversity
- Supports pollination
- Enables inclusion of habitat analogues
- Increases ecological connectivity in the urban landscape

Land

- Helps regulate urban heat
- Contributes to urban greening

Water

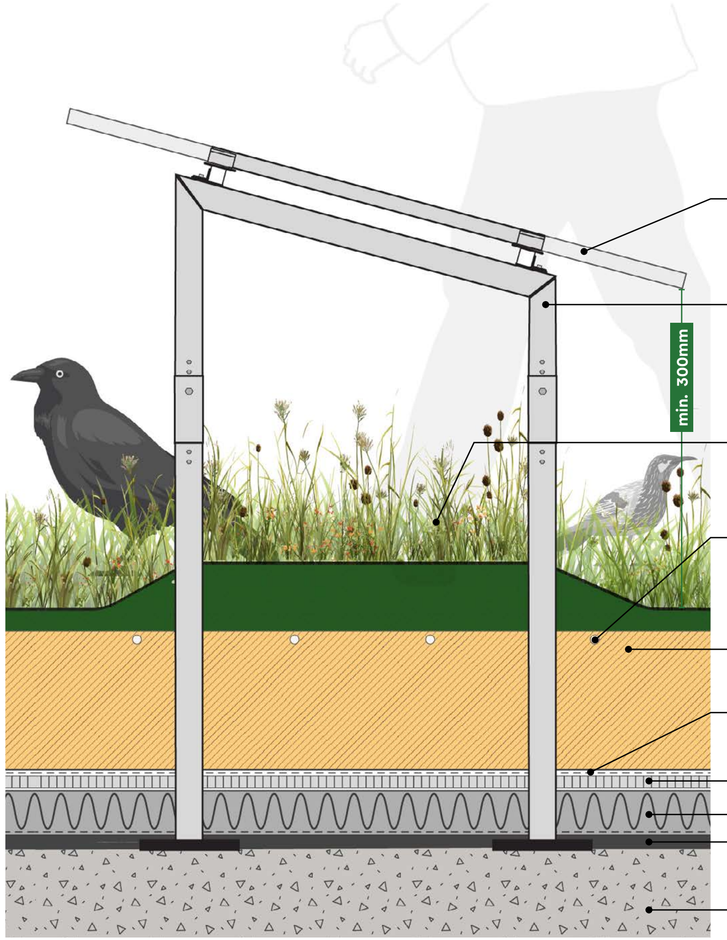
- Retains stormwater, reduces runoff and peak flows
- Improves water quality
- Enables rainwater harvesting

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration
- Carbon emission savings from renewable energy
- Carbon emission savings from reduced building energy consumption
- Provides noise attenuation

People

- Enhances connection to Country and Nature
- Improves urban aesthetics
- Reduces energy costs
- Supports education and nature stewardship



NOTE:

Provide safe maintenance access for both green roof and solar components

Edge protection and fall arrest systems

Solar panel mounting system with biodiversity-optimized spacing

Elevated panel installation (typically 300-900mm above substrate to allow for plant growth)

Diverse vegetation layer adapted to specific solar panel microclimates

Integrated irrigation system with moisture sensors

Engineered light-weight substrate media profile (typically 120-200mm)

Filter fabric to prevent substrate migration

Drainage layer with water retention capabilities

Additional Insulation (Optional)

Protection layer to prevent membrane damage

Existing Reinforced Concrete Roof

Biosolar green roof

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Specialist input:** Involve ecologists, landscape architects, Green roof specialists, waterproofing suppliers, electrical engineers and structural specialists early in the design process.
- **Landscape connectivity:** Locate the roof within a broader green infrastructure network near areas where biodiversity already exists.
- **Plant selection:** Use diverse native and indigenous groundcovers suited to high exposure and microclimate zones under panels. Avoid species that grow too tall and shade solar panels.
- **Planting structure:** Incorporate varied low vegetation types such as tussocks and mat-forming species to support ecological diversity.
- **Disturbance mitigation:**
  i. Minimise artificial lighting (see Light Guideline). Where lighting is essential, use downward-facing, low-intensity amber light.
  ii. Limit human access where target fauna are sensitive to disturbance.
  iii. Create raised walkways or stepping pavers to minimise damage to flora and fauna.
- **Building height:** Roofs above five storeys may reduce access for species such as bees, bats, birds and butterflies due to limited connectivity with ground habitats.
- **Microclimates:** Create varied sun/shade areas and structural niches to support fauna.
- **Water management:** Irrigation is critical during establishment and for future sustainable growth. Account for varying moisture zones caused by panel shading via utilising free draining engineered media.

Optional (as needed):

- Install habitat analogues (e.g. insect hotels, bird perches, logs and rock piles).
- Incorporate surface water features or ephemeral pools.
- Adopt pesticide-free maintenance protocols.

LIMITATIONS

- Does not replicate the full ecological function of ground-level habitats.
- Favours mobile species already present in the local landscape.
- Shade can reduce flowering diversity, affecting pollinators and ecological services.
- Panel placement limits total vegetation coverage.
- Higher cost and technical complexity due to combined systems.

COMBINING WITH OTHER ELEMENTS

- Enhance biodiversity impact by connecting biosolar green roofs to other green infrastructure such as green walls or adjacent ground-level habitat. This enables movement for less-mobile species and strengthens ecological networks.

DESIGN CONSIDERATIONS

Structure:

- Confirm structural capacity for dead/live loads (e.g. saturated substrate + solar infrastructure).
- Coordinate systems across horticultural and electrical services.

Panels:

- Evaluate solar access, shading and optimal orientation.
- Design for clean cabling and inverter integration without compromising waterproofing.

Cost:

- Higher up-front costs than standalone green roofs or solar systems.
- Lower cost per m² when integrated into new builds compared to retrofits.

Wind:

- Assess wind loads and mitigate with secure panel mounts and resilient plants.

Substrate:

- Use engineered, lightweight media with high air filled porosity and hydraulic conductivity to cope with the varying exposed and shaded zones.
- Substrate depth 120-200mm.

Waterproofing:

- Specify high-performance membranes – incorporate non-penetration attachment systems for the solar sub-frame.
- Include leak detection systems.

Water management:

- Use smart irrigation with flow meters for ensuring flow has occurred and Rain-clik or similar to shut off watering if a recent rain event means it is not required.
- Account for rain shadow effects under panels.

Maintenance:

- Plan for safe access and long-term maintenance of both green roof and solar components.
- Budget for establishment and ongoing horticultural care.
- Prevent scheduling conflicts between solar system servicing and vegetation maintenance.

Fire safety:

- Select low-risk plant species.
- Integrate fire-rated materials.

APPLICABILITY

Suitable for single buildings and precinct-scale applications.

INTEGRATION ACROSS PROJECT LIFECYCLE

Masterplanning:

- Identify viable rooftops and high-level biodiversity/energy goals.

Concept design:

- Assess sun/shade conditions, wind, microclimate and structural capacity.
- Outline spatial layout for PV arrays and planting zones.

Detailed design:

- Specify plant species, irrigation systems, substrate depth and PV components.
- Detail maintenance protocols for both systems.

Construction:

- Coordinate waterproofing, irrigation, planting and solar array installation.
- Conduct quality assurance and system commissioning.

Operation:

- Monitor plant health and solar performance.
- Adapt maintenance as needed.
- Record biodiversity outcomes and energy savings.

BIODIVERSITY
CASE STUDY

CASE STUDY: DARAMU HOUSE

PROJECT OVERVIEW

Daramu House is a seven-storey mass timber commercial building located in Barangaroo—a 7.5-hectare waterfront urban renewal precinct on the western edge of Sydney's CBD.

The building features a 1,800 m² biosolar roof planted with 10,000 plants from 12 species (a mix of native and exotic), set within a 120 mm-deep substrate and supported by an integrated irrigation system. The roof also includes an insect hotel, beehive, bee watering areas and a variety of surface textures and loose materials to enhance habitat diversity.

A comparative research study led by the University of Technology Sydney evaluated the performance of the biosolar roof at Daramu House against a conventional solar roof on the nearby International House. The study explored benefits relating to biodiversity, air pollution, stormwater quantity and quality, insulation and renewable energy output.

Both rooftops were 1,800 m², with Daramu House supporting 590 m² of PV panels and a planted area of 1,460 m² (78.4% of roof space), with PV panels covering approximately 40.66% of the vegetated areas.

> **"The benefits provided by green roofs are clearly substantial. We observed increased biodiversity, reductions in some air pollutants, improved stormwater management, better insulation and a surprisingly high increase in solar energy output**
>
> — City of Sydney Final Report

Client:
Lendlease

Project type:
New build

Completion date:
2019

Location:
Barangaroo, Sydney NSW

First Nations Country:
Gadigal Country

Key Partners:

- Research partner: University of Technology Sydney
- Green infrastructure: Junglefy
- Developer: Lendlease
- Architect: Tzannes
- Local government: City of Sydney
- Energy consultant: Autonomous Energy

Image courtesy of Lendlease

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

Plants

The green roof includes a mix of native and non-native grasses and herbaceous plants selected to provide flowering throughout the year, attracting a diversity of fauna.

Shade-tolerant groundcovers such as *Viola hederacea* and *Dichondra repens* were planted beneath solar panels, while sun-exposed areas between panels feature bee-attracting species like *Dianella caerulea* and *Aptenia cordifolia*, an exotic groundcover.

Fauna

"We observed a nine-fold increase in insect species diversity and a four-fold increase in bird species diversity on the green roof. The presence of predatory species suggests the emergence of a functioning food web."

— City of Sydney Final Report

Plant succession was observed throughout the study, particularly in shaded zones beneath the panels—areas often difficult to cultivate. *Aptenia cordifolia*, for example, increased from ~6% to ~85% coverage, demonstrating the roof's self-regulating and adaptive qualities.

Species recorded on the biosolar roof included:

- **27 invertebrate species**, including Lychee Metallic Shield Bug (*Scutiphora pedicellata*), Australian Blue Banded Bee (*Amegilla cingulata*) and Garden Snail (*Cantareus aspersus*).
- **4 bird species**, including Spotted Dove (*Spilopelia chinensis*), Pied Currawong (*Strepera graculina*) and Australian Raven (*Corvus coronoides*).

Land

The study demonstrated that the biosolar roof helped moderate high ambient temperatures typical of the Australian climate. By reducing surface heat, the green roof contributes to urban heat island mitigation—offering a scalable strategy for cooling dense city environments.

Water

Stormwater: Modelling using DRAINS and SWMM software indicated that the green roof significantly reduced peak stormwater flow during rainfall events of varying magnitudes. Flow rates during a 1-in-40-year storm event were reduced by up to 600 L/s compared to the conventional roof.

Stormwater pollution: The biosolar roof demonstrated notable reductions in metal pollutants entering the stormwater system. Compared to the conventional roof, the green roof discharged lower levels of both soluble and insoluble copper, as well as insoluble zinc and chromium—likely due to plant uptake or sequestration, although these mechanisms were not directly tested in the study.

People

Insulation and thermal performance: Despite similar solar exposure across both test roofs, the green roof significantly reduced surface temperatures—by up to 20°C in some areas, including concrete flooring and exposed foliage.

Below the solar panels, both the average and maximum daily temperatures were consistently lower on the green roof. Interestingly, minimum temperatures were higher, highlighting the insulative benefits of the vegetated system. These effects reduce heat transfer into the building during hot periods and help retain warmth during cooler times—enhancing comfort and reducing energy demand year-round.

Atmosphere

Air quality

Green roofs have the potential to reduce air pollutant concentrations. In this study, ozone (O_3) levels were significantly lower on the green roof—likely due to uptake by plant foliage during photosynthesis. While nitrogen dioxide (NO_2) levels were unexpectedly higher, the cause remains unclear. PM2.5 results were affected by adjacent construction activity.

Estimated annual removal rates based on plant coverage were:

- 2.3 kg of NO_2
- 6.9 kg of O_3
- 0.5 kg of PM2.5

Renewable energy and PV performance

Both roofs generated substantial renewable energy over the study period:

- Green roof: 69 MWh
- Conventional roof: 59.5 MWh

After adjusting for variable factors, the biosolar roof produced 9.5 MWh more energy—valued at $2,595 over eight months. This performance boost is attributed to cooler surface temperatures enabling more efficient panel operation.

In terms of greenhouse gas mitigation:

- Green roof offset: 55.9 tonnes CO_2e
- Conventional roof offset: 48.2 tonnes CO_2e
- Additional sequestration from plant photosynthesis: ~1.1 tonnes CO_2e

"The green roof paired with the solar panels worked symbiotically—the plants cooled the surrounding area, allowing the solar panels to function at optimum efficiency, while the panels provided shade that helped the plants thrive."

— Junglefy

BIODIVERSITY
CASE STUDY

DESIGN CONSIDERATIONS

- **Irrigation system:** An integrated irrigation system was installed to support plant health, particularly during dry periods.
- **Panel placement:** Solar panels were carefully positioned to optimise energy generation while minimising shading of planted areas.
- **Panel type:** Panels were selected for compatibility with green roof conditions and maintenance needs.
- **Plant selection:** Drought-tolerant native species were prioritised for their low water use and ability to attract pollinators and other fauna.
- **Structural considerations:** Structural assessments were conducted to ensure the roof could safely support the combined load of vegetation, soil and solar infrastructure.

CONSTRUCTION CONSIDERATIONS

- **Structural integrity:** The building's structure was assessed and confirmed to support the combined weight of the green roof and solar panels.
- **Drainage:** A high-performing drainage system was installed to prevent waterlogging and support healthy plant growth.
- **Waterproofing:** A durable waterproof membrane was applied to protect the building from water ingress.
- **Fire safety:** Fire-resistant materials and design measures were incorporated to meet relevant fire safety standards.

OPERATIONAL CONSIDERATIONS

- **Weed management:** Ongoing removal of wind-dispersed weeds is essential to protect the health and integrity of the planted system.
- **Irrigation maintenance:** Regular inspections ensure the irrigation system continues to function effectively.
- **Stormwater performance:** The green roof continues to deliver a substantial reduction in stormwater runoff compared to conventional roofs.
- **Thermal regulation and energy performance:** The green roof improves thermal insulation, reducing indoor heat transfer and lowering energy use for heating and cooling. The integration of vegetation also moderates panel temperatures, supporting more consistent energy output throughout the year.

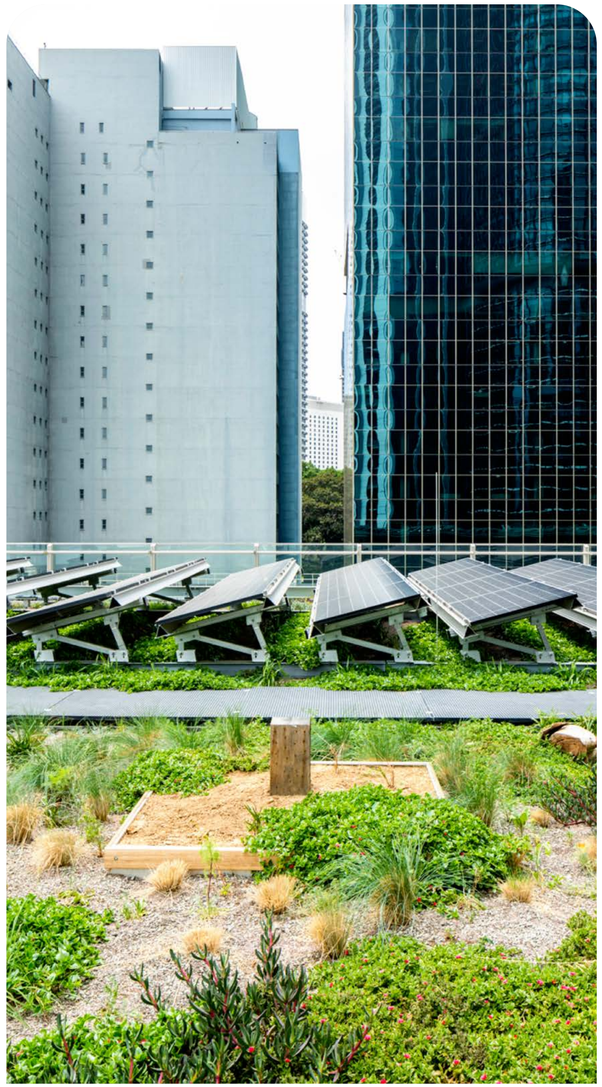


Image source: Tzannes

FURTHER READING

Fytogreen:
- Fytogreen Website

Livingroofs.org:
- Introduction to Biosolar Green Roofs

Green Roofs UK:
- Biosolar Roof Installation: The Ultimate Guide

Architecture Today:
- Biosolar Roofing Best Practice

Government Architect NSW:
- Biodiversity in Place

Junglefy:
- Daramu House

NSW Government:
- Biodiversity in Place: Daramu House case study

Tzannes:
- Daramu House

University of Techonology Sydney:
- Final Report: Green Roof & Solar Array – Comparative Research Project

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: EXTERNAL GREEN WALL

External green walls are engineered vertical ecosystems that transform otherwise bare building façades into living habitats. These systems integrate specialised growing media, diverse vegetation and controlled irrigation within a structural framework.

Unlike decorative green walls, biodiversity-focused systems are designed to provide habitat, support invertebrates and birds, and improve ecological connectivity across fragmented urban landscapes. When properly integrated, they offer thermal benefits, aesthetic value, and co-benefits for people and place.

System typologies

- **Modular systems** – Plants are housed in individual containers, limiting root spread and hydrological connectivity. Easier to install, maintain and replace, but limited in ecological function.
- **Integrated textile-type systems** – Use fibrous material as inert growing media, enabling continuous root development across the wall. Lightweight, hydroponic and better suited to supporting specialised, vertically adapted species.

BIODIVERSITY AND CO-BENEFITS

Biodiversity

- Creates habitat for invertebrates, birds, bats and microfauna, and increases urban plant diversity
- Supports pollination
- Enables inclusion of habitat analogues (e.g. bird and bat boxes)
- Increases ecological connectivity in the urban landscape

Land

- Contributes to urban greening
- Supports temperature regulation (reduces urban heat island effect)
- Reduces wind tunnel effect between solid structures

Water

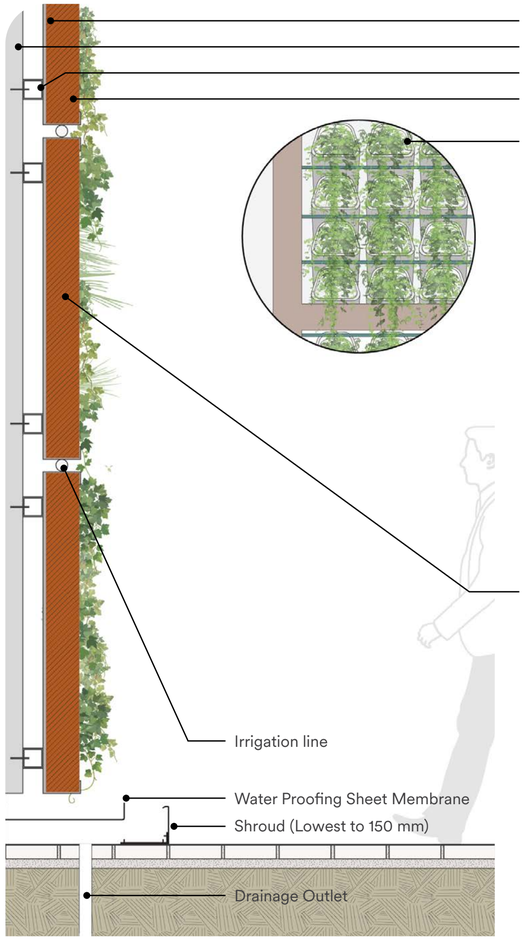
- Provides limited stormwater retention
- May improve local water quality
- Potential for rainwater harvesting

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration
- Carbon emission savings from reduced building energy consumption
- Provides noise attenuation

People

- Improves urban aesthetics
- Promotes mental wellbeing
- Reduces energy costs through insulation
- Supports connection to Country and nature
- Supports education and nature stewardship



External green wall

Wall Panel
Stainless Steel Wall Channel
Stainless Steel Purlin Fixed to Wall Channel
Growing Medium

Planting in Modular Systems

- Containerised/isolated modules:
  1. Plants housed in individual compartments within larger panel structures
  2. Root system bound by modules size
  3. Restricted hydrological interconnectivity
- Set modular sizes
- Modules placed adjacent to each other to give the perception of continuous green wall
- Limited ecological functioning
- Easy component replacement
- Fixed via structural framing and brackets
- Subject to a limited lifespan, and often systemised for replacement
- Suitable to a greater range of plants without the need to longevity

Planting in Integrated Textile-Type Systems

- Utilization of natural or synthetic fibrous material as inert growing media:
  1. Material available for continuous root development across panels
  2. Manufacutred in panels for easy transport, installation, and system integration
  3. Functions hydroponically, with controlled saturation and fertigation
- A lightweight solution with minimised profile
- Easy installation, simple fixing and non-intrusive to the host structure
- Long-lived and sustainable solution for the life of the build
- Suitable to a wide range of specialised plant species, inherently tolerant of vertical application and high environmental exposures

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Landscape connectivity planning:** Locate green walls within an existing or planned green infrastructure network, preferably near habitats where target biodiversity is already present.
- **System selection:** Select a system that supports functional biodiversity outcomes, including species diversity, system longevity, water quality management, and maintenance requirements.
- **Specialist expertise:** Engage designers with experience in aerial or vertical ecologies.
- **Plant selection:** Prioritise native and indigenous species with evolutionary adaptations for vertical habitats (e.g. cliff-dwelling, lithophytic, epiphytic). Avoid forcing terrestrial species into incompatible orientations.
- **Planting structure:** create diverse microhabitats through varied planting densities, spatial patterns, and stages of maturity.
- **Habitat analogues:** Integrate bird and bat boxes to replicate lost hollows and support nesting and roosting.
- **Height constraints:** Walls above five storeys may reduce accessibility for ground-dwelling or less-mobile fauna.

DESIGN CONSIDERATIONS

System Selection and Engineering

- Installation and maintenance require specialist skills beyond typical landscaping.
- Choose systems that support root development and long-term plant stability.
- Design for even moisture distribution and hydrological connectivity.
- Ensure safe, discreet access for maintenance without compromising aesthetics.
- Plan for long-term management to support both habitat value and system longevity.
- Coordinate carefully with building design for structural support and moisture management.
- Ensure ability to comply with Fire Engineer requirements.

Structural Requirements

- Conduct engineering assessments to confirm wall load capacity and support requirements.
- Account for saturated weight and increasing biomass over time.
- Design appropriate mounting and load distribution systems.
- Ensure material compatibility with host wall and local building code.
- Include seismic bracing or flexible connections where required.
- Assess feasibility for retrofit applications on existing structures.

Waterproofing and Moisture Management

- Install high-quality waterproofing membranes behind green wall systems.
- Seal all penetrations (mounts, irrigation feeds, drainage points) carefully.
- Include protective layers to prevent moisture ingress.
- Ensure a 10-20mm air gap between back of module and host wall.

System constraints:

- Performance varies significantly between system types, with limited standardisation.
- Poorly designed systems may suffer from substrate deterioration or limited root space.
- Modular systems offer ease of replacement but limit ecological complexity compared to integrated systems.
- Fire compliance.

Plant Selection and Ecology

- Select hardy species suited to vertical conditions, including exposure to sun, wind and shade.
- Prioritise plants with biodiversity value and local ecological relevance.
- Choose species with manageable maintenance needs and long-term survival.
- Match species to system characteristics, especially root volume.
- Plan for community succession and seasonal variation over time.
- Design should incorporate species compatibility over time.

BIODIVERSITY
DESIGN ELEMENT

DESIGN CONSIDERATIONS

Biological challenges:

- Avoid unsuitable terrestrial species not adapted to vertical growth.
- Recognise reduced lifespan of plants in non-natural orientations.
- Address gaps in aerial ecology expertise during design.
- Ensure system resilience to irrigation or lighting inconsistencies.

Growing Medium Options

- Substrate-based systems – Use engineered media.
- Hydroponic systems – Deliver nutrients in solution without soil.
- Each approach has unique requirements for water use, plant selection and maintenance.

Water Supply and Irrigation

- Design integrated drainage and water catchment systems.
- Where possible, connect to alternative water sources - stormwater, greywater or water re-use irrigation water tanks.
- Design dedicated irrigation systems with automated control and flow monitoring with alarms and remote access.
- Ensure adequate pressure and even distribution across elevation.
- Include remote monitoring and fault detection capabilities.
- Integrate fertigation systems where nutrient delivery is needed.
- Monitor water quality for pH, salinity and mineral content.
- Link irrigation systems to building management systems, if applicable.
- System design capable of integrating with either BMS activated fire alarm or Fire Board.

Environmental Assessment

- Assess wall orientation in relation to building and surrounding conditions.
- Map microclimates, considering sun, shade, wind and thermal variation.
- Conduct a light study to track daily and seasonal patterns.
- Anticipate more extreme environmental exposure than ground-level planting.

Maintenance and Access

- Develop a maintenance plan covering both establishment and long-term care.
- Define safe access methods (e.g. walk-up, rope, EWP) in early design.
- Provide clearance and load-bearing capacity for maintenance equipment.
- Ensure system design supports required maintenance frequency.
- Document safe work methods for both routine and emergency scenarios.

INTEGRATION ACROSS PROJECT LIFECYCLE

Masterplanning:

- Identify potential wall locations within the broader ecological network. Define biodiversity goals and target species. Assess building suitability and structural potential.

Concept design:

- Analyse local environmental conditions (sun, wind, shade, aspect). Select a suitable green wall system. Identify preliminary plant communities and microclimate zones.

Detailed design:

- Specify plant species and substrate types. Finalise irrigation, drainage and monitoring systems. Develop a project-specific maintenance plan.

Construction:

- Sequence installation to protect waterproofing and structure. Procure and establish plantings in line with design intent.

Operation:

- Monitor vegetation health, habitat performance and irrigation efficiency. Implement adaptive management strategies. Regularly update maintenance protocols and assess retrofit or upgrade opportunities.

APPLICABILITY

Suitable for individual buildings and precinct-scale applications. Highly combinable with other green infrastructure (e.g. green roofs, raingardens)

BIODIVERSITY
CASE STUDY

CASE STUDY:
THE STANDARD EXTERNAL GREEN WALL

Image courtesy of Fytogreen

Contributed by:
Fytogreen

Client:
Aria Property Group

Project type:
New build

Completion date:
April 2021

Location:
Manning Street, South Brisbane QLD

First Nations Country:
Yuggera Country

Key Partners:

- Architect: Woods Bagot
- Landscape Architect: Form
- Project Builder: Hutchinson Builders
- Design and installation: Fytogreen Australia
- Maintenance: Fytogreen Australia

PROJECT OVERVIEW

Located in the heart of Brisbane's Fish Lane arts precinct, this landmark development features Queensland's largest green wall, covering 410 m² with FC_FytoFelt living wall systems.

The spectacular vertical garden incorporates 68 plant species and more than 9,300 individual plants, creating a lush and vibrant façade. From the top of the podium down, the green wall brings vegetation into a dense urban environment while enhancing the building's architectural identity.

Image courtesy of Fytogreen

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Plant diversity:** The green wall incorporates 68 plant species and over 9,300 individual plants, including a tropical rainforest zone at its base. Selected species include native Australian cymbidium orchids and ferns placed in the protective niches of decorative steel columns, along with White Rabbit's Foot Fern and Green Mat-Rush.
- **Habitat creation:** By introducing a vertical landscape, the green wall provides nesting and foraging opportunities for birds and other urban wildlife—supporting habitat diversity in a highly built-up area.

Water

- **Improved water quality:** Vegetation within the green wall helps slow and filter rainwater, reducing the volume and velocity of runoff.
- **Water management:** The system incorporates rainwater harvesting and greywater reuse to minimise overall water consumption—supporting sustainable irrigation practices along with remote monitoring and flow alarms enabling live adjustment to climatic conditions.

Land

- **Reduced urban heat island effect:** By introducing dense vegetation across the building façade, the green wall helps cool the surrounding environment—reducing surface temperatures and contributing to mitigation of the urban heat island effect.

People

- **Aesthetic enhancement:** The green wall adds visual interest and appeal to both the building and its surroundings, creating a more inviting and pleasant environment.
- **Acoustic and visual privacy:** The vertical garden provides a natural buffer that enhances privacy and helps reduce noise from nearby streets and public spaces.
- **Positive street activation:** By transforming a blank façade into a living landmark, the green wall contributes to a more vibrant and engaging streetscape—drawing people into the area and supporting the cultural identity of the Fish Lane precinct.

Atmosphere

- **Air quality:** While not directly measured in this project, green walls are known to improve air quality by capturing airborne particulates and absorbing pollutants—contributing to a healthier urban microclimate.

DESIGN CONSIDERATIONS

Fire-resistant backing: The green wall system uses aluminium backing sheets covered with felt designed to comply with fire resistance standards in conjunction with engineered support solutions.

Species selection: Plants were chosen for their suitability to the vertical growing system, aesthetic value and ability to thrive in Brisbane's subtropical climate.

Microclimate integration: Niches within the decorative steel columns were used to shelter sensitive species such as native ferns and orchids, supporting plant health and diversity.

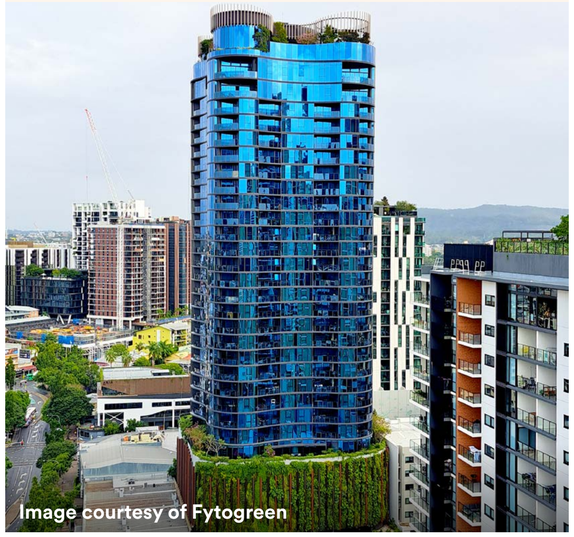


Image courtesy of Fytogreen

FURTHER READING

City of Melbourne:
- Growing Green Guide

Fytogreen:
- Green Walls

NSW Government Architect:
- Biodiversity in Place

NSW Department of Environment & Heritage:
- Green Roofs and Walls for Nature

Urban Ecosystems Journal:
- The Value of Green Walls for Birds

Latham Australia:
- Living Walls

Featured Project: The Standard, Brisbane:
- Greenroofs.com

WGIC Awards:
- The Standard's project video

Aria, The Standard:
- https://ariaproperty.com.au/project/the-standard/

Fytogreen Project Page:
- https://fytogreen.com.au/award-winning-the-standard/?srsltid=AfmBOoozqfgQWmgo57w09qtnmCfC4hPWsr0G6FsnsDNnKo9w0byczl7w

Vertical Garden Biodiversity:
- https://fytogreen.com.au/vertical-garden-biodiversity/

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: NOVEL HABITAT ANALOGUES

Biodiversity habitat analogues are artificial or modified environments designed to mimic the structure and function of natural habitats, capable of supporting some species when natural resources may be missing. These human-made features aim to provide shelter and nesting resources for native species that may be struggling in degraded or fragmented environments.

Habitat analogues encompass a wide range of elements that create small refuges for animals such as birds, bats, and invertebrates. Examples include artificial hollows, crevices, cracks, and refugia such as rocks or logs. These can be attached to buildings, integrated into building structures, or placed within open space areas.

Types of habitat analogues include:

- Habitat, roosting and nesting boxes
- Crevices, cracks, and small refugia
- Invertebrate or insect hotels
- Floating wetlands

> “Novel habitat analogues can be attached to or integrated into building structures, or installed within surrounding landscaping.

Design specifications vary significantly by species or species group (taxon), with key differences in:

- **Size:** internal volume and external dimensions
- **Shape:** suited to species-specific needs
- **Entrance design and orientation:** e.g. some birds enter from the side or top, microbats from below
- **Material:** thermal, textural, and structural suitability
- **Location and aspect:** including elevation, sunlight, and shelter conditions

Habitat analogues also create valuable opportunities for people to observe wildlife, particularly when designed to attract species that return regularly. Some artificial hollows can incorporate built-in monitoring tools, such as cameras or heat sensors, enabling direct observation of otherwise hidden fauna.

As such, habitat analogues not only support biodiversity but also foster nature connection, encourage stewardship, and provide opportunities for education, ecological literacy, and citizen science.

BENEFITS AND CO-BENEFITS

Biodiversity

- **Habitat creation**: Novel habitat analogues provide nesting sites or shelter for a diverse range of fauna, including invertebrates, birds, bats, frogs and reptiles. These features replicate natural elements—such as crevices, cracks, hollows, and holes—that would typically occur in old trees, fallen logs, rocks, or boulders.
- **Supports pollination:** Habitat analogues that attract invertebrates, such as native bees, help support local pollinator activity.

People

- **Nature stewardship:** Encourages positive human–nature relationships through education and engagement with biodiversity.
- **Caring for Country practices**: Supports Indigenous cultural connections to land and Country through habitat restoration and stewardship.

Image courtesy of Hollow Log Homes

BIODIVERSITY
DESIGN ELEMENT

HABITAT, ROOSTING AND NESTING BOXES

- **Artificial boxes replicate natural hollows** and are designed to provide nesting, roosting, and shelter.
- They are used by a variety of species, including bats, arboreal mammals, some lizards, frogs, snakes, and a wide range of birds—from small species like spotted pardalotes to larger ones such as black-cockatoos.
- Boxes are commonly constructed from sustainably sourced plywood (minimum 15 mm thick) or food-grade HDPE.
- They can be attached to building exteriors, hung from trees, or mounted on other tall structures.
- To protect tree health, attachment systems must allow for tree growth. Systems like the **Habisure® system** or similar are recommended. Screws or hardware that penetrate and damage the tree can compromise tree health and increase the risk of the box falling.
- Boxes are best placed in quiet areas to reduce disturbance to occupants.
- **Natural hollows** can also be created by cutting into dead trees where safe and appropriate.
- Box designs vary significantly depending on the target species, with factors such as size, shape, material, height, aspect, and entrance design tailored accordingly. Examples include:
  - **Bird nesting boxes:** Small entrances for species like pardalotes and rosellas; open-fronted designs or large spouts for kookaburras, ducks, and owls; extra-large openings for cockatoos.
  - **Possum boxes:** Designed for brush-tail and ringtail possums; typically feature either front- or rear-facing entrances.
  - **Microbat boxes:** Available in single or multi-chambered configurations, offering daytime roosts and maternity sites.
  - **Glider boxes:** Provide shelter and nesting for sugar gliders, squirrel gliders and others; typically rear-facing to deter birds. A single glider family may require at least five separate shelters.
  - **Bat boxes** can be used to provide alternative roosting opportunities for crevice-dwelling bats—especially when roosting in crevices of structures like bridges (e.g. expansion joints) or culverts (e.g. joins between culvert sections) is not desirable.

Note: Nest box specifications—including size, entrance type, placement and orientation—must be tailored to the ecological needs of the target species. As such, all designs should be developed or reviewed by a qualified professional to ensure functionality, safety, and species-specific suitability.

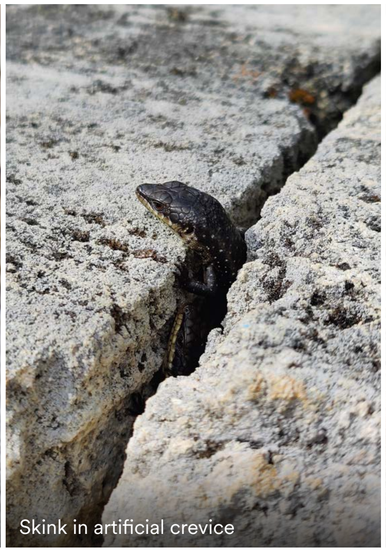
Images courtesy of Hollow Log Homes

BIODIVERSITY
DESIGN ELEMENT

SMALL REFUGIA

- Primarily designed to provide shelter, rather than nesting sites
- Used by a variety of species including lizards, frogs, and some invertebrates.
- Can be created by piling bricks or slabs, moulding or cutting slots into substrates, forming tunnels with terracotta or concrete pots, or constructing wooden ground boxes. Gabion walls can also serve as refugia.
- Leaving dead wood in the landscape can provide excellent refugia for a range of species, especially large logs with bark or loose layers of wood.
- Tree frogs require a specific design, such as vertical pipes that hold water and remain damp.
- Size, shape, and materials must be tailored to the needs of the target species.
- Placement is critical: refuges for ground-dwelling species should be near the ground, while those for climbing species (e.g. geckos) can be positioned higher on walls or structures.

Jacky Dragon on habitat log



Skink in artificial crevice

Gecko hotel

Images courtesy of Holly Kirk

CREVICES AND CRACKS IN BUILDINGS AND STRUCTURES

- Designed to be integrated into buildings or structures such as bridges and culverts. Bats are known to use existing features, including culvert joins and bridge Super-T girder expansion joints.
- Primarily provide shelter, not nesting, for birds and serve as roosting and breeding sites for microbats.
- Size and shape should be tailored to the target species.

Integrated bat box in wall structure

Image source: www.nestbox.co.uk

Integrated bat box

Image source: www.wildcare.co.uk

BIODIVERSITY
DESIGN ELEMENT

INVERTEBRATE HOTELS

- Designed to provide nesting and shelter.
- Used by a variety of species including native bees, wasps, moths, spiders, and other small invertebrates.
- Constructed from materials such as drilled bricks, mud bricks, wooden blocks, bamboo bundles, and bundles of sticks.
- Designs vary depending on the target species—particularly among native bees, which nest in different structures depending on the group.
- Can be attached to buildings, incorporated into gabion walls, placed in open space landscaping, or—via bee bricks—integrated into the built form. Note: bee bricks only support a small subset of bee species.

Image source: Weeds & Wildflowers

Image source: Learning Landscapes Design

Daramu House Bee Hotels

Image courtesy of Lendlease

FLOATING WETLANDS

- Primarily designed to improve water quality and reduce pollutants, while also providing nesting and shelter opportunities for wildlife.
- Used by a variety of species, including cormorants, darters, ducks, gulls, black swans, frogs, reptiles (e.g. water dragons, turtles), aquatic invertebrates, and even small mammals.
- The structure consists of a constructed raft planted with native species and integrated habitat features, replicating natural riparian and wetland habitats.
- Habitat elements may include perching posts, drying banisters, basking areas, sunken plantings, and access ramps.
- Designed with soft, low-lying edges to allow easy access from the water.
- Moorings and anchors are used to keep the structure in place.

Birrarung Floating Wetland, Melbourne

Image courtesy of Holly Kirk

BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

Interactions with habitat
Habitat analogues must be complemented by appropriate ground-level, vertical, or rooftop planting using diverse native vegetation that provides food resources, and, where necessary, water sources.

Providing a range of analogue types on site can enhance biodiversity outcomes. For example, installing both bird nesting boxes and bat boxes helps prevent small passerine birds from occupying bat boxes by offering suitable alternatives.

Materials
Materials used for habitat analogues must be non-toxic and free from chemicals that could harm the target species or their young—especially in nesting structures. Avoid materials like black plastic, which can overheat, or others that may pose hygiene risks.

Appropriate design for species
One size does not fit all. Habitat analogues should be species-specific in design and placement.

- Understand which species are present or could access the site from the surrounding landscape.
- Consult with a local ecological expert to ensure analogue features meet local species requirements.
- Consider potential risks to non-target species. For instance, large artificial hollows should include escape routes for smaller animals that may fall in.

Ongoing monitoring and research

Allocate budget and resources for long-term monitoring of habitat analogue use and biodiversity outcomes.

- Longer monitoring periods improve the conservation value of data.
- Consider partnering with local universities or research organisations to support data collection, analysis, and industry-wide knowledge sharing.

Ongoing maintenance/cleaning

Regularly maintain and inspect all habitat analogue structures.

- Replace or repair damaged or degraded boxes that no longer provide adequate shelter (e.g. allow rain or wind entry).
- Well-maintained boxes are more likely to remain in active use and contribute to ongoing habitat value.

LIMITATIONS

- Habitat analogues provide supplementary shelter or nesting sites for species lacking these in urban environments. However, they must be paired with landscaping that includes appropriate plant species to supply food resources. Artificial shelters without nearby food will likely go unused.
- These features do not replicate the full ecological value of natural habitats and should not be treated as replacements, offsets, or compensation for habitat loss.
- Designs are species-specific—size, shape, material, and placement vary by animal group. Design guidelines are now available for most Australian fauna (see links below).
- Landscape context matters. For example, nest boxes for disturbance-sensitive species are unlikely to succeed in busy urban areas. Ecological advice should guide target species selection.
- Many species adapt well to cities. In commercial or industrial areas, analogues should focus on invertebrate hotels or shelters for lizards and birds, rather than nesting boxes for sensitive fauna.

DESIGN CONSIDERATIONS

- Design must be species-specific – Each species or group has unique requirements. Specifications such as size, shape, and entrance type vary greatly.
- Maintenance is essential – Nesting hollows, especially for birds, should be designed for seasonal cleaning to prevent disease transmission.
- Material selection matters – Materials should be appropriate for the target species. In general, natural, untreated, and light-coloured materials are preferred to avoid overheating.
- Weatherproofing and access – Most nest boxes must be waterproof and include an additional opening for inspection and cleaning.
- Bee hotels – Designed for nesting, these must be cleaned and emptied regularly. Materials must not be treated with insecticides or other harmful chemicals.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Master Planning:** Ideally considered at the masterplan stage so that costs can be embedded into the project budget. Establish broad biodiversity goals early.
- **Concept Design :** Identify potential locations for habitat analogues within the site layout.
- **Detailed Design :** Integration is essential at this stage, especially when habitat features are to be built into the building form.
- **Construction:** Install habitat analogues as part of construction works.
- **Retrofit:** Habitat features can also be retrofitted to existing buildings or structures where integration during construction is not possible.

APPLICABILITY

- Suitable for single buildings as well as buildings within larger precincts
- Can potentially be integrated with lighting fixtures or other pole-based infrastructure
- May also be combined with green roofs, external green walls and green façade designs

BIODIVERSITY
DESIGN ELEMENT

Images courtesy of David Francis and Hollow Log Homes

FURTHER READING

Hollow Log Homes:
- https://www.hollowloghomes.com.au/

BirdLife Australia:
- https://www.birdsinbackyards.net/Nest-Box-Plans-0

DELWP, Victorian Government:
- https://www.ari.vic.gov.au/__data/assets/pdf_file/0024/328191/Nest-box-fact-sheet-general-guide.pdf

Wildlife Preservation Society of Queensland:
- https://wildlife.org.au/how-to-build-a-frog-hotel/

Rewild Perth:
- https://rewildperth.com.au/resource/bobtail/

Aussie Bee:
- https://www.aussiebee.com.au/bee-hotel-building-tips.html

Australasian Bat Society:
- https://www.ausbats.org.au/bat-fact-sheets.html

Ecological Society of Australia:
- https://www.ecolsoc.org.au/bulletin/floating-wetlands-wildlife-habitat/

City of Melbourne:
- https://www.melbourne.vic.gov.au/birrarung-trial-floating-wetlands

BIODIVERSITY
CASE STUDY

CASE STUDY: HOLLOW LOG HOMES

Image courtesy of Hollow Log Homes

Project type:
Installation of new nesting boxes

Completion date:
Ongoing – audits conducted annually from 2023 to 2025 as part of a seven-year program

Locations:
Logan, Queensland

First Nations Country:
Yuggera, Yugambeh & Turrbal Country

Key Partners:
Hollow Log Homes

Image courtesy of Hollow Log Homes

PROJECT OVERVIEW

A Nest Box Strategy was implemented in 2020, with 521 nest boxes installed by Hollow Log Homes in 2022. The boxes were distributed across a 100-hectare area within a larger designated conservation zone in Logan, Queensland.

The project includes a seven-year auditing program designed to track patterns of use across the site's ecological corridors. Audits have been completed in 2023, 2024 and 2025.

BIODIVERSITY
CASE STUDY

BENEFITS AND CO-BENEFITS

Biodiversity

In the 2025 audit, 511 of the 521 nest boxes were reviewed. Fourteen species were recorded using 371 boxes, reflecting a 72% habitation rate—consistent with 2024 and an improvement from 68% in 2023.

Key findings include:

- **Possums:** 41 possums were directly sighted, with evidence of use in another 63 boxes. Two species were observed: the Common Brushtail Possum (most prevalent) and Ringtail Possum (sighted in 2 boxes, with evidence of use in 10 more). Possums accounted for 23% of all habitation.
- **Microbats:** Sighted in 7 boxes, with signs of use in one additional box. These species were also recorded in previous audits (2023, 2024).
- **Scansorial mammals:** Antechinus were sighted in 2 boxes, with additional evidence of use by Antechinus, Melomys and Phascogales in 14 boxes. Their overall habitat presence increased in 2025. It's likely that some boxes with "undetermined" evidence were also used by these small mammals.
- **Birds:** Five bird species were identified, with evidence of nesting. The Owlet-nightjar was most common, alongside Wood Ducks, Treecreepers, Rainbow Lorikeets and others.
- **Native bees:** Two boxes were occupied by native bees, indicating strong ecological health and biodiversity.

Image courtesy of Hollow Log Homes

BIODIVERSITY
CASE STUDY

CASE STUDY:
BELVOIR LAKE FLOATING WETLANDS

PROJECT OVERVIEW

The Belvoir Lake Floating Wetlands project is a nature-based initiative funded by the City of Wodonga, designed and delivered by Fytogreen Australia to improve biodiversity, water quality, and community engagement in an urban park setting. Installed in September 2023, the system comprises 12 modular floating wetland units covering 50 m², located within Belvoir Park Lake—a key ecological and recreational space in Wodonga.

Each module is constructed using durable, buoyant, and recyclable materials, supporting a hydroponic growing system that hosts 360 plants from 9 native wetland species. These plants provide habitat and food for aquatic birds, turtles, insects, and amphibians, while also filtering nutrients and pollutants from the water.

The wetlands are designed to be publicly visible and accessible, with educational signage and walking paths encouraging community interaction. The project also supports local conservation efforts, including turtle monitoring walks led by the Wodonga Urban Landcare Network.

This installation serves as a replicable model for urban lakes and stormwater basins across Australia, demonstrating how floating wetlands can deliver ecological, social, and climate adaptation benefits in public green spaces.

Client:
City of Wodonga

Project type:
Public green space enhancement

Completion date:
September 2023

Locations:
Belvoir Park Lake, Reuss Road, Wodonga VIC 3690

First Nations Country:
Wiradjuri and Dhudhuroa Country

Key Partners:

- Fytogreen Australia
- Wodonga Urban Landcare Network

Image courtesy of Fytogreen

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Habitat provision:** The floating wetlands provide a refuge for a variety of aquatic and terrestrial species, offering new breeding, resting and feeding habitats within the highly urbanised environment.
- **Plant selection:** The floating wetlands at Belvoir Lake incorporate 360 plants from 9 native wetland species, selected for their ecological compatibility with the lake's aquatic environment. These species were chosen to support local biodiversity, including aquatic birds, amphibians, and turtles, while thriving in the nutrient-rich conditions of the lake.
- **Fauna observations**
  Since installation, the wetlands have attracted a variety of wildlife:
  - Waterbirds such as ducks, coots, and herons have been observed nesting, foraging, and resting on the modules.
  - Eastern long-necked turtles use the structures for basking and shelter.
  - Aquatic insects and amphibians are increasingly present, indicating improved habitat quality.

  Fauna-focused design elements
  The wetlands were designed with wildlife in mind, incorporating:
  - Low-profile edges to allow easy access for swimming birds and turtles.
  - Open central zones within modules to provide safe swimming areas for ducklings and small aquatic species.
  - Vegetation density and layering to offer shelter, nesting sites, and foraging opportunities.
  - Buoyant, stable platforms that tolerate movement and interaction from wildlife without compromising structure or plant health.

Land

- **Climate regulation:** Floating wetlands help cool surrounding water bodies and reduce the urban heat island effect by reintroducing greenery and moderating local microclimates—especially in areas dominated by concrete edges and built form.

Atmosphere

- **Carbon sequestration:** Native wetland vegetation contributes to carbon capture through photosynthesis, helping sequester carbon in both plant biomass and root systems.

Water

- **Water quality improvement:** Wetland plants act as natural filters—absorbing excess nutrients and pollutants. Their exposed root systems provide surface area for biofilms and beneficial microbes that further enhance pollutant removal. This supports reduced algal blooms and cleaner, healthier water.
- **Improved clarity:** By lowering nutrient and sediment loads, the wetlands help improve water clarity, enhancing light penetration and supporting submerged aquatic vegetation.
- **Subsurface root habitat**: Plant roots extend over a metre below the floating structures, creating diverse microhabitats that support algae, bacteria and invertebrates—all contributing to pollutant breakdown and improved ecosystem function.
- **Temperature regulation:** The vegetation provides shade, reducing solar exposure on the water's surface and contributing to more stable water temperatures.

People

- **Recreational value:** The wetlands enhance the visual appeal and recreational potential, creating spaces that encourage passive enjoyment such as birdwatching and riverside walking.
- **Aesthetic and sensory benefits:** By softening hard urban edges, the wetlands contribute to a more calming, nature-connected environment—improving amenity and public enjoyment.
- **Educational opportunities:** The wetlands serve as living classrooms—offering hands-on learning about water quality, biodiversity and ecosystem restoration for schools, universities and the wider community.
- **Connection to Country:** Belvoir Park Lake is located on land traditionally cared for by the **Wiradjuri people**, whose deep connection to water and Country continues to shape the region's cultural landscape. The floating wetlands offer an opportunity to reflect on and respect this connection, while promoting ecological stewardship in a shared public space.
- **Community engagement:** The project has fostered strong local involvement through collaboration with the **Wodonga Urban Landcare Network**, which supports wildlife monitoring and community education. Public interest has grown through events like **turtle conservation walks**, and the wetlands' visibility within the park encourages ongoing community pride and environmental awareness.

CONSTRUCTION CONSIDERATIONS

- **Material selection:** Fytogreen's floating wetlands are built using Australian-made, long-life components engineered for durability, positive buoyancy, and resistance to aquatic degradation.
- **Plant palette:** Each module supports 100% vegetation coverage, allowing extensive root growth and stratified foliage that creates diverse habitat niches for wetland fauna.
- **Bringing back greenery:** The system reintroduces verdant plantings into urban water bodies, enhancing ecological function, visual appeal, and habitat value in public spaces.
- **Anchoring system:** Modules are tethered using in-lake or bank anchor systems, designed to restrict lateral movement while allowing vertical flexibility with water level changes.
- **Water interaction:** The hydroponic design ensures plants absorb nutrients directly from the water column, promoting efficient pollutant uptake and bio-remediation.

MODULAR SYSTEM

- **Modular design:** Each module is lightweight (25 kg dry weight) and expandable to over 1,000 m², with engineered buoyancy supporting up to 300 kg per module for flora, fauna, and maintenance.
- **Surface treatment:** Modules feature a fibrous structure that supports root penetration and microbial biofilm formation, enhancing water treatment capacity.
- **Planting strategy:** Indigenous wetland species are selected to meet project goals, with root systems extending into multiple temperature and light zones, supporting aquatic biodiversity.
- **Sediment resilience:** Floating design avoids sediment disturbance and helps control silt deposition by moderating water flow.

OPERATIONAL CONSIDERATIONS

- **Informing future decisions:** The Belvoir Lake installation serves as a replicable model for urban lakes and stormwater basins, demonstrating scalable ecological benefits.
- **Monitoring and maintenance:** Fytogreen provides ongoing maintenance, including plant health checks, weed control, and seasonal replanting, supported by community wildlife monitoring.
- **Maintenance access:** The system remains above the waterline when walked on, allowing safe and easy access for vegetation management and debris removal.

BIODIVERSITY
CASE STUDY

CASE STUDY:
MONASH UNIVERSITY POLLINATOR PADS RESEARCH PROJECT

PROJECT OVERVIEW

Declining bee populations pose a growing threat in urban environments. The Pollinator Pads Research Project—led by OCULUS in collaboration with Monash University—aims to address this issue through research, design and prototyping of affordable insect habitat structures.

The project began with ecological investigations at Monash University's Clayton campus to identify broad taxonomic groups and priority pollinator species. Drawing on global research into effective insect hotel designs, OCULUS then explored the specific nesting and habitat needs of native bees.

The result is a patent-pending design developed with Monash University and fabricator Tony Smith. It was prototyped, field-tested and designed to be scalable and affordable through mass production using recycled plastic.

Owner:
Monash University

Project type:
New build

Completion date:
2023

Locations:
Clayton, VIC

First Nations Country:
Bunurong Country

Key Partners:

- OCULUS
- Monash University

Artist impression. Image courtesy of OCULUS

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

The project identified key habitat needs for native pollinators, including their foraging, nesting and burrowing behaviours; microclimate preferences; proximity requirements; suitable plant species; and environmental threats.

Suggested infill materials—such as rammed earth, masonry, rocks, hardwood with drilled holes, bamboo, rotting wood and dry pithy-stemmed plants—provide diverse nesting options for a range of bee species.

DESIGN CONSIDERATIONS

The project was grounded in deep collaboration—with ecologists, researchers, manufacturers and community groups informing the final outcome. A strong understanding of site conditions underpinned the design process, including research into local plant species, native bee behaviour across Monash campuses and the microhabitats needed for successful nesting.

Key design considerations included:

- **Nest elevation:** Pads are raised above ground level to reduce exposure to ground-dwelling threats like ants and spiders and to avoid ground moisture.
- **Drainage design:** Integrated to prevent waterlogging and moisture build-up, reducing risks of mould and bee mortality.
- **Modular construction:** Allows for relocation, scalability and future mass production.
- **Protective barriers:** Optional barriers prevent birds from removing infill materials for nesting.
- **Use of colour:** Colour selection—without excessive patterning—supports bee recognition, navigation and memory.
- **Weather protection:** Sheltered nest entrances create favourable microclimates that encourage occupation.

CONSTRUCTION CONSIDERATIONS

The project integrates materiality, modularity and sculptural form to create a habitat structure that is both functional and visually engaging.

- **Modular system:** Designed for ease of replication, large-scale production and potential community distribution. Modular elements also improve accessibility and allow for easier cleaning.
- **Site integration:** Where a natural water source is unavailable, artificial water bodies are recommended nearby.
- **Vegetation support:** Surrounding planting provides foraging opportunities and access to nesting materials for bees.
- **Recycled materials:** The patent-pending design was prototyped using recycled plastics, aligning with the project's goals for affordability, scalability and sustainability.

OPERATIONAL CONSIDERATIONS

- **Seasonal maintenance:** Access points allow infill materials to be cleaned or replaced in spring—minimising pest risks, encouraging renewed nesting activity and enabling monitoring of bee use.
- **Monitoring potential:** The modular design offers opportunities for ongoing research, education and data collection on pollinator behaviour and habitat effectiveness.

