

# Landscape Infrastructure in Sydney: Exemplars of Landscape Synergies and Capacity by Design

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The landscape architecture undergraduate programme at the University of Technology Sydney introduced landscape infrastructure as a subject into its curriculum in 2016. This subject contained two aims relating to the application of landscape infrastructure to an Australian context, extending beyond its North American origins. First, it aimed to identify and test the principles of landscape infrastructure that could be 'generalisable' and that exist outside of site specifics or a particular context. Second, it sought novel instances of its application in the Sydney region. Principles were distilled through an evaluation of relevant literature and were then tested through two exercises.

The first required students to reimagine *The GreenWay*, a multifunctional landscape corridor in Sydney's Inner West and part of a proposed metropolitan-wide *Green Grid* network. Students then applied the framework of landscape infrastructure through design proposals in one of Australia's fastest-growing urban centres, Parramatta. The findings of this research distilled and clarified the definition of landscape infrastructure; demonstrated the inherent capacity of landscape to act as the conduit for multifunctional, flexible, localised and synergistic infrastructural systems; and highlighted its potential for application in an Australian context. This work supports landscape infrastructure's position to move beyond the integration of infrastructure within landscape and instead proposes that landscape itself is infrastructural.

**L**andscape architecture is a discipline characterised as expansive, diverse, fluid and open, which sits on the boundaries of a range of disciplines including art, engineering, urban design and architecture (Thompson, 2014, pp 22–23). Landscape architecture can also be described by what it aims to achieve; for example, Weller (2006) describes its role as a 'holistic enterprise ... that is at best both art and science' (p 71). From a research perspective it is a discipline with a growing demand for the 'production and consumption of knowledge' while simultaneously requiring development concerning how knowledge generation and validation occur (Deming and Swaffield, 2011, pp 1–44).

For its part, landscape infrastructure contributes to the ongoing development of landscape architecture by generating continued discourse and new practice that 'reimagines' infrastructure 'for the advancement of our culture' (Aquino, 2013, p 7). Landscape infrastructure has been described as a methodology (SWA Group, 2015), a set of attributes (Hung, 2013, p 17) and a project (Bélanger, 2012, p 290). Deming and Swaffield propose that emergent ideas in landscape architecture that are yet to develop theoretical status 'should be more correctly termed frameworks' (2011, p 32) and as such cultivate discourse and practice

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## RESEARCH

that develop and validate new knowledge. Landscape infrastructure is therefore a framework for discourse in and practice of landscape architecture and one that this research embraces.

### **An overview of landscape infrastructure**

Pierre Bélanger, a leader of the framework's discourse, considers that landscape infrastructure emerged as a response to urban and industrial decline in North American cities. As he explains, the task of determining and consigning infrastructure has previously been allotted to engineers and the 'historic lack of engagement of infrastructure as a territory of design stems from its dystopic [sic] and banal nature' (Bélanger, 2012, p 281). Landscape infrastructure therefore emerges as an alternative to what Bélanger describes as the 'overexertion of engineering and the inertia of urban planning' (ibid, p 276) to reconsider 'a landscape of systems, services, scales, resources, flows, processes and dynamics'. Mossop (2006) also calls for a re-examination of landscape, highlighting that 'all types of spaces are valuable' and therefore worthy of designers' consideration (p 171). It follows that the challenge is to 'engage' with infrastructure *through* landscape, including 'mundane parking facilities, difficult spaces under elevated roads, complex transit interchanges, and landscapes generated by waste processes' (ibid). These types of systems are carried by landscape, are of landscape, and so should be under consideration by landscape architects through landscape infrastructure frameworks.

Landscape's capability to carry and generate infrastructure was first prescribed by landscape urbanism. Landscape urbanism repositions landscape as the primary system at the centre of all systems that determine environments. Corner (2006) describes landscape urbanism as 'first and last an imaginative project, a speculative thickening of the world of possibilities' (p 32) and from its origins a focus on infrastructure is apparent. According to Weller (2006), 'landscape is the infrastructure to which all other infrastructure elements or networks are answerable' (p 79), while Waldheim (2016) suggests it is positioned as 'thinking urbanism through the lens, or lenses, of landscape' (p 2). This notion is carried and translated to landscape infrastructure and is an idea developed further by reimagining historical landscapes, such as the ancient Silk Road (Carlson, 2011) where sites are 'the result of modification or utilisation' or have been shaped in order to achieve 'facilitation of program' – an infrastructural positioning. Landscape becomes capable of conveying infrastructure when landscape itself is understood as infrastructural. Landscape is redefined as capable of generating new strategies for infrastructural systems through their integration within the landscape itself.

### ***Landscape infrastructure, ecology and culture***

Landscape urbanism has extended into other new areas of discourse, in particular ecological urbanism. Landscape urbanism is credited by ecological urbanism as the means by which ecology, as it is understood by the design disciplines, was 'brought' into urbanism (Hagan, 2015, p 29). Gray (2011) also suggests that landscape urbanism has been a means to 'reintroduce critical connections with natural and hidden systems'. A focus on ecological systems as essential is inherited

by landscape infrastructure, repositioning ecology as an infrastructural system. Landscape is therefore proposed as the carrier for infrastructure in all its forms, and landscape infrastructure recognises not only traditional – sometimes called grey – infrastructure but also blue and green infrastructures, which concern hydrological and ecological systems respectively (Benedict and McMahon, 2006; Kilbane, 2013, Pungetti and Jongman, 2004).

Infrastructural systems (grey, blue and green) are mediated in landscape infrastructure through a position of ‘cultural relativity’ (Waldheim, 2016, p 50). This is most clearly articulated in relation to ecology, where landscape infrastructure follows landscape urbanism’s ‘deployment of ecology as model or metaphor’ in which ecology is ‘a model for understanding the complex interactions between nature and culture’ (ibid). Infrastructure systems are therefore culturally and socially dynamic, as well as the deliverers of services, structures and processes needed to sustain urban life (Millennium Ecosystem Assessment, 2005).

These multifunctional qualities (Ahern, 2007) or polyfunctional and synergistic qualities (Ezban, 2013) are proposed as localised solutions that generate public space and adaptive, productive new landscape forms, particularly those with hydrological focus. In Ezban’s ‘Aqueous Ecologies’ project (2013), ecology and landscape infrastructure are innately connected and mediated by culture. Ezban forecasts landscape’s capability to enable ‘unique connections to adjacent communities and regional ecologies’. Infrastructural systems and processes become the means of supporting new types of communities and new understanding of how we structure our environments. This is supported by Hung (2013), who sees infrastructural approaches as important to create greater connectivity for ‘people to places, communities to communities ... nature to city ... and contribute to the betterment of urban life’ (p 19).

### *Praxis and principles of landscape infrastructure*

Landscape infrastructure discourse positions landscape architecture to consider systems and processes previously unconsidered by or unassociated with the discipline. The SWA Group, based in the United States of America, has documented examples of practice for the framework through the recent publication *Landscape Infrastructure: Case Studies by SWA* (The Infrastructure Research Initiative at SWA, 2013). It identifies and emphasises the capacity of landscape to carry infrastructure, explaining that it is landscape’s ability to consider the relationships between ‘interconnected and interdependent systems’ (Hung, 2013, p 14) that gives it credence to reconsider infrastructure. Hung, a member of the SWA Group, discusses the principal differences between infrastructure as traditionally approached and the ‘new paradigm’ of landscape infrastructure, defining three core principles that were distilled into a table (see table 1) to establish the basis for further enquiry.