FURTHER READING

Fytogreen: Water is Life – Floating Wetlands

- https://fytogreen.com.au/water-is-life/

Melbourne's Floating Wetlands:

- https://www.youtube.com/watch?v=3DluOzl348w&t=41s

BIODIVERSITY
DESIGN ELEMENT

DESIGN ELEMENT: LIVING SEAWALLS AND HABITAT ENHANCEMENT MODULES

Urban shorelines are often hardened with structures like seawalls, pilings and revetments, which typically lack the complexity of natural habitats. Living Seawalls offers a science-led solution to retrofit or integrate habitat features into these structures, enhancing their ecological value without compromising function.

Built on over 20 years of research, Living Seawalls modules improve biodiversity by mimicking natural marine features. Installed in locations like Sydney Harbour, these panels have been shown to support up to 36% more species than unmodified seawalls. Benefiting organisms include invertebrates, seaweeds and fish, which shelter, feed and reproduce within the microhabitats provided.

Living Seawalls blends marine ecology with innovative industrial design, creating textured surfaces that support colonisation and growth and provide shelter against predation. Panels can also buffer organisms against heat exposure.

> “these panels have been shown to support up to 36% more species than unmodified seawalls.

BIODIVERSITY AND CO-BENEFITS

Biodiversity

- Creates habitat for invertebrates, seaweeds and fish, enhancing ecological value of grey infrastructure
- Increases habitat connectivity

Water

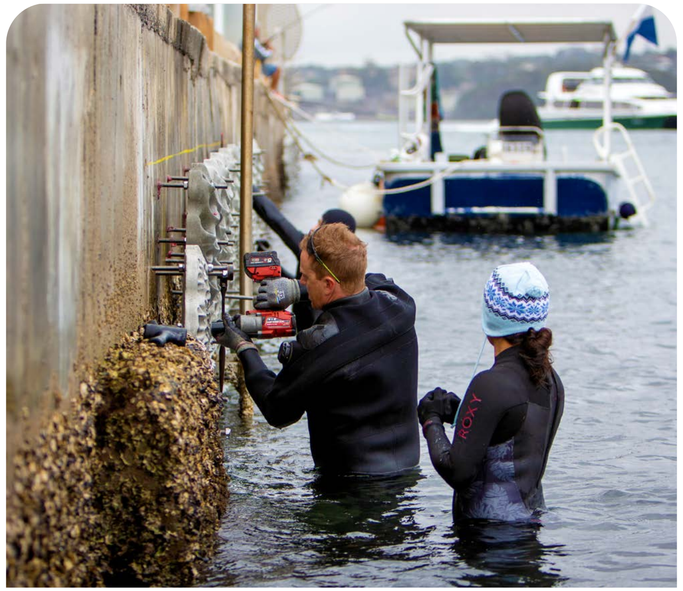
- Potential to improves water clarity where filter-feeders (e.g. oysters, mussels) colonise panels
- Can support localised water quality improvement

People

- Enhances connection to Country and Nature
- Enables Caring for Country practices
- Supports recreational activities (swimming, fishing, kayaking)
- Improves aesthetics of shoreline environments
- Enables education, interpretation and citizen science
- Fosters marine stewardship

Image courtesy of Alex Goad

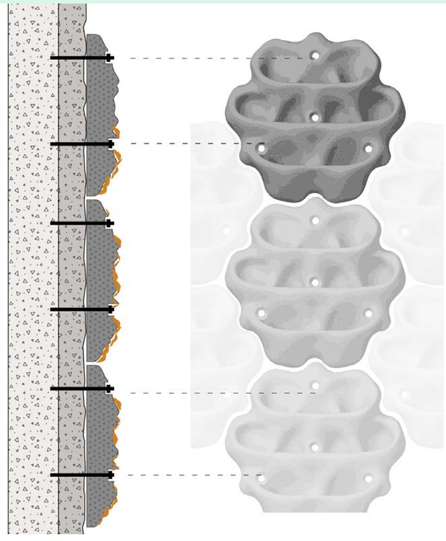
BIODIVERSITY
DESIGN ELEMENT



Images courtesy of Leah Wood

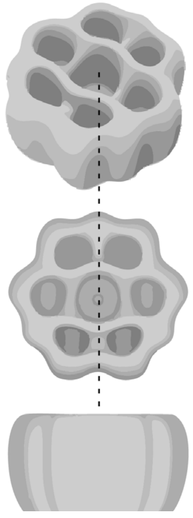
LIVING SEAWALL PANELS

- Ten+ panel designs inspired by natural shoreline features (e.g. crevices, sponge forms)
- Cast in eco-blend cement (includes fly ash, slag, recycled aggregates) from reusable silicon moulds, produced from 3D printed blanks
- Designed by Reef Design Lab using site-specific ecological data
- Modular, scalable and lightweight (23–27 kg)



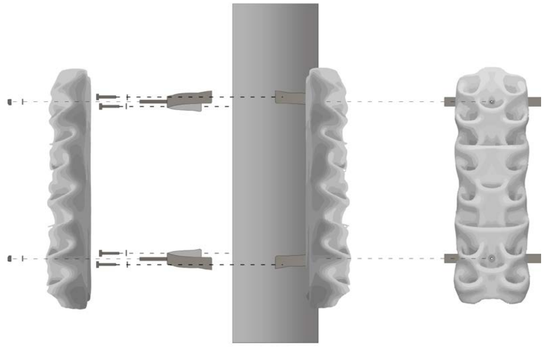
LIVING BOULDERS

- Artificial rock units with integrated rock pools,
that support biodiversity
- Designed to sit within breakwaters and revetments
- Design can be modified to ensure seamless placement



LIVING PILINGS

- Strap-on habitat modules for marine piles
- Made from eco-blend concrete and stainless steel
- Weigh approx. 73 kg
- Designed for durability, low maintenance and habitat uplift



BIODIVERSITY
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Ecological integration:** Collaborate with marine ecologists early to align module types with local species and environmental conditions.
- **Surface complexity:** Panels with textured surfaces and cavities replicate key features of natural habitats such as rocky shores.
- **Local species presence:** Success depends on the presence of larval stages of marine organisms in the surrounding waters.
- **Durability:** Materials and formwork are designed for long-term submersion and structural integration.

LIMITATIONS

- Cannot replicate the ecological value of undisturbed natural shorelines.
- Not suitable for highly polluted or degraded sites where marine species are absent.
- Works by enhancing colonisation—requires larval supply and water quality conducive to survival.

COMBINING WITH OTHER ELEMENTS

- Living Seawalls modules can be paired with intertidal planting, floating wetlands, or adjacent shoreline revegetation to amplify ecological outcomes and support greater habitat connectivity across blue–green infrastructure.

DESIGN CONSIDERATIONS

Two delivery pathways:

- **Integration (new builds):** Collaborate at the design stage to incorporate modules into formwork or panel systems.
- **Retrofit (existing infrastructure):** Attach habitat modules to existing seawalls, revetments or pilings without structural changes.

Materials:

- Made from Eco-blend concrete (30 MPa), including recycled industrial by-products and aggregates.
- Reinforced with Mateenbar composite (non-corrosive).
- Panels have a design life of 20+ years, with increased longevity due to biological colonisation.

Installation:

- Requires coordination with structural engineers and marine contractors.
- Living Boulders and Piling Modules designed for ease of installation without anchoring or heavy equipment.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify shoreline zones suitable for habitat retrofit or integration. Define objectives of installation, including e.g. increased biodiversity, enhancement of a particular function, community outreach etc.
- **Concept Design:** Determine applicable module types based on local shoreline form, species presence, and project goals.
- **Detailed Design:** Finalise modules layouts, installation methods and long-term monitoring approach.
- **Construction:** Install modules with quality control for materials and placement.
- **Operation:** Monitor ecological colonisation, maintain public safety, and adapt management strategies. Assess future retrofit opportunities.

APPLICABILITY

- Suitable for buildings and precincts with aquatic-facing infrastructure
- Applicable to intertidal and subtidal structures
- Can be integrated or retrofitted to seawalls, revetments, breakwaters, pilings and pontoons

BIODIVERSITY
CASE STUDY

CASE STUDY: BARANGAROO LIVING SEAWALL

Image courtesy of Aria Lee

PROJECT OVERVIEW

The Barangaroo Living Seawall is a pioneering Australian retrofit project located beneath the Watermans Cove boardwalk in Sydney. Completed in November 2020, it features 384 habitat enhancement panels—the largest Living Seawalls installation at the time—designed to introduce important natural marine environments such as rock pools, oyster clusters, sponge fingers and kelp holdfasts in a highly modified urbanised area. Installed at intertidal and subtidal depths on a bespoke frame connected to existing pylons, the panels provide 96 m² of complex habitat for marine life.

The project was designed not only to improve local biodiversity but also to demonstrate how urban marine environments can be retrofitted to improve the health of highly modified habitats. Ongoing scientific monitoring led by the Sydney Institute of Marine Science (SIMS) is informing future marine infrastructure projects and coastal planning.

Client:
Infrastructure NSW

Completion date:
2020

Project type:
Retrofit using a bespoke frame system

Contributed by:
Sydney Institute of Marine Science

Location:
Watermans Cove, Barangaroo, NSW

First Nations Country:
Gadigal Country

Owner:
Public project supported by Infrastructure NSW and Lendlease

Key Partners:

- Lead Scientist & Monitoring: Sydney Institute of Marine Science
- Design & Fabrication: Reef Design Lab
- Installation: Lendlease
- Funding & Oversight: Lendlease and Infrastructure NSW
- Plant operator: AquaSure

Image courtesy of Aria Lee

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- Installation of 384 Living Seawall panels, covering 96 m² of habitat across intertidal and subtidal zones
- Over 100 native species observed within 16 months (80 intertidal, 85 subtidal)
- Indigenous brown kelp (Ecklonia radiata) transplanted to encourage colonisation
- Non-indigenous species reduced to 0.1% by gardening (from 32% pre-installation)
- 22 native fish species observed; previously, no fish were recorded
- Kelp holdfast design supported the highest biodiversity; Horned Blenny (Parablennius intermedius) was the most abundant fish
- Results demonstrate urgent need for nature-inclusive design in urban marine infrastructure

Water

- Potential to support localised water quality improvement by promoting growth of filter-feeders

People

- Public boardwalk above creates passive observation opportunities and educational value

DESIGN CONSIDERATIONS

Unlike traditional installations that retrofit vertical seawalls, this project demonstrates the versatility of Living Seawalls by mounting panels on a custom horizontal frame attached to concrete piles—highlighting the modular adaptability of the system.

CONSTRUCTION CONSIDERATIONS

- Panels fabricated in five distinct bioinspired designs
- Materials chosen to withstand marine conditions
- Weight of panels and supporting structures carefully considered during design and installation

OPERATIONAL CONSIDERATIONS

- Ongoing scientific monitoring and ‘gardening’ of panels to remove invasive species
- Performance tracking through 2026 to guide future design, maintenance and policy development

PROJECT COSTS

- AUD $180,000 for panel design (5 types) and fabrication (384 units)
- Installation funded by Lendlease
- Monitoring and data analysis funded by Infrastructure NSW

FURTHER READING

Sydney Institute of Marine Science:

- Living Seawalls

Barangaroo Living Seawall project:

- Infrastructure NSW

Reef Design Lab:

- www.reefdesignlab.com

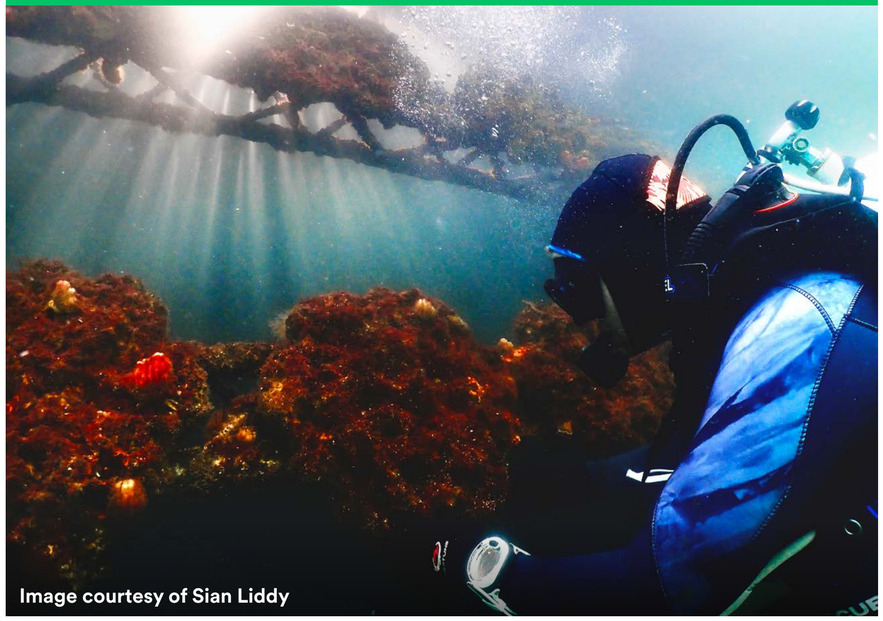


Image courtesy of Sian Liddy

BIODIVERSITY
CASE STUDY

CASE STUDY:
GOOWEEBAHREE / LAVENDER BAY LIVING BOULDERS

Image courtesy of Aria Lee

PROJECT OVERVIEW

Gooweebahree/Lavender Bay Living Boulders project introduces artificial boulders embedded with rockpool habitats along the modified revetment shoreline of Sydney Harbour. Installed in April 2023, the first 15 units were strategically placed among existing shoreline rocks, along the intertidal area, to create missing water-retaining features for native marine species.

Funded through a partnership between Sydney by Kayak and North Sydney Council, the project merges citizen engagement with ecological rehabilitation. It represents an innovative model where eco-tourism directly supports biodiversity outcomes while raising public awareness of local sustainability initiatives.

Client:
Sydney by Kayak and North Sydney Council

Contributed by:
Sydney Institute of Marine Science

Project type:
Retrofit using artificial rockpools

Completion date:
2023

Location:
Lavender Bay, Sydney Harbour, NSW

First Nations Country:
Cammeraygal Country

Key Partners:

- Community Partner & Funder: Sydney by Kayak
- Installation & Maintenance: North Sydney Council
- Scientific Monitoring: Sydney Institute of Marine Science, with funding from the NSW Environmental Trust
- Design & Fabrication: Reef Design Lab

Image courtesy of Aria Lee

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- By 22 months, 70 marine species recorded on Living Boulders—75% more than on adjacent unmodified revetment.
- Within 12 months, ecological communities in Living Boulder rockpools were comparable to those found in natural rockpools.

Water

- Not applicable in a direct sense, but awareness-raising efforts support broader sustainability goals.
- May contribute to improvements in water quality over the longer-term, depending on development of filter-feeder (e.g. oysters, mussels) biomass.

Land

- Potential to enhance coastal protection while also enhancing local biodiversity.

People

- Ecotourism-led funding model: a portion of every corporate kayak tour seat funds marine restoration.
- Public education integrated into kayak tours to build community understanding of urban marine biodiversity.

Atmosphere

- Not applicable in a direct sense, but awareness-raising efforts support broader sustainability goals.

DESIGN CONSIDERATIONS

Modules were cast to match the dimensions of existing shoreline rocks, enabling integration into the revetment without requiring physical anchoring—preserving shoreline stability while introducing biodiversity-enhancing features.

CONSTRUCTION CONSIDERATIONS

- Consideration of the local wave energy conditions to determine correct size/weight of boulder module used - higher energy areas will require larger boulders.
- Modules were 60 cm in diameter and approximately 130 kg in weight.
- Installed in a sheltered embayment environment, minimising structural risk.

OPERATIONAL CONSIDERATIONS

- Minimal maintenance required; site conditions suitable for long-term performance.
- Scientific monitoring evaluated performance and informs future applications.

PROJECT COSTS

- AUD $30,000 for boulder unit supply and installation.
- Installation funded by North Sydney Council; module production funded by Sydney by Kayak through tour contributions.
- Ecological monitoring and evaluation funded by Sydney by Kayak, NSW Environmental Trust and Adobe.

FURTHER READING

Sydney by Kayak:
- Eco Tours

Living Seawalls:
- Lavender Bay

Reef Design Lab:
- www.reefdesignlab.com

Macquarie University:
- The Lighthouse

BIODIVERSITY
CASE STUDY

CASE STUDY: LIVING PILINGS PILOT

Image courtesy of Aria Lee

PROJECT OVERVIEW

The Living Pilings Pilot at Sawmillers Reserve demonstrates an innovative retrofit of urban marine infrastructure using habitat-modified piling modules. Installed in December 2023, twelve precast concrete modules were affixed to 6 existing timber wharf pilings under the public wharf at McMahons Point.

This pilot was supported by North Sydney Council and funded by the Sapphire Project. It represents an important test case for integrating marine habitat into existing pile structures within active harbours, contributing to local biodiversity without disrupting infrastructure function.

Client:
Funded and supported as a collaborative pilot

Contributed by:
Sydney Institute of Marine Science

Project type:
Retrofit using precast concrete modules

Completion date:
2023

Location:
Sawmillers Reserve, Berrys Bay, Sydney Harbour, NSW

First Nations Country:
Cammeraygal Country

Owner:
Public project supported by North Sydney Council

Key Partners:

- Funder: Sapphire Project
- Installation & Oversight: North Sydney Council
- Scientific Monitoring: Sydney Institute of Marine Science
- Design & Fabrication: Reef Design Lab

Image courtesy of Aria Lee

BIODIVERSITY
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- 12 Living Pilings modules installed on timber piles
- 63 species of seaweeds and invertebrates recorded after 12 months of installation
- Represents a 16% increase in biodiversity above baseline levels
- Further increases expected in ongoing 2025 ecological evaluations

Water

- Potential to support localised water quality improvement through increased filter feeder (e.g. oysters, mussels) biomass

People

- Passive viewing opportunity for visitors to Sawmillers Reserve
- Pilot contributes to local community pride in coastal conservation initiatives

Atmosphere

- Potential to contribute to carbon sequestration through increased seaweed and shellfish biomass

DESIGN CONSIDERATIONS

Modules were fabricated using 50MPa concrete blended with Ecoblend cement, incorporating upcycled industrial materials (fly ash and blast furnace slag) to reduce embodied carbon. Each unit weighs approximately 73 kg and was designed for easy retrofit to existing pile structures.

CONSTRUCTION CONSIDERATIONS

- Structural integrity, weight, and durability in tidal environments were key design drivers
- Installed below the public wharf using marine-grade attachment methods

OPERATIONAL CONSIDERATIONS

- Minimal maintenance anticipated
- Performance and biodiversity impact to be monitored through 2025

PROJECT COSTS

- AUD $25,000 for module fabrication and installation

FURTHER READING

Living Seawalls:

- Living Pilings Pilot

Sydney Institute of Marine Science:

- www.sims.org.au

Reef Design Lab:

- www.reefdesignlab.com

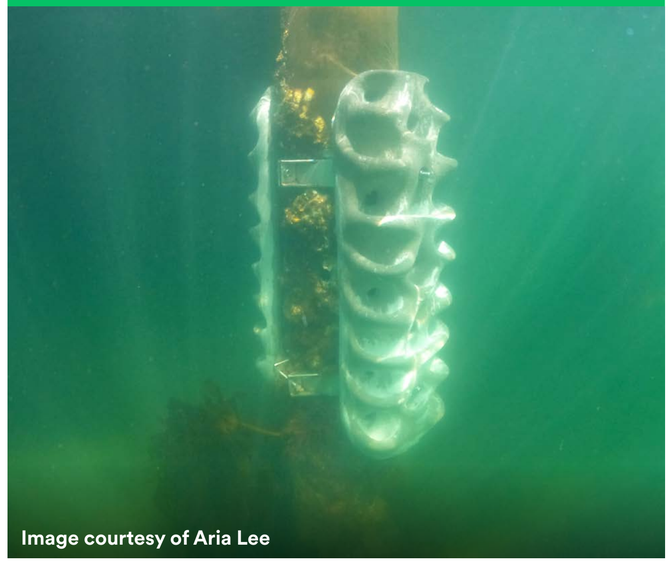


Image courtesy of Aria Lee

Land

Concept, design elements
and case studies

LAND
CONCEPT

LAND

ASPIRATION

Protect, regenerate and restore natural landforms and soil health, and introduce urban greening to connect to surrounding landscapes.

DESIGNING WITH COUNTRY

Grampians, Badu Island and the Pilbara, postcard landscapes span this broad continent from snowfields to deserts. Shaped over millennia these lands are home to 65,000 years+ of occupation by over 350 nations whose boundaries are defined by the landscape. Embedded within these landscapes are the origins, memory and continuation of culture, when designing and interacting with the land consider its function in wider systems, the heritage within and its significance to community.

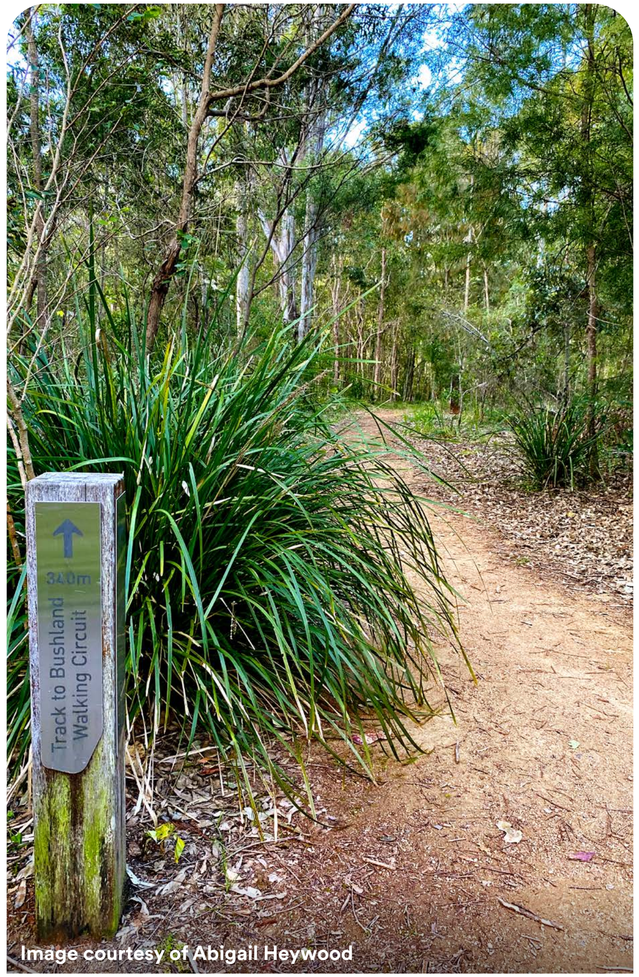


Image courtesy of Abigail Heywood

WHAT IS LAND REGENERATION - AND WHY DOES IT MATTER?

Land is the foundation of life. It includes the soils, rocks and surface formations that shape our cities, communities and ecosystems. Natural landforms—such as hills, gullies, foreshores and floodplains—support ecological processes and vital habitat, regulate climate and forms a critical component of the water cycle.

Urban development often disrupts these systems. As land is cleared, flattened or sealed with hard surfaces, natural formations are lost, water flows are altered and soil health declines. These changes reduce biodiversity, alter stormwater flow paths, increase erosion, amplify urban heat and weaken climate resilience.

Globally, land system change is recognised as one of the most critical planetary boundaries already exceeded. According to the Potsdam Institute for Climate Impact Research (2024), transformations such as deforestation and urbanisation are disrupting key ecological functions—carbon sequestration, moisture recycling and nutrient cycling—while increasing the severity of natural disasters like flooding and heatwaves. This aligns with the Planetary Boundaries Framework from the Stockholm Resilience Centre, which lists land system change among the nine boundaries essential to maintaining a safe operating space for humanity.

Regenerating land means protecting and restoring the physical and ecological functions of the landscape (Stockholm Resilience Centre; Potsdam Institute, 2024). This includes retaining natural landforms where possible, restoring topography that has been altered and supporting water movement, carbon cycling and biodiversity recovery. In urban environments, these actions improve resilience, reconnect people with place and create more liveable, climate-adapted communities.

WHAT IS SOIL RESTORATION - AND WHY DOES IT MATTER?

Soil is a living system—and a vital layer of the Earth's surface that supports biodiversity, ecosystem function and human wellbeing. It stores and recycles nutrients, retains and filters water, sequesters carbon and provides the foundation for both natural ecosystems and food production.

Healthy soil includes a mix of topsoil and subsoil layers. Topsoil contains organic matter, nutrients, microbes and seed banks. Subsoil supports structure, drainage and deep root systems. Together, they host diverse life—from bacteria and fungi to insects, worms and vertebrates—all of which contribute to ecological processes like decomposition, nutrient cycling and water filtration.

Development activities such as land clearing, compaction, stockpiling and erosion can degrade soil structure and function. These impacts reduce productivity, disrupt microbiomes and compromise the viability of landscaping and ecological restoration efforts.

Soil restoration involves protecting intact soil systems where possible and actively repairing degraded or contaminated soils. This includes:

- Minimising disturbance of natural soil profiles
- Separating and storing topsoil and subsoil for reuse
- Rebuilding structure through compost and organic amelioration
- Remediating legacy pollution where required
- Selecting vegetation suited to soil type, moisture and nutrient conditions

Because soils and habitats are closely co-adapted, planting should be guided by the site's soil properties. Seeds from native, local-provenance species help preserve genetic diversity and promote resilience.

Healthy soils are foundational to ecosystem recovery, climate resilience and sustainable urban development.

WHAT IS URBAN GREENING - AND WHY DOES IT MATTER?

Urban greening is the integration of vegetation into built environments—on the ground, on buildings and in public spaces (Standards Australia, 2023). It includes everything from parks, green corridors and community gardens to green roofs, façades and planter boxes. Whether linear or clustered, formal or rewilded, green spaces provide habitat, regulate climate and offer daily connection to nature.

In a functioning urban ecosystem, green infrastructure is not just aesthetic—it supports biodiversity, cools the city, filters air and water and improves quality of life. Linear green infrastructure—such as green streets, rail corridors and riparian edges—also plays a critical role in habitat and human connectivity, while isolated patches (e.g. pocket parks, roof gardens) act as stepping stones for more mobile species (NSW Government Architect, *Biodiversity in Place*).

Without sufficient vegetation, urban environments become hotter, less liveable and more vulnerable to climate impacts. The Urban Heat Island Effect—driven by hard surfaces like asphalt and rooftops—raises ambient temperatures, placing stress on people, plants and wildlife. Native species may be displaced and ecological cycles disrupted. Biodiversity research highlights that phenological changes—such as earlier flowering or breeding—are already occurring in response to rising temperatures (Kirk et al., 2021).

Urban greening reduces these impacts. Vegetation provides shade, cools air through evapotranspiration and supports more comfortable microclimates. When designed as a connected network, green infrastructure enables species movement, restores lost habitat and enhances urban biodiversity (University of Melbourne, 2023).

Urban greening also delivers social benefits: improved mental wellbeing, more walkable neighbourhoods and stronger connections between people and place (NSW Government Architect, *Biodiversity in Place*; Standards Australia, 2023).

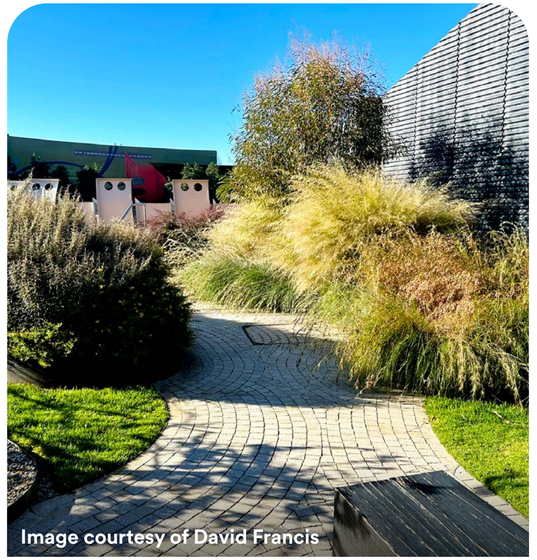


Image courtesy of David Francis

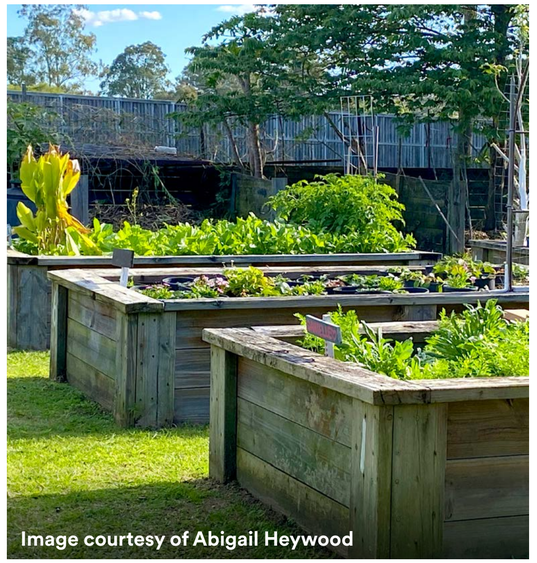


Image courtesy of Abigail Heywood

LAND
CONCEPT

HOW TO REGENERATE LAND, RESTORE SOIL AND INCREASE URBAN GREENING

Every project presents an opportunity to regenerate land, restore ecological function and reconnect people with place.

THE FOLLOWING STEPS CAN GUIDE A LOCALLY RESPONSIVE APPROACH TO LAND REGENERATION, SOIL RESTORATION AND URBAN GREENING:

STEP 1

Understand the historical context of the land

Study how the land naturally formed—its topography, waterways and ecological function—prior to urban development. Historic landforms like hills, gullies or floodplains can offer insight into how to re-establish healthy soil, water flow and biodiversity.

STEP 2

Engage with Traditional Custodians

Work alongside Traditional Owners to understand how land was cared for and used. Culturally informed knowledge can guide stewardship, design intent and the identification of species and practices that honour Country.

STEP 3

Retain and restore natural landforms

Where possible, preserve existing topography and habitats, and integrate the built environment into the landform. Look for opportunities to restore historical landforms to support carbon, water and nutrient cycles. Landforms also influence permeability, flood resilience and subsoil moisture critical for tree health. Reclaim seeds prior to site disturbance where possible.

STEP 4

Protect and repair soils

Assess the site's soil profile and aim to minimise disturbance. Where disturbance is unavoidable, topsoil and subsoil should be stripped, stored and reused carefully to retain structure, productivity and the native seedbank. Where soils are degraded or contaminated, implement appropriate remediation or amelioration strategies. Healthy soils enhance biodiversity, plant success and stormwater management.

STEP 5

Introduce urban greening to support biodiversity

Integrate vegetation into buildings, streetscapes and public spaces. Focus on native species suited to local soil and climate conditions, including local provenance plants to support ecological resilience. Propagate from local seed banks were possible. Ensure spatial planning allows space for mature trees, include deep soil zones and ensure adequate soil volume for long-term plant health.

STEP 6

Create connected green infrastructure

Connect green spaces onsite to a broader network. Link ground-level planting with blue-green streets, green façades, roofs or public space to enhance connectivity for both people and wildlife. Linear corridors and stepping stone habitats increase mobility, resilience and biodiversity value.

LAND
CONCEPT

CO-BENEFITS OF LAND, SOIL REGENERATION AND URBAN GREENING

Designing with land supports broader ecosystem health and improves outcomes for people, place and the planet.
The following co-benefits highlight how regenerative land practices contribute to climate resilience, liveability and Connection to Country.

Land

- Preserves natural landforms, improving visual identity and site character
- Supports erosion control and slope stabilisation
- Restores nutrient cycling and soil health
- Increases moisture retention in soils, supporting vegetation
- Enables rewilding of degraded areas and landscape-scale connectivity
- Reduces urban heat through shading and evapotranspiration

Water

- Improves stormwater infiltration and reduces runoff
- Enhances water quality through natural filtration
- Restores natural hydrological flows and groundwater recharge

Biodiversity

- Re-establishes habitats and associated species
- Improves habitat connectivity
- Supports healthy soil microbiomes and pollination services

Atmosphere

- Improves air quality by filtering dust and particulates
- Supports carbon sequestration through soils and vegetation
- Undulating landform provides noise attenuation

People

- Enhances urban aesthetics, identity and sense of place
- Increases walkability, shade and outdoor comfort
- Provides opportunities for positive human-nature relationships through stewardship
- Strengthens Connection to Country and supports Caring for Country practice
- Improves mental and physical wellbeing through access to nature
- Improves community cohesion


Image courtesy of OCULUS


Image courtesy of Peter Clarke - Bendigo Hospital

SUPPORTING DESIGN ELEMENTS

Well-designed and maintained features at the precinct scale can actively support land regeneration, soil restoration and urban greening. The following elements can be integrated into site and precinct planning to maximise ecological and place-based outcomes:

- Land formation retention and restoration
- Soil retention and restoration
- Blue-green streetscape
- Green space
- Community gardens
- Elevated park
- External green façade
- External planter boxes

Image courtesy of Fytogreen

COMBINING DESIGN ELEMENTS

Integrating design strategies across a site or precinct can amplify ecological and functional outcomes.

- Landform protection can enhance stormwater management and should be coordinated with water sensitive urban design, overland flow paths, buffer zones, riparian planting and river restoration.
- Soil restoration is critical to the success of urban greening and can be supported by seed harvesting, seed banking and propagation strategies.
- Urban green space should be planned as part of a connected, city-wide open space network wherever possible. Linear infrastructure—such as streetscapes, rail corridors and drainage lines—can support biodiversity and water-sensitive design while repairing historical landscape severance.

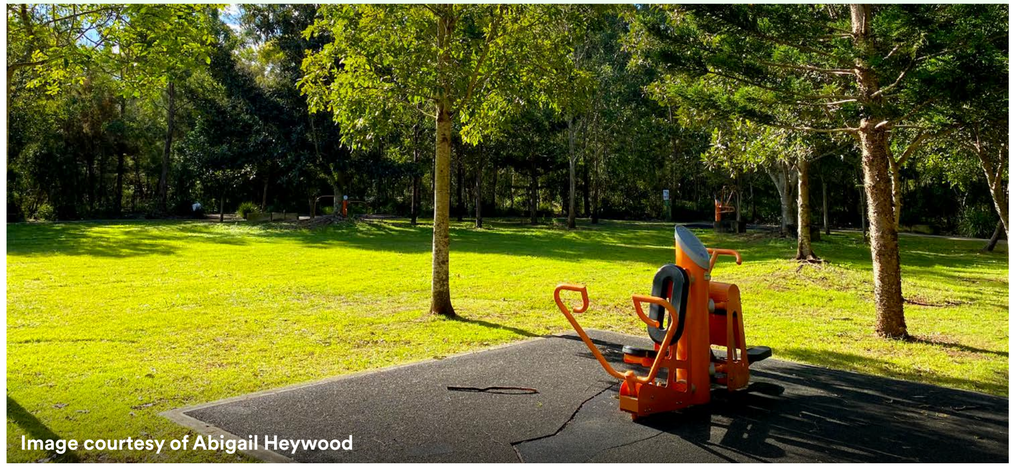


Image courtesy of Abigail Heywood

REFERENCES

Standards Australia SA HB 214:2023.

- **Urban Green Infrastructure – Planning and Decision Framework**

NSW Government Architect.

- **Biodiversity in Place**

Kirk, H. et al. (2021).

- **Urban Forestry & Urban Greening, 62, 127176**

University of Melbourne (2023).

- **Playbook for Urban Biodiversity**

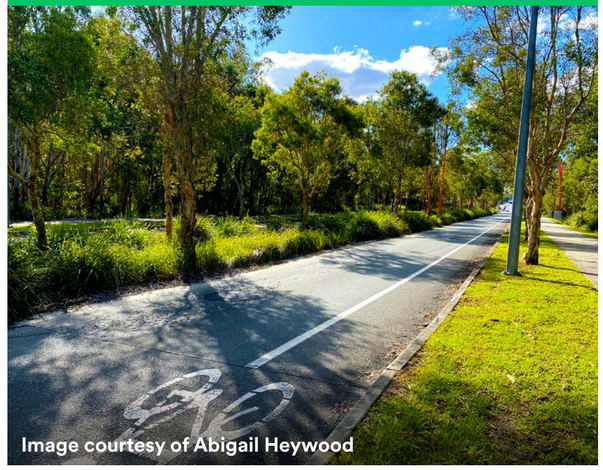


Image courtesy of Abigail Heywood

LAND
DESIGN ELEMENT

DESIGN ELEMENT: LAND FORMATION RETENTION AND RESTORATION

Natural landforms—such as hills, ridgelines, valleys and gullies—are often flattened or removed during development, resulting in significant ecological disruption. This includes the loss of topographic identity, soil structure and stability, altered hydrological patterns, reduced biodiversity and the breakdown of natural processes such as carbon, nitrogen and phosphorus cycling.

Designing with landforms means working with the existing terrain to guide built form and landscape responses. This reduces the need for land clearing, cut-and-fill earthworks, retains natural contours and hydrological function and integrates landform features into the overall design. Preserved landforms create distinctive, place-based environments that support habitat and help manage stormwater.

Where topography has already been disturbed, projects should aim to restore key landscape features—such as hills, swales or gullies—to re-establish water systems, provide habitat and improve resilience to climate risks such as flooding, bushfires and heat.

Understanding historical landform patterns and pre-development water flows offers critical design insights and supports regenerative, Country-aligned outcomes.

BENEFITS AND CO-BENEFITS

Land

- Retains and protects natural landforms
- Restores historic topographies
- Regulates urban temperature (reduces urban heat island effect)
- Contributes to urban greening
- Supports soil restoration and erosion control
- Enhances nutrient cycling
- Provides space for habitat

Water

- Supports natural water cycling, including groundwater recharge
- Improves water quality through filtration
- Contributes to flood control

Biodiversity

- Restores habitat and supports local species
- Improves overall biodiversity health

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration

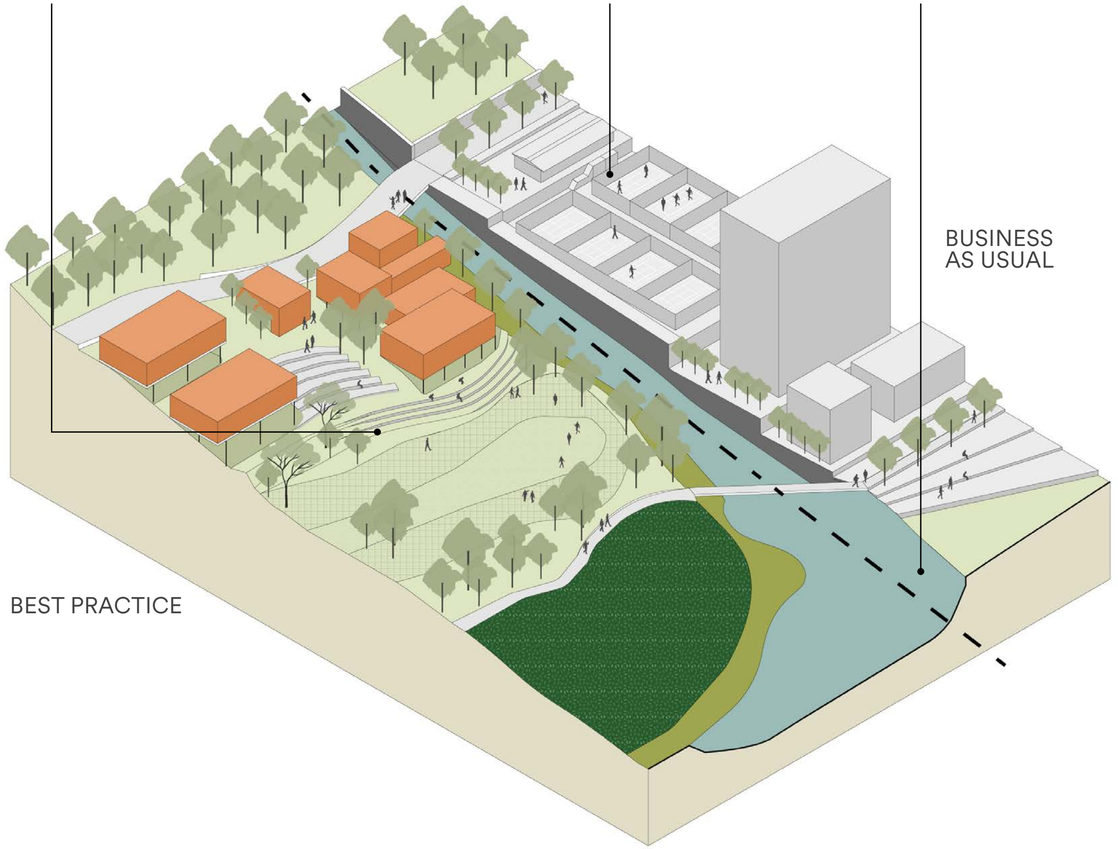
People

- Strengthens Connection to Country and Nature
- Enables Caring for Country practice
- Encourages physical activity through walkable terrain
- Fosters education, engagement and stewardship
- Supports mental wellbeing

Incorporating natural landforms into building design, following ground contours, and minimise excavation that alters the existing topography.

Natural landforms such as hills and gullies, have often been disturbed by development, which commonly “flattens” land for easy development leading to the loss of these land formations and natural land contours, biodiversity, damages soil, alters water flows and effects natural cycles such as carbon, nitrogen and phosphorus.

Restore original landforms and support habitats and allow for free flowing water systems.



LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Topographic mapping and analysis:**
  Understand existing and pre-development landforms through site surveys, historical data and mapping tools.
- **Design integration:**
  Use landform as a design driver to retain vegetation and inform site layout, building orientation, road alignments and public realm planning.
- **Hydrological function:**
  Work with natural gradients to support infiltration, overland flow, filtration and storage—reducing runoff and supporting biodiversity.
- **Restorative ambition:**
  Where landform has been lost, consider re-contouring key features to re-establish ecological function, identity and place.
- **Collaborative input:**
  Engage engineers, ecologists, landscape architects and Traditional Custodians early to inform site-responsive and culturally aligned design.

LIMITATIONS

- Restoration can be complex, site-specific and may reduce the area available for development.
- Adapting to non-flat terrain may require bespoke building design and infrastructure solutions.
- Retained landforms can introduce challenges related to access, maintenance and construction sequencing.
- High perceived cost or limited awareness of benefits may reduce uptake.

DESIGN CONSIDERATIONS

- **Site structure:**
  Assess slope stability and erosion risk for both retained and recontoured landforms.
- **Stormwater:**
  Align swales and surface drainage with natural water paths to support overland flows, infiltration and slow flows.
- **Maintenance:**
  Plan for vegetation management and erosion control to preserve contours and soil function over time.
- **Construction logistics:**
  Minimise soil compaction and protect restored landforms during site access, staging and construction.
- **Interfaces:**
  Design safe transitions between varied terrain and built elements such as buildings, roads and open spaces.

APPLICABILITY

Suitable for buildings and precinct-scale developments.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:**
  Identify and assess historical and existing landforms. Align site layout and circulation with natural topography and habitat protection.
- **Concept Design:**
  Incorporate landform into building massing and open space design. Support natural water movement and establish visual identity.
- **Detailed Design:**
  Finalise grading, planting and material strategies to stabilise landforms and reinforce ecological function.
- **Construction:**
  Minimise cut-and-fill earthworks. Protect existing contours and rehabilitate disturbed areas using native planting and soil amendments.
- **Operation:**
  Maintain restored or retained landforms through erosion control, vegetation management and safety checks in public areas.

LAND
CASE STUDY

CASE STUDY: BARANGAROO RESERVE

Image courtesy of Lendlease

PROJECT OVERVIEW

Barangaroo Reserve is a 6-hectare headland park on the edge of Sydney Harbour, transforming a former stevedoring container terminal into a naturalised, public landscape inspired by the area's pre-1836 shoreline.

Reinstating the sandstone topography of Millers Point, the design reimagines the historic landform using excavated materials from site works. Native planting—including angophoras, banksias and salvaged mature fig trees—restores the ecological character of the harbour's sandstone bushland.

Below the headland, a large cultural space is carved into the original 20th-century sandstone escarpment, dramatically juxtaposing history with renewal.

Barangaroo Reserve honours the site's Indigenous and colonial histories while creating a vibrant, accessible waterfront park with sweeping harbour views, rich cultural interpretation and more than 75,000 native plants. The design draws from historic maps, botanical records and oral histories to shape a meaningful and place-connected landscape.

Client
NSW Government
(Barangaroo Development Authority)

Project type:
New build

Completion date:
Aug 2015

Location:

Barangaroo, Sydney, NSW

First Nations Country:

Cammaralygal Country.

Key Partners:

- Barangaroo Development Authority
- Landscape architects: Peter Walker & Partners (PWP) and Johnson Pilton Walker (JPW)
- Delivery partner: Lendlease (formerly Balderstone)
- Soil science: Simon Leake (SESL Australia)
- Horticulture: Stuart Pittendrigh
- Civil and marine works: Aurecon
- Environmental consultancy: JBS&G
- Historic interpretation: Judith Rintoul
- Landscape contractor: Regal Innovations
- Plant procurement nursery: Andreasens Green

Barangaroo Reserve 2022. Image courtesy of SESL

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Native planting and habitat creation:** The reserve features over 75,000 native trees, shrubs and groundcovers—many species chosen to reflect the local sandstone ecology of Sydney Harbour. Key plantings include angophoras, banksias and 15 mature fig trees (Moreton Bay and Port Jackson) salvaged from other developments.
- **Ecological restoration:** The project re-established a native bushland landscape on a formerly industrial site—restoring ecological functions and providing habitat for birds, reptiles, mammals and invertebrates.
- **Pollinator support:** Native bee colonies were introduced to aid pollination and support the long-term health of the plant community.

Water

- **Rainwater harvesting and reuse:** Integrated beneath the reserve are water reuse tanks that collect and store rainwater and seepage. This system supports irrigation and reduces reliance on external water supplies.
- **Irrigation efficiency:** Water collected on site is treated and reused through a dedicated irrigation network—supporting plant health, conserving potable water and helping maintain the landscape year-round.

Land

- **Headland restoration:** Barangaroo Reserve reinterprets the original pre-colonial topography of Millers Point—reconnecting the harbour's natural system of headlands and coves. The reconstructed landform used site-won sandstone and fill to shape the foreshore and terraces.
- **Sustainable landscaping**: The use of site-won sandstone blocks—minimising importation of blocks.
- **Soil innovation:** A reconstructed soil profile was created using 80% reused materials, including crushed sandstone from excavations, composted green waste and sand, mimicking the original ecosystem pre-settlement. In partnership with the NSW EPA and SESL, a trial incorporated crushed glass as a sand replacement in terrace soils—demonstrating sustainable innovation in urban soil design.
- **Urban cooling:** Extensive vegetation provides shade and evapotranspiration from plantings, mitigating the urban heat island effect.

Atmosphere

- **Carbon neutral precinct:** Barangaroo Reserve is part of the broader Barangaroo development—Australia's first certified carbon neutral precinct. The park contributes to this through on-site energy, water and materials strategies.
- **Air quality:** Extensive vegetation helps sequester carbon and capture airborne particulates, improving local air quality.

People

- **Cultural naming and storytelling**: The reserve is named after Barangaroo, a prominent Cammeraygal woman known for her leadership, resilience and resistance to colonial customs. Her legacy is embedded in the project's identity and interpretive design.
- **Connection to Country:** Design was guided by the site's significance to the Gadigal people, whose presence on the land dates back thousands of years. Public artworks, cultural tours and storytelling installations reflect ongoing First Nations knowledge and connection.
- **Public accessibility**: Formerly a closed industrial site, Barangaroo Reserve is now open to the public 24/7. It offers walking trails, picnic areas, foreshore access and views of Sydney Harbour—enhancing health, wellbeing and community connection.
- **Cultural interpretation and public art:** Features include:
  - Barangaroo Ngangamay: Five hand-carved rock engravings created by Aboriginal Elders, each paired with a short film by Aboriginal artists Genevieve Grieves and Amanda Jane Reynolds.
  - Guided cultural tours: Led by First Nations guides, these tours explore Gadigal history, contemporary culture and the site's transformation.
- **Universal access and amenity:** The site is well connected by public transport, with ferry terminals and train stations nearby and is designed for inclusive access across its terrain.
- **Recreational activities and community wellbeing:** The reserve provides recreational areas, picnic spots, walking trails and foreshore walk, encouraging outdoor recreational activities and overall increasing community wellbeing.

DESIGN CONSIDERATIONS

- **First Nations heritage and cultural landscape:** The design team sought to honour the site's significance to the Gadigal people—recreating a landscape once used for fishing, hunting and gathering. This informed both spatial layout and planting.
- **Reconstructed landform:** The headland was reshaped using 10,000 sandstone blocks sourced from on-site excavation, restoring the topography to mirror the pre-colonial shoreline.
- **Sustainable material reuse:**
  - Fill from Nawi Cove excavation was reused to form the headland
  - Foreshore design incorporated sandstone quarried on site
  - Soils were reconstructed using recycled materials, including recovered crushed glass and composted green waste
- **Heritage integration:** The design incorporated historic features such as Munn's Slipway, preserving and embedding Sydney's maritime history into the new shoreline.

Barangaroo 1929. Image courtesy of SESL

LAND
CASE STUDY

CONSTRUCTION CONSIDERATIONS

- **Community engagement and placemaking:** Historical maps, oral histories and landscape interpretation informed the reshaping of the headland—ensuring community stories and cultural values were embedded in the physical transformation.
- **Minimising environmental impact:** Construction reused on-site materials such as sandstone and soil and employed sediment and erosion control measures to protect Sydney Harbour water quality.
- **Archaeological preservation:** Excavation uncovered remnants of 19th-century shipbuilding infrastructure, including Moore's Wharf, Munn's Slipway and Cuthbert's shipyard and seawall—all documented and integrated into the site where possible.
- **Site remediation:** Contaminated land from previous reclamation works was identified and remediated, preparing the site for safe public use.

OPERATIONAL CONSIDERATIONS

- **Carbon neutral operations:** As part of the Barangaroo carbon-neutral precinct, the reserve is maintained with sustainability front of mind—from energy use to emissions and waste management.
- **Heritage stewardship:** Ongoing operations respect and preserve the site's layered histories—including First Nations stories, colonial heritage and maritime archaeology—through maintenance, programming and guided experiences.
- **Environmental management:** Operational protocols ensure impacts such as noise, waste and wildlife disturbance are monitored and managed to support ecological health and public amenity.
- **Maintenance:** Regular maintenance ensures the longevity of vegetation, public art and infrastructure—preserving the site's appearance, safety and functionality over time.

Barangaroo 2005. Image courtesy of SESL

Barangaroo Reserve 2015. Image courtesy of SESL

FURTHER READING

Barangaroo Reserve:
- Green Building Council of Australia
- Official Website
- Past, Present & Future
- Sustainability at Barangaroo
- Plants at Barangaroo

Barangaroo Case Study:
- Urban Transformation

Landscape Australia:
- A Naturalised Landscape

NSW Government:
- Barangaroo – Realising the Vision

PWP Landscape Architecture:
- Barangaroo

SESL Australia:
- Barangaroo Headland

LAND
DESIGN ELEMENT

DESIGN ELEMENT: SOIL RETENTION AND RESTORATION

Soil is a living system and a vital layer of the Earth's surface that supports biodiversity, ecosystem function and human wellbeing. Healthy soil is made up of minerals, organic matter, water, air and a wide range of organisms—from microbes and fungi to insects and small animals.

In urban development, soil is often overlooked or degraded through clearing, compaction, contamination, erosion or removal. These impacts reduce the land's capacity to support vegetation, filter water, sequester carbon and maintain ecological processes.

Soil retention and restoration involves protecting soil in place where possible and restoring soil health where it has been disturbed. This includes reusing site-derived topsoil and subsoil, managing stockpiles correctly, remediating contamination and selecting plant species that are suited to the site's soil type.

Providing adequate soil depth and volume—especially deep soil zones for trees—is essential for long-term vegetation health, stormwater management and habitat provision. Integrating soil planning early in the design process supports resilient landscapes and regenerative outcomes.

> "Soil retention and restoration involves protecting soil in place where possible and restoring soil health where it has been disturbed.

BENEFITS AND CO-BENEFITS

Land

- Restores soil function and structure
- Controls erosion and surface runoff
- Supports nutrient cycling

Water

- Improves water quality through filtration
- Supports water cycling including groundwater recharge

Biodiversity

- Protects and restores habitat by maintaining living soils
- Supports biodiversity health by providing nutrients and microhabitats

Atmosphere

- Supports carbon sequestration through healthy plant-soil systems

People

- Embeds Caring for Country practices through respect for soil systems

FURTHER READING

Western Sydney Street Design Guidelines:

- 240110-Western-Sydney-Street-Design-Guidelines.pdf

Global Street Design Guide:

- Streets for Environmental Sustainability - Global Designing Cities Initiative

Soil retention and restoration is crucial to supporting nature outcomes

LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Soil retention:** Maximise areas of soil and habitat retained in situ to reduce disturbance and preserve soil structure and ecosystems.
- **On-site reuse:** Store and reuse topsoil and subsoil on site to maintain local soil characteristics and minimise the need for import.
- **Seed bank protection:** Retain topsoil with its native seed bank and manage storage to preserve biological integrity. Explore opportunities for propagation.
- **Soil assessment and treatment:** Undertake site-wide soil assessments to identify quality, contaminants or degradation. Apply remediation or amelioration as required.
- **Plant-soil compatibility:** Select plants suited to existing soil types to ensure resilience, reduce stress and minimise maintenance needs.
- **Adequate soil volumes:** Ensure sufficient soil depths and horizontal area to support the intended planting, especially deep soil zones for trees.

LIMITATIONS

- Soil storage and reuse may be constrained by limited space, timing or construction staging.
- Public concerns about microorganisms in healthy soil may require education and engagement.
- Root barriers can help protect infrastructure but may restrict tree growth or fail to prevent root spread entirely.
- Shallow soil depths or confined areas may limit plant selection and long-term vegetation performance.

DESIGN CONSIDERATIONS

- **Early integration:** Incorporate spatial planning for deep soil zones for trees during the masterplanning stage to ensure adequate space for root spread and growth.
- **Soil management planning:** Develop a Soil Management Plan that includes assessment of soil profiles, quality and contamination and outlines reuse, storage and remediation strategies.
- **Storage and handling:** Specify practices to protect soil biology and structure—such as limiting stockpile height, avoiding compaction and regular turning.
- **Contamination remediation:** Apply sustainable remediation principles (AS ISO 18504:2022), considering environmental, social and economic factors.
- **Structural capacity:** Assess structural loads for planting above built structures, including deep soils over underground car parks.
- **Soil maintenance:** Plan and budget for ongoing soil health through fertilising, mulching and composting.
- **WSUD integration:** Pair soil zones with water sensitive urban design elements to improve filtration, drainage and water retention.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify and retain areas of high-quality soil and habitat. Allocate space for deep soil zones to support large trees and vegetation.
- **Concept Design:** Incorporate soil retention, reuse and planting strategies into site layout and landscape planning.
- **Detailed Design:** Develop a Soil Management Plan. Specify soil depths, plant-soil compatibility, storage protocols for retained soils and managing seed banks.
- **Construction:** Implement the Soil Management Plan. Protect stockpiles, minimise compaction and apply soil treatments as needed.
- **Operation:** Maintain soil health through regular fertilising, mulching and composting. Monitor vegetation performance and adapt management accordingly.

APPLICABILITY

Suitable for precinct-scale developments.

LAND
DESIGN ELEMENT

DESIGN ELEMENT: BLUE GREEN STREETSCAPE

Blue green streetscapes integrate living vegetation with water infrastructure to create streets that are functional, biodiverse and climate-responsive. Unlike grey streetscapes that prioritise hard surfaces and lawn, blue green designs incorporate ecological and hydrological systems to restore landscape function in the public realm.

By combining deep soil planting, native and culturally significant species, passive irrigation and water-sensitive urban design (WSUD), these streetscapes improve water quality and management, enhance biodiversity, provide shade and cooling and support active transport. When designed at scale, they become part of a broader network of green infrastructure, contributing to ecological connectivity and improved liveability.

Key features include water features, raingardens, bioswales, passive irrigation, diverse planting including street trees and integration with local landscape character and climate. These systems are most effective when planned early and designed collaboratively across disciplines. They offer both ecological and social benefits, supporting regeneration, community connection and Caring for Country outcomes.

BENEFITS AND CO-BENEFITS

Land

- Reduces urban heat island effect through canopy cover
- Controls soil erosion
- Improves urban greening

Water

- Restores natural drainage patterns and overland flow
- Improves water quality via filtration
- Manages stormwater by retaining runoff and reducing flooding

Biodiversity

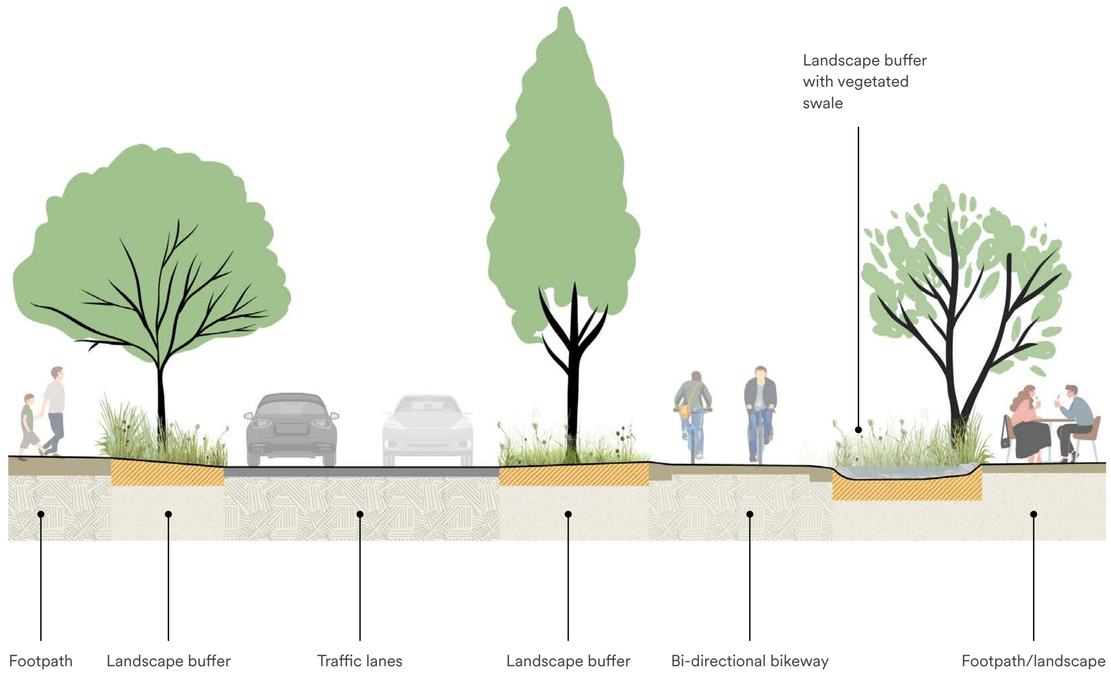
- Creates new urban habitat for fauna and flora
- Enhances habitat connectivity through green corridors

Atmosphere

- Improves air quality by capturing particulates
- Reduces carbon emissions due to avoided grey infrastructure
- Supports carbon sequestration through vegetation

People

- Encourages walking and cycling through shaded, active transport routes
- Improves public health and mental wellbeing
- Strengthens Connection to Country
- Enhances aesthetic value of streetscapes and improves property values



LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Early integration:** Incorporate blue green streets into the masterplan from the outset to allocate adequate space and avoid spatial conflicts with other infrastructure. Oversizing of grey infrastructure can also be avoided.
- **Collaborative design:** Coordinate input from a broad design team and include landscape architects, ecologists, First Nations representatives, drainage engineers, transport planners and accessibility specialists.
- **Plant selection:** Choose drought-tolerant, climate-resilient species, including locally endemic and culturally significant plants.
- **Tree planting:** Allow for deep soil zones in planning and design. Incorporate passive irrigation and drainage that supports long-term tree health.
- **Stakeholder education:** Address concerns about unmanicured or unfamiliar vegetation through clear communication and engagement to support community buy-in.

LIMITATIONS

- Natural systems within streetscapes can be vulnerable to climate extremes such as drought or flooding.
- Vegetation may be perceived as untidy or unmanaged compared to traditional landscaping.
- Deep soil zones and WSUD elements require early planning and may be limited by existing underground services.
- Non-standard designs may face resistance from local authorities or require additional approvals.

COMBINING WITH OTHER ELEMENTS

- Link blue green streetscapes with adjacent green infrastructure such as green walls, green roofs or landscaped verges to enhance ecological function.
- Re-landscape building frontages and verges to form part of a broader green corridor or ecological spine.
- Integrate with WSUD elements across the precinct to support stormwater retention, treatment and reuse.

DESIGN CONSIDERATIONS

- **Early integration:** Plan blue green infrastructure from the masterplanning stage to ensure adequate space and coordination with other services, and integration with active transport.
- **Root barriers:** Install barriers on no more than two sides of tree pits to protect infrastructure while allowing healthy root development.
- **Lighting coordination:** Align tree placement and canopy growth with street lighting to prevent conflict and ensure safety.
- **Accessibility:** Design for compliance with accessibility standards, including clear paths of travel and DDA requirements.
- **Maintenance planning:** Budget for both establishment and long-term care. Include tasks such as weeding, pruning, irrigation and soil health in a project-specific Maintenance Plan.
- **WSUD features:** Incorporate raingardens, bioswales and passive irrigation within verges, kerbs, medians and carriageways.
- **Wildlife connectivity:** Use tall trees with overlapping canopies to create aerial pathways for birds, insects and small mammals. Integrate with existing corridors and habitats.
- **Future options:** Consider how the needs of the space may change over time and allow options for expanding blue green infrastructure ie future reduced single car use.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Understand the site's pre-colonial landscape and explore opportunities for restoration. Define street hierarchy and allocate space for green and blue infrastructure, especially along active transport routes. Engage local authorities early to address non-standard design requirements.
- **Concept Design:** Establish a multidisciplinary team to develop coordinated strategies across ecology, landscape, drainage, access, transport and culture. Define placemaking vision including signage, indigenous language and art.
- **Detailed Design:** Refine WSUD, planting, soil depth and irrigation details. Confirm maintenance requirements and secure authority approval for any customised elements.
- **Construction:** Implement a project-specific Maintenance Plan. Prioritise soil preparation, passive irrigation installation and vegetation establishment during landscape works.
- **Operation:** Monitor plant health, canopy development and WSUD performance. Maintain vegetation through weeding, pruning and watering. Adapt strategies as needed to manage long-term resilience.

APPLICABILITY

Suitable for precinct-scale streetscape and public realm applications.

LAND
CASE STUDY

CASE STUDY: NORTHSHORE BRISBANE

PROJECT OVERVIEW

Northshore Brisbane is Queensland's largest waterfront urban renewal project. This mixed-use precinct has achieved a 6 Star Green Star Communities v1.1 Rating.

EDQ's Northshore Street Renewal Program aims to deliver more than 50% shade cover across the site—reducing heat stress and building climate resilience. The project incorporates culturally significant vegetation and climate-resilient species to support a sustainable lifestyle.

Success is driven by a digital-first workflow and interdisciplinary collaboration, addressing lighting, passive irrigation, flooding, water quality and accessibility. This integrated approach enhances active transport, supports cultural knowledge-sharing, and delivers cooler, more comfortable spaces.

Key program features include:

- Extensive street tree canopy for urban cooling
- Integrated stormwater and passive irrigation systems
- First Nations-led species selection
- Universal design beyond DDA compliance

Partners EDQ, Urbis, ADG, Mott MacDonald and Roesner and Hamilton worked collaboratively to integrate trees, lighting and water infrastructure for a high-performing, climate-adapted streetscape.

Client:
Economic Development Queensland (EDQ)

Project type:
Brownfield redevelopment

Completion date:
2050

Location:
MacArthur Ave, Hamilton, Brisbane

First Nations Country:
Turrbal and Yuggera Country

Key Partners:

- EDQ
- Urbis
- ADG
- Mott MacDonald
- Roesner and Hamilton

Image courtesy of Abigail Heywood

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Native species planting:** Local vegetation is used to support native wildlife and enhance biodiversity.
- **Tree selection:** Species were chosen in consultation with landscape consultants, Brisbane City Council and Traditional Owners to ensure ecological suitability and cultural relevance.
- **Habitat creation:** Increased canopy and green space provide new habitats for local fauna.
- **Climate resilience:** Climate-resilient and culturally significant vegetation promotes a sustainable, adaptable urban ecosystem.

People

- **Biophilic design:** Connects people to nature, supporting mental health.
- **Active transport:** Shaded routes promote walking, cycling and lower emissions.
- **Sense of place:** Native species and tree canopy create visual identity and community pride.
- **Traditional Owner engagement:** Indigenous knowledge guides planting and design.
- **Public benefit:** Precinct includes parks, playgrounds and riverside spaces like Maritime Green.
- **Economic impact:** Expected to generate $14 billion in investment and job creation.

Water

- **Water access:** A collaborative design process ensures adequate water for the growing canopy, including rain gardens and structural soil cells.
- **Water reuse:** Drainage and civil works have been refined to support passive irrigation, water storage and quality treatment.
- **Water quality:** A monitoring program tracks water quality to assess risk and guide public access to Brisbane's waterways.

Land

- **Tree canopy strategy:** Streets with high heat and active transport use are prioritised for dense tree planting to enhance green infrastructure.
- **Verge design:** Wider verges support extensive street tree planting.
- **Green space:** Large green areas, shaded public zones and walkable waterfronts promote recreation and wellbeing.
- **Urban cooling:** Increased shade and climate-resilient vegetation help reduce urban temperatures, improving comfort for residents and visitors.

Atmosphere

- **Air quality:** Extensive planting improves air quality across the site.
- **Urban heat reduction:** The Street Renewal Program targets more than 50% overall site coverage, significantly reducing the urban heat island effect and creating cooler, more comfortable spaces.

CONSTRUCTION CONSIDERATIONS

A staged delivery approach allows a mix of mature and younger plantings to establish and grow toward long-term canopy targets.

OPERATIONAL CONSIDERATIONS

Ongoing maintenance is planned throughout the project's lifecycle to support tree health and canopy performance.

Image courtesy of Abigail Heywood

LAND
CASE STUDY

Image courtesy of Abigail Heywood

FURTHER READING

Standards Australia:

- SA HB 214:2023 Urban Green Infrastructure - Planning and decision framework

Macquarie University, Melbourne:

- Designing and managing biodiverse streetscapes: key lessons from the City of Melbourne - Macquarie University

Queensland

- Northshore Brisbane

Northshore Brisbane

- Northshore Vision

LAND
DESIGN ELEMENT

DESIGN ELEMENT: GREEN SPACE

Urban green space encompasses a range of public and semi-public landscapes that support biodiversity, community connection and climate resilience. These spaces can take many forms—from urban forests, parks, gardens and reserves to green corridors and riparian zones.

Well-designed green space provides habitat, supports pollinators, contributes to water and air quality, reduces urban heat and offers diverse recreation opportunities. It can also serve as a place for cultural expression, social interaction and learning.

Typologies include green spines, pocket parks, urban forests, outdoor play and sports areas, community gardens and nature reserves. Successful green space integrates multiple functions—balancing ecological value with accessibility, safety and amenity.

To maximise impact, green space should be connected to the wider open space network and reflect local biodiversity, culture and community needs. Diverse vegetation structure, endemic planting, fauna friendly design and passive irrigation all contribute to long-term success.

BENEFITS AND CO-BENEFITS

Land

- Retains landform and minimises soil disturbance
- Regulates urban temperature and reduces heat island effect
- Prevents erosion and supports soil restoration
- Contributes to nutrient cycling and urban greening
- Provides space for habitats

Water

- Manages stormwater and restores overland flow paths
- Improves water quality through filtration
- Enables infrastructure for rainwater harvesting
- Supports groundwater recharge and water cycling

Atmosphere

- Improves air quality by capturing particulates
- Supports carbon sequestration

Biodiversity

- Creates habitat for invertebrates, birds, bats, microfauna and increases urban plant diversity
- Enhances pollination services
- Restores and protects habitat
- Increases urban habitat connectivity

People

- Strengthens Connection to Country and supports Caring for Country practices
- Fosters community cohesion and nature stewardship
- Enhances physical and mental health
- Encourages walking and cycling through active transport routes
- Improves urban aesthetics and property value
- Provides spaces for recreation

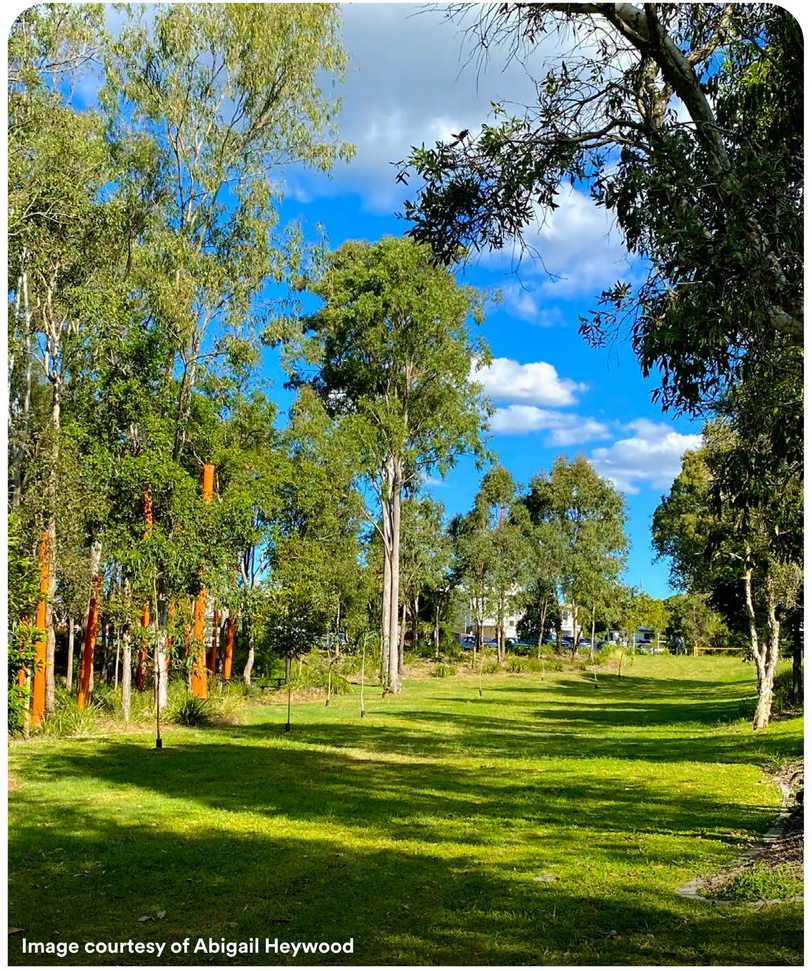


Image courtesy of Abigail Heywood

LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Contextual integration:** Build on existing nature, topography and cultural values. Retain landform, habitats and mature trees and restore degraded habitat areas where possible.
- **Strategic alignment:** Align green space outcomes with local biodiversity targets, tree canopy goals and open space strategies. Ensure connectivity to city-wide green networks.
- **Diverse planting zones:** Include a mix of trees, shrubs and groundcovers, with both formal and rewilded areas to support varied habitat and microclimates.
- **Fauna support:** Provide habitat resources such as logs, hollows, nest boxes, bee hotels and water sources to support species throughout their life cycles.
- **Water balance:** Design for moisture gradients, using drought-tolerant plants and non-potable water sources like rain tanks to minimise irrigation demand.
- **Community connection:** Engage community early in planning to build stewardship. Incorporate culturally significant species, interpretive signage and inclusive spaces for rest, play and learning.

LIMITATIONS

- Formal landscaping may offer limited biodiversity value if planting is simplified or overly manicured.
- Space must be balanced between recreational needs and ecological function, which may create design trade-offs.
- Rewilded or bushland areas may not align with all community aesthetic preferences and may attract insects or animals that may sometimes be considered a nuisance.
- Domestic pets, lighting, noise and high levels of human activity can negatively impact wildlife.

DESIGN CONSIDERATIONS

- **Vegetation structure:** Incorporate multiple vegetation layers—canopy, mid-storey and groundcover—to support varied habitat and microclimate.
- **Water supply:** Use non-potable sources such as rainwater tanks where possible. Design for passive irrigation and for moisture gradients to reduce irrigation needs.
- **Access and refuge:** Balance public accessibility with protected areas that support wildlife refuge and movement.
- **Community engagement:** Engage community early to shape the green space vision and build long-term stewardship.
- **Interpretation and education:** Include signage, bush tucker gardens, Indigenous plant names and outdoor learning zones to support cultural connection and education.
- **Safety and accessibility:** Design for diverse users with DDA compliance, passive surveillance, quiet areas and sensory elements.
- **Art and identity:** Incorporate community or Indigenous art, play elements and local stories to embed cultural expression and place identity.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Understand the site's ecological, cultural and urban context. Retain areas of biodiversity value, minimise disturbance and define zones based on function, community needs and local biodiversity priorities.
- **Concept Design:** Develop objectives for each zone. Prioritise co-benefits, spatial layout and early opportunities for community engagement or co-design.
- **Detailed Design:** Design for diverse planting structure, passive irrigation and accessible layouts. Include interpretive features, safety measures and long-term maintenance planning.
- **Construction:** Prepare soil, manage weeds and pests and allow for appropriate establishment periods. Engage community where possible through initiatives like planting days.
- **Operation:** Monitor vegetation health and biodiversity outcomes. Apply adaptive management and ensure maintenance plans support long-term ecological and social goals.

APPLICABILITY

Suitable for precinct-scale applications.

LAND
DESIGN ELEMENT

Image courtesy of Abigail Heywood

FURTHER READING

Greener Places:

- Greener Places

Urban Greening Strategy:

- 1076678-GA-Urban-Greening-Strategy-2025-V20-WEB.pdf

Monash University / Water Sensitive Cities Case Study:

- Cooling-cities-using-green-open-space-Industry-note.pdf

Monash University / Water Sensitive Cities On-Nut Forst Park Case Study:

- On-Nut-case-study-report-English.pdf

Standards Australia:

- SA HB 214:2023 Urban Green Infrastructure - Planning and decision framework

LAND
CASE STUDY

CASE STUDY: BENDIGO HOSPITAL

PROJECT OVERVIEW

Bendigo Hospital is a world-class healthcare precinct delivering clinical care within a landscape designed to support healing, wellbeing, and strong connection to place. Set within a 13-hectare site, the design integrates nature throughout the hospital experience.

The project includes more than 46 landscaped balconies, green roofs, roof decks, and courtyards—including 20 specifically designed for mental health patients. Ten extensive green roofs totalling 965 m² span four levels, planted with 8,672 plants across 33 species. The planting reflects the site's regional context, referencing the row cropping patterns of the surrounding Loddon Valley.

The on-structure landscapes are designed for performance and visual benefit, using microclimate-responsive planting located to reduce glare and provide shade. Courtyards include both intensive and extensive systems with layered, drought-tolerant species. A 1,900 m² therapeutic garden provides a restorative experience for patients and visitors, with low-allergy native species selected for colour, scent, and texture.

This landscape-first approach—coupled with deep community and cultural engagement—positions Bendigo Hospital as a benchmark in biophilic, inclusive, and sustainable health infrastructure.

Client:
State Government of Victoria

Project type:
New build

Completion date:
2019

Location:
Barnard St, Bendigo, VIC

First Nations Country:
Dja Dja Wurrung and Taungurung Country

Owner:
Exemplar Health (NBH) Partnership

Key Partners:

- Green roof design and plant selection: OCULUS, Bates Smart, Fytogreen
- Courtyard green roofs: In collaboration with Silver Thomas Hanley
- Project delivery: Exemplar Health, Lendlease

Image courtesy of Peter Clarke

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Diverse, microclimate-responsive planting:** The green roofs and courtyards feature a biodiverse mix of Australian native and adapted exotic species—including low-growing shrubs, flowering herbs, groundcovers, and grasses—selected for their drought tolerance, seasonal interest, and habitat value.
- **Habitat creation:** The layered planting provides potential habitat for birds, insects, and pollinators, increasing biodiversity within an urban healthcare setting.
- **Locally inspired design:** The roof garden planting design draws inspiration from the agricultural row cropping patterns of the Loddon Valley, linking the hospital landscape to its broader regional context.

People

- **Cultural connection and inclusion:** The design team worked with the Dja Dja Wurrung Clans Aboriginal Corporation through the Closing the Gap initiative. The Aboriginal Services Courtyard includes a fire pit and local Indigenous plants to support cultural practice, ceremonies, and education. The led to First Nations patient presentations increasing by 67%, demonstrating improved cultural safety and access.
- **Therapeutic and sensory design:** A 1,900 m² therapeutic garden offers a calming, inclusive environment with raised planters, native species, and low-allergy selections chosen for colour, texture, and scent. These spaces support mental health, reduce stress, and promote recovery.
- **Encouraging healthy behaviours:** Outdoor spaces—including play decks, walking paths, and courtyards—support movement and exercise for staff, patients, and visitors, aligning landscape with clinical outcomes and wellbeing.

Atmosphere

- **Carbon and energy performance:** The hospital includes a 770-panel solar array that feeds renewable energy into the building's main power systems—reducing greenhouse gas emissions by approximately 300,000 kg CO_2 annually.
- **Green roofs for thermal comfort:** The 1,000 m² green roof and other landscaped spaces help regulate internal temperatures by reducing glare, improving insulation, and enhancing acoustic performance—lowering overall energy demand and improving environmental quality.

Water

- **Rainwater harvesting and reuse:** The hospital roof collects and stores over 300,000 L of potable and non-potable rainwater in an underground tank. This harvested water is used for irrigation, toilet flushing, and heat rejection systems—crucial in this drought-prone region.
- **Smart irrigation:** Recycled water is used as the primary source for landscape irrigation. The system is seasonally adjusted—irrigating up to four times per day in summer and typically not at all in winter unless conditions are excessively dry.
- **Water savings:** Between 2018 and 2021, the hospital saved approximately 54.5 million litres of potable water—equivalent to 22 Olympic-sized swimming pools.

Land

- **Regionally grounded landscape:** Planting across the site references agriculture in the region, using swathes of grasses and structured patterns to reflect local land use and identity.
- **Soil performance and reuse:** Food waste from hospital operations is processed in an on-site dehydrator to produce compost powder, which is reused in garden beds—minimising landfill waste and supporting healthy soil systems.
- **Urban cooling and performance:** Green roofs reduce heat island effects, lower glare, and improve the building's acoustic and thermal performance—enhancing comfort for occupants and reducing energy demands.

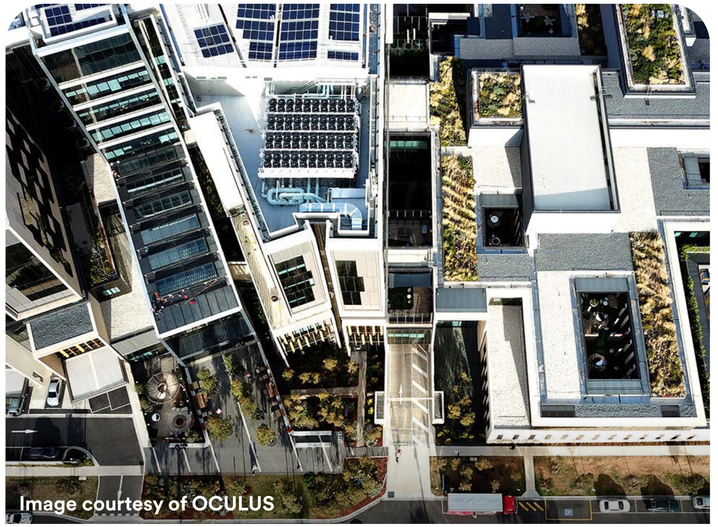


Image courtesy of OCULUS

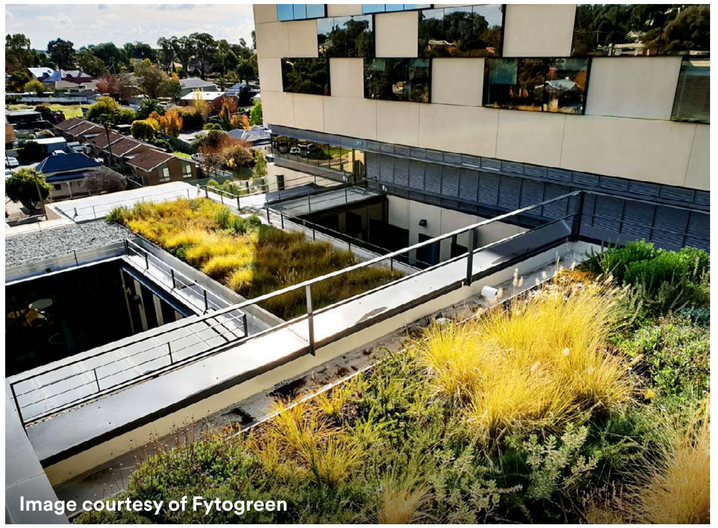


Image courtesy of Fytogreen

LAND
CASE STUDY

DESIGN CONSIDERATIONS

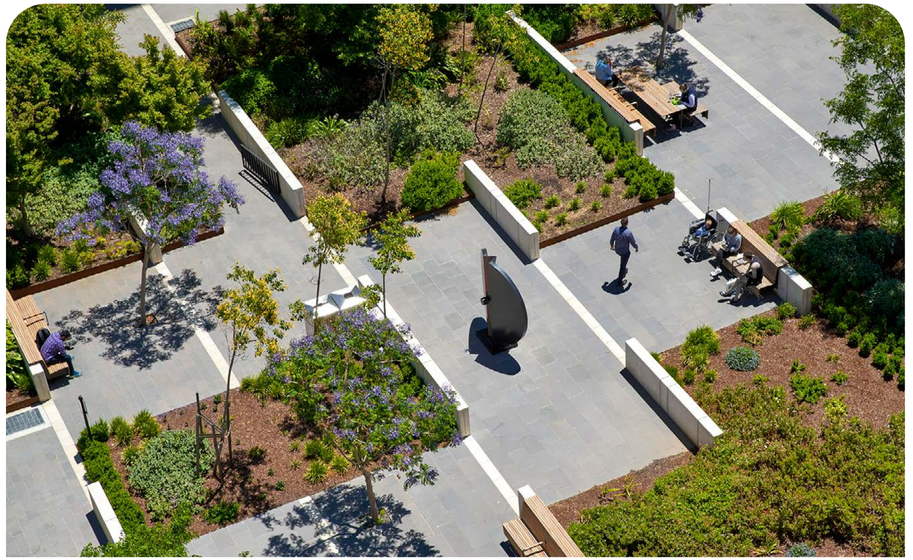
- **Biophilic design approach:** The project integrates nature into every level of the hospital through textured planting, water, natural materials, and views to greenery. Ferns with fractal leaf patterns—known to have psychological benefits—are positioned near chemotherapy chairs and along corridors to support calm and healing.
- **Connection to place:** Design elements draw from regional topography, landscape, and culture. Colour palettes and interior graphics were inspired by aerial photography and local flora, creating a sense of identity across departments.
- **Inclusive cultural design:** Collaboration with First Nations stakeholders informed the co-design of key spaces, including the Aboriginal Services Courtyard and a First Nations Garden featuring a relocated scarred tree and community-specified planting.
- **Plant selection and performance:** Species were selected for sun tolerance, low maintenance, and ecological value. Minor die-off was observed in early phases and successfully mitigated through irrigation adjustment and replanting.

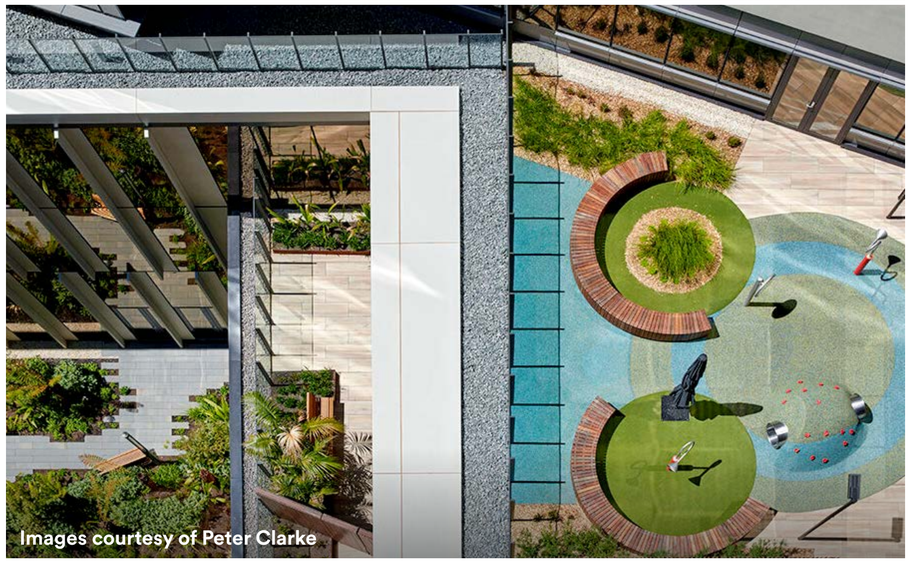
CONSTRUCTION CONSIDERATIONS

- **Structural design for landscape load:** Roof and podium structures were engineered to support green roofs of varying depths, including soil, planting, and irrigation infrastructure—ensuring long-term safety and performance.
- **Cultural heritage protection:** Construction teams worked collaboratively with local stakeholders to protect and honour First Nations culture, including the integration of culturally significant spaces and artefacts such as a relocated scarred tree.
- **Material reuse and local procurement:** Natural and locally sourced materials were prioritised throughout, supporting regional economies and reducing embodied carbon.

OPERATIONAL CONSIDERATIONS

- **Ongoing landscape maintenance:** A fortnightly program includes weeding, plant health checks, irrigation monitoring, and seasonal tasks such as pruning and mulching. Maintenance teams adapt irrigation systems based on observed plant health and microclimate needs.
- **Lessons learned:** The complexity and diversity of planting typologies across the site highlighted the need for a tailored and responsive maintenance strategy. Insights gained during the early stages informed a refinement of the maintenance contract, leading to improved outcomes and long-term success of the landscape.
- **Water management efficiency:** Harvested rainwater continues to support landscape and building systems, delivering measurable savings in water and energy while maintaining resilient green infrastructure during drought periods.





Images courtesy of Peter Clarke

LAND
CASE STUDY


Image courtesy of Fytogreen

FURTHER READING

OCULUS:
- Bendigo Hospital Case Study

Landscape Performance Series:
- Bendigo Hospital

Victorian Health Building Authority:
- Designing Sustainable Health Infrastructure

Green Roofs:
- Bendigo Hospital Roof Gardens


Image courtesy of Tom Adolph


Image courtesy of Tom Adolph


Image courtesy of OCULUS

LAND
CASE STUDY

CASE STUDY: ROMSEY ECOTHERAPY PARK

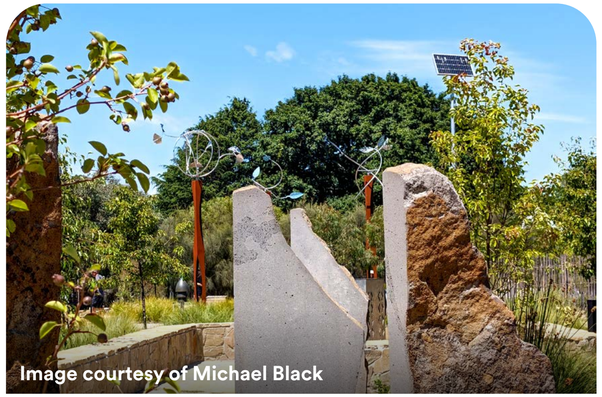


Image courtesy of Michael Black

PROJECT OVERVIEW

Romsey Ecotherapy Park is the result of a 14-year, community-led initiative to transform the town's abandoned primary school into an inclusive, nature-based park for healing, recreation, and cultural expression.

Led by Romsey Ecotherapy Park Inc. (REPI), the project has delivered a dynamic public landscape featuring therapeutic gardens, movement-activated water features, kinetic sculptures, a bespoke play space, accessible picnic areas, and capacity for community events and performances.

The park addresses gaps identified in the Macedon Ranges Council's 2013 Open Space Strategy, creating a diverse, high-quality environment that supports health and wellbeing across all ages and abilities.

Client:
Macedon Ranges Shire Council

Project type:
New build

Completion date:
October 2022

Location:
Romsey, VIC

First Nations Country:
Wurundjeri Woi-wurrung Country

Key Partners:

- Community lead: Romsey Ecotherapy Park Inc. (REPI)
- Design and delivery: ACLA
- Funding and advocacy: Macedon Ranges Shire Council, Regional Development Victoria, Bendigo Bank
- Artists and community contributors: Local artists commissioned through REPI's $200,000 fundraising efforts

Image courtesy of Steven Pam

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Planting for biodiversity:** The design retained all significant trees on site and introduced approximately 6,500 drought-tolerant plants and 100 new trees. This mix of species increases local biodiversity and provides new habitat for birds, insects, and other wildlife.

Water

- **Passive irrigation and filtration:** Stormwater is directed into garden beds and swales across the park, passively irrigating plantings and filtering runoff. This approach removes nutrients and suspended solids before they can reach nearby waterways and supports groundwater recharge.

Land

- **Land restoration and urban greening:** The project transformed a disused school site into a vibrant green public space—returning a forgotten site to community use.
- **Microclimate improvement:** The preservation of mature canopy trees and the planting of 100 additional trees mitigate urban heat, improve shade, and contribute to a more comfortable microclimate for visitors.

Atmosphere

- **Carbon sequestration and climate contribution:** Park vegetation contributes to carbon sequestration, cooling, and improved air quality—supporting broader environmental goals while creating a more pleasant and comfortable outdoor experience.

People

- **Inclusive and intergenerational design:** The park welcomes people of all ages, genders, and abilities—encouraging intergenerational use and repeat visitation through accessible paths, therapeutic gardens, and creative play spaces.
- **Community-led vision:** This project exemplifies community ownership. REPI's 14-year campaign not only shaped the vision but continues to influence how the park is used, cared for, and celebrated today.
- **Wellbeing and social connection:** Designed as a place of healing and reflection, the park provides restorative experiences, encourages passive recreation, and serves as a gathering space for performances, events, and everyday encounters—connecting people to each other and to nature.

Image courtesy of Angelo Carrafa

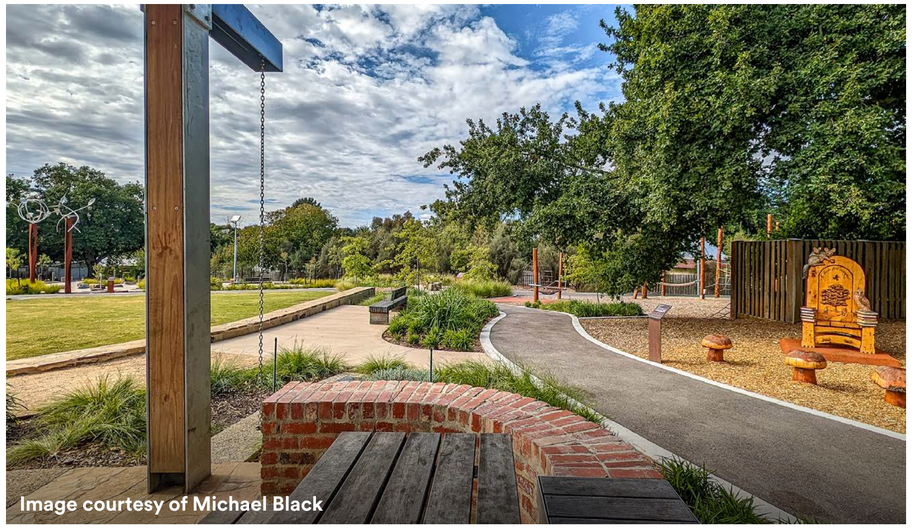


Image courtesy of Michael Black

LAND
CASE STUDY

DESIGN CONSIDERATIONS

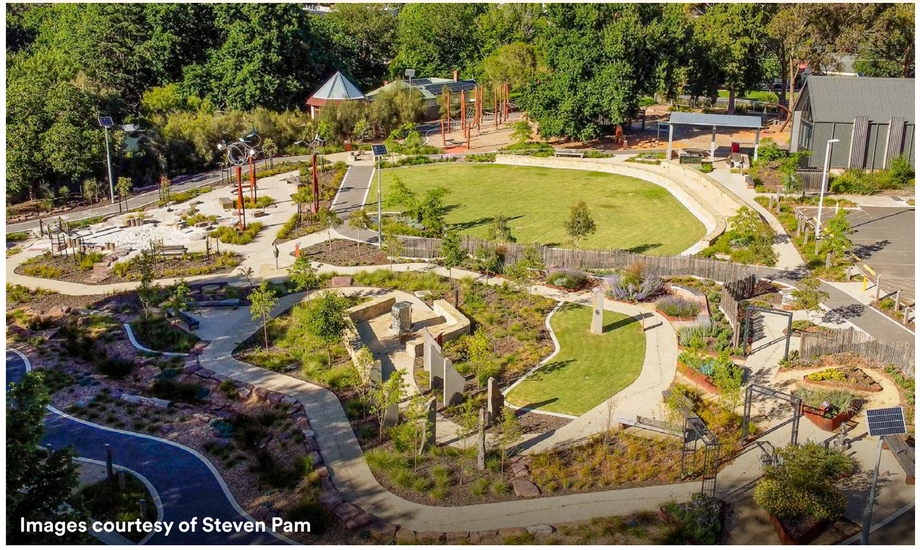
- **Collaborative and staged approach:** The design process included extensive community consultation, master planning, schematic design, and detailed documentation for staged construction aligned with available funding.
- **Sustainable materials:** Locally sourced recycled brick and stone were used to reduce embodied carbon and transport impacts.
- **Accessibility and wayfinding:** DDA-compliant paths navigate the steeply graded site, connecting activity zones while maintaining legibility and comfort.
- **Immersive experience:** Secondary, narrower paths encourage slower journeys and self-guided discovery.
- **Therapeutic placemaking:** Sculptural installations, kinetic wind features, and movement-activated water elements are placed to support calm, curiosity, and sensory engagement.
- **Cultural storytelling:** The Meeting Place—*Ngalampa Biik Yaluk* (“Come sit on Country by the Creek”)—and the Storytelling Chair reflect local narratives, history, and connection to place.

CONSTRUCTION CONSIDERATIONS

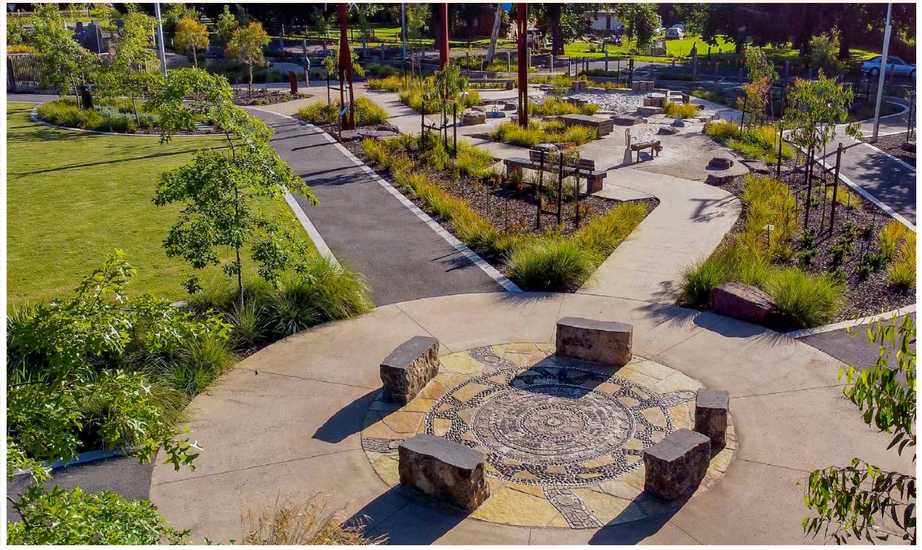
- **Staged delivery:** Construction occurred over three stages across four years, guided by available funding and access logistics. This phased approach allowed flexibility in delivery while maintaining design integrity.
- **Responsive implementation:** Design and construction teams worked closely to adapt the built outcomes to real-time conditions, preserving the park’s intent and ensuring accessibility, safety, and long-term performance.

OPERATIONAL CONSIDERATIONS

- **Community stewardship:** Ongoing care and programming are supported by continued involvement from REPI and the local community, ensuring the park remains responsive to evolving needs and values.
- **Durable, low-maintenance design:** Materials and plantings were selected for longevity and climate resilience, reducing maintenance needs while supporting year-round accessibility and enjoyment.



Images courtesy of Steven Pam



FURTHER READING

ACLA

- https://acla.net.au/ecotherapy-park/

MRSC

- https://www.mrsc.vic.gov.au/See-Do/Parks-Gardens-Reserves/Find-a-park/Romsey-Ecotherapy-Park

LAND
CASE STUDY

CASE STUDY:
477 PITT STREET – NATIVE FOOD GARDEN

PROJECT OVERVIEW

The Native Food Garden is a transformative retrofit that reimagines a previously underutilised and inaccessible site into a vibrant, inclusive and biodiverse urban sanctuary. Through culturally informed and ecologically sensitive design, the space now invites all visitors to engage, reflect and connect with Country.

Since its establishment, the garden has flourished—maturing into an urban oasis where native vegetation brings colour, movement and biodiversity back into the heart of the city. As the planting continues to grow, the space will offer greater shade, amenity and moments of respite.

Beyond aesthetics, the garden offers a layered, place-based experience grounded in Aboriginal custodianship. It highlights the enduring relevance of Indigenous food systems and Traditional Ecological Knowledge while supporting education, exchange and connection to living systems.

Blending food production, cultural storytelling and ecological restoration, the project sets a new benchmark for inclusive, sustainable design in an urban context.

Client:
ISPT

Project type:
Retrofit

Completion date:
2024

Location:
477 Pitt Street, Sydney NSW

First Nations Country:
Gadigal Country

Key Partners:

- Architecture: Wardle
- Builder: Buildcorp
- Cultural advisors: Aunty Barb and Uncle Ray
- Landscape and civil construction: AYZ Landscapes and Civil Construction

Image courtesy of Yerrabingin

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Native planting and habitat creation:** The garden features 100% native plant species—70% of which are edible—selected for their ecological value and cultural significance. This planting strategy supports urban biodiversity by creating habitat for birds, insects and pollinators, while also showcasing the richness of Indigenous food systems.

Water

- **Low-water design:** The planting palette consists of drought-tolerant native species requiring minimal irrigation. A targeted system supports plant establishment, with ongoing water needs significantly reduced—especially following rainfall.
- **Efficient irrigation:** A simple irrigation system ensures healthy growth while conserving water, contributing to sustainable long-term landscape performance.

Land

- **Reclaiming overlooked space:** The garden transforms a previously neglected site into a vibrant, living landscape that reflects care, culture and connection to Country.
- **Cooling and microclimate:** Through canopy planting and groundcover, the garden reduces the urban heat island effect and contributes to a cooler, more comfortable microclimate for both people and surrounding buildings.

People

- **Connection to Country:** The garden fosters meaningful reconnection with Indigenous food systems, ecological principles and the cultural responsibilities of custodianship. Grounded in First Nations knowledge, the space offers a calm, welcoming atmosphere where design becomes a vehicle for storytelling, reflection and learning.
- **Inclusive and immersive experience:** Every element is intentionally designed to invite multi-sensory engagement—through native plants, textures, scents and gathering spaces. The garden supports informal interaction, public education and community wellbeing, balancing beauty, ecology and culture.

Atmosphere

- **Sensory richness and retreat:** The garden creates a layered urban atmosphere—combining colour, texture, scent and movement to offer a restorative experience. Native planting, seasonal change and soundscapes from rustling leaves and visiting wildlife transform the space into a calm, reflective haven within the city.

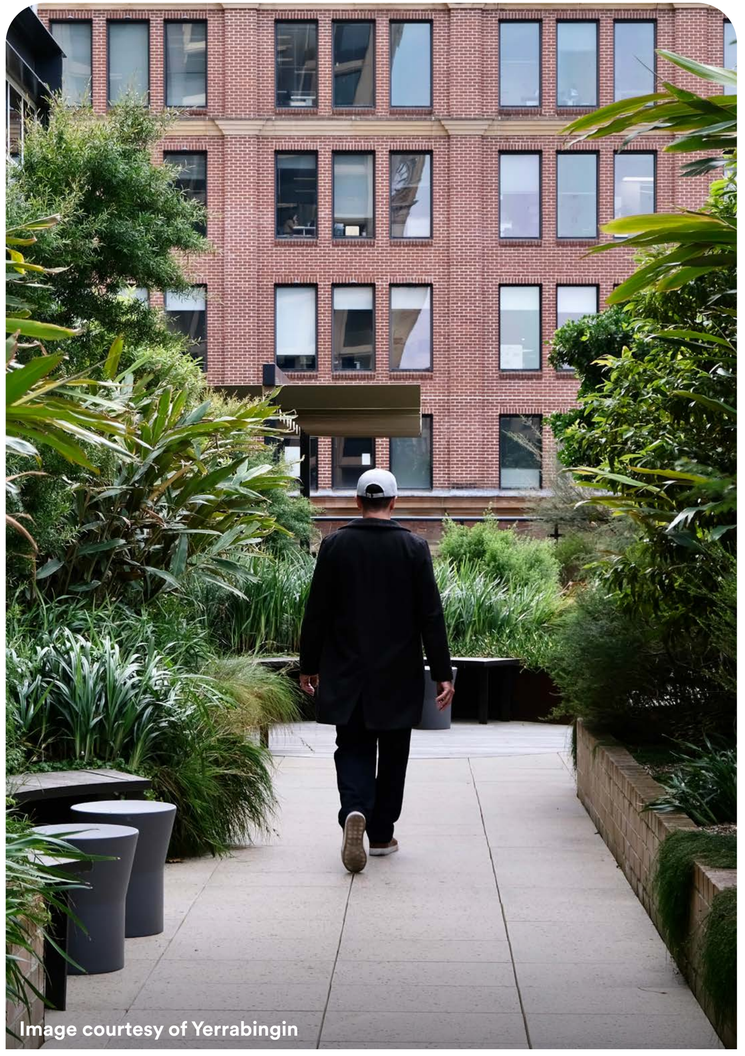


Image courtesy of Yerrabingin

LAND
CASE STUDY

DESIGN CONSIDERATIONS

- **Celebrate Indigenous food systems:** Showcase the diversity, sustainability and significance of native edible plants.
- **Promote Traditional Ecological Knowledge:** Embed Aboriginal perspectives into spatial design and planting choices.
- **Native planting for climate resilience:** 100% native species were selected for habitat creation, biodiversity value and low water needs.
- **Material reuse:** Existing walls, drainage and slab levels were retained to reduce waste and embodied carbon.
- **Accessibility and inclusivity:** The design prioritises comfort, safety and welcome for all users.
- **Wellbeing and connection:** Nature-based design promotes mental health, social connection and cultural learning.
- **Community engagement:** The space supports gatherings, events and informal interaction.
- **Urban greening:** Introduces shade, softness and visual amenity within a dense city context.

CONSTRUCTION CONSIDERATIONS

- **Adaptive delivery in a constrained site:** During demolition, the team uncovered deteriorated infrastructure and non-compliant legacy systems. Rather than defaulting to full replacement, the design team adopted a flexible, problem-solving approach—assessing what could be salvaged and creatively adapting the design to fit site constraints.
- **Sustainability under pressure:** Despite unforeseen challenges, the team remained committed to the project's environmental goals. Careful construction supervision ensured the reuse of materials where possible and minimal disruption to the site's ecological vision.

OPERATIONAL CONSIDERATIONS

- **Cultural programming and events:** The garden is designed to support community events and informal gatherings—facilitating cultural exchange, education and shared celebration of Country.
- **Low-maintenance design:** Native, climate-resilient planting and efficient irrigation reduce the need for intensive upkeep. The space is designed for longevity, with durable materials and simple systems that support ease of care over time.

Images courtesy of Yerrabingin

FURTHER READING

AILA - Project Spotlight:
- 477 Pitt Street – Native Food Garden

Landscape Australia – National Awards Feature:
- Award of Excellence for Small Projects

Wardle Studio:
- Project Overview

LAND
CASE STUDY

CASE STUDY: WADANGGARI PARK

PROJECT OVERVIEW

Wadanggari Park is Australia's first park built over a railway line—a bold example of spatial innovation in a dense urban setting. With a narrative grounded in the resilience and renewal of the banksia (wadanggari), the park transforms airspace infrastructure into green, open public realm.

Set above the North Shore railway line, Wadanggari Park delivers 4,750 m² of valuable open space in St Leonards' rapidly growing CBD, creating a lush connection between new residential developments and public transport hubs including train, bus and the new Crows Nest metro station.

The park extends ecological corridors linking bushland to Sydney Harbour while also addressing the social, cultural and economic needs of a precinct undergoing major transformation.

Project type:
New build

Client:
Lane Cove Council

Location:
Pacific Highway,
St Leonards, NSW

Completion date:
September 2023

First Nations Country:
Cammeraygal Country

Key Partners:

- Project management: Aurecon
- Landscape Architect: Arcadia Landscape Architecture
- Construction: Arenco
- Landscape construction: Landscape Solutions
- Public art: Cola Studio
- First Nations collaboration: Uncle Dennis Foley (Cammeraygal Elder)
- Lighting: iGuzzini
- Adjoining development: JQZ (Developer – Eighty Eight), PTW (Architect – Eighty Eight)

Image courtesy of Paul McMillan

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Extending ecological corridors:** The park widens bushland habitat links between the St Leonards CBD and Sydney Harbour.
- **Habitat creation:** Over 50 trees and diverse Indigenous shrubs and ferns were planted to attract birds, insects and small fauna.

Water

- **Water-sensitive species selection:** Drought-tolerant, low-maintenance native plants reduce irrigation needs and support long-term water efficiency.
- **Hardy planting for high-use areas:** Species were chosen to thrive under foot traffic, limited soil depth and rooftop conditions.

Land

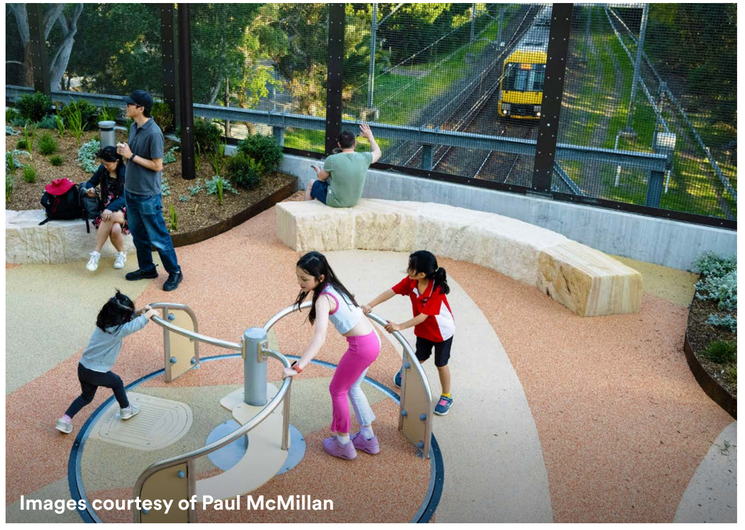
- **Reclaiming airspace:** Built over the rail corridor, the park demonstrates how airspace infrastructure can deliver public benefit and open space in constrained urban areas.
- **Cooling the city:** Trees and planting provide vital shade and reduce localised heat island effects in a high-density precinct.

People

- **Community destination:** Wadanggari Park offers a central green heart for the growing St Leonards community, supporting relaxation, play, events and daily commutes.
- **Intergenerational design:** Inclusive for all ages and abilities, the park's layout supports active use, informal gathering and cultural learning.
- **Cultural narrative:** With guidance from Cammeraygal Elder Uncle Dennis Foley, the design centres the wadanggari (banksia) as a symbol of resilience. Public art, interpretive structures and storytelling elements express local Indigenous culture in meaningful ways.
- **Precinct revitalisation:** The park activates the surrounding mixed-use development, contributing to the economic and social vibrancy of St Leonards.

Atmosphere

- **Sensory richness:** The landscape evokes the textures, scents and sounds of bushland—creating a unique sensory atmosphere amidst the urban fabric.
- **Cultural resonance:** Place-based stories and symbols bring depth and distinctiveness to the space, embedding meaning in every detail.



Images courtesy of Paul McMillan

LAND
CASE STUDY

DESIGN CONSIDERATIONS

- **Site analysis and programming:** Detailed studies informed the layout to accommodate active movement, connection to transport and passive recreation.
- **Cultural identity:** The wadanggari lifecycle guided the spatial narrative, embedded through planting, sculptural play, interpretive structures and paving patterns.
- **Community engagement:** Feedback shaped diverse amenity and ensured alignment with resident needs.
- **Integrated access:** The park connects directly to underground rail links via stairs and lifts—reducing pedestrian pressure on the highway and increasing safety.
- **Indigenous collaboration:** The project team worked closely with Elders and designers to authentically express Indigenous culture and values in the public realm.

CONSTRUCTION CONSIDERATIONS

- **Engineering a park over rail:** The park platform is built on 31 precast Super-T girders (60 tonnes each), lifted into place with Australia's largest mobile crane.
- **Tight construction window:** All works occurred over 31 scheduled rail closures to minimise disruption to rail and freight services.
- **Load-bearing design:** Arcadia and Arenco mapped load-bearing zones to safely support trees, play equipment and infrastructure over the rail corridor.
- **Design constraints:** The park layout was influenced by the location of Sydney's second-largest telecommunications node, requiring careful spatial planning and circulation design.