- Principle 1: Landscape infrastructure is *flexible and adaptable*.
- Principle 2: Landscape infrastructure considers *decentralised* and locally managed solutions.
- Principle 3: Landscape infrastructure is *multifunctional* such that ‘the city and its infrastructure are one and the same’ (ibid, p 17).

Table 1: Traditional infrastructure versus landscape infrastructure according to Hung (2013)

Traditional infrastructure		Landscape infrastructure	
Traditional approach	Example	New paradigm	Example
Successional, may quickly become obsolete	Streets for vehicular movement	<b>Flexible and adaptable</b> (Principle 1)	Streets as pedestrian connections, green corridors, stormwater management and urban heat mitigation
Performance fixed to set criteria	Highways for peak-traffic efficiency	Performance not fixed: design for multiple parameters and change (adaptive and resilient)	
Centralised, single-purpose system	Channelled waterways Rail corridors Energy	<b>Decentralised</b> (Principle 2), allowing for localised, multifunctional solutions	Water sensitive, localised stormwater management Rail corridors as recreation trails, promoting ecological connectivity, social and health benefits and sustainable local transport options Local-scale renewable energy generation, such as solar and wind
Efficiency based, focused on one system; does not consider broader or related issues	Stormwater and sewage discharge into waterways and seas	<b>Multifunctional</b> (Principle 3), carries many systems simultaneously	Urban runoff retention in wetlands, recycled water used for irrigation, resulting in ecological benefits, cost benefits, social benefits through greater open space amenity
Aims to maximise benefits to one system in isolation	Roads for vehicular movement only	Aims for synergistic relationships Diverse, optimised condition; city and infrastructure are one and the same	Roads as corridors for connectivity to open space, public transport hubs, stormwater management, resulting in sustainable transport, greater use of public space, economic development

Other theorists reinforce the paradigm shift and reframing. For instance, Bélanger (2012) explains that landscape infrastructure slides ‘across different scales, systems and strategies’ (p 301) aligning with the principles of flexibility/adaptability and multifunctionality. In addition, he gives an expanded list of principles that include ‘flexible’, ‘synergistic’, ‘multidisciplinary’, ‘distributed and disaggregated’ and ‘regionalised’ or localised (ibid, pp 305–309).<sup>1</sup> The principles of flexibility, synergy and localised systems align with the distillation of principles used by this research.

## Research aims

This research had two aims.

1. Identify and test landscape infrastructure principles: Landscape infrastructure offers repeated claims about what constitutes its approach. Based on Hung’s (2013) principles, this research sought to understand the

fundamental or ‘generalisable’ principles of landscape infrastructure that exist beyond a particular geopolitical context and how these differed from traditional approaches to infrastructure design and management. In the first instance, an existing landscape was reimagined as infrastructure in order to test identified principles. In the second instance, new types of landscapes were proposed for a region that has been essential to the growth of Sydney historically and will continue to be so in the near future.

2. Conduct a detailed investigation and application in an Australian context: This research aimed to apply the framework of landscape infrastructure in the Sydney region through a series of investigations and propositional design exercises that effectively communicated the principles identified in meeting the first aim of the research. These were applied to investigate sites through both thinking and design processes described and recognisable as *landscape infrastructure*. To achieve this aim, it was first necessary to consider landscape as infrastructural and to understand its potential to carry other infrastructural systems. It was intended that the investigative process would identify and generate examples of potential Australian landscape infrastructure. Emulating the framework’s shift away from the master plan towards strategies that embrace open-endedness and uncertainty was fundamental to the success of the application.

## Method

Undergraduate landscape architecture students were engaged to critically investigate the novel application of landscape infrastructure in an Australian context. This involved two phases undertaken between March and May 2016, with each phase aligned to its particular geographical location. Students used a variety of tools across a range of scales, including expert briefings and site visits; mapping; design with computer aided drafting (CAD) programs, such as AutoCAD and Rhino; and the construction of sketch and final models to develop designs.

### *Study area: The GreenWay and New Parramatta*

To identify potential sites for investigating the application of the framework, it was necessary to return to the literature to identify a means of selection. The literature demonstrates that retrospectively considering existing sites as examples of the framework is an accepted technique applied by academics in the field. Mossop (2006) discusses the designs of Canberra and of Victoria Park and Clear Paddock Creek in Sydney as examples that illustrate infrastructure as ‘generative public landscape’ (p 171). Carlson (2011), in his ‘re-contextualising’ of historic landscapes as examples of landscape infrastructure, ‘expands’ and ‘solidifies’ the redefinition of existing landscapes as infrastructural, suggesting that we understand landscape as ‘the operative ground for infrastructure’ and characterising ‘any landscape intervention as infrastructural’. The SWA Group also retrospectively repositions past project case studies, including the Buffalo Bayou promenade, a project started in the 1980s (Aquino and Hung, 2013). This survey established a method for discussing and claiming existing landscapes as examples of landscape infrastructure. Landscape infrastructure in the Sydney context was – correspondingly – thereby identified through considering the ability of infrastructure to form new types of public space and contribute to quality of life.



### *Phase one: The GreenWay*

The first site students considered was an existing landscape, *The GreenWay* (figure 1), a multi-use corridor in Sydney's Inner West<sup>2</sup> and part of a broader metropolitan-scale *Sydney Green Grid* network (Office of the Government Architect NSW, 2013). *The GreenWay* was investigated as an example of an established landscape also functions as infrastructure as well as a new type of public space. While this site is currently unrecognised more widely as an example of landscape infrastructure (the theory was unknown to those who work within it), the corridor shares several characteristics with SWA case studies, including the Buffalo Bayou promenade, and is crossed by major roads such as the high-volume Parramatta Road.<sup>3</sup> *The GreenWay* corridor includes disused industrial and contemporary rail transportation, along with ecological *bushcare* sites.<sup>4</sup> It is also a popular, active transport trail for cycling and walking and a historical drainage line and canal, which connects Cooks River to Sydney Harbour as well as adjacent parks.

Students were tasked with reimagining *The GreenWay* as an example of landscape infrastructure in Sydney by presenting creative mapping in poster format to communicate how *The GreenWay* corridor operates as landscape infrastructure to an unfamiliar, non-expert audience. After a briefing and tour of the corridor by *The GreenWay* place manager,<sup>5</sup> the exercise involved visiting the site, and mapping and illustrating landscape infrastructural qualities and attributes. To produce a poster the students needed to distil both theory and site