OPERATIONAL CONSIDERATIONS

- **Low-maintenance materials:** Aluminium cladding and durable surfaces were used to withstand heavy use and reduce maintenance burdens.
- **Planting resilience:** Drought-tolerant native species reduce irrigation needs and suit local conditions.
- **Pedestrian integration:** The subterranean connection and vertical circulation infrastructure (stairs and lifts) help shift thousands of pedestrian crossings off the Pacific Highway—improving safety and minimising wear on surrounding infrastructure.
- **Public asset longevity:** Design decisions were made to reduce whole-of-life costs and ensure the park remains resilient under heavy daily use.

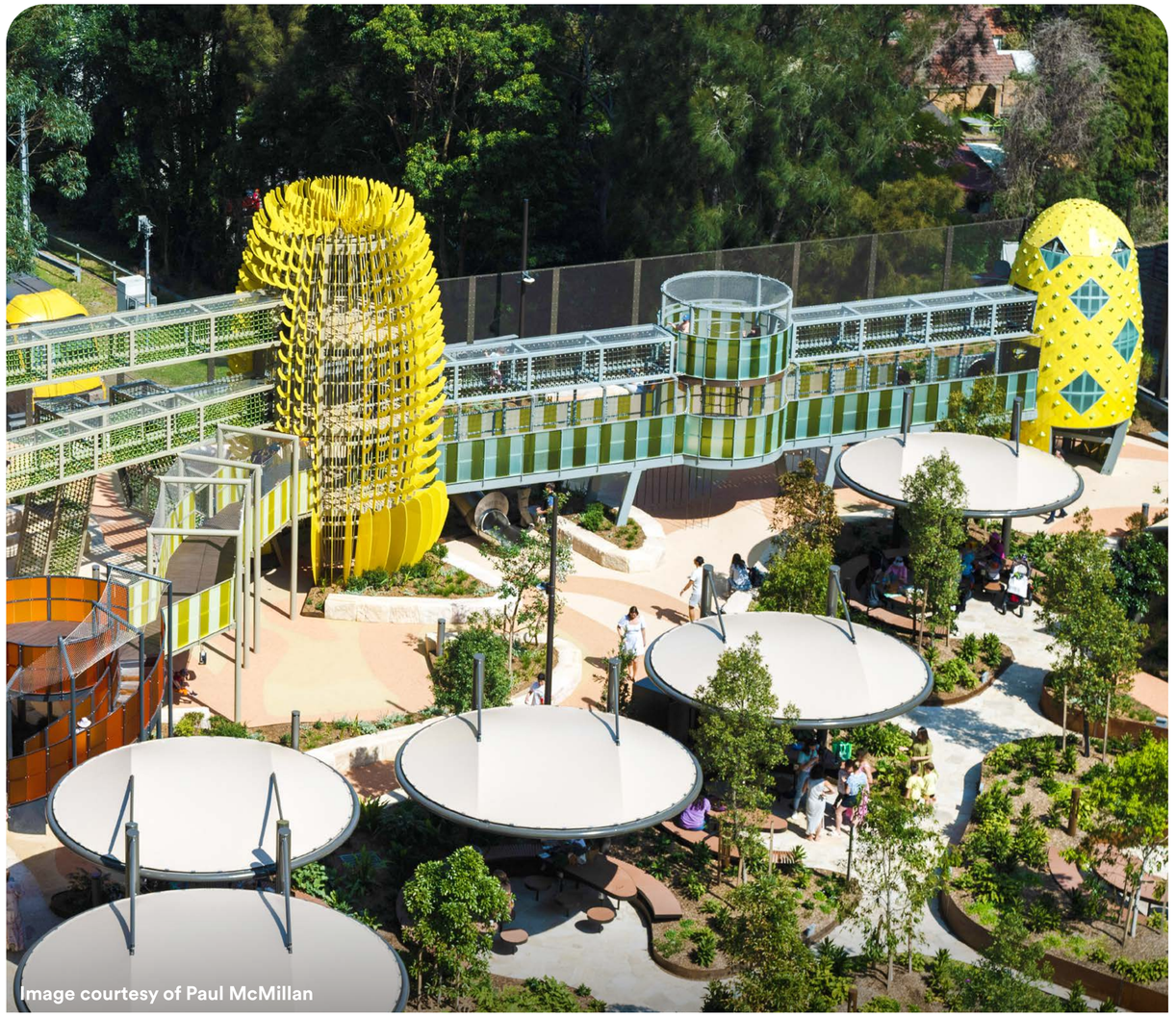


Image courtesy of Paul McMillan

LAND
DESIGN ELEMENT

DESIGN ELEMENT: COMMUNITY GARDEN

Community gardens and city farms are shared spaces where individuals or groups can grow food, herbs and native plants. Typically located on public or underutilised land, they are managed by councils, not-for-profits or local volunteers and provide a mix of private plots and communal areas.

These gardens support social inclusion, education and food security, while contributing to local biodiversity and climate resilience. Common features include raised garden beds, composting systems, rainwater tanks, shade structures, seating and shared tool storage.

Community gardens also provide habitat for pollinators and microfauna, support soil restoration and enable passive water management. Incorporating native species, permaculture practices and habitat features can further enhance their ecological value.

As both productive and social landscapes, community gardens offer opportunities for nature stewardship, learning and connection to Country. Their success depends on strong community governance, clear planning and ongoing care.

BENEFITS AND CO-BENEFITS

Land

- Can be delivered with minimal disturbance using raised garden beds
- Regulates urban temperature and reduces heat island effect
- Restores nutrient cycling, soil health and prevents erosion
- Contributes to urban greening

Water

- Retains stormwater and reduces runoff volumes and peak flows
- Improves water quality through on-site filtration

Biodiversity

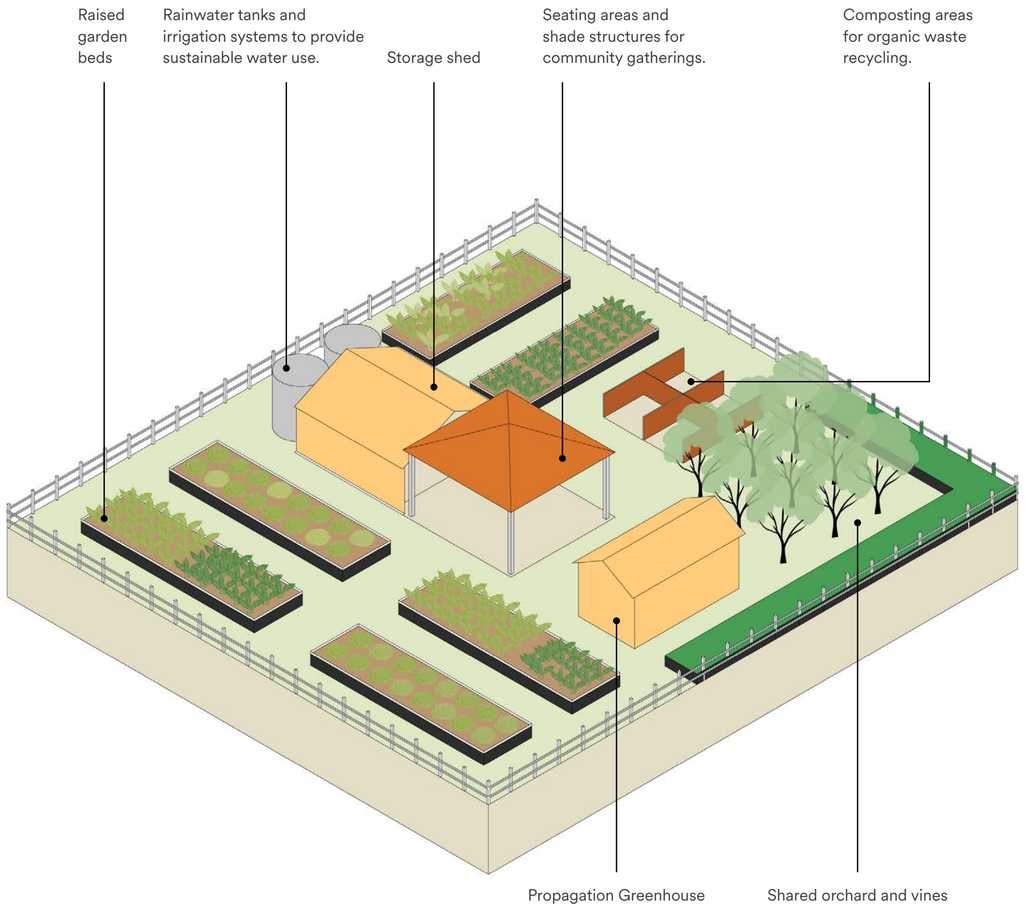
- Increases urban plant diversity
- Provides habitat for invertebrates, birds, bats and microfauna
- Supports pollinators through flowering and fruiting plant selection

Atmosphere

- Improves air quality by capturing particulates
- Supports carbon sequestration through vegetation and soil

People

- Enhances urban aesthetics and landscape value
- Fosters Connection to Country and nature
- Builds nature stewardship through hands-on engagement
- Improves mental wellbeing and physical health
- Offers financial savings through local food production
- Strengthens community cohesion and social inclusion



LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Community-led planning:** Successful gardens are underpinned by early community involvement, strong governance and co-designed layouts that reflect local needs.
- **Partnerships and funding:** Build connections with councils, schools, businesses and community groups. Consider long-term funding, grants or in-kind support. Selling gardening supplies, seeds or plants of engagement workshops can also provide opportunities for income to maintain the garden.
- **Site functionality:** Ensure access to quality soil, water and composting. Provide space for garden beds, compost, tools, shade, propagation and social interaction.
- **Inclusive design:** Plan for accessibility, visibility and safety. Raised beds, seating and paths should support people of all ages and abilities.
- **Ongoing maintenance:** Develop clear roles for management and maintenance of both individual plots and shared infrastructure. Include plans for compost, irrigation and weeding.

LIMITATIONS

- Long-term success depends on active governance and community engagement.
- Gardens must be accessible by foot, bike, vehicle and to people of all abilities.
- Space must accommodate productive areas, support infrastructure and social gathering zones.
- Poor soil quality, limited water access or insufficient composting may hinder viability.
- Gardens may generate concerns from neighbours regarding pests, odour or maintenance.

DESIGN CONSIDERATIONS

- **Layout planning:** Include zones for private plots, communal growing, learning spaces and shared infrastructure like tool sheds and compost bays.
- **Water and drainage:** Provide non-potable water sources such as rainwater tanks. Design for passive irrigation, water harvesting and runoff reduction.
- **Soil and compost:** Avoid soil import where possible. Use on-site composting and mulch from local biomass to restore soil health.
- **Waste management:** Focus on organic waste recycling via composting and worm farms. Include facilities for non-organic waste disposal, management and recycling.
- **Planting and biodiversity:** Incorporate a diverse mix of productive and native species. Use legumes, crop rotation and permaculture practices to support soil and pest management.
- **Habitat support:** Include features like bird boxes, bee hotels, frog ponds and water sources to support local fauna.
- **Community engagement:** Design for sensory appeal, signage, outdoor learning, Indigenous language and bush tucker gardens. Include quiet spaces and community art.
- **Access and safety:** Ensure safe, inclusive access and passive surveillance. Incorporate lighting, fencing and clear sightlines.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify suitable sites and connect gardens to the wider open space network. Explore opportunities for multi-use public land and minimise soil disturbance.
- **Concept Design:** Engage local communities and key stakeholders to co-design garden zoning, access, infrastructure and planting strategies. Prioritise safety, visibility and welcoming entrances.
- **Detailed Design:** Specify materials, accessibility features, water systems and composting areas. Detail planting plans and integration of cultural, educational and biodiversity elements.
- **Construction:** Install infrastructure progressively based on funding and evolving community needs. Include signage, paths, garden beds and key services.
- **Operation:** Monitor use and community engagement. Support long-term management with maintenance plans and defined governance structures.

APPLICABILITY

Suitable for individual buildings (e.g. rooftop or terrace gardens) but best suited to precinct-scale applications for greater impact and flexibility.

LAND
CASE STUDY

CASE STUDY: NORTHEY STREET CITY FARM

Image courtesy of Anne Kovachevich

PROJECT OVERVIEW

Northey Street City Farm is a 2.5-hectare urban permaculture site in inner Brisbane, established in 1994. Operated by a not-for-profit community organisation, the farm demonstrates sustainability and serves as a vital green hub in the city.

Home to more than 1,500 native and exotic fruit trees, bush food plants, herbs, and groundcovers, the farm is a working model of urban biodiversity and permaculture in action. It provides community allotments, native forest regeneration, organic markets, workshops, and events—supporting food sovereignty, cultural knowledge-sharing, and ecological restoration.

Rooted in a vision of abundance, connection, and harmony, the farm promotes inclusion, climate resilience, and social wellbeing. It also plays a reparative role by collaborating with Traditional Owners and embedding First Nations perspectives in its programs and purpose.

Client:
Community-led initiative

Project type:
Community-established and evolving site

Completion date:
Founded in 1994

Location:
16 Victoria Street, Windsor, Brisbane, QLD

First Nations Country:
Yuggera and Turrbal Country

Owner:
Brisbane City Council

Key Partners:

- Permaculture Australia
- Local volunteers and residents
- Educational and cultural organisations


Image courtesy of Anne Kovachevich

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- Over 1,500 fruit trees, bush foods, shrubs, and groundcovers contribute to habitat creation and ecological resilience.
- A native forest regeneration area strengthens local biodiversity and connects habitat corridors.
- Chickens and a bee shed support pollination, food production, and education.
- Plant and seed sales encourage biodiversity beyond the farm through local propagation.

Water

- **Permaculture-based water strategies:** Swales, plant grouping, and soil health reduce irrigation needs and improve infiltration.
- **Wicking beds:** Self-watering raised beds reduce water use through subsurface irrigation.
- **Rainwater harvesting:** Collected in tanks and reused across the site.
- Water is naturally filtered before entering Breakfast Creek, improving catchment health.

Atmosphere

- **Carbon sequestration:** Trees and plants sequester carbon and cool the surrounding area.
- **Air purification:** Vegetation acts as a natural filter, improving urban air quality.
- **Reduced food miles:** Local food production significantly cuts transport-related emissions and builds food resilience.

Land

- **Composting:** A large community composting operation supports circular nutrient cycles and diverts waste from landfill.
- **Soil regeneration:** Practices like worm farming, cover cropping, and organic cultivation enhance soil health and reduce reliance on synthetic inputs.
- **Urban heat mitigation:** Dense vegetation and edible water plants reduce localised temperatures and create a cool, shaded microclimate.

People

- **Education and empowerment:** Workshops, school programs, and courses in permaculture and ecological living build local capacity.
- **Demonstration and inspiration:** The site acts as a living classroom, showcasing food forests, organic gardens, and native regeneration.
- **Events and connection:** Festivals, cultural gatherings, and weekly farmers markets create a vibrant social atmosphere.
- **Allotments and access to land:** Plot rentals give individuals access to land, tools, and knowledge—especially important for apartment dwellers.
- **Local produce:** The market garden and farm-based enterprises provide fresh, organic food to the community.

Images courtesy of Anne Kovachevich

LAND
CASE STUDY

DESIGN CONSIDERATIONS

- **Wind protection:** Planting and structures buffer cold winds and protect crops.
- **Site layout:** Buildings, sheds, and circulation paths are arranged for efficient movement and farm functionality.
- **Ecological systems:** Forest gardens and agroecological zones mimic natural ecosystems to support biodiversity and productivity.
- **Flood resilience:** Recurrent flood events have informed new design phases focused on withstanding future climate shocks.
- **Place-based design:** Every zone is shaped by local climate, hydrology, and community needs.

CONSTRUCTION CONSIDERATIONS

- **Sustainable materials:** Recycled timber and locally sourced resources were used for infrastructure.
- **Community contribution:** Residents participated in hands-on construction, including a terrazzo mosaic that reflects the farm's identity and story.

OPERATIONAL CONSIDERATIONS

- **Soil care:** Composting, cover cropping, and organic inputs ensure long-term productivity and health.
- **Integrated pest management:** Natural systems are used to manage pests without chemicals.
- **Maintenance and upkeep:** Ongoing community engagement ensures systems for waste, water, and composting are maintained effectively.
- **Climate adaptation:** The farm continues to evolve in response to flooding, drought, and urban development pressures.

Image courtesy of Anne Kovachevich

FURTHER READING

Freemantle Community Gardening Guide:
- Community Gardens Booklet.pdf

City of Ballarat – A Guide to Community Gardens:
- Community Gardens Guide.pdf

Community Gardens Manual:
- HMST-manual.pdf

Northey Street City Farm:
- Our Organisation

LAND
DESIGN ELEMENT

DESIGN ELEMENT: ELEVATED PARK

Elevated parks are public green spaces built on rooftops or raised structures, functioning as a hybrid between green roofs and urban parks. They typically include lawns, garden beds, planter boxes, trees, shaded seating and gathering areas—creating a vibrant urban space above ground level.

By bringing vegetation into the urban canopy, elevated parks contribute to biodiversity, reduce the urban heat island effect, support stormwater management and enhance recreational opportunities in dense environments.

Though often smaller and more exposed than ground-level parks, elevated parks provide valuable open space in constrained urban settings. When integrated with green infrastructure networks, they can support habitat creation, pollination and urban cooling while offering a unique opportunity for education, cultural expression and community connection.

Read in conjunction with the *Biodiverse Green Roof* design element for complementary technical guidance.

BENEFITS AND CO-BENEFITS

Land

- Regulates urban temperature and reduces heat island effect
- Contributes to urban greening and visual amenity

Water

- Retains and detains stormwater, reducing runoff and peak flows
- Improves water quality through natural filtration
- Enables rainwater harvesting and reuse

Atmosphere

- Improves air quality by capturing particulates
- Supports carbon sequestration
- Reduces building energy use and associated carbon emissions through thermal insulation
- Improves noise attenuation

Biodiversity

- Creates novel habitats for invertebrates, birds and microfauna
- Increases urban plant diversity and supports pollinators
- Incorporates habitat analogues such as nest boxes and bee hotels
- Enhances ecological connectivity across rooftops and green corridors

People

- Provides opportunities for recreation
- Strengthens Connection to Country and Caring for Country practices
- Enhances mental wellbeing and community cohesion
- Improves urban aesthetics and property values
- Offers education, interpretation and nature stewardship opportunities
- Reduces building energy use and cost due to insulation properties

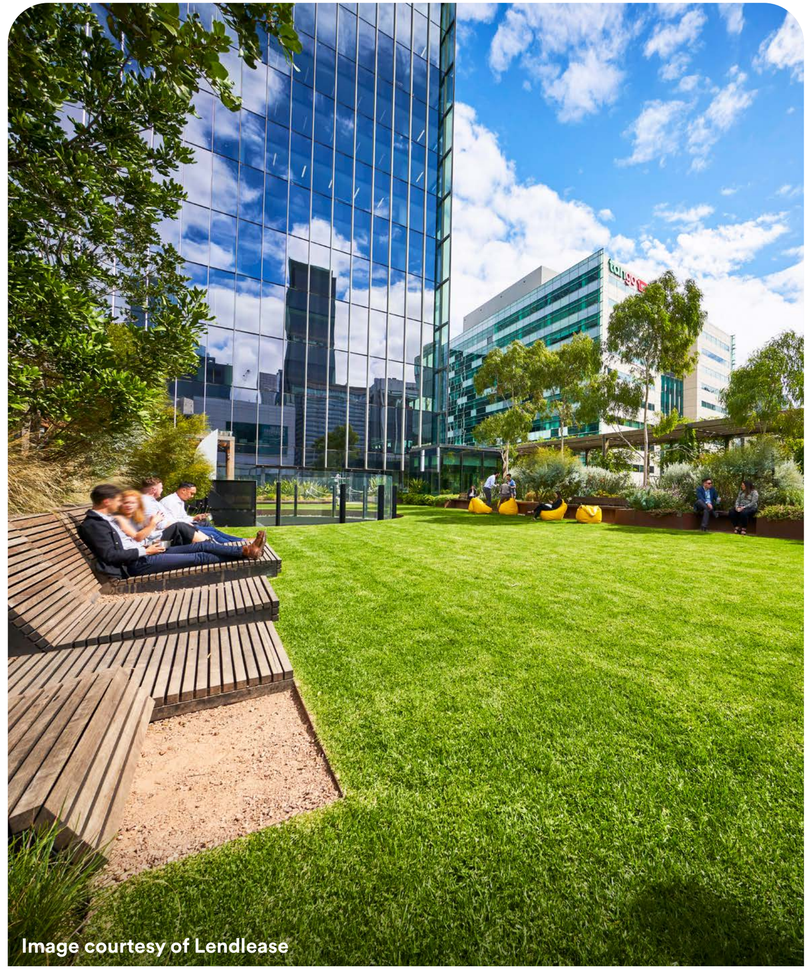


Image courtesy of Lendlease

LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Specialist input:** Engage ecologists, landscape architects, structural and drainage engineers early to ensure feasibility, safety and ecological value.
- **Plant selection:** Use native or indigenous species suited to high-exposure rooftop conditions. Consider exotics for resilience or functional value where appropriate.
- **Planting structure:** Incorporate multiple vegetation layers—groundcovers, shrubs and trees—to support biodiversity.
- **Microclimate variation:** Design for sun and shade zones, plus consideration for wind. Use flowering species across seasons and include shelter to support insect and bird life.
- **Water management:** Install efficient irrigation systems and prioritise passive watering where possible. Water access is critical during establishment and hot periods. Design drainage catchment for water re-use.
- **Connectivity:** Locate elevated parks within a broader green infrastructure network to maximise habitat connectivity and ecological value.

LIMITATIONS

- Smaller planting areas and rooftop constraints may limit biodiversity outcomes compared to ground-level landscapes.
- Building height above five storeys can reduce ecological connectivity with ground-level habitats.
- Fauna may be disturbed by lighting, noise and regular human activity.
- Structural and cost considerations may limit feasibility for retrofits.
- Potential pedestrian comfort review due to wind exposure.

DESIGN CONSIDERATIONS

- **Structure and loading:** Confirm that the building can support live and dead loads, including saturated substrate, vegetation and public use.
- **Substrate and waterproofing:** Use lightweight engineered soils and specify high-quality waterproof membranes and leak detection systems.
- **Wind and exposure:** Select plant species based on wind tolerance. Use mounding and structural planting to mitigate rooftop wind impacts.
- **Water management:** Incorporate smart irrigation and passive watering strategies. Design for adequate drainage and potential rainwater harvesting.
- **Fire safety:** Use low-risk plant species and design irrigation to reduce fire hazard in elevated environments.
- **Access and safety:** Plan for safe public access, including edge protection, lighting, DDA compliance and wayfinding.
- **Community engagement:** Integrate signage, learning areas, Indigenous language, bush tucker species and opportunities for stewardship or activation.
- **Cultural and social elements:** Incorporate seating, shade structures, play elements, art and sensory features to encourage diverse use and connection to place.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify rooftops or elevated structures suitable for greening. Define biodiversity and community objectives early, including how the space connects with surrounding green infrastructure.
- **Concept Design:** Assess site exposure, access and microclimate conditions. Develop planting and layout strategies that balance recreational use with ecological outcomes.
- **Detailed Design:** Specify plant species, soil depths, irrigation systems and safety features. Detail maintenance protocols and community engagement elements.
- **Construction:** Oversee installation of waterproofing, substrate, drainage, irrigation and planting. Ensure safe access and site protection during works.
- **Operation:** Monitor vegetation health, irrigation performance and community use. Maintain infrastructure and adapt management based on user feedback and ecological outcomes.

APPLICABILITY

Suitable for individual buildings and precinct-scale applications

LAND
CASE STUDY

CASE STUDY: MELBOURNE QUARTER SKYPARK

PROJECT OVERVIEW

Melbourne Quarter Sky Park is an elevated urban park—suspended 10.5metres above Collins Street—that transforms underutilised airspace into a 2,000 m² green oasis in the heart of the city. Designed for public access and workplace wellbeing, the park delivers biophilic benefits, social connectivity, and ecological value in a dense, vertical precinct.

Featuring immersive landscape zones—The Waiting Room, The Cluster, The Lawn, The Lounges, and The Bleachers—the Sky Park integrates seating, vertical greening, native planting, and natural materials to support rest, work, and social activity. Amenities like Wi-Fi, power outlets, and USB ports invite extended stays and workplace integration.

As one of Australia's most ambitious rooftop parks, Sky Park demonstrates what is possible when green infrastructure, architectural innovation, and biophilic design converge—creating a thriving ecosystem above one of Melbourne's busiest streets.

Client:
Lendlease

Project type:
New build

Completion date:
2012

Location:
600 Collins Street, Docklands, Melbourne, VIC

First Nations Country:
Wurundjeri Country

Owner:
Public-private partnership between the Victorian Government and AquaSure

Key Partners:

- Landscape architecture: Aspect Studios & OCULUS
- Architecture: Denton Corker Marshall

Image courtesy of Lendlease

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Pollinator habitat:** A diverse flowering palette supports native bees, butterflies, and other pollinators—strengthening city-wide ecological networks.
- **Target species:** Designed to attract blue-banded bees, superb fairy-wrens, red-rumped parrots, and butterflies.
- **Native planting:** Vegetation includes dwarf lemon-scented gums, banksia, wattles, and native frangipani—chosen for biodiversity value, aesthetics, and resilience.
- **Ecological observations:** Regular bee and insect activity confirms habitat success in this elevated context.

People

- **Public amenity:** The park is open to all—serving city workers, residents, and visitors. Its mix of lawn, lounges, shaded seating, and communal zones supports a range of activities.
- **Workplace wellbeing:** Tenants have reported “exceptional results” from integrating the park into their daily routines—using it for meetings, breaks, and solo work.
- **Biophilic experience:** Natural materials including timber, evoke bushland qualities and reduce stress through biophilic design.
- **Access and connectivity:** Visitors access the park via a striking spiral staircase or lift, connecting directly to ground-level circulation networks.
- **Programming flexibility:** Zones accommodate everything from solitary rest to social gatherings, offering dynamic use across times of day and seasons.

Atmosphere

- **Carbon and air quality benefits:** Dense vegetation helps sequester carbon and filter air pollutants—amplified by the park’s scale compared to typical rooftop gardens.
- **Sensory richness:** The mix of vegetation, natural textures, and elevated views creates a unique atmosphere—part sanctuary, part stage—for Melbourne’s evolving skyline.

Water

- **Stormwater management:** Built-in systems slow and retain rainwater, helping reduce runoff volume and improve water quality.
- **Rainwater harvesting:** Irrigation is supported by the collection and reuse of rainwater—reducing reliance on potable water and pressure on stormwater infrastructure.

Land

- **Urban greening at height:** The Sky Park expands public green space vertically, offering natural habitat and ecological function beyond ground-level.
- **Heat island mitigation:** Extensive planting, tree canopy, and vertical greening reduce surface temperatures and provide shade.

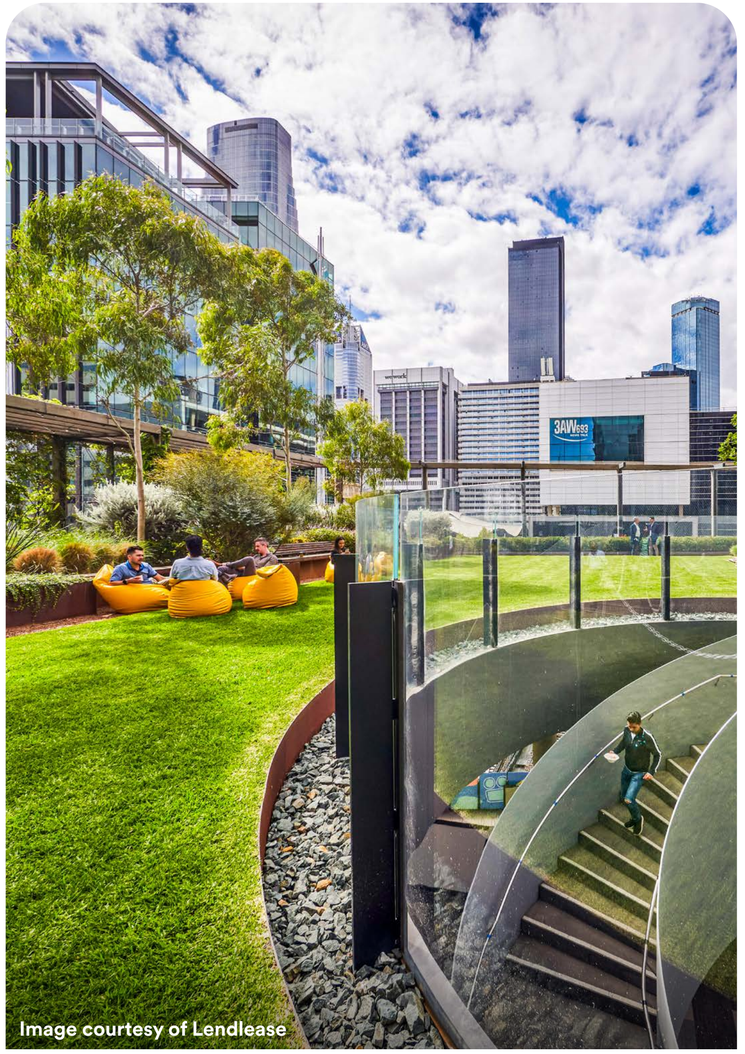


Image courtesy of Lendlease

LAND
CASE STUDY

DESIGN CONSIDERATIONS

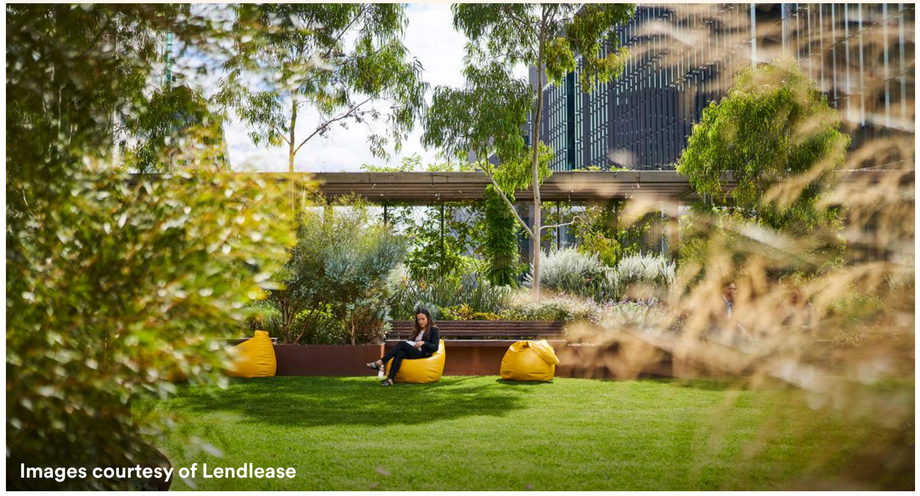
- **Wind mitigation:** Elevated exposure called for strategic planting, structure orientation, and screening for visitor comfort.
- **Accessibility:** The park is universally accessible via lift and stairs, encouraging inclusivity and safe movement across levels.
- **Structural innovation:** The park is supported by a diaphragm and raked column system, transferring load to the tower's lift core and eliminating bulky transfer structures.
- **Biophilia and biomimicry:** Curved timber elements, canopy-inspired forms, and textural detailing evoke natural bushland and connect people to place.
- **Amenity planning:** Zones were designed for varied use—sunny lawns, shaded lounges, quiet corners—supported by integrated power, Wi-Fi, and lighting.
- **Expert collaboration:** Planting success relied on input from botanists, horticulturists, and arborists to ensure long-term resilience in an exposed, elevated context.

CONSTRUCTION CONSIDERATIONS

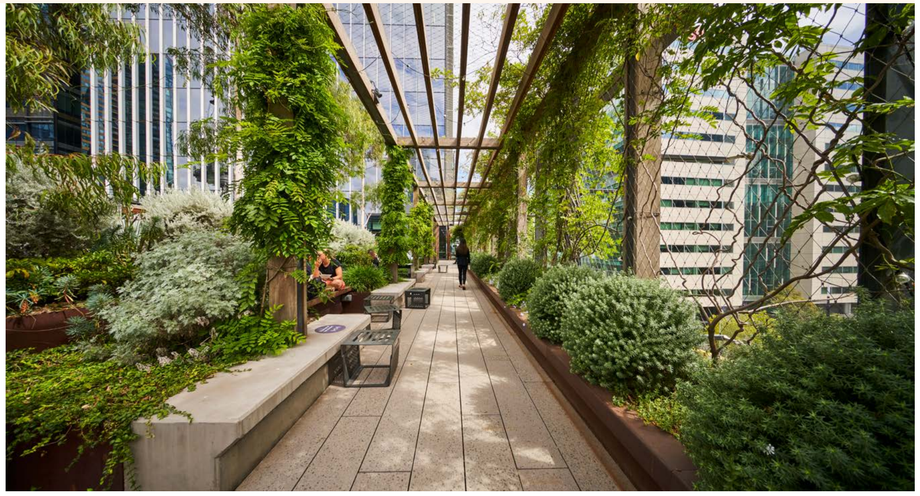
- **Above a major road and near rail:** Complex logistics were managed to construct above live infrastructure with minimal disruption.
- **Safety and access:** Safety barriers double as trellises for climbing plants, while offering transparency to enjoy city views.
- **Public interface:** Every element was designed to balance engineering, safety, and beauty in a highly visible and constrained location.

OPERATIONAL CONSIDERATIONS

- **Maintenance:** Ongoing horticultural care is essential to ensure plant health, irrigation function, and visitor amenity.
- **Growth management:** As population and demand increase, strategies may be needed to balance high visitation with park longevity.
- **Durable design:** Materials were chosen for resilience, with key areas protected from wear and water stress to ensure long-term performance in a high-traffic setting.



Images courtesy of Lendlease



FURTHER READING

Australia Government:

- Green Walls, Roofs, and Facades – City of Melbourne

OCULUS:

- Melbourne Quarter Sky Park Case Study

Landscape Australia:

- An elevated exchange: Sky Park, One Melbourne Quarter

Melbourne Quarter:

- Project Overview
- Sustainability News

Australasian Green Infrastructure Network: Skypark - Melbourne

- https://www.agin.org.au/project-library/skypark---melbourne

Tensile:

- Melbourne Quarter Sky Park

LAND
DESIGN ELEMENT

DESIGN ELEMENT: EXTERNAL GREEN FAÇADE

External green façades are vertical greening systems that use climbing or cascading plants to cover the walls of buildings. They mimic natural climbing behaviour found in wild habitats, using structural supports such as cables, meshes or trellises to guide plant growth while keeping vegetation separated from the building envelope.

These façades can be fed from ground-level planting zones or containerised planters installed at various heights. Compared to green walls, green façades rely on root systems external to the vertical surface and offer a lightweight, lower-impact alternative for creating dynamic, living architecture.

They enhance building performance, provide habitat, support microclimate regulation and deliver visual and cultural value. As the vegetation matures, façades evolve over time, supporting biodiversity, improving air quality and contributing to urban greening.

External green façades can be designed into new developments or retrofitted and work particularly well when integrated with broader green infrastructure networks.

BENEFITS AND CO-BENEFITS

Land

- Contributes to urban greening
- Regulates urban temperature and reduces heat island effect

Water

- Offers potential integration with rainwater harvesting and passive irrigation systems

Biodiversity

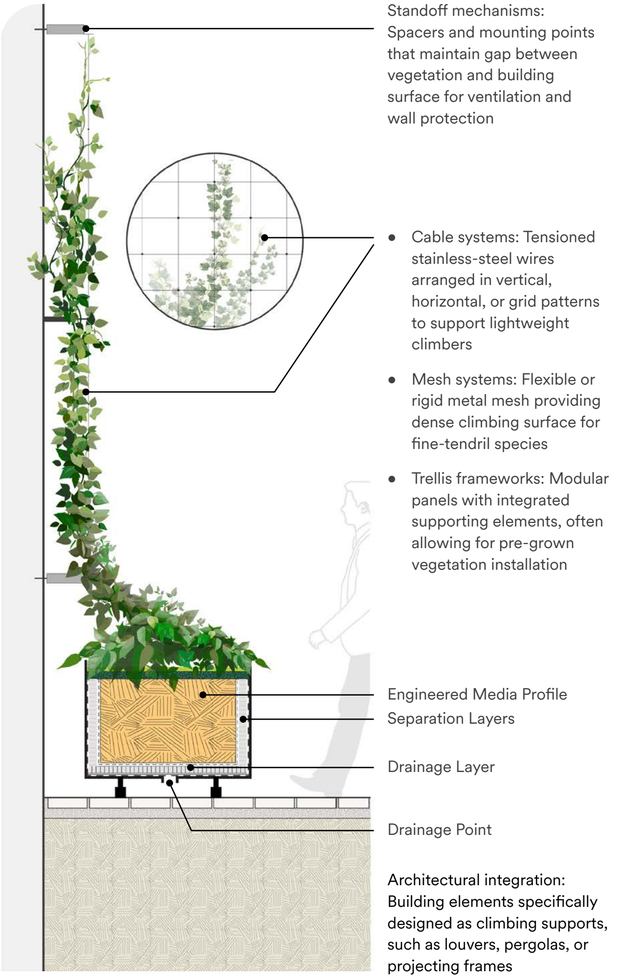
- Creates limited vertical habitat for birds and invertebrates
- Provides pollinator services

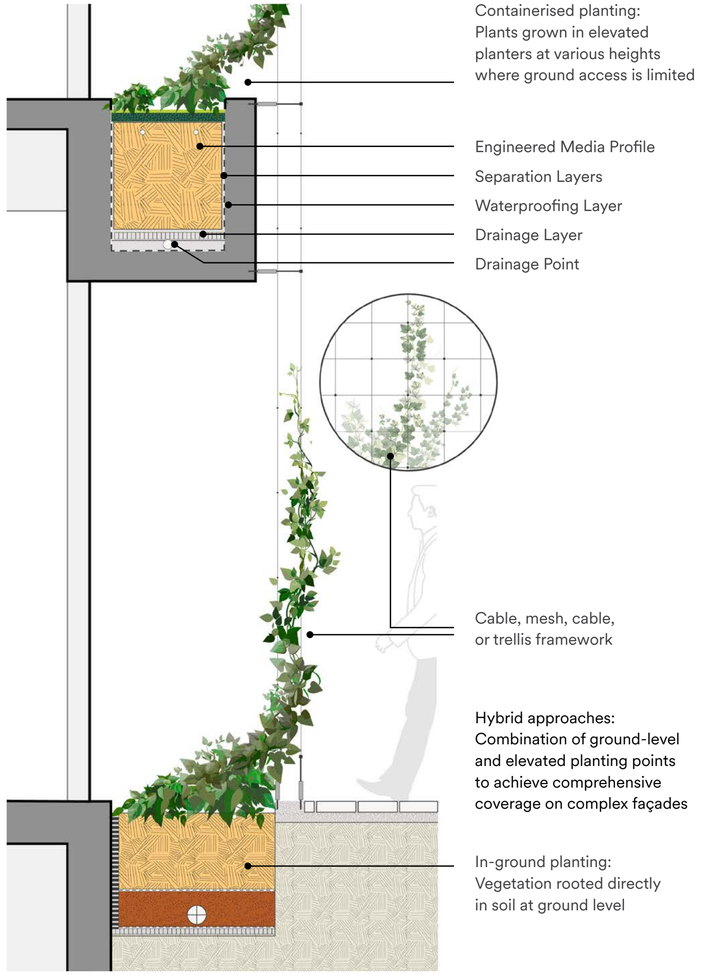
Atmosphere

- Improves air quality by filtering airborne particulates

People

- Enhances urban aesthetics and property values
- Supports mental wellbeing
- Provides Connection to Country and Nature





LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Design integration:** Coordinate façade greening with architectural design early to ensure structural support, waterproofing and façade protection.
- **Plant selection:** Select species with climbing habits suited to the chosen support system. Prioritise climate-resilient plants that perform well in local conditions. Consider flowering species to support pollinators.
- **Microclimate response:** Analyse solar orientation, wind exposure and seasonal performance to guide planting strategy and support healthy growth.
- **Structural design:** Engineer support structures to withstand mature plant weight and environmental loads. Maintain adequate separation from the building surface.
- **Irrigation systems:** Design targeted, reliable remotely monitored irrigation systems to support establishment and long-term plant health, particularly in elevated or exposed areas.
- **Ongoing maintenance:** Plan for safe, long-term access and care, including pruning, training, health monitoring and system inspections.

LIMITATIONS

- Plant establishment may take 3–5 years, delaying full coverage and visual impact.
- Limited plant palette in extreme climates may affect biodiversity and appearance.
- High exposure to wind, pests and seasonal variation can impact plant health and consistency.
- Upfront and maintenance costs are typically higher than conventional façades.
- Safe access for maintenance must be factored in from the outset, especially for tall buildings.
- Property boundaries may restrict ground-level planting opportunities in dense urban contexts.

DESIGN CONSIDERATIONS

- **Support structure:** Design for mature plant weight and environmental loads. Use corrosion-resistant materials and maintain standoff distance from the building façade.
- **Façade protection:** Ensure compatible cladding, seal all penetrations and provide an air gap between plants and the wall to prevent moisture damage.
- **Planting zones:** Use in-ground planting where possible. For elevated locations, provide adequate soil volume in planters and consider hybrid systems for full coverage.
- **Species selection:** Choose species suited to site conditions, solar exposure and support type. Use diverse, climatically appropriate and non-invasive species.
- **Water management:** Incorporate irrigation systems with smart controllers and weather monitoring. Prevent water ingress into the building envelope.
- **Maintenance and access:** Design for safe access with anchor points or platforms. Allow space for maintenance equipment and ensure clear maintenance protocols.
- **Training and succession:** Plan for initial growth direction, seasonal pruning and replacement over the lifecycle. Monitor growth and performance regularly.
- **Integration opportunities:** Combine with roof gardens or rain gardens as part of a broader green infrastructure network. Highlight Indigenous plant species or culturally significant climbers where appropriate.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify suitable façades based on orientation, wind exposure and urban context. Consider how façade greening can contribute to district-scale green infrastructure.
- **Concept Design:** Define system type and greening extent. Set performance targets and develop a planting concept suited to local conditions and architectural intent.
- **Detailed Design:** Engineer support structures and façade attachments. Finalise plant selection, irrigation layout, soil requirements and maintenance access strategies.
- **Construction:** Coordinate installation of supports, planting zones and irrigation systems. Sequence planting carefully and test all systems before handover.
- **Operation:** Implement a structured maintenance program. Monitor plant health, system performance and structural integrity. Adjust strategies as vegetation matures.

APPLICABILITY

Suitable for individual buildings of all scales—from residential to high-rise—and adaptable to both new construction and retrofit projects. Can also be applied at precinct scale as part of a coordinated greening strategy.

LAND
CASE STUDY

CASE STUDY: GREEN SQUARE TOWN CENTRE

PROJECT OVERVIEW

Green Square Town Centre forms the heart of one of Australia's largest urban renewal projects—set to deliver over 1,600 apartments, commercial and retail space, and a major new public domain in inner Sydney.

A defining feature of the precinct is its commitment to integrated green infrastructure. This includes tree-lined streets, stormwater-irrigated parks, separated cycleways, and self-watering raingardens. A network of 40+ planned parks is supported by one of the country's largest urban stormwater recycling schemes. The precinct has received a 6 Star Green Star – Communities rating from the Green Building Council of Australia.

As part of the Town Centre, Fytogreen designed and installed 145 m² of green facades across the northern and southern exteriors of Building B. Using Tensile trellis and Jakob wire rope systems, the vertical gardens contribute to biodiversity, urban cooling, and visual amenity in a dense cityscape.

Contributed by:
Fytogreen

Client:
Mirvac

Project type:
New build

Completion date:
March 2024

Location:

Green Square Town Centre, Zetland, Sydney, NSW

First Nations Country:

Gadigal Country

Owner:
City of Sydney

Key Partners:

- Architects: Smart Design Studio & Mirvac Design
- Builder: Mirvac Pty Ltd
- Design and installation: Fytogreen Australia
- Maintenance: Fytogreen Australia

Image source: Australian Institute of Architects

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Urban habitat creation:** The green façades provide shelter, nesting opportunities, and food sources for birds, pollinators, and other small fauna.
- **Climbing plant palette:** Plant species were selected for sun and wind exposure, air movement, and vertical adaptability—ensuring resilience and habitat function.

Water

- **Stormwater recycling:** Irrigation is supplied through the precinct's recycled stormwater scheme, reducing potable water use.
- **Automated irrigation:** A smart flow monitored watering system supports healthy vertical growth and incorporates drainage strategies to avoid run-off hazards.

Atmosphere

- **Air quality improvement:** Vegetation captures airborne particulates, helping to filter and clean the air in a high-traffic urban setting.

Land

- **Heat island mitigation:** Green façades reduce surface temperatures by shading built form and absorbing heat—improving thermal performance and outdoor comfort.
- **Climate-sensitive planting:** Vegetation contributes to a more breathable, resilient public realm within an increasingly dense neighbourhood.

People

- **Visual and experiential amenity:** Green façades soften the built environment, adding colour, texture, and seasonal change to everyday experiences.
- **Community benefit:** As part of the broader Green Square vision, the project enhances liveability for residents, workers, and visitors—creating a more walkable, engaging, and sustainable precinct.

DESIGN CONSIDERATIONS

- **Façade integration:** Trellises and tensioned mesh were designed to align with building architecture while supporting long-term plant growth.
- **Planting systems:** Fytogreen's proprietary growing media with Hydrocell was used to promote water efficiency and plant health.
- **Precinct alignment:** The vertical gardens form part of a broader strategy of precinct-scale greening and integrated stormwater reuse.

CONSTRUCTION CONSIDERATIONS

- **Microclimate response:** Light, temperature, and wind conditions shaped plant selection and installation strategy.
- **Material selection:** Stainless steel cables and mesh allow climbing species to establish quickly while providing durability and architectural clarity.

OPERATIONAL CONSIDERATIONS

- **Ongoing maintenance:** Regular irrigation flow monitoring checks, pruning, fertilisation, and pest monitoring ensure healthy growth and long-term impact.
- **Environmental performance tracking:** Fytogreen monitors the façade's contribution to biodiversity and amenity, adapting care strategies as needed.

FURTHER READING

City of Melbourne, Growing Green Guide:
- www.melbourne.vic.gov.au/growing-green-guide

Mirvac:
- Green Square project

Australian Institute of Architects:
- https://www.architecture.com.au/archives/awards/green-square-site-15

Fytogreen:
- Green Square Green Facade

City of Sydney Green Square Development:
- https://www.cityofsydney.nsw.gov.au/green-square

LAND
DESIGN ELEMENT

DESIGN ELEMENT: EXTERNAL PLANTER BOXES

External planter boxes are contained planting systems used to introduce greenery in locations where in-ground planting is not feasible. Installed on building façades, rooftops, podiums, balconies or streetscapes, these systems support vegetation by providing engineered soil volumes within prefabricated or custom-built containers.

Planter boxes offer flexibility in scale and form—ranging from small windowsill installations to large integrated elements that define space, provide shade or support climbing vegetation. While limited in root volume, they bring nature closer to people, enhance biophilic connection and contribute to microclimate regulation.

When designed well, external planter boxes improve building aesthetics, provide privacy, enable passive cooling, and support local biodiversity. Their success relies on appropriate structural support, drainage, irrigation and maintenance—particularly in exposed or elevated settings.

Planters can be standalone or integrated into a broader green infrastructure strategy, including façades, podium landscapes and rooftop gardens.

> “external planter boxes improve building aesthetics, provide privacy, enable passive cooling, and support local biodiversity.

BIODIVERSITY AND CO-BENEFITS

Land

- Regulates local temperatures and reduces urban heat island effect
- Enhances urban greening

Biodiversity

- Provides pollination services

Atmosphere

- Improves air quality by capturing airborne particulates (limited scale)

People

- Strengthens Connection to Country and nature through accessible greening
- Enhances mental wellbeing and urban visual amenity and increases property values

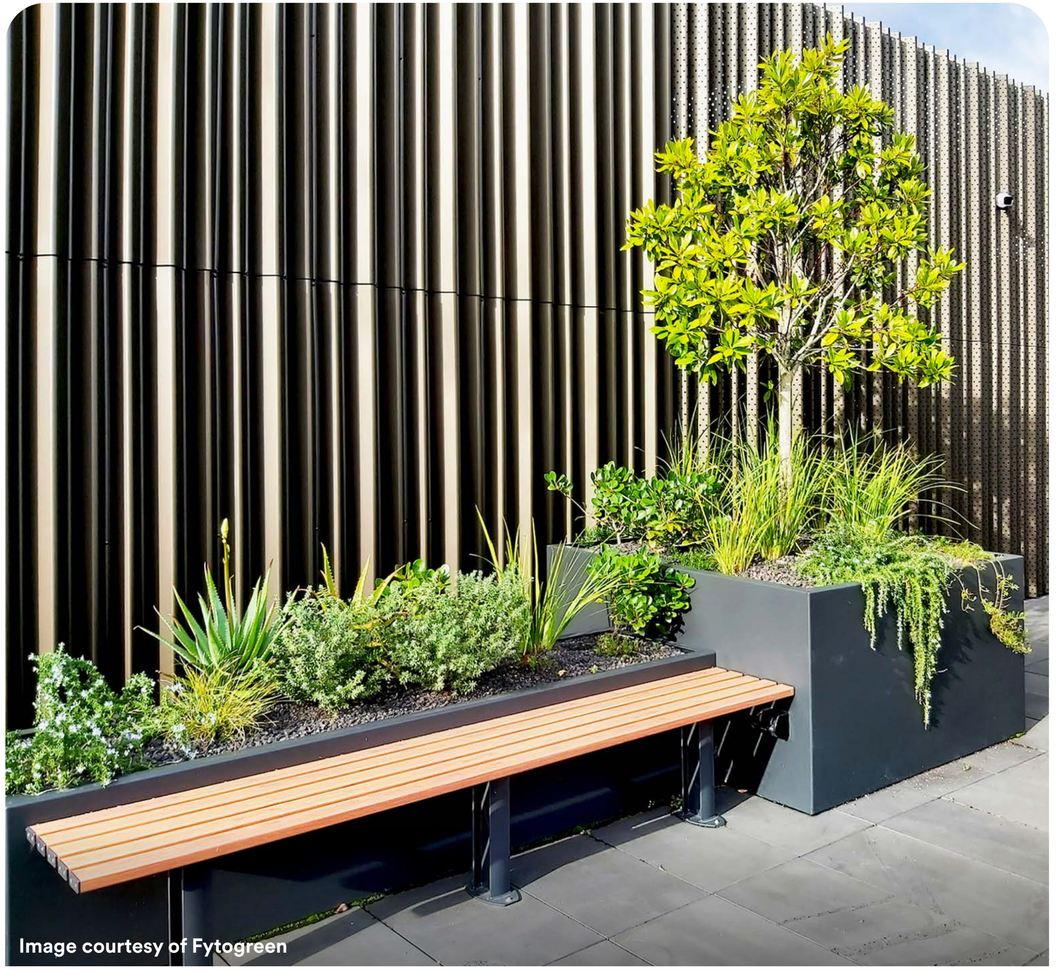


Image courtesy of Fytogreen

LAND
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Appropriate scale and placement:** Position planters where they offer strong visual impact, human interaction or functional benefit. Integrate with the architectural context and intended use.
- **Plant selection for amenity:** Choose species suited to container conditions and desired outcomes—such as colour, screening, scent or pollinator support. Consider seasonal interest and drought tolerance.
- **Plant health and presentation:** Provide adequate soil volume for plants, engineered growing media, consistent irrigation and drainage to support vigorous, healthy vegetation.
- **Consistent maintenance:** Develop and implement a reliable maintenance plan to preserve plant health, prevent visual decline and protect structural elements.
- **Water management:** Design efficient remotely monitored irrigation systems and effective drainage to avoid water stress, root rot (should not be an issue with engineered media) or surface staining (drainage should be directed away and not over exposed surfaces).
- **Material durability and integration:** Use weather-resistant materials suited to environmental exposure and aesthetic goals. Align form and finish with surrounding architecture.
- **Biophilic and microclimate benefits:** Support shade, cooling and visual softening of hard surfaces while providing everyday contact with nature.

LIMITATIONS

- Limited soil volume restricts plant size, species selection and long-term root development. Should set minimum litres per lineal metre.
- High dependency on consistent monitored irrigation and maintenance—particularly in exposed or elevated locations.
- Requires regular access for care and structural inspection, which can be challenging in some settings. Always design for future maintenance access.
- Improper design or neglected maintenance can lead to water leakage, staining or safety risks. These projects should not proceed – builder design workshops should address this issue.

DESIGN CONSIDERATIONS

- **Structural design:** Confirm that slabs, façades or balustrades can support planter weight including saturated soil and mature plants. Use secure certified fixings for elevated or mounted units.
- **Material selection:** Choose durable, UV fire compliant to AS1530.1 and weather-resistant materials with thermal insulation to protect roots. Align finishes with architectural context.
- **Waterproofing and drainage:** Install internal membranes or sealed containers. Ensure drainage layers, filter fabric and adequate outlets are included to prevent waterlogging or overflow. Inspection pipes over drain outlet to comply with AS4564.2.
- **Irrigation systems:** Specify automated remote flow monitored irrigation. Include filtration, zoning and control systems for efficiency and risk mitigation.
- **Growing media:** Use engineered, lightweight mixes with good water retention, air filled porosity, plant available water and long-term stability. Match media volume per lineal metre to plant selection.
- **Plant selection:** Select species for container conditions, local climate, exposure and intended function. Prioritise resilience and visual impact.
- **Maintenance access:** Design for safe, practical access for irrigation checks, pruning, replanting and structural inspections—especially for elevated installations.
- **Integrated function:** Planters may also serve as barriers, screen elements or bases for green façades. Ensure these functions do not compromise plant health or safety.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify key opportunities to integrate planters into façades, podiums, rooftops and streetscapes. Consider desired user experience, views and shade outcomes.
- **Concept Design:** Define planter types, placements and scale. Outline intended functions—such as screening, amenity or cooling. Begin structural and irrigation planning.
- **Detailed Design:** Finalise planter dimensions, materials and mounting details. Confirm growing media depth, plant selection, irrigation layout and drainage strategy. Plan for maintenance access.
- **Construction:** Verify structural capacity and install planter systems per specification. Ensure waterproofing, drainage and irrigation systems are tested and functioning.
- **Operation:** Implement a proactive maintenance plan for irrigation, pruning, replanting and inspections. Monitor performance and adapt planting as conditions evolve.

APPLICABILITY

Building scale: Ideal for façades, balconies, rooftops, podiums, terraces and windowsills across residential, commercial and institutional developments.

Precinct scale: Suited to streetscapes, public spaces and multi-building developments where coordinated greening strategies are implemented.

Combinability: Can support climbing plants as part of green façades, complement rooftop gardens and integrate with street furniture or edge treatments.

LAND
CASE STUDY

CASE STUDY: RAELENE BOYLE VILLAGE

PROJECT OVERVIEW

Raelene Boyle Village is a retirement living development by Ryman Healthcare that integrates over 2,185 m² of planted rooftop and on-grade landscapes into a constrained urban site. Completed in 2022, the project includes 109 modular aluminium planter boxes, open lawn areas, and a Fytofelt green wall—bringing more than 6,490 plants into a previously unplanted podium environment.

Fytogreen's engineered open-base planter system was key to the design. The planters "float" 380 mm above the waterproof membrane to protect structural integrity while ensuring optimal drainage and root health. Their placement across three stages maximises green cover, improves stormwater performance, and brings greenery directly to residents' doorsteps.

The project delivers a resilient, modular solution to urban greening—supporting biodiversity, thermal comfort, and the mental and physical wellbeing of the village's senior residents.

Client:
Ryman Healthcare

Project type:
New build

Completion date:
October 2022

Location:
2 Vida Street, Aberfeldie, VIC

First Nations Country:
Wurundjeri Woi-wurrung

Key Partners:

- Landscape architect: FFLA
- Design and installation: Fytogreen Australia

Image courtesy of Fytogreen

LAND
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Diverse planting:** 6,490 plants were installed across varied species, supporting urban biodiversity and creating microhabitats.
- **Pollinator support:** Native and ornamental flowering species attract local bees, birds, and beneficial insects.

Water

- **Efficient irrigation:** Integrated, automated flow monitored systems ensure water efficiency and reduce waste.
- **Planter design:** Open-base planters allow natural drainage while protecting waterproofing systems.

Land

- **Greening constrained space:** Rooftop and podium areas were transformed into functional green space, increasing vegetation without increasing footprint.
- **Cooling effect:** Vegetation moderates rooftop temperatures, reducing urban heat and enhancing comfort for adjacent apartments.

Atmosphere

- **Air quality improvement:** Dense vegetation helps filter airborne pollutants, improving the microclimate around the building.
- **Visual warmth:** Planting and natural textures soften the architecture and bring a sense of vibrancy and life to the built form.
- **Wind Tunnel Mitigation:** Planting reduces the wind tunnel effect between the buildings.

People

- **Therapeutic benefit:** The landscape supports mental wellbeing through views to greenery, sensory planting, and social gathering areas.
- **Resident empowerment:** Planter boxes enable hands-on gardening, allowing residents to personalise their balconies and develop daily routines around nature.
- **Social connection:** Green communal spaces encourage interaction, conversation, and a sense of belonging among residents.

DESIGN CONSIDERATIONS

- **Structural compatibility:** Lightweight planter systems and growing media were chosen to suit rooftop conditions without compromising building structure.
- **Plant performance:** Species were selected for microclimate suitability—including sun, wind, and exposure to reflected heat.
- **System integration:** The planters were carefully coordinated with architectural detailing and non penetration of the waterproofing systems.

CONSTRUCTION CONSIDERATIONS

- **Staged delivery:** Installation occurred across three stages to align with broader construction sequencing.
- **Access logistics:** Planter placement required coordination with other trades and careful management of media blow in and rooftop access.
- **Prefabrication:** Modular systems reduced on-site construction time and allowed high-quality control prior to delivery.

OPERATIONAL CONSIDERATIONS

- **Professional maintenance:** Fytogreen provides ongoing care, including seasonal plant health checks, irrigation system oversight, and pest and fertiliser monitoring.
- **Resident interaction:** While professional maintenance ensures baseline care, residents are actively engaged in supplementing watering, pruning, and plant selection within their private zones—building personal connection with the landscape.

FURTHER READING

ABC News:

- Rooftop gardens in cities

Fytogreen:

- Raelene Boyle Village

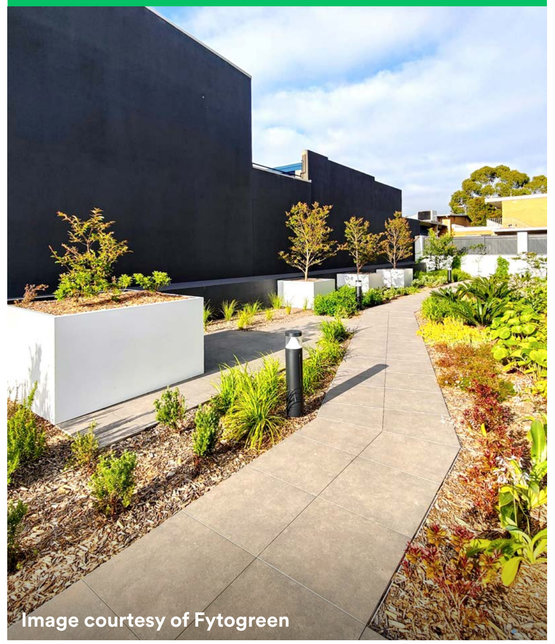
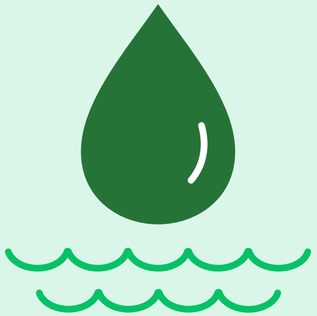


Image courtesy of Fytogreen

Water



Concept, design elements and case studies

WATER
CONCEPT

WATER

ASPIRATION

Achieve integrated water management to restore degraded urban waterways, reduce flood risk and support resilient urban environments.

DESIGNING WITH COUNTRY

From Kati Thanda–Lake Eyre to the Murrumbidgee and Kamay–Botany Bay, water is central to the identity of this continent. It shapes place, culture and Country—freshwater, sweetwater, bitterwater, saltwater. In Designing with Country, we recognise water as life-giving, interconnected and essential to regenerating nature.

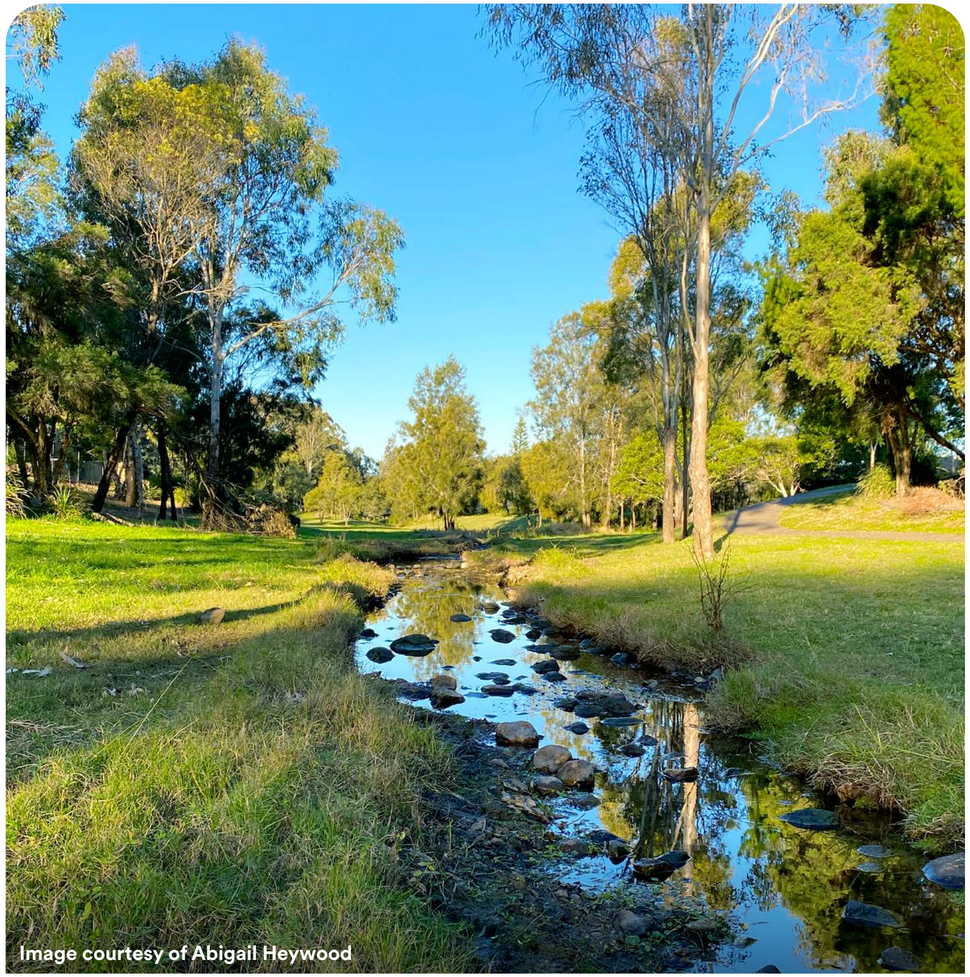


Image courtesy of Abigail Heywood

WHAT IS WATER SENSITIVE URBAN DESIGN - AND WHY DOES IT MATTER?

Water Sensitive Urban Design (WSUD) is an approach that integrates the entire urban water cycle —including potable supply, sewerage and stormwater— into the design of the built environment.

Urban areas are dominated by hard, impermeable surfaces and limited green infrastructure, leading to excessive runoff and pollution. Coastal regions are also under pressure, with marine infrastructure now covering more seafloor than the world's mangroves and seagrass meadows[1]. These conditions contribute to flooding, water contamination, ecosystem degradation and increased climate vulnerability.

WSUD responds to these challenges by creating harmony between natural hydrological systems, engineered water infrastructure and urban development. It reframes water from a risk to a resource—improving water quality, reducing demand and increasing resilience.

1. https://lighthouse.mq.edu.au/article/september-2021/Living-Seawalls-in-global-spotlight-for-boosting-marine-habitat

WATER
CONCEPT

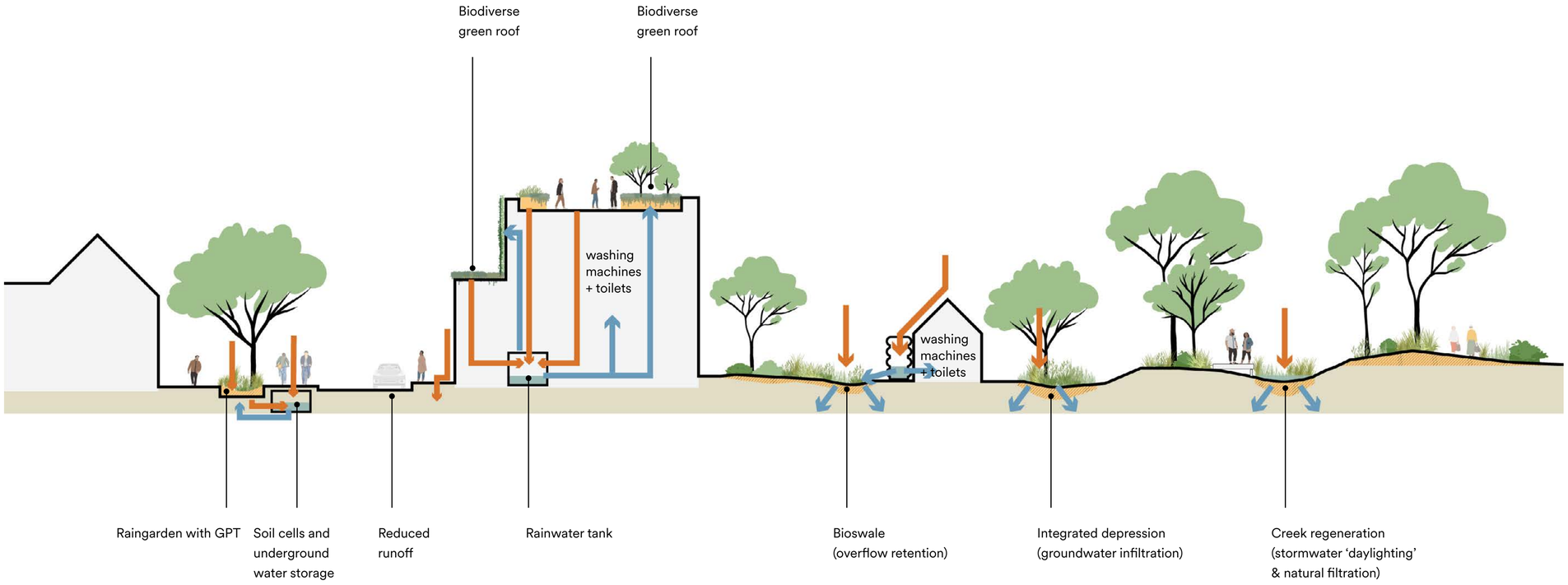
WSUD PRINCIPLES

WSUD aims to:

- Slow and reduce runoff
- Collect, absorb and reuse rainfall
- Enhance natural filtration processes
- Improve water quality
- Reduce potable water demand
- Protect freshwater and marine ecosystems

Ultimately, a core principle of WSUD is ensuring stormwater is treated before discharge, directly benefiting our ecosystems. This focus, alongside the early integration of WSUD into project planning, enables superior long-term outcomes.

Image courtesy of Abigail Heywood



WATER
CONCEPT

BENEFITS AND CO-BENEFITS OF WSUD

Water

- WSUD filters urban pollutants—like heavy metals, nutrients and oils—before they reach natural waterways. It promotes infiltration, evaporation and groundwater recharge, restoring the water cycle.
- Rainwater harvesting systems reduce reliance on mains supply and provide water for irrigation and non-potable uses, increasing resilience during drought or infrastructure failure.
- WSUD reduces runoff volume and peak flow, easing pressure on conventional drainage systems and mitigating flood risk. Natural filtration reduces the need for energy-intensive water treatment, lowering carbon impacts.
- WSUD cools stormwater, reducing thermal impacts on receiving waterways.

Land

- Supports urban greening and cools urban areas through evapotranspiration.
- Improves soil health and prevents erosion.
- Supports nutrient cycling.

People

- Enhances connection to Country.
- Improves urban aesthetics and property values.
- Improves amenity of green spaces and recreation.
- Offers cost savings over traditional drainage systems.

Biodiversity

- Creates habitat in freshwater, terrestrial and marine environments.
- Enhances ecological corridors.
- Supports pollination.

Atmosphere

- Improves air quality by vegetation capturing particulates.
- Supports carbon sequestration via healthy soils and vegetation.

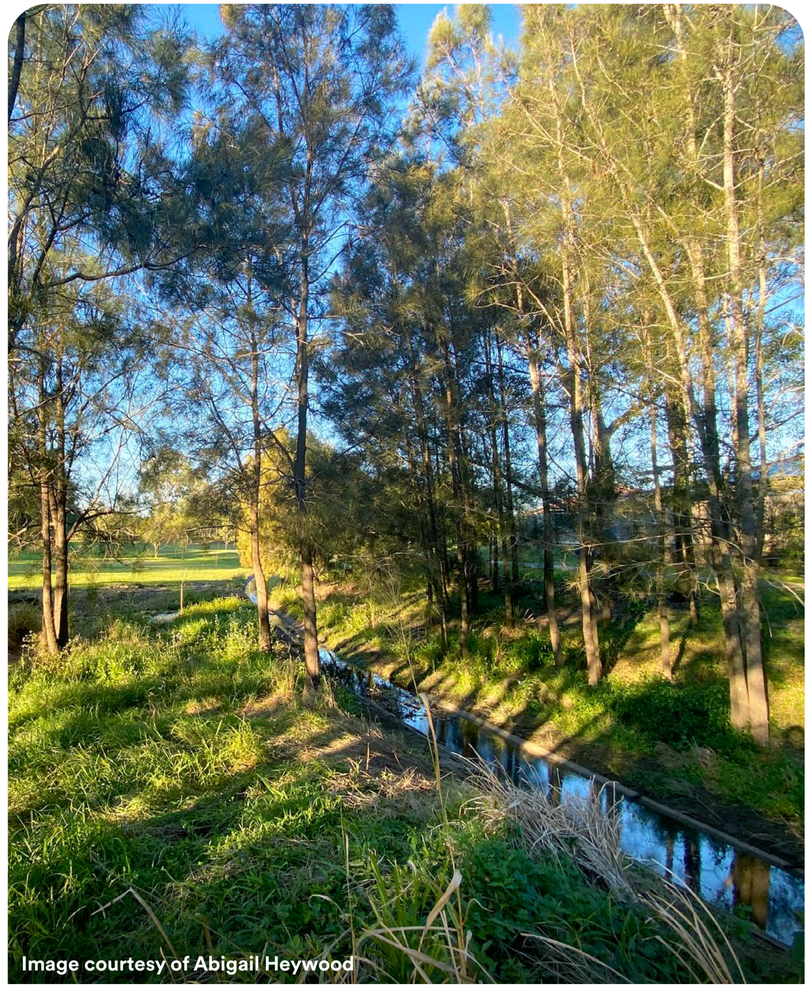


Image courtesy of Abigail Heywood

WATER
CONCEPT

FOUNDATIONS FOR SUCCESSFUL WSUD

Delivering successful WSUD requires a shift from conventional drainage thinking to a holistic, integrated approach. It means designing with the water cycle in mind—across every scale, every stage and every layer of the urban environment.

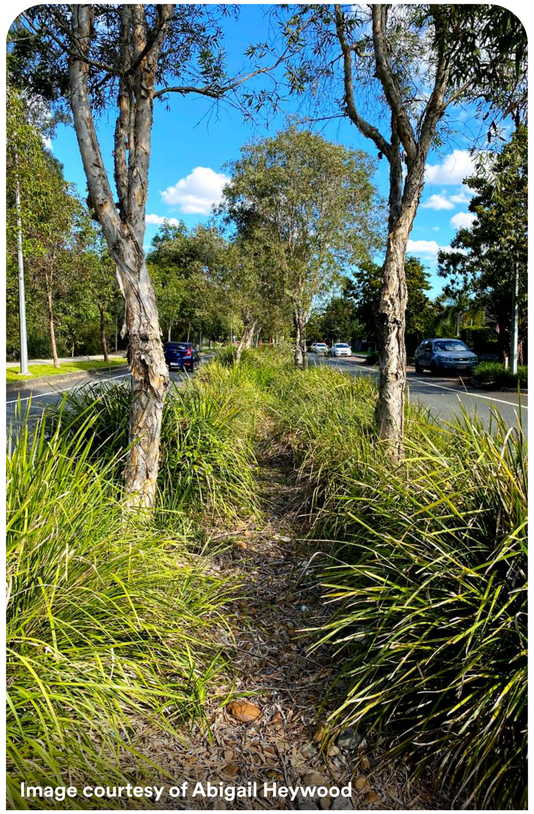


Image courtesy of Abigail Heywood

KEY FOUNDATIONS INCLUDE:

- **Work with natural systems, not against them:** Understand how water naturally moves through a site—its flow paths, infiltration potential and downstream connections. Protect and restore these systems wherever possible.
- **Design with Country:** Honour the cultural significance of water by integrating First Nations knowledge from the outset. Recognise water as living and relational, shaped by story, law and kinship.
- **Think in systems, not silos:** Connect stormwater, wastewater, groundwater and potable water systems in a cohesive water cycle approach that supports both ecology and community.
- **Embed WSUD early in planning:** Integrate water thinking into zoning, masterplanning and site selection—not just engineering stages. Support implementation through planning controls and design guidelines.
- **Design for place and purpose:** Tailor WSUD solutions to local climate, landform, soils and community values. One size does not fit all.
- **Plan for long-term care:** Naturalised systems require stewardship. Design for maintenance access, clarify ownership and build operational capacity across teams.
- **Co-design with community:** Water systems are part of public life. Involve communities early and meaningfully to foster ownership, care and connection.

IMPLEMENTATION CONSIDERATIONS

- **Landscape Context:** Nature-based systems perform best in areas with gentle gradients. Steep slopes can increase erosion risk.
- **Maintenance:** WSUD relies on living systems that are vulnerable to stressors such as drought, waterlogging, pathogens and sediment. Poor maintenance can lead to blockages, flooding and contamination. Regular maintenance responsibilities must be defined early and embedded in project planning.
- **Integrated Design:** Combining WSUD elements can maximise benefits. For example, pairing swales or basins with rainwater tanks allows water reuse while reducing runoff. Integrated systems also help mitigate the urban heat island effect, especially when vegetation is used for shade and cooling.
- **Vegetation and Substrate Selection:** Choosing the right species and soil media is critical. Native plants are more resilient and suitable for local climates. Substrates should support permeability, filtration and plant health. Designs must consider seasonality, runoff characteristics and pollutant loads. Collaboration between designers, hydrologists and ecologists is essential.
- **Scale and Distribution:** Effectiveness depends on how much—and where—WSUD is implemented. Features like rain gardens require strategic placement and thoughtful planting to maximise cooling and evapotranspiration.
- **Pollutant Management:** WSUD targets a range of pollutants including:
  - Sediment and gross pollutants from erosion and urban debris
  - Nutrients (nitrogen, phosphorus) from gardens and organic matter
  - Heavy metals from roads and buildings
  - Pathogens from animal waste and urban runoff

  WSUD designs should align with regulatory water quality objectives to protect ecosystems and human health.
- **Integrated Treatment Train Approach:** WSUD uses a ‘treatment train’—a sequence of interventions to manage water at every stage:
  1. Source Control – e.g. permeable pavements, rain gardens
  2. Conveyance Treatment – e.g. vegetated swales
  3. End-of-Pipe Treatment – e.g. wetlands and retention basins

  Together, these systems enhance pollutant removal and flood mitigation.

SUPPORTING DESIGN ELEMENTS

Well-designed and maintained features can actively support habitats, water security and stormwater management.

River, Creek and Shoreline Restoration

- Re-naturalise flow paths
- Restore riparian vegetation and floodplains
- Reintroduce mangroves and native species
- Use Living Seawalls where hard structures are necessary

Stormwater Management

Nature-based features replicate natural processes and include:

- Bio-retention systems
- Swales
- Naturalised basins

Water Harvesting

Rainwater tanks for irrigation, flushing and reuse

Green Infrastructure

- Green roofs
- Wetlands
- Blue-green grids that integrate water and open space

The following design elements detailed in this guide can be integrated into site and precinct planning to maximise ecological and place-based outcomes:

- River and Creek Restoration
- Reconnecting river and floodplain
- Bioretention systems
- Swales
- Naturalised basin
- Constructed Wetlands
- Rainwater Tanks

COMBINING DESIGN ELEMENTS TO MAXIMISE WATER OUTCOMES

WSUD performs best when layered across the landscape to reflect the way water flows through it—capturing, treating and reusing water at every stage of the journey.

- **Green roofs slow and collect rainfall**
  Pair with rainwater tanks for reuse and overflow to rain gardens or swales to support downstream treatment.
- **Swales and bioretention systems follow natural flows**
  Align with landform and integrate into streets and parks to treat runoff, support vegetation and create biodiverse corridors.
- **Wetlands and detention basins manage volume and peak flows**
  Located downstream, they slow water, improve quality and offer habitat, cooling and community amenity.
- **Rainwater tanks reduce mains water demand**
  Connect to toilets, irrigation or laundry; size tanks to balance supply, demand and site conditions.
- **Linear infrastructure can enhance water connections**
  Design streets, paths and laneways to slow and convey water while restoring lost hydrological links.
- **Retrofitting unlocks value in existing places**
  Convert road verges, car parks or rooftops into active WSUD systems that manage water and support greening.

Every built surface can contribute—whether through collection, filtration, infiltration or reuse.

Images courtesy of Abigail Heywood

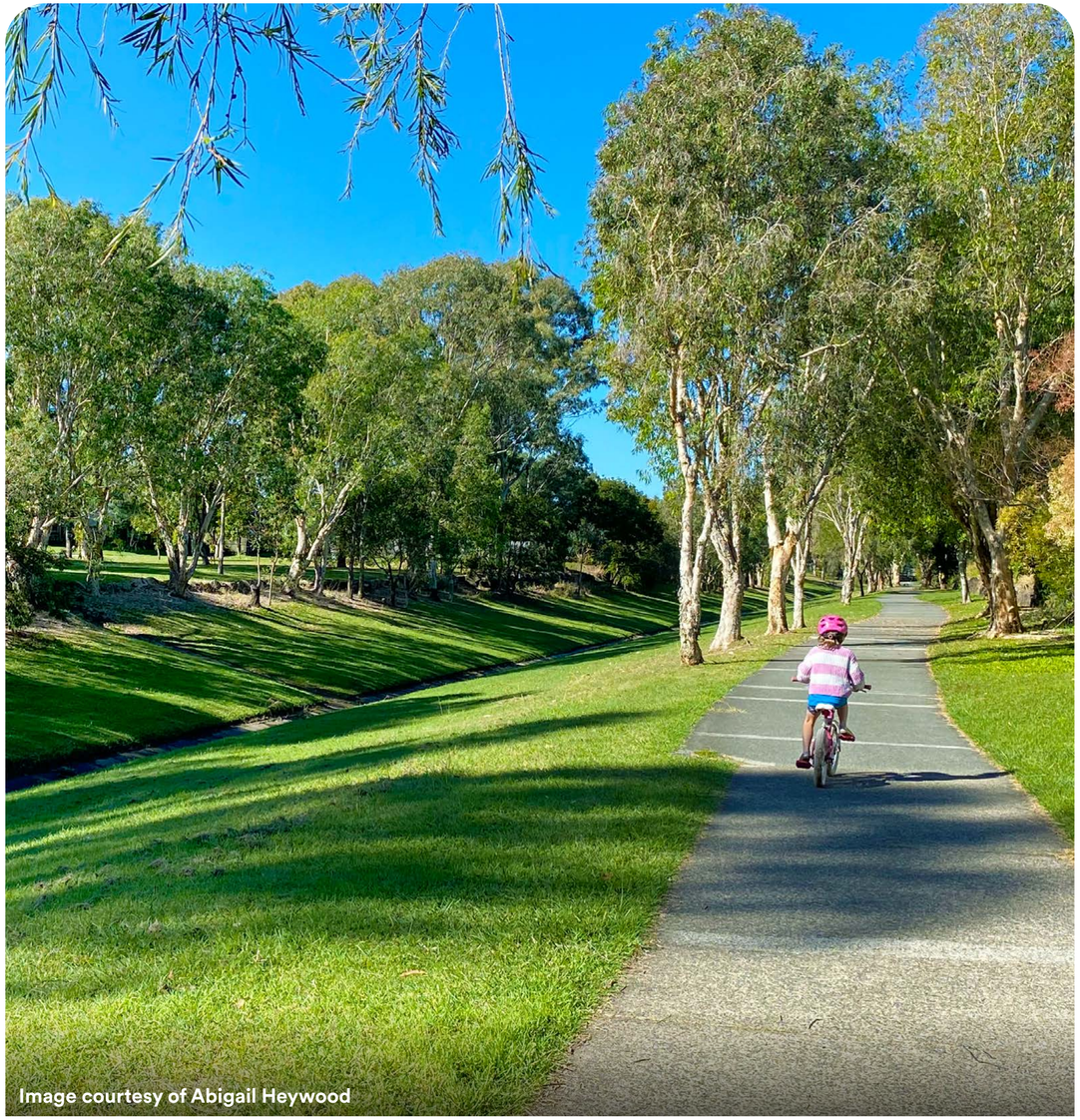


Image courtesy of Abigail Heywood

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Assessing and managing water quality in temporary waters:

- https://www.waterquality.gov.au/sites/default/files/documents/assessing-and-managing-water-quality-in-temporary-waters.pdf

Impacts of urbanisation on hydrological and water quality dynamics, and urban water management:

- Full article: a review

Water sensitive urban design: a comprehensive guide

- https://arkresources.com.au/water-sensitive-urban-design-a-comprehensive-guide/

Planning and governing nature-based solutions in river landscapes: Concepts, cases, and insights | Ambio

- https://link.springer.com/article/10.1007/s13280-021-01569-z

The National Water Initiative (NWI):

- https://www.dcceew.gov.au/water/policy/policy/nwi

Wong, T. H. F. (Editor-in-Chief). Australian Runoff Quality

- A guide to Water Sensitive Urban Design. Engineers Australia

Choi, L and McIlrath, B (2017) Policy Framework for Water Sensitive Urban Design in 5 Australian Cities. Melbourne, Australia

- Cooperative Research Centre for Water Sensitive Cities.

State Environment Protection Policy (SEPP) (Waters of Victoria):

- (EPA Victoria, 2003)

Melbourne Water

- Water Sensitive Urban Design Guidelines.

TfNSW

- Water sensitive urban design guideline

WATER
DESIGN ELEMENT

DESIGN ELEMENT: RIVER AND CREEK RESTORATION

River and creek restoration re-establishes the natural form and function of watercourses that have been degraded, culverted or modified by urban development. These projects aim to transform engineered channels into ecologically rich, dynamic waterways that integrate with the urban landscape and support diverse aquatic and riparian ecosystems.

Restoration typically involves daylighting underground streams, reshaping channels to mimic natural geomorphology, introducing habitat features such as riffles, pools and woody debris, and revegetating banks with native species. These interventions restore ecological processes such as sediment transport, oxygenation and nutrient cycling—while also enhancing flood resilience, water quality and liveability.

> **Transforming engineered channels into ecologically rich, dynamic waterways that enhance resilience, water quality and liveability.**

BENEFITS AND CO-BENEFITS

Land

- Reduces soil erosion
- Supports nutrient cycling
- Contributes to urban greening and regulating local temperatures
- Creates habitat space

Water

- Improves water quality through natural filtration
- Supports flood control and water cycling including ground water recharge
- Restores rivers and natural flow paths

Biodiversity

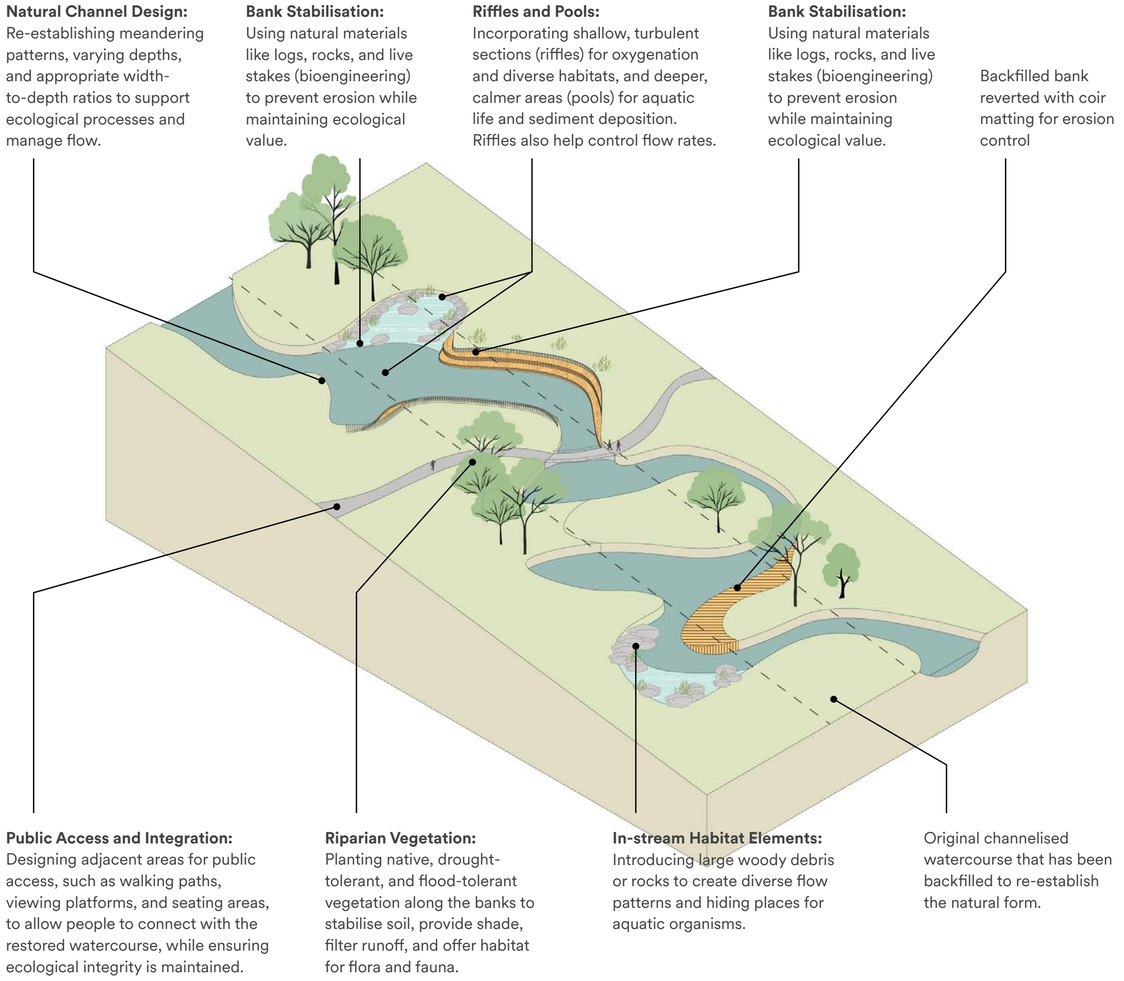
- Restores aquatic and riparian habitats for invertebrates, fish, birds, reptiles and small mammals
- Increases habitat connectivity across urban landscapes
- Supports pollination and natural ecological processes
- Enhances biodiversity health and resilience

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration through riparian vegetation

People

- Enhances urban aesthetic value
- Supports Connection to Country and Nature
- Enables Caring for Country practice
- Enables active transport via connected green corridors
- Provides educational and recreational opportunities and fosters stewardship
- Supports physical health and mental wellbeing



WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Ecological and hydrological expertise**
  Engage ecologists, hydrologists and geomorphologists early to ensure the restored system delivers ecological function, habitat value and flow performance.
- **Hydrological connectivity**
  Design for connection with natural catchment flows, groundwater and surrounding wetlands or floodplains to support water movement and seasonal variability.
- **Native, climate-resilient planting**
  Select riparian and aquatic species that are endemic to the region and adapted to wet–dry cycles, floods and droughts.
- **Flow regime and flood management**
  Incorporate a variety of flow conditions—from base flows to flood events—using features like riffles, pools and energy dissipaters to protect habitats and reduce erosion.
- **Long-term maintenance and monitoring**
  Plan for weed control, sediment management, vegetation health, and ecological monitoring across a multi-year horizon.
- **Habitat complexity**
  Include structural diversity (logs, boulders, overhangs, varied substrates) to support a range of aquatic and riparian species.
- **Community stewardship**
  Build awareness and care through visible design, interpretive signage and community access points, encouraging long-term guardianship and cultural connection.

LIMITATIONS

- **Space constraints**
  Restored systems require more land than piped channels, which can be challenging in dense urban areas.
- **Cost and complexity**
  Design, construction and maintenance can be resource-intensive and require specialist input.
- **Infrastructure conflicts**
  Existing utilities or built form may limit restoration options.
- **Flood safety**
  Public access must be carefully managed during high-flow events.
- **Delayed outcomes**
  Full ecological benefits may take years as vegetation and habitat mature.

DESIGN CONSIDERATIONS

Site assessment

- Assess hydrology, geology, soil, flood levels, topography and historic waterway alignments.
- Identify infrastructure conflicts and any site contamination.

Channel design

- Design for variable flows with appropriate width, depth and gradient.
- Incorporate natural features like meanders, riffles and pools to slow water and support habitat.

Flood risk

- Ensure adequate freeboard for buildings and infrastructure.
- Integrate with stormwater strategies to manage high-flow events safely.

Bank stability

- Prioritise bioengineering (e.g. logs, coir matting, deep-rooted vegetation).
- Use hard infrastructure only where necessary.

Vegetation

- Use native, locally endemic, climate-resilient species.
- Include a mix of sedges, shrubs and trees for structural and ecological diversity.

Maintenance

- Allow for safe access for sediment removal, weed control and vegetation upkeep.
- Plan for storm-related debris clearance.

Public Safety

- Design edges, signage and access points to minimise risk during high flows.
- Avoid steep drops near walkways or viewing areas.

Integration

- Connect with pedestrian and cycle paths, open space networks and green infrastructure.
- Include educational signage to support stewardship and cultural connection.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify waterway restoration opportunities and allocate space for naturalised channels and floodplains. Align restoration with green infrastructure networks and broader stormwater strategies.
- **Concept Design:** Define the general alignment, key habitat features and how the restored watercourse interfaces with public access and adjacent land uses.
- **Detailed Design:** Specify channel form, planting palette, bank treatments and safety measures. Plan for long-term maintenance, monitoring and ecological management.
- **Construction:** Implement channel shaping, stabilisation and planting while minimising ecological disruption. Ensure erosion and sediment control measures are in place throughout.
- **Operation:** Monitor vegetation health, water quality and ecological performance. Maintain access, control weeds and sediment, and identify retrofit opportunities for degraded systems.

APPLICABILITY

Building scale: Limited use, though adjacent buildings can connect via signage or stormwater features.

Precinct scale: Ideal for larger sites with space for naturalised watercourses and habitat corridors.

Retrofit potential: Possible in urban areas with degraded waterways, depending on available space.

Integration: Combines well with wetlands and WSUD for improved connectivity.

WATER
CASE STUDY

CASE STUDY: CADDIES CREEK PRECINCT

PROJECT OVERVIEW

Caddies Creek is a defining landscape feature for the Rouse Hill Regional Town Centre community.

In 2004, OCULUS developed Design Guidelines for the Caddies Creek Precinct, outlining seven key principles:

1. Protect and enhance the natural riparian system
2. Create smooth transitions between bushland and urban areas
3. Support a diversity of open space uses
4. Celebrate local landscape character
5. Improve water quality and biodiversity
6. Reflect Aboriginal heritage through design
7. Encourage cultural and educational opportunities

The most recent stage—Caddies Creek Regional Open Space and Playground—delivered new public realm assets including a regional cycleway, two new creek crossings, picnic areas and an environmental playground featuring custom-designed play experiences in a natural setting.

Client:
Lendlease, GPT

Completion date:

- Design Guidelines completed: 2004
- Caddies Creek Regional Open Space completed: 2014

Location:
Rouse Hill, NSW

First Nations Country:
Darug Country

Owner:
Sydney Water

Key Partners:

- Design and planning: OCULUS
- Civil engineering: Civitas
- Water systems: Arcadis

Image courtesy of Simon Wood

WATER
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Riparian habitat restoration**

  To protect and enhance remnants of Sydney Coastal River-flat Forest and Shale/Sandstone Transition Forest, vegetation within the precinct was restored and rehabilitated based on four key vegetation zones:

  1. Full Riparian
  2. Low Riparian
  3. Sedgeland
  4. Lawn Areas

  This zoned approach supported the recovery of native habitats and the reestablishment of plant communities critical to the site's ecological resilience.

Water

- **Stormwater quality and management**

  A comprehensive water strategy was implemented, including:

  - **Pond design** with naturalised edges and gentle slopes to support sedge colonisation and improve filtration.
  - **Bioretention swales** to treat runoff and increase infiltration prior to entering the pond system.
  - **Dual flow channels** designed to manage both low-flow (up to 3-month ARI) and high-flow (up to 100-year ARI) storm events.

People

- **Inclusive and active public space:** The precinct supports a range of recreational and social experiences, including walking, cycling, play, picnicking and informal gathering. The environmental playground and open spaces are designed to encourage exploration, interaction and discovery across all age groups.
- **Accessibility and safety:** Universal access is prioritised throughout the design, with pathways, crossings and viewing areas designed to be inclusive and easy to navigate. Sightlines and open views enhance passive surveillance in line with NSW Safer by Design principles.
- **Cultural interpretation and education:** An Aboriginal Heritage Management Plan guideed protection of artifacts and cultural heritage. The landscape also provides opportunities for community learning around water, biodiversity and landcare.

Land

- **Urban heat island mitigation:** The integration of riparian vegetation, canopy cover and open water bodies reduces ambient temperatures and contributes to localised cooling—mitigating the urban heat island effect within the precinct.

Atmosphere

- **Carbon sequestration:** Vegetation across the precinct contributes to carbon capture through photosynthesis—supporting climate resilience and improving air quality.

DESIGN CONSIDERATIONS

The vision for Caddies Creek was to create a flexible, engaging landscape that supports both ecological health and community needs. The guidelines were underpinned by three integrated principles:

Environmental principles

- Preserve and enhance sensitive natural areas.
- Strengthen ecological connections across the precinct.
- Retain and restore native vegetation.
- Prioritise indigenous species of local provenance.
- Limit public access to sensitive zones (e.g. 20 m riparian buffer).

Structural principles

- Transition gently between natural systems and developed areas.
- Integrate pedestrian and cycle paths that connect with neighbourhoods and community assets.
- Avoid hard edges; reflect the natural landscape character.

Social principles

- Provide diverse, accessible open spaces.
- Encourage social interaction with seating, public art and informal play areas.
- Design for passive surveillance and comply with NSW Safer by Design guidelines.
- Protect First Nations cultural heritage through landscape design and management.

CONSTRUCTION CONSIDERATIONS

- Boardwalks and bridges were designed with adequate spacing to allow sunlight and rainfall to reach vegetation below—supporting plant growth and maintaining healthy aquatic and riparian ecosystems.
- Construction methods were sensitive to hydrology and vegetation, ensuring the integrity of the restored landscape during delivery.

OPERATIONAL CONSIDERATIONS

- Vegetation Management Plan and Tree Management Report guide the long-term care of the precinct's plantings.
- Four distinct vegetation zones allow for targeted maintenance approaches that respect the ecological function of each area.
- Ongoing stewardship ensures that biodiversity and water quality objectives are maintained over time.

FURTHER READING

Victorian Government: Technical guidelines for waterway management

- https://www.water.vic.gov.au/waterways/technical-guidelines-for-waterway-management

Australian River Restoration Centre:

- https://www.arrc.com.au/

Melbourne Water: Healthy Waterways Strategy

- https://www.melbournewater.com.au/about/what-we-do/publications/healthy-waterways-strategy

Water Sensitive Cities Australia: River & Creek Restoration Case Studies

- https://watersensitivecities.org.au/ (search "river and creek restoration")

WATER
DESIGN ELEMENT

DESIGN ELEMENT: RECONNECTING RIVER AND FLOODPLAIN

Reconnecting rivers with their floodplains allows urban waterways to function more naturally by creating space for floodwaters to spread and soak into the surrounding landscape. Rather than confining rivers to engineered channels, this approach lets watercourses “breathe” during high flows—restoring natural inundation processes, reducing flood risk and supporting ecological health.

Floodplain reconnection enhances water storage, nutrient exchange and sediment movement. It also provides valuable habitat, improves water quality, and delivers climate resilience and co-benefits when integrated with public open space and urban infrastructure.

> **Floodplain reconnection enhances water storage, nutrient exchange and sediment movement.**

BENEFITS AND CO-BENEFITS

Land

- Supports nutrient cycling and land restoration
- Controls soil erosion and promotes stability through vegetation
- Contributes to urban greening and urban temperature regulation
- Provides space for habitats

Water

- Supports river restoration
- Reduces flood risk by slowing and spreading floodwaters
- Supports water cycling, recharges groundwater and supports baseflows
- Filters sediments and pollutants, improving water quality

Biodiversity

- Restores floodplain wetland habitats for invertebrates, fish, birds, mammals and reptiles
- Enhances habitat connectivity and species movement across urban areas
- Supports pollination
- Improves ecological resilience and biodiversity health

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration through wetland plants

People

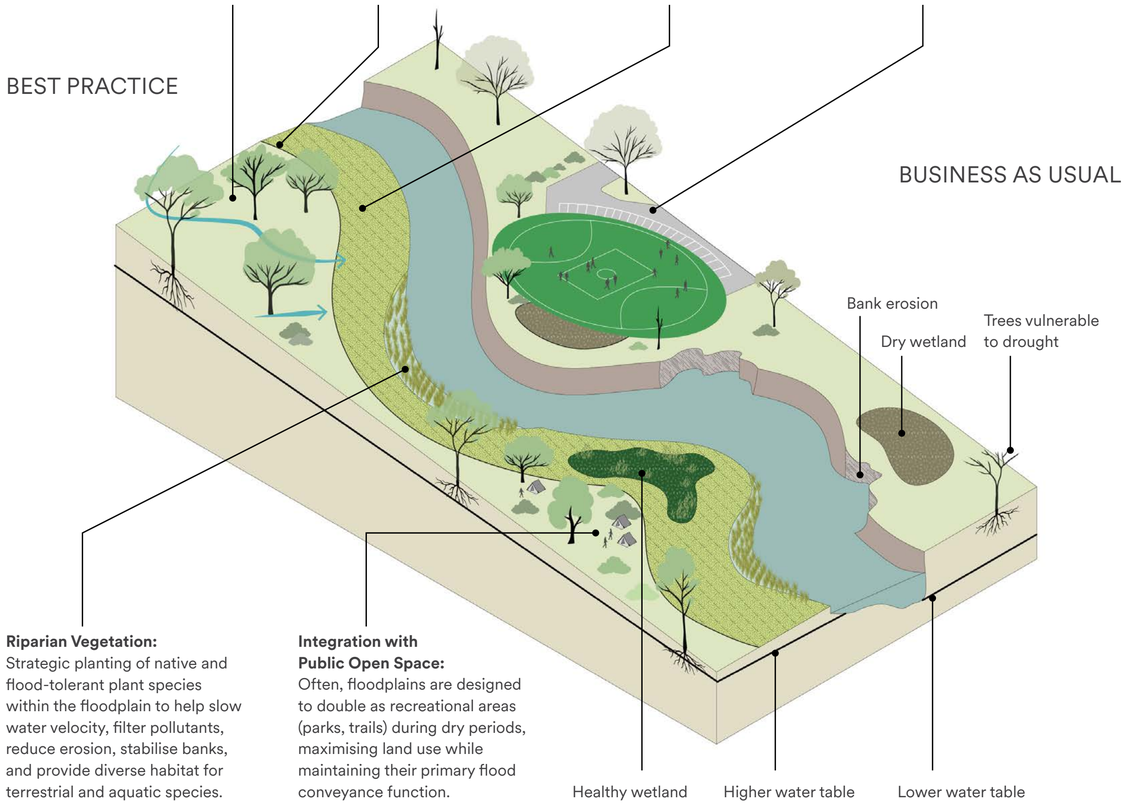
- Enhances recreation opportunities
- Enhances urban aesthetic value
- Supports Connection to Country and Nature
- Enables Caring for Country practice
- Provides educational opportunities and fosters stewardship
- Supports physical health and mental wellbeing

Overland Flow Paths:
Designated, often vegetated, routes for floodwaters to safely move through the urban development without causing significant damage or hazard to critical infrastructure or buildings. These paths are designed to manage flow depths and velocities.

Expanded Floodplain Area:
Dedicated open space, often vegetated, directly adjacent to the main river channel that can be safely inundated during high-flow events. This area is designed to temporarily store and convey floodwaters

Terraced or Graded Banks:
Gradual slopes from the main channel to the elevated floodplain, allowing water to spread and recede smoothly, reducing erosion, and promoting natural transitions.

Minimal Hard Structures:
Impervious surfaces, hard-engineered banks, and rigid structures should be limited within the floodplain to maintain natural flow patterns, promote infiltration, and enhance ecological connectivity.



Riparian Vegetation:
Strategic planting of native and flood-tolerant plant species within the floodplain to help slow water velocity, filter pollutants, reduce erosion, stabilise banks, and provide diverse habitat for terrestrial and aquatic species.

Integration with Public Open Space:
Often, floodplains are designed to double as recreational areas (parks, trails) during dry periods, maximising land use while maintaining their primary flood conveyance function.

WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Integrated land use planning**
  Floodplains must be zoned and protected early in the planning process, ensuring space is set aside for both flood conveyance and ecological function.
- **Hydraulic modelling and hazard mitigation**
  Accurate flood modelling is critical to design flood storage, manage flow velocities, and ensure safety for people and property.
- **Community acceptance and engagement**
  Public perception of floodplains as ‘wasted’ or unsafe land can be a barrier—education and stewardship programs build support and long-term care.
- **Native, flood-tolerant vegetation**
  Selecting locally adapted plant species improves ecological performance, supports biodiversity and reduces erosion during and after inundation.
- **Public interface design**
  Access, signage and multi-use functions should support recreation and learning while maintaining ecological integrity and safety during flood events.
- **Long-term maintenance and monitoring**
  Effective floodplain function depends on ongoing vegetation management, erosion control and sediment monitoring.

LIMITATIONS

- Requires substantial land, which may be limited in urban areas.
- Floodplain extent is often constrained by existing urban development.
- Biodiversity benefits take time to establish.

DESIGN CONSIDERATIONS

- **Site-specific flood modelling**
  Conduct detailed hydrological and hydraulic modelling to determine flow paths, flood extents, depths and velocities.
- **Hazard assessment**
  Design for public safety during flood events by managing flow depths and velocities with grading, vegetation and clear warning signage.
- **Freeboard and building protection**
  Ensure adjacent development is elevated above design flood levels with appropriate freeboard, in line with local planning and flood guidelines.
- **Bank stability and erosion control**
  Use bioengineering techniques such as rock armouring with vegetation, live staking or dense planting to reduce scour and stabilise banks.
- **Vegetation selection**
  Choose native, flood- and drought-tolerant species suited to variable conditions, providing ecological function and structural stability.
- **Public interface and access**
  Design walking paths, viewing platforms and open space areas to be flood-tolerant, safe, and compatible with ecological goals.
- **Water quality management**
  Incorporate vegetated buffers or wetlands to treat urban runoff entering the floodplain and improve downstream water quality.
- **Maintenance planning**
  Allocate resources for vegetation management, debris removal, erosion repair and sediment monitoring.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify opportunities to reconnect rivers and allocate adequate space for floodplain function. Align with natural hydrological flow paths, green infrastructure, and urban open space networks.
- **Concept Design:** Define the broad extent and form of the r econnected floodplain. Ensure compatibility with proposed land uses, infrastructure and flood risk considerations.
- **Detailed Design:** Specify floodplain geometry, vegetation, bank treatments, and protection measures for adjacent development. Ensure compliance with flood level overlays and freeboard requirements.
- **Construction:** Shape landforms, install stabilisation measures and establish riparian vegetation. Minimise ecological disturbance and follow environmental protection protocols.
- **Operation:** Monitor flood conveyance capacity, vegetation condition, erosion and sediment accumulation. Adapt management to changing conditions. Ensure safety planning for public use during flood events.

APPLICABILITY

Precinct scale: Ideal for larger sites where space allows floodplain function and habitat integration.

Integration: Works well with wetlands, stormwater features and riparian restoration.

WATER
CASE STUDY

CASE STUDY: BUR'UDA / HANLON PARK

PROJECT OVERVIEW

The Bur'uda / Hanlon Park project is a landmark initiative that reimagines urban public space by integrating recreation, environmental resilience, and community connectivity. As part of the staged rollout of the Norman Creek 2012–2031 Master Plan, it demonstrates how long-term visions can be successfully implemented.

Originally a large turfed area with a deteriorating concrete drain, the site was revitalised to:

- Naturalise Norman Creek
- Improve drainage and climate resilience
- Create shaded recreation and nature play areas
- Avoid exacerbating flood risk

A multidisciplinary team replaced a 500m long concrete channel with a meandering waterway, planted 462 shade trees and more than 43,000 plants, and delivered the Logan Road underpass to reconnect pedestrian and cycle routes.

Community engagement was central, with co-design and ongoing input shaping outcomes. The project sets a benchmark for future precincts like Kingfisher Creek, showcasing sustainable urban renewal and stronger connections between people, water, and place.

Client:
Brisbane City Council

Project type:
Upgrade

Completion date:
June 2022

Location:
Coorparoo, Brisbane, Queensland

First Nations Country:
Turrbal and Yuggera Country

Key Partners:

- Epoca Construction
- Tract Consultants
- Littoria
- Webb Australia
- Core Consultants

Image courtesy of Brisbane City Council

WATER
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Creation of ecological niches** such as pools and riffles, and planting of diverse emergent macrophytes.
- **Preservation of existing trees** for carbon sequestration and reuse of unsafe trees for habitat and bank stabilisation.
- **Planting** of 462 trees and more than 43,000 shrubs, groundcovers and reeds.
- **Conversion of a concrete channel into a naturalised creek** to support aquatic and terrestrial habitats, fish passage and waterway health.
- **Addition of wildlife-friendly features** like basking stones and log crossings to improve habitat quality and cooling.
- **Post-construction outcomes:**
  - Fish abundance tripled, and species richness doubled.
  - 40% of fish recorded were native to freshwater habitats.
  - Presence of turtles, eels and waterbirds.
  - Improved water clarity has supported submerged plant growth.
- By **harnessing natural processes,** the project supports long-term ecological balance with a focus on native species and community connection to nature.

Water

- **Slower, safer water movement** through a flood-adapted landscape.
- **Restoration of natural floodplain dynamics** with low and high flow zones.
- **Improved public safety** and increased community engagement with the waterway.
- **Proven performance** during real-world flood events, including a major flood in February 2022.
- **Enhanced water quality** via slowed flows that allow for stormwater filtration and infiltration.
- **Balanced flood management with ecological restoration,** resulting in a safer, more engaging, and sustainable public space.

Atmosphere

- **Carbon sequestration:** Preservation of existing trees for carbon sequestration.

Land

- **Urban cooling:** By integrating water features and extensive vegetation, the project helps reduce the urban heat island effect. This creates a cooler microclimate, encouraging outdoor activity—even during hotter months.

People

- The transformation of Hanlon Park / Bur'uda was guided by the **Norman Creek 2012–2031 Master Plan.** Key planning priorities included:
  - Recognising open space as essential to healthy, active lifestyles and community connection.
  - Designing interconnected green spaces, plazas and streets to foster social interaction.
  - Supporting active transport—walking, cycling and public transit—to strengthen connectivity across the Norman Creek corridor.
- **Key outcomes included:**
  - Strong collaboration between Brisbane City Council, Traditional Custodians, residents, and groups like the Norman Creek Catchment Coordinating Committee.
  - Community engagement through surveys, interviews, co-design workshops and reviews.
  - Community input into the park's name, interpretive signage and the selection of public artwork re-wild by Belinda Smith.

WATER
CASE STUDY

DESIGN CONSIDERATIONS

The Hanlon Park project delivers a vibrant inner-city park that balances community use with ecological restoration. Key considerations included:

- **Placemaking & amenity:** Nature play areas, educational signage, public artwork, upgraded shared paths, creek crossings, gathering spaces and an amphitheatre.
- **Ecological restoration included:** Replacement of the concrete channel with a naturalised creek to enhance habitat, fish passage and waterway health; wildlife-friendly features such as basking stones and log crossings; and extensive planting to support biodiversity and urban cooling.
- **Design Challenges Overcome:** Innovative solutions addressed shallow groundwater and existing sewer infrastructure. Some manholes were repurposed as elevated lookouts.
- **Sustainable Transport:** Improved connections via shared paths, two new pedestrian bridges and an underpass linked to public transport.
- **Technical Support:** Robust design informed by geotechnical, ecological and water quality investigations ensured the project's long-term resilience.

CONSTRUCTION CONSIDERATIONS

The Hanlon Park project prioritised ecological restoration and climate resilience through innovative construction methods.

Key strategies included:

- **Planting-based creek treatments:** Vegetation was used in place of concrete or rock to stabilise banks, support varied water flows and retain natural topography.
- **Recycled materials:** On-site concrete was repurposed for retaining walls, bank stabilisation and pathways—reducing emissions and landfill waste.
- **Collaborative design process:** Landscape architects, engineers and the community worked together to balance ecological restoration with flood management.
- **Proven flood resilience:** The naturalised creek successfully withstood multiple flood events during construction, including a major flood in February 2022.

OPERATIONAL CONSIDERATIONS

The Hanlon Park project prioritised accessibility and long-term functionality through careful operational planning.