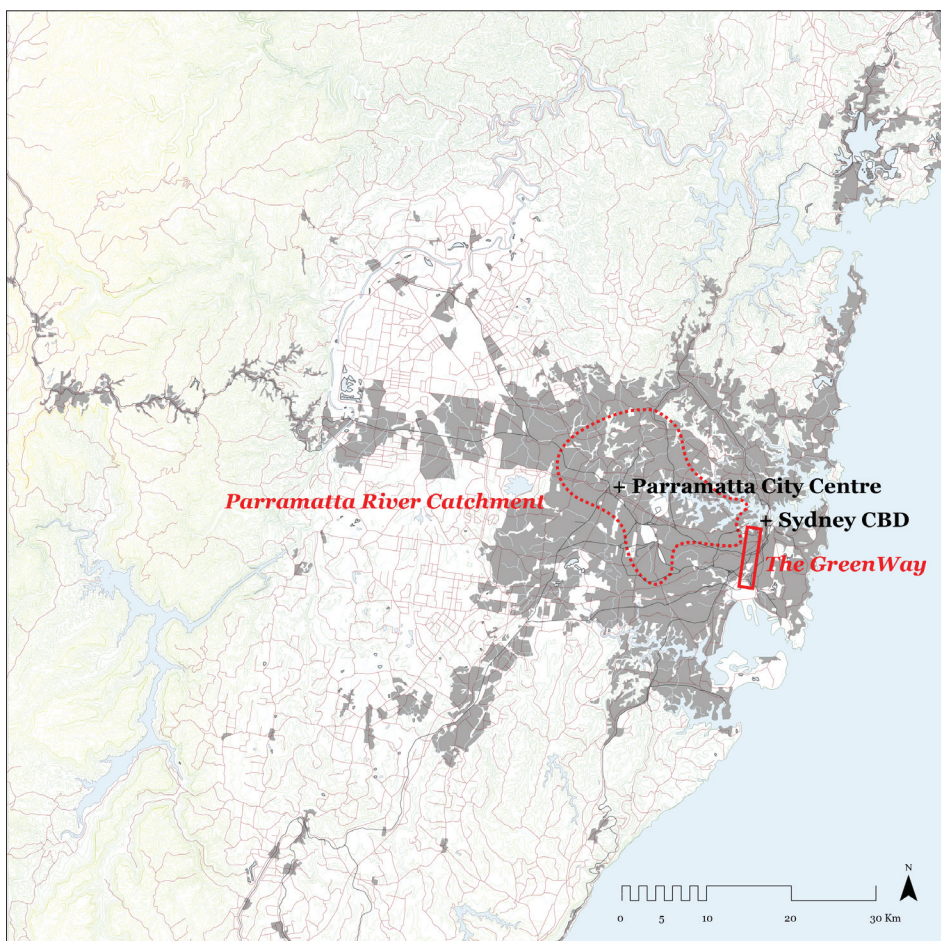


Figure 1: Location map of The GreenWay and the Parramatta River catchment. (Image: Geoscience Australia, 2007. Geodata topo 250K. Series 3 for Google Earth, 1:250,000 scale vector map data (DVD). Geoscience Australia, Canberra.)

and each student sought to illustrate the complexity of both. This exercise posed three challenges to the students:

1. evaluating the fundamental principles of landscape infrastructure based on literature;
2. translating principles to an existing site within Sydney;<sup>6</sup> and
3. successfully distilling and communicating landscape infrastructure outside of the discipline of landscape architecture to a lay audience through an exhibition.<sup>7</sup>

Because their work had to be suitable for a lay audience, students needed to both distil and apply principles in this phase. As a result, this phase addressed both aims of this research.

### *Phase two: New Parramatta design proposals*

The second site chosen for investigation, Parramatta, is located above a weir that separates the Parramatta River from the Parramatta Estuary and Sydney Harbour. Containing several World Heritage listed and significant archaeological sites associated with indigenous, convict and colonial heritage, this growing area is Sydney's second most important centre for business, employment, health and justice. Key projects already under way include *Parramatta Square*, which is surrounded by a new campus for Western Sydney University, and new residential construction including a river foreshore tower over 50 storeys high.

In the Parramatta design phase, students considered how the application of landscape infrastructure principles could create new types of landscapes in Sydney. This involved investigating and developing ways to apply a landscape infrastructure framework in a propositional capacity. This work was underpinned by site visits and detailed briefings from local expert stakeholders, including the Parramatta City Council<sup>8</sup> and the Parramatta River Catchment Group.<sup>9</sup> They outlined issues facing the region, explained planning responses and offered two clear additional design agendas:

1. to improve water quality in the Parramatta River to achieve a safe level for swimming; and
2. to decrease urban heat in and around the centre of Parramatta.

The project site was defined at two scales. The first comprised the entire Parramatta River catchment and the second was a specific design site where students could develop their own focus and study as detailed landscape infrastructure strategy. Any systems that could be described as *infrastructural* were open for consideration as a topic of study. Strategies had to address a challenge for the region by including in greater detail a *catalyst* or an *exemplar* to enable further positive change staged over 30 years (to 2045).

### *Phase One: The GreenWay*

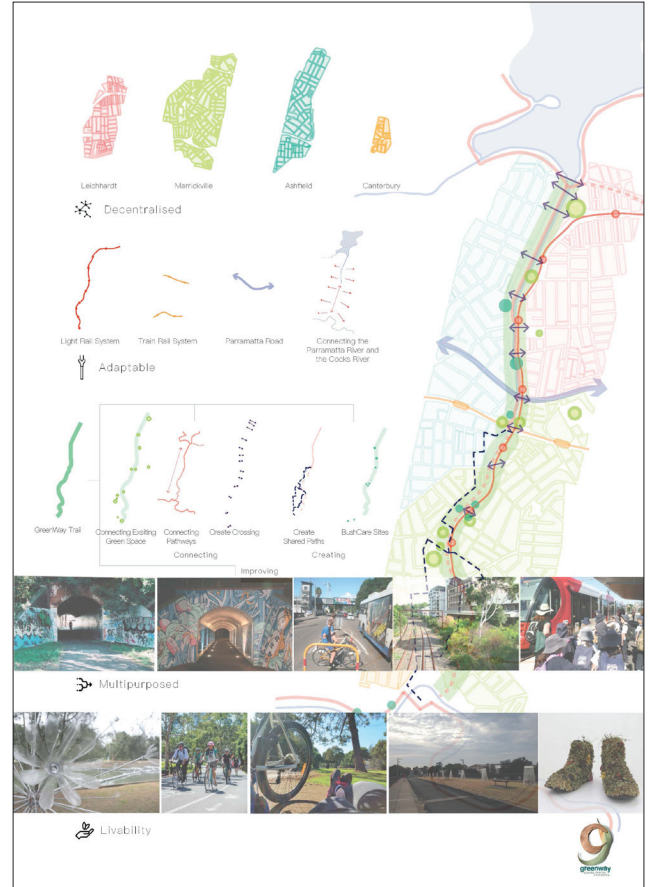
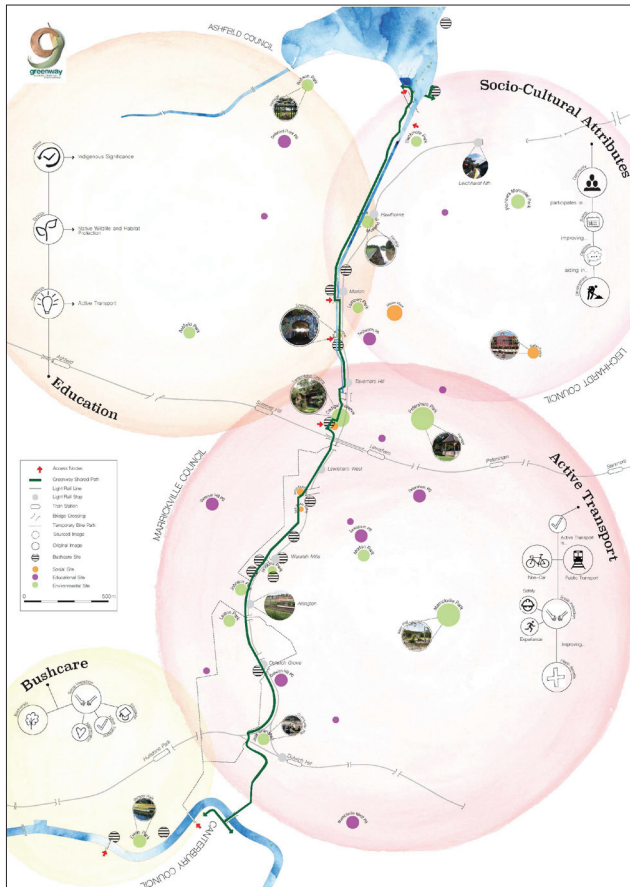
#### *Results*

This exercise addressed both aims of this research, identifying and testing the 'generalised' principles of landscape infrastructure and investigating their application to a site in Sydney. Three posters (from a total of 15) will be discussed.