- A **staged delivery approach** ensured continued community access during construction.
- **Essential services** (sewer, water, telecommunications, electricity) were carefully integrated through close coordination with service authorities.
- This approach maintained **design integrity** and ensured the park remained inclusive and fully functional without compromising accessibility.

Image courtesy of Brisbane City Council

WATER
CASE STUDY

Image courtesy of Brisbane City Council

FURTHER READING

Queensland Government – WetlandInfo: Reinstating Floodplain Connection

- https://wetlandinfo.des.qld.gov.au/wetlands/management/rehabilitation/rehab-process/step-4/intervention-options/reinstate-floodplain-connection.html

NSW Department of Planning and Environment: Floodplain Management

- Floodplain management program | Floodplains | Environment and Heritage

Melbourne Water: Floodplain Management Strategy

- Flood Management Strategy for Port Phillip and Westernport 2021-2031 | Melbourne Water

Water Sensitive Cities Australia: Floodplain Management Insights

- https://watersensitivecities.org.au/ (search “river and creek restoration”)

International River Foundation: Floodplain Restoration

- https://riverfoundation.org.au/ (search “river and creek restoration”)

WATER
DESIGN ELEMENT

DESIGN ELEMENT: BIORETENTION SYSTEMS

Bioretention systems, also known as biofiltration systems or raingardens, are vegetated landscape features that treat and manage stormwater runoff. Designed to mimic the natural filtration and absorption functions of soil and vegetation, these systems capture water from surrounding hard surfaces and remove pollutants before releasing or infiltrating it.

They are commonly used in urban areas to manage water quality and quantity, reduce localised flooding, and support urban cooling. By integrating vegetation, engineered media and drainage infrastructure, bioretention systems offer a multifunctional solution that enhances stormwater outcomes while supporting biodiversity and amenity.

> “these systems collect water from surrounding hard surfaces and remove pollutants before releasing or infiltrating it.

BENEFITS AND CO-BENEFITS

Land

- Reduces soil erosion
- Contributes to urban greening and microclimate regulation

Water

- Manages stormwater
- Improves water quality by filtering sediments, nutrients and pollutants
- Reduces stormwater thermal pollution by cooling runoff before it enters natural waterways
- Supports groundwater recharge and restores natural water cycling

Biodiversity

- Provides habitat for insects, birds and small fauna through native planting
- Supports pollination and small-scale ecological connectivity

Atmosphere

- Captures airborne particulates and improves air quality
- Supports carbon sequestration through vegetation

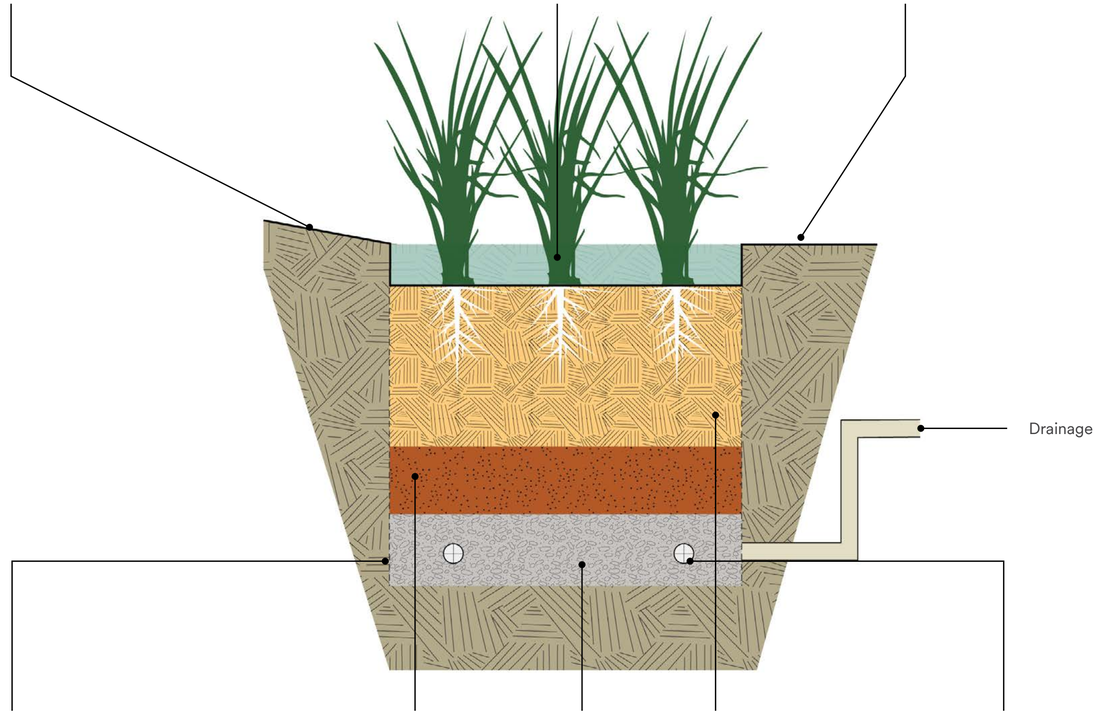
People

- Enhances urban aesthetic value
- Often more cost-effective than traditional piped infrastructure
- Supports Caring for Country practice

Inlet Structure:
Designed for efficient water entry, such as curb cuts, swales, or grated inlets, to manage flow velocities and prevent scour.

Surface Layer:
Mulch (e.g. hardwood mulch) and appropriate vegetation (native or climate-resilient species).

Overflow System:
A high-flow bypass (e.g., weir or riser) to manage flows exceeding the system’s treatment capacity during large rainfall events.



Lining (Optional):
An impermeable liner (e.g., geomembrane or compacted clay) at the base and sides, used when infiltration into native soils is undesirable (e.g., near building foundations, contaminated sites, or where groundwater protection is critical).

Transition Layer (Optional):
A granular layer (e.g., washed sand or fine gravel) placed between the engineered media and drainage layer to prevent media migration.

Drainage Layer:
A coarse aggregate layer (e.g., gravel) that collects and conveys treated water.

Engineered Media:
A specially formulated soil mix (e.g., sand, organic matter, specific soil amendments) designed for optimal hydraulic conductivity, pollutant removal efficiency, and plant health.

Underdrain System:
Perforated pipes installed within the drainage layer to convey treated water away from the system, either to a downstream collection point or for reuse.

WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Catchment and pollutant assessment**
  Understand the quantity and type of pollutants likely to enter the system—such as sediments, nutrients, hydrocarbons or heavy metals—to inform media composition and sizing.
- **Engineered soil media**
  Use a certified mix that ensures effective filtration, plant growth and long-term hydraulic performance. The wrong mix can cause clogging or reduce treatment capacity.
- **Vegetation selection**
  Choose native or climate-resilient plants suited to alternating wet and dry conditions. Different species offer varying capacities for pollutant uptake and hydraulic performance.
- **Hydraulic design**
  Ensure correct sizing of inlets, drainage, and overflow components to manage flow rates, avoid ponding and prevent media erosion.
- **Site integration**
  Position systems where they can effectively intercept runoff while contributing to public realm design and ecological connectivity.
- **Climate resilience**
  Design for increasingly intense rainfall and longer dry periods. Include species and system features that can handle both.
- **Maintenance planning**
  Include long-term access and maintenance strategies such as sediment removal, vegetation management and media replacement to prevent clogging and decline.

LIMITATIONS

- Requires space, which can be limited in dense urban areas.
- Cannot replace the full ecological value of natural habitats.
- May need liners or pre-treatment on contaminated sites.
- Performance declines without regular maintenance.
- Takes time for vegetation to fully establish.

DESIGN CONSIDERATIONS

- **Site assessment**
  Analyse catchment size, runoff volumes, soil conditions, topography and nearby infrastructure to inform system size and placement.
- **Hydraulic sizing**
  Design to manage runoff volumes using local rainfall data. Ensure appropriate inlet, overflow and underdrain capacity.
- **Water quality targets**
  Define pollutant removal goals (e.g. nutrients, sediments, hydrocarbons) and design media and vegetation accordingly.
- **Structural integrity**
  Ensure stability near roads or buildings, including load-bearing design if needed.
- **Waterproofing/lining**
  Use liners where infiltration is undesirable (e.g. near foundations or contaminated soils).
- **Vegetation selection**
  Prioritise native, deep-rooted, and flood/drought-tolerant species with high pollutant uptake capacity.
- **Maintenance access**
  Plan for safe, regular access for inspection, sediment removal, pruning and media rejuvenation.
- **Integration with urban fabric**
  Align with streetscape, public realm and pedestrian flows while avoiding utility conflicts.
- **Construction quality**
  Ensure correct media placement, compaction and installation of drainage elements to avoid early failure.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify priority locations for stormwater collection based on flow paths and runoff risk. Allocate sufficient surface area and align with green infrastructure or landscape strategies.
- **Concept Design:** Define system footprint, general form and integration with surrounding uses. Ensure compatibility with site layout, traffic movement and public realm.
- **Detailed Design:** Specify media composition, vegetation, inlets, drainage layers and overflow elements. Prepare construction documentation and ensure alignment with local stormwater standards.
- **Construction:** Oversee correct installation of layers and drainage infrastructure. Verify material quality and prevent compaction or contamination of media.
- **Operation:** Implement a maintenance plan for vegetation care, sediment removal and system performance monitoring. Plan for media replacement over time if needed. Consider retrofit potential in hardscaped areas.

APPLICABILITY

Building scale: Suited to rain gardens, planter boxes and green roofs for local runoff treatment.

Precinct scale: Ideal for streetscapes, parks and public spaces to manage catchment-scale runoff.

Retrofit potential: Can be added to existing urban sites with sufficient space and flow access.

Integration: Pairs well with other WSUD features like swales and permeable paving.

WATER
DESIGN ELEMENT

DESIGN ELEMENT: SWALES

Swales are shallow, vegetated channels that manage stormwater by slowing, conveying and partially treating runoff. Designed with gentle slopes and resilient planting, swales reduce peak flows, improve water quality and support infiltration where soil conditions allow.

They are often used as part of a treatment train—conveying water to other features such as bioretention systems or detention basins—and can include dry swales, wet swales and bioswales with enhanced filtration media. In addition to their water management role, swales offer co-benefits such as cooling, habitat support and landscape integration.

> “swales reduce peak flows, improve water quality and support infiltration where soil conditions allow.

BENEFITS AND CO-BENEFITS

Land

- Controls soil erosion
- Enhances urban greening
- Contributes to microclimate regulation through evapotranspiration

Water

- Manages stormwater
- Improves water quality by filtering sediments, nutrients and pollutants
- Cools stormwater, reducing thermal impacts on receiving waterways
- Supports natural water cycling

Biodiversity

- Provides habitat for insects, small birds, and amphibians.
- Supports ecological corridors and connectivity in urban areas.

Atmosphere

- Improves air quality by capturing dust and particulates

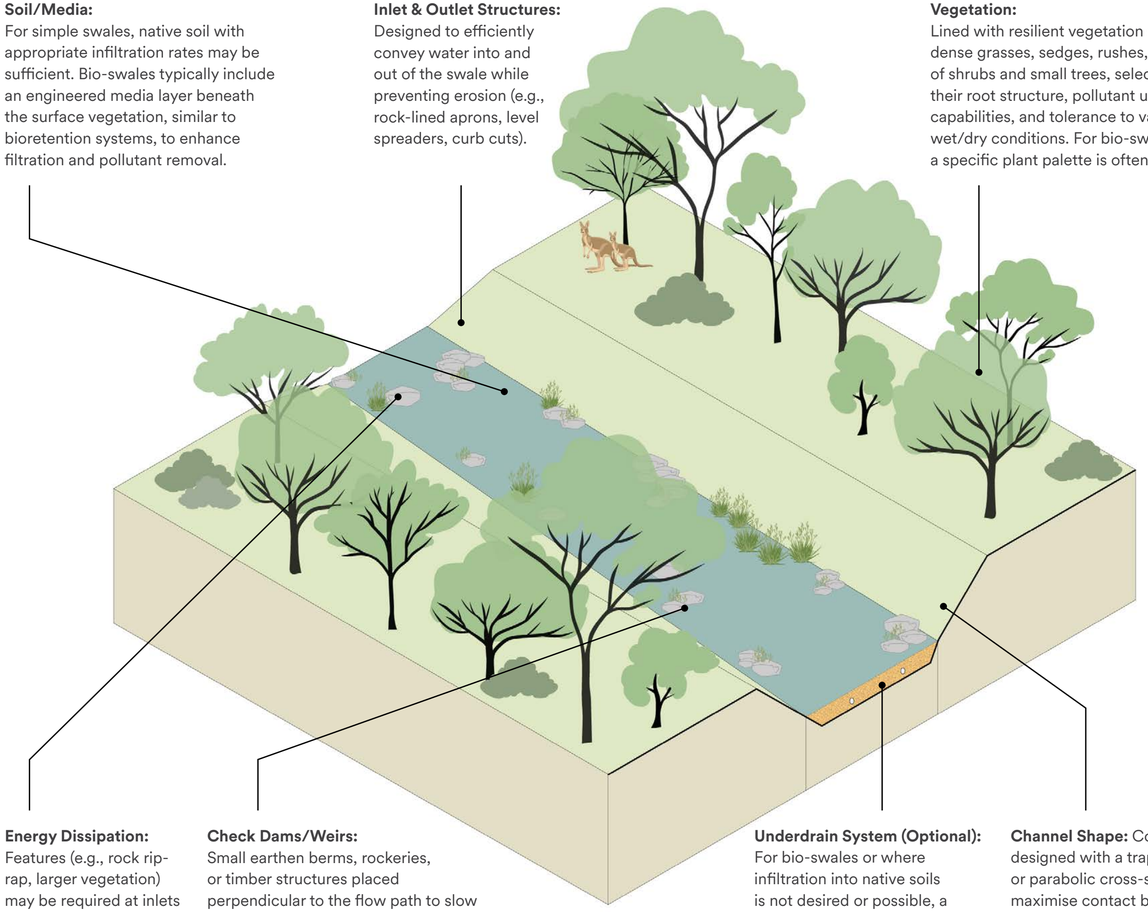
People

- Cost-effective alternative to underground drainage
- Improves Urban aesthetic value
- Supports Connection to Country, recreation and active transport.

Soil/Media:
For simple swales, native soil with appropriate infiltration rates may be sufficient. Bio-swales typically include an engineered media layer beneath the surface vegetation, similar to bioretention systems, to enhance filtration and pollutant removal.

Inlet & Outlet Structures:
Designed to efficiently convey water into and out of the swale while preventing erosion (e.g., rock-lined aprons, level spreaders, curb cuts).

Vegetation:
Lined with resilient vegetation such as dense grasses, sedges, rushes, or a mix of shrubs and small trees, selected for their root structure, pollutant uptake capabilities, and tolerance to varying wet/dry conditions. For bio-swales, a specific plant palette is often used.



Energy Dissipation:
Features (e.g., rock rip-rap, larger vegetation) may be required at inlets or along the channel to manage high-velocity flows and prevent scour.

Check Dams/Weirs:
Small earthen berms, rockeries, or timber structures placed perpendicular to the flow path to slow down runoff, promote infiltration, enhance pollutant settlement, and create a series of stepped pools.

Underdrain System (Optional):
For bio-swales or where infiltration into native soils is not desired or possible, a perforated pipe can be installed within a gravel layer to collect and convey treated water.

Channel Shape: Commonly designed with a trapezoidal or parabolic cross-section to maximise contact between water and vegetation, but can also be curvilinear to suit landscape aesthetics.

WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Site suitability**
  Requires gently sloping terrain, adequate space, and suitable soil for infiltration (if unlined). Swales are less effective on steep gradients or highly compacted soils.
- **Hydraulic design**
  Longitudinal slopes of 1–3% are ideal. Slopes that are too steep increase erosion risk; too flat may cause ponding or stagnation.
- **Channel sizing and length**
  Design channel width and depth to handle peak flows without erosion. Longer swales increase treatment time and improve pollutant removal.
- **Vegetation and soil selection**
  Use resilient, deep-rooted native plants suited to wet/dry cycles. Engineered media in bioswales enhances filtration and supports plant health.
- **Check dams and flow control**
  Strategic placement of check dams slows water, promotes infiltration, and reduces sediment transport.
- **Inlet/outlet design**
  Well-designed entry and exit points minimise erosion, evenly distribute flow and reduce sediment build-up.
- **Climate responsiveness**
  Design for local rainfall patterns, including provisions for extreme events or prolonged wet/dry periods.
- **Maintenance**
  Regular clearing of sediment, debris and overgrowth is essential for long-term hydraulic and water quality performance.

LIMITATIONS

- Requires significant land area, which may be difficult in dense urban settings.
- Effectiveness varies depending on pollutant type, storm event and site conditions.
- Can perform poorly in areas with high rainfall or saturated soils.
- Risk of erosion if not properly designed.
- Limited infiltration where groundwater is high or soils are compacted.

DESIGN CONSIDERATIONS

- **Site assessment**
  Evaluate hydrology, soil type, slope, and surrounding infrastructure to determine feasibility and placement.
- **Hydraulic design**
  Maintain 1–3% slope for optimal flow; size channels to accommodate runoff without causing scour or stagnation.
- **Water quality targets**
  Tailor design based on key pollutants expected (e.g. sediment, nitrogen, phosphorus).
- **Vegetation selection**
  Choose native, resilient species suited to variable moisture and pollutant uptake. Match to swale type (dry, wet, bioswale).
- **Structural stability**
  Incorporate check dams, energy dissipation and appropriate linings to reduce erosion.
- **Maintenance access**
  Ensure safe access for regular sediment removal, vegetation care and system inspection.
- **Constructability**
  Ensure grading, soil placement and vegetation installation meet specifications to avoid long-term performance issues.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify suitable locations early, based on slope, hydrological flow paths and land availability. Allocate space for linear alignment and consider integration with streetscapes or open space networks.
- **Concept design:** Determine swale type and preliminary layout. Align with urban design, pedestrian movement, and broader WSUD objectives.
- **Detailed design:** Specify dimensions, materials, planting palette, hydraulic components, check dams, and inlet/outlet structures. Ensure constructability and maintainability are addressed.
- **Construction:** Oversee grading, soil placement and installation of swale elements. Ensure materials and vegetation meet design standards and that slopes are consistent.
- **Operation:** Implement a maintenance plan covering sediment and debris removal, vegetation care and erosion monitoring. Monitor performance and adapt as needed. Consider retrofitting into existing streets or landscapes.

APPLICABILITY

Building scale: Suitable for managing local runoff in courtyards or landscaped areas, but space may be limited.

Precinct scale: Ideal for parks, streetscapes and open spaces where longer systems can operate effectively.

Retrofit potential: Can be added to existing road verges or open spaces with enough linear area.

Integration: Works well with rain gardens, wetlands, permeable pavements and green roofs.

WATER
DESIGN ELEMENT

DESIGN ELEMENT: NATURALISED BASIN

Naturalised basins—also referred to as vegetated detention basins or bioretention basins—are shallow, flat-bottomed depressions designed to temporarily store, treat and slowly release stormwater runoff.

They use natural processes such as sedimentation, filtration and vegetative uptake to improve water quality while managing flow volumes. By mimicking wetland functions, naturalised basins contribute to flood mitigation, support biodiversity and enhance landscape amenity.

Often designed with extended detention capacity, these basins are an integral part of WSUD and green infrastructure strategies in parks, public spaces and community-scale developments.

> “naturalised basins contribute to flood mitigation, support biodiversity and enhance landscape amenity.

BENEFITS AND CO-BENEFITS

Land

- Controls soil erosion and promotes nutrient cycling
- Contributes to urban greening and local temperature regulation

Water

- Manages stormwater by retaining water, reducing runoff, peak flows and flooding
- Improves water quality through sedimentation and filtration
- Supports groundwater recharge and natural water cycling

Biodiversity

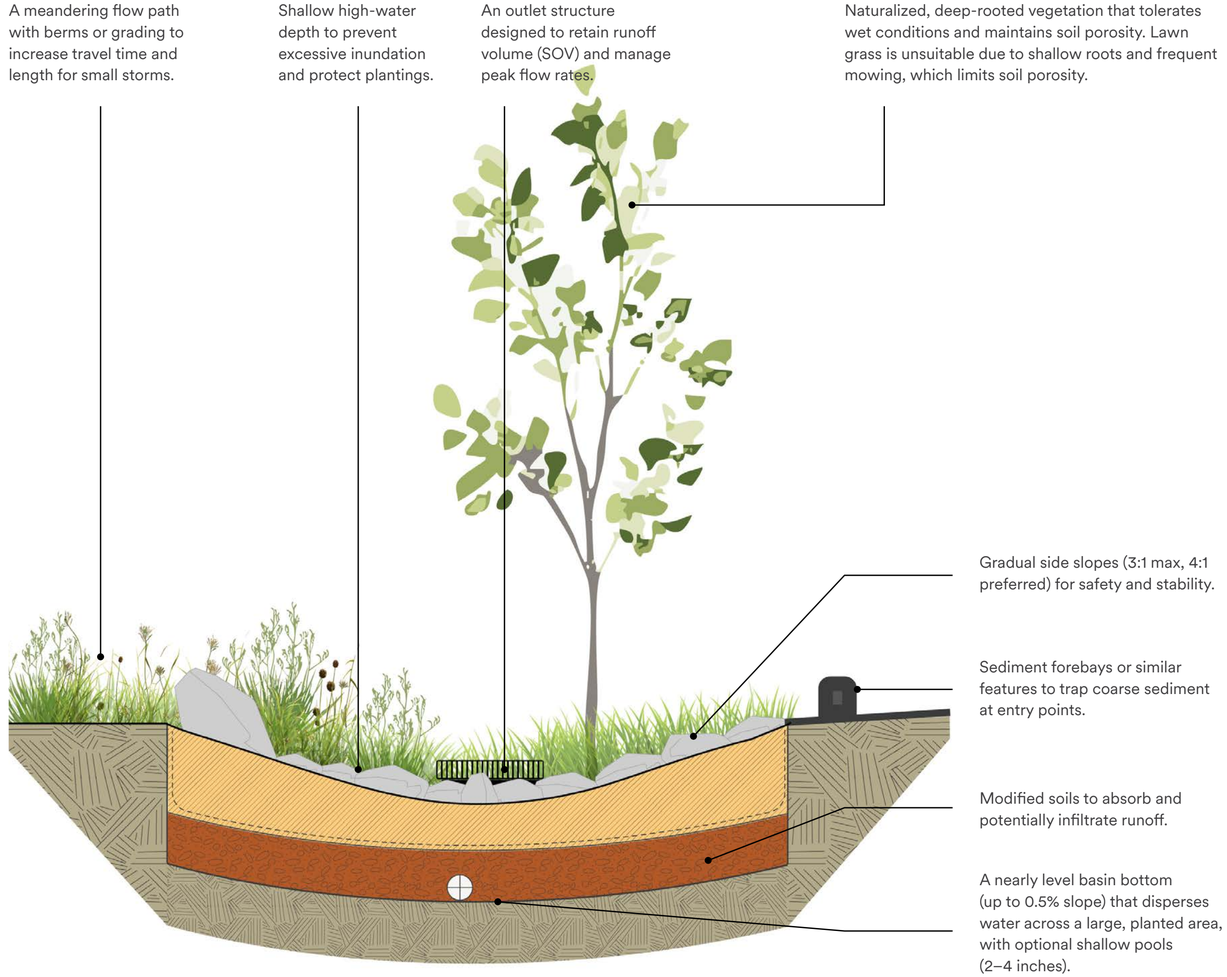
- Provides wetland-like habitat, supporting birds, insects and amphibians
- Enhances habitat connectivity in urban areas
- Supports pollination and ecological function

Atmosphere

- Improves air quality by capturing particulates
- Supports carbon sequestration through vegetation

People

- Enhances urban aesthetic value
- Supports Connection to Country and Nature



WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Vegetation strategy**
  Use native species with local provenance, tolerant of wet and dry cycles. Prioritise multi-layered planting to reduce erosion and improve habitat value.
- **Substrate quality**
  Ensure soils support plant health, have appropriate nutrient levels and water retention capacity, and promote infiltration where needed.
- **Hydrological design**
  Design for local rainfall conditions, with appropriate ponding depth and drawdown times (typically within 24–48 hours) to reduce mosquito risk.
- **Community engagement**
  Early stakeholder involvement can improve acceptance, reduce land-use conflicts, and support stewardship over time.
- **Soil protection during construction**
  Avoid compaction to preserve infiltration performance; if needed, de-compact or “rip” soil to a depth of at least 150 mm post-construction.
- **Maintenance planning**
  Basins require regular upkeep—particularly in the first 1–3 years—including weeding, sediment removal, and monitoring plant establishment.
- **Aesthetic integration**
  Design for visual appeal with diverse planting and edges that align with community expectations and site context.

LIMITATIONS

- Requires significant land, limiting use in dense urban areas.
- Generally unsuitable for active recreation due to potential for inundation or soft ground.
- Effectiveness may decline in extreme weather or storm events.
- Limited treatment of dissolved or toxic pollutants.
- Not a substitute for natural wetlands.

DESIGN CONSIDERATIONS

- **Climate resilience**
  Design for both heavy rainfall (robust overflow) and drought (drought-tolerant plants or supplementary irrigation during establishment).
- **Hydraulic performance**
  Calculate storage volumes (e.g. WQV, extended detention) and ensure drawdown within 24–48 hours to prevent mosquito breeding.
- **Soil and geotechnical assessment**
  Test infiltration rates, groundwater levels and stability. Liners may be needed for containment or to protect groundwater.
- **Engineered media (if used)**
  Specify particle size, permeability, nutrient retention and organic content to support both treatment and plant growth.
- **Vegetation planning**
  Select species suited to local climate, ponding depth and duration. Use multi-layered planting for function and aesthetics.
- **Pre-treatment**
  Include sediment forebays or swales upstream to reduce sediment load and prolong basin performance.
- **Safety and amenity**
  Ensure safe slopes (4:1 preferred), clear signage and accessible paths. Design for public amenity and visual appeal.
- **Establishment and maintenance**
  Plan for a 1–3 year establishment period with intensive weeding, and develop an ongoing maintenance strategy for sediment removal and vegetation care.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify locations based on topography, runoff patterns and community needs. Engage stakeholders early to align land use expectations and assess compatibility with existing open space.
- **Concept design:** Define the basin’s general size and location. Consider integration with surrounding ecosystems, urban design features (e.g. walking paths, viewing areas), and site biodiversity goals.
- **Detailed design:** Specify plant species, soil/media types, inflow/outflow structures and maintenance needs. Prepare a costed plan for construction, establishment and long-term upkeep.
- **Construction:** Implement grading, infrastructure and planting. Protect soil during works and monitor for compaction or erosion. Ensure works comply with design intent.
- **Operation:** Conduct regular sediment removal, weed control and vegetation management. Monitor water quality and basin function, and adapt maintenance as needed over time.

APPLICABILITY

Building scale: Limited use—generally unsuitable unless large open space is available.

Precinct scale: Well-suited for parks, public spaces and community developments.

Retrofit potential: Feasible in existing open spaces with compatible grading.

Integration: Pairs well with wetlands, swales and rainwater harvesting systems.

WATER
DESIGN ELEMENT

DESIGN ELEMENT: CONSTRUCTED WETLANDS

Constructed wetlands are engineered systems designed to replicate the water treatment functions of natural wetlands using vegetation, soil and microbial processes. Typically used in Water Sensitive Urban Design (WSUD), they remove pollutants from stormwater or wastewater through sedimentation, filtration, plant uptake and microbial breakdown.

These wetlands can take various forms—including free water surface (FWS), subsurface flow (SSF) and hybrid systems—and provide co-benefits beyond water treatment. They contribute to biodiversity, offer habitat, support urban cooling, and can enhance landscape amenity and recreation when well designed and maintained.

> **“These systems remove pollutants from wastewater through sedimentation, filtration, plant uptake and microbial breakdown.**

BENEFITS AND CO-BENEFITS

Land

- Controls erosion and promotes nutrient cycling
- Contributes to urban greening and microclimate regulation

Water

- Manages stormwater by retaining water, reducing runoff, peak flows and flooding
- Improves water quality by removing pollutants including nutrients, solids and pathogens
- Supports groundwater recharge and water cycling

Biodiversity

- Provides wetland habitat for aquatic birds, amphibians and invertebrates
- Enhances habitat connectivity in urban areas
- Supports pollination and ecological function

Atmosphere

- Improves air quality by capturing airborne particulates
- Supports carbon sequestration through dense vegetation

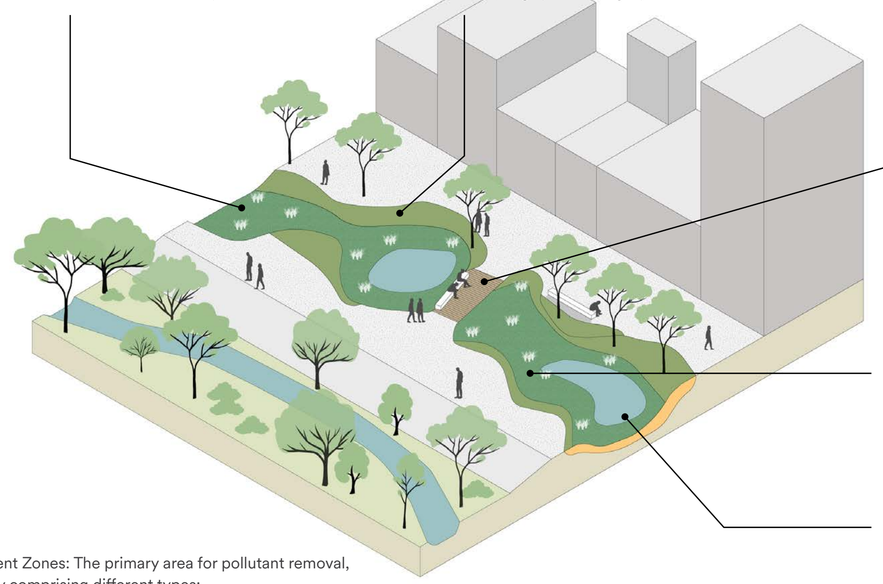
People

- Enhances urban aesthetic value
- Supports Caring for Country practice

Inlet Zone:
Designed to distribute incoming water evenly across the wetland, manage flow velocity, and facilitate the sedimentation of gross pollutants and coarse sediments. This often includes a sediment forebay or trash rack.

Overflow System:
A high-flow bypass is typically incorporated to manage large storm events that exceed the wetland’s design capacity, preventing damage and ensuring system integrity.

Maintenance Access:
Designed for ease of access for routine monitoring, vegetation harvesting, sediment removal, and substrate replacement if required.

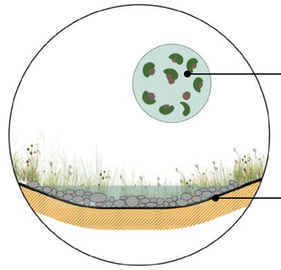


Vegetation (Macrophytes): Water-tolerant plants (e.g. Phragmites australis, Typha spp., Juncus spp., Carex spp.) are planted in the wetland. Their roots help to stabilise the media, provide oxygen to the rhizosphere for microbial activity, and directly take up nutrients and some pollutants.

Outlet Zone: Designed to collect treated water and control the water level within the wetland. This often includes an adjustable weir or pipe.

Treatment Zones: The primary area for pollutant removal, typically comprising different types:

- Free Water Surface (FWS) Wetlands: Feature a shallow depth of water (typically 0.1-0.6 m) flowing over a soil substrate, with emergent vegetation (e.g., reeds, rushes) rooted in the sediment. They are visually similar to natural wetlands and provide significant habitat benefits.
- Subsurface Flow (SSF) Wetlands: Water flows horizontally or vertically beneath the surface of a gravel or sand media bed where plant roots are established. These are less prone to mosquito breeding and have reduced odour potential compared to FWS wetlands.
- Hybrid Systems: Combine elements of both FWS and SSF wetlands or incorporate vertical flow components to enhance pollutant removal efficiency (e.g., alternating aerobic/anaerobic conditions).



Bacteria break down cotaminants

Lining: An impermeable liner (e.g., compacted clay, geomembrane) is typically installed at the base and sides to prevent treated or untreated water from seeping into the surrounding ground or groundwater, especially when treating wastewater or in areas with sensitive aquifers.

WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Hydraulic design**
  Optimise hydraulic loading rate (HLR) and residence time (HRT) to ensure effective pollutant removal. Ensure even flow distribution to avoid short-circuiting.
- **Pollutant targeting**
  Select wetland type and design parameters based on expected pollutant loads (e.g. nutrients, sediments, pathogens). Hybrid systems are highly effective for removing multiple pollutants.
- **Vegetation selection**
  Choose hardy, water-tolerant macrophytes (e.g. Phragmites, Typha, Juncus) that tolerate local conditions and enhance pollutant removal.
- **Media specification**
  For SSF systems, use appropriately graded, porous substrates that support microbial activity and maintain hydraulic conductivity.
- **Pre-treatment**
  Incorporate gross pollutant traps and sediment forebays to protect downstream zones and reduce maintenance frequency.
- **Monitoring and adaptation**
  Track key water quality indicators (e.g. TSS, nutrients, DO) and adjust operation or maintenance as needed to optimise performance.
- **Vegetation harvesting**
  Periodically remove mature biomass to prevent nutrient re-release and maintain system health.
- **Climate responsiveness**
  Design for local extremes—such as drought, heavy rain or high evaporation—using overflow systems, supplementary water sources or drought-tolerant vegetation.

LIMITATIONS

- Requires significant land, especially for Free Water Surface systems.
- Less effective for high or fluctuating flow volumes.
- Performance may decline in extreme weather conditions.
- Sensitive to toxic inflows and pollutant spikes.
- Poor maintenance can lead to negative public perception.

DESIGN CONSIDERATIONS

- **Site assessment**
  Investigate hydrology, soil conditions, groundwater levels and contamination risks to determine wetland suitability and placement.
- **Hydraulic design**
  Calculate loading rates, residence times, and define flow paths. Include overflow capacity for storm events and prevent short-circuiting.
- **Lining system**
  Specify appropriate impermeable liners (e.g. clay or geomembrane) to ensure containment and protect groundwater.
- **Inlet/outlet structures**
  Design for even inflow, energy dissipation, and adjustable water level control. Include high-flow bypass mechanisms.
- **Pre-treatment**
  Install sediment forebays, trash racks or GPTs to protect the wetland from clogging and reduce maintenance needs.
- **Media selection (SSF)**
  Choose porous, durable substrates (e.g. gravel, sand, zeolite) with good hydraulic conductivity and pollutant removal capacity.
- **Vegetation planning**
  Select macrophytes suited to hydrological conditions and pollutant uptake. Plan for dense planting and staged establishment.
- **Mosquito and odour management**
  Ensure adequate drawdown, avoid stagnant zones, and plan vegetation to reduce mosquito habitat. Design to minimise odour for wastewater applications.
- **Maintenance and access**
  Provide access for sediment removal, vegetation harvesting, and monitoring. Develop a long-term O&M plan.
- **Maturation period**
  Expect a 1–3 year establishment phase before full treatment performance is achieved.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify large, strategically located sites based on hydrology, land availability, and stormwater or wastewater needs. Consider integration with parklands, corridors or ecological restoration areas. Engage stakeholders early to manage land use expectations.
- **Concept design:** Refine wetland type (FWS, SSF, hybrid), conceptual layout, and contribution to WSUD and biodiversity goals. Plan for integration with existing flow paths, infrastructure and open space.
- **Construction:** Ensure quality control during liner installation, earthworks, media placement and planting. Monitor compliance with design and environmental management requirements.
- **Detailed design:** Specify dimensions, flow depths, media, vegetation, liner systems, pre-treatment, inlet/outlet structures, and overflow mechanisms. Include detailed drawings and performance objectives. Plan for maintenance and monitoring.
- **Operation:** Implement monitoring, vegetation harvesting, sediment management and adaptive maintenance. Track water quality performance and plan for periodic media replacement in SSF systems.

APPLICABILITY

Building scale: Best suited to larger sites; smaller systems may work for commercial or institutional buildings.

Precinct scale: Ideal for parks, industrial areas and neighbourhoods with adequate open space.

Retrofit potential: Can be added to existing open spaces with compatible drainage and grading.

Integration: Works well with swales, rain gardens and other WSUD features.

WATER
CASE STUDY

CASE STUDY:
ROUSE HILL - REGIONAL CENTRE

PROJECT OVERVIEW

The New Rouse Hill is a landmark $1 billion development spanning 120 hectares, centred around the Rouse Hill Town Centre. Located off Windsor Road in Sydney's fast-growing north-west, the precinct integrates residential, retail and community uses.

Since 2000, Arcadis has led civil and structural engineering, stormwater design and service coordination, working closely with OCULUS and other partners to embed water-sensitive urban design (WSUD) into the landscape.

This precinct-scale WSUD approach included the early integration of hydrological, hydraulic and water quality modelling. WSUD features were coordinated with open space and street design - setting a precedent for sustainable water management in the district. As of today, Arcadis is working on a major retail and mixed-use expansion similar to the future precinct.

Key WSUD elements include:

- Bio-retention systems for filtering runoff through layered vegetation and engineered soils
- Wetlands to treat stormwater, absorb pollutants and create ecological habitat
- Rain gardens to collect and infiltrate runoff from roads and buildings
- Swales to slow, convey and filter surface water while connecting open space corridors

This integrated suite of features reflects a comprehensive, site-responsive strategy for managing both water quality and quantity at precinct scale.

Client:
Lendlease, Landcom & GPT Group

Project type:
New build, with retrofit elements as part of the expanded retail centre

Completion date:
2000 - ongoing

Location:
Rouse Hill, NSW

First Nations Country:
Darug Country

Key Partners:

- OCULUS
- Arcadis

Image courtesy of OCULUS

WATER
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Habitat restoration and integration:** The precinct design retained existing mature trees wherever possible, with porous walkways introduced to protect root zones. Additional vegetation was integrated throughout public spaces, streets and WSUD systems.
- **Ecological water infrastructure:** Bio-retention systems, swales, rain gardens and constructed wetlands were planted with native species to create habitat and improve water quality. These features support a range of local flora and fauna and link with natural corridors such as Caddies Creek.
- **Zoned water treatment:** A series of rain gardens and ponds were implemented along Caddies Creek to ensure stormwater is treated before entering the natural waterway – enhancing habitat value and maintaining ecological health.

People

- **Integrated community design:** The Rouse Hill Regional Centre was designed as a vibrant, mixed-use precinct – offering homes, schools, shops, offices and public amenities within walkable distances.
- **Recreation and liveability:** Residents benefit from sports courts, swimming pools, picnic areas and shaded walkways – all supported by WSUD infrastructure that ensures these spaces remain accessible and safe during heavy rain or flood events.
- **Community resilience and health:** WSUD features not only protect infrastructure but enhance daily experience – providing green, shaded and biodiverse environments that encourage physical activity, social interaction and wellbeing.

Atmosphere

- **Carbon sequestration and air quality:** Extensive planting across the precinct, including trees, shrubs, and aquatic vegetation, supports carbon capture and helps improve local air quality. These green systems contribute to long-term climate resilience.

Water

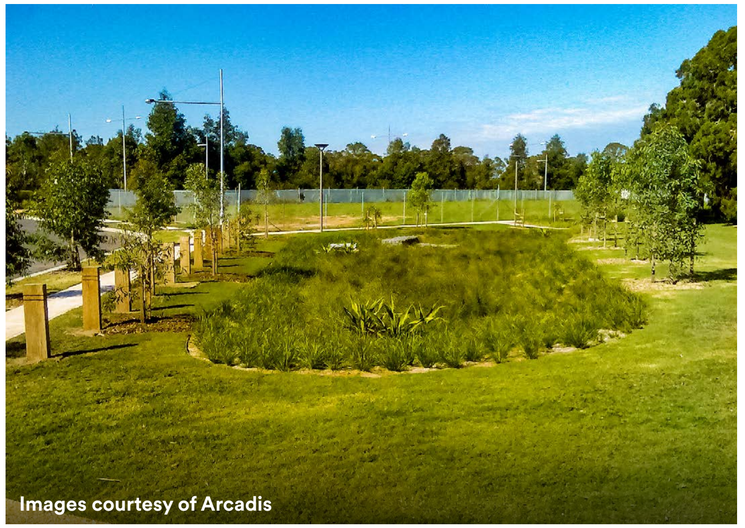
- **Integrated stormwater management:** Arcadis employed a comprehensive approach to WSUD, using hydrological, hydraulic and water quality modelling to guide the integration of:
  - Bio-retention systems
  - Rain gardens
  - Wetlands
  - Swales

  These systems filter and treat runoff before discharging to Caddies Creek and the site's four ponds.
- **Flood resilience and flow control:** WSUD features were designed to manage both everyday rainfall and intense storm events.
  - Low-flow channels capture frequent rainfall (up to 3-month ARI)
  - High-flow channels manage larger events (up to 100-year ARI)

  These systems slow, absorb and gradually release water – reducing flood risk and pressure on built infrastructure.
- **Water conservation and infiltration:** Wetlands and rain gardens support groundwater recharge – vital for resilience during dry periods.

Land

- **Urban greening and soil stability:** The WSUD-led design retained mature trees and introduced new vegetation throughout streetscapes and public spaces – reducing erosion and enhancing the site's natural character.
- **Urban heat island mitigation:** Increased canopy cover and vegetation help cool the environment through shading and evapotranspiration. This makes the town centre more comfortable and liveable – especially during Western Sydney's hot summers.
- **Erosion control:** WSUD systems promote infiltration and slow down runoff, reducing the risk of soil erosion along Caddies Creek and surrounding open spaces.



Images courtesy of Arcadis

WATER
CASE STUDY

DESIGN CONSIDERATIONS

- **Upfront delivery of key infrastructure** ensured early functionality and resilience.
- **Integrated planning** combined urban design and water cycle management from the outset, enabling WSUD to be embedded across open space and street networks.
- **Minimised earthworks** through careful site planning, reducing the need for bulk material relocation and limiting environmental disturbance.
- **Material reuse** was prioritised wherever possible to support circular outcomes and reduce embodied emissions.
- **Location-responsive WSUD:** The type and placement of rain gardens, swales and wetlands were tailored to complement surrounding uses – enhancing amenity while improving ecological function.

CONSTRUCTION CONSIDERATIONS

- **Site history and sensitivity:** The project site's land was formerly used for farming and a golf course, with some asbestos-contaminated infrastructure. Caddies Creek, a natural waterway managed by Sydney Water, bisects the site – necessitating a careful, water-sensitive approach.
- **Pollutant treatment and flow regulation:**
  - WSUD features filter runoff to remove sediments, nutrients, and heavy metals before it discharges into Caddies Creek.
  - These systems slow flow velocity and promote infiltration, protecting creek banks from erosion and reducing downstream impacts.
- **Holistic stormwater strategy:** Rather than relying solely on conventional pipe-and-drain infrastructure, the team adopted an integrated WSUD approach tailored to the site's complex hydrology, contamination risks and ecological context.

OPERATIONAL CONSIDERATIONS

- **Shared community stewardship:** Rouse Hill is one of the few precincts where residents contribute to a shared maintenance fund that supports the upkeep of community facilities and open spaces.
- **Maintainable WSUD design:**

  Wetlands, rain gardens and bioswales were designed with long-term operation in mind:

  - Accessible for maintenance teams
  - Vegetation management and filter media replacement accounted for
  - Designed to remain effective and attractive over time

  This upfront investment ensures WSUD infrastructure's continuous delivery of ecological, amenity and resilience benefits well into the future.

FURTHER READING

Landcom:

- Rouse Hill Town Centre

issuu:

- Rouse Hill Precinct Plan

Image courtesy of OCULUS

WATER
DESIGN ELEMENT

DESIGN ELEMENT: WATER HARVESTING - RAINWATER TANKS

Rainwater tanks are a key component of rainwater harvesting systems, used to collect and store rainwater—typically from roof surfaces—for non-potable uses such as toilet flushing, laundry, garden irrigation and car washing.

By capturing water at the source, rainwater tanks help reduce reliance on potable mains water and improve stormwater management by lowering runoff volumes, peak flows and pollutant loads. Though not a nature-based solution themselves, tanks can support broader water-sensitive design strategies when integrated with green infrastructure such as rain gardens or green roofs. They also offer a resilient alternative water source during drought conditions.

> “rainwater tanks help reduce reliance on potable mains water and improve stormwater management by lowering runoff volumes, peak flows and pollutant loads.

BENEFITS AND CO-BENEFITS

Water

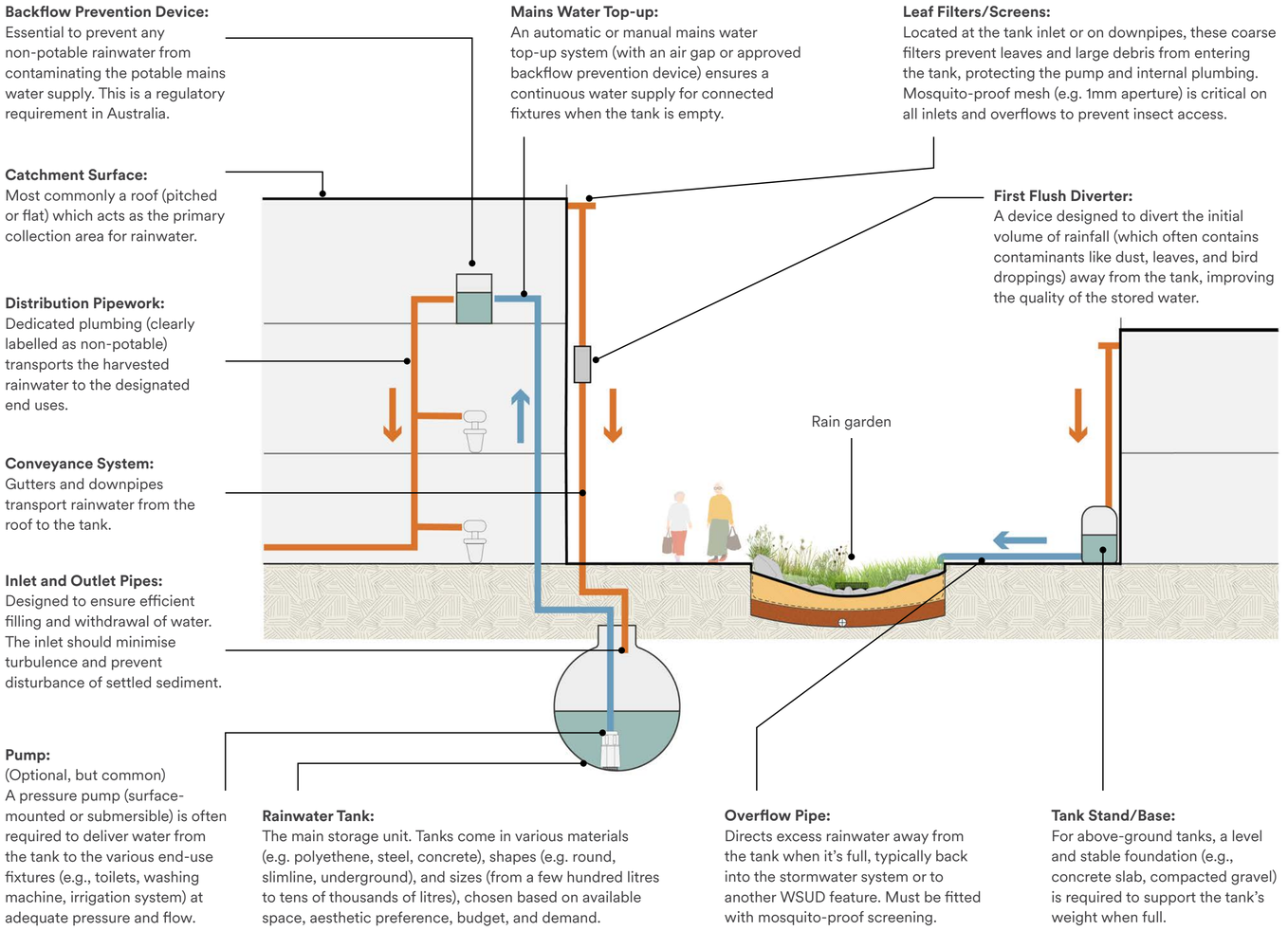
- Reduces reliance on mains water by supplying rainwater for non-potable uses.
- Manages stormwater by reducing stormwater runoff volumes and peak flows.
- Improves water quality by intercepting pollutants at the source.

Atmosphere

- Lowers carbon emissions by reducing energy use associated with centralised water treatment and pumping.

People

- Delivers financial savings through reduced water bills.



WATER
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Correct tank sizing**
  Match tank size to catchment area, rainfall patterns and intended non-potable water demand. Oversized tanks may stagnate; undersized tanks limit savings.
- **Suitable catchment surface**
  Use clean, non-toxic roofing materials (e.g. Colorbond, tiles) and maintain gutters to minimise contamination.
- **Effective pre-treatment**
  Install and maintain first flush diverters and filters to reduce debris, sediment and pollutants entering the tank.
- **Water quality protection**
  Seal the tank, and fit all inlets and overflows with mosquito-proof mesh. Clean the tank every 2–5 years to remove sediment.
- **Appropriate end-use selection**
  Use rainwater for toilets, laundry, irrigation and external washing in line with water quality and local regulations.
- **Efficient pump and plumbing**
  Select an energy-efficient pump and design plumbing to deliver reliable pressure while preventing cross-connections.
- **Backflow prevention**
  Ensure all connections with mains water include compliant backflow devices or air gaps.
- **Regular maintenance**
  Maintain filters, gutters, pumps and mosquito screens to ensure performance and system longevity.

LIMITATIONS

- Dependent on rainfall; may run dry during droughts.
- Water is non-potable unless treated.
- Quality can be affected by roof debris and pollutants.
- Requires space; underground tanks increase cost.
- Higher upfront cost compared to traditional systems.

DESIGN CONSIDERATIONS

- **Sizing and site assessment**
  Calculate optimal tank size using roof area, local rainfall data and non-potable demand. Check council regulations on placement and overflow management.
- **Tank material and type**
  Select based on available space, durability, budget and visual impact. Options include above-ground, slimline, underground, and various materials (e.g. polyethylene, steel, concrete).
- **Foundation and placement**
  Install on a level, load-bearing base near end uses. Ensure easy access for maintenance and minimise pipe runs.
- **Plumbing and filtration**
  Include first flush diverters, leaf filters, mosquito-proof mesh on all openings, and appropriately sized pipes.
- **Mains water top-up**
  Design with a compliant air gap or backflow prevention device to prevent cross-contamination.
- **Maintenance access**
  Allow for safe inspection and cleaning of filters, pumps and tank interiors. Anchor tanks where required for safety.
- **System integration**
  Design dedicated non-potable plumbing to connect to toilets, irrigation or laundry, clearly labelled to meet plumbing codes.
- **Water quality management**
  Provide a maintenance guide outlining routine checks (e.g. gutters, filters, pump function) and sediment removal every 2–5 years.

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning / Concept design:** Identify buildings or precincts where rainwater harvesting can offset potable water use. Consider centralised vs decentralised systems and assess total roof catchment, water demands, and integration with stormwater management goals.
- **Detailed design:** Size tanks based on rainfall and water use. Specify tank material, location, plumbing layout, filtration, first flush devices, pumps, mains top-up systems, and backflow prevention. Prepare detailed plans for foundations and overflow management.
- **Construction:** Install tanks, plumbing, filtration and electrical components according to specifications and Australian standards. Test for leaks, ensure mosquito-proofing and verify backflow compliance.
- **Operation:** Maintain gutters, filters and pumps. Monitor sediment levels and clean tanks every few years. Ensure the mains top-up functions correctly and track water use to assess effectiveness.

APPLICABILITY

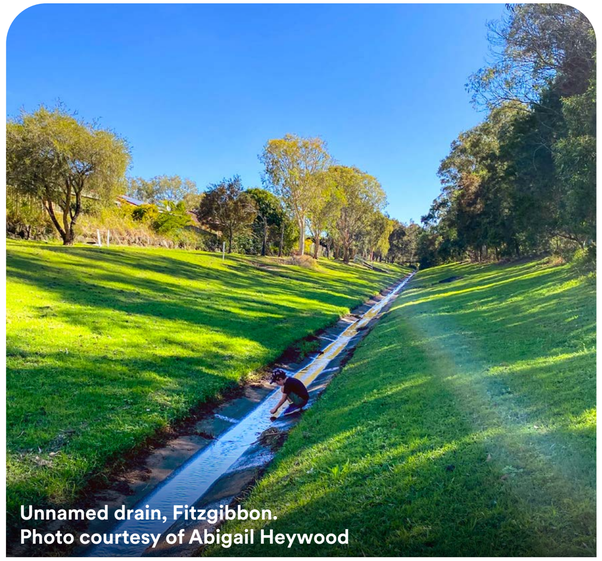
Building scale: Ideal for homes and commercial buildings to offset potable use.

Precinct scale: Suited to schools, parks or multi-residential sites using shared tanks.

Retrofit potential: Can be installed on existing buildings with adequate space.

Integration: Combines well with WSUD features like swales or rain gardens.

WATER
DESIGN ELEMENT



Unnamed drain, Fitzgibbon.
Photo courtesy of Abigail Heywood

Unnamed drain, Fitzgibbon. Cyclone Alfred 2025.
Photo courtesy of Abigail Heywood

FURTHER READING

BIORETENTION SYSTEMS:

ScienceDirect: Bioretention systems for stormwater management – Recent advances and future prospects

- https://pubmed.ncbi.nlm.nih.gov/33984642/

SWALES:

Autodesk One Water Blog: How swales work – and why they're an increasingly popular sustainable design option

- https://www.autodesk.com/blogs/water/2025/02/25/how-swales-work-and-why-theyre-an-increasingly-popular-sustainable-design-option/?msockid=1865127a729c66d2355907b2730c67f5

Next generation swale design for stormwater runoff treatment: A comprehensive approach

- https://pubmed.ncbi.nlm.nih.gov/33360437/

Unlocking the Positive Impact of Bio-Swales on Hydrology, Water Quality, and Biodiversity: A Bibliometric Review:

- https://www.mdpi.com/2071-1050/15/10/8141

NATURALISED BASIN:

City of Chattanooga (2017): Rainwater Management Guide – Features of Naturalised Basins

- https://chattanooga.gov/sites/default/files/2024-06/5.3.13_Naturalized_Basins.pdf

LDP Watersheds: Managing Detention Basins for Healthy Communities

- https://ldpwatersheds.org/managing-detention-basins-for-healthy-communities/

Wetlands as Nature-Based Solutions for Water Management in Different Environments:

- https://www.sciencedirect.com/science/article/pii/S2468584423000363

Wiley – WIREs Water: Managing Floodplains Using Nature-Based Solutions to Support Multiple Ecosystem Functions and Services:

- https://wires.onlinelibrary.wiley.com/doi/10.1002/wat2.1545

CONSTRUCTED WETLANDS:

ScienceDirect: Artificial wetlands and water quality improvement

- https://www.sciencedirect.com/science/article/abs/pii/S0160412001000253

Nature Reviews Earth & Environment: Constructed wetlands for pollution control

- https://www.nature.com/articles/s43017-023-00395-z

Design, Operation and Optimization of Constructed Wetland for Removal of Pollutant:

- https://pmc.ncbi.nlm.nih.gov/articles/PMC7698012/

WATER HARVESTING:

AS/NZS 3500.1:2021 – Plumbing and drainage – Water services

- (Access via Standards Australia or institutional subscription)

Smart WaterMark – Water saving resources and accreditation:

- https://www.smartwatermark.org/

Water Sensitive Cities Australia – Integrated water management tools and case studies:

- https://watersensitivecities.org.au/

Department of Climate Change, Energy, the Environment and Water: National Water Initiative (NWI)

- https://www.dcceew.gov.au/water/policy/policy/nwi

Atmosphere

Concept, design elements and case studies

ATMOSPHERE
CONCEPT

ATMOSPHERE

ASPIRATION

Regenerate the urban atmosphere by sequestering carbon, improving air quality, and designing restorative sound and light environments.

DESIGNING WITH COUNTRY

From the misty ranges of the Dandenongs to the dry clarity of the Nullarbor skies, the atmosphere of this continent carries stories, breath and memory. In Designing with Country, we regenerate the urban atmosphere by sequestering carbon through vegetation and soil, improving air quality to support all life, and shaping restorative sound and light environments that reflect the rhythms of Country.

Silence, natural light and clean air are not just environmental conditions—they are signs of healthy Country and essential to life. By listening to the wind, respecting the night and softening the urban soundscape, we honour the non-human kin who navigate by stars, echo through valleys and breathe with the trees. Atmosphere is not empty—it is alive and central to Country.

This section contains:

- Carbon sequestration
- Air Quality
- Sound environment
- Light environment


Image courtesy of Abigail Heywood


Image courtesy of House of Bamboo


Image courtesy of Abigail Heywood

ATMOSPHERE
CONCEPT

CARBON SEQUESTRATION

CARBON IN THE BUILT ENVIRONMENT

The buildings and construction sector is a major contributor to climate change, responsible for approximately 37% of global energy and process-related CO_2 emissions in 2021 (UNEP, 2022). These emissions include both:

- **Operational carbon**, from building use—such as heating, cooling, lighting and equipment, and
- **Embodied carbon**, from the extraction, manufacturing and transport of materials such as cement, steel and aluminium.

Embodied carbon is further divided into:

- **Upfront emissions**, released during material production and construction;
- **In-use emissions**, from ongoing maintenance and upgrades; and
- **End-of-life emissions**, generated during demolition and disposal.

Of these, upfront emissions are the most critical, making up around 70% of total embodied carbon (Orr et al., 2025). These emissions are locked in once construction is complete and cannot be reduced after the fact.

While embodied carbon is a well-researched field (see Orr et al., 2025; Pomponi et al., 2020), this guide focuses on carbon sequestration—strategies for actively removing and storing atmospheric carbon within the built environment.

Image courtesy of Abigail Heywood

WHAT IS CARBON SEQUESTRATION - AND WHY DOES IT MATTER?

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide (CO_2), helping to reduce the concentration of greenhouse gases in the atmosphere. It plays a vital role in mitigating climate change and is a key strategy in climate-positive design (UNEP, 2022).

Carbon can be sequestered naturally through biological processes such as:

- **Plants:** Trees, shrubs and groundcovers absorb CO_2 during photosynthesis and store it in their biomass—trunks, branches, leaves and roots.
- **Soils:** Organic matter from dead plants and microorganisms stores carbon in the soil, particularly in healthy, undisturbed systems.
- **Oceans:** Marine organisms such as phytoplankton absorb CO_2; some of this carbon is transferred to ocean sediments via the biological pump (Pomponi et al., 2020).

This is known as biogenic carbon. It is generally considered carbon-neutral, provided the biomass is managed sustainably (Leskinen et al., 2018). In contrast, fossil carbon—from coal, oil and natural gas—adds new carbon to the atmosphere when burned, accelerating climate change.

ATMOSPHERE
CONCEPT

CARBON SEQUESTRATION IN THE BUILT ENVIRONMENT

Image courtesy of House of Bamboo

In urban development, carbon sequestration can be achieved through urban greening and the use of bio-based materials. Both approaches reduce atmospheric CO_2—either by increasing the amount captured and stored in vegetation and soils, or by selecting materials that store biogenic carbon instead of emitting fossil carbon.

URBAN GREENING

Urban vegetation acts as a living carbon sink. While each tree or shrub may sequester a small amount of carbon, the cumulative effect across a city can be significant—especially when integrated at scale. Plants store carbon in their biomass and surrounding soils through photosynthesis (Leskinen et al., 2018).

Carbon sequestration from vegetation is most effective when integrated with other design goals, such as biodiversity enhancement, water management and urban cooling.

Common nature-based design elements that are detailed throughout the guide and support carbon sequestration include:

NATURE REALM	NATURE-BASED DESIGN ELEMENT
Biodiversity	• Landscape planting for habitat creation • Habitat restoration • Biodiverse green roofs • Biosolar green roofs • External green walls
Land	• Land formation retention and restoration • Blue / green streetscapes • Green spaces • Community gardens • Elevated parks • External green façades • External planter boxes
Water	• River and creek restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed wetlands

BENEFITS OF URBAN GREENING

Biodiversity

- Increases habitat for species such as invertebrates, birds, bats and microfauna
- Supports pollination services
- Enhances urban plant diversity
- Improves habitat connectivity across the urban landscape

Land

- Helps regulate urban temperatures through evapotranspiration and shading

Water

- Supports stormwater management through infiltration and reduced runoff
- Improves water quality by filtering pollutants

Atmosphere

- Sequesters carbon through vegetation and soils
- Improves air quality by capturing airborne particulates

People

- Strengthens connection to Country and Nature
- Supports Caring for Country practices
- Enhances mental wellbeing
- Improves urban amenity and visual appeal, with flow-on effects for property value
- Encourages stewardship and positive human–nature relationships

ATMOSPHERE
CONCEPT

BIO-BASED MATERIALS

Bio-based materials are construction products made from renewable biological sources. When sustainably sourced, they contribute to carbon sequestration by locking carbon into the built form—storing biogenic carbon rather than emitting fossil carbon (Leskinen et al., 2018). They also reduce embodied carbon compared to conventional, emissions-intensive materials (Orr et al., 2025).

Examples include:

- **Mass engineered timber (MET):** Structural timber products from certified forestry, suitable for construction.
- **Engineered bamboo:** A strong, fast-growing material used for structural (Structural Engineered Bamboo) and decorative applications.
- **Mycelium:** Made from fungal networks. Lightweight, compostable and insulating—used in bricks, panels and packaging (EIT, 2023).
- **Straw bales:** Cost-effective insulation with excellent thermal performance.
- **Plant-based fibres:** Flax, jute and kenaf used in insulation and composite panels.
- **Algae and seaweed:** Emerging materials with potential for insulation and lightweight building products.
- **Hempcrete:** A mix of hemp and lime for breathable, non-structural walls, bricks and renders.

Mass engineered timber and bamboo are explored further as standalone design elements.

BENEFITS OF BIO-BASED MATERIALS

Benefits of using bio-based materials within the built environment include carbon sequestration and lower embodied carbon per functional unit, as well as benefits to people including, connection to Country and nature, increasing urban aesthetic values and mental wellbeing.

Bio-based materials also create benefits that occur offsite during material production such as supporting carbon storage and co-benefits for biodiversity, water systems, land restoration and community wellbeing.

Collectively, these offsite and onsite benefits include:

Atmosphere

- **Sequester carbon** by storing biogenic carbon in the bio-based materials.
- **Lower embodied carbon** per functional unit.

Biodiversity

- **Habitat preservation:** Reduces reliance on extractive mining and supports ecosystems that mimic natural habitats.
- **Pollution reduction:** Fewer synthetic chemicals lower risks to pollinators, aquatic life and soil microbes.
- **Regenerative design:** Aligns with circular economy principles and supports ecological restoration.

Land

- **Sustainable use:** Grown on marginal land, relieving pressure on forests and arable soils.
- **Reduced degradation:** Circular harvesting limits disturbance and protects land for other uses.

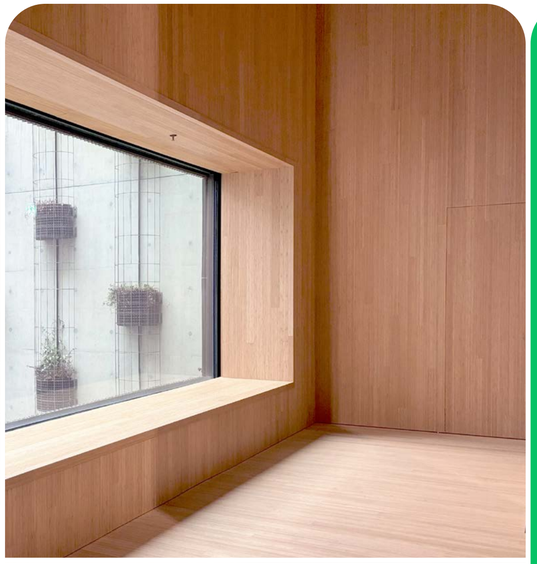
Water

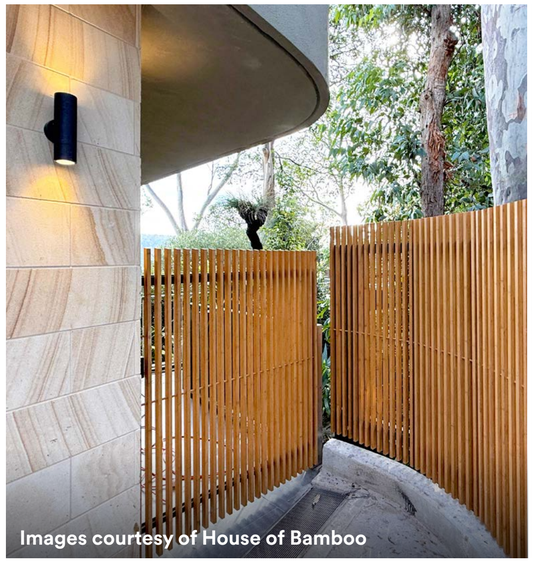
- **Lower pollution:** Less toxic processing reduces runoff into waterways.
- **Humidity regulation:** Materials like straw and hempcrete help regulate moisture, reducing energy demand.
- **Water retention:** Healthy soils supported by regenerative practices improve flood and drought resilience.
- **Reduced water footprint:** Most bio-based materials require less water to produce than concrete or steel (Ellen MacArthur Foundation, 2023).

People

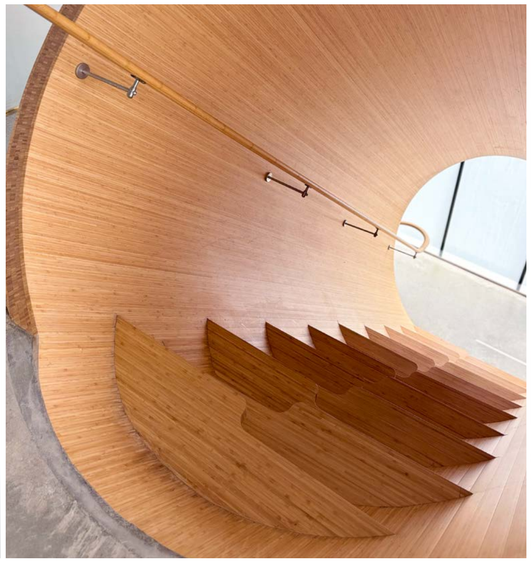
- **Connection to Country and Nature:** Natural materials support cultural values and design that honours Country.
- **Mental wellbeing:** Nature-connected spaces reduce stress and promote health.
- **Aesthetic value:** Enhances urban environments and property values.
- **Stewardship:** Encourages community engagement with regenerative systems.
- **Rural employment:** Supports jobs in regional and agricultural industries.

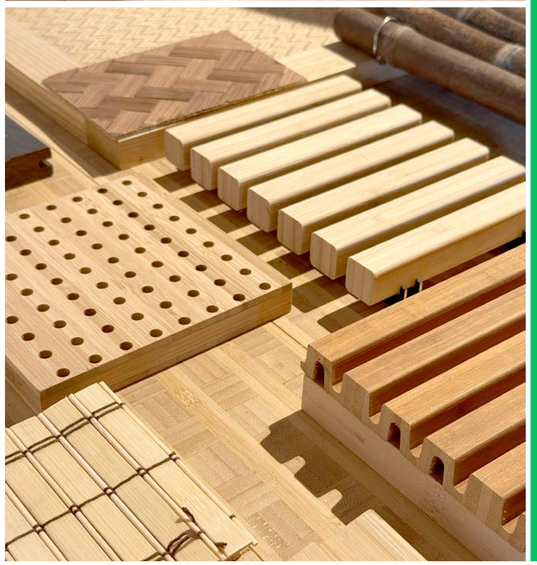
ATMOSPHERE
CONCEPT





Images courtesy of House of Bamboo





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ATMOSPHERE
DESIGN ELEMENT

DESIGN ELEMENT: MASS ENGINEERED TIMBER (MET)

Mass engineered timber includes products such as Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL) and Glue-Laminated Timber (Glulam).

Cross Laminated Timber (CLT)
CLT is made by layering solid-sawn timber boards at 90° angles and bonding them with structural adhesives. This crosswise arrangement delivers high strength, stability and rigidity, making CLT ideal for floors, walls and roofs—even in mid- and high-rise buildings.

Key Features

- **Layered structure:** Typically 3, 5 or 7 layers.
- **Cross-grain orientation:** Enhances load capacity and dimensional stability.
- **Prefabricated:** Precision-manufactured off-site to reduce waste and speed up assembly.
- **Flexible integration:** Often used with steel and concrete in hybrid systems.

Common Uses

- **Structural components:** Load-bearing walls, floor slabs and roof panels.
- **Tall timber buildings:** Suitable for multi-storey construction due to strength and fire resistance.
- **Two-way spanning:** Allows beamless floor systems and flexible design.

Laminated Veneer Lumber (LVL)
LVL is made by bonding thin wood veneers with the grain aligned. It offers high strength and is commonly used in beams and other structural elements.

Glue-Laminated Timber (Glulam)
Glulam consists of layers of lumber glued with the grain parallel. Strong and versatile, it's used for beams, columns and curved structures like arches.

BIODIVERSITY AND CO-BENEFITS

Land

Supply Chain benefits

- Promotes sustainable forest management
- Restores degraded land and soil health
- Reduces reliance on mineral extraction

Water

Supply Chain benefits

- Improves water quality
- Supports water cycling, including groundwater recharge
- Uses significantly less water in manufacturing than non-bio-based materials

Biodiversity

Supply Chain benefits

- Creates habitat
- Supports species protection and ecological restoration

Built environment benefits

- Encourages nature stewardship and education on sustainable land practices

Atmosphere

Supply Chain benefits

- Supports carbon sequestration

Built environment benefits

- Reduces embodied carbon compared to concrete and stee

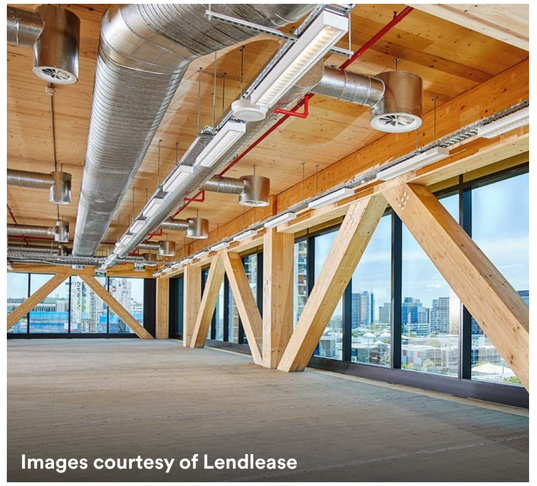
People

Supply Chain benefits

- Creates rural employment opportunities

Built environment benefits

- Fosters connection to Country and Nature
- Enhances urban aesthetics through natural materials
- Improves mental wellbeing in built environments



Images courtesy of Lendlease

ATMOSPHERE
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Sourcing of MET:** Ensure timber is sustainably harvested and that forest management supports biodiversity, carbon storage and overall ecosystem health. Certification schemes such as FSC or PEFC help verify responsible sourcing.
- **End-of-Life and Circularity:** Design with end-of-life in mind to maintain carbon sequestration. Prioritise disassembly, reuse and recycling to minimise landfill waste and support circular economy principles.
- **Lifecycle Assessment (LCA):** Conduct a full LCA to quantify the environmental benefits and trade-offs of using MET compared to conventional materials.

DESIGN CONSIDERATIONS

Load Orientation

- In walls, outer CLT layers should be vertical to align with gravity loads.
- In floors and roofs, outer layers should run horizontally, parallel to the span.

Panel Thickness & Layering

- CLT panels typically have 3, 5 or 7 layers.
- Layering affects strength, vibration and fire resistance.

Connections & Fasteners

- Connectors (screws, bolts, plates) must be designed to transfer loads effectively.
- Detailing should address shear, uplift and seismic performance.

Fire Performance

- MET chars predictably, creating a protective layer.
- Fire design must consider charring rate, panel thickness and duration of exposure.
- Ensure compliance with relevant fire codes.

Moisture & Durability

- Prolonged moisture exposure can degrade MET.
- Use weather barriers, ventilation and careful detailing.

Vibration & Acoustics

- Floor systems must minimise vibration and meet acoustic standards, especially in residential or office settings.

Design Optimisation

- Tailoring structural grids to MET improves efficiency and reduces waste.
- Optimising layer orientation and panel size enhances performance and avoids overengineering.

Perceived Risk & Insurance

- Insurance for mass timber buildings can be up to 800% higher than conventional materials (TAH, 2022), due to concerns around fire, moisture and repairs.
- Limited testing and professional familiarity remain challenges—requiring thorough planning and skilled execution.

Code Compliance

- The NCC 2022 allows timber construction under Deemed-to-Satisfy (DTS) provisions for buildings up to 25 m in height.
- Taller buildings require performance-based approvals.

Building Height (Australia)

- No fixed national height limit for CLT buildings. Approval depends on:
  - NCC compliance
  - Fire engineering solutions
  - Local council requirements
  - Project-specific assessments

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify opportunities for timber construction, considering site constraints, sustainability targets and prefabrication potential.
- **Concept Design:** Assess suitable structural systems for MET based on span, fire, acoustics and desired timber visibility.
- **Detailed Design:** Define panel sizes, connection details, moisture protection and integration with other materials (e.g. steel, concrete).
- **Construction:** Coordinate delivery and install of prefabricated panels; ensure correct handling, lifting and sealing; maintain moisture control.
- **Operation:** Monitor structural and fire performance over time; schedule inspections and support occupant connection to timber's biophilic benefits.

APPLICABILITY

Applicable to buildings

ATMOSPHERE
CASE STUDY

CASE STUDY:
USE OF CROSS LAMINATED TIMBER - 25 KING STREET

PROJECT OVERVIEW

25 King Street is a 10-storey commercial office tower located near the RNA Showgrounds in Brisbane. The building incorporates approximately 5,970 m³ of engineered timber, including 4,500 m³ of Cross Laminated Timber (CLT) and 1,470 m³ of Glulam (glue-laminated timber).

CLT was used for floors, lift shafts and escape stairs, while Glulam was used for structural beams and columns. When sourced from sustainably managed forests, CLT has significantly less environmental impact than concrete or steel. It also sequesters carbon during tree growth, contributing to reduced embodied emissions.

Beyond environmental performance, CLT provides acoustic benefits, thermal efficiency, structural strength and enhanced safety during construction. Its use enabled faster, cleaner and quieter project delivery.

Client:
Lendlease

Project type:
New build

Completion date:
Nov 2018

Location:
25 King Street, Bowen Hills, QLD

First Nations Country:
Turrbal and Yuggera Country

Key Partners:

- Engineer: Aurecon
- Architect: Bates Smart

Image courtesy of Lendlease

ATMOSPHERE
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Certified timber use:** All timber used in the project was sustainably sourced, with PEFC certification and Environmental Product Declarations (EPDs) in place to verify responsible forest management and minimise environmental impact.
- The timber supply—provided by Stora Enso—included 3,402 spruce pine trees with verified credentials, supporting traceability and biodiversity-conscious sourcing.

People

- **Biophilic design:** Exposed timber surfaces contribute to a biophilic design approach, supporting occupants' innate connection to nature. Studies show visible wood in the workplace can:
  - Reduce stress
  - Improve concentration
  - Enhance overall wellbeing
  - Increase satisfaction with work life
  - Boost productivity
- The extensive use of CLT throughout the interior promotes a warm, natural aesthetic that supports health and wellbeing in the built environment.

Water

- **Reduced water consumption in production:** The manufacturing of CLT panels requires significantly less water than conventional materials like concrete and steel. This reduction contributes to lower environmental impact across the construction lifecycle.

Land

- **Reduced construction waste:** The project's extensive use of prefabricated CLT slabs and walls led to a safer, cleaner construction site with minimal waste—just 3.75 kg/m² sent to landfill. Offsite fabrication also reduced disruption and improved material efficiency.

Atmosphere

- **Upfront carbon reduction:** The building achieved a 38.7% reduction in upfront carbon emissions (Modules A1–A3) compared to a reference building as defined by GBCA guidance.
- **Carbon sequestration:** The CLT structure stores biogenic carbon absorbed during tree growth, contributing to net-negative emissions at the material stage.
- **Moisture regulation:** CLT's hygroscopic properties help regulate indoor humidity, potentially improving air quality and thermal comfort.

Image courtesy of Lendlease

ATMOSPHERE
CASE STUDY

DESIGN CONSIDERATIONS FOR CLT AND GLULAM

Embodied carbon considerations

- Transport emissions must be balanced against the benefits of prefabrication.
- Lifecycle impacts vary by location, logistics and construction methods.
- End-of-life pathways (e.g. landfill vs. reuse or energy recovery) affect long-term sequestration outcomes.
- Accurate carbon accounting must avoid double counting biogenic carbon—clarifying whether sequestration is credited to forest operations or building materials.

Moisture and hygrothermal management

- CLT's ability to absorb and release moisture requires careful detailing to avoid mould or decay.
- Moisture control was addressed through design, materials and construction sequencing.

Fire safety

- Structural design incorporated required fire resistance ratings to ensure performance during fire events.

Termite protection

- Code-compliant detailing ensures termite resistance, including good drainage, ventilation and physical separation between timber and foundations.

Disassembly and reuse

- Prefabricated components were designed to be demountable, supporting circular economy principles.

CONSTRUCTION CONSIDERATIONS FOR CLT AND GLULAM

Reduced material volume and transport

- CLT panels are lightweight and compact, enabling more efficient transport and assembly with reduced emissions.

Moisture protection during build

- Moisture management during construction was critical—vapour barriers, low-permeability insulation and drying protocols were used to protect exposed timber.

Improved safety and site conditions

- Fewer injuries due to reduced formwork and reinforcing requirements.
- Quieter, cleaner worksite with less dust, vibration and noise.
- No hot works, lightweight battery-powered tools used instead of high-voltage equipment.
- Pre-installed handrails on floor panels minimised live-edge risks.
- Safety nets installed between beams improved fall protection.

CLT + Glulam integration

- Structural beams and columns used Glulam; CLT was used for floors, lifts and stairs—leveraging offsite precision and fast, safe onsite assembly.

Lightweight structural system

- The timber superstructure was essential for building above a tunnel, reducing structural load.

Transport and storage coordination

- Efficient logistics planning minimised burden shifting associated with changing to a timber superstructure from standard construction techniques.

Offsite fabrication benefits

- Prefabrication and early design coordination enabled a shorter build time— 25 King was constructed in 15 months (69 fewer days of impact), representing a reduction of 20 per cent compared to similar steel/concrete buildings.

OPERATIONAL CONSIDERATIONS

Passive design and thermal comfort

- A high-performance façade—including external shading and solar-oriented glazing—supports occupant comfort while reducing energy use for heating and cooling.

End-of-life management

- End-of-life pathways for CLT must be carefully considered. If not properly recycled or reused, timber disposal may result in unnecessary waste or lost carbon storage benefits.

Image courtesy of Lendlease

FURTHER READING

GUIDES & REPORTS

Institution of Structural Engineers (Orr et al., 2025):

- How to Calculate Embodied Carbon

Timber Accelerator Hub (TAH):

- Mass Timber – Challenges & Potential Solutions (2022)

Built by Nature:

- Fire Safe Design of Mass Timber Buildings

Think Wood:

- Cross Laminated Timber (CLT) Overview
- CLT Handbook Download

WoodWorks:

- Design Strategies for Two-Way Spanning CLT

RESEARCH ARTICLES & ACADEMIC PUBLICATIONS

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- Substitution effects of wood-based products in climate change mitigation. EFI

25 KING STREET

- Green Building Council Australia
- Aurecon
- Sustainability Awards
- MECLA Case Study
- AG Coombs: 25 King St Experience

Infrastructure Global:

- Timber Commercial Tower

Stora Enso:

- Supplying Sustainable Wood

Brisbane Development:

- Lendlease unveils Australia's Tallest Timber Tower

Beck Fastening:

- Understanding the Environmental Impact of CLT Construction

ScienceDirect:

- Hygrothermal properties analysis of cross-laminated timber wall with internal and external insulation systems

ScienceDirect:

- Moisture risk assessment of cross-laminated timber walls

WoodSolutions:

- CLT at Work

ATMOSPHERE
DESIGN ELEMENT

DESIGN ELEMENT: ENGINEERED BAMBOO

Engineered bamboo is a composite material made by processing natural bamboo into strips or fibres, then bonding them under heat and pressure to create panels, beams or boards. It offers a strong, durable and sustainable alternative to conventional materials such as wood, steel and concrete.

Key Features

- **High strength-to-weight ratio:** Stronger than many hardwoods and some steels, making it suitable for structural applications.
- **Dimensional stability:** Engineered for minimal warping and shrinkage.
- **Versatile applications:** Used in flooring, wall panels, furniture and increasingly in structural elements.
- **Sustainability:** Bamboo grows rapidly (up to 1 m/day), regenerates without replanting and stores biogenic carbon, helping reduce embodied carbon in buildings.
- **Carbon sequestration:** Bamboo stores CO_2 both above ground (culms, branches, leaves) and below ground (roots and rhizomes), adding carbon to soil and enhancing long-term carbon storage.
- **Natural aesthetic:** Warm, wood-like finish with unique grain patterns.

Applications

- **Structural components:** Beams, columns and trusses for low- to mid-rise buildings, offering high tensile strength comparable to steel.
- **Flooring & decking:** Durable, moisture-resistant and visually appealing for indoor/outdoor use.
- **Wall & ceiling panels:** Ideal for cladding and acoustic treatments, contributing to biophilic design.
- **Hybrid systems:** Often paired with mass timber or steel to optimise performance and sustainability.

Despite its potential, engineered bamboo remains underutilised in Australia. It represents a compelling option for reducing embodied carbon and promoting regenerative material use in construction.

BIODIVERSITY AND CO-BENEFITS

Land

Supply chain benefits

- **Land & soil restoration:** Bamboo thrives on marginal land, with deep roots that stabilise soil, prevent erosion and restore degraded land.
- **Supports sustainable forestry:** Fast-growing and self-regenerating, bamboo eases pressure on hardwood forests. Non-invasive species are selected to protect local ecosystems.
- **Reduces mineral extraction:** As a renewable alternative to steel and concrete, bamboo lowers demand for resource-intensive materials.

Water

Supply chain benefits

- **Low water demand:** Bamboo requires far less water than many timber species and often grows without irrigation.
- **Pollution reduction:** Grows without fertilisers or pesticides, reducing contamination risk from runoff.
- **Hydrological benefits:** Enhances groundwater recharge and supports water cycling.
- **Water filtration:** Can help purify wastewater and improve wetland water quality.
- **Efficient manufacturing:** Production uses less water than steel or concrete, with water recycling and treatment often in place.

Biodiversity

Supply chain benefits

- **Habitat creation:** Bamboo forests support diverse species, offering food and shelter for birds, insects and small mammals.
- **Ecosystem restoration:** Cultivation aids native species protection and restores degraded habitats.

Atmosphere

Supply chain benefits

- **Carbon sequestration:** Bamboo absorbs more CO_2 than many fast-growing trees. Its root system remains intact during harvest, allowing continuous regeneration and year-round carbon uptake.

Built environment benefits

- **Lower embodied carbon:** Engineered bamboo has a significantly smaller carbon footprint than materials like steel and concrete.

People

Supply chain benefits

- **Rural employment:** Bamboo cultivation and manufacturing create long-term jobs, particularly for smallholder farmers and factory workers in Asia.
- **Local industry potential:** A 10-year plan led by the Bamboo Society of Australia aims to establish plantations, supporting regional economic growth.

Built environment benefits

- **Connection to place:** Bamboo's natural aesthetic strengthens connection to Country and the environment.
- **Enhanced urban appeal:** Its warm texture and biophilic qualities improve the visual quality of urban spaces.
- **Mental wellbeing:** Natural materials like bamboo promote calming, restorative environments.
- **Community education:** Bamboo initiatives often support learning around sustainable land use and restoration.

Images courtesy of House of Bamboo

ATMOSPHERE
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

Sustainable sourcing and harvesting

- Bamboo must be harvested responsibly to protect biodiversity and maintain carbon storage.
- Non-invasive clumping varieties are preferred.
- Certification (e.g. Global GreenTag, FSC, PEFC) verifies sustainable sourcing.

Manufacturing

- Adhesive type, lamination and pressing methods affect environmental impact.
- Low-VOC adhesives improve indoor air quality and reduce embodied emissions.

Design for disassembly

- When designed for modularity, engineered bamboo can be reused or recycled—supporting a circular economy and reducing waste.

Carbon sequestration and embodied carbon

- Bamboo absorbs more CO_2 per hectare than most trees and retains it in the final product.
- Harvesting above the second node protects root systems and soil carbon. Only 20–25% of culms are harvested at a time.
- Embodied carbon is significantly lower than steel or concrete alternatives.

Lifecycle assessment (LCA)

- LCA quantifies environmental benefits and trade-offs compared to conventional materials.
- Dynamic LCA offers improved recognition of short-cycle, renewable bio-based materials like bamboo.

Standardisation and certification

- ISO standards support quality and performance:
  - ISO 22156: design guidance for whole culm construction
  - ISO 22157-1 & 22157-2: test methods for physical and mechanical properties
  - ISO 23478:2022: standards for engineered bamboo
- Certification (e.g. ISO, ASTM, green building schemes) ensures compliance and quality.

Construction and training

- Effective use relies on skilled labour, safe practices and builder education.
- Industry training is key to unlocking bamboo's sustainable potential.

DESIGN CONSIDERATIONS

Material behaviour

- Engineered bamboo offers high tensile and compressive strength, with greater uniformity and reliability than natural bamboo.

Load behaviour

- Performs well under axial loads but requires careful design for bending and shear.
- Laminated products can be customised for specific load requirements, similar to glulam timber.

Durability and preservation

- Susceptible to moisture, insects and fungi without treatment.
- Protection via lamination, sealing and good detailing is essential for longevity.

Connections and fasteners

- Bamboo's anisotropic nature requires precise connection design.
- Bolted, dowelled and glued joints must be engineered to prevent splitting and ensure load transfer.

Displacement and flexibility

More flexible than conventional materials—beneficial in seismic zones but must be accounted for in design.

Failure modes

- Risks include buckling, splitting and delamination.
- Design must include safety factors and testing to mitigate these.

Fire performance

- Chars like timber; fire resistance depends on thickness, treatment and finishes.
- Must meet local fire codes and standards.

Standardisation and codes

- As bamboo enters more markets, compliance with ISO, ASTM and local standards is key.

Building height

- No formal height limit, but taller structures require performance-based assessments under the NCC, addressing:
  - Fire resistance
  - Structural integrity
  - Moisture and durability

INTEGRATION ACROSS PROJECT LIFECYCLE

- **Masterplanning:** Identify opportunities to use engineered bamboo in structural or architectural elements. Align with sustainability targets, local sourcing and carbon reduction goals.
- **Concept Design:** Assess suitability for specific applications (e.g. beams, panels, flooring), considering load capacity, fire performance and aesthetics.
- **Detailed Design:** Specify product types, connection details, finishes and protection against moisture, UV and pests. Integrate with other materials as required.
- **Construction:** Plan for prefabrication and efficient assembly. Handle and store carefully to avoid warping or damage. Follow installation and sealing guidelines.
- **Operation:** Establish maintenance routines for finishes and inspect for wear or degradation. Monitor durability, especially in humid or high-traffic conditions.

APPLICABILITY

Applicable to buildings

ATMOSPHERE
CASE STUDY

CASE STUDY:
FIRST BUILDING, BRADFIELD CITY DEVELOPMENT – AMRF FACILITY

PROJECT OVERVIEW

Showcasing Bamboo as a Regenerative Material.

The First Building was conceived as a flexible, future-ready structure built from a modular 'kit of parts'. A key feature is its prefabricated engineered bamboo façade, developed in collaboration with House of Bamboo and Hassell. Designed for ease of disassembly, expansion, or relocation, the building aligns with circular design principles and reduces long-term environmental impact.

The bamboo batten screens not only articulate the façade and provide shading to high-performance glazing but also support the project's broader sustainability goals. Extensive testing of batten sizes, screen profiles, and modular construction methods ensured the system was efficient to install and perform over time.

Chosen for its low-carbon, rapidly renewable properties, bamboo reflects the project's commitment to materials that work in harmony with natural ecological cycles. Its inclusion reinforces the ambition to achieve 6-Star Green Star and Living Building Challenge certifications—making this a standout example of how sustainable design and material innovation can coexist in modern Australian architecture.

First Building, Gross Floor Area: 2,800sqm.

Client:
Bradfield Development Authority (NSW Government)

Project type:
New build

Completion date:
2024

Location:
215 Badgerys Creek Road, Bradfield NSW 2556

First Nations Country:
Dharug Country

Key Partners:

- Architect: Hassell
- Indigenous design: Djinjama (Danièle Hromek)
- Builder: Taylors Building
- Construction partner: Hi-Tec

Image courtesy of House of Bamboo

ATMOSPHERE
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Biodiversity

- **Low-impact harvesting:** House of Bamboo's engineered bamboo is harvested using selective cutting methods—only mature culms (typically 5–7 years old) are removed. No more than 25% of any forest is harvested at one time, preserving the ecological integrity of the stand.
- This technique minimises disturbance to surrounding flora and fauna, supports continuous canopy cover and encourages natural regeneration.

People

- **Supporting rural employment:** Bamboo cultivation and manufacturing support long-term employment in rural regions—particularly for smallholder farmers and factory workers across Asia.
- House of Bamboo's supply partners prioritise ethical labour practices, safe working conditions and fair wages, contributing to socially responsible supply chains.

Land

- **Soil restoration and erosion control:** Bamboo is cultivated on land often unsuitable for food crops or conventional forestry. Its rhizome root systems stabilise soil, reduce erosion and help regenerate degraded landscapes—improving long-term soil health and land resilience.

Water

- **Low water demand:** Bamboo cultivation requires significantly less water than traditional timber species. In many climates, it thrives without irrigation after initial establishment.
- **Reduced water pollution:** Bamboo is typically grown without fertilisers or pesticides, minimising the risk of nutrient runoff and water contamination.

Atmosphere

- **Carbon sequestration:** Bamboo absorbs more carbon dioxide than many fast-growing tree species. Because it regenerates from its root system, it continues to sequester carbon year-round without the need for replanting.
- **Reduced embodied carbon:** Engineered bamboo has a significantly lower embodied carbon footprint than conventional building materials like concrete and steel—making it a strong alternative for low-impact construction.

Images courtesy of House of Bamboo

DESIGN CONSIDERATIONS

The design required a modular cladding system that could be securely fixed to a custom aluminium framework installed directly onto glazed surfaces. Due to the rooftop location and limited site access, the system was prefabricated off-site to enable efficient transport and rapid installation with minimal equipment.

Key considerations included:

- Panel size and weight for safe manual handling at height
- Compatibility with the substructure and ease of alignment
- Fixings suited to both aluminium and engineered bamboo movement characteristics
- Long-term durability in an exposed setting, including UV resistance and weather protection

The bamboo used has a stable moisture content and is pre-treated for mould resistance and pre-oiled with Woca oil offsite—ensuring long-term performance and reduced labour onsite.

CONSTRUCTION CONSIDERATIONS

To streamline delivery and reduce on-site labour, the bamboo system was prefabricated as modular units with all fixings and penetrations pre-drilled to align with the aluminium subframe.

Key construction features included:

- Clearly numbered panels and a detailed layout schedule to guide installation sequence
- Minimal equipment required for on-site assembly
- A modular, ready-to-install system designed for safe handling in a rooftop environment
- Efficient logistics planning to reduce time on site and minimise potential for error

This approach enabled a high-quality finish with minimal disruption—despite restricted access and elevated installation conditions.

OPERATIONAL CONSIDERATIONS

Operational requirements were determined by the site contractor based on logistics and scheduling. House of Bamboo's role focused on the supply and delivery of prefabricated modules—each component clearly labelled and packaged for efficient handling and installation.

Close coordination with the site team ensured seamless integration into the broader construction program and minimised disruption during delivery.

FURTHER READING

GENERAL RESOURCES

Built by Nature:
- Fire Safe Design of Mass Timber Buildings

Global Green Tag:
- https://www.globalgreentag.com

Dynamic Life Cycle Assessments:
- Fast-growing bio-based materials as an opportunity for storing carbon in exterior walls

ENGINEERED LAMINATED BAMBOO PRODUCTS

Global Green Tag:
- Engineered Laminated Bamboo
- Engineered Laminated Bamboo with Wugu Bio-Glue

BAMBOO – ARTICLES, RESEARCH & CASE STUDIES

Design Horizons:
- Engineered Bamboo: Types, Manufacturing, Properties and Applications

Cogent Engineering (Taylor & Francis):
- Research Article: Philosophies of bamboo structural design and key parameters for developing the philosophies

ScienceDirect:
- Engineered bamboo for structural applications

Institution of Civil Engineers:
- Building with Bamboo: a sustainable solution for the future

Institution of Structural Engineers:
- Structural Use of Bamboo

MDPI:
- Engineered Bamboo for Sustainable Construction: A Systematic Review of Characterization Methods

Emerald Insight:
- International Journal of Productivity and Performance Management

Springer Nature:
- Reference Work Entry on Bamboo

AUSTRALIA-SPECIFIC

House of Bamboo – Australia:
- Bamboo and rattan specialists

Mirage News:
- Australia's 10-Year Engineered Bamboo Plan

Hassell Studio:
- AMRF Building

ATMOSPHERE
CONCEPT

OUTDOOR AIR QUALITY

There is no more fundamental human need than clean air. Yet increasingly, we live in densely populated cities where air pollution is a growing concern. The United Nations has identified air pollution as the leading environmental risk to human health. While Australian cities generally have cleaner air than many global counterparts, we cannot be complacent. Climate change and population growth are expected to worsen air pollution across the country (Parris et al., 2020).

Severe air quality events in Australian cities are often caused by bushfires and dust storms. During the 2019–20 Black Summer fires, millions of people in Sydney, Canberra and Melbourne were exposed to hazardous air for extended periods - some cities reached pollution levels comparable to the firegrounds themselves (Nguyen et al., 2021).

Globally, air pollution causes an estimated 7 million premature deaths each year (World Bank, 2022). In Australia, the pollutants of most concern are PM2.5 (particulate matter smaller than 2.5 microns) and ozone. Even at low concentrations, both have been shown to negatively impact human health (Lelieveld et al., 2015).

Particulate matter (PM) is a mix of solid and liquid compounds that can be inhaled into the lungs. The finer the particle, the deeper it can penetrate. PM2.5, which is smaller than a tenth the width of a human hair, is particularly hazardous. These particles can lodge deep in the lungs and enter the bloodstream, with proven effects on the brain, heart, lungs, circulatory system, immune and endocrine systems and increased risks during pregnancy.

Key urban sources of PM2.5 include smoke and traffic emissions. Reducing exposure will require coordinated action to reduce emissions from bushfires, transport and combustion-based energy sources.

Image source: www.bbc.co.uk/newsround/50470842

ATMOSPHERE
CONCEPT

URBAN GREENING

Vegetation plays an important role in regulating air quality. Plants improve air quality by removing particulate matter and other airborne pollutants through deposition on leaves, absorption into plant tissues and microbial activity in the soil (Kumar et al., 2019). Dense and complex foliage provides the most effective pollutant capture (Growing Green Guide, 2014).

Vegetation can also improve air quality indirectly. Through transpiration and shading, plants help cool urban areas, which in turn reduces ozone formation, a pollutant generated by photochemical reactions on hot surfaces (Rowe, 2011).

The built environment can support air quality outcomes by integrating vegetation - including trees, shrubs and groundcovers - into site design. These can be incorporated across buildings and public spaces through:

- Habitat creation and restoration
- Landform and soil restoration
- River and floodplain restoration
- Urban greening and water-sensitive design

Clean air is essential for life - and for the health of Country.

Through thoughtful design, we can reduce pollution, embed green infrastructure and create breathable, liveable places. By integrating vegetation into buildings, streetscapes and public spaces, we not only filter the air, but regenerate the systems that sustain it.

Common nature-based design elements that are detailed throughout the guide and support air quality regulation include:

NATURE REALM	NATURE-BASED DESIGN ELEMENT
Biodiversity	• Landscape planting for habitat creation • Habitat restoration • Biodiverse green roofs • Biosolar green roofs • External green walls
Land	• Land formation retention and restoration • Blue / green streetscapes • Green spaces • Community gardens • Elevated parks • External green façades • External planter boxes
Water	• River and creek restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed wetlands

BENEFITS OF URBAN GREENING

In addition to improving air quality, vegetation provides a range of co-benefits for biodiversity, water management, climate regulation and human wellbeing:

Biodiversity

- Enhances habitat for birds, bats, invertebrates and other fauna
- Increases plant diversity
- Supports pollination services
- Improves ecological connectivity

Land

- Regulates urban temperatures through shading and evapotranspiration

Water

- Improves stormwater management and reduces runoff
- Filters pollutants and improves water quality

Atmosphere

- Sequesters carbon through vegetation and soils
- Improves air quality by removing airborne particulates

People

- Strengthens connection to Country and Nature
- Embeds Caring for Country practices
- Enhances mental wellbeing
- Increases urban amenity and property value
- Encourages nature stewardship and community engagement

Image source: www.bbc.com/news/world-australia-50722650

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ATMOSPHERE
CONCEPT

SOUND ENVIRONMENT

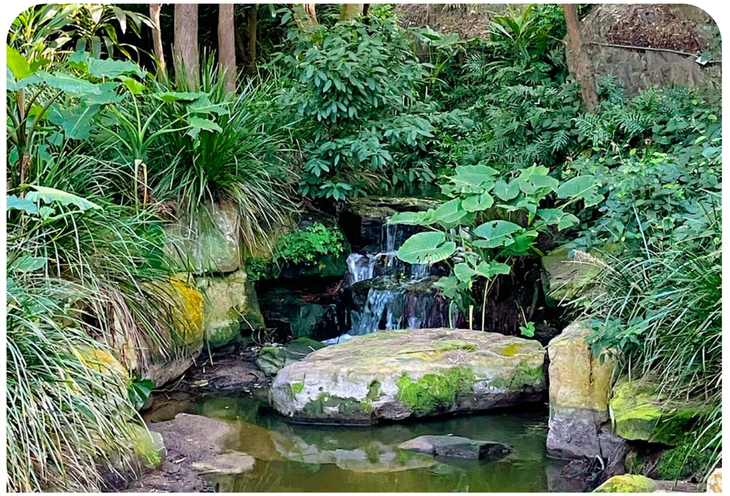
INTRODUCTION

Excessive noise and poor acoustics can have a range of negative effects on people, including short- and long-term health impacts, as well as reduced comfort and productivity. The World Health Organization's *Guidelines for Community Noise* (1999) outlines impacts such as interference with communication, noise-induced hearing loss, sleep disturbance, cardiovascular and psycho-physiological effects, reduced performance, annoyance responses and impacts on social behaviour.

Common sources of external noise in urban environments include vehicle movements (e.g. road traffic, loading docks, carparks, driveways), railways, mechanical plant and noisy activities such as sports, restaurants and outdoor recreation/play areas.

Natural sounds—such as birdsong, wind in vegetation and running water—can provide positive benefits. Studies have shown that natural sounds can reduce stress and annoyance, improve mood and enhance cognitive performance (Buxton et al., 2020).

Images courtesy of Abigail Heywood



ATMOSPHERE
CONCEPT

REDUCING NOISE IN THE BUILT ENVIRONMENT

SITE LAYOUT

Considering noise during the initial planning and layout of a development can help reduce impacts and limit reliance on built noise mitigation measures. Strategies may include locating noise-sensitive uses (e.g. residences, schools, offices, outdoor relaxation areas) as far from noise sources as possible, orienting buildings to shield sensitive areas, or placing less sensitive uses in higher-noise zones.

Retaining existing vegetation and incorporating elements such as nature strips, landscaped buffers and gardens can create visual and physical buffers, while also delivering psychological benefits to people affected by nearby noise sources.

VEGETATION AND EARTH BERMS

Noise barriers are a common measure to address external noise sources. Typical materials include timber, concrete and panel products that offer high density and stiffness. However, natural alternatives such as earth berms and vegetation can offer similar outcomes with added benefits.

Earth berms may be used instead of, or in combination with, conventional noise barriers. They can reduce material use and visual impact and when vegetated, provide additional acoustic absorption. However, they do require more space than traditional barriers.

Vegetation alone has limited acoustic performance. For example, a hedge may provide around 1–3 dB of noise shielding, depending on its density, depth and height—often below the threshold of perceptibility. A belt of trees must be around 15 metres deep and reasonably dense to achieve similar reductions to a low-height noise barrier (~5 dB).

That said, vegetation can improve performance when used alongside conventional barriers. Sufficient foliage adjacent to a hard surface can reduce sound reflection. In some cases, vegetation may also influence local micrometeorology (e.g. reducing wind effects or temperature inversions) to enhance barrier effectiveness.

There is also a psychological benefit: the visible presence of vegetation can reduce the annoyance response to noise, effectively lowering perceived noise levels (Van Renterghem, 2024).

Vegetated ground surfaces—such as grass, shrubs and bushes—are also more acoustically absorptive than hard, reflective surfaces like concrete or asphalt. This can help reduce noise propagation over distance.

Vegetation can be used for acoustic absorption indoors as well. Green walls, planter boxes and groups of pot plants can reduce reverberation and improve speech intelligibility by absorbing sound within a space.

SOUNDSCAPING

Soundscaping involves introducing desirable sounds to mask or balance undesirable ones. Natural water features—such as fountains, water walls and streams—can be used to reduce the perception of traffic or mechanical noise. For example, a fountain in a garden or relaxation area can help mask road noise.

Facilitating or enhancing natural sounds can also offer wellbeing benefits. Creating spaces that attract birds, retain vegetation or include flowing water can enrich the ambient sound environment.

Sound is part of how we experience place. By softening unwanted noise, enhancing natural sounds and embedding acoustic thinking into design, we can create calmer, more comfortable environments. Designing for sound is designing for wellbeing.

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ATMOSPHERE
DESIGN ELEMENT

DESIGN ELEMENT: SOUNDSCAPING – WATER FEATURE

Soundscaping broadly refers to the manipulation of the acoustic environment to enhance its perceived quality. As a design element, this involves generating nature-based sounds. These sounds can improve perception of a space and reduce stress and annoyance, while supporting improved mood and cognitive performance (Buxton et al., 2020). They may also help mask less desirable noise such as road traffic or building services.

This feature focuses on water-induced sound sources, such as fountains, streams, water walls and rain curtains. Other natural sounds—like wind in foliage or birdsong—can also provide benefits but are not consistent or controllable, and are therefore outside the scope of this design element.

TYPES OF WATER FEATURES FOR SOUNDSCAPING

Fountains

- Type: Freestanding, wall-mounted, or tiered
- Sound: Gentle splashing or bubbling
- Use: Urban plazas, courtyards, and entryways

Streams and Runnels

- Type: Narrow channels with flowing water
- Sound: Gentle trickling
- Use: Pathways, gardens, and meditative spaces

Water Walls

- Type: Vertical surfaces with cascading water
- Sound: Continuous cascading sound
- Use: Indoor lobbies, outdoor seating areas

Rain Curtains

- Type: Thin streams of water falling from overhead
- Sound: Simulates rainfall, evoking natural ambiance
- Use: Transitional zones, immersive installations

Reflecting Pools with Bubblers

- Type: Still water with subtle bubbling jets
- Sound: Subtle bubbling adds ambient texture without overwhelming quiet zones
- Use: Museums, memorials, contemplative gardens

BIODIVERSITY AND CO-BENEFITS

Land

- Urban temperature regulation: Evaporative cooling improves microclimate and thermal comfort.

Biodiversity

- Habitat creation: Attracts birds, insects and amphibians.
- Reduced disturbance: Masking human-made noise helps reduce stress for sensitive species.

Atmosphere

- Natural sound generation enhances environmental quality.
- Noise masking helps soften mechanical or urban noise.
- Noise attenuation (limited): Effectiveness varies with design.

People

- Connection to Country and Nature: Supports Indigenous-led design and cultural storytelling.
- Nature stewardship: Encourages awareness of ecological processes through audible experiences.
- Urban aesthetic: Adds a sensory layer to public and private spaces.
- Property value uplift: Water features in public open space can increase desirability.
- Mental wellbeing: Natural sound supports mindfulness, relaxation and cognitive restoration.

Image courtesy of Abigail Heywood

ATMOSPHERE
DESIGN ELEMENT

KEY DRIVERS OF SUCCESS

- **Existing sound environment:** Best suited to environments where masking unwanted noise adds value. In naturally quiet settings, or where focus is required (e.g. libraries), water features may offer limited benefit or cause distraction.
- **Location:** Works best in spaces where people dwell—such as parks, courtyards or building forecourts—not just in transient zones.
- **Noise level:** Must generate sufficient, but not excessive, sound. Too soft and the benefit is lost; too loud and it may create annoyance.
- **Scale and coverage:** Larger features or multiple installations provide broader acoustic benefit. In noisy settings, higher output may be required to provide masking.

LIMITATIONS

- Water features are generally less effective at masking low-frequency noise (e.g. trucks, HVAC).
- Their sound dissipates quickly with distance so effectiveness of the water feature for soundscaping may have a limited range.
- Unlike solid barriers, they don't absorb or block sound—masking is their primary mechanism.

DESIGN CONSIDERATIONS

- Water features require ongoing maintenance, which should be factored into both the decision to install a feature and its design—considering aspects such as type, size, water volume, cleanability and pump requirements.
- Input from other specialists is essential for non-acoustic design considerations, including landscape architects, hydraulic and civil engineers, and maintenance or facilities teams.
- Engage acoustic consultants to undertake sound assessments—such as baseline acoustic analysis and contextual sound mapping—and gather user insights through stakeholder engagement to inform water feature requirements.

INTEGRATION ACROSS PROJECT LIFECYCLE

Water features for soundscaping can be introduced at any stage of the project lifecycle:

- **Masterplanning:** Identify locations where soundscaping can enhance wellness, biodiversity and placemaking outcomes.
- **Concept design:** Evaluate water feature types based on desired sound profiles. Consider site acoustics, user experience and integration with landscaping.
- **Detailed design:** Specify flow rates, materials and acoustic targets. Integrate water and lighting systems, and confirm maintenance plans.
- **Construction:** Install plumbing, filtration, and structural elements. Monitor performance and adjust as needed.
- **Operation:** Maintain water quality, adjust flow seasonally, and monitor user feedback. Features may be retrofitted post-construction.

APPLICABILITY

Primarily suited to external areas across both building and precinct scale projects.

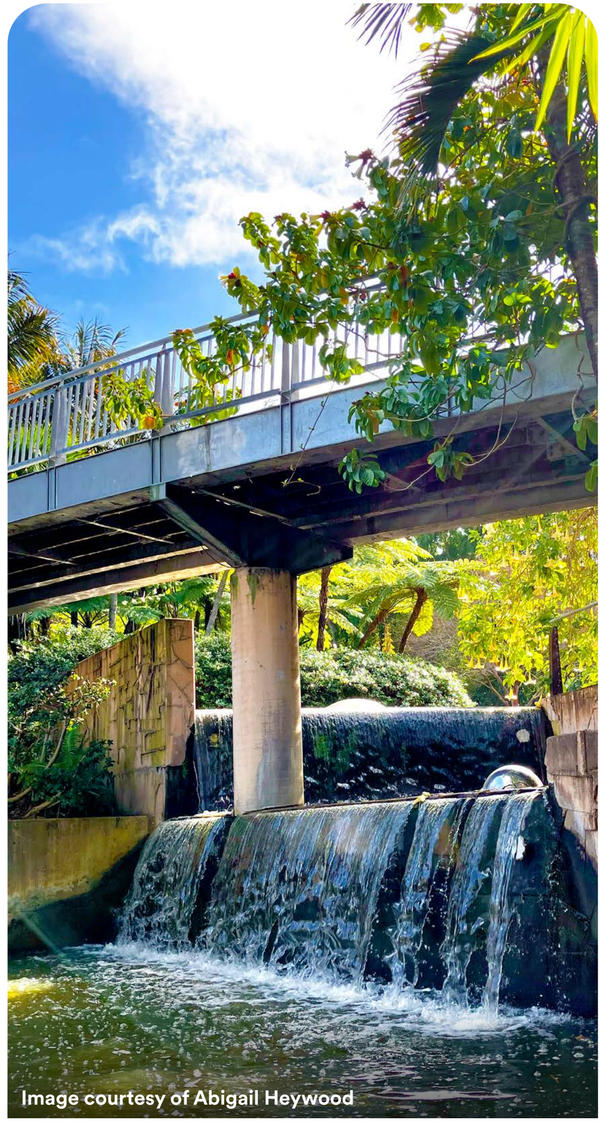

Image courtesy of Abigail Heywood

ATMOSPHERE
CASE STUDY

CASE STUDY:
TARRAWARRA MUSEUM OF ART: EVA AND MARC BESEN CENTRE

PROJECT OVERVIEW

The Eva and Marc Besen Centre is a multi-purpose learning and performance space designed for family and children's programs, talks, forums, workshops, live arts, and educational activities.

This 100% electric, fossil fuel free building nestles into the landscape, complementing the main TarraWarra Museum of Art building. The design integrates architecture, infrastructure and ecology—expressing a strong connection to place.

A key feature is the cascading water element, which falls from the roof onto a hand-carved rock and flows down a planted open channel. Inspired by the meaning of TarraWarra—slow moving water in Wurundjeri Woi Wurrung language—the feature evokes the sound and feel of a meandering creek, weaving water and landscape into the visitor arrival experience.