In the first poster, McCarthy simultaneously represented four categories of systems and outcomes as identified by the four neighbouring local government authorities: education, active transport, social-cultural attributes and bushcare (see figure 2). In the case of transport, a combination of public transport (light-rail) and ‘non-car’ movement (cycling and walking) was linked to outcomes. Through a diagram of transport systems and positive health outcomes (namely increased safety and an enhanced, more closely connected experience of place), McCarthy’s work effectively communicated how synergistic and multifunctional systems enabled a spectrum of social, health and environmental benefits as interlinked, high-quality public spaces to engender social interaction: an exemplar for new forms of open space, where a drainage and rail corridor also becomes an opportunity for greater social engagement. This implied that *The GreenWay* was indeed an example of the three principles of landscape infrastructure identified by Hung (2013): ‘flexibility and adaptability’, ‘localised management’ and ‘multi-functionalism’.

Shing revealed the corridor’s ‘decentralised’ quality, placing surrounding councils – Leichardt, Marrickville, Ashfield and Canterbury – at the top of a hierarchical diagram (see figure 3). This approach demonstrated the corridor’s history, beginning with life as a canal connecting Cooks River to the harbour, and leading to the repurposing of the rail corridor for light-rail in 1997. Further adaptation, incorporating additional cycling and walking trail connections to existing parks along with bushcare sites, highlighted *The GreenWay*’s function as a spine for ecological connectivity as well as incorporating transport,

Figures 2 and 3: (left) The GreenWay poster by McCarthy and (right) The GreenWay poster by Shing





recreation and drainage. Through a photographic exploration of ‘multipurpose’ and ‘liveability’, this work skilfully communicated correlations between *The GreenWay*, landscape infrastructure principles and the capacity of landscape. By implication, Shing’s work demonstrated how site operated as an example of landscape infrastructure in an Australian context.

Considering the existing and the ‘reimagined/reimagined’, Hardy-Clements revealed *The GreenWay*’s current operation by engaging with its ‘mundane’ elements, including light fixtures, to explain how incremental change could provide synergistic outcomes (see figure 4). This was achieved by overlaying graphic discussion threads on a map of the broader region and was further illustrated with photography. In one thread, road crossing improvements were linked to improving lighting to enhance overlooking from adjacent housing for greater safety. These improvements identified ‘lost pockets associated with train

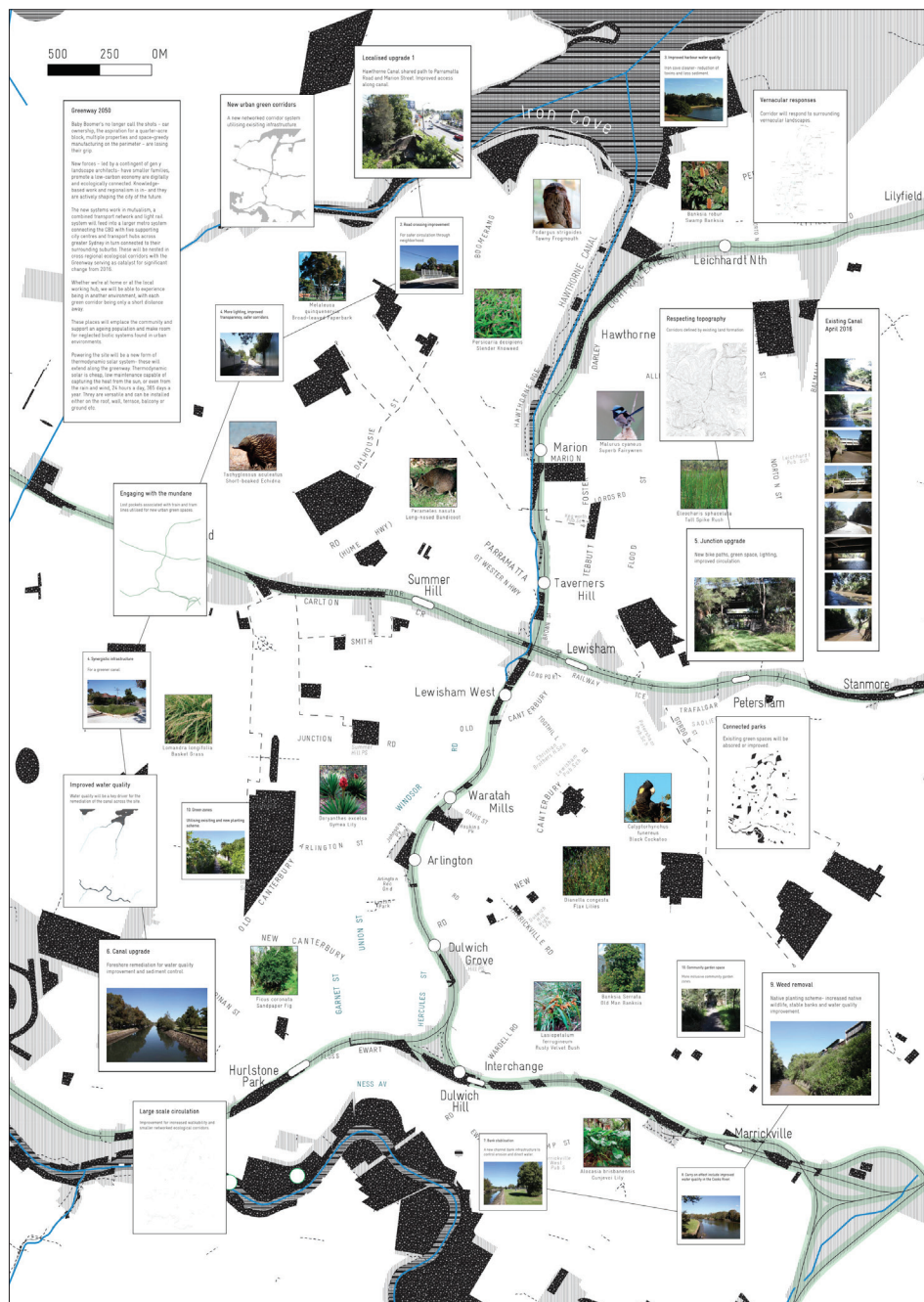


Figure 4: The GreenWay poster by Hardy-Clements

and tram lines for new urban green spaces'. This in turn was linked to improved water-quality outcomes, such as a proposed upgrade to the canal 'foreshore', currently a concrete channel. To complete this thread, the canal was reimagined as a vital, new and synergistic infrastructure with enhanced connectivity (through road crossings), safety (via lighting and visual permeability) and improved water quality. Because Hardy-Clements' work was less evident in achieving the first aim of stating particular principles, it was more successful in the second aim of discussing how this site could operate as landscape infrastructure.

### *Discussion*

*The GreenWay* poster exercise required students to distil and successfully communicate the complexity of infrastructural systems located in the corridor. The best examples combined diagrams with mapping and photography, using a hierarchy of graphical layout to relate elements on the page. McCarthy (figure 2) linked health with safety and experience of place, while Shing (figure 3) explored multifunctionality and adaptation. The difficulty in communicating how landscape infrastructure operates without a single, fixed end-point but rather with inherent flexibility – as explored by Hardy-Clements (figure 4) – was an important finding. In reality, *The GreenWay* functions through a mix of grassroots activism and response to external pressures, including adjacent housing infill development. Funds for improvements to the multi-use trail and maintenance of bushcare sites are limited; and uncertainty and risk must be embraced to ensure their continuing development.

The students' work begins a successful translation of the framework of landscape infrastructure where *The GreenWay* could be understood as a site shaped to achieve 'facilitation of program' (Carlson, 2011). *The GreenWay* 'program' has become more diverse over time, shifting between drainage corridor, goods transportation and now light-rail, and increasingly reflects the principles of 'flexibility and adaptability', 'localised management' and 'multi-functionalism' espoused by Hung (2013) and demonstrated by the students' work. This project could therefore be seen as the beginning of establishing *The GreenWay* as a Sydney-based, Australian example of landscape infrastructure.

Table 2 summarises the results from this phase.

## **Phase Two: New Parramatta design proposals**

### *Results*

The studio then shifted its gaze to Parramatta, with detailed briefings from local experts and a group exercise to research and define this complex 'site' across three scales: the *central business district*, the *local government authority* and the *whole of Parramatta River catchment*. This exercise challenged students to expand the scope of 'infrastructure' by including systems such as patterns of consumption and distribution, waste management, energy, land use, heritage, culture and geology across multiple scales. It encouraged students to consider how infrastructure might be carried by landscape in the region already, but above all it required them to develop catalytic design insertions or exemplar design elements that would illustrate the overall strength and potential of their strategies.

Table 2: Summary of achieving research aims through The GreenWay poster exercise

	<b>Aim 1: Identify and test landscape infrastructure principles</b>	<b>Aim 2: Conduct a detailed investigation and application in an Australian context</b>
<b>Student</b>	<p>Proposed principles:</p> <ol style="list-style-type: none"> <li>1. Landscape Infrastructure is <b>flexible and adaptable</b>.</li> <li>2. Landscape Infrastructure considers <b>decentralised</b> and locally managed solutions.</li> <li>3. Landscape Infrastructure is <b>multifunctional</b> such that 'the city and its infrastructure are one and the same'.</li> </ol>	<p>Methods for application:</p> <p>Communicate how an existing site operates as landscape infrastructure.</p> <p>Propose new forms of open space – landscape as infrastructure, infrastructure as landscape.</p>
<b>McCarthy</b>	<p>Four systems carried by landscape: education, active transport, social-cultural attributes and bushcare <b>(flexible, multifunctional)</b>.</p> <p>Managed by four local authorities <b>(decentralised)</b>.</p>	<p>Transport systems increased safety and experience of place <b>(infrastructure as open space)</b>.</p> <p>Positive health outcomes for the surrounding community through linking infrastructural systems to create high-quality public spaces <b>(example of landscape infrastructure)</b>.</p>
<b>Shing</b>	<p>'Decentralised' quality highlighted.</p> <p>Adaptive historical infrastructure characterises the corridor: canal, the goods line, light-rail and finally shared pedestrian and cycle path <b>(adaptive and multifunctional)</b>.</p> <p>Ecological connectivity incorporated with transport, recreation and drainage <b>(multifunctional)</b>.</p>	<p>'Multipurpose' linked to 'liveability' <b>(illustrates the potential role of landscapes as infrastructure)</b>.</p>
<b>Hardy-Clements</b>	<p>Links road crossing improvements with improving lighting and making overlooking from housing more transparent, which increased perception of safety <b>(multifunctional)</b>.</p>	<p>Projective in nature, communicating both what <i>The GreenWay</i> corridor is and what it could be; an open-ended proposition for how <i>The GreenWay</i> could operate <b>(example of landscape infrastructure, a proposal for a new type of open space and use of open-ended strategic design approaches)</b>.</p> <p>Engages with 'mundane' elements, such as light fixtures, to explain how incremental changes across a whole-of-corridor scale would provide synergistic outcomes from greater connectivity to improved safety and water quality <b>(example of landscape infrastructure)</b>.</p>





Two more students, Gowers and Shing, focused on the Parramatta city centre. Gowers sought the catalytic potential of improving central business district streetscapes via hydrological systems and vegetation (see figure 7). Shing repurposed a street and heritage bridge into a pedestrian space with park-like insertions (see figure 8). These two strategies clearly demonstrated the principles of *multifunction* and *decentralisation*. Gowers detailed water-sensitive treatment of stormwater through tree planting, simultaneously providing a range of benefits such as giving individual streets a stronger identity. Shing’s work focused on Church Street – otherwise known as ‘Eat Street’, an area with a high concentration of restaurants and cafés –and dedicated the road to pedestrians and outdoor dining. This treatment extended to the river where the historic colonial Lennox Bridge was redesigned as a park over the river. Through redesign Shing also proposed undertaking local stormwater treatment and mitigating urban heat by increasing the amount of vegetation and changing ground surfaces. Shing and Gower both proposed engineered ecological processes to improve the quality of the city environment. In this way they provided examples of how landscape infrastructure harnesses a culturally mediated approach to ecology: its purpose was to increase the use of public space through improving quality.

While successful in many respects, the projects by both Shing and Gowers highlighted a problem for landscape infrastructure and the second aim of this research: the need to develop communication techniques that legibly demonstrate the full complexity of a design proposal. Projects that effectively illustrated the difficulty of considering open-ended approaches to infrastructure had that difficulty compounded by the need to design without a fixed end-point when showing landscape design details. Shing’s work also emphasised the difficulty of expressing change over time in a drawing format, yet she verbally expressed credible transformations to the region into the future as a result of her design. Developing techniques of communication outside of contemporary conventional drawing, even for an advanced student, was a barrier to achieving the second aim of this research. Gowers addressed this challenge through a text-based timeline