Client:
TarraWarra Museum of Art

Project type:
New build

Completion date:
2025

Location:
Yarra Valley, VIC

First Nations Country:
Wurundjeri Country

Key Partners:

- Architect: Kerstin Thompson Architects
- Landscape architecture: OCULUS and Craig Murphy-Wandin (Wurundjeri horticulturalist and artist)
- Collaborators: Finding Infinity, Greenwood Consulting, International Fountains Australia, Reshape Development, Urban Develop, Webber Design, WSP, 2B Designed, Architecture & Access, Terramatrix, Paoli Smith, McCorkell Constructions

Image courtesy of OCULUS

ATMOSPHERE
CASE STUDY

OUTCOMES:

BENEFITS AND CO-BENEFITS

Water

- **Site-sourced water:** Water is collected on site and reused within the landscape, contributing to passive cooling and reducing reliance on external water supplies.
- **Water-sensitive feature design:** The cascading water feature mimics natural hydrology—flowing over salvaged rock and through a planted swale—both enhancing microclimate and reinforcing the site's connection to water.
- **Recycled use:** The water feature connects to sustainable water management and nutrient cycling across the site.

People

- **Cultural connection and education:** The project celebrates local language and Country's hydrological systems. The arrival experience becomes both sensory and educational, deepening visitor connection to place.
- **Sensory engagement:** The sound of water accompanies visitors through the site, offering a calm, immersive experience.
- **Community experience:** Designed as a multi-purpose venue, the Eva and Marc Besen Centre will support family and children's programs, live arts, workshops and forums—strengthening TarraWarra's role as a community and cultural destination.

Land

- **Landscape-led integration:** The building's form and water feature respond directly to the slope and natural rhythms of the land—transforming a former roadway into a planted sculpture walk and reconnecting the site to Country.
- **Passive cooling:** The use of native planting and site-sourced water contributes to ambient cooling—reducing heat build-up in the surrounding landscape and enhancing microclimate resilience.

Biodiversity

- **Native vegetation:** The landscape design draws inspiration from the native plant communities found along local waterways, aligning with the site's ecological character and supporting habitat resilience.
- **Plant diversity:** The project includes over 17,000 individual plants across 50 different species, contributing to increased biodiversity, seasonal variation and ecological function.

Atmosphere

- The cascading water feature is central to the arrival experience—creating a layered soundscape as water falls from the roof onto a hand-carved rock and flows through a rocky, planted swale.
- This auditory journey references the varied sounds of water across the broader landscape—from crashing to babbling to trickling—and transforms a once-vehicular space into a contemplative, sensory entry that reinforces the meaning of TarraWarra: *slow moving water.*

Image courtesy of OCULUS

ATMOSPHERE
CASE STUDY

DESIGN CONSIDERATIONS

- **Site-sourced water:** The water feature operates with water collected from across the site and reused, reducing external demand and reflecting natural hydrological cycles.
- **Site-salvaged rock:** Locally sourced rock was used for the main water landing feature and to line the planted swale, grounding the design in place.
- **Native plant selection:** Plantings reflect the local Ecological Vegetation Class (EVC), supporting site-specific biodiversity and landscape character.
- **Closed-loop water reuse:** Water discharges from the feature into an on-site dam for reuse across the site's landscape systems.

CONSTRUCTION CONSIDERATIONS

- **Hand-placed stone:** Rocks were individually placed to modulate the speed, volume and sound of water—shaping the sensory experience from dramatic splashes to gentle trickles.
- **Sound-led shaping:** The construction process was guided not just by flow rates but by desired acoustic effects, with the water feature crafted to evoke the emotional qualities of a natural creek.
- **Sculptural transformation:** What was once a road has been reimagined as a planted, water-led sculpture walk—physically and experientially reshaping arrival at TarraWarra.

OPERATIONAL CONSIDERATIONS

- **Rain-sensitive automation:** A built-in sensor automatically shuts off the water feature during heavy rainfall to prevent overflow and conserve energy.
- **Low-intervention system:** Designed for long-term durability, the feature uses passive systems and recycled water to reduce maintenance demands and support efficient operation year-round.

Images courtesy of OCULUS

FURTHER READING

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MDPI:

- **Neuroarchitecture: How the Perception of Our Surroundings Impacts the Brain**

Springer Nature:

- **Soundscape in City and Built Environment – Current Developments and Design Potentials**

ATMOSPHERE
CONCEPT

LIGHT ENVIRONMENT

WHAT IS LIGHT ENVIRONMENT - AND WHY DOES IT MATTER?

The light environment in the built environment refers to the complex interplay of natural and artificial light within urban and architectural spaces. It significantly influences human comfort, energy use and ecological dynamics, including vegetation growth. Components include natural daylight, artificial light and reflected or diffused light.

Urbanised areas can impact the light environment in two key ways: by creating shade during the day and adding artificial light at night (ALAN).

SHADING DURING THE DAY

Shading can be created naturally by trees, hills and vegetation, or artificially by buildings, fences, solar panels and other infrastructure. It can have significant impacts across terrestrial, freshwater and marine ecosystems, including:

- **Reduced photosynthesis:** Lower light intensity reduces plant growth and energy available to support higher trophic levels.
- **Altered plant morphology:** Shade-adapted plants may grow taller, thinner and weaker in an attempt to access light or even fail.
- **Delayed flowering and fruiting:** Many plants rely on light cues (photoperiods) to flower and reproduce. Shade can disrupt these cues or inhibit entirely.
- **Species competition and community shifts:** Shade-tolerant or invasive species may outcompete others, reducing ecological diversity and resilience.
- **Changes in marine recruitment:** Larvae of several species in the marine environment are phototropic, so shading can disrupt settlement patterns, with implications to local biodiversity.
- **Microclimate effects:** Shading alters soil, air and water temperature, evaporation and humidity. This can affect animals—such as reptiles, fish and invertebrates—that rely on external heat for metabolic regulation, prompting behavioural and distribution changes.

LIGHT POLLUTION AT NIGHT

Artificial light at night (ALAN) can disrupt natural rhythms and behaviour in many species in terrestrial, freshwater and marine habitats. Impacts include:

- **Disruption of wildlife behaviour:** ALAN interferes with natural light–dark cycles, affecting navigation, foraging, mating and migration—especially in nocturnal species such as bats, moths, fish and amphibians.
- **Habitat fragmentation:** Bright lighting can act as a barrier, discouraging light-sensitive species from using otherwise suitable habitat.
- **Impact on reproductive cycles**: ALAN alters seasonal and circadian rhythms, reducing breeding success in some birds, insects, corals and other animals.
- **Loss of natural darkness:** Darkness is an ecological resource. Its loss affects entire ecosystems, particularly protected areas designed to conserve biodiversity.
- **Changes in species interactions and community shifts:** ALAN alters species interactions, e.g. increasing predation. ALAN can also cause local re-distribution of species, with implications to ecosystem diversity and functioning.

Sydney, NSW. Artificial light at night.

ATMOSPHERE
CONCEPT

LIGHTSCAPING

Lightscaping is the strategic and integrated design of natural daylight and artificial lighting in the built environment. It considers light as a vital ecological and atmospheric component—alongside its human, land and water implications.

A lightscape is not a physical element but a **design overlay** applied at precinct or building scale. It optimises ecological function (e.g. photosynthesis, nocturnal connectivity), minimises harm (e.g. light pollution, excess heat) and supports human health, safety and comfort.

Lightscape design is informed by multiple technical inputs, including:

- **Solar path analysis:** Maps the sun's trajectory across seasons to inform planting, orientation and passive shading.
- **Sun/shade modelling:** Quantifies shadow impacts from existing and proposed structures.
- **Daylight analysis:** Simulates light intensity and Photosynthetically Active Radiation (PAR), often using Daily Light Integral (DLI) mapping to guide plant selection and shading requirements.
- **Artificial light mapping:** Audits the location in respect to the direction, quantity and quality of artificial lighting. For example, intensity (lux), spectrum/colour temperature (kelvin), photosynthetic photon flux density (PPFD).
- **Ecological sensitivity mapping:** Overlays lighting data with ecological assets (e.g. corridors, vegetation, wetlands) to identify risk areas and mitigate impact.

Image courtesy of Abigail Heywood

HOW DOES LIGHTSCAPING INTERACT WITH NATURE-BASED DESIGN ELEMENTS?

Lightscaping is deeply interconnected with all nature-based elements in this guide:

- **Biodiverse green roofs and green walls:** Light availability determines plant viability and selection.
- **Water sensitive urban design:** Light affects evaporation rates, water temperature and soil moisture in raingardens and wetlands.
- **Habitat restoration:** Light pollution can fragment habitats and reduce usability for nocturnal species.
- **People:** Light shapes the comfort, safety and biophilic experience of open spaces.

FOUNDATIONS FOR SUCCESSFUL LIGHTSCAPING

Light is more than illumination—it's a force that shapes ecosystems, wellbeing and experience. By designing with both light and darkness in mind, we can restore ecological balance, protect biodiversity and create healthier environments for all life.

To implement a lightscape strategy effectively, the following should be considered:

- **Early integration:**
  - Master planning / concept stage: Ensure early consideration of building orientation, massing, and open space design to optimise solar access and minimise overshadowing.
  - Detailed design: Specify species, lighting types and controls.
  - Operations: Retrofitting (e.g. shielding, planting) is possible but less effective.

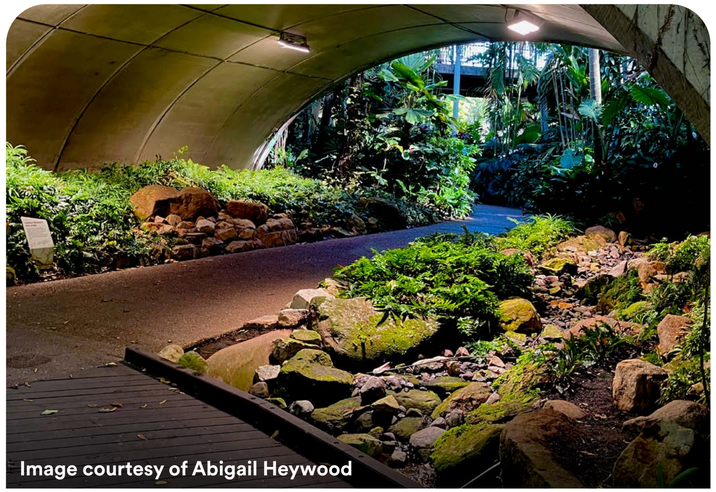

Image courtesy of Abigail Heywood

- **Holistic light audit:** Capture existing and proposed light conditions to guide design decisions.
- **Plant-centric lighting:** Align light availability with physiological needs of plants. Reference PPFD and DLI requirements. Engage specialist horticultural expertise.
- **Minimising light pollution:** These practices are critical to protect nocturnal fauna such as bats, moths and marine life:
  - Use warm-spectrum lighting (≤3000K; amber preferred)
  - Employ cut-off fixtures and direct light only where needed
  - Keep lighting intensity low
  - Use motion sensors and timers
- **Strategic use of shade:** Design shading (built and vegetative) to provide thermal refuge, reduce evaporation and protect light-sensitive species and environments.
- **Diverse planting structure:** Mimic natural ecosystems using canopy trees, understorey shrubs and groundcovers to create dappled light and deep shade. Dense vegetation can act as a "living curtain" to shield sensitive areas from light intrusion.
- **Multidisciplinary coordination:** Lightscaping requires collaboration across multiple technical disciplines.
- **Adequate resourcing:** Accurate modelling of natural and artificial light is complex and resource-intensive although helps mitigate some of the largest risk categories for a project's success.
- **Stakeholder engagement:** Balancing human lighting standards with ecological protection requires consultation with regulators and community stakeholders.

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05 AFTER DESIGN:

Allowances in Design for Construction and Operation

AFTER DESIGN: ALLOWANCES IN DESIGN FOR CONSTRUCTION AND OPERATION

KEY STEPS INCLUDE:

STEP 1

PLAN FOR LONG-TERM MAINTENANCE

Plant maintenance

Maintenance requirements for post-establishment phases of vegetation must be identified and budgeted for during the design and planning stage, and incorporated into a project-specific Maintenance Plan. Ensure maintenance is considered in both the design process and facility management planning.
The building owner and operator must understand their responsibilities in caring for Nature and Country.

Capacity building

Maintenance strategies may need to be revisited over time to improve outcomes. For example, is your maintenance team struggling with a design because it's unfamiliar? Could training be provided or the maintenance approach be adapted? Ongoing care is essential for achieving Nature outcomes.

Project planning, design, and budgeting must include provisions for long-term maintenance of nature-based elements such as:

- Irrigation
- Weed control
- Monitoring plant health and growth
- Replacing plants when needed

This should be addressed through:

- Thoughtful planting design that matches maintenance capability.
- Early engagement with facility managers to ensure alignment on scope, skills, and budget.
- Inclusion of project objectives in any Landscape Management Plans (where required through planning approvals).

Design with maintenance in mind

What types of maintenance are appropriate to your ecology? Can habitat types be selected to reduce intensive maintenance needs? Align your planting strategy with the expected availability of maintenance resources.

Cultural maintenance and engagement:

- Traditional Owners must be engaged in maintenance to ensure ongoing alignment with Caring for Country principles.
- Community-led site management supports intergenerational knowledge sharing.
- Culturally significant practices—such as cultural burns—should be enabled and supported.
- Ensure continued access and stewardship by Indigenous communities through culturally significant site upkeep.
- Provide training and employment opportunities for Indigenous people to support long-term involvement.

Image courtesy of Abigail Heywood

STEP 2

MONITOR, EVALUATE AND ADAPT

Embed monitoring and evaluation strategies for all Nature realms to ensure design elements deliver the intended benefits and co-benefits. Projects that aim to achieve Country and Nature outcomes must go beyond implementation—allocating both scope and budget to monitor outcomes post-construction and allow for timely intervention if targets are not met.

Performance review

Designers and developers should evaluate the performance of nature-based elements after completion to:

- Confirm outcomes
- Build knowledge
- Share lessons across the industry
- Improve future initiatives

Biodiversity-specific monitoring

- Monitoring should be planned from the outset and resourced accordingly.
- Aim to measure ecologically meaningful metrics (e.g. species richness, habitat condition, or ecological function), rather than simply inputs like plant counts.
- If priority species were part of the strategy, biodiversity surveys should be designed to track these.
- Data should be collected across seasons and years—consider referencing First Nations seasonal calendars rather than Western seasonal frameworks.
- Engage ecologists to document species presence, biodiversity health, and related findings.

Participatory monitoring

- Involve Traditional Owners and local communities in monitoring outcomes.
- Encourage collaborative partnerships with local universities or research institutions for data analysis and knowledge sharing.
- Explore alternative methods of recording habitat health—through art, storytelling, and songlines—to reflect cultural knowledge and support intergenerational learning.
- Support collaborative research involving Indigenous scientists and knowledge holders.

Adaptive management

Be prepared to make changes if nature-based design elements are not performing as intended. Use monitoring insights to guide adjustments and continue tracking progress.

Images courtesy of Abigail Heywood

STEP 3

KNOWLEDGE SHARING AND CAPACITY BUILDING

Knowledge sharing

Communicate project outcomes openly and respectfully with stakeholders, industry, and community to support continuous improvement.

Amplify success

Celebrate and share Country and Nature outcomes through:

- Media articles
- Industry conferences and events
- Advocacy to clients, government, supply chains, and industry bodies
- Collaboration with organisations tracking nature impacts at larger scales

STEP 4

PRIORITISE BUILDING LONG-TERM PARTNERSHIPS

Support First Nations-led initiatives

Build industry capability by supporting First Nations-led businesses, land management programs, and governance structures.

Inclusive governance

Where possible, include Traditional Owners and local communities in governance, monitoring, and decision-making frameworks.

Plan for legacy

Ensure long-term benefits and stewardship extend beyond project delivery. This includes knowledge sharing, access to Country, and mechanisms for ongoing care and management.

Image source: ABC News

Deciding which nature-based design elements for your project

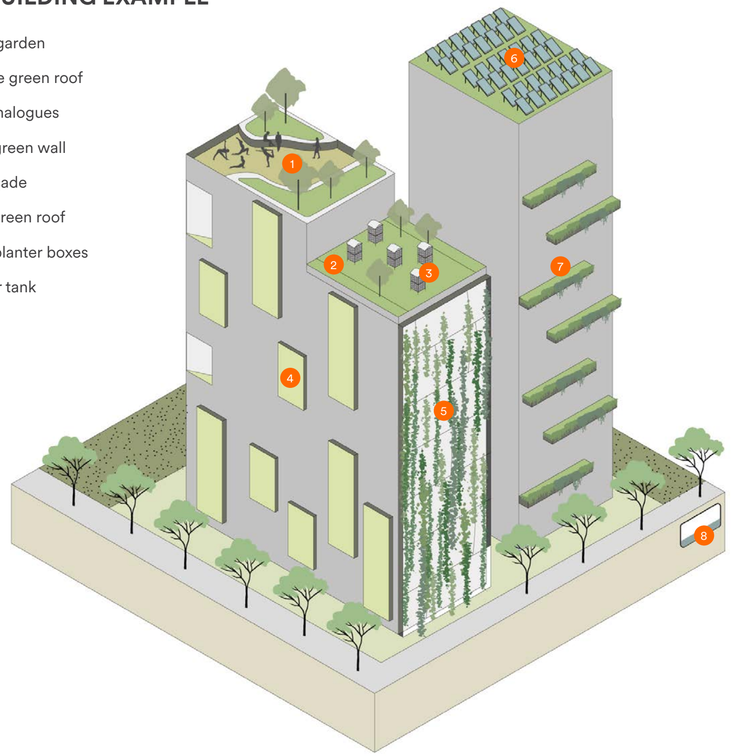
DECIDING WHICH NATURE-BASED DESIGN ELEMENTS FOR YOUR PROJECT

WHAT DOES GOOD LOOK LIKE?

Benefits and co-benefits to nature and people are strengthened when design elements are not applied in isolation but combined. When integrated, the scale of benefits is amplified, supporting more complex and connected biodiversity, land, water and atmospheric outcomes. Examples of combined applications for single buildings and precincts are shown in the following diagrams.

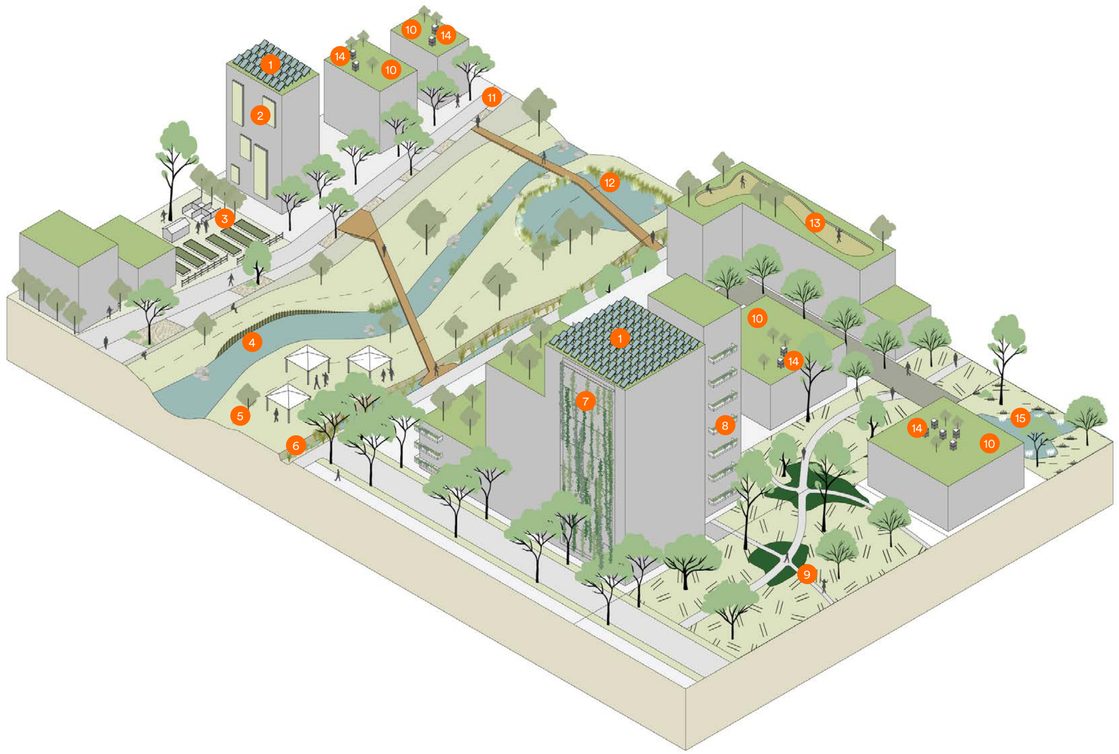
SINGLE BUILDING EXAMPLE

1. Roof top garden
2. Biodiverse green roof
3. Habitat analogues
4. External green wall
5. Green façade
6. Biosolar green roof
7. External planter boxes
8. Rainwater tank



PRECINCT EXAMPLE

1. Biosolar green roof
2. Green wall
3. Community garden
4. River restoration
5. Extent of floodplain
6. Swale
7. Green façade
8. External planter boxes
9. Area of habitat creation
10. Biodiverse green roof
11. Blue/green street
12. Wetland
13. Elevated park
14. Habitat analogues
15. Naturalised basins

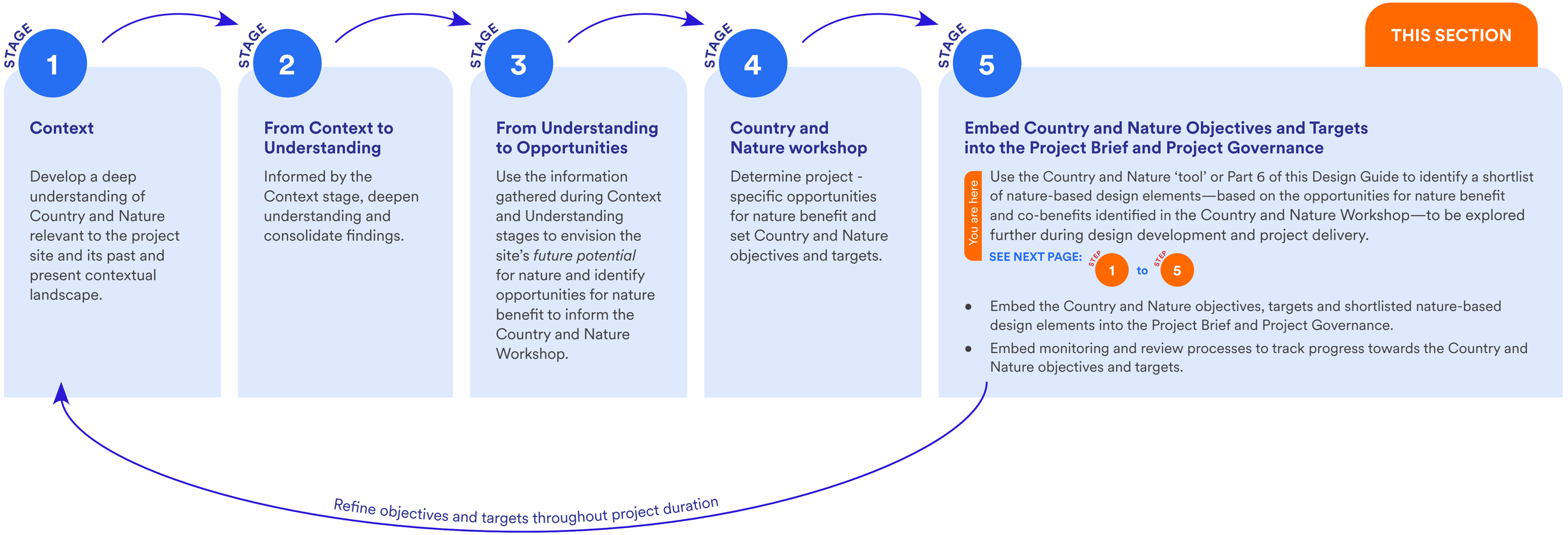


HOW DO I DECIDE WHICH DESIGN ELEMENTS TO INCLUDE?

This section provides guidance to help projects identify a shortlist of nature-based design elements.

Before using this process, it is recommended to complete the steps in Part 2 of this guide which are shown in the diagram below. By stage 4 of that process, you will have determined the project specific opportunities for nature and co-benefits identified through the Country and Nature Workshop. You are now at stage 5 of this process.

PROCESS DETAILED IN PART 2: BEFORE DESIGN: EMBEDDING COUNTRY AND NATURE FROM THE START



USING THIS SECTION AND TOOL TO SHORTLIST DESIGN ELEMENTS

To support this process, information is available during the following pages in long-form tables for cross-referencing, along with a supporting beta version of a Country and Nature design tool in Excel format. The tables summarise the Benefits and Design Considerations outlined in Part 4.

Conducting this exercise early in the design lifecycle supports an integrated and coordinated approach, leading to stronger outcomes for both built and natural environments.

STEP 1

Task

Confirm the opportunities for nature benefit and co-benefits identified in the Country and Nature Workshop.

Information / Reference

Part 2: Before Design, Embedding Country and Nature from the Start (Stages 3 and 4).

STEP 2

Task

Cross-reference:

- Opportunities for nature benefits and co-benefits
- Project typology (single building / precinct / retrofit)
- Design elements that contribute to Green Star, Living Building Challenge and Green Factor Tool requirements

Information / Reference

Tables 1A, 2A, 3A, 4A or Excel tool version.

STEP 3

Task

Cross reference design elements that **increase impact** when combined.

Information / Reference

Tables 5A, 5B, 5C, 5D or Excel tool.

STEP 4

Task

For each design element, review **design considerations** and integrate them into your design process as early as possible. *(**Note:** This is not an exhaustive list—other considerations may apply.)*

Information / Reference

Tables 1B, 2B, 3B, 4B or Excel tool.

STEP 5

Task

Confirm the list of project-specific nature-based design elements to be explored further during design development and delivery.

IMPORTANT NOTE:

The Excel tool is a beta version provided to complement this guide. It contains the same information as this section but is intended for testing and feedback. Future versions will improve the fidelity of information (e.g. scaling of benefits, relative comparisons between elements, and more detailed design considerations). Industry feedback will help refine and expand the tool, with potential sponsorship to increase reach and usability.

The information in this section and the tool is intended as guidance only. It does not replace the need to consult or engage with experts to deliver nature-based design elements. However, it should provide enough insight into potential risks and opportunities to support informed engagement with specialists.

BIODIVERSITY
TABLES

TABLE 1A: BIODIVERSITY NATURE BENEFITS AND CO-BENEFITS

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

Nature Realm: BIODIVERSITY

Nature benefits and co-benefits within the built environment

Opportunity for Nature Benefit	Nature-based Design Element	BIODIVERSITY: Habitat Creation	Habitat and Species Protection and Restoration	Habitat Connection	Pollination	Biodiversity health	LAND: Land restoration	Retaining landforms	Soil restoration	Urban Greening	Urban temperature regulation	Nutrient cycling	Soil erosion control	Food production	Space for habitats
Habitat creation and connection	Landscape planting for habitat creation	x		x	x				x	x	x	x	x		x
Habitat protection and restoration	Habitat restoration		x	x	x	x	x	x	x	x	x	x	x		x
Habitat Creation and connection (building)	Biodiverse green roofs	x		x	x					x	x				
Habitat Creation and connection (building)	Biosolar green roof	x		x	x					x	x				
Habitat Creation and connection (building)	External green wall	x		x	x					x	x				
Habitat Creation	Habitat Analogues	x			x										
Habitat Creation and connection	Living Seawalls habitat enhancement modules	x		x											

Opportunity for Nature Benefit	Nature-based Design Element	WATER: Stormwater management	River Restoration	Restoration of drainage lines and overland flows	River flooding management	Water harvesting	Flood control	Improves water quality	Water cycling (e.g. ground water recharge)	Water supply	Reduce stormwater thermal pollution	ATMOSPHERE: Use of biobased materials	Carbon emission savings from renewable energy use	Carbon emission savings from reduced energy use of building	Carbon emission savings from reduced energy use of water treatment	Carbon sequestration	Improves air quality	Noise attenuation
Habitat creation and connection	Landscape planting for habitat creation						x	x	x							x	x	
Habitat protection and restoration	Habitat restoration						x	x	x							x	x	
Habitat Creation and connection (building)	Biodiverse green roofs	x				x		x			x			x		x	x	x
Habitat Creation and connection (building)	Biosolar green roof	x				x		x			x		x	x		x	x	x
Habitat Creation and connection (building)	External green wall							x						x		x	x	x
Habitat Creation	Habitat Analogues																	
Habitat Creation and connection	Living Seawalls habitat enhancement modules							x										

Opportunity for Nature Benefit	Nature-based Design Element	PEOPLE: Financial savings	Renewable energy	Energy use savings	Active transport	Caring for Country practice	Connection to Country and nature	Nature stewardship	Recreation (e.g. walking cycling, swimming, fishing)	Community cohesion	Urban Aesthetic values	Increase in property values	Education and research	Physical health	Mental wellbeing	Typology Applicable to: Single Building	Developments / Precincts	Retrofit	Rating tools: Green Star	Living Building Challenge	Green Factor Tools (Melbourne and Brisbane)
Habitat creation and connection	Landscape planting for habitat creation					x	x	x			x	x	x	x	x	x	x		x	x	x
Habitat protection and restoration	Habitat restoration					x	x	x			x	x	x	x	x		x		x	x	
Habitat Creation and connection (building)	Biodiverse green roofs	x		x			x	x			x		x			x	x	x	x	x	x
Habitat Creation and connection (building)	Biosolar green roof	x		x			x	x			x		x			x	x	x	x	x	x
Habitat Creation and connection (building)	External green wall	x		x			x	x			x				x	x	x	x	x	x	x
Habitat Creation	Habitat Analogues					x		x					x			x	x	x	x	x	
Habitat Creation and connection	Living Seawalls habitat enhancement modules					x	x	x	x		x		x				x	x	x		

TABLE 1B: BIODIVERSITY DESIGN CONSIDERATIONS

Design considerations to factor into your design development process as early as possible (not exhaustive list, other design considerations may be applicable that are not highlighted here).

			CLIMATE RESILIENCE	VEGETATION, PLANTS AND SOILS				WATER	SPECIALISTS			PLANNING			WIDER ENVIRONMENT		BUILDING SPECIFIC											PRECINCT SPECIFIC						COMMUNITY	
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	Design for Climate Resilienc	Vegetation and Plant Selection	Soil condition and preparation	Engineered plant substrate media requirements (depth, weight, hydraulic)	Assess suitability of environment for plants (wind, sun, shade, microclimate and thermal variation)	Water Management - drainage and irrigation	Design element specific specialists	Specialist installation	Coordination of multiple specialisms for design element (electrical, drainage, horticulture, waterproofing, divers)	Ensure early planning and allow for lead in times	Plan and budget for maintenance	Plan and budget for ecological / environmental monitoring	Understand and integrate landform into project design	Understand Hydrological function including flooding and stormwater (undertake site specific modelling if required)	Assess building structural capacity	Waterproofing	Potential Fire Safety Risk and fire engineering advice recommended	Suitability for Solar Panel (wind loads, solar access and shading)	Space provision on roof considering competing services infrastructure	Structural Performance and connections (load, thickness, loads on connectors)	Ensure pre-treatment, weather barriers and ventilation requirements are met	Consider Vibration and Acoustic impacts	Perceived Risk & Insurance	NCC Code compliance	Sustainable Sourcing and Harvesting, Life Cycle Assessments (including dynamic LCA)	Design for Disassembly	Accessibility	Specialist Lighting	Waste Management	Design for Public Safety	Integration with other infrastructure (cycle paths, green infrastructure)	Assessment of sound environment to inform design	Community Engagement	Incorporation of social elements (seating, shade structures, play elements, art)
BIODIVERSITY	Habitat creation and connection	Landscape planting for habitat creation	x	x	x				x		x		x	x																			x	
	Habitat protection and restoration	Habitat restoration	x	x					x		x	x	x	x																			x	
	Habitat Creation and connection (building)	Biodiverse green roofs	x	x		x	x	x	x		x		x				x	x	x		x				x	x							x	
	Habitat Creation and connection (building)	Biosolar green roof	x	x			x	x	x		x		x	x			x	x	x	x	x				x	x							x	
	Habitat Creation and connection (building)	External green wall	x	x		x	x	x	x		x		x				x	x	x			x			x	x				x				
	Habitat Creation	Habitat Analogues							x		x		x	x				x																
	Habitat Creation and connection	Living Seawalls habitat enhancement modules	x						x	x	x																			x				

TABLE 2A: LAND NATURE BENEFITS AND CO-BENEFITS

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

Nature benefits and co-benefits within the built environment

NATURE REALM			BIODIVERSITY					LAND								
	Opportunity for Nature Benefit	Nature-based Design Element	Habitat Creation	Habitat and Species Protection and Restoration	Habitat Connection	Pollination	Biodiversity health	Land restoration	Retaining landforms	Soil restoration	Urban Greening	Urban temperature regulation	Nutrient cycling	Soil erosion control	Food production	Space for habitats
LAND	Land restoration	Land formation retention and restoration		x			x	x	x	x	x	x	x	x		x
LAND	Soil restoration	Soil retention and restoration		x			x			x			x	x		
LAND	Urban Greening	Blue / Green Streetscape	x		x						x	x		x		
LAND	Urban Greening	Green Space	x	x	x	x			x	x	x	x	x	x		x
LAND	Urban Greening	Community gardens	x			x				x	x	x		x		
LAND	Urban Greening	Elevated park	x		x	x					x	x				
LAND	Urban Greening	External green façade				x					x	x				
LAND	Urban Greening	External Planter Boxes				x					x	x				

NATURE REALM			WATER										ATMOSPHERE						
	Opportunity for Nature Benefit	Nature-based Design Element	Stormwater management	River Restoration	Restoration of drainage lines and overland flows	River flooding management	Water harvesting	Flood control	Improves water quality	Water cycling (e.g. ground water recharge)	Water supply	Reduce stormwater thermal pollution	Use of biobased materials	Carbon emission savings from renewable energy use	Carbon emission savings from reduced energy use of building	Carbon emission savings from reduced energy use of water treatment	Carbon sequestration	Improves air quality	Noise attenuation
LAND	Land restoration	Land formation retention and restoration						x	x	x							x	x	
LAND	Soil restoration	Soil retention and restoration							x	x							x		
LAND	Urban Greening	Blue / Green Streetscape	x		x				x								x	x	
LAND	Urban Greening	Green Space	x		x			x	x	x							x	x	
LAND	Urban Greening	Community gardens	x						x								x	x	
LAND	Urban Greening	Elevated park	x						x						x		x	x	x
LAND	Urban Greening	External green façade	x						x									x	
LAND	Urban Greening	External Planter Boxes																x	

NATURE REALM			PEOPLE														Typology Applicable to			Rating tools		
	Opportunity for Nature Benefit	Nature-based Design Element	Financial savings	Renewable energy	Energy use savings	Active transport	Caring for Country practice	Connection to Country and nature	Nature stewardship	Recreation (e.g. walking cycling, swimming, fishing)	Community cohesion	Urban Aesthetic values	Increase in property values	Education and research	Physical health	Mental wellbeing	Single Building	Developments / Precincts	Retrofit	Green Star	Living Building Challenge	Green Factor Tools (Melbourne and Brisbane)
LAND	Land restoration	Land formation retention and restoration					x	x						x	x	x		x		x	x	
LAND	Soil restoration	Soil retention and restoration					x											x				
LAND	Urban Greening	Blue / Green Streetscape				x		x		x		x	x		x	x		x		x	x	x
LAND	Urban Greening	Green Space				x	x	x	x	x	x	x	x		x	x		x		x	x	x
LAND	Urban Greening	Community gardens	x					x	x	x	x	x		x	x	x	x	x		x	x	x
LAND	Urban Greening	Elevated park	x		x		x	x	x	x	x	x	x		x	x	x	x		x	x	x
LAND	Urban Greening	External green façade						x				x	x			x	x	x	x	x	x	
LAND	Urban Greening	External Planter Boxes						x				x	x			x	x	x	x	x	x	x

TABLE 2B: LAND DESIGN CONSIDERATIONS

Design considerations to factor into your design development process as early as possible (not exhaustive list, other design considerations may be applicable that are not highlighted here).

			CLIMATE RESILIENCE	VEGETATION, PLANTS AND SOILS				WATER	SPECIALISTS			PLANNING			WIDER ENVIRONMENT		BUILDING SPECIFIC												PRECINCT SPECIFIC						COMMUNITY	
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	Design for Climate Resilience	Vegetation and Plant Selection	Soil condition and preparation	Engineered plant substrate media requirements (depth, weight, hydraulic)	Assess suitability of environment for plants (wind, sun, shade, microclimate and thermal variation)	Water Management - drainage and irrigation	Design element specific specialists	Specialist installation	Coordination of multiple specialisms for design element (electrical, drainage, horticulture, waterproofing, divers)	Ensure early planning and allow for lead in times	Plan and budget for maintenance	Plan and budget for ecological / environmental monitoring	Understand and integrate landform into project design	Understand Hydrological function including flooding and stormwater (undertake site specific modelling if required)	Assess building structural capacity	Waterproofing	Potential Fire Safety Risk and fire engineering advice recommended	Suitability for Solar Panel (wind loads, solar access and shading)	Space provision on roof considering competing services infrastructure	Structural Performance and connections (load, thickness, loads on connectors)	Ensure pre-treatment, weather barriers and ventilation requirements are met	Consider Vibration and Acoustic impacts	Perceived Risk & Insurance	NCC Code compliance	Sustainable Sourcing and Harvesting, Life Cycle Assessments (including dynamic LCA)	Design for Disassembly	Accessibility	Specialist Lighting	Waste Management	Design for Public Safety	Integration with other infrastructure (cycle paths, green infrastructure)	Assessment of sound environment to inform design	Community Engagement	Incorporation of social elements (seating, shade structures, play elements, art)
LAND	Land restoration	Land formation retention and restoration	x						x		x	x	x	x	x	x																			x	
	Soil restoration	Soil retention and restoration		x	x				x		x	x	x			x																				
	Urban Greening	Blue / Green Streetscape	x	x	x				x		x	x			x	x															x	x		x		x
	Urban Greening	Green Space	x	x	x				x		x	x	x		x	x															x		x	x	x	x
	Urban Greening	Community gardens		x	x			x	x		x	x	x																		x		x	x	x	x
	Urban Greening	Elevated park	x	x	x	x	x	x	x		x	x	x				x	x	x		x										x		x	x	x	x
	Urban Greening	External green façade	x	x		x	x	x	x		x		x				x	x	x			x				x	x			x						
	Urban Greening	External Planter Boxes		x		x	x	x			x		x				x	x												x						

TABLE 3A: WATER NATURE BENEFITS AND CO-BENEFITS

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

			Nature benefits and co-benefits within the built environment: BIODIVERSITY					LAND									WATER										ATMOSPHERE							PEOPLE														Typology Applicable to			Rating tools		
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	Habitat Creation	Habitat and Species Protection and Restoration	Habitat Connection	Pollination	Biodiversity health	Land restoration	Retaining landforms	Soil restoration	Urban Greening	Urban temperature regulation	Nutrient cycling	Soil erosion control	Food production	Space for habitats	Stormwater management	River Restoration	Restoration of drainage lines and overland flows	River flooding management	Water harvesting	Flood control	Improves water quality	Water cycling (e.g. ground water recharge)	Water supply	Reduce stormwater thermal pollution	Use of biobased materials	Carbon emission savings from renewable energy use	Carbon emission savings from reduced energy use of building	Carbon emission savings from reduced energy use of water treatment	Carbon sequestration	Improves air quality	Noise attenuation	Financial savings	Renewable energy	Energy use savings	Active transport	Caring for Country practice	Connection to Country and nature	Nature stewardship	Recreation (e.g. walking cycling, swimming, fishing)	Community cohesion	Urban Aesthetic values	Increase in property values	Education and research	Physical health	Mental wellbeing	Single Building	Developments / Precincts	Retrofit	Green Star	Living Building Challenge	Green Factor Tools (Melbourne and Brisbane)
BIODIVERSITY	River Restoration	River and Creek Restoration	x	x	x	x	x				x	x	x	x		x		x	x	x		x	x	x							x	x					x	x	x	x	x		x		x	x	x		x		x	x	
	River Flood Management	Reconnecting river and floodplain	x	x	x	x	x	x			x	x	x	x		x		x		x		x	x	x							x	x						x	x	x	x		x		x	x	x		x			x	
	Stormwater Management	Bioretention systems	x			x					x	x		x			x						x	x		x					x	x		x				x					x					x	x		x	x	x
	Stormwater Management	Swales	x		x						x	x		x			x						x	x		x						x		x			x		x		x		x					x	x		x	x	x
	Stormwater Management	Naturalised basin	x		x	x					x	x	x	x			x						x	x							x	x							x				x						x		x	x	x
	Stormwater Management	Constructed Wetlands	x		x	x					x	x	x	x			x						x	x							x	x						x					x					x	x		x	x	x
	Water harvesting	Rainwater Tanks															x				x		x		x					x				x														x	x		x	x	x

TABLE 3B: WATER DESIGN CONSIDERATIONS

Design considerations to factor into your design development process as early as possible (not exhaustive list, other design considerations may be applicable that are not highlighted here).

			CLIMATE RESILIENCE	VEGETATION, PLANTS AND SOILS				WATER	SPECIALISTS			PLANNING			WIDER ENVIRONMENT		PRECINCT SPECIFIC						COMMUNITY		WSUD SPECIFIC					
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	Design for Climate Resilience	Vegetation and Plant Selection	Soil condition and preparation	Engineered plant substrate media requirements (depth, weight, hydraulic)	Assess suitability of environment for plants (wind, sun, shade, microclimate and thermal variation)	Water Management - drainage and irrigation	Design element specific specialists	Specialist installation	Coordination of multiple specialisms for design element (electrical, drainage, horticulture, waterproofing, divers)	Ensure early planning and allow for lead in times	Plan and budget for maintenance	Plan and budget for ecological / environmental monitoring	Understand and integrate landform into project design	Understand Hydrological function including flooding and stormwater (undertake site specific modelling if required)	Accessibility	Specialist Lighting	Waste Management	Design for Public Safety	Integration with other infrastructure (cycle paths, green infrastructure)	Assessment of sound environment to inform design	Community Engagement	Incorporation of social elements (seating, shade structures, play elements, art)	River / Creek - Incorporation of features to replicate natural watercourse dynamics (meanders, riffles and pools)	Channel design and bank stabilisation	Catchment and pollution assessment, identification of water quality targets and pre-treatment requirements	Hydraulic Design (sizing of inlets, drainage, flow rates, erosion control)	Mosquito and Odour Management	Assessment of catchment area, surface and ensure correct sizing of tanks
WATER	River Restoration	River and Creek Restoration	x	x					x		x	x	x	x	x	x				x	x		x		x	x				
	River Flood Management	Reconnecting river and floodplain	x	x					x		x	x	x	x	x	x				x	x		x			x				
	Stormwater Management	Bioretention systems	x	x		x			x		x	x	x		x	x				x	x						x	x		
	Stormwater Management	Swales	x	x					x		x	x	x		x	x				x	x					x	x	x		
	Stormwater Management	Naturalised basin	x	x	x	x			x		x	x	x		x	x				x	x		x				x	x		
	Stormwater Management	Constructed Wetlands	x	x	x	x			x		x	x	x	x	x	x				x	x						x	x	x	
	Water harvesting	Rainwater Tanks						x	x		x		x														x			x

TABLE 4A: ATMOSPHERE NATURE BENEFITS AND CO-BENEFITS

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

Nature benefits and co-benefits within the built environment

BIODIVERSITY

Nature Realm	Opportunity for Nature Benefit	Nature-based Design Element	Habitat Creation	Habitat and Species Protection and Restoration	Habitat Connection	Pollination	Biodiversity health
ATMOSPHERE	Carbon Sequestration	Cross Laminated Timber					
ATMOSPHERE	Carbon Sequestration	Engineered Bamboo					
ATMOSPHERE	Sound environment	Soundscaping - water feature	x				

LAND

Opportunity for Nature Benefit	Nature-based Design Element	Land restoration	Retaining landforms	Soil restoration	Urban Greening	Urban temperature regulation	Nutrient cycling	Soil erosion control	Food production	Space for habitats
Carbon Sequestration	Cross Laminated Timber									
Carbon Sequestration	Engineered Bamboo									
Sound environment	Soundscaping - water feature					x				

WATER

Opportunity for Nature Benefit	Nature-based Design Element	Stormwater management	River Restoration	Restoration of drainage lines and overland flows	River flooding management	Water harvesting	Flood control	Improves water quality	Water cycling (e.g. ground water recharge)	Water supply	Reduce stormwater thermal pollution
Carbon Sequestration	Cross Laminated Timber										
Carbon Sequestration	Engineered Bamboo										
Sound environment	Soundscaping - water feature										

ATMOSPHERE

Opportunity for Nature Benefit	Nature-based Design Element	Use of biobased materials	Carbon emission savings from renewable energy use	Carbon emission savings from reduced energy use of building	Carbon emission savings from reduced energy use of water treatment	Carbon sequestration	Improves air quality	Noise attenuation
Carbon Sequestration	Cross Laminated Timber					x		
Carbon Sequestration	Engineered Bamboo					x		
Sound environment	Soundscaping - water feature							x

PEOPLE

Opportunity for Nature Benefit	Nature-based Design Element	Financial savings	Renewable energy	Energy use savings	Active transport	Caring for Country practice	Connection to Country and nature	Nature stewardship	Recreation (e.g. walking cycling, swimming, fishing)	Community cohesion	Urban Aesthetic values	Increase in property values	Education and research	Physical health	Mental wellbeing
Carbon Sequestration	Cross Laminated Timber						x	x			x				x
Carbon Sequestration	Engineered Bamboo						x	x			x				x
Sound environment	Soundscaping - water feature						x	x			x	x			x

Typology Applicable to / **Rating tools**

Opportunity for Nature Benefit	Nature-based Design Element	Single Building	Developments / Precincts	Retrofit	Green Star	Living Building Challenge	Green Factor Tools (Melbourne and Brisbane)
Carbon Sequestration	Cross Laminated Timber	x			x	x	
Carbon Sequestration	Engineered Bamboo	x			x	x	
Sound environment	Soundscaping - water feature	x	x	x	x	x	

TABLE 4B: ATMOSPHERE DESIGN CONSIDERATIONS

Design considerations to factor into your design development process as early as possible (not exhaustive list, other design considerations may be applicable that are not highlighted here).

			WATER	SPECIALISTS			PLANNING			BUILDING SPECIFIC											PRECINCT SPECIFIC					
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	Water Management - drainage and irrigation	Design element specific specialists	Specialist installation	Coordination of multiple specialisms for design element (electrical, drainage, horticulture, waterproofing, divers)	Ensure early planning and allow for lead in times	Plan and budget for maintenance	Plan and budget for ecological / environmental monitoring	Assess building structural capacity	Waterproofing	Potential Fire Safety Risk and fire engineering advice recommended	Suitability for Solar Panel (wind loads, solar access and shading)	Space provision on roof considering competing services infrastructure	Structural Performance and connections (load, thickness, loads on connectors)	Ensure pre-treatment, weather barriers and ventilation requirements are met	Consider Vibration and Acoustic impacts	Perceived Risk & Insurance	NCC Code compliance	Sustainable Sourcing and Harvesting, Life Cycle Assessments (including dynamic LCA)	Design for Disassembly	Accessibility	Specialist Lighting	Waste Management	Design for Public Safety	Integration with other infrastructure (cycle paths, green infrastructure)	Assessment of sound environment to inform design
ATMOSPHERE	Carbon Sequestration	Mass Engineered Timber		x		x						x			x	x	x	x	x	x	x					
	Carbon Sequestration	Engineered Bamboo		x		x						x			x	x			x	x	x					
	Sound environment	Soundscaping - water feature	x	x		x		x																		x

BIODIVERSITY
TABLES

TABLE 5A: COMPOUNDING BENEFITS - BIODIVERSITY

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

	Nature benefits and co-benefits within the built environment		Increasing nature benefits by combining design elements				
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	BIODIVERSITY	LAND		WATER	ATMOSPHERE
BIODIVERSITY	Habitat creation and connection	Landscape planting for habitat creation	• Habitat restoration • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues • Living Seawalls habitat enhancement modules	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space	• Community gardens • Elevated park • External green façade • External Planter Boxes	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed Wetlands	• Soundscaping - water feature
	Habitat protection and restoration	Habitat restoration	• Landscape planting for habitat creation • Habitat Analogues • Living Seawalls habitat enhancement modules	• Land formation retention and restoration • Soil retention and restoration	• Green Space	• River and Creek Restoration • Reconnecting river and floodplain	
	Habitat Creation and connection (building)	Biodiverse green roofs	• Landscape planting for habitat creation • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Blue / Green Streetscape • Green Space	• Community gardens • Elevated park • External green façade • External Planter Boxes	• Rainwater Tanks	• Soundscaping - water feature
	Habitat Creation and connection (building)	Biosolar green roof	• Landscape planting for habitat creation • Biodiverse green roofs • External green wall • Habitat Analogues	• Land formation retention and restoration • Blue / Green Streetscape • Green Space	• Community gardens • Elevated park • External green façade • External Planter Boxes	• Rainwater Tanks	• Soundscaping - water feature
	Habitat Creation and connection (building)	External green wall	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Blue / Green Streetscape • Green Space	• Community gardens • Elevated park • External green façade • External Planter Boxes	• Rainwater Tanks	• Soundscaping - water feature
	Habitat Creation	Habitat Analogues	• Landscape planting for habitat creation • Habitat restoration • Biodiverse green roofs • Biosolar green roof • External green wall	• Green Space • Community gardens	• Elevated park • External green façade	• River and Creek Restoration • Constructed Wetlands	
	Habitat Creation and connection	Living Seawalls habitat enhancement modules	• Habitat restoration				

TABLE 5B: COMPOUNDING BENEFITS - LAND

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

	Nature benefits and co-benefits within the built environment		Increasing nature benefits by combining design elements			
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	BIODIVERSITY	LAND	WATER	ATMOSPHERE
LAND	Land restoration	Land formation retention and restoration	• Landscape planting for habitat creation • Habitat restoration • Biodiverse green roofs • Biosolar green roof • External green wall	• Soil retention and restoration • Blue / Green Streetscape • Green Space • Community gardens • Elevated park • External green façade	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed Wetlands	
	Soil restoration	Soil retention and restoration	• Landscape planting for habitat creation • Habitat restoration	• Land formation retention and restoration • Blue / Green Streetscape • Green Space • Community gardens	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed Wetlands	
	Urban Greening	Blue / Green Streetscape	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall	• Land formation retention and restoration • Soil retention and restoration • Green Space • Community gardens • Elevated park • External green façade • External Planter Boxes	• Bioretention systems • Swales • Naturalised basin • Constructed Wetlands	• Soundscaping - water feature
	Urban Greening	Green Space	• Landscape planting for habitat creation • Habitat restoration • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Community gardens • Elevated park • External green façade • External Planter Boxes	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin • Constructed Wetlands	• Soundscaping - water feature
	Urban Greening	Community gardens	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space • Elevated park • External green façade • External Planter Boxes	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Rainwater Tanks	• Soundscaping - water feature
	Urban Greening	Elevated park	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Blue / Green Streetscape • Green Space • Community gardens • External green façade • External Planter Boxes		• Soundscaping - water feature
	Urban Greening	External green façade	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall • Habitat Analogues	• Land formation retention and restoration • Blue / Green Streetscape • Green Space • Community gardens • Elevated park • External Planter Boxes		• Soundscaping - water feature
	Urban Greening	External Planter Boxes	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall	• Blue / Green Streetscape • Green Space • Community gardens • Elevated park • External green façade		• Soundscaping - water feature

WATER
TABLES

TABLE 5C: COMPOUNDING BENEFITS - WATER

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

	Nature benefits and co-benefits within the built environment		Increasing nature benefits by combining design elements			
NATURE REALM	Opportunity for Nature Benefit	Nature-based Design Element	BIODIVERSITY	LAND	WATER	ATMOSPHERE
WATER	River Restoration	River and Creek Restoration	• Landscape planting for habitat creation • Habitat restoration • Habitat Analogues	• Land formation retention and restoration • Soil retention and restoration • Green Space • Community gardens	• Reconnecting river and floodplain • Naturalised basin • Constructed Wetlands	
	River Flood Management	Reconnecting river and floodplain	• Landscape planting for habitat creation • Habitat restoration	• Land formation retention and restoration • Soil retention and restoration • Green Space • Community gardens	• River and Creek Restoration • Naturalised basin • Constructed Wetlands	
	Stormwater Management	Bioretention systems	• Landscape planting for habitat creation	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space • Community gardens	• Swales • Naturalised basin • Constructed Wetlands • Rainwater Tanks	• Soundscaping - water feature
	Stormwater Management	Swales	• Landscape planting for habitat creation	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space	• Bioretention systems • Naturalised basin • Constructed Wetlands	
	Stormwater Management	Naturalised basin	• Landscape planting for habitat creation	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Constructed Wetlands	
	Stormwater Management	Constructed Wetlands	• Landscape planting for habitat creation	• Land formation retention and restoration • Soil retention and restoration • Blue / Green Streetscape • Green Space	• River and Creek Restoration • Reconnecting river and floodplain • Bioretention systems • Swales • Naturalised basin	
	Water harvesting	Rainwater Tanks	• Biodiverse green roofs • Biosolar green roof • External green wall	• Community gardens	• Bioretention systems	• Soundscaping - water feature

ATMOSPHERE
TABLES

TABLE 5D: COMPOUNDING BENEFITS - ATMOSPHERE

Nature benefits and co-benefits within the built environment, typology applicable to and rating tools design elements can contribute to.

	Nature benefits and co-benefits within the built environment		Increasing nature benefits by combining design elements			
NATURE REALM	**Opportunity for Nature Benefit**	**Nature-based Design Element**	**BIODIVERSITY**	**LAND**	**WATER**	**ATMOSPHERE**
ATMOSPHERE	Carbon Sequestration	Cross Laminated Timber				
	Carbon Sequestration	Engineered Bamboo				
	Sound environment	Soundscaping - water feature	• Landscape planting for habitat creation • Biodiverse green roofs • Biosolar green roof • External green wall	• Blue / Green Streetscape • Green Space • Community gardens • Elevated park • External green façade • External Planter Boxes	• Bioretention systems • Rainwater Tanks	

07 CONCLUSION:

Conclusion

LET'S LEAD TOGETHER — FOR NATURE, FOR COUNTRY AND FOR FUTURE GENERATIONS.

CONCLUSION

The future of the built environment depends on how well we learn from, design with and care for Nature.

This guide demonstrates that outcomes that deliver benefits for Country and Nature are not only possible — they are essential. By embedding biodiversity, water, land and atmosphere considerations into project design, we can create places that are more resilient, equitable and alive.

When we listen to Traditional Owners, embrace long-term thinking and design with ecological and cultural integrity, we restore more than ecosystems — we restore connection, meaning and possibility.

Nature is not a backdrop. It is a collaborator, a teacher and a legacy.

CALL TO ACTION

We invite everyone — designers, developers, planners, policymakers and communities — to join us in reshaping the built environment through Nature.

Use this guide as a reference, a challenge and a catalyst.

Ask bold questions. Collaborate early. Embed Country.

Design places that are generous to people and to planet.

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THANK YOU