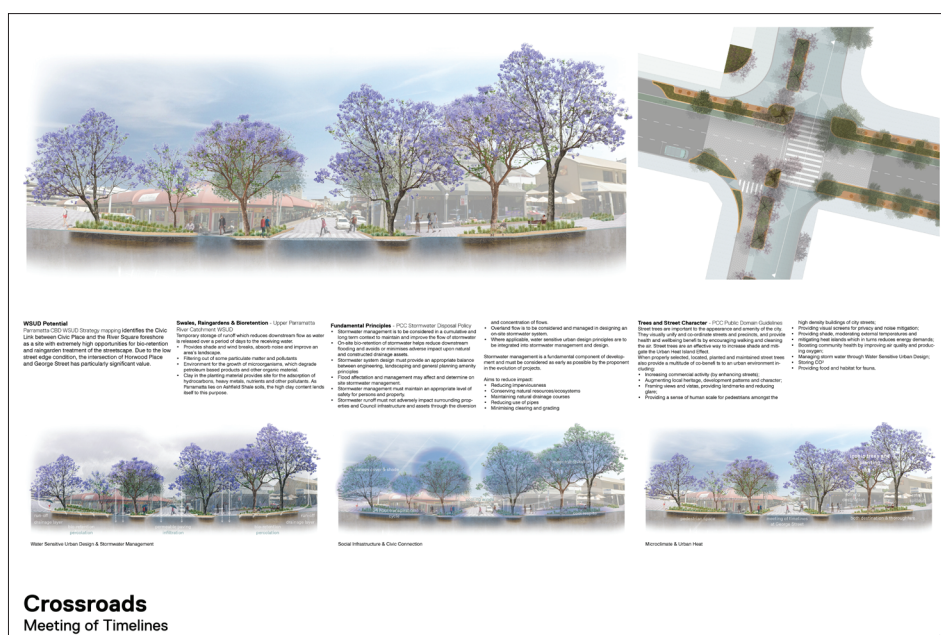


Figure 7: Shaping street identity: combining street character with water-sensitive urban design by Gowers (Extract, Panel 3)

that demonstrated a flexible approach to the catchment condition over 50 years. He also explored his proposal through changes in scale, demonstrating evidence of working across local and wider contexts, thereby aligning with the principle of decentralisation.

In two further projects, which were the most complex, Murphy and Edwards defined strategies to connect the river and the city centre. Murphy's work challenged dominant 'master plan' approaches to site, using an alternative method, including diagrams and a supporting document, to attempt an integrative strategy across the scale from site to region. Murphy investigated the region around the Westmead Hospital and considered food production, water-quality improvements via a renovated Parramatta River tributary, and new ways of living in a health precinct. These included a series of proposals ranging from future planning work on a section scaled from deep below ground to air space over head (see figure 9). Murphy's work was an example of all the principles of the framework with an emphasis on synergistic outcomes and his selection of a large and multilayered site proved beneficial in demonstrating landscape infrastructure, but a weakness when trying to resolve design elements.

Edwards similarly applied a breadth of landscape infrastructural principles as a framework and as an adaptive approach that allowed for continuing change over time. Through proposing seemingly banal changes incrementally over a suite of sites, Edwards cumulatively created what had the potential to become 'monumental' change (see figure 10). The project sites included easily replicable solutions for roundabouts and treatments to 'ordinary' residential streets. Edwards also identified a potentially crucial but forgotten site related to the Parramatta train station.

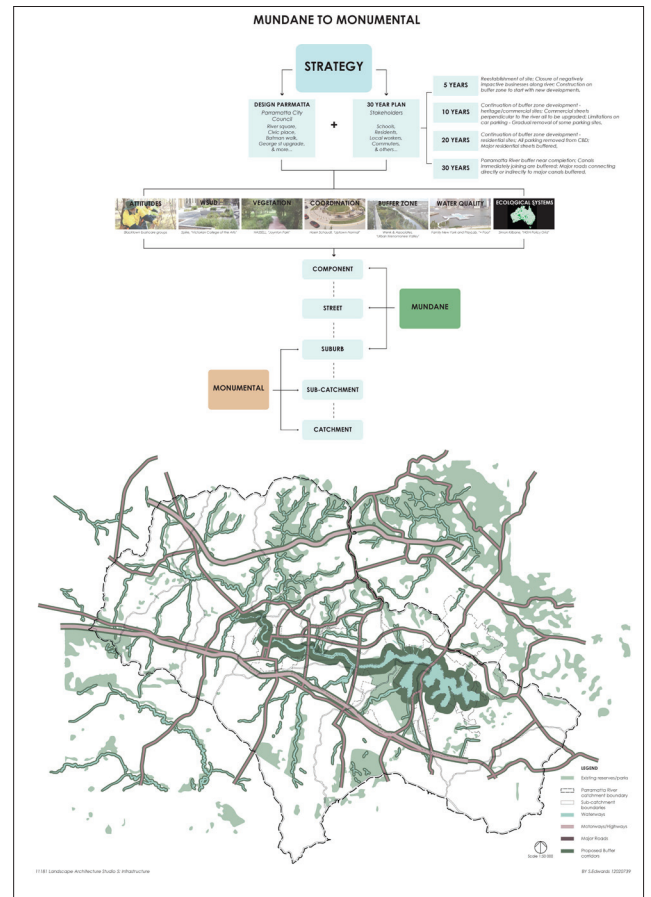
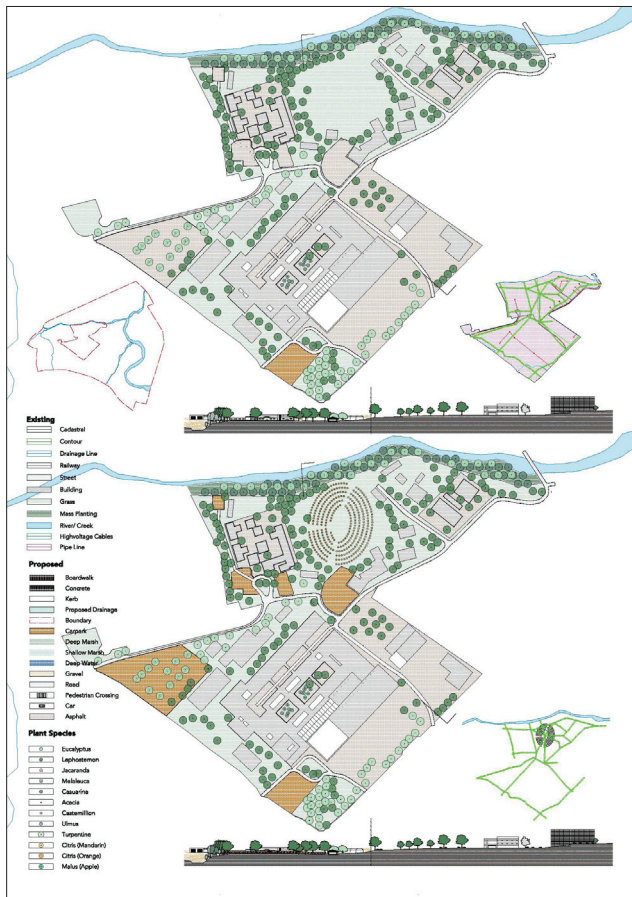
Murphy's use of diagrams and documents to demonstrate a strategy made it difficult for the student to 'pin down' any one idea and explain its full implications on site. Murphy instead provided the beginnings for a range of potential projects. The work was intended to be a strategy for the whole Westmead precinct, therefore achieving the second aim of the research with some success. By demonstrating resolved proposals for the chosen project sites, including changes over time, and then expressing how these sites cumulatively presented a strategy that was potentially open-ended, Edwards successfully put forward a project that met the second aim of the research. As with Murphy, Edwards was able to do this because her work embraced complexity and considered a range of sites across the region. Edwards' selection of sites allowed her to also present the work in more detail.

## Discussion

Contemporary Parramatta was established during Australia's European colonisation, immediately hosting successful agricultural pursuits and the seat of government, which demonstrated the area's position as essential infrastructure for the early New South Wales colony. Parramatta is once again a focus for essential infrastructure for Sydney and over the next 20 years the population of greater Sydney – and Parramatta with it – is expected to double. Coupled with this growth, future projections suggest the number of jobs in Parramatta will increase by 100,000 within two decades (Department of Planning and Environment, 2016). These projections show the urgency of resilient and flexible development to meet future needs.



Figure 8: Reclaiming infrastructure: a proposal for an icon infrastructural landscape in Parramatta's 'Eat Street' by Shing (Extract, Panel 3)



The students' work generally followed one of three main themes: strategies that addressed the river corridor directly; strategies that focused on the Parramatta city centre; and strategies that were located across larger scales outside both these regions, but that remained linked to both. Defining the site at the catchment scale inherently gave preference to hydrological systems and made water infrastructure an essential consideration for every student. It is interesting that none of the students' work considered infrastructural systems such as energy generation (despite its inclusion in the material-gathering group exercise), possibly because it is harder to translate energy to a 'landscape as infrastructure' viewpoint. By explicitly biasing the project towards water infrastructure (in line with the local stakeholders' desires), the first aim of the research – identifying and applying the principles of landscape infrastructure – was assured. This was because it was not possible to consider the health of the river without considering a localised solution to stormwater – an approach typically solved through re-creating streets as corridors for ecologically engineered water management. From this outcome, it might be observed that certain infrastructural systems are more likely to lend themselves to a landscape infrastructural framework, especially the systems that are hydrological. This is reflected in the SWA Group's case studies, many of which link hydrological infrastructure with ecological systems and new types of public space.

Students were required to design a strategy or proposal instead of a master plan. This became a significant challenge in their work and limited the extent to

Figures 9 and 10: (left) Open and closed systems: reconnecting landscape and infrastructure within Westmead by Murphy (Panel 4) and (right) Mundane to monumental: a proposal for small-scale intervention to achieve large-scale realisation of landscape as infrastructure by Edwards (Extract, Panel 1)

which they could achieve the second aim of this research. This requirement was set based on the practice of landscape infrastructure, which begins by departing from design processes that aspire to a single fixed end-point. The rejection of Euclidean, fixed end-point design processes comes from landscape urbanism, which Corner (2006) describes as 'a kind of urbanism that anticipates change, open-endedness and negotiation' (p 31). In the context of landscape infrastructure, Bélanger (2012) criticises fixed end-point approaches to urbanism as 'outmoded patterns of land development upheld by the spread of standardised, end-of-pipe engineering' (p 276). Departing from a designed 'plan' and instead developing a strategy, proposal or vision was a barrier to progressing work for students in the Parramatta studio. A requirement for students' work to include a catalyst or exemplar site to demonstrate how their strategy might be applied was intended to assist with this. However, the impact this requirement had on their ability to achieve the second aim of this research later became apparent.

The student work that attempted more detailed resolutions to strategies with a smaller-scaled focus was most strongly confronted by the shift away from the master plan. These projects highlighted the importance of using creative communication techniques to demonstrate the potential for continuing change over time, with the greatest success achieved by students who focused on strategy proven through detail. To do this, successful students needed to use drawing techniques that were 'representational', rather than only traditional features such as plans and sections across scales. In developing a comprehensive vision of how a detailed proposal would meet the principle of flexibility, they had to produce sophisticated representations of possible futures to comprehensively apply the framework. This work limited their ability to achieve the second aim of this research because students were rarely successful in demonstrating open-ended, strategic and uncertain outcomes, doing so only when they experimented with methods of communication and presented a range of proposals across different scales.

The proposals that considered larger-scale, regional strategies were the strongest examples of the framework's application and, as a result, the most successful in achieving the second aim of this research. They also represented the best attempts at communicating 'design' in the spirit of landscape infrastructure as flexible, contingent and without a single, optimal end. The work demonstrates that the best examples of applying landscape infrastructure were also the most complex. This may be a barrier to using the framework more broadly, and perhaps even is the reason for its lack of application outside an academic environment. It also demonstrates that tackling this framework at an undergraduate level creates significant challenges. One of these was the need to depart from master plan, fixed end-point approaches and instead communicate flexibility and change over time. Other challenges were identified difficulties in working at a high level of complexity and working individually on projects that should be supported by multidisciplinary teams.

Table 3 summarises the results from this phase.



Table 3: Summary of achieving research aims through the New Parramatta projects and generalisable principles (as evidenced by student work)

Student	Aim 1: Identify and test landscape infrastructure principles	Aim 2: Conduct a detailed investigation and application in an Australian context	Assessment of research
Leite	Achieved	Partially achieved	Flaw in research; demonstrating open-ended, strategic, uncertain outcomes over time is restricted when specialised knowledge is required.
Wang	Achieved	Partially achieved	
Shing	Achieved	Partially achieved	Problem for landscape infrastructure and the second aim of this research; developing communication techniques that legibly demonstrate complexity
Gowers	Achieved	Partially achieved	
Murphy	Achieved	Achieved	Examples of proposals that experimented with methods of communication and presented a range of proposals across different scales
Edwards	Achieved	Achieved	

## Conclusion: Meeting the research aims

### *Identifying and testing landscape infrastructure principles*

Based on the results generated for both *The GreenWay* and the New Parramatta design strategies, it is reasonable to propose that landscapes demonstrating ‘generalisable’ principles of landscape infrastructure in Sydney actively exist. Numerous challenges, including communicating how landscapes can function as and carry other systems of infrastructure without a fixed end-point, raise new questions about both this emergent ‘theory’ and its application. As such, this research highlights the need to demonstrate landscape infrastructure’s benefits in order to justify the difficulty associated with applying it.

Establishing principles from literature, supported by published case studies described as landscape infrastructure, was critical for this work to be considered research. This is especially important considering the research is based on hypothetical design strategies developed in an academic environment. Such a strategy, according to Deming and Swaffield (2011), represents ‘an autonomous research strategy when it produces new “generalisable” knowledge about the world through its purposes, protocols and outcomes’ (pp 205–206).<sup>10</sup> Identifying a resolute list of principles that can reasonably be defined as the essentials of landscape infrastructure was therefore necessary to fulfilling the first aim of this work. Testing these principles in the first of the projects undertaken, the reimagining of *The GreenWay*, was successful.

The students’ work for *The GreenWay* also partially met the second aim of the research where the site could be understood as landscape infrastructure

retrospectively. The work they developed as part of the New Parramatta projects was found to inadvertently bias hydrological or blue infrastructure. Landscape-based proposals for hydrological systems required solutions that were multifunctional, localised and flexible. As a result, achieving the first aim of the project, to identify and meaningfully test 'generalisable' principles, was assured in the proposals.

### *New explorations and applications of landscape as infrastructure in Sydney, Australia*

In the work on *The GreenWay*, the research successfully demonstrated the inherently infrastructural nature of landscape. The New Parramatta projects, however, showed the difficulty in achieving the research's second aim when proposing new design. Here two barriers were identified. The first was the difficulty in applying specialised knowledge, especially where a multidisciplinary approach would realistically be needed. The second barrier was in relation to the limits of communication techniques where complex ideas over time needed to be articulated for designs that gave detailed, localised solutions to infrastructure. The projects that best achieved the second aim shifted scale across the region and offered multiple proposals. Such projects were able to demonstrate strategic and open-ended outcomes.

Among the work students proposed for Parramatta are some examples that go beyond the integration of infrastructure within landscape, potentially confirming landscape infrastructure's claim that landscape itself is infrastructural. The New Parramatta projects may also have wider implications for landscape infrastructure. Their observed bias towards blue or water infrastructure, and therefore their success in meeting the first aim of this research, suggests that the framework most readily applies to hydrological infrastructural systems. Central to landscape infrastructure is the acceptance of uncertainty and recognition of positive outcomes from embracing risk. This research has tempered this outlook by highlighting the need for multidisciplinary approaches to design in ways that address complexity. It is questionable whether a landscape architect, and in particular a student of the discipline, can embrace risk and uncertainty while also addressing complexity unless they involve other disciplines.

Although two key theoretical contributors, Weller and Mossop, are of Australian origin, much of the supporting landscape infrastructure literature comes from North America and an Australian context for landscape infrastructure has not yet been established. By investigating the framework of landscape infrastructure and applying it to locations in Sydney, first through exploring an existing site as an example of the principles (as in *The GreenWay*) and then through propositional design exercises (as in New Parramatta), this research represents a first, if brief, exploration of landscape infrastructure in Australia.

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## NOTES

- 1 This was not based on region alone and can be attributed to the decline of the master plan as *modus operandi* in landscape architecture.
- 2 *The GreenWay* is a recreation, drainage and transport corridor in Sydney's Inner West. It includes the Light Rail Corridor from Central Station to Dulwich Hill. The corridor trail began construction as part of the Inner West Light Rail Extension and connects Cooks River to Iron Cove in Sydney Harbour. A master plan for *The GreenWay* was accepted by the four local councils that surround the corridor in 2009. *The GreenWay* is supported by the *Friends of The GreenWay* community action group and has also received numerous state government grants.
- 3 Parramatta Road is incidentally one of Australia's first transport infrastructure corridors. It extends approximately 20 kilometres from the centre of Sydney to the historical seat of government at Parramatta.
- 4 'Bushcare' sites are specific zones of focus for environmental restoration efforts, as recognised by local governance structures and funding.
- 5 The research is indebted to Nick Chapman, place manager for the Inner West Council, for his time and energy.
- 6 No site in Sydney is currently presented in any published material as an example of landscape infrastructure, making this project a research first.
- 7 The students' posters were designed to be viewed by the general public and were displayed at *The GreenWay* Art Exhibition from 10–20 November 2016.
- 8 Leanne Niblock represented the Parramatta City Council. The council is working towards achieving a liveable urban realm into the future as Parramatta increases in density and becomes the region's second central business district. Other particular concerns for the council include the Urban Heat Island effect, the potential for an improved pedestrian realm, and the activation of the Parramatta River within the central business district.
- 9 Sarah Clift represented the Parramatta River Catchment Group. The group crosses 13 local government boundaries and works with local authorities and the community to implement its plan *Our Living River: Our Progress to a World Class River* (Parramatta River Catchment Group, 2014).
- 10 Deming and Swaffield's (2011) text *Landscape Architecture Research: Inquiry, Strategy and Design* is arguably the first and most comprehensive source of research strategies for the discipline.

## REFERENCES

- Ahern, J (2007) Green Infrastructure for Cities: The Spatial Dimension. In *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management*, Vladimir Novotny and Paul Brown (eds), London: IWA Publishing.
- Aquino, G (2013) Preface. In *Landscape Infrastructure: Case Studies by SWA*, 2nd edition, The Infrastructure Research Initiative at SWA (ed), Basel: Birkhauser.
- and Hung, Y (2013) Buffalo Bayou Promenade and Rosemont Pedestrian Bridge. In *Landscape Infrastructure: Case Studies by SWA*, The Infrastructure Research Initiative at SWA (ed), Berlin: Birkhauser, pp 44–61.
- Bélangier, P (2012) Landscape Infrastructure: Urbanism beyond Engineering. In *Infrastructure, Sustainability and Design*, S Pollalis, A Georgoulas, S Ramos and D Schodek (eds), New York: Routledge, pp 276–315.
- Benedict, M and McMahon, E (2006) *Green Infrastructure: Linking Landscapes and Communities*, Washington, DC: Island Press.
- Carlson D (2011) *The Humanity of Infrastructure: Landscape as Operative Ground*. Accessed 21 August 2017, <http://scenariojournal.com/article/humanity-of-infrastructure>.
- Corner, J (2006) Terra Fluxus. In *The Landscape Urbanism Reader*, C Waldheim (ed), New York: Princeton Architectural Press.
- Deming, E and Swaffield, S (2011) *Landscape Architecture Research: Inquiry, Strategy and Design*, Hoboken: John Wiley & Sons.
- Department of Planning and Environment (2016) *A Plan for Growing Sydney: Greater Parramatta*. Accessed 18 October 2016, [www.planning.nsw.gov.au/Plans-for-your-area/Sydney/A-Plan-for-Growing-Sydney.html](http://www.planning.nsw.gov.au/Plans-for-your-area/Sydney/A-Plan-for-Growing-Sydney.html).
- Ezban, M (2013) *Aqueous Ecologies: Parametric Aquaculture and Urbanism*. Accessed 21 August 2017, <http://scenariojournal.com/article/aqueous-ecologies>.
- Gray, C (2011) *Landscape Urbanism: Definitions and Trajectory*. Accessed 21 August 2017, <https://scenariojournal.com/lu-landscape-urbanism-definitions>.
- Hagan, S (2015) *Ecological Urbanism: The Nature of the City*, Abingdon: Routledge.
- Hung, Y (2013) Landscape Infrastructure: Systems of Contingency, Flexibility, and Adaptation. In *Landscape Infrastructure: Case Studies by SWA*, The Infrastructure Research Initiative at SWA (ed), Berlin: Birkhauser, pp 14–16.
- The Infrastructure Research Initiative at SWA (ed) (2013) *Landscape Infrastructure: Case Studies by SWA*, Berlin: Birkhauser.
- Kilbane, S (2013) Green Infrastructure: Planning a National Green Network for Australia, *Journal of Landscape Architecture* 8(1), pp 64–73.
- Millennium Ecosystem Assessment (2005) *Ecosystems and Human Well-being: Synthesis*, Washington, DC: Island Press.
- Mossop, E (2006) Landscapes of Infrastructure. In *The Landscape Urbanism Reader*, C Waldheim (ed), New York: Princeton Architectural Press, pp 163–177.
- Office of the Government Architect NSW (2013) *Sydney Green Grid*. Accessed 15 January 2014, <http://202020vision.com.au/media/7200/barbara-schaffer-gao-sydneys-green-grid.pdf>.
- Parramatta River Catchment Group (2014) *Our Living River: Our Progress to a World Class River*. Accessed 18 October 2016, [www.ourlivingriver.com.au](http://www.ourlivingriver.com.au).
- Pungetti, G and Jongman, RH (2004) *Ecological Networks and Greenways: Concept, Design Implementation*, New York: Cambridge University Press.
- SWA Group (2015) *Design Briefing: Landscape Infrastructure: A Tool for Making Our Cities Better*. Accessed 15 February 2016, [www.swagroup.com/brochures/design-briefing-landscape-infrastructure](http://www.swagroup.com/brochures/design-briefing-landscape-infrastructure).
- Thompson, I (2014) *Landscape Architecture: A Very Short Introduction*, Oxford: Oxford University Press.
- Waldheim, C (2016) *Landscape as Urbanism: A General Theory*, Princeton: Princeton University Press.
- Weller, R (2006) An Art of Instrumentality: Thinking through Landscape Urbanism. In *The Landscape Urbanism Reader*, C Waldheim (ed), New York: Princeton Architectural Press, pp 69–85